



A HYBRID APPROACH OF SENTIMENT BASED ALGORITHM FOR COMPUTERIZED OPINION ANALYSIS IN THE CONTEXT OF PUBLIC UNIVERSITY ADMISSION SYSTEM IN BANGLADESH

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Abstract

In this study of opinion analysis, we propose a new algorithm which takes the Public University Admission System in Bangladesh issue as the case study. This study reviews previous approaches of opinion analysis to identify drawbacks and strengths in manual approach and procedures. This study proposes a hybrid approach of sentiment analysis including supervised machine learning algorithm and lexicon-based approach to overcome the drawbacks of manual approach. For the development of the algorithm, corpus data-store including keywords and machine learning approach's rule-based classifier's if-else method has been used which is able to categorize the given sentences by using the data store. On the basis of the algorithm, we develop a computerized approach for checking whether the algorithm is working or not. The evaluation on computerized opinion analysis approach indicates significantly better and effective results in comparison with the manual approach.

Keywords: Sentiment analysis, Opinion analysis, Framework, Algorithm, Machine learning approach, manual approach.

Introduction

As Bangladesh is a democratic country so there is always need to take opinion from the citizen of the country and public university admission system has a disagreement. Public university admission system is an argumentative issue of Bangladesh. So, this issue has been taken as a context of developing our algorithm and the state-of-art technology will be an excellent solution for these kinds of problem.



1. Type of Approaches

This issue can be solved in many ways but it can be faster and effective if we consider the opinions of people. In this paper, two type of approaches has been utilized to solve these kinds of problem.

1.1 Manual Approach

Opinion or feedback analysis can be done manually with documentation and surveys. Manual approach needs more time, needs more labor and more attention when it is used for bigger datasets and critical contexts like Public University Admission System.

1.2 Computerized Approach

There are many methods for computerized opinion analysis such as video analysis, voice analysis, text analysis and speech analysis. These approaches are beneficial in their own fields but they also have limitations. But the limitations are optimizable. This research proposes a new framework for computerized opinion analysis algorithms. It utilizes a hybrid approach of sentiment analysis of supervised machine learning and lexicon-based algorithms.

Supervised machine learning method can apply on the situation where what has been learned in the past to new data using label on examples to predict future events. Here, supervised learning's rule-based classifier has been used.

lexicon-based algorithm used for divided sense from text. Using this approach to find positive, negative and suggestion word from any sentence. In this algorithm corpus-based method has been used. It is basically used for finding the exact meaning of adjective and attributes. Because, different sentence varied different meaning of adjectives.

To develop this approach, XP (Extreme programming) method has been used. The algorithm will classify the opinion into different categories such as: positive, negative, neutral and suggestion.

Background Study

An essential part of our information-gathering behavior has always been to find out what others think. There are types of approaches to how people express their opinion. By using those opinions as input, computer engineers can find out the ratio of positive, negative, neutral and suggestion sentiment. The manual approach is one of them. It categorizes sentences by keyword where no algorithm or computation is necessary. However, for opinion analysis procedure, there needs a collection of opinions rather than only one. Because one or two will not represent the view of average and which will not make enough for action (Lui, 2011). By reading the structure of a sentence manually, it can be told the nature of the sentence either it is positive or negative or neutral or suggestion etc. It is a beneficial property for opinion classification using an authoritative resource that is bound to execute better (Aye & Aung, 2018). But, as the world wrapped around with technology, there are numerous approaches related to computers. It makes the task easier and faster. As a result, computerized methods have received much attention from researchers and industry communities recently (Cesarano et al., 2006). Othma & Moawa (2014) divided sentiment analysis into three levels. First one Document-level such as product views, product update, blogs, and forum posts etc. Then Sentence-levelwhich identifies if a sentence is opinionated and its nature and last one Attribute-level. It extracts the object attributes (e.g., image quality, zoom size) that could be a subject of opinion. Mainly Attribute-level fully dependent on the computerizing system.

Sentiment analysis is also an opinion analysis technique. It is the opposite of the manual approach. Unlike the manual approach, here needed an algorithm and computation to find out the



result. In sentiment analysis, approaches can split into two main groups either a machine learning approach or a lexical-based approach (García, Gaines & Linaza, 2012).

A polarity classification method was proposed using unigrams and bigrams as input features to several classifiers (Pang, Lee & Vaithyanathan, 2002). They used a machine learning approach to exploit the statistical properties of the dataset. The supervised machine learning algorithm works with a known set of input data. So that they know responses to the data output, supervised methods cannot work with data that is not trained. According to Hu & Liu (2004); Kim & Hovy, (2004) the lexicon-based approach uses a function to determine the nature of any sentence. The function goes over the opinion document and analyzes the words of the document. The word analysis of the lexicon approach occurs in two ways. Dictionary-based and corpus-based. The dictionary-based approach is where the central focus goes on searching words, the synonyms and antonyms of the words in the dictionary. Furthermore, the corpus- based approach derives a searching list of opinion words and search for opinion words using a significant corpus which is defined contextually explores how that language relates to other languages (Xiaowen, Bing & Philip 2008; Taboada, Brooke, Tofiloski, Voll & Stede, 2011).

By combining these two approaches- machine learning and lexicon-based approach, we get a Hybrid approach. Previous researches have shown that both of the approaches have their advantages and limitations (Roh, Heo, & Whang, 2018). So, the hybrid approach will get the advantages of both approaches and will eliminate the limitations. Research has shown that the hybrid approach can provide more accurate results and performance, which individual machine learning approach or lexicon-based approach cannot do (Hu & Liu 2004; Kim & Hovy, 2004).

Methodology

The main concern of this study is to analyze opinions for the algorithm on this topic. This study collects textual opinions from students, teachers and guardians. Based on the drawbacks of the previous research, the study proposes a new framework for the algorithm. This approach aims to overcome the limitations of other approaches and find better and efficient solution for the issues of manual systems. It focuses on the betterment of the computerized system for opinion analysis.



Picture 1: Proposed Framework of Sentiment Analysis Algorithm

According to the framework of our proposed algorithm, it will take input from users for their registration process. Here, users are a targeted group of people consisting of students, teachers and



guardians who are involved with the public university admission system. They have to give a valid email for using the system. After the registration, the user can see the question about the topic. The system will take the answer which has to be in text, either a word or a sentence. In database storage, all these data of the proposed computerized system will be stored. This computerized system will utilize MySQL as an open-source database platform to store all the information of users and also the opinion-based sentences. In the intelligent system component, the proposed machine learning algorithm will analyze all the user inputs. The keywords are also stored in a database system. The algorithm will generate categories according to the given categorized keywords to evaluate users' opinion in the context of public university admission system.

In the result analysis component, the overall result will be shown by the computerized system. This result includes percentages of the categories; positive, negative, neutral and suggestion.

IgorithmDevelopment Process of the Proposed A

For the development system, XP (Extreme Programming) has been considered as a system for the development process. In this project corpus data store has been used. So, after the term of data labelling manually, we found-

- 120 Positive keywords,
- 135 Negative keywords,
- 15 Negation keywords and
- 24 Suggestion keywords.

Here are some examples of data.

Number	Keyword	Туре
130	incredible	Pkey
131	harsh	Nkey
190	fantastic	Pkey
183	successful	Pkey
156	disappointed	Nkey
157	ineffective	Nkey
158	adequate	Pkey

Table 1: Data Labelling

Design of The Algorithm

The framework of the proposed algorithm, is a hybrid approach of sentiment analysis where machine learning based approach and lexicon-based approach both are used. This hybrid approach utilizes supervised machine learning algorithms with customized sentiment keywords which are constructed and categorized in the context of the public university admission system.

Framework of The Algorithm

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Picture 2: Framework of the algorithm

The framework has a set of steps in order to analyze a category of opinion. There are different rules for different category extraction in a sentence. Finally, these words will together determine the category of that sentence.

The computerized system reads each and every word of a sentence and detects the positive, negative, negation and suggestion-based words based on the polarity classification algorithm and corpus datastore.

 Table 2: Working process of the algorithm

Step No	Process Details
01	For each word in a sentence, find its category in the predefined data store.
02	Detect polarity-based words in each sentence in the data store.
03	Count polarity-based words by using polarity classification approach and will
	determine the sentences either as positive or negative or neutral or suggestion.
04	After categorizing all the sentence, it will give a percentage of those sentences.

Here is the polarity Classification Algorithm

• Positive Word Detection:

Word_(positive) = Sentence (Polarity = Positive)

Word (Negation word) + Word (Negative) = Sentence Polarity (Positive)

• Negative word detection:

Word (Negative) = Sentence (Polarity = Negative)

Word (Negation word) + Word (Positive) =Sentence Polarity (Negative)

• Neutral Word detection:

Word (positive)=Word (Negative) =Word (Suggestion)= 0 = Sentence Polarity (Neutral)

• Suggestion Word Detection:

Word (Suggestion) = Sentence Polarity (Suggestion)

The computerized system reads each and every word of a sentence and detects the positive, negative, negation and suggestion-based words based on the polarity classification algorithm and corpus datastore.



If Sentence Polarity is positive, the sentence counts as positive opinion (sentence_pos). If it is negative, then the sentence counts as a negative opinion (sentence_neg). If both positive, negative and suggestion words are zero, then the sentence counts as neutral (sentence_neu) and If it is suggestion then the sentence counts as suggestion opinion(sentence_sugg).

Implementation of The Algorithm

A hybrid approach of sentiment analysis where the combination of machine learning and lexicon-based approach algorithm proposes to find out the result. This algorithm has been following supervised learning's rule-based classifier's IF-Else method and corpus-based approach of Lexicon-based approach for generating final results. For the implementation of the code PHP language has been used.

Evaluation and Result Analysis

This computerized approach has been evaluated by measuring the effectiveness and efficiency compared to the manual opinion analysis system in the context of public university admission systems. Once the calculation is done manually and then done by computationally. The computerized approach utilized the corpus-based stored data that we give as input to the system.



Picture 3: Result Comparison between Computerized Approach and Manual Approach

The overall result analysis has been conducted over 1000 sentences. The difference between the number of categorized sentences achieved both by manual and computerized approach can be seen. 469 sentences are manually categorized as Positive sentences, while computerized approaches categorized 499 sentences as Positive. Manually 319 sentences are Negative and define 335 as Negative sentences. Neutral are both low, in manual it is 77 and 50 sentences found systematically. There are 135 Suggestion sentences manually and 116 sentences found systematically.

The effectiveness of the approach is measured by accuracy. The accuracy of the computerized system is compared with the labelled data of manual approach. Here is the comparison.



Sentence	Manual Approach	Computerized Approach	Error
Positive	47%	49%	2%
Negative	32%	33%	1%
Neutral	8%	5%	3%
Suggestion	13%	11%	2%

Table 3:	Outcome	comparison	between	manual	approach	and co	omputerized	approach
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Here is the result analysis of the manual approach and computerized approach through the pie chart.



Picture 4: Result Analysis of Manual Approach and Computerized Approach

Out of 1000 sentences, the system categorized 908 sentences correctly utilizing the datastore. Only 8% of all the sentences have not been categorized correctly. So, the overall error sentences 92. These sentences are wrongly categorized, or unable to detect proper keywords to classify a sentence correctly.

The manual approach is 100% accurate based on the result analysis. We could be categorized by the manual process because of proper keywords or understanding all the meaning of the sentences.

The efficiency of the computerized approach is measured by time, cost and labor compare with the manual approach. Here is the comparison for finding the efficiency.

Procedure	Manual Approach (Time)	Computerized Approach (Time)
Data Collection	3 Weeks	2-3 Days
Sampling	2 Weeks	Instant
Categorization	3 Weeks	Instant
Cost	3000 Taka	No Cost

Table 4:	Efficiency	Comparison
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It has taken almost 5 weeks to collect the data and sampling it. After that, manual approach needed three weeks more to be completed to categorize the sentence into four different categories and this all costs 3000 Taka. Whereas computerized needed only a few seconds to categorize all the sentences and give the result and this all needs no costs.



Eventually, the computerized approach got an overall satisfactory result in terms of effectiveness and efficiency compared to the manual approach in the context of public university admission system.

Significance of The Research

Now-a-days sentiment analysis is an important field of study. The study describes our proposed approach on sentiment-based algorithm of computerized opinion analysis system in the context of public university admission system. So, the usefulness and proficiency of the proposed algorithm can be found out if we take a look on the previous approaches, though it may not give the accurate output which is expected. Therefore, it will be very beneficial and helpful as we can use it this type issue for analyzing opinions. As it is a computerized based algorithm that is why it will take a very less time. This sentiment based algorithm on computerized system can be effective and efficient because of easy functions, easy data management process, less analysis time, less labor involvement, less cost and more accurate output. So, it can be a source of help for the government, if the authority really aims to solve the issues of public university admission system in future.

Limitation and Future Work

There are some sentences which are filled with positive words but as a whole it refers to negative meaning or vice versa. Now-a-days people like to express their feelings through emoticons so it can be a further area of study. Sometimes, few sentences express more than one opinion so it also can be a further area of study in future. Some words are not clear if they are positive or negative. So, these kinds of confusing words can be a further area of study. This research should be carried on not only in the context of public university admission system but also for all the opinion analysis systems.

There are some limitations in our research those are given below:

- Our algorithm could not detect some sentences because of some data shortage.
- Some sentence's classification was not classified correctly.
- Due to time limitations the complete system is yet to develop.

Conclusion

This study reviews the remaining opinion analysis methods and techniques to find out the strengths and shortage of those approaches. From the study reviews get an idea about sentiment-based opinion analysis. The study proposes a new idea of computerized opinion analysis systems from manual systems from the lack of manual systems. After completing the proposal this study also implemented a sentiment- based algorithm for computerized opinion analysis system for public university admission system. The algorithm integrates corpus dataset which is made of opinion-based keywords including machine learning and lexicon-based approach to analyze collected opinion-based sentences and categorize them. Comparing the manual approach, the result of algorithm obtained satisfactory results in terms of efficiency and effectiveness. That means the study met the goal. The study also has some future aspects of research in the area of opinion analysis.

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AN IOT BASED FIRE ALARMING AND RESCUE ASSIST SYSTEM FOR HOUSEHOLD & INDUSTRY USING GSM MODULE

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Abstract

Nowadays, Bangladesh is known mostly around the world one of the main reasons for that is our industries. Our Ready Made Garments industry is already one of the largest in the world and still it's growing. Industries like leather, electronic appliance, Agro-food processing, and different others are also growing at a rapid speed which is reflecting in our economy as well. To reach our goal of getting a status developed country by 2041 we need to be more productive and some problems are coming between this goal. Fire accidents are one of the top in the list of those problems. It's making life difficult for both industry owners and workers.Now it's not only limited to industries as fire accidents are occurring almost everywhere like shopping mall corporate offices and also in residential houses.IoT has already solved thousands of real-life problems including emergency health careresponse, automated water supply, and soon.A lot of researchers have also implemented it to reduce the damage of fire accidents by alerting the responsible persons as early as possible. So, we have also made a prototype of a system named EFARAS which will help to reduce the losses and will detect fire less than 10 seconds after the fire ignition. It can detect the exact location of the source of the fire and after detecting fire it will end an alert to the owners, in habitants, and emergency services i.e, fire brigade, police station etc. It has some safety features as we like in strong smoke during evacuation it will glow fluorescent light strips to show the path of the emergency fire exit, automatically open the fire exit door, and activated the hydrant system of the building before the arrival of emergency response. It also has safety measures to nullify the false alarms. It's one of the efficient systems in the market right now as it takes only 3 seconds to detect the fire after ignition and from our public survey and reviews over 85% of people are satisfied with the prototype system. Though there was a concern over the visual confirmation of fire via video/image feed which is not done yet but an objective which will be performed in the future iterations.

Keywords: Fire Detection;Internet of Things;GSM module;Sensors; Arduino; Motor; Automation; Notification.

Introduction

TODAYs Bangladesh is no more dependent on Agriculture only perhaps it's been turned in to a nation with rapid industrial growth. This growth helped Bangladesh's economy to boomand



properly use the vast population of the country.Despite the economic boom of over 7% a year in GDP Bangladesh is also facing some problems with this industrialization, that's why there is a saying with great power comes great responsibilities.Bangladesh is also facing a similar type of problem with its industries and also with its densely populated urban commercial and residential spaces which had several fire accidents from the last couple of decades now .It's turning into a mass acreon the last few events.Alone only Ready-Made Garments (RMG) industry is employing a massive 4.2 million employment [1] and other industries are also employing a large amount of population. But this large population is in a vulnerable position as these factories and industries are having frequent accidents[1].

In the last 12 years the RMG of Bangladesh has seen several tragic accidents [1]. The main chunk of them were because of fire. A report suggests that on November 27th, 2012 a fire accident on "Tazreen Fashion factory" in capital Dhaka took 117 lives [2]. On 9th May 2013, 8 people were killed when a fire broke out at a textile factory in Mirpur Industrial Area (Vivek- infotech. in). 30 people were killed and 200 more being injured seriously while the fire broke out in a factory near Ashulia, Dhaka [1]. In 2010, 20 more people died because of this horrible fire accident this time the factory name was "Garib and Garib" [3]. These tragic incidents show the volatile infrastructure of the industry and factory of the nation. Even they do not have the minimum equipment to prevent fire and rescue the hostages in an emergency. These factories are vulnerable to fire as they lack the minimum safety tools and fire detection technology[1]. On the contrary they don't even have an automated system that can turn off the electricity during an emergency. That's why an automated device is required to detect fire and which also can alarm the employees before it breaks out is a highly demanded device. That's why we have designed a device that can detect fire as soon as flame ignites and help to save the valuable life of humans and millions of dollar worth assets. The device will use several sensors to detect fire and gas. The device's sensors will be set to the appropriate place so that it can cover the whole area of the industry/factory. The places will be chosen by surveys on the factory and later the sensor will be placed accurately and will be activated. The data collected from sensors will be sent back to the Arduino microcontroller. The algorithm will be developed to detect the fire out break and open alarm for fire. As well as, the device will stop supplies of gas and electricity after sensing fire break out and will open fire hydrant system of the building. Instantly the system will send an Alert Message using the GSM module to the nearby fire service station informing them about the accident and also send SMS to the factory owner and officials.

Background

Sowah and Robert designed and developed a system for fire detection on vehicles using fuzzy logics[3]. They used three different sensors to detect the fire and those sensors are flame, smoke and smoke sensors. There system also can extinguish fire within only 20 seconds and they implemented the air-conditioning system to extinguish the fire. Yu, Liang, Nengand Xiaoqiao proposed a paradigm to detect fire accidents in fire, they used wire lessens or networks to detect the fire[4]. They have worked on collected data and process them to use further. They used netural network to process the data and also use different techniques to make it energy efficient so that WSN can work better. Chen and Thou-Ho has proposed another fire alarm system which is based on video processing [6]. They used existing camera and combine them with AI system which enables them to detect smoke. They gave smoke color and its pattern to the AI system to detect fire. This system was based on Image Processing based AI system which takes bit time to detect a possible fire outbreak. Gaikwad and K. M. designed a fire monitor and controlling system on which they implemented different sensors such as flame, gas and smoke to detect fire and they also have the manual system to extinguishing process[7]. To find the



exact location they used GSM/GPS system.IoT, Internet of things means the millions of physical devices which are around the world are connected to the internet by collecting and sharing data. The IoT is a network of connected things and people also.All of which collect data and share data on the way they are used and on the environment surrounding them. The concept of IoT was invented by a member of the Radio Frequency Identification Development(RFID) community in 1999.IoT has now become more connected to the real world because of the increase of embedded , mobile devices , cloud computing , ubiquitous communication and data analytics.

IoT is defined into three categories as below :

(1) People to people.

(2) People to machine /things.

(3) Machine/Things to Machine/Things.

The characteristics of the IoT are given below :

Interconnetivity : Regarding to the IoT, everything can be connected with the information and communication infrastructure.

Heterogeneity : The devices based on IoT are heterogenous. The devices are from different networks and hardware platforms. They can connect with other devices and service platforms through different networks.

Things-related services : The IoT provides thing-related services within the constraints of things, such as privacy protection and semantic consistency between physical things and their associated virtual things.For providing thing-related services within the constraints of things, both the technologies in information world and physical world will change.

Connectivity : It can enable network accessibility with compatibility. Accessibility is important for connecting with network and compatibility is necessary for consuming and producing data.

IoT Architechture : There remains different layers of technologies in IoT Architechture. Those are described below:

1. Sensor layer : Smart objects made this layer which is connected with sensors. The sensors have the ability to measurement such as humidity, air quality, temperature, speed, pressure, electricity and movement etc.

2. Gateway and Networks : This sensors produce massive volume of data and which requires a strong and high performance wired network infrastructure or wireless network infrastructure for a transport medium.

3. Management Service Layer : It brings connections of objects which provide information within a form of contextual data such as current location ,traffic data and temperature of goods.

4. Application Layer : Application based on IoT covers smart environment in domains such as Lifestyle, Supplychain, Transportation, Factory, Retail, Agriculture, Healthcare, Environment and Energy, Culture and tourism.

IoT based systems : Lots of systems have been developed in IoT.Some of them is described below :

1) IoT based humidity and temperature monitoring using Arduinno Uno:If We want to know the temperature of our home, we can see it in our smart mobile.In this project DHT11 sensor, arduino microcontroller and ESP8266-01 is used.

2) IoT weather reporting system using raspberry pi:This is a project for weather reporting Rasbherry Pi gathers informations and uploads them in IoT platform.



3) IoT connected healthcare applications:Firstly here it checks the condition of health of a person and then report the health condition to a specialized doctor.Using this we can detect blood pressure, heartbeat, hemoglobin content etc.

4) IoT based intelligent traffic management system:Traffic system is checked here through internet.RasberryPi and Camera is used to monitor the real-time traffic and update the report to the traffic control officer's panel.

5) IoT based smart parking system using RFID:In this system car must have RFID sensor to identify vehicle.Whenever we need to park car in a parking slot, we can find the available slot for vehicle in this system.

6) Smart irrigation system using IoT:Different sensors are used here to sense humidity, temperature and moisture for better production.

7) IoT smart home automation using node mcu:This project is developed using node mcu.Node MCU has inbuilt wifi in it-ESP8266wi-fisoc.

8) IoT based forest fire alarm system :This project mainly works with MCU and fire sensors which is interconnected to the things peak cloud.

9) IoT based water level monitoring system using FPGA:FPGA and Ultrasonic sensor is used here to calculate the level of water.In this project 6 FPGA and wifi module is used.

10) MQTT based smart waste collection management using raspberry pi:In this project MQTT is used which is a very lightweight protocol that can work through low internet speed with high speed transfer data. There are so many systems like these which are making our life more comfortable. IoT reduces cost, increases safety and it is stimulating our economy also.

Arduino uno:It is a microcontroller board which is based on ATmega328.Uno comes from Italian term.Arduino uno which is available in market named as Arduino uno 1.0.It includes dishital I/O pins-14,analog i/ps-6,usb connection,icsp header,power jack,ceramic resonator- A16MHz and an RST button.This components are connected to micro controller for operation by giving input to the board of the computer.AC to DC adapter,USB cable ensures the power supply properly.

- 1. Input voltage range from 7v to 12v
- 2. The operating voltage is 5V
- 3. Input voltage ranges from 6v to 20V
- 4. Digital input/output pins are 14
- 5. Analog i/p pins
- 6. DC Current for each input/output pin is 40 mA
- 7. DC Current for 3.3V Pin is 50 mA
- 8. Flash Memory is 32 KB
- 9. SRAM is 2 KB
- 10. EEPROM is 1 KB
- 11. CLK Speed is 16 MHz

Communication : It offers UART TTL-serial communication.Here remains two LEDs within board called RX & TX and they blinks whenever data broadcasts through USB.

How to use: It can detect the surroundings from the input. Arduino board can be programmed with Arduino programming language and the IDE.

GSM:It is like a modem known as mobile communication.It is an open and digital cellular technology which is used for mobile voice and data services operates at 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.Time division multiple access (TDMA) technique is used for the development of GSM.GSM digitizes the data , reduces the data after that sends it down through a channel which is connected with two different client data,each remains their own particular



time slot. This system has access to carry 64 kbps to 120 Mbps of data rates. There are different call sizes in a GSM system those are micro, macro, pico and umbrella cells. Each cell differs through the implementation domain.

GSM Architechture : GSM has the following components :

Mobile Station : Mobile phone has transceiver, the processor and the display and it is controlled by a SIM card operating over the network.

Base Station Subsystem: It works as an interface between the network subsystem and the mobile station. It includes the base transceiver station which includes the radio transceiver and make connections through the protocols for communication with mobiles. It also has the Base Station Controller for controlling the Base Transceiver station and acts as a interface between mobile switching centre and mobile station

Network Subsystem:Network connection is provided to the mobile stations here.Network Subsystem has a basic part and that is the Mobile Service Switching Centre that provides access to different networks like ISDN,PSTN etc.

Features of GSM Module:

- 1. Improved spectrum efficiency
- 2. International roaming
- 3. Compatibility with integrated services digital network (ISDN)
- 4. Support for new services.
- 5. SIM phonebook management
- 6. Fixed dialing number (FDN)
- 7. Real time clock with alarm management
- 8. High-quality speech
- 9. Uses encryption to make phone calls more secure
- 10. Short message service (SMS)

Servo Motor: A servo motor is an electrical device. It can push object and rotate also with great precision. A simple motor is used for making servo motor that run servo mechanism.

Servo mechanism: It has three parts.1st one is controlled device 2nd one is output sensor and 3rd one is feedback system.It is a looping system.It uses positive feedback system for controlling motion and final position of the shaft.

Working principal of servo motors: It has a motor, a potentiometer, a controlling circuit and gear assembly. At first gear assembly is used for reducing RPM and for increasing torque of motor. Two signals are generated. One come from potentiometer and rest one comes from other source. By changing potentiometer's angular position, its output feedback signal changes. Sometime the position of potentiometer reaches in such a position that the output of potentiometer remains same as external signal provided. At that condition, amplifier provides no output signal to the motor input as there remains no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

Controlling servo motor: There remains three wires in motor. Two is used for supply and another is sent from MCU which is used for signal. PWM controls servo motor that is provided by the control wires. It remains two pulses one is minimum pulse another is maximum pulse and repetation rate.90 degres turn is possible in servo motor which is directed form its neutral position.20 milliseconds (ms) pulses is available in servo motor and pulse's length can determine how far the motor turns.

It works on PMW(Pulse with modulation) principle that means it's rotation is controlled by the duration of applied pulse from Control PIN.Basically DC motor is used for making servo motor



which is maintained by a variable resistor and some gears.DC motor has high speed force which is converted into torque by Gears.0 to 180 degres rotation can be done by servo motor, but it can be maximum up to 210 degree, depending on the manufacturing.By electrical Pulse and Control pin, we can control the degree of rotation.The pulse is checked by servo in every 20 milliseconds. 0 degree rotation can be done in 1 ms(milisecond),90 degres rotation can be done in 1.5 ms (neutral position) and 180 degres rotation can be done in 2 ms.Servo motors can work with +5V supply rails but we should be careful on the amount of current the motor would consume.For using more than two servo motors, we have to design a proper servo shield.

Gas Sensor: A gas sensor may be a device which detects the presence or concentration of gases within the atmosphere. Supported the concentration of the gas the sensor produces a corresponding voltage by changing the resistance of the fabric inside the sensor, which may be measured as output voltage. supported this voltage value the kind and concentration of the gas may be estimated. The kind of gas the sensor could detect depends on the sensing material present inside the sensor. Basically these sensors are available with comparators as shown above. These comparators may be set for a selected threshold value of gas concentration. Threshold the digital pin goes high by increasing the gas. The analog pin may be accustomed measure the concentration of the gas.

Different Types of Gas sensors Gas sensors are typically classified into various types supported the sort of the detector it's built with.Below is that the classification of the assorted sorts of gas sensors supported the detector that are generally utilized in various applications:

- 1. Optical gas Sensor.
- 2. Metal oxide gas Sensor.
- 3. Electrochemical gas Sensor.
- 4. Capacitance-based gas Sensor.
- 5. Calorimeter gas Sensor.
- 6. Acoustic based gas Sensor.

Gas Sensor Construction Of all the above-listed types, the foremost commonly used gas sensor is that the Metal oxide semiconductor based gas sensor.All Gas sensors will include a device which comprises of the subsequent parts.

- 1. Gas sensing layer
- 2. Heater Coil
- 3. Electrode line
- 4. Tubular ceramic
- 5. Electrode

Temperature Sensor: A temperature sensor may be a device, usually an RTD (resistance temperature detector) or a thermocouple, that collects the information about temperature from a selected source and converts the information into understandable form for a tool or an observer. Temperature sensors are utilized in many applications like HV and AC system environmental controls, food processing units, medical devices, chemical handling and automotive under the hood monitoring and controlling systems, etc The most common variety of temperature sensor may be a thermometer, which is employed to live temperature of solids, liquids and gases. It is also a standard variety of temperature sensor mostly used for non-scientific purposes because it's not so accurate gas. Types of Temperature Sensors. There are different types of temperature sensors that have sensing capacity depending upon their range of application. Differing types of temperature sensors are as follows:

- Thermocouples
- Resistor temperature detectors



- Thermistors
- Infrared sensors
- Semiconductors
- Thermometers.

Methodology

The main goal of this research is to develop the IOT based fire alarm system with the interaction of 2 sensors and GSM module and water pump with the controlling with Arduino. Moreover, there search's objective is to save the people who working in garments factories and the corporates office and many other big companies.



Figure 1: SystemArchitecture

The methodology of this research development was based on the Water fall development process. The Waterfall development process is a combination of collecting all the requirement before starting the development process. The model allows the developer to make the requirements very strong. The system was built on the basis of the system architecture. The whole system was simulated on a software called Proteus Design Suite. After successful simulation the device were ready to build. Circuit Diagram was tested on the Proteus Design Suite and after it passed on the test the circuit diagram was finalized.

The simulation of the circuit diagram for EFARAS is shown below:





Figure 2: System Design

Because the model not allows to make any change in the development time. In this research fire alarm system based on IoT will work smartly in the system. The system can detect any smoke, gas, fire & the temperature by the sensors.

Arduino programming : After installing Arduino IDE , we have to attach arduino board to the computer by USB cable. This board can be programmed by Arduino programming language depends on wiring.

Physical characteristics: Arduino uno's circuit boards length is 2.7 inches and width is 2.1 inches. Power jack can be extend and USB connector can also be extend with the previous measurement. The board can also be attached through surface otherwise case with the scre holes.

Applications of Arduino Uno ATmega328:It's applications are given below :

- 1. It is used through do-it-yourself projects prototyping.
- 2. It is code-based control for developing projects.
- 3. Development of Automation System.
- 4. Designing of basic circuit designs.

1. Water Pump Motor is used to demo as a buildings water hydrant system. This pump is a dc motor takes a 5v direct current from the arduino uno board.

2. GSM Module is used to send emergency alert messages. This device requires a full sized SIM Card to send messages. This device also need 5v to power and it has 4 pin. Txd and Rxd pin sends the signal to arduino.

3. LED Lamp is to demonstrate the emergency exit path this is also connected to the board.

4. Buzzer is used as a emergency bell which will ring if anything awkward happens. This also have two pins.

5. Servo Motor is demonstrated as an automated emergency exit door which will open automatically in a possible fire outbreak.

6. MQ4 sensor is used detect methane gas, smoke and cng gas. It also has three pins and one of them used as input of the device to detect fire outbreaks.

7. LM35 sensor is used to detect the heat signature which will trigger if the temperature exceeds 50 degree Celsius. It has 3 pins two of them carry power and one give an input to the board to detect fire.

8. Arduino Uno is the main brain in this system. This system is designed to be autonomous and arduino micro-controller let it achieve that autonomy.



Since the requirements of the system are very difficult.From the many garments we got all the requirements. The model can be applied in the area of Networking.The software which will run the system shall boot automatically whenever the Arduino is powered on.Smoke detector, fire detector, temperature detector, gas detector and GSM modular will be activated automatically while the software boots on.The software will always make asynchronous calls to Smokedetector, fire detector, temperature detector and gas detector to check the irresponses.

The software shall provide such a feature which will set a threshold point of temperature which will help to determine the response from temperature detector as positive or negative. If there is negative responses from all the devices of Smoke detector and fire detector and temperature detector and gas detector then the software will make call to the mentioned sensors again to get their responses. If there is any positive response from the Smoke detector or fire detector or temperature detector or gas detector the software will activate the buzzer, GSM modular, LED light, servo motor and the water pump simultaneously. When the GSM modular is activated, the software will send a hazard message to the nearest fire service center and the admin of the user company. The software will keep sending hazard message until it is sent successful.

Software requirements:

1. The software which will run the system shall boot automatically whenever the Arduino is powered on.

2. Smoke detector, fire detector, temperature detector, gas detector and GSM modular will be activated automatically while the software boots on.

3. The software will always make asynchronous calls to Smoke detector, fire detector, temperature detector and gas detector to check their responses.

4. The software shall provide such a feature which will set a threshold point of temperature which will help to determine the response from temperature detector as positive or negative.

5. If there is negative responses from all the devices of Smoke detector and fire detector and temperature detector and gas detector then the software will make call to the mentioned sensors again to get their responses.

6. If there is any positive response from the Smoke detector or fire detector or temperature detector or gas detector the software will activate the buzzer, GSM modular, LED light, servo motor and the water pump simultaneously.

7. When the GSM modular is activated, the software will send a hazard message to the nearest fire service center and the admin of the user company. The software will keep sending hazard message until it is sent successful. The system will be installed in Arduino Uno. All the peripheral devices (Smoke detector, fire detector, temperature detector, gas detector, LED lights, water pump, servo motor, Buzzer and GSM modular) will be connected to the Arduino Uno. Arduino Uno will act as the control point of the system.





Figure 3: Flowchart

Initially, the system will start by booting up the system in Arduino while it's power on. Then smoke detector, fire detector, temperature detector, gas detector and GSM modular will be activated automatically. After that, the system will make asynchronous calls to Smoke detector, fire detector, temperature detector and gas detector to check their responses. Next, if the register negative responses from all the devices of Smoke detector and fire detector and temperature detector and gas detector then the system will make call to the mentioned sensors again to get their responses. Then, if there is any positive response from the Smoke detector or fire detector or temperature detector or gas detector the system will activate the buzzer, GSM modular, LED light, servo motor and the water pump at the same time. After that, when the GSM modularis activated, the system will send a hazard message to the nearest fire service center and the admin of the user company. The system will keep sending hazard message until it is sent successfully.

Testing:

Testing should be conducted after successful integration of all the individual modules of the system. For testing, responses of smoke detector, fire detector, temperature detector, gas detector will be considered as inputs. Each of the mentioned input devices should be tested individually to check there responses as per the criteria discussed in the requirement section. Further, responses of buzzer, GSM modular, LED light, servo motor and the water pump will be considered as output devices. Each of the mentioned output devices should be tested individually to check there responses as per the criteria discussed in the sate pump will be considered as output devices. Each of the mentioned output devices should be tested individually to check there responses as per the criteria discussed in the requirement section. A test suite should be prepared to execute all the test cases for the sake of a better quality system.

Development

This chapter discusses the implementation process of the IoT Based "Emergency Fire Alarm & Rescue Assist System" (EFARAS) and its performance evaluation. Arduino cc were used to code on Arduino Uno. The GSM Module was used for sending SMS is discussed here. This chapter also discusses the integration of different sensors(e.g. Smoke sensor, Gas Sensor, LDR sensor, temperature sensor) in to the Arduino Uno Board. Next, Integration of Motor to portrait the use of water hydrant is also discussed. Finally, user evaluation of the device by performing a public survey and findings from the user review is discussed. The methodology of this research development was based on the Water fall development process. The Waterfall development process is a combination of collecting all the



requirement before starting the development process. The model allows the developer to make the requirements very strong. Because the model does not allow to make any change in the development time. In this research fire alarm system based on IoT will work smartly in the system. The system can detect any smoke, gas, fire & the temperature by the sensors. Emergency exit path is available in our system. At the time of fire employes can save their life by using emergency exit path. Since the requirements of the system are very difficult. From the many garments we got all the requirements. The model can be applied in the area of Networking.

There are five steps of the development methodology:

- i) Requirements
- ii) System design
- iii) Implementation
- iv) Testing
- v) Deployment

Before implementing our device EFARAS, a system architecture was develop to know that how the system will work and which step will be important for deciding actions. The device will follow this steps to detect fire and then start the rescue assist procedure. System Architecture is the core of designing the EFARAS. Basing on this architecture the device was built on a simulation software. Then the prototype was built on the software and tested on the software is to check, it works or not. Lastly the actual device was built. Here smoke sensor, gas sensor, temperature sensor were used to detect the fire. The sensors were integrated to an Arduino Uno and was program to detect the fire when a threshold amount crosses. After crossing the threshold amount it triggers the microcontroller to activate the buzzer which is used as an alarm in this demo device in the same time it also triggers the GSM 37 Module which then sends an SMS to responsible personnel. It also activates the LED lamps which mark the emergency exit way out and emergency exit door opens. Finally, water hydrant system open and rescue assist system ends. User evaluation was done to get the effectiveness of the device from random sampling of the dedicated population and findings were discussed based on their reviews.

Implementation:

The implementation is done on several stages. Creating circuit diagram is the first step of the stages. After creating the circuit diagram the actual components has to be collected then Integration of those components on Arduino Uno. After connecting the components on the board Arduino board need to be programmed. To program the Arduino Uno board Arduino IDE was used and the code was written and it was uploaded to the board. Lastly Experimented result after implementation will be provided.

Integration Components to Arduino uno:

Arduino Uno is the main board so all the components was connected to it and it was powered by a USB cable and for sufficient power external power source was added.Water Motor has two pins so to trigger the motor it was connected to arduino's digital pin 4 and the at her pin was connected to the ground of the arduino. On the other hand, GSM Module requires 4 pins to be connected to the arduino and two of them for digital input/output which are Txd and Rxd, those were connected to digital pin 10, 11 respectively and others pin are connected to Vcc which is 5v in this case and to GND.LED Lamp is connected to digital pin 3 and connected to common GND.Buzzer was connected to digital pin 3 and to common GND.Servo motor was connected to common GND and to digital pin 4.MQ4 sensor is a Gas sensor/Smoke sensor was connected digital pin 2 and other pin were connected



to Vcc and GND respectively.Last but not the least LM35 sensor aka Temperature/Fire sensor was connected to A0 pin which is the analog pin of Arduino Uno and other pins were connect to Vcc and GND.After building the device it was very essential part to configure them to detect fire.So, it was time to code the arduino.So,be low the coding part of the system will be discussed.

Coding on Arduino uno:

#include <SoftwareSerial.h> #include <Servo.h>
Servomyservo; SoftwareSerialSIM900A(10,11);//Rx,Txintsmoke=2;
int fire=A0; floattempc; intled=3; int mot=4; void setup()
{
myservo.attach(9); pinMode(smoke,INPUT); pinMode(fire,INPUT); pinMode(led,OUTPUT);
pinMode(mot,OUTPUT);
SIM900A.begin(9600);//Settingthe baud rate of GSM Module
Serial.begin(9600);//SettingtherateofSerial Monitor (Arduino)
Serial.println ("SIM900A Ready"); delay(100); }

Experimented Result:

The experimented results were positive the system is working perfectly. The pictures below is showing how the system is working. It takes only 3 seconds to detect the fire after ignition. Following pictures describes the systems performance after each situations.



Figure 4: The system is being tested using fire



Figure 5: The system is working and Led lamps turns on



Evaluation:

To evaluate this system, public questionnaire survey was done as this is a practical solution of a very practical problem.So, we thought to evaluate the system and its effectiveness it's better that we take the opinion of the public.So, about 20 random volunteer we reinvited to see a live demonstration of the device and they were asked couple of questions.The questions were asked them after the physical demonstration of the device via Google Forms. The questions are given below

1. After detecting the Fire/Smoke/Gas, Does the Buzzer, Emergency exit gate, LED light and Water pump works properly?

- 2. Does EFARAS can detect Gas, Smoke and Temperature in a emergency situation?
- 3. Does EFARAS sends SMS with alert messages in an emergency fire accident?
- 4. Do you think the system(EFARAS) is capable to fight fire accidents?
- 5. Are you satisfied with the system (EFARAS)?

Result of the Survey:

The Survey suggest 80% of them thinks the system is capable of fighting fire

Limitations and Future Work

In every system, there remains some limitations. It has some limitations also. Our system works only for a single floor. But industry is not only a single floor. There remains multiple floors. But It doesn't work within multiple floors. In our system, it only sends message but if it could send pictures of fire or videos of the fire at a time. Then it would be very helpful for the fire Brigade people.

We used in our system arduino uno.In future we will use Raspberry pi which will work fast.As it doesn't work within multiple floor.It is the limitations of our system.So we will make our system for multiple floor in future.When fire is detected in an industry, our system will send message to the fire Brigade.But in future we will attach more cameras in multiple places so that it will be able to send picture as mms and videos.With those pictures and videos fire brigade will find the right place to work with fire extinguisher.We did not use IoT here as, it is our demo category system, when we will make this system for industry level use then we will use IoT for SMS purpose.GSM is also good but it is not so much fast as IoT.If we meet up our limitations, then we can use our system in industry which can save many lives.Because with the fire attack many people dies. So hopefully we will work with our limitations in our next phase.

Conclusion

The objectives of our research was to built Emergency Fire Alarm & Rescue Assist System(EFARAS). This system is necessary for the industry level. Because many times fire burns in industry and many people died in that situation lack of a good system. Many fire alarm systems are available also. But Our system can perform multiple task at a time. It can give alarm with buzzer, it can show emergency exit path, it can pump water and it can also sends massage to fire Brigade. We have developed a demo project but some limitations are also available here. In future we will add raspberry pi here to work more smoothly. As industries are multiple floors. So we will make our system for multiple floor and it will be able to give pictures and videos at a time so that fire brigades people can identify the starting point of fire. It will be very helpful for them for reducing fire. By adding new features our system will be more productive. It will be further improved with the implementation of new features in future studies.



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BRAIN FUNCTION ANALYSIS OF COMPUTER-BASED AND PAPER-BASED TESTS USING EEG: A PILOT STUDY

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Abstract

Education is rapidly changing in response to worldwide lockdowns, accelerating the adoption of digital classroom technology and online learning. In this disruptive era, the delivery of assessment is shifting from pencil-and-paper to computer based. This may raise concerns regarding whether these tools can more or less effectively assess learning outcomes than traditional testing instruments. To explore this question, we considered assessment performance and objective measures of brain function during computer and paper-based reading comprehension examinations. Test takers had their EEG recorded whilst undertaking exams in each modality. This aimed to provide objective evidence of test takers' mental workload associated with each delivery format. Five healthy volunteers at the B1 CEFR level participated in this pilot study. Based on their performance in a screening test, each participant was allocated to one of two difficulty levels for the assessments, which were subsequently delivered in both paper-based and computer-based modalities. Following these tests, EEG data was analyzed to distinguish features associated with each assessment. The findings suggest that participants attain a higher level of achievement in paper-based testing, perhaps reflecting greater familiarity with the test medium. Power spectral density of EEG recordings and average frequency of alpha and beta waves were positively correlated to predict test familiarity with the correlation coefficient (CBT-difficult: r = 0.82, p < 0.05), (CBT-easy: r = 0.82, p < 0.05), (PBT-difficult: r = 0.82, 0.82, p < 0.05), (PBT-easy: r = 0.65, p < 0.05). These promising results suggest that exam performance may be linked to modulation of brain activity associated with different test mediums, and further work is required to confirm these results.

Keywords: Brain Function Analysis, Electroencephalography (EEG), Computer-Based Tests (CBT), Paper-Based Tests (PBT)

Introduction

The advantages of computer-based tests (CBT) are the rapid turnaround of results, reducing paper costs, and increasing student engagement. These benefits have encouraged the shift from paper-based tests (PBT) to CBT. The quick turnaround in results provides formative assessment that lecturers, instructors, and administrators can use to adapt their approach according to students' needs (Abrams, McMillan, & Wetzel, 2015). The benefits of CBT appear to outweigh those of PBT to such



a degree that they will eventually become the preferred choice in many areas. Universities are regarded as one of the settings where frequent and reliable feedback is most required; however, the transition from PBT to CBT raises numerous questions that must be addressed to ensure that students are not negatively affected by these changes. In particular, there are concerns related to the availability of the necessary technology at different institutions, reliability of these technologies (e.g., "glitches"), familiarity of students with these technologies, psychometric differences between assessment delivery formats, and student achievement scores. All of these questions should be addressed during the early stages of transition between PBT and CBT. Furthermore, these two kinds of tests may affect different groups of learners in different ways, raising concerns over potential fairness issues. It would be a deeply regrettable consequence if the increasing use of technologies for examination was to widen the economic gap between socioeconomic groups.

At the present time, in the midst of the global COVID-19 pandemic, educators are responding by changing the delivery of education at all levels. It has never been more critical to evaluate the potential effects of using digital technologies on students' performance and overall achievement. Moreover, in language learning, CBT are one of the fastest and most available methods for students to obtain rapid feedback (Ockey, 2009). However, in some developing countries, where English is taught as second language, administering CBT to learners may be comparatively uncommon due to unfamiliarity with appropriate platforms and protocols. For instance, some students may occasionally feel that their score following a CBT is not representative of their actual proficiency, mainly due to difficulties associated with the test modality. Needless to say, this can be challenging to resolve for teachers. Educational institutions have a responsibility to ensure that efforts to improve efficiency by introducing CBT do not generate further problems for both students and teachers.

For this reason, familiarizing students with CBT before they encounter these situations is vital for their confidence and ultimate success. Instructors and test developers must be aware of these requirements and prepare their students accordingly. Given the popularity and broad applicability of CBT to language learning in Thailand universities, this presents an ideal opportunity to evaluate this technology and address any outstanding issues before rolling out CBT on a much wider scale.

Research Objectives

In the present work, brain activity associated with PBT and CBT was examined using electroencephalography (EEG) data recorded from English language students during assessments of reading comprehension. The aim of this pilot study was to determine the features of EEG for evaluating brain activity associated with the two types of assessment, PBT and CBT. The null hypothesis was that there is no correlation between EEG features (e.g., attention level, response time, entropy, power spectral density and average frequency).

Literature Review

CBT and **PBT** tests

Several studies have investigated the differences between computerized tests and traditional paper and pencil tests (Khoshsima, Hosseini, & Toroujeni, 2017; Bodmann, & Robinson, 2004). and found significant differences between them. For instance, one found that students reportedly enjoy CBT more than PBT. Moreover, recent studies have highlighted advantages of CBT for the students as well as for the lecturers. With dynamic visuals and user interactivity as well as flexibility to individual test-takers and real-time score reporting, CBT expands the features of assessment beyond the limitations of traditional PBT. There are some studies (e.g., Sawaki, 2001; Butcher, Perry, & Atlis, 2000) conducted an experimental study to compare speed and performance differences between CBT



and PBT. In their study, both CBT and PBT contained 30 MCQ items with a time limit of 35 minutes. Approximately half of the class (i.e., 28 students) took the first test on the computer and the rest performed the first test on paper. Assessment modality was swapped for the second tests, with the first group receiving PBT and second group received CBT, after two weeks. It was concluded that undergraduates completed the CBT faster than PBT with no difference in scores.

Isleem (2003), in research conducted on Ohioan technology education teachers, found that computer competence and experience were the strongest predictors of attitudes towards computer use and assimilating CBT. Likewise, Albirini (2006) conducted a study on the importance of computer competence in determining teachers' attitudes towards ICT. The results of his study confirmed that computer competency was the most significant predictor of teachers' interest in using computers in education. Many studies have investigated the effects of computer ownership on the teachers' computer competence and concentration on improving computer attitudes and usage. To summarize, the results consistently correlate with attitudes towards using computers in examinations and positive effects for preparing teaching and learning materials (Deutsch, Herrmann, Frese, & Sandholzer, 2012). In specific cases, substantial differences between paper and computer-based testing may occur depending on the specific measure, the participants, software and hardware realizations, and in overall computer familiarity and competency (Shuster, & Pearl, 2011).

Studies have compared students' reading scores in a computer-based test as a function of different screen sizes and resolutions. They found that small screens at low resolution impair reading performance and reasoned that the requirement for scrolling caused differences in performance. However, they suggest that increased experience using CBT could decrease the influence of such factors. Clariana and Wallace (2002) found that the response procedures, and not the characteristics of the presentation (e.g., screen resolution), are decisive for differences in reading performance across media. For example, clicking the correct answer with a mouse is more time-consuming than ticking the solution on a sheet with a pen, especially with speeded measures. This extra time may be a disadvantage for participants completing a computerized test version, although scores could be corrected for speediness. This is also related to computer competency and experience. Yunus (2007) has also investigated the relationship between attitude and computer use in teaching contexts in Malaysia. He found the same positive relationship between computer competency and attitude towards using computers in educational contexts, either in teaching or in testing.

The results of numerous studies on the comparability of PBT and CBT have shown that identical paper-based and computer-based are not equivalent, and do not obtain the same results. The factors that may influence the test results instead of the construct being measured are referred to as the "test mode effect" (Noyes, & Garland, 2008). This means that external factors influence the test performance of examinees, such as computer familiarity, attitude towards computers, age, gender, and environmental contexts. These factors are suggested to explain some of the variety in the results of comparability studies between PBT and CBT. For example, paper-based test scores were greater than computer-based test scores for both mathematics and English tests in Hosseini, Abidin and Baghdarnia,'s (2014) study. In contrast, computer-based test scores were greater than paper-based test scores for a dental hygiene course unit midterm examination (Jeong, 2014). Furthermore, some studies have reported no significant differences between computer and paper-based test performance (Anakwe, 2008).

For a review of the current literature on this topic, research on the comparability of CBT and PBT provides some guidance for what to avoid when creating these tests, as described above; however, there is a need to continuously improve our understanding of best practices for designing and administrating equivalent CBT and PBT.



Electroencephalography (EEG) as Measurement for Brain Activity of the Test Takers

EEG is a non-invasive, functional neuroimaging technique (Pittau, Grouiller, Spinelli, Seeck, Michel, & Vulliemoz, 2014), which consists of measuring electrical activity from the cerebral cortex using electrodes placed on the scalp. EEG has high temporal resolution, which makes it suitable for capturing dynamic brain activity near-instantaneously. In the literature, mental workload has been associated with a range of physiological variables. These include power in the alpha waves and beta waves derived from EEG, as reviewed by Stevens and Zabelina (2019).

A question that arises when one aims to put this knowledge into practical use is which variables should be measured to get the best mental workload assessment for a specific individual. This is not easy to answer based on the current literature because of several complications. Firstly, limited sets of variables are recorded and analyzed in each study, precluding easy comparison of performance across variables. Secondly, variables are often analyzed and reported at a group level rather than assessing workload in individual subjects. Finally, some of these workload studies present challenging experimental methods in which variables being measured are confounded, for instance with body movements (potentially affecting heart rate and related variables) or visual information processing (potentially affecting eye- and EEG-based measures).

In this study, we aim to evaluate the feasibility of using EEG to measure mental workload in both PBT and CBT reading comprehension examinations categorized as easy and difficult. EEG has demonstrated potential for gaining new insights on the neurocognitive basis of natural reading (Weiss, & Mueller, 2003). Hence, we hope to use this methodology to evaluate brain function during CBT and traditional PBT reading comprehension exams.

Methodology

Participants

Five healthy young adult participants from Rangsit University (2 males and 3 females) volunteered to take part in this pilot study. The average age of this group was 22.2 years old. These participants were selected based on a purposive sampling method, following the criteria shown in Table 1 below.

Table 1: Selection Criteria of Participants

a · .	•
Crit	eria
0110	0114

- 1. English language learners (CEFR level B1)
- 2. Normal color vision
- 3. No prior memory disorders
- 4. No history of neurological or psychological disorders

Instrument

This study employed the CBT and the PBT formats of Thai Reading Assessment and Decoding System (Thai-READS) as the main research instrument used for data collection. The Thai-READS instrument classified with three reading comprehension skills: literal, re-organization, and inferential. These have been reported to successfully gauge undergraduates reading performance at any level (Hui, Saeed, & Khemanuwong, 2020). It is worth mentioning that we examined the internal



consistency or reliability (KR20) of each testing mode. The results revealed high (KR20= 0.91) and moderate (KR20= 0.64) reliability coefficients for PBT and CBT, respectively.

The CBT and PBT instruments consist of 30 items categorized equivalently as *Difficult* and *Easy* (15:15). The test items were selected to be of similar length. Different text topics were chosen to introduce variability in the degree of reading effort required. Nystrand, Wu, Gamoran, Zeiser, and Long (2003) state that, depending on an individual, the time that test takers need to complete a multiple-choice exam differ. Khemanuwong, Mohamed, and Ismail (2018) recommend that each item in a multiple-choice exam should allow approximately 60 to 75 seconds. The time a student takes to review the question before submitting an answer must also be considered.

In this study, two equivalent tests were administered to each participant one after another: one in CBT format, administered in laboratories equipped with computers, and the other in PBT format, as shown in Table 2. Before taking part, participants were given some instruction about how to answer the computerized questions.

Table 2: Components of CBT and PBT Tests

Number of Comprehension Questions	Educational Levels	Weightage	Level of Difficulty	Time Allocated	
15	Undergraduate	50%	Easy	60 seconds per item	
15	Undergraduate	50%	Difficult	oo seconds per item	

Procedure

Prior to the experiment, we introduced the scope and procedure of the experiment to the participants and informed them that the experiment would not cause any risk to their health as well as to ensure that the participants could participate in the experiment voluntarily and sign the informed consent before the experiment. All participants were also provided with detailed written instructions about the procedure.

In line with a study by Straker et al. (2008), the participants were seated in a comfortable height-adjustable chair, set at approximately 50 cm away from a computer screen. The participant was asked to sit and rest for one minute, then look at the mark on the black screen to prepare for the computerized exam test. Then, the participant did the 30 items for 30 minutes, in which the participant was asked to press the button once he finished each item before doing the next one. When the participant completed the CBT test, he was required to rest for 15 minutes. The participants were informed to press a button to start doing the PBT. The blank page was replaced with a text page.

After they have finished reading, the participants were asked to press a button to proceed to the next page. The participant was asked to look at the mark (X) on the black screen to prepare for the PBT experiment. Then, the participant did the 30 paper-based test for 30 minutes. Before, during, and after the experiment, EEG signals were recorded. The experimental process was sequential, as shown in Figure 1 below. A study concept block diagram is shown in Figure 2. Note that a button press was used to send a trigger signal that synchronized EEG recordings with each exam question.





Figure 1: Experimental process of CBT and PBT





Electrophysiology and data analysis

EEG data was recorded using MindWave Mobile 2 (NeuroSky Inc.; San Jose, USA). This device was developed directly as a biosensor to read the electric activities of the brain, and it is relatively low-cost and easy to use. Attached onto the earlobes and the forehead, this device amplifies and filters electrical signals detected at the microvolt level from the scalp with the aid of electrodes. This obtains brain signals primarily from the prefrontal cortex, as shown in Figure 3.



Figure 3: Neurosky Mindwave Mobile Source: Alnemari, M. (2017)



Data was obtained from the EEG headset using the program, Unity (Unity Software Inc.; San Francisco, USA). This data was then exported to Matlab (R2017b; The MathWorks Inc.; Natick, USA) for analysis. EEG signal features associated with CBT and PBT sessions were calculated as shown in Figure 4. These features included mean alpha power, mean beta power, mean alpha frequency, mean beta frequency, 'attention level' (NeuroSky proprietary algorithm), and sample entropy. Response time to each question was also recorded during both PBT and CBT assessments. These features were extracted from data recorded during four separate conditions: E1 = easy-correct, E0 = easy-incorrect, D1 = difficult-correct, and D0 = difficult-incorrect (the first letter indicating the level of difficulty and the second one indicating whether they answered correctly). To account for differences in scale, each feature was standardized to have zero mean and unit variance.



Figure 4: Procedure for analyzing EEG signals

Results

As shown in Figure 5, the results indicated that the mean scores of CBT was 18.80 ± 3.31 SD, and PBT was 20.20 ± 3.12 SD. Comparing students' Thai-READS performance between CBT and PBT, it can be seen that PBT appeared to produce slightly higher mean scores (M = 20.20, SD = 3.12); although this is not a statistically significant difference.



Figure 5: CBT and PBT descriptive statistics results

Response time

Response time of each participant was recorded while they answered questions during CBT and PBT assessments. This data analysis is presented in Figure 6. It can be seen that the average time required for the CBT is relatively greater than that of PBT.

Moreover, comparing between easy and difficult levels, time spent on difficult items is longer than that of the easy ones. The results also revealed that time spent on correct items is less than that of the incorrect ones.





Figure 6: Average time the participants spent on CBT and PBT

Entropy level

Regarding entropy level, which is taken to reflect overall complexity of the EEG signal associated with cognitive processing (Angsuwatanakul et al., 2020), this was found to be marginally higher during difficult questions compared with easy questions. Interestingly, entropy level was also slightly higher in PBT than CBT assessments, as shown in Figure 7.



Figure 7: Comparison of entropy level

Attention level

Using EEG to capture dynamic brain activity, the PBT exam appears to evoke higher levels of attention than the CBT format, as shown in Figure 8.





Figure 8: Attention level

Feature correlation analysis

Correlation analysis shows how much one variable is affected by another. Here scatter plots are used to observe relationships between pair of features. If y increases and x increases, the features have a positive correlation, whereas a negative correlation occurs when y increases as x decreases.

Figure 9 presents a feature correlation matrix of data from the whole study group recorded during CBT and PBT assessments. Seven features, including those derived from EEG signals, are analyzed: attention level, response time, sample entropy, mean beta power, mean alpha power, mean beta frequency, and mean alpha frequency. Note that each of these has been standardized to zero mean and unit variance to ensure comparability of scale. Pairwise comparisons are made between each of these features, represented by scatterplots that can be used to identify correlations. Histograms are shown along the diagonal, representing the distribution of each feature values. Each data point represents the response during an individual test item.

We examined the distribution of this data and the relationships between features to determine whether the correlations between pairs of features were statistically significant. For example, response time and sample entropy are clustered, whereas the relationship between response time and other features appears to be comparatively linear. It may be noted from this analysis that there is a linear correlation between mean beta power and mean alpha power, and also between mean beta frequency and mean alpha power.





Figure 9: Feature correlation analysis from whole study group

Group-wise evaluation

To more closely examine specific brain activity related to each experimental group, feature correlation analysis was performed group-wise, as shown in Figure 10. These plots present the study average from all participants in four different conditions: CBT-easy, CBT-difficult, PBT-easy, and PBT-difficult; according to test modality and question level. Features were extracted from each of the five participants, who answered 15 questions in each category, producing equal group sample numbers (N = 75) for each condition.

As shown in Figure 10 below, the results revealed that all groups had similar patterns in terms of the distribution of datasets. This also represents similar distinguishing features of mental workload measured from two assessment types. All of these relationships were quantified using Pearson's correlation coefficient using SPSS program (Version 22; Inc.; New York, USA).

Pairwise comparisons of the participants' responses during the CBT-difficult condition demonstrate significant correlations (p < 0.05) in positive direction between the following:

(i) Attention with: sample entropy, beta power, alpha power

(ii) Sample entropy with: beta power, alpha power, beta frequency

(iii) Beta power with: alpha power, beta frequency

(iv) Alpha power with: beta frequency, alpha frequency

During the CBT-easy condition, the following positive correlations were also found to be statistically significant:

(i) Attention with: sample entropy, beta power, alpha power, beta frequency

(ii) Sample entropy with: beta power, alpha power, beta frequency

(iii) Beta power with: alpha power, beta frequency

(iv) Alpha power with: beta frequency, alpha frequency

Regarding the PBT-difficult condition, there was a significant positive correlation between:

(i) Attention with: sample entropy, beta frequency

(ii) Sample entropy with: beta power, alpha power, beta frequency, alpha frequency

(iii) Beta power with: alpha power, beta frequency



- (iv) Alpha power with: beta frequency, alpha frequency
- (V) Beta frequency with alpha frequency

As for the PBT-easy condition, there were also significant positive correlations between:

- (i) Attention with sample entropy
- (ii) Sample entropy with: alpha power, beta frequency, alpha frequency
- (iii) Beta power with: alpha power, alpha frequency
- (iv) Alpha power with beta frequency









Figure 10: Feature correlation analysis of four experimental groups The layout of features in each panel matches Figure 9.

All scattering models were confirmed by Pearson's correlation coefficient, as reported in Table 3.



Table 3: Group-wise Pearson's Correlation Coefficients

3A: CBT-difficult

	Correlations									
			Response	Sample	Beta	Alpha	Beta	Alpha		
		Attention	Time	Entropy	Power	Power	Frequency	Frequency		
Attention	Pearson Correlation	1	.112	.390**	295*	346**	.068	.183		
	Sig. (2-tailed)		.340	.001	.010	.002	.561	.116		
	Ν	75	75	75	75	75	75	75		
Response	Pearson Correlation	.112	1	.015	.176	.224	208	.059		
Time	Sig. (2-tailed)	.340		.900	.130	.054	.074	.614		
	Ν	75	75	75	75	75	75	75		
SampEntropy	Pearson Correlation	.390**	.015	1	409**	536**	.490**	.214		
	Sig. (2-tailed)	.001	.900		.000	.000	.000	.065		
	Ν	75	75	75	75	75	75	75		
Beta	Pearson Correlation	295*	.176	409**	1	.814**	350**	.062		
Power	Sig. (2-tailed)	.010	.130	.000		.000	.002	.597		
	Ν	75	75	75	75	75	75	75		
Alpha	Pearson Correlation	346**	.224	536**	.814**	1	518**	306**		
Power	Sig. (2-tailed)	.002	.054	.000	.000		.000	.007		
	Ν	75	75	75	75	75	75	75		
Beta	Pearson Correlation	.068	208	.490**	350**	518**	1	.220		
Frequency	Sig. (2-tailed)	.561	.074	.000	.002	.000		.058		
	Ν	75	75	75	75	75	75	75		
Alpha	Pearson Correlation	.183	.059	.214	.062	306**	.220	1		
Frequency	Sig. (2-tailed)	.116	.614	.065	.597	.007	.058			
	Ν	75	75	75	75	75	75	75		

3B: CBT-easy

		A	Response	Sample	Beta	Alpha	Beta	Alpha
	D G 1.1	Attention	11me	Entropy	Power	Power	Frequency	Frequency
Attention	Pearson Correlation	1	.055	.261	396	309	.246	.004
	Sig. (2-tailed)		.637	.023	.000	.007	.033	.975
	Ν	75	75	75	75	75	75	75
Response	Pearson Correlation	.055	1	152	.236*	.203	242*	.097
Time	Sig. (2-tailed)	.637		.194	.041	.080	.036	.406
	Ν	75	75	75	75	75	75	75
SampEntropy	Pearson Correlation	.261*	152	1	250*	471**	.532**	.311**
	Sig. (2-tailed)	.023	.194		.031	.000	.000	.007
	Ν	75	75	75	75	75	75	75
Beta	Pearson Correlation	396**	.236*	250*	1	.831**	289*	076
Power	Sig. (2-tailed)	.000	.041	.031		.000	.012	.518
	Ν	75	75	75	75	75	75	75
Alpha	Pearson Correlation	309**	.203	471**	.831**	1	601**	374**
Power	Sig. (2-tailed)	.007	.080	.000	.000		.000	.001
	Ν	75	75	75	75	75	75	75
Beta	Pearson Correlation	.246*	242*	.532**	289*	601**	1	.225
Frequency	Sig. (2-tailed)	.033	.036	.000	.012	.000		.052
	Ν	75	75	75	75	75	75	75
Alpha	Pearson Correlation	.004	.097	.311**	076	374**	.225	1
Frequency	Sig. (2-tailed)	.975	.406	.007	.518	.001	.052	
	Ν	75	75	75	75	75	75	75


Response Sample Beta Alpha Beta Alpha Entropy Attention Time Power Power Frequency Frequency Attention Pearson Correlation .118 .384 -.151 -.136 .415 .223 1 Sig. (2-tailed) .311 .001 .195 .244 .000 .055 Ν 75 75 75 75 75 75 75 -.377** Response Pearson Correlation .118 1 -.130 -.029 .053 -.139 Time Sig. (2-tailed) .311 .266 .805 .652 .233 .001 Ν 75 75 75 75 75 75 75 .384** -.359** -.581** .681** .454** Pearson Correlation SampEntropy -.130 1 .002 .000 .000 Sig. (2-tailed) .001 .266 .000 Ν 75 75 75 75 75 75 75 Beta Pearson Correlation -.151 -.029 -.359* .822* -.272* .080 1 .002 .000 Power Sig. (2-tailed) .195 .805 .018 .495 75 75 75 75 75 75 Ν 75 Alpha Pearson Correlation -.136 .053 -.581** .822** -.569** -.249* 1 Power .244 .652 .000 .000 .000 .031 Sig. (2-tailed) Ν 75 75 75 75 75 75 75 .547** .415** Beta Pearson Correlation -.139 .681 -.272 -.569 1 .000 Frequency Sig. (2-tailed) .000 .233 .000 .018 .000 75 75 75 Ν 75 75 75 75 -.377* Alpha Pearson Correlation .223 .454 .080 -.249 .547* 1 Frequency Sig. (2-tailed) .055 .001 .000 .495 .031 .000 Ν 75 75 75 75 75 75 75

3C: PBT-difficult

3D: PBT-easy

			D	G 1	D /	41.1	D (41.1
			Response	Sample	Beta	Alpha	Beta	Alpha
		Attention	Time	Entropy	Power	Power	Frequency	Frequency
Attention	Pearson Correlation	1	004	.377**	.059	186	.141	.222
	Sig. (2-tailed)		.971	.001	.617	.112	.230	.057
	Ν	74	74	74	74	74	74	74
Response	Pearson Correlation	004	1	.096	204	127	.056	180
Time	Sig. (2-tailed)	.971		.414	.082	.283	.637	.124
	Ν	74	74	74	74	74	74	74
SampEntropy	Pearson Correlation	.377**	.096	1	101	370**	.563**	.344**
	Sig. (2-tailed)	.001	.414		.392	.001	.000	.003
	Ν	74	74	74	74	74	74	74
Beta	Pearson Correlation	.059	204	101	1	.644**	152	.297*
Power	Sig. (2-tailed)	.617	.082	.392		.000	.195	.010
	Ν	74	74	74	74	74	74	74
Alpha	Pearson Correlation	186	127	370**	.644**	1	480**	100
Power	Sig. (2-tailed)	.112	.283	.001	.000		.000	.398
	Ν	74	74	74	74	74	74	74
Beta	Pearson Correlation	.141	.056	.563**	152	480**	1	.206
Frequency	Sig. (2-tailed)	.230	.637	.000	.195	.000		.078
	Ν	74	74	74	74	74	74	74
Alpha	Pearson Correlation	.222	180	.344**	$.297^{*}$	100	.206	1
Frequency	Sig. (2-tailed)	.057	.124	.003	.010	.398	.078	
	Ν	74	74	74	74	74	74	74

Discussion and Conclusion

From this tentative analysis, it can be seen that EEG might be a useful technique for evaluating the brain activity of students undergoing PBT and CBT. To test the hypothesis, Pearson Correlation was used to determine the linear relationship between pair of EEG features. It can be seen that power spectral density of EEG recordings and average frequency of alpha and beta waves were



positively correlated to predict test familiarity with the correlation coefficient (CBT-difficult: r = 0.82, p < 0.05), (CBT-easy: r = 0.82, p < 0.05), (PBT-difficult: r = 0.82, p < 0.05), (PBT-easy: r = 0.65, p < 0.05).

Advantages of using EEG as a neuroimaging tool in these types of experiments are that subjects can sit comfortably and adjust themselves easily while undergoing the exams, therefore natural movements and behavior are less perturbed than with alternative neuroimaging techniques such as fMRI or MEG. Furthermore, this non-invasive technology is relatively inexpensive and does not present any significant risk of physical harm (Ruiz-Gómez et. al, 2018; Angsuwatanakul, Iramina, & Kaewkamnerdpong, 2014).

The analysis of EEG recorded during these experiments indicates that there may be several differences between modalities and difficulty levels. For instance, minimal changes in spectral power recorded during the PBT-easy exam format may be taken to reflect less mental workload during this assessment type than the other conditions. This may be related to (1) the test modality, (2) the difficulty level, or an interaction between these factors. From the analysis of pairwise correlations (see Figure 10), the mean EEG power spectrum was found to correlate with test format. These features had a moderately positive, statistically significant correlation coefficient. For example, power spectral density of EEG recordings and average frequency of alpha and beta waves were positively correlated to predict test familiarity with the correlation coefficients (CBT-difficult: r = 0.82, p < 0.05), (CBT-easy: r = 0.82, p < 0.05), (PBT-difficult: r = 0.82, p < 0.05), (PBT-difficult: r = 0.82, p < 0.05), (r² = 0.59, p < 0.05). In the future, it may be possible to use these features to identify test modality and potentially infer whether student performance is likely to be affected by modality-driven effects; however, a much larger sample size will be required to confirm these results and provide enough data to develop reliable predictive models.

Given that this was a small pilot study, we are unable to decisively conclude whether PBT or CBT differ significantly in their effectiveness for measuring learning outcome attainment. There are numerable factors related to this general question that cannot be addressed in a single study of second language reading comprehension. Therefore, it is essential that further research in this area be precise in the function of PBT and CBT examinations. It could be the case that certain functions, like language learning, are more suitable for one modality than other functions, such as mathematics. By including the analysis of brain activity during these examinations we can hopefully increase knowledge of the underlying behavior and neuroscience of learning, as well as promote best practices in the application of modern testing in education.

In conclusion, while this pilot study is by no means conclusive, it provides a starting point for further work evaluating objective markers of brain function associated with different test modalities. Importantly, if EEG recordings are correlated with student outcomes in respective test modalities, this data could be used to support the design of student-centered assessment plans that will most effectively evaluate their levels of achievement.

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CARBON EMISSIONS OF INTERLOCKING CEMENT-STABILIZED COMPRESSED EARTH BRICK HOUSES IN DHUNGENTAR, NEPAL

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Abstract

Global warming due to greenhouse gas (GHG) emissions has been increasingly a burning issue for the last few decades. Efforts have been applied to reduce GHG emissions in the construction industry by adopting appropriate construction materials and technologies. The 2015 earthquakes in Nepal destroyed thousands of buildings and other structures. International Center for Integrated Mountain Development (ICIMOD) in association with National Reconstruction Authority (NRA), Nepal and International Development Research Center (IDRC) started a low-cost house reconstruction project in Dhungentar, Nepal in 2016. Fifty-five single storeyed houses, toilets and one community building for the local residents were constructed using interlocking cement-stabilized compressed earth blocks (CSCEB) instead of conventional fired bricks (CFB) under the project.

This study aimed to estimate carbon emissions of the newly constructed interlocking CSCEB houses and other facilities in Dhungentar using the Bilan Carbone[®] tool, and compare the results with those of CFB houses. A two-day field visit of the project site was conducted in October 2018 for collecting necessary primary data. The emission factors and other data required in the Bilan Carbone[®] tool for carbon emission calculations were collected through an extensive literature survey.

As per the Bilan Carbone[®] tool used for carbon emission estimation, construction materials, energy generation, food consumption, freight, and waste & wastewater were the contributing sectors to carbon emissions in Dhungentar reconstruction project. For the same quantities of CSCEB and CFB, the quantities of cement, sand and aggregates required in case of CSCEB houses were respectively 36%, 47% and 15% less as volume of a CSCEB is about three-times of a CFB. The "Construction materials" sector was the only highest contributor to carbon emission in Dhungentar. In terms of both total emissions and emissions of individual houses, emissions of CFB houses were about 1.6-folds higher than those of CSCEB houses as no kiln burning process is involved in case of CSCEB. Moreover, indirect emissions in both types of houses were quite higher (3 to 17-folds) than the direct emissions. The smaller direct emission values of CFB houses were considered obvious as CFB were not manufactured within the project site. The emissions were directly correlated with plinth areas of the houses in the both cases as all the constructed houses are single storeyed.

The emission values estimated in this study are in good agreement with the results of a similar study conducted in Nepal, and suggested that CSCEB is superior to CFB in curbing carbon emissions from the construction sector of Civil Engineering field. More advanced technologies to manufacture CSCEB are available these days and this will further enhance the superiority of CSCEB construction in curbing carbon emissions.

Keywords: Climate change, Carbon footprint, Emission factors, Emission sectors, Global warming.



1. Introduction

1.1 Background

In the aftermath of 2015 earthquakes in Nepal, the people's perception and awareness level towards earthquake resilient construction have changed drastically. As 498,852 private houses were completely damaged due to the earthquakes (NPC, 2015), the people urgently need safe and earthquake resilient houses to live in. On the other hand, climate change has been a serious global, regional and national issue for the last few decades. Therefore, conventional construction materials and methods should be appropriately modified and used in the construction fields to address the climate change issue.

The conventional fired bricks (CFB) have been in use in almost all the construction works around the world since the ancient time. As the manufacture of conventional burnt bricks emits huge amounts of greenhouse gases (GHG), which is a major contributor of global warming and climate change, alternatives to these conventional burnt bricks have been explored and researched since the climate change issue came into light very significantly. Cement-Stabilized Compressed Earth Brick (CSCEB) is a viable alternative to CFB. CSCEB is produced by mixing clay soil with cement, compressing it with high pressure, curing with water and then use it like the conventional bricks. Burning in kiln is not required in CSCEB manufacture. The history of CSCEB dates back to early 1900 and pressure compaction of the cement-soil mixture started only in 1950s. Despite the long history of the CSCEB, it was not in the limelight until GHG emission and climate change issue emerged as a threat to the world environment.

From April 2016, International Centre for Integrated Mountain Development (ICIMOD) in association with National Reconstruction Authority (NRA), Nepal and support from International Development Research Center (IDRC) initiated and implemented building reconstruction project entitled "Resilient Mountain Village: A Pilot Demonstration Project on Earthquake Reconstruction and Rehabilitation in Dhungentar, Nuwakot, Nepal", after badly affected by the 2015 earthquakes. This pilot project addresses four core areas namely, i) disaster-resilient infrastructure, ii) community mobilization and capacity development, iii) livelihoods and enterprise development and iv) access to services and environment.

1.2 Rationale

The GHG emissions and climate change have now become a major global issue for sustenance of human civilization (Lee et al., 2018). Developmental and construction projects these days are screened on the basis of GHG emission and emphasis is given for low carbon emission to reduce global warming impacts. The GHG emission due to manufacture of CFB is high (335.0 kg CO_2 equivalent/tonne of brick (AVEI, 2018). This is the new kind of project in the context of Nepal with the use of CSCEB in place of CFB, it is essential to examine carbon footprint of the project and differentiate between CFB and CSCEB in terms of CO_2 emission and replication of the environmental-friendly construction technology.

S.N.	House Type	Number	Plinth area of each house (m ²)
1	Type-1	10	20.16
2	Type-2	9	25.92
3	Type-3A	4	38.78

Table 1: Summary of interlocking CSCEB houses constructed in Dhungentar.



S.N.	House Type Number		Plinth area of each house (m ²)		
4	Type-3B		16	38.08	
5	Type-4		16	26.43	
6	Multipurpose community b	ouilding	1	168.24	
7	Exterior toilet		55	3.15	

Table 1: Summary of interlocking CSCEB houses constructed in Dhungentar. (cont.)

1.3 Study Area

Dhungentar (latitude: 27° 53' 14'' N, longitude: 85° 06' 33'' E, altitude: 2,152 feet above mean sea level) is a small rural settlement (project area: 50 hectares) in Bidur Municipality of Nuwakot district. It is located at 50 km North-West of Kathmandu. The nearest town from Dhungentar project area is Battar, which is 7 km away from Dhungentar (**Figure 1 and 2**).

Mainly poor and marginalized people are living in the project area. Construction of low-cost houses using locally available construction materials and interlocking CSCEB in place of CFB is the main characteristic feature of the project. This project had the capacity of producing around 4,000 CSCEBs/day with approximately 25 local workers and using six compression machines (ICIMOD, 2018). The types and number of CSCEB houses together with their plinth areas constructed under the project are summarized in **Table 1**.







ICIMOD

1.4 Research Objectives

The overall objective of this study was to estimate carbon footprint of CSCEB houses constructed in Dhungentar and compare the case with CFB houses. The specific objectives are as follows:

- Identification of carbon emission sources in the Dhungentar project area.
- Estimation of carbon emission due to reconstruction of interlocking CSCEB houses in Dhungentar based on Bilan Carbone[®] tool.
- Comparison of carbon emission from the CSCEB houses with those of CFB houses.



2. Literature Review

2.1 History of Clay Bricks

Sun-dried clay bricks are one of the oldest forms of building materials dating back to around 8,300 BC (Jan et al., 2018). The Sun-dried clay bricks were made with the mixture of straw, bitumen slime and clay mud. The most ancient settlements with clay brick structures were discovered in Turkey. However, the history of fired clay bricks dates back to about 3,500 BC (A. Lee and Thomas 2021; BrickArchitecture.com 2021) and it has been very popular in the construction industry since then. The history of making clay bricks in South Asia is found to be about 5,000 years back from now (Sridhar et al., 2014).

2.2 Fired Clay Bricks & Carbon Emission

Production of fired clay bricks requires huge amounts of thermal energy and the process produces harmful gases like CO₂, SO₂, black carbon and particulate matters resulting in air pollution and global warming (Eil et al., 2020; Nepal et al., 2019). Several studies have been conducted in estimating carbon emissions from the manufacture of conventional fired bricks and the estimated values vary greatly depending on the types of kilns and fuels used, and geographical regions. The values vary between 428 and 670 kg CO₂e per 1,000 number of country fired bricks (AVEI, 2018; Maheshwari and Jain, 2017). However, very high values up to 6,000 kg CO₂e per 1,000 number of bricks are also reported for conventional types of kilns and fuel materials (Dabaieh et al., 2020).

2.3 CSCEB and Carbon Footprint Reduction

Manufacture of fired bricks is energy intensive (Riza et al., 2010). Moreover, it generates huge amounts of GHGs including CO_2 . Therefore, its production and uses have been a challenge in combating global warming, and researches have been conducted for long time on alternative building materials to replace the conventional fired bricks. One of such attractive building materials is stabilized earth blocks and cement is one of the popular stabilizers used in this case. The history of cement-stabilized compressed earth blocks (CSCEB) as a building construction material dates back to 1950s (Parera, 2009). Its uses as a building construction material gained more popularity in Nepal after the 2015 earthquakes.

One CSCEB ($30\text{cm} \times 15\text{cm} \times 10\text{cm}$) is about three-times bigger in volume than one conventional fired brick (CFB: $23\text{cm} \times 11\text{cm} \times 5.5\text{cm}$). As burning is not involved in the process of manufacturing CSCEB, no energy is required in its production resulting in significantly reduced carbon emission due to construction activities involving CSCEB. Several investigations have been conducted around the globe on carbon footprint of CSCEB constructions (AVEI, 2018; Built Up Nepal, 2018; Dabaieh et al., 2020; Morton, 2008; Riza et al., 2010) and they reported two to nine-folds smaller carbon emissions of CSCEB constructions compared to those of CFB constructions.

2.4 Carbon Emission Estimation Tools

Reliable estimation of carbon emissions from various activities and sectors is essential to understand its impact on climate change and take appropriate mitigation measures. Many tools for carbon emission estimation based on the Intergovernmental Panel on Climate Change (IPCC) guidelines are available these days. IPCC is the United Nation (UN) body on climate change, which provides scientific basis and guidelines for governments at all levels to develop climate related policies (IPCC, 2021). The IPCC Guidelines for National Greenhouse Gas Inventories published in



2006, which includes recommended emission factors, is the basis for all carbon emission estimation tools (Eggleston et al., 2006). Many online tools for carbon emission estimation are also available now a days (Anon, 2020c; Carbon Footprint Ltd., 2021a; ICAO/UNO, 2021b). One such tool to estimate carbon footprint is "Life Cycle Assessment" (Adalbert et al. 2001; Dabaieh et al., 2020; Singh et al., 2011; Wibowo and Uda, 2018). Bilan Carbone[®] is another popular tool for this purpose developed by Environment Agency and Energy Management in France and it is now used around the globe. This tool provides a set of methodology, emission factors and documentation options (ADEME, 2009).

3. Methodology

The steps/methods adopted in this study to achieve the objectives mentioned in the earlier section is illustrated in the flow diagram below (**Figure 3**) and briefly discussed in the following sections.



Figure 3: A flow diagram illustrating steps adopted for carbon emission estimation in this study.

3.1 Planning and Organization

The required activities for estimating carbon emission of interlocking CSEB houses in Dhungentar were identified and arranged in order. Then, the concerned authorities and stakeholders related to Dhungentar reconstruction project were contacted to collect basic information on the project and project site. The collected information were reviewed and potential GHG emission sources were identified (refer to **Figure 4**). Data collection sheets, questionnaires and check-lists were developed, and field visit of Dhungentar reconstruction project site was planned based on the identified GHG emission sources before embarking to the field site.





Figure 4: The direct and indirect emission sources adopted for Dhungentar case.

The emission sources were divided into two categories (ADEME, 2009) in this study. The direct emissions are due to the reconstruction activities involving CSEB carried out within the Dhungentar project boundary whereas the indirect emissions are due to the third-party activities or the activities related to CSCEB reconstruction works carried out outside the Dhungentar boundary. The direct emissions sources included onsite food cooking by using fuel wood (CO₂), onsite electricity generation by fuel generators (CO₂), use of private vehicles for transportation at the project site (CO₂) and use of private vehicles for goods transportation (CO₂). On the other hand, the indirect sources included air travelled by visitors (CO₂), buses or cars used by visitors to travel to and from Dhungentar (CO₂), food consumption by workers during the reconstruction works (CO₂), materials used for manufacturing vehicles and CSCEB compressor machines (CO₂), hired vehicles used to transport goods (CO₂), and waste and wastewater generation within the Dhungentar project premises (CH₄).

3.2 Data Collection

An extensive field survey was conducted for collecting primary and secondary data on interlocking CSCEB houses and related activities in Dhungentar. The primary data were collected directly through field observation and questionnaires, which included electricity and fossil fuel consumption (diesel, petrol, fuel wood, etc.), energy used for food production, consumed materials and other products, travel by workers (amount of fuel used by vehicles, travelled distance by vehicles, etc.), fuel combustion for goods transport, waste and wastewater generation due to consumption of food & water, and assets/property purchased during the interlocking CSCEB house construction project period. The primary data on the interlocking CSCEB houses design and materials used for their construction, and staff travel to and from Dhungentar field site were collected from ICIMOD's project office in Dhungentar, its head office in Kathmandu and other partner institutions.

The secondary data referrers to the data other than the collected directly through field observations and questionnaires. These include number of staff/workers and equipment in the construction site, distances travelled by vehicles at the site, number of visitors to the site, vehicle



types and their average weights etc. based on the records maintained by site staff in the Dhungentar site office. Literature survey was a very important source of secondary data used in this study. Emission factors for the selected/relevant items/activities (e.g., electricity, food, material consumption) for emission estimation in this study were obtained by an extensive survey of published literatures and from the IPCC published documents.

3.3 Material Quantity Estimation

The quantities of construction materials like cement, sand, aggregates, metals, plastics, interlocking CSCEB, glass, etc. used in the construction of interlocking CSCEB houses in Dhungentar were calculated based on the designs and drawings of the houses and other facilities provided by ICIMOD project office and verified in the field. Standard unit weights of materials were taken from Indian Standard Codes (IS875: Part-1, 1987), adopted design concepts in the construction were checked with Nepal Building Code (NBC, 2003), and Nepal Design Catalogue for Reconstruction of Earthquake Resistant Houses (DUDBC, 2017; NBC, 2003) in this study.

Quantities of some of the items/activities, for example, fuel wood used for cooking foods, food consumption, waste and wastewater generation by the workers etc. could not be estimated from the collected primary as well as secondary information/data. Therefore, some assumptions were made for estimation of such items/activities as mentioned in the following section.

3.4 Assumptions

Appropriate assumptions are made when the available data are insufficient in this kind of study. The following points were assumed in estimating carbon emission of interlocking CSCEB and CFB houses in Dhungentar, Nuwakot to supplement the collected primary and secondary data in this study.

- <u>Fuel wood</u>: Workers the Dhungentar reconstruction project site used dry fuel wood for cooking their daily meals (lunch and dinner) during the project period. The average amount of fuel wood used to cook workers' daily meals was assumed to be 1.5 kg per person per day in this study based on the conversations with some of the workers involved in cooking at the site.
- <u>Food consumption</u>: It was assumed that workers took non-vegetarian meals for two days and vegetarian meals for the remaining five days based on the conversations with the workers involved in daily cooking.
- <u>Waste and wastewater generation</u>: The workers more often did not finish their taken meals and disposed the leftover foods near to the kitchen area. The total amount of the leftover foods was assumed to be 100 grams per worker per day based on the conversations with the workers involved in the kitchen. Moreover, the workers used a common toilet for defecation and hence wastewater was generated at the site. The biochemical oxygen demand (BOD) of the discharged wastewater from the common toilet was assumed to be 30 grams per person per day.
- <u>Number of workers</u>: The numbers of workers required for the reconstruction project in Dhungentar were assumed based on "Engineering Labor Norms" published by the Department of Urban Development and Building Construction, Nepal.
- <u>Workers' travel</u>: Most of the skilled and unskilled workers were from Dhungentar itself and they stayed at the project site (close to the CSEB production site). Therefore, carbon emission due to the workers' daily travel to and from the construction site using buses and other vehicles was assumed to be insignificant.



- <u>Conventional fired brick production</u>: As mentioned earlier, interlocking CSEB were produced within the project area in Dhungentar. But the nearest point for production and sell of the conventional burnt bricks is Battar, which is 7 km away from the Dhungentar reconstruction project area. Therefore, transportation distance for the conventional burnt bricks was assumed as 7 km in this study.
- <u>Foreign visitors travel</u>: A number of foreign visitors travelled to Dhungentar during the project period, but they might not have reached there directly. The carbon emission due to a visitor's travel is assumed to be proportionate to the visitor's total travel distance to Dhungentar (according to his/her travel schedule). An individual visitor's contribution to carbon emission in Dhungentar reconstruction project was calculated accordingly.

3.5 Emission Calculation

An "Emission factor" for an activity/item is defined as the average GHG emission rate per unit activity/item, and the value for the activity/item varies from place to place. Similarly, "Activity data" of the item/activity is defined as the total amount/quantity of the item/activity. Then, carbon emission of the activity/item is defined as the product of "Activity data" and the corresponding "Emission factor" as illustrated by the following equation (Olaguer, 2016).

Carbon Emission = Emission Factor
$$\times$$
 Activity Data (1)

Emission factors are generally derived from measurements made on a number of sources representative of a particular emission sector. The carbon emission of interlocking CSCEB houses in Dhungentar was calculated in "tones of CO_2 equivalent" unit.

Carbon emissions of the reconstructed houses and other facilities in Dhungentar if constructed with conventional fired bricks instead of CSCEB were also calculated following the same steps. Finally, the emissions from these two types of reconstructions were compared sector-wise (i.e., construction material used, energy generation, food consumption, freight, travel, waste & wastewater, and property) in this study. The emission factors used in in this study for different kinds of materials were obtained from literatures (ADEME, 2009; Akagi et al., 2011; Doorn et al., 2006; IFC, 2017).

4. Results

4.1 Construction Materials

Bricks, cement, sand and stone aggregates were the major construction materials used in the Dhungentar house reconstruction project. The required quantities of these materials for constructing CSCEB and CFB houses (**Table 1**) are shown in **Figure 5**. Although the required brick quantities were almost the same in both CSCEB and CFB houses, the quantities of cement, sand and stone aggregates required in case of CSCEB houses were 15% to 47% lesser than those for CFB houses. This result simply shows that the quantities of mortar materials required for constructing CSCEB houses in Dhungentar were considerably reduced owing to the bigger volume (3.2-times) of a CSCEB ($30cm \times 15cm \times 10cm$) than that of a CFB ($23cm \times 11cm \times 5.5cm$).





Figure 5: Calculated quantities of construction materials required for CSCEB and CFB houses in Dhungentar.

4.2 Sector-wise Carbon Emission

Five sectors, namely "Construction materials", "Energy generation", "Food consumption", "Freight" and "Waste and wastewater", mainly contributed to carbon emissions in the Dhungentar reconstruction project based on the Bilan Carbone[®] emission estimation tool adopted in this study. The total carbon emissions from these five sectors during the project period (two years) are shown in **Figure 6**. The "Construction materials" was the only sector with major contribution to carbon emissions in both CSCEB and CFB cases. Contributions of other four sectors were very low (16 to 181-folds) compared to those of the "Construction materials" sector. Moreover, the total emissions in case of CFB houses were larger than those of CSCEB houses (**Figure 6**). The total emission from CFB houses in case of the largest contributing sector (i.e., "Construction materials") was about 1.6-folds of the corresponding total emission from CSCEB houses.

4.3 Direct and Indirect Emissions

Carbon emissions are often divided into "Direct emission" and "Indirect emission" types depending on whether the activities are carried out at the construction sites or elsewhere. For the Dhungentar reconstruction project of this study, the activities involved in "Direct" and "Indirect" emissions are shown in **Figure 4**, and total "Direct" and "Indirect" emissions for both types of brick houses are illustrated in **Figure 7**. As distinctly exhibited in the figure, the indirect emissions were quite higher than the corresponding direct emissions in this study. For example, the total indirect emissions for CSCEB and CFB houses were about 3-folds and 17-folds of the corresponding total direct emission. The higher indirect emission values demonstrate that activities involved outside the project boundary were more responsible for carbon emission in this project. Furthermore, the indirect emission of CFB was about 1.9-fold higher than that for CSCEB, which is in agreement with the sector-wise emission results (**Figure 6**). However, interestingly the direct emission of CSCEB was about 2.8-folds of the value for CFB. It should be noted here that CSCEBs were manufactured within the project area while CFBs were manufactured outside and transported to Dhungentar resulting in low direct emissions of the latter.





Figure 6: ector-wise emissions of CSCEB & CFB houses in Dhungentar reconstruction project.





4.4 House Type and Carbon Emission

Five types of single storeyed CSCEB houses, one community building and exterior toilets for each of the houses were constructed in this project (**Table 1**). Carbon emissions of each type of the CSCEB and CFB houses are shown in **Figure 8**. The emissions of CFB houses were about 1.6-folds higher than those of CSCEB houses, which are in confirmation with the sector-wise emission results shown in **Figure 6**. Therefore, carbon emissions from the residential house reconstruction project in Dhungentar were reduced by 60% by using CSCEB in place of CFB.

As all the reconstructed houses in Dhungentar were single storeyed, plinth area of each type of the houses were plotted against the corresponding total carbon emissions as shown in **Figure 9**. Although there is a big gap in plinth areas between community building and other types of houses, good linear correlations between these two parameters were observed in this study. The 1.6-folds larger carbon emissions in case of CFB houses in Dhungentar is exhibited in this plot also. The



increasing carbon emissions for larger plinth areas in case of single storeyed houses of Dhungentar in this study is understandable.



Figure 8: Emissions of different types of CSCEB & CFB houses (individual) in Dhungentar.





4.5 Overall Emissions

As observed in earlier sections of this article, "Construction materials" sector was the only dominant contributor to carbon emissions in the Dhungentar reconstruction project. The total carbon emissions from CSCEB and CFB house construction per ton of construction materials were respectively 522.7 and 859.1 kg of CO_2 equivalent for the Dhungentar project (**Figure 5** and **Figure 6**), and the emission from CFB construction was 1.6-times of the CSCEB construction. Similarly, total emissions of the overall project for CSCEB and CFB house construction were respectively 894.6 and 1,422.7 kg of CO_2 equivalent (**Figure 5**), and the overall emission from CFB constructions was



again 1.6-times of the CSCEB constructions as contributions from sectors other than the "Construction materials" were negligibly small.

5. Discussion

This study attempted to look at carbon emissions from CSCEB and CFB houses in the Dhungentar reconstruction project from a different perspective than the other similar studies have done so far. The emissions from different sectors relevant to reconstruction projects were estimated separately, which revealed the major contribution of "Construction materials" sector in the total emissions. Furthermore, the quite higher indirect emissions than the corresponding direct emissions clearly showed that activities carried out outside the project boundary like production, transportation etc. were more responsible for carbon emission than the activities carried out inside the project boundary. Therefore, this type of emission categorization can be helpful in locating the emission sources and adopt appropriate remedial measures whenever applicable.

The bigger amounts of bonding materials (e.g., cement, sand) required in case of CFB houses in this study is obvious as the total volume of three CFB is equivalent to the volume of one CSCEB, and particularly cement as a bonding material in house construction definitely contributes more to carbon emission. Although carbon emissions from CFB were larger than those of CSCEB in all the results of this study, the total direct emission from CSCEB houses was quite higher than the corresponding total direct emission of CFB houses due to the fact that CFBs were manufactured outside the project area whereas CSCEB were manufactured within the project site.

Estimation of carbon emissions of CFB and CSCEB houses in the Dhungentar project in this study includes all the activities involved in the project. Both in terms of emission of individual houses as well as total emissions, the emissions of CFB houses were about 60% higher than the corresponding emission values for CSCEB houses in Dhungentar, which is more or less in agreement with the results of similar earlier studies (AVEI, 2018; Morton, 2008; Riza et al., 2010; Built Up Nepal, 2018; Parera, 2009). However, the emission values greatly vary depending on the activities included in emission calculations and their units. The emission values also greatly depend on emission factors for a region adopted in emission calculations. Nevertheless, the emissions from CFB and CSCEB houses of Dhungentar estimated in this study are very close to those of Built Up Nepal (2018) estimated for a three-roomed single storeyed house in Nepal.

6. Conclusions

Carbon emissions due to construction of CFB and CSCEB houses in Dhungentar was looked upon from a slightly different perspective unlike in other similar published studies. "Construction materials" was found to be the single sector contributing to most of the carbon emissions from both types of houses. Emissions from CFB houses were about 1.6-folds higher than those of CSCEB houses in Dhungentar in terms of total emissions as well as emissions from single houses. The indirect emissions from the both types of houses were about 3 to 17-folds than the direct emissions in this study. The lower value of total direct emission of CFB houses than those of the CSCEB houses was attributed to manufacturing of CFB outside the project area. The carbon emission in the Dhungentar project was directly correlated with plinth area of the houses as all the houses were single storeyed. The carbon emission values estimated in this study are in good agreement with the results of a similar study conducted in Nepal. The results in general suggested that CSCEB is superior to CFB in reducing carbon emissions from building construction. This superiority will be further enhanced in the days ahead as more advanced CSCEB manufacturing technologies are being developed.



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DEVELOPMENT OF COMPUTER APPLICATION FOR GHS-BASED CHEMICAL HAZARD COMMUNICATION

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Abstract

This research and development effort aimed to develop an application for hazardous chemical labelling according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). The research method consisted of seven stages including: (1) problem analysis in chemical hazard classification as per GHS and; (2) holding the 1st meeting of experts in GHS and application development, and entrepreneurs involved in preparing labels of household hazardous products, to seek comments on application framework; (3) writing an application based on the Agile MVC and Framework on Microsoft Windows 10; (4) application testing and verification by presenting it at the 2nd meeting to seek comments for application revision; and the application efficiency was assessed with five household hazardous product formulas; (5) preparing an instruction manual on the application; (6) pre-testing the application with 28 entrepreneurs involved in preparing labels of household hazardous products; and (7) finalizing the application after the trial.

The results showed that the newly developed computer and mobile application in Thai and English versions comprises seven modules for labelling household hazardous products, namely: (1) guideline for physical hazard classification; (2) calculation of acute toxicity; (3) calculation for health hazard classification; (4) calculation for classification of acute and chronic aquatic hazards; (5) calculation for classification of hazards to the atmospheric ozone layer; (6) summary of calculated physical, health, and environmental hazards; and (7) preparation of hazardous product labels: pictograms, signal words, hazard statements, and precautionary statements.

Keywords: Computer application, Mobile application, Chemical hazard communication, Globally Harmonized System of Classification and Labelling of Chemicals

Introduction

In 1992, the United Nations developed the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) to create standards in chemical classification of physical, health and environment hazards. Thereafter, hazard communications have been undertaken through labelling on hazardous chemical containers in the industrial sector and safety data sheets (SDS) for chemical-related target groups including chemical workplaces, transporters, emergency responders, and consumers.

In Thailand, the GHS has been adopted by relevant agencies under the Ministries of Industry, Agriculture and Cooperatives, Transport, and Public Health, and implemented in the industrial sector since March 13, 2012 (Department of Industrial Works, Ministry of Industry, 2015). After that the Thai Food and Drug Administration (FDA) has supported the GHS-based labelling of hazardous household products according to the Notification of the Ministry of Public Health (MOPH) on



Hazardous Substance Classification and Communication System under FDA's Responsibility B.E. 2558 (2015) (www.fda.moph.go.th/sites/Hazardous/Site Pages / GHS.aspx), published in the Government Gazette on 19 March 2015, and effective thereafter. As per the notification, actions for single substances had to be completed within 1 year (March 19, 2016), while those for mixtures had to be completed within 5 years. Additionally, the labelling of hazardous household products has to comply with the MOPH Notification on the Labelling of Hazardous Substances under FDA's Responsibility B.E. 2558 (Soontornchai, 2015), published in the Government Gazette on 15 September 2015, and effective after the expiration of 180 days from the date of its publication

Based on the MOPH Notification of 2015, business operators or entrepreneurs of hazardous household products must have in place the production processes, which meet international standards to ensure the safety for human health and the environment (www.fda.moph.go.th/sites/Hazardous/Site Pages / GHS.aspx). They must also have the capability to produce quality and safe products for consumers, to compete in international markets, and to respond to the current trend of consumers. To classify the chemical hazards and prepare their labels in accordance with the GHS, such operators who do not have sufficient knowledge or know-how in labeling need a tool to help with such an effort . A computer application could assist in chemical hazard classification which is quite complicated. Apart from that, the programs currently available are produced with a foreign language, expensive, and inconsistent with the knowledge and understanding of Thai entrepreneurs. In addition, it has been found that most Thai computer programs related to existing chemicals are those related to chemical storage.

Therefore, it is necessary to develop a computer application to classify the hazards. Moreover, the use of hazard classification information for preparing labels consisting of pictograms, signal words, and hazard statements of both single chemical substances and mixtures. Thus, a computer application is needed for assisting entrepreneurs involved with chemicals to produce labels of hazardous household products resulting in consumers' awareness of dangers, precautions, and self-protection while using the products. Finally, the application could respond to effective chemical management for law enforcement in 2020.

Research Objective (s)

To develop a computer application for labeling chemical hazards in accordance with the GHS.

Literature Review

Globally Harmonized System of Classification and Labelling of Chemicals (GHS) was developed by the United Nations. It is a document which will be regularly revised and updated once in 2 years to reflect new national, regional and international experiences in the area of hazard communication. GHS enhances the protection of human health and the environment by providing an internationally comprehensible system for hazard communication. GHS reduces the need for testing and evaluation of chemicals, and facilitate international trade in chemicals whose hazards have been properly assessed on the international basis.

GHS covers harmonized criteria for classifying substance and mixtures according to their physical, health, and environmental hazards and harmonized hazard communication elements, including requirements for labelling and safety data sheets (United Nations, 2019)..

Physical Hazards consist of 17 classes hazard including 1) explosives 2) flammable gases 3) aerosols and chemicals under pressure 4) oxidizing gases 5) gases under pressure 6) flammable liquids 7) flammable solids 8) self-reactive substances and mixtures 9) pyrophoric liquids 10)



pyrophoric solids11) self-heating substances and mixtures 12) substances and mixtures, which in contact with water, emit flammable gases 13) oxidizing liquids 14) oxidizing solids 15) organic peroxides 16) corrosive to metals and 17) desensitized explosives.

Health Hazards consist of 10 classes including1) acute toxicity 2) skin corrosive/irritation 3) serious eye damage/eye irritation 4) respiratory or skin sensitization 5) germ cell mutagenicity 6) carcinogenicity 7) reproductive toxicity 8) specific target organ toxicity -single exposure 9) specific target organ toxicity - repeated exposure and 10) aspiration toxicity.

Environmental Hazards consist of 1) hazardous to the aquatic environment and 2) hazardous to the ozone layer).

A web search has shown that currently there are several GHS-related software packages such as TEKLYNX for GHS labeling (https://www.teklynx.com/en-TH/products/enterprise-labelmanagement-solutions/teklynx-central-gh), BarTender for GHS labeling in chemical plants, and ChemWatch for preparing safety data sheets of chemical products and management, all of which are owned by private companies with copyright protection and high cost (https:// chemical watch.com/chemwatch/). There are also many other pieces of ready-made software from foreign and Thai companies developed for in-house use only. The newly developed application under this project is therefore an alternative for use by industrial chemical plants that have not yet created their own software as it is difficult and costly. It may also be used in government chemical agencies for further effective monitoring of chemical safety and consumer protection programs required by law.

Methodology

1) **Participants** The study participants were divided into three groups as follows:

(1) Experts: three GHS experts and two application development experts purposively chosen to give feedback for application development of GHS-based labelling of hazardous substances.

(2) Entrepreneurs: five to six persons who were involved in preparing labels of hazardous household products and volunteered to be purposively selected to provide comments on the draft application for GHS-based labelling of hazardous substances.

(3) Entrepreneurs: twenty-eight entrepreneurs involved in preparing labels of hazardous household products and volunteered to try out the draft application for GHS-based labelling of hazardous substances.

2) Research Tools

(1) An evaluation form for assessing the performance efficiency of the draft application for preparing GHS-based chemical hazard labels in terms of label validity, time reduction, human resources reduction, and rapidity.

(2) A form for assessing the satisfaction with the draft application for preparing GHSbased chemical hazard labels among the entrepreneurs involved in producing labels of hazardous household products.

The research tools were validated by three GHS-related experts to find the Index of Item-Objective Congruence (IOC). The research protocol had been reviewed and certified by the Human Research Ethics Subcommittee under STOU's School of Health Science, No. SR 0602.20/1136.

3) Research Procedures

Step 1 – Problem Analysis: The researcher analyzed major problems in order to design a computer application in accordance with the requirements of the chemical entrepreneurs involved in correctly preparing labels of hazardous household products as well as to respond to effective chemical management complied with laws.



Step 2 – **Application Design**: A meeting was held for the GHS/application experts and chemical entrepreneurs involved in preparing labels of hazardous household products in order to seek comments on the application's content outline. Then the researcher and programmers designed an application using the flowcharts that could be easily read and understood with a clear overview of all procedures.

Step 3 – Application Writing: The programmers developed a Windows 10-based application using the concept of Agile MVC and Ionic Framework Version 5.4.16, which could be used on either a computer or a mobile phone, using either Android or iOS with a report-printing function.

Step 4 – Application Testing and Editing: The researcher and programmers presented the draft application to the second meeting of the GHS/application experts and chemical entrepreneurs in order to solicit comments on the application's content.

After that, the programmers edited the draft application; and the researcher then evaluated the effectiveness of the draft application against five formulas of hazardous household products using the application efficiency assessment form.

Step 5 – **Application Instruction Manual Preparation:** The researcher and programmers prepared an application instruction manual.

Step 6 – **Application Trial**: The researcher organized an application trial among 28 entrepreneurs involved in the labeling of hazardous household products and asked about their satisfaction, using the application satisfaction assessment form.

Step 7 – Application Finalization: The researcher and programmers finalized the application in accordance with the entrepreneurs' needs and comments.

Data Analysis

Content analysis was undertaken on the data obtained from the two meetings.

Results

1) **Problem Analysis** The researcher analyzed major problems leading to the preparation of an application. It was noted that the application had to be consistent with the 4th National Strategic Plan on Chemical Management (2012–2021) in Thailand (Food and Drug Administration, 2012).: Strategy 1, developing a chemical database, mechanisms and tools for a fully integrated system of chemical management, and Strategy 2, developing capacity and roles of all sectors in chemical management.

The problems expressed by the entrepreneurs were obtained from (1) a research report on Thailand's Preparedness for GHS-Based Chemical Safety Management related to Consumer Products for the ASEAN Economic Community (Soontornchai, 2016); (2) a research report on Computer Application for GHS-Based Community Household Products in Nonthaburi Province (Soontornchai, 2018).; (3) a research report on Policy Recommendations for Capacity Building on Chemical Safety Management Based on the GHS for Household Dangerous Product Enterprises (Soontornchai, 2019); and (4) lectures given in five training courses on GHS-based chemical hazard classification held by STOU's Office of Continuing Education – the entrepreneurs had received relatively trivial knowledge of GHS from chemical traders; so they needed software technology and templates for chemical hazard classification.

2) Application Design The researcher presented the content outline comprising seven modules of the draft Windows 10-based application for hazardous household product label preparation; and useful suggestions were received for application development as follows: (1)



guidelines for physical hazard classification; (2) calculation of acute toxicity; (3) calculation for health hazard classification; (4) calculation for classification of acute and chronic aquatic environment; (5) calculation of hazard to the ozone layer; (6) summary of calculated physical, health, and environmental hazards; and (7) preparation of hazardous product labels with pictograms, signal words, hazard statements, and precautionary statements. Application cover, Menu, and label example are shown as followed.





Warning	
Hazard Statement H315 Causes skin irritation H319 Causes serious eye irritation H317 May cause an allergic skin reaction Precautionary Statement P264 Wash hands thoroughly after handling P280 Wear protective gloves P302 + 352 + P353 If on skin: If on skin or hair, wash with sop and plenty of water. Rinse skin with water/shower P305 + 338 + 351 If in eyes : rinse with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing P313 + P332 + P333 If skin irritation or rash occurs: get medical advice/attention P321 Specific treatment (see Section 4 on this label) P313 + P337 If eye irritation persisted: get medical advice/attention.	

3) Application Writing After the meeting, the programmers developed a Windows 10based application through periodic meetings with the researcher, using the concept of Agile MVC and Ionic Framework Version 5.4.16.

4) Application Testing and Editing The researcher and programmers presented the draft application to the experts and entrepreneurs at the aforementioned meeting; the comments received were: the application should work on either a computer or a mobile phone (Android and iOS); data recording should be mainly based on chemical CAS numbers, not by weight percentage, because chemicals can be used in products with different content percentages; hazard warning messages should appear while using the application with an amount of chemical ingredients being more or less than 100%; and the application must be stable without having to log in frequently in case of using a mobile phone.

After the meeting, the researcher and programmers revised the draft application via periodic meetings. Then, the draft application was tried out with five formula samples of hazardous household products using the application efficiency assessment form. The five samples included (1) a floor cleaner product (2) a stain remover product, (3) an antiseptic product, (4) a rat poison product, and (5) a Citronella oil-based insect repellent gel.

5) Application Instruction Manual Preparation An instruction manual for using the application (Modules 1–7) was prepared by the researcher and programmers after fixing such problems and after that,.

6) Application Trial Of all 28 entrepreneurs (participants), most of them agreed that the content and layout design of the draft application were more than 80% suitable, while its menu was easy to use (78.6%), the application functions were more than 80% suitable, and its speed was 75% acceptable. As for application user satisfaction, they were satisfied with all seven modules and the participants were more than 80% satisfied with its shorter working time, saving resources, usage speed, accuracy and completeness, and 75% with the speed of use (Table 1)

Table 1: Satisfaction with the use of the computer application: number of participants and satisfaction percentage in parentheses

Satisfaction with	the	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7
Application								
1. Reduction in working tim	ie	26 (92.86)	26 (92.86)	26 (92.86)	25 (89.29)	26 (92.86)	26 (92.86)	26 (92.86)
2. Saving resources		26 (92.86)	27 (96.43)	27 (96.43)	27 (96.43)	27 (96.43)	27 (96.43)	27 (96.43)
3. Speed of use		21 (75.00)	24 (85.71)	24 (85.71)	23 (82.14)	24 (85.71)	25 (89.29)	25 (89.29)
4. Accuracy and completeness		23 (82.14)	25 (89.29)	25 (89.29)	25 (89.29)	26 (92.86)	26 (92.86)	25 (89.29)



7) Application Finalization After the draft application trial, the researcher and programmers improved the content and format on the application page for appropriate use by (1) adjusting the application for more accurate data analysis and easier use, (2) creating a warning system in case of filling in incomplete data; and (3) fixing its stability problem.

Discussion

1) **Problem Analysis** According to the analysis of Thailand's 4th National Strategic Plan on Chemical Management (2012–2021), the application development is in line with Strategy 1, developing a chemical database, mechanisms and tools for a fully integrated system of chemical management, and Strategy 2, developing capacity and roles of all sectors in chemical management. The application may help improve the knowledge and potential of chemical management personnel in preparing labels and a safety data sheet (SDS). The results were in accordance with several other studies (Soontornchai, 2016, 2018, and 2019) as well as the opinions of the participants in five programs of STOU's Office of Continuing Education. Relevant small and medium-sized enterprises still require the knowledge of GHS as previously most of the information had been obtained from chemical traders or suppliers through SDS. As the entrepreneurs also needed software technology and templates that facilitate hazard classification in order to help them classify preliminary data, the application might be an alternative for the entrepreneurs.

2) Application Design At the meeting, the researcher presented the application's content layout consisting of seven modules covering physical, health, and environmental hazards according to the GHS (2019) (United Nations, 2019).; and the participants (experts and entrepreneurs) made comments beneficial to the development of an application for preparing GHS-based labels including pictograms, signal words, and hazard statements. Moreover, precautionary statement was also obtained for use in preparing SDS. The chemical information used in the application may come from supplier's SDS data and some other information may be searched for. That is to ensure that the hazardous substance classification could be properly carried out, especially for single substances that would be used for producing mixtures of hazardous household products.

3) Application Writing At the meeting, the researcher and programmers presented the draft application and obtained comments from the participants for further improvement of the draft application before the trial.

4) Application Testing and Editing Based on the 2^{nd} meeting's comments, the researcher and programmers revised the draft application so that it was user-friendly and the entrepreneurs could use the information of the chemical substances from supplier's SDS. If there were uncertain or unclear types of hazards, further information might be searched for. According to the application's efficiency assessment of labels in terms of validity, time reduction, resource savings, and working speed, all such aspects were suitable except for the delays in displaying the results, especially for Modules 6 and 7. Moreover, the application's stability when used on a mobile phone still needed to be improved.

5) Application Instruction Manual Preparation The researcher and programmers fixed such problems and after that, an instruction manual for using the application (Modules 1–7) was prepared.

6) Application Trial A total of 28 entrepreneurs who tried out the draft application were satisfied with the content and layout design on the application page. The use of the application was more than 80% appropriate, except for the menu and speed of the application. However, there were some important suggestions to revise the page design – the main menu should have bigger letters, a warning system in case of incomplete information, and system instability when used with a mobile



phone. Some of the buttons needed to be modified – the "Edit" button was not useable and some required information could not be entered.

7) Application Finalization Based on the application trial results, the researcher and programmers finalized the application's content, format and usage pages as follows: enlarging the fonts of the main menu; adding a warning system in case of incomplete information; improving the system stability; improving the Thai-English language accuracy; making clearer characters; making it more user-friendly; adjusting the data in Module 7 to show complete hazard classification results (pictograms, signal words, hazard statements, and precautionary statements with correct and complete ingredients in the products); and adding a "Print" function for the final chemical classification in Modules 6 and 7.

Conclusion

The computer application was developed for GHS-based label and safety data sheet (SDS) of hazardous chemicals by using the concept of Agile MVC and Ionic Framework Version 5.4.16. This application could be used both in Thai and English version on computers and mobile phones either Android or iOS with a report-printing function.

Suggestions

1) Suggestions Based on Research Results

(1) The application must contain the hazard information on any chemical substance in the product. In order to use the application, the CAS numbers of the chemical substances are required to provide hazardous chemical classification results correctly. In practice, chemical suppliers' SDS may be used for primary classification and the information from reliable databases is required to ensure the accurate classification. The application will store such information based chiefly on CAS numbers, not on the content percentage and generic or trade name of the chemical. This is because the same synonyms may refer to different substances.

(2) When using the percentage of ingredients in chemical hazard classification, the application requires that the contents of all ingredients add up to 100%, if not, a warning sign will pop up; and the user has to fill in the correct data.

2) Suggestions for future research

(1) Development of a computer application for SDS preparation based on the 16 items of the GHS.

(2) Development of potential for GHS-based hazard classification of household community products.

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DIRTY DATA CLEANING FOR THE BETTERMENT OF ONLINE BUSINESSES

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Article Info

Abstract

F-commerce a very new and popular addition of F-commerce that became popular among young entrepreneurs and young generation. F-commerce emerging getting as one of the way of unemployment solution specially during the pandemic situation. The success, competence, reliability and sustainability of f-commerce relies on the quality of its relevant data. However, it is very challenging to maintain the quality of data generated from the F-commerce platform which are produced from numerous sources. In F-commerce Generally, data comes from various sources and communication channels hence it is troublesome to integrate and manage data compare to conventional business data. There are several methods, tools and exists that is being used for cleaning dirty data. This research highlights the current literature reviews of dirty data, discusses existing tools and techniques. The review finds out a finding that even though several works exist those works have some constraints and none of the existing works addressing the specific problem in the context of an F-commerce platform. Based on the finding it provides a recommendation for future research direction to encounter the problem of cleaning dirty data in the F-commerce platform.

Keyword: Dirty Data, Quality Data, F-commerce, New Technology, Machine Learning

Introduction

With the rapid increase of technology and internet the scope of F-commerce is growing very fast [1]. Because of the large digital business and customers, digital data is increasing twice in every two. Hence, managing the quality of this huge amount of data is much more difficult compare to deal with traditional business data. Besides, online trades occur from numerous individuals, sources that could generate dirty data. People are not always careful about what they are sending over the internet which sometimes makes data irrelevant. The long-term business largely depends on the efficiency of its data quality management and proper analysis of the data. However, a very good analysis of data directly depends on having quality data. Quality data refers to the suitability of data for the use of targeted purposes. However, in practice, most of the data in F-commerce that comes from various sources such as business sites, Facebook and so on are inconsistent, incomplete and irrelevant that makes the data dirty.

Consequently, it is important to have research to handle dirty data for the betterment of the Fcommerce. Even though, the main aim of all internet is to produce an interface for users to have relevant information the user wants with a particular service point. Due to the data errors, poor data



quality users could be misguided to the wrong direction instead of providing exact information, services or product that they are looking for at any particular time. As a result, data received to business owners could be erroneous and misleads them to invest in the wrong business because of poor data quality. There are many statics and report on the growth of data. It is predicted that beyond 2020 digital data will grow exponentially.

However, a mutual view on the increase in data will be twice every two years It is because the number of computer and internet users are increasing day by day vastly. One of the relatively fast addition is f-commerce. Especially due to the corona pandemic people getting more used to with f-commerce. Here f-commerce stands for the Facebook commerce that focuses on developing and designing storefront and content site using Facebook. It is one of the newest forms of online business that is getting popular among young people. according to a survey only in Dhaka 22 million active Facebook users in and more than 300,000 Bangladeshi stores are operating on Facebook [2]. Hence the load and number off-commerce is getting more challenging than any other form of F-commerce since many of the f-commerce users are not very concern about what they are clicking, commenting, liking and so on. Therefore, this research aims to discuss the features o the data quality of an F-commerce platform. To achieve the objective, it has demonstrated the current techniques, tools, methods, addresses existing weaknesses and provides a future research direction to proactively maintain data quality by cleaning dirty data.

Literature Review

It is classically defined as the suitability of data to gratify implied and stated needs when under particular conditions [5]. It is also described as the fit for the use. There are numerous features of quality data such as timeliness, accuracy, completeness, consistency, accessibility, security, relevance, interpretability, representation, reputation, consciousness, objectivity, believability, appropriateness, value-added, validity, understandability, preciousness and correctness [6]. Dirty data refers to the data that comprises error records. Data warehousing institute reported that due to dirty data it costs U.S. business more than \$600 billion per year

Dirty data could be caused by various factors such as unformatted data, outdated data, incomplete data, duplicate data and so on [8], [9]. Dirty data brings huge negative effects on an organization [10]. A study by stated that the entire cost of dirty data has proven very troublesome to calculate.



Figure 1: Spend time by data scientist [24]

Various surveys show the negative effects of dirty data. [12] provides a summary of the negative effects of dirty data. According to the summary, 88% of projects fail either run-over their budget pointedly or completely. 75% organizations are in a mutual opinion regarding the cost of dirty data, 33% companies cancelled or delayed new system due to lack of quality data, in U.S. 611 dollar is lost in poorly aimed staff and sending overheads. However, [9] has reported much more statics of



negative effects that clearly shows the loss of business due to the dirty data. A study by [13] stated that sales and marketing departments lose 550 hours and \$32,2000 per sale year due to poor data quality. It reports that dirty data could take a tol1 on business that results in damage of sales opportunities to dismiss bond with clientless, causes unwelcome cultural impacts on staffs. Even there are many more undesirable penalties of dirty data that tends to be untrustworthy and make it troublesome to propose to solve challenges for the organization.

By analyzing data correctly, customer choices can easily be understood, close could be made, an e-business could engage opportunities and many more [14]. Excellence data empowers e-business management to define an insight story and advertise the brand loyalty confidently that is significant for making more revenues. With the lack of accurate data, it is difficult for e-business marketers to embrace new trends or opportunities in the business world [14]. Weak data makes it difficult to obtain, meaning it damages valued resources in unprofitable ways. Therefore, the more business achievement a business owner wants the more data quality he or she must ensure. Because e-business success strongly depends on the quality data. The more quality data pass to an algorithm or tools it can provide faster and better results. The data protection regulation consciously forcing business to achieve their data precisely.

The bulky and heterogenous business communication requires investigation utilizing proper data analytics. Appropriate data analysis helps to discover concealed patterns, consumers choices, market conditions and other aspects to become maintainable in the market. It helps companies to be better and faster decision-maker to be up to date. For managing data quality, a user should follow appropriate systems and rules should be enforced to the customer and stockholders to follow exactly. But in the reality of F-commerce, if hard rules and regulation are defining and set people will not love that system hence they would tend to leave the business sites and look for alternative [15]. Hence, the system must be tolerable to accept error data to some extent. Therefore, there should have a balance between the strict rules and flexibility level. To make a balance it becomes tough to maintain data quality. If the algorithm or system does not impose regulations and offer consumers the freedom to send whatever in whatever format, then the data quality will be degraded. The aforementioned arguments show that cleaning data quality is a challenging task. Hence, Ted Friedman [10] in his lecture note explained that data quality is not just an IT issue but also much more relevant to the people who are using the system.

In F-commerce, cleaning of dirty data is more challenging as data originates from mixed sources According to a survey, the annual penalties of dirty data is around 13.3 dollars per year [6]. This problem is equally and hypothetically predominant outside frightening in an F-commerce, organization or and health care [3]. For instance, in the telecommunication sector, dirty data has consumed a huge cost. Around 12% of business drops because of faulty data involvement from the users that creates productivity reduction, incomes consumption and many more losses [3]. Online medical-related business or services can kill patients due to dirty data. In 1999 due to the communication gap around 44,000 to 98000 people died. In the existing literature, there are several tools and techniques available that provides the service of data cleaning. Some of the remarkable tools are plyr, reshape2, open fine and so on [17] [18]. ETL is another tool that offers complex convention method by merging and repairing data [19]. Apart from these, this study has found a few more tools for data managing that are summarized in the following table.



Merchant	Tools	Pros	Cons
Melissa Data	Global data quality suite	It is an easy and direct API that	Does not have proper
		can utilize phonics for	
		correcting	documentation, Real-
		addresses	time recital is slow,
SAP	SP Data Services	Capability to identify the	Unable to integrate and
		business requirement	hence no source code
SAS	Data Quality management	Can manage the learning curve	Needed to be cultured
			and wants training for
			the usage.
IBM	Infosphere Quality Stage	Integrates with metadata from	not much support for
		Excellence stage, data stage and	cleaning
		from metadata	communication-related
		virtuous for the warehouse of	
		data	data
Melissa Data	Global data quality suite	It is an easy and direct API that	Does not have proper
		can utilize phonics for	
		correcting	documentation, Real-
		addresses	time recital is slow,
		It can migrate data and exists on	
Informatically	Data quality governance	the cloud.	User must have SQL
IDQ	addition		knowledge.

Table 1:	Summarv	of existing	data cleanin	g tools [23]
I dole II	Sammary	or emoting	aata ereanni	

Research Finding

For businesses most often mistakes of information collection are neglected. Hence data comes with the unorganized or incomplete pattern. This type of data is generally recognized as dirty data besides to clean dirty data businesses faces many encounters. Physically removing dirty data requires much experience and most often human tends to make mistakes. Artificial intelligence can automatically clean dirty data by training classification models. Currently, machine learning is being used in diverse ranges for cleaning dirty data robotically such as [20]. However, these tools have some limitations. For example, the integration of data quality for the data that comes from several communications, channels are not entertained in [21]. The primary responsibility for developing a system to clean low-quality data is to identify the reasons behind the dirty data. It is not true that the dirty data gets intentionally rather in may happen unintentionally. Faults could include faults just like rules violation, type declaration, poorly trained model, data collection, wrong programming, hardware failure and many more





Figure 2: System Architecture [22]

According to the authors, a realistic, influencing, sensible and confirmable framework for data cleansing is proposed in [22]. There are three types of rules among those central repository makes comparison which are Business rules, Transformation rules and Extraction rules. For extracting important data from larger data set extraction rule is important to clean dirty data. To clean data transformation rules is important which helps for data formatting, duplicate records removal, adjust missing values with duplicates values and related issues etc. according to the input as shown in fig. 2. And most importantly it defines parameters, functions and approaches which is mandatory to clean dirty data.

To achieve sustainable business data quality plays a primary role. As there occurs a negative effect of low-quality data so it is hard to measure & fight against it for any business. There is a high chance to become collapsed for any business if the quality of the data is not updated as well as it creates a difficult situation for the employees to interact with the dots also.

However, low-quality data creates due to the flexible system. When the user gets flexible system then the quality of the data becomes lower and it is a very important reason for any business system for financial penalties. Traditional plantations to achieve quality data are done after data created by the development and judgement of the data and this type of system is called a reactive system. If the data quality gets more focus and priority then the business system must get a better system. As there are numerous different sources every year around 550 hours is lost by e-business companies and creates the business analysis complexity. The reason behind this business analysis complexity is multiple types of data source with individual formats [14]. Furthermore, even now the main success of electronic business totally relies on the effectiveness with its employees, customers and related persons, yet the collected data from the customer is not prepared to analyze directly and often it is ignored. Moreover, the different channels of data collection are unstructured and incomplete also [20]. Even though, there are some tools still exists but some matters such as not pro-active, integration issue and physical involvement issue also. [21]. Hence it is very important to analyze the improvement of data quality as that may measure and remove immediately dirty data to empower the data quality. In today's electronic business the new technologies like artificial intelligence, marketing automation and machine learning could be used for improving data quality.

Conclusion

Recently the trend of f-commerce increased rapidly especially during this pandemic situation the growth rate of f-commerce is very significant. Since it is very easy to start a business over the



Facebook platform, anyone at any time can start selling and buying products that sometimes gives opportunities to do fraud. again, there might be some fake customers as well. Hence it is important to have a better algorithm to collect and store data received from f-commerce and become fake or dirty data from the context. Otherwise due to fraudulent and lack of professionalism businesses will lose customers and will no longer sustain as their easy grown-up. In this study several apprehensions regarding the quality of data in the f-commerce. To discourse the apprehensions associated with the eminence of data it has emphasized various issues such, the essentials of data quality, data quality measures, the problematic of data quality. From the conclusion of the study, it has initiated some matters associated with the current works on data quality on F-commerce platform. Besides, it proposes a necessity to do more study to deal with F-commerce data that will eliminate the dirty data proactively and will deliver the righteous quality of data.

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INTERACTIVE LEARNING MEDIA FOR KIDS

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Abstract

Augmented Reality is probably the most recent innovation being joined into educational materials to draw in understudies and to make the learning experience all the more captivating. With the rising popularity of handled gadgets, for example, smartphones and tablets, utilizing Augmented Reality on smartphones have become a wonder. Since the kids of country Bangladesh don't have any interactive study method yet, this exploration means to overcome that issue utilizing Mobile Augmented Reality. The reason for this research is to find and introduce newer and more interactive ways of learning for the Kids, using Augmented Reality rather than traditional textbooks, and furthermore acquaint them with the space of Augmented Reality. The system is manufactured utilizing the Vuforia Target Library, Unity Game Engine, and Android SDK. The research comprises client foundation data, usefulness tests, and a client criticism survey. This paper sums up how to separate pertinent data for college understudies to pick up information by utilizing Augmented Reality by means of Smartphones.

Keywords: Augmented Reality, Mobile Augmented Reality, Vuforia Target Library, Unity Game Engine, Android SDK

Introduction

Augmented Reality (AR), the technology which is an interactive experience of a real-world environment where the objects are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities (Huffington, 2016). Mobile Augmented Reality (AR) is a type of mobile application that contains and adds integrated components in mobile phones and offers special applications for the provision of services and functions that are based on reality. New technology like Mobile AR is based on augmented and can be used on mobile devices such as smartphones, headsets, glasses (Nincarean, 2013). These days there are a lot of ways to educate kids. But the important thing is to make sure that children need to enjoy what they are learning. A kid learns the most when the lesson is visual and interactive. Learning can be transformed from a routine, problematic, tiring activity to a new journey of discovering fueled with the imagination with the help of AR. It teaches them more about what they view and experience. It is playing an important role as it is helping kids to overcome the stress of theoretical learning. In Bangladesh, when children learn the Bengali language, it seems quite tough for them to remember those letters because in most cases they find it boring and lose interest after a few moments. With the help of mobile, our system provides



them a new way of learning with the visualization and sound of 3D animation which is related to the letter. The system will provide them a platform to play the 3D animation models which can be viewed from all different angles. By simply putting the book in front of the smartphone device, anyone can learn about the things in the book.

Research Objective (s)

The purpose of this study is to design a framework for Augmented Reality based learning media for kids. In this research, we are proposing to develop an interactive AR-based system for learning purposes for Kids. The specific objectives are:

- To design a Framework for learning media for Kids.
- To develop a mobile Augmented Reality (AR) system using the Framework.
- The system will utilize the Vuforia Target Library and Unity Graphics SDK.
- To build Vuforia supported solid images using letters and relevant images together, and integrated those images into the Vuforia library.
- Therefore, evaluating the effectiveness and efficiency of the modules in the application will be based on the user's feedback. Thus, the study will be developed using this mentioned framework.

Literature Review

Augmented Reality, innovation, which covers artificial items (Augmented elements) into the real world. A great explanation of Augmented Reality is given in the review by Azuma (1997). According to this definition, Augmented Reality is just a modification of Virtual Reality. AR was first presented as a preparation device for aircraft and Air Force pilots during the 1990s (Caudell & Mizell, 1992). One of the most significant reasons that AR innovation is so generally utilized is that it never requires costly hardware. AR inventions can be used in smart mobiles or laptops or the computer. According to Horizon Report (2011), AR, with its layering of data over 3D space, does new familiarity with the world and recommended that AR should be embraced within a few years to give a new way to teach, learn, investigate, or invent. By taking benefits of virtual items or information covering physical items or environments, makes a mixed reality in which virtual items and the real-world exist together in a significant way to increase uses of augmented learning (Dunleavy, Dede & Mitchell, 2008). As indicated by many research, Augmented Reality Technologies give special benefits in the education sector (Cheng & Tsai, 2013). AR encourages students to study as it gives real visualization about real objects (Dede, 2009). It inspires students to research in-depth to gain more skills (Sotiriou & Bogner, 2008).

Mobile AR / Handheld devices have become so powerful that they can do daily basic tasks like sending or receiving emails, can record audio or video, and are able to capture images (Lee, Yang, Kim, Kim & Choi, 2009). Even some highly configured 3D games can be played on smart mobile phones. Smartphone features are developed very fast and these advanced features have made a connection between mobile and handheld AR which is becoming more popular. Utilizing an AR interface on a handheld device, a user can see virtual particles superimposed on live video of this present reality utilizing visual tracking or design rendering. A different smartphone AR communication method can likewise be utilized to control these virtual articles, for example, performing interpretation, scaling to change the area, rotation, posture, and size of virtual items in space (Bai, Lee & Billinghurst, 2012). The tangible user interface in augmented technologies likewise Magic Book (Billinghurst, Kato & Poupyrev, 2001), describes using movable fiducial markers in the


dynamic sections of the application. AR as another medium is interesting for schooling, for example, exhibition halls. The joining of AR upgraded shows can run AR display to a whole display acknowledged utilizing AR effects (Bimber, Fröhlich, Schmalstieg & Encarnação, 2001; Höllerer, Feiner & Pavlik, 1999). Portable AR innovation can offer an interesting substitution for the conventional sound tape visit control. Visit guides are a common application topic for portable AR explore, incompletely because they show the quality of phone AR, to be specific to exhibit useful data enlisted to static areas in reality.

Evolution of Mobile AR





Vuforia is an AR SDK that is used in smart mobile to build an augmented reality system. Mobile augmented reality is implemented by Vuforia SDK (Xiao & Lifeng, 2014). In 2010, Qualcomm was invented by Vuforia SDK which is now in version 9.6. Vuforia is supported by Android, iOS, and also Unity3D. Vuforia SDK is used as a connector of mobile with the augmented reality world (Peng & Zhai, 2017). It provides the ability of mobile software to observe the augmented reality. It also gives multiple options likewise target recognition, tracing register technologies, text recognition, etc. Vuforia is a software platform that uses computer technology to trace and list physical objects and compare them with virtual objects and recognize the 3D object in life (Peng & Zhai, 2017). It also increases the virtual ability for developers for locating and aiming and also three-dimensional objects along with other data. So that users can adjust the location of virtual elements along with real objects using the mobile screen in life. In this way, the display of virtual objects and real environments seems similar to the user view. All pictures are not used in the Vuforia SDK as a target. At first, Vuforia developers assessed its quality of detecting well pictures. To do this, pictures have been uploaded which will be evaluated by developers. A score will be used to describe the accuracy of the detected and tracked picture. The score will be in a range and more score means better detecting and tracking ability of Vuforia SDK.





Picture 2: Vuforia Engine

Source: (https://library.vuforia.com/articles/Training/vuforia-fusion-article.html)

Unity is a cross-platform game engine created by Unity Technologies, first declared and discharged in June 2005 at Apple Inc. Worldwide Developers Conference as a Mac OS X-selective game motor. The game engine can be used to create three-dimensional, two-dimensional, virtual reality, and augmented reality games, as well as simulations and other experiences. The engine has been adopted by industries outside video gaming, such as film, automotive, architecture, engineering, and construction (Axon & Samuel, 2016). The Verge said of 2015's Unity 5 release: "Unity started with the goal of making game development universally accessible. Unity is a game engine and finishes coordinated advancement conditions (IDE) with an incorporated editorial manager, resource work process, scene manufacturer, scripting, systems administration and that's only the tip of the iceberg. It likewise has a tremendous network and gathering where any individual needing to know and figure out how to utilize Unity can proceed to have every one of their inquiries replied. There are five primary perspectives utilized in the Unity editorial manager to complete all the work, the undertaking view, scene see, game view, order view, and monitor see, which are all clarified in more detail underneath. The Unity game engine launched in 2005, aiming to "democratize" game development by making it accessible to more developers (Axon & Samuel, 2016; Brodkin & Jon, 2013). The next year, Unity was named runner-up in the Best Use of Mac OS X Graphics category in Apple Inc.'s Apple Design Awards (Smykill & Jeff, 2006). Unity was initially released for Mac OS X, later adding support for Microsoft Windows and Web browsers (Brodkin & Jon, 2013).





Picture 3: Unity Game Engine

Source: (https://www.researchgate.net/figure/The-User-interface-of-Unity-3D-game-engine_fig1_326434680)

Chief Operating Officer at Grant Thornton U.K, Robert Hannah said that Generation Alpha will number 2 billion globally within 2025 and also added that it might be the wealthiest, 10 most educated, and technologically literate in history. Institution organizations that utilize the most recent innovation in the study hall just as in field trips will make a unique learning experience open the door for the kids. What's more, with it, they will add to a superior groundwork for the pioneers of things to come. Schools, instructors, and instructive foundations are going to think that it's difficult to adapt to the requests of Generation Alpha youngsters if they disregard to refresh themselves, their strategy, and educational programs to receive another way to deal with them with training. Alpha youngsters are acquainted with procuring information by doing, screen-contacting, and encountering. Schools need to give a sufficient domain that improves this sort of learning. This kind of condition requires changes and another way to deal with instruction at all levels. Schools and universities ought to prepare by making projects of concentration that require profound learning. Schools need to begin planning programs that are adaptable enough to be adjusted and changed rapidly as indicated by the youthful Alphas' curious psyche. AR innovation grows the physical world; it incorporates advanced data that can be seen by the vacant eye, which enlarges the encompassing that includes audio, visual as well as illustrations. VR (Virtual Reality) makes a unique world, a counterfeit world that can transform the genuine one, in which we can be diverted as the personalities do like the characters in Steven Spielberg's movie, named 'Ready Player One.' In 1990, when Augmented Reality came to light, a portion of principal business utilization was, obviously, in TV and the military. In any case, from that point forward the AR innovation has altogether developed, nowadays AR-based applications inside each enterprise along with detailed advantages from both the clients and training. Researchers have given an account of the positive effect that Augmented Reality encounters have on students when contrasted with the application that is not based on AR: Expanded substance perception, adapting spatial models, capacity, language affiliations, large haul storage maintenance, physically improved assignment execution, coordinated effort, Expanded understudy inspiration. The scientists likewise revealed only a couple of taking in impairments from Augmented Reality, all of which can effectively be kept away from consideration burrowing, Ease of use challenges, Inadequate study hall reconciliation, Student contrasts.



Augmented Reality apparatuses let understudies draw in with the innovation as well as it gives them the likelihood to make their substance. This is central to advance 21st-century aptitudes, for example, imagination, critical thinking, basic reasoning, investigation, coding, and iterative testing, the way toward putting together tests for experiences accumulated from past tests that change slowly, those are based on proof. In the library, a pioneer named EBSCO, enterprise administrations gathered 10 all-around chosen for Study hall based on AR, which is a capable upgrade or customizes perceptions for K-12 understudies (Fourtane, 2019). Two levels, multi-staged and suitable for all age groups, do not accompany anyone who operates the analysis:

CoSpaces Edu: A structured instrument, which permits understudies along with the experiences of coding that make multidimensional universes. Likewise, visual representation of information recounts histories with the help of artificial shows or visits. With this, educators can arrange classes or upload assignments. Pictures, 360-degree photographs which are possible to transfer, also a friend's system is accessible (Fourtane, 2019).



Picture 4: CoSpaces Edu **Source:** (https://cospaces.io/edu/)

Merge Cube: A versatile instrument, which is an AR-based multi-stage device that resembles grasping a 3D image. Contingent upon the Merge's system which is able to become a wide range of things. With this, instructors can make STEM exercises or experience general science or world history, and understudies, likewise build up substances, make systems, or observe inventive items spring up in AR. This is an incredible method to get understudies to see the consequences of what they make, an absolute initial step towards inspiring the engineers. Additionally, utilizing conceivable 'Google Sky Map' helps to reach close up to stars and planets right now planetarium (Fourtane, 2019).

Methodology

The research procedure is helpful to set up the structure of research, for example, technique, approach, examine the theory, and segments of the philosophy and methodology.

Research Methodology: The main objective of this research is to introduce a new education platform using Graphics, Interaction (GAI) module, Audio-visual and integrated into ARToolKitPlus library. The general objective of the search work is to build up an intelligent Augmented Reality based Android OS application for learning purposes for Kids. The principal objective is to manufacture Vuforia supported strong pictures utilizing letters and pertinent pictures together,



coordinate those pictures into the open-source Vuforia library, which will permit clients or children to utilize those for their examination or study purpose.

Development Methodology: The development strategy for this research depended on the Software Development Life Cycle (SDLC). The SDLC is a procedure to create a high-quality product that meets requirements, reaches completion within times, and costs estimates. To develop the system, there are five steps that we followed:

- 1. Requirement collecting and Analysis
- 2. Planning and making prototype
- 3. Development and Implementation
- 4. Software Testing
- 5. Deployment



Picture 5: Software Development Life Cycle (SDLC)

1. Requirement collecting and analysis: Essential information related to the project was gathered from various sources, the majority of necessary documents were collected from Google. Data was collected from different schools, websites, and libraries. The Android platform was considered for this research and the SDK was downloaded from Google Developer Server and Vuforia library from the Vuforia Developer Portal.

2. Planning and making prototypes: Without an ideal arrangement, the advancement of any framework is good for nothing. The part of making a prototype after gathering the proper requirements is an equally important and initial part of dive into a project. Besides giving a clear concept, it helps to consider the perfect design of a project.

3. Development and Implementation: The gathered requirements were adjusted by the execution of the framework. For Mobile Augmented Reality, a smartphone camera is utilized to capture the markers from a constant picture, with the help of the camera API of the Android SDK. The project was built on the Unity Game Engine. To display the video and sound after successfully detect the image marker, Default-Trackable-Event-Handler was utilized which works in the C# content.

4. Software Testing: After developing the system it was deployed in the testing environment. All the functionality was tested by doing user evaluation. Troubleshooting was done to fix the bugs and issues that were found in the framework.



5. Deployment: After effective testing both of the framework and the system, it was proclaimed prepared to use with the understudy magazine.

Framework:



Picture 6: System Architecture

Picture 7: System Flowchart

When the system starts, the camera API calls and opens itself to capture the image. Subsequent to getting a sample, it processes the picture and tries to distinguish the marker. If the detected marker exists in the database, the output shows at the top of the marker area. Else, it returns to video snatching.

System Development: To build up the product we need to experience the accompanying processes.

Data Collection: To gather the necessary information we have utilized an Android phone camera. We have made a few samples of the Bengali alphabets. A portion of the recordings is gathered from the web and online networking.

Integration and Testing: All modules were incorporated with solidarity 3D and afterward tested the modules. A few issues came up while testing, but all the issues resolved very carefully. The issues were like after the picture object was lost, the model was still appearing on the screen, videos were playing with no sound, and object audio was playing wrongly.

Testing Methodologies: Testing methodologies for this research was completely based on User Experiences & Evaluation and Technical Evaluation. User satisfaction and experiences were first priority in this research.

User Evaluation: The system was tested through the user evaluation, and the evaluation has been carried out to determine the effectiveness and efficiency and mostly the users' satisfaction toward the interactive learning media. As the targeted users are Kids, their experiences using this app was fully monitored as they are understanding the interfaces or not.





Picture 8: User Evaluation Flow

The subject of this research was the Kids randomly chosen from the neighbors and nearby schools under the supervision of their parents and teachers. Evaluation sessions are taken to make the system understandable to them and also observed and monitored the sessions.

Users' Feedback from the students of the different disciplines were taken to improve the application. Debugging was done to fix the bugs and problems in the coding structure which was found in the users' evaluation.

Technical Evaluation: Performance measurement was done to evaluate the system in frame per second (FPS) and benchmark on the STbES library which measures the performance in FPS value.

Research Instruments: The researched instruments of this study are considered as AR-based Interactive Learning Media for Kids, consent forms, user background questionnaires, one set of user tasks, and user feedback questionnaires on their feedback on the learning application.

Equipment Used: The system testing was conducted in Xiaomi Note 8 Pro, ASUS M2, OnePlus7, and Huawei Smartphones. Specifications were above 1.6 GHz processors, respectively 6 GB and 4 GB of RAM, and dedicated 3D hardware accelerator with all plug-in pre-installed.

User Task: The targeted subjects were given a functionality user task which was designed to test how well the subject and surroundings could navigate the AR-based learning application by using touch and hands-free conditions. Each subject was fully pre-session about the application, its usage, and its purpose. They were given 15 mins to complete the functionality user task. Some sets of the task assigned to test the Graphics, Audio-Visuals, Interface, and Interactions. All the functionalities of the system were tested through the following activities. 3D model, Video playback, and animation pop-up were tested as to whether it should be performed.

Results

When the camera turns on at the starting of the application, it calls a function named 'OnTrackingFound()', which detects the correct alphabet and shows the appropriate 3D model or video accordingly.

The system auto-detects markers that exist on the database or not, and according to 'OnTrackingFound()' and 'OnTrackingLost()' functionality it shows or hides the appropriate object.

The snapshot of an integrated 3D model in the system:





Picture 9: Snap of 3D Models used in the system

The snapshot of integrated videos in the system:



Picture 10: Snap of multimedia (video) used in the system

Discussion

In this research, we have surveyed 10 people from different disciplines of University to evaluate the AR-based learning system. They were very much familiar with Android smartphones.

They had followed the testing criteria for the 11 letters by switching letters, playing sound, video, play and pause functionality, and object rotating option.

All operations were smooth and responding time was remarkable. They were pretty much satisfied with our developed system.

Functionality Task of the Application: We recorded the response of 10 people on the main functionality of the AR-based learning media for the kids application, which was to recognize the target image and respond according to the letter by showing 3D Models or Playing Video. We have got pretty much satisfying results and a total of 90% of the success rate and 10% of the failure rate.



Table 1:	System	functionality	test table
	J		

No	Statements	Response	
		Success	Failure
1	Use the alphabet (অ, আ, ই, ঈ, উ, এ, এ, ও, ঔ) marker to detect, view 3D model from all angles and listen to the sound effect	90%	10%
2	Use the alphabet (觉, 책) marker detect and watch the video with sound effect	90%	10%

Overall performance of the Application: We have recorded a response of 10 people on the overall performance of the application based on Graphical Glitch, Broken Audio, and 3D model rotation problems. From this section mentioned above for individuals, we have got a total of 94% of the success rate and 6% of the failure rate.

Table 2: Over	rall performance measure	ement table
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No	Statements	Response	
		Success	Failure
1	Have you faced any kind of Graphical glitch/problem while using the Application?	1 10%	9 90%
2	Have you faced any kind of Sound related problem while using the Application?	0 0%	10 100%
3	Have you faced any kind of problem regarding 3D Model Rotation, while using the Application?	1 10%	9 90%

Conclusion

The general goal of this research was to structure an Augmented Reality based interactive multimedia learning system for children. The accompanying objectives were to coordinate 3D models and interactive media modules into the framework utilizing Vuforia and Unity Game Engine for Android Smartphones and learn about them. Alongside that, an examination was led to test the productivity, efficiency, and client fulfillment of the system.

The book for the children was developed dependent on the proposed structure utilizing the Vuforia library and the Unity Game Engine for Android Smartphones. Vuforia was utilized in this system for image tracking and Unity Game Engine was utilized for AR rendering.

The virtual model was structured utilizing unity's ProBuilder apparatuses. Features, for example, solid shape, circle, and lines were controlled to structure the 3D model of alphabets. In this research, Unity's work in the following, and AR enrollment frameworks were utilized. At any point the tracker recognized a marker coordinating the picture transferred in the database, it called the capacity "OnTrackingFound()". If no match was discovered, at that point the framework called the "OnTrackingLost()" function.



The development methodology followed was SDLC. The five stages of SDLC include requirement gathering, planning, development and implementation, testing, and deployment. The proposed testing methodology for this study was based on user and technical evaluation.

The limitation of the study is, the system can just identify the pictures that are available in the database, and therefore, it doesn't recognize different markers that might be available containing a comparative picture. Additionally, the capacity to recognize markers in poor lighting conditions was an issue.

Some recommendations for future research and studies in terms of this research are to improve the efficiency and smoothness of switching between letters, introduce more Bengali alphabets, introduce interactive 3D animations, and recognizing character by OCR.

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METHOD FOR CLASSIFICATION OF PERMANENT TOOTH CLASSES FROM PHOTOGRAPHS

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Abstract

In this work the system of methods in digital image processing was proposed to classify teeth in the photographs of the model of permanent teeth. The system consisted of segmentation the dental arch by colors, and classification of the individual teeth by image registration. Image registration was the major technique chosen by discussion from former works on the photographs of oral cavity. The images of teeth were obtained from the 'sim kit' model (teeth model) in different angles of tilt and pan. The method could classify teeth correctly up to 8 teeth out of 14 teeth. The best view to take the photographs was suggested by the result to be the extremal elevation angles and the model pointing directly to the image sensor.

Keywords: Digital image processing, Image segmentation, Image registration, Dental photography, Teeth type classification

Introduction

Diagnosing oral health diseases usually is done by experts from dentistry area, for the sake of accuracy. However, the accessibility problems such as too few experts and difficult travelling to healthcare facilities, which often happen in rural areas, decrease the chance for patients to see doctor and get cured on time.

Digital image processing is a study of applying mathematical and computational methods on digital images to gain information. Some of its application are medical image analysis (Tanthanuch, Kaptsov, and Meleshko, 2019), and traffic management (Hasan et al., 2014). When combining with other technology like artificial intelligence, it helps automate systems, which means decrease human workload.

This work is the first part of developing an automated system which can be used to analyze dental images (various types of images taken from oral cavity). The colored photographs are taken from different views of permanent teeth model. The teeth in the photographs are to be classified into one of four types of teeth: incisors, canines, premolars, and molars. Techniques in digital image processing are considered into helping automate the system of analyzing the images (the photographs) and classifying the teeth. If the system yields high enough accuracy, it can be used to increase the speed and accuracy of the artificial intelligence in the part of learning dental images, and develop the system which can detect disease traces in photographs.

This paper is organized as follows: first, in the literature review, the model of human teeth and the teeth types are presented, the imaging methods in dentistry are gathered and the related works on dental images are reviewed. Choosing the main method - the image registration - is also discussed.



Then in the methodology, the view setting and the image acquisition are shown. The image segmentation by color components and morphological operations is then employed to decrease computational complexity. The image registration is then applied and the results are discussed.

Research Objective

To find an efficient method in digital image processing that can classify teeth in the photographs of permanent teeth model.

Literature Review

1. Human teeth and their types

1.1 Teeth – general information

Teeth are an organ / a structure located in a mouth and is the first part of digestive system. Teeth break down food particles and help pronounce words when one speaks. Usually, humans have 2 sets of teeth: primary teeth and permanent teeth. Primary teeth are found in children approximately from the age 6 months to 12 years old. Permanent teeth or complete permanent dentition is found in people age from approximately 12 years old.

1.2 Permanent teeth

The set of permanent teeth consists of 32 teeth, and these teeth can be classified into 4 types, as follows:

1) Incisors are at the front of the dental arch. There are 8 teeth; 4 uppers and 4 lowers. They are thin and flat. They cut food from the big piece into a smaller one that can be taken in the mouth.

2) Canines are next to incisors. There are 4 teeth; 2 uppers and 2 lowers. They are sharp, spike-like shape. They tear and hold food piece.

3) Premolars or bicuspids are next to canines. There are 8 teeth; 4 uppers and 4 lowers. They are bigger than incisors and canines. They tear and crunch food particles.

4) Molars, including wisdom teeth or third molars, are next to premolars and at the deepest part of the dental arch. They are 12 teeth; 6 uppers and 6 lowers. They are the biggest teeth. They are with flat faces which crunch food particles.





Picture 1: Permanent teeth diagram

2. Imaging in dentistry

Defined by American Dental Association, dentistry, also known as dental medicine and oral medicine, is a branch of medicine that consists of the study, diagnosis, prevention, and treatment of diseases, disorders, and conditions of the oral cavity, commonly in the dentition but also the oral mucosa, and of adjacent and related structures and tissues, particularly in the maxillofacial (jaw and facial) area.

In the past three decades it benefits much from helping technologies, especially imaging methods. Shah, Bansal, and Logani (2014) gathered the imaging methods used in dentistry. Table 1 shows the imaging methods they gathered and examples. It also includes some methods not mentioned in their paper.

methods	examples	source of examples
X-ray	TOTAL TOTAL	https://www.hawkins familydental.com/bl
		og/understanding-
		dental-x-rays/
Cone Beam	Avenue of Scheme Provide States	https://johannlochner
Computed	2 3 Patrice Date	.com/treatments-
Tomography	S O CONTRACTOR	offered/3d-x-rays-
(CBCT)		cbct/
(3D)	Pages on All De Delans Wat	

Table 1: Imaging methods in dentistry and examples





Table 1: Imaging methods in dentistry and examples (cont.)

Each type of images has advantages and disadvantages. Usually image acquisition for X-ray, CBCT, MRI, and US could be counted expensive, since it is done by specifically-built tools presenting only in some healthcare facilities. Their main advantage is precise diagnosis. The image



acquisition of photography is the cheapest, but with the limitation of views, especially to the inside of teeth and jawbones.

3. Tasks in medical image analysis

In the survey paper of Litjens et al. (2017), the medical image analysis tasks in which technologies are employed to help decrease human workload can be grouped as follows:

3.1 Classification

Examples of classification in medical image analysis are image/exam classification, in which the goal is to tell if the disease is present or not, and object/lesion classification, in which the objects in the images are to be classified into types.

3.2 Detection

Detecting objects in images such as organs, regions, lesion, consists of 2 tasks: localization of the object and object identification.

3.3 Segmentation

Segmentation is the pixel-level work. It is to segment every pixel that belongs to some specific objects or regions. Segmentation helps with analysis involving volume and shape such as cardiac or brain analysis.



Picture 2: Image segmentation

3.4 Registration

Registration, or spatial alignment of medical images, is a task in which one medical image is transformed geometrically to another image. Then the data existing in one image can be transferred to another image easily. It is used mostly in brain analysis but is found also in implant surgery.





Picture 3: Examples of geometric transformations



Picture 4: Image registration

3.5 Other tasks

The other tasks include learning image database, image generation, and matching images with reports.

4. Related works

In medical image analysis, there are many types of images since the purposes of analysis are vary and the image sensors are different. It is so with the dental images. The types of dental images include the x-ray images, the CT scanned images, the 3D meshes, and the photographs, with the x-ray images being the most used since they show the inner parts of teeth. The methods from digital image processing are chosen by considering the type of the images and the purpose of analysis. The following are some works involving with dental image analysis and teeth classification:



Kim, Shin, and Hong (2010) detect teeth area in the photographs of human face, which are taken by smartphone. They use Haar-like features to locate teeth region, thresholding and geometric transformation to pre-process the teeth region images, and the classification techniques PDA, LDA, and EHMM to recognize the teeth owner in the database. The detection rate using Haar-like features, although with time consumption, can reach 98.80%. The false detection includes detecting eyes and eyebrows, instead of teeth.

Zheng, Zhang, and Ding (2010) detect molars in the gray photographs of occlusal view of teeth images. They use the technique called Hybrid Differential Method or HDM with Turnpoint analysis to get the detail of molars. The HDM + Turnpoint analysis is claimed to detect molars in the teeth images well even when the images are degraded.

Amer and Aqel (2015) divide x-ray panoramic images of teeth into parts to extract the wisdom teeth (the third molars) from the whole images. The extraction using simple ratio of each part of the images, together with histogram equalization, thresholding, and morphological operations to delete unwanted regions to get the wisdom teeth regions. Since the x-ray panoramic images are the most delicate image acquisition, the fixed ratios possibly work on almost every image of this type. Then the steps of image processing can be lessened significantly.

Lins et al. (2017) detect and classify teeth in the colored photographs of occlusal view of teeth. They use color components and morphological operations to segment the dental arch from the whole image, and then apply the Watershed algorithm to separate individual teeth, before using Support Vector Machine to classify teeth into four types: incisors, canines, premolars, and molars. The Watershed algorithm yields 83.37% accuracy of segmentation.

Kang et al. (2017) detect a dental implant in the gray photographs of teeth at front view and top view. They find the threshold value range which can be used to binarize the images and still the titanium dental implant can be detected from the whole images. The binarization is praised for the simplicity of computation, hence less time consumption, if it can be applied to any case of image analysis.

Rattana and Tanthanuch (2019) segment dental arch from the colored photographs of oral cavity by using color components of teeth and morphological operations. The color ratio is applied later to get the deep parts of the dental arch segmented too. The result is the photographs with other parts except teeth being masked out, so that they can be used as pre-processed images for machine learning system with less noise.

It is worth noting that individual teeth in the photographs of oral cavity cannot be segmented easily if the image acquisition is not done with special helping tools such as dental mirror and retractor, since the edges and the grooves of teeth look very similar to each other.

The same problem happens in the case of brain image analysis, in which the edges of different regions of the brain are not clear. In the database survey of Yaakub et al. (2020), manual segmentation does not work well on brain images, and then the atlas-guided segmentation becomes more of use in brain image analysis. The atlas-guided segmentation is the image segmentation which is based on image registration and knowledge transferring from an expert-generated atlas to the targeted image. The image registration itself relies on shape similarity and geometric transformation, so it does not require well-acquired images much and can be taken into consideration for this work.



Methodology

1. The images and the image acquisition

In this work, the colored photographs of permanent teeth model are considered into use. A model consists of 2 parts: the upper teeth and the lower teeth. Both parts are photographed by 15 different views; 3 different elevation angles x 5 different horizontal angles, so there are 30 photographs taken from the model. The setting is shown in Picture 5 and some examples of the photographs are shown in Picture 6.



Picture 5: Setting of image acquisition



Picture 6: Examples of the model being photographed by different views





Picture 7: View setting: (a) elevation angles, and (b) horizontal angles Source: Teeth images https://flyclipart.com/brush-teeth-clipart-brushing-teeth-clipartmonk-free-clip-art-girl-brushing-teeth-clipart-810970 http://jacaconce.blogspot.com/2006/06/arcada-bucal.html Iphone image https://www.pinclipart.com/downpngs/mwxTR_clip-art-freeuse-iphone-smartphone-icon-png-transparent/

2. Image pre-processing

The images from 1. are pre-processed so that the teeth region in each image is segmented and the other parts are masked out by these steps:

1) The colored photographs are binarized by thresholding the red color component of the images, to mask out the black background.

2) The gum part of the model, which is red, is masked out by thresholding the green color component of the images.

* The steps 1) and 2) cannot be done together since it segments the wrong part of the model.





3. Image registration and teeth classification

In this step, only the images with correct segmentation (with only one part of the model is segmented) are to be registered. The reference image, which is to be transformed, is shown in Picture 8. The reference image already contains the classification of teeth types. The geometric transformation is fixed to be affine (translation + rotation + scaling + shearing).





Picture 9: The reference image of teeth: (a) upper teeth, and (b) lower teeth

4. Hardware and software used in this work

Image sensor: Iphone 7

Image segmentation and registration: MATLAB R2020b, The MathWorks, Inc., Natick, Massachusetts, United States.

Reference image preparation: PhotoStudio 6, ArcSoft, Inc., Fremont, California, United States.

Results

1. Segmentation

From 30 images, 26 images are segmented correctly. The correct segmentations show only one part of the teeth; the upper teeth or the lower teeth. The incorrect segmentations can show two parts or even not a whole part. They are shown in Picture 9.



Picture 10: Incorrect segmentation

2. Registration

Both the one part of the model and the reference image contain 14 teeth. Table 2 shows the number of teeth that are classified correctly (out of 14) in each image. The images with incorrect segmentation will not be registered and their number of correctly classified teeth will be recorded as x.





Picture 11: The result of image registration: (a) the worst, and (b) the best

Elevation angles	Horizontal angles							
	А	В	C	D	E			
Lower 1	Х	х	0	Х	Х			
Lower 2	1	2	8	3	2			
Lower 3	2	6	7	3	4			
Upper 1	1	6	8	8	7			
Upper 2	2	5	7	2	0			
Upper 3	4	1	3	3	0			

Table 2: The number of teeth correctly classified in each image

3. Statistical data

Number of registered photographs: 26 Maximum number of teeth correctly classified in a photograph: 8 Minimum number of teeth correctly classified in a photograph: 0 Total number of teeth to be classified in a photograph: 14 incisors: 4, canines: 2, premolars: 4, molars: 4 Total number of teeth to be classified: $26 \times 14 = 364$ incisors: 104, canines: 52, premolars: 104, molars: 104 Number of teeth correctly classified: 95 incisors: 46, canines: 8, premolars: 24, molars: 17 Accuracy of the chosen classification method, by type of teeth incisors: 44.23%, canines: 15.38%, premolars: 23.08%, molars: 16.35%

Discussion

A permanent teeth model is taken into 30 photographs of different views. There are 2 parts of the model: the upper teeth and the lower teeth. Each part is taken into 15 photographs of different views. The photographs are segmented until only teeth region is left, and then are registered.

The segmentation steps, which use the color components and the morphological operations, work successfully on 26 out of 30 photographs. It means that the color components, with the help of morphological operations, can be used to segment teeth region in the photographs. The incorrect



segmentation happens with bad angles, in which both parts of the model overlap, since they are of the same color.

The registration step works differently on different views. In the best view photographs, in which the elevation angle is extremal and the model points directly to the image sensor – in this case – the smartphone, the registration can classify types of teeth correctly 7-8 teeth out of 14 teeth. In the worst view photographs, in which the dental plane points straight to the image sensor, the registration does not work at all so no teeth are classified correctly.

The type of teeth that is classified most accurately by the chosen method is incisors, followed by premolars, molars, and the least accurately classified type is canines.

Conclusion

The purpose of this work is to find an efficient way to classify teeth in photographs of permanent teeth model. The photographs are the targeted type of images in this work since photography is an image acquisition which is not expensive, but is the most difficult for image analysis by computer.

By the study of former works on the similar problem, the image registration is indicated to work better than manual segmentation, hence it is tested in this work.

Out of 14 teeth the method can classify teeth correctly up to 8 teeth, which shows that the method works well in some specific conditions. In the results of this work, it is obvious that the angles affect the accuracy of the classification by image registration.

Since the image registration itself consists of chosen geometric transformation of the reference image and the similarity optimization, the chosen geometric transformation should be considered in further works. The geometric transformation used in this work is an affine transformation, which carries not too many parameters to be optimized. Also, the reference image should be remade to suit the photographs of 3D teeth model better.

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STATISTICAL DISTRIBUTIONS APPEARING IN MEDICAL ULTRASOUND IMAGES

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Abstract

The ultrasound imaging technique is mostly used for medical diagnostic purposes. An unclear image leads to misdiagnosis causing a deficiency in a treatment. The purpose of this research is to study the statistical distributions of signals appearing in medical ultrasound images. The understanding of the phenomenon of occurring medical ultrasound images helps in the further various research of ultrasound image enhancement.

The study extended concepts of using basic statistical distributions to characterize signals in medical ultrasound images, Rayleigh and Rician distributions. K-distribution and homodyned K-distribution and Rician distribution with modulated inverse Gaussian distribution parameter and Nakagami distribution with modulated generalized inverse gaussian distribution were considered in giving a physical explanation of the signals.

Graphs of the proposed distributions, their mean, variance, skewness, and kurtosis were constructed by the Python code. The analysis was found that Nakagami distribution with modulated generalized inverse Gaussian parameters was the most generalized distribution than other distributions mentioned before.

Keywords: Medical ultrasound image Rayleigh distribution Rician distribution Nakagami distribution

Introduction

Ultrasound denotes sound waves that have frequencies higher than the human hearing upper audible limit. It can be considered as a mechanical disturbance that moves as a pressure wave through a medium. Medical ultrasound imaging is an ultrasound-based diagnostic imaging technique sending the high-frequency sound wave through skin, muscles and internal organs and producing an image from the echoes. The ultrasound echo signals received via the diagnostic transducer are transformed to electric voltage and then the series of detected voltages are processed to the brightness at points of the soft tissue image.

When the ultrasonic wave encounters several reflexive interfaces, it produces a masking effect of the reflectors and scattering. That phenomenon implies coherent and incoherent (diffuse scattering) effects. The incoherent effect causes the degradation of a medical image quality, which is called **noise**. To enrich the quality of the appearance image one needs to understand the process of imaging. However, there are many types of noise that contribute to the reduction of the quality of a medical ultrasound image. In practice, **speckle noise** is the dominating disturbance that is clearly noticeable on a medical ultrasound image (Mamou and Oelze, 2013).

Speckle noise has specific characteristics that can be described by some probability distribution functions. The mathematical model of the speckle noise probability distribution is derived from the envelope of the voltage signal received from an ultrasound transducer. An understanding of



the characteristics of ultrasound waves and their behavior in various media were studied (Destrempes and Cloutier, 2010 and Cai, 2016, Jensakda and Tanthanuch, 2018, Seekot and Tanthanuch, 2008, Tanthanuch, Kaptsov and Meleshko, 2019, Tanthanuch, Seekot, and Schulz, 2012). The probability distributions found in many research about explaining the ultrasound noise characteristic are Gaussian distribution, Poisson distribution, Rayleigh distribution, Rician distribution, K-distribution, homodyned K-distribution, generalized K-distribution, ascending order K distribution, Nakagami distribution, Nakagami-gamma distribution, Rician inverse Gaussian distribution, and Nakagamigeneralized inverse Gaussian distribution.

In this research, many probability distributions related to ultrasound imaging will be analyzed. Then the probability distribution properly being best describing image noise will be proposed.

Research Objective

To study and analyze probability distributions related to ultrasound noise imaging.

Literature Review

1. Statistical Parameters

Random variables are real value functions on the probability space, whose values are governed by outcomes of the randomness. They can be classified into two basic categories, **discrete** and **continuous**.

Definition 1. The random variable X is called **discrete** if its images are in some countable subset $\{x_1, x_2, ...\}$ of real numbers. The **mass function** (or **probability function**) of the **discrete** random variable X is defined by $f: R \to [0,1]$ and f(x) = P(X = x), where P(X) is a **probability distribution**.

If the random variable X has a distribution function expressed by the integral term

$$F(x) = \int_{-\infty}^{x} f(u) du, x \in R,$$

for some integrable function $f: R \to [0, \infty)$, the random variable X is classified as **continuous.** The function f is called a **density function** of X (or **probability function**).

Definition 2. For discrete random variable *X*, If *k* is a natural number (a positive integer), the *k*th **moment** m_k of *X* is defined by

$$m_k = \sum_x x^k P(X = x).$$

For continuous random variable X, we define the kth **moment of a continuous variable** X as the following.

$$m_k = \int_{-\infty}^{\infty} x^k f(x) dx,$$

whenever the integral exists.



The mean, expectation, or expected value of random variable X can be defined as the following.

Definition 3. For discrete random variable *X*, the **expectation** is defined by $E(X) = \sum_{x} xP(X = x)$. On the other hand, for continuous random variable *X*, the **expectation** is defined as integrals,

$$E(X) = \int_{-\infty}^{\infty} x f(x) dx.$$

We may sometimes denote the *k*th moment of variable *X* by $m_k = E(X^k)$. **Definition 4.** The most commonly used parameters in statistics are as follows.

- $\mu = E(X)$, called the **mean** of *X*;
- $\sigma^2 = E\left[\left(X E(X)\right)^2\right] = E(X^2) \mu^2$, called the **variance** of *X*;
- $\sigma = \sqrt{E(X^2) \mu^2}$, called the standard deviation of *X*;

•
$$\widetilde{\mu_3} = E\left[\left(\frac{X-\mu}{\sigma}\right)^3\right]$$
, called the skewness of *X*;

• Kurt[X] = $E\left[\left(\frac{X-\mu}{\sigma}\right)^4\right]$, called the **kurtosis** of *X*.

The meaning of the parameters mentioned above is simply giving here. **Mean** or **expected value** is the weighted average. **Standard deviation** is a measure of the amount of dispersion of a set of values. **Variance** is the expectation of the squared deviation of a random variable from its mean. **Skewness** and **Kurtosis** are measures of the asymmetry and the tailedness of the probability distribution, respectively. They are used to describe the shape of a probability distribution.

2. Wave

To understand ultrasound image processing, some basic related knowledge is provided. **Definition 5.** The **differential wave equation** of speed v and time t is defined by

$$\nabla^2 \psi = \frac{1}{v^2} \frac{\partial^2 \psi}{\partial t^2},$$

where $\psi = \psi(x_1, ..., x_n, t)$ is called a wave and the Laplacian $\nabla^2 \psi$ of ψ is expressed by $\nabla^2 \psi = \frac{\partial^2 \psi}{\partial x_1^2} + \dots + \frac{\partial^2 \psi}{\partial x_n^2}.$

Definition 6. For the particular case of a differential wave equation, if n = 1, the differential wave equation can be derived as

$$\frac{\partial^2 \psi}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 \psi}{\partial t^2}.$$

The above differential wave equation is the **one-dimensional differential equation**. We call a function $\psi = f(x \pm vt)$ satisfying the one-dimensional differential equation (a solution of the equation) **one-dimensional wave**. A **harmonic wave** is a particular case of a one-dimensional wave which is defined by the sine function, $\psi = A\sin[c(x \pm vt)]$, or the cosine function, $\psi = A\cos[c(x \pm vt)]$, where A and c are constants. The coefficient A is called the **amplitude** of the wave



and $\omega = cv$ is called the **angular frequency**. A **harmonic wave** is just a particular solution of a onedimensional differential equation.

Definition 7. The linear combination of two or more harmonic waves is called the **superposition of waves**. Since a superposition of N harmonic waves of the same frequency is still a harmonic wave, which has also the same frequency. Waves are said to be **coherent** if they have an identical frequency. On the other hand, they are **incoherent** if they have random different frequencies.

Definition 8. Speckle is a random intensity pattern appearing on coherent imaging. It is always observable on an ultrasound image. Speckle can be presented by an interference of the superposition of incoherent waves.

3. Medical Ultrasound Image

A primary component of an ultrasound transducer is made from an array of a piezoelectric crystal. Its function is to convert electrical energy into ultrasound energy and vice versa. The process of the imaging of soft tissues starts by transforming the ultrasound echo signals received to electrical voltage. Then the series of detected voltages are converted to the brightness at each point of the image defined by their x- and y-coordinates. In the case of no compression of filters, the amplitude corresponds to the gray-scale level of the brightness mode (B-mode) image. The mean intensity, which is considered according to the intensity distribution, is interpreted as the signal intensity averaged over the space. To be precise, the gray-scale intensity of each pixel of a B-mode image is obtained from the envelope of the received voltage signal. The envelope of the signal can be derived by applying the Hilbert transform to the signal. In practice, not only pure echo signals from the surface but signal contaminations also pass through the piezoelectric receiver. The diffusion scattering of ultrasound signals can be modeled by some probability distribution (Destrempes and Cloutier, 2010).

The mathematics and statistical models related to the diffusion scattering of ultrasound signals are presented in the methodology section.

Methodology

In this section, distributions used in ultrasound image processing are reviewed and analyzed as follows.

Rayleigh distribution

In the ultrasound imaging process, it is assumed that the superposition of received echo ultrasound is a linear summation. The envelope detection process in B-scanning is a nonlinear step that yields essentially the magnitude of the complex detected voltage. Wagner et. al. (1983) showed that the Rayleigh distribution with PDF

$$P_{Ra}(x) = \frac{x}{\sigma^2} e^{-\frac{x^2}{2\sigma^2}},$$

where x > 0 and parameter σ^2 is a variance, governs the fist-order behavior of the magnitude.



Rician distribution

Specular reflection consists of sound interactions with smooth tissue interfaces where the surface features are much larger than the wavelength of ultrasound. Assume that specular echo has a large amplitude (when compared to the diffuse scattering echo) sine wave. Consider the sum of a specular echo and diffuse echoes, the resulting amplitude is still considered as the length of a twodimensional vector of two Gaussian random variables. However, only one of them has a zero mean. If the two components are independent, then the distribution of amplitude x is a Rician distribution,

$$P(x; x_0, \sigma) = \frac{x}{\sigma^2} e^{-(x_0^2 + x^2)/(2\sigma^2)} I_0\left(\frac{x_0 A}{\sigma^2}\right),$$

where $x \ge 0, x_0 > 0$ represent the amplitude of the specular echo, σ is a parameter, and I_0 is the modified Bessel functions of the first kind of zero-order defined by $I_0(s) = \frac{1}{\pi} e^{s\cos\theta} d\theta$.

K-distribution

Jakeman (1980) considered noise by the concept of a random walk. Then the results of the received ultrasound signal at the transducer face is possible to be non-Gaussian. He proposed that the modified Bessel function or K-distribution with PDF

$$P(x; \alpha, b) = 2\left(\frac{x}{2}\right)^{\alpha} \frac{b^{\alpha+1}}{\Gamma(\alpha)} K_{\alpha-1}(bx),$$

where x > 0 and $\Gamma(\cdot)$ is the gamma function, α and $b = \sqrt{\frac{4\alpha}{E(x^2)}}$ are parameters, is more appropriate to model the amplitude statistics of the scattered radiation in medical ultrasound images.

Homodyned-K distribution

The random variable $x \ge 0$ has the Homodyned-K distribution with parameters $\alpha, b > 0$ if it has PDF

$$P(x;\alpha,\sigma,s) = x \int_0^\infty t J_0(xt) J_0(st) \left(1 + \frac{t^2 \sigma^2}{2\alpha}\right)^{-\alpha} dt,$$

where $J_0(\cdot)$ is the zeroth order Bessel function of the first kind and $\alpha > 0$.

Nakagami distribution

Koundal, Gupta, and Singh (2015) mentioned that the Nakagami model is better in statistical modeling of speckle in ultrasound images than the Rayleigh distribution. They presented the noise removal method based on the Nakagami distribution, which is more efficient to enhance the quality of thyroid ultrasound images. The statistics of medical ultrasound images with log-compressed in that research are derived from the Nakagami distribution. The PDF of the Nakagami distribution is



$$P(x; m, \sigma^2) = \frac{2m^m}{\Gamma(m)(2\sigma^2)^m} x^{2m-1} e^{-\frac{mx^2}{2\sigma^2}},$$

where x > 0, $\Gamma(\cdot)$ is the gamma function, $m \ge 0.5$ is the Nakagami shape parameter defined by $\frac{E(x^2)}{var(x^2)}$ and $2\sigma^2$ is the scaling parameter defined by $E(x^2)$. Note that Rayleigh distribution is the limiting distribution of K-distribution and it is a specific case of the Nakagami distribution when m = 1.

Compound probability distribution

The distribution H is a **mixed**, **mixture**, or **compound** distribution if the random variable X is distributed according to some parametrized distribution F with an unknown parameter θ , which is also distributed according to another distribution G, (Lovric, 2011). The resulting distribution H is said to be the distribution that results from compounding F with G, which means the distribution F is compounded by the distribution G and the parameter's distribution G is known as the compounding (mixing or latent) distribution.

The unconditional distribution *H* is technically obtained from marginalizing over *G*, which is resulted from integrating out the unknown parameter(s) θ . This probability density function is provided by

$$P_{H(x)} = \int P_F(x|\theta) P_G(\theta) d\theta.$$

Results

The **Rayleigh distribution** corresponds to the distribution of the gray-scale level of each pixel in the image (or amplitude of the ultrasound signal before transformed to the image) in the case of a high density of random scatterers with no coherent signal component (Wagner et al., 1983).

Similar to the Rayleigh distribution, the **Rician distribution** also corresponds to the distribution of the amplitude. However, the Rician distribution has a parameter that can be used for describing an appearing coherent signal component.

K-distribution corresponds to a variable density α of random scatterers, without a coherent signal component. The K-distribution can be represented in the compound form of Rayleigh distribution with modulated gamma distribution parameter:

$$P_k(x|\sigma^2,\alpha) = \int_0^\infty P_{Ra}(x|\sigma^2w) G(w|\alpha,1)dw,$$

where G is gamma distribution.

The **Homodyned K-distribution** corresponds to a variable density α of random scatterers similar to K-distribution but it has a parameter which is able to describe an appearing coherent signal component ε . The Homodyned K-distribution is defined by a Rician distribution with modulated gamma distribution parameter



$$P_{HK}(x|\varepsilon,\sigma^2,\alpha) = \int_0^\infty P_{Ri}(x|\varepsilon,\sigma^2w)G(w|\alpha,1)dw$$

By modulating both parameters of the Rician distribution, the coherent signal component ε , and the variance σ^2 , one obtains the **Generalized K-distribution**,

$$P_{GK}(x|\varepsilon,\sigma^2,\alpha) = \int_0^\infty P_{Ri}(x|\varepsilon w,\sigma^2 w) G(w|\alpha,1) dw.$$

The other representation of the generalized K-distribution can be derived as a Rician distribution with both the mean-square noise component and the coherent amplitude varying according to a gamma distribution.

The Gaussian or normal distribution describes a Brownian motion's level at a considering time, whereas the inverse Gaussian describes the distribution of the time a Brownian motion with a fixed positive level (Folks and Chhikara, 1978). Therefore, the inverse Gaussian distribution is more appropriate to describe the random reflexive ultrasound signal phenomena than the Gaussian distribution. The Inverse Gaussian distribution is a distribution with 2 parameters, mean μ and shape parameter λ . In the case that $\mu = \sqrt{\lambda}$, the inverse Gaussian distribution has variance $\sqrt{\lambda}$ also. On the other hand, the gamma distribution which has shape parameter α and scale parameter equal to 1, its mean and variance are exactly the same α . That is an intuitive idea to assume that gamma distribution can be generalized to inverse Gaussian distribution.

The Rician distribution with modulated inverse Gaussian distribution parameters can be defined by

$$P_{RiIG}(x|\varepsilon,\sigma^2,\lambda) = \int_0^\infty P_{Ri}(x|\varepsilon w,\sigma^2 w) IG(w|\sqrt{\lambda},\lambda) dw,$$

where IG is an inverse Gaussian distribution probability density function.

The distribution proposed is more general to describe the physical meaning of an ultrasound signal than homodyned K-distribution. Homodyned K-distribution has only one modulated parameter, whereas this distribution has more modulated parameters, which are the coherent signal component ε and variance σ^2 .

Destrempes and Cloutier (2010) show that the **Nakagami distribution** can be approximated to the Rayleigh distribution, Rician distribution, and K-distribution, which depend on the parameters Ω and *m*. Therefore, the Nakagami distribution is claimed to be better in describing the ultrasound signal with coherent signal component ε , which has a high density of random scatterers.

In order to extend the concept using Nakagami distribution to be able to specify a density α of random scatterers, Nakagami distribution with modulated gamma distribution parameter

was introduced (Shankar, 2003). The compound representation of the distribution is

$$P_{NG}(A|m,\Omega,\alpha) = \int_0^\infty N(A|m,\Omega w) G(w|\alpha,1) dw,$$

where *N* is the Nakagami distribution and $G(w|\alpha, 1)$ is the gamma distribution with mean and variance α .



The Nakagami distribution with modulated generalized inverse Gaussian parameters is the distribution with 4 parameters, i.e. m, Ω, θ and λ , defined by

$$P_{NGIG}(x|m,\Omega,\theta,\lambda) = \int_0^\infty N(x|m,\Omega w) GIG(w|\theta,\sqrt{\lambda},\lambda) dw,$$

where *N* is Nakagami distribution and $GIG(w|\theta, \sqrt{\lambda}, \lambda)$ is the gamma distribution with mean $\mu = \sqrt{\lambda}$ defined by,

$$GIG(w|\theta,\mu,\lambda) = \frac{1}{2\mu^{\theta}K_{\theta}(\lambda/\mu)} w^{\theta-1} \exp\left[-\frac{1}{2}\left(\frac{\lambda}{w} + \frac{\lambda}{\mu^{2}}w\right)\right],$$

and K_{θ} is the modified Bessel function of the second kind.

This distribution is the most generalized in describing the ultrasound signal than other distribution mentioned before. Therefore, the graph of the distribution with the various parameters and graphs of its parameters, which are expectation value, variance, skewness and kurtosis, are presented as the following.



Picture 1: Graph of Nakagami distribution with modulated generalized inverse Gaussian parameters, m = 1, $\Omega = 2$ and a density parameter $\alpha = 1, 2, 3$.





Picture 2: Graph of expectation value with of Nakagami distribution with modulated gamma distribution parameter.



Picture 3: Graph of variance value with of Nakagami distribution with modulated gamma distribution parameter.



Picture 4: Graph of skewness value with of Nakagami distribution with modulated gamma distribution parameter



Picture 5: Graph of kurtosis value with of Nakagami distribution with modulated gamma distribution parameter



Distribution	high density of random scatterers	coherent component	Specific density of random scatterers	intensity parameter modulated by gamma distribution	intensity & coherent	parameters modulated by gamma distribution intensity &	coherent parameters	modulated by IG distribution intensity &	coherent	parameters modulated by GIG distribution
Rayleigh	1									
Rician	✓	1								
К			1							
HK		1	1	1						
GK		1	1			\checkmark				
RiIG		1	1				1			
Nakagami	1	1								
NG		1	1				1			
NGIG		\checkmark	1							 Image: A start of the start of

Table 1: The summarized analysis of statistical distributions appearing in medical ultrasound images.

Remark: The words mentioned in table 1 mean

- K means K-distribution;
- HK means Homodyned K-distribution;
- GK means Generalized K-distribution;
- IG means inverse Gaussian distribution;
- GIG means generalized inverse Gaussian distribution;
- RiIG means Rician distribution with modulated inverse Gaussian distribution parameters;
- NG means Nakagami distribution with modulated gamma distribution parameter;
- NGIG means Nakagami distribution with modulated generalized inverse Gaussian parameters.

Discussion

In this research, we performed an analysis of the statistical distributions appearing in medical ultrasound images. For the case of the high density of random scatterers, Rayleigh, Rician, and Nakagami distributions were proposed for modeling the ultrasound wave. However, just Rician and Nakagami distributions are able to explain in the part of the coherent component. If one wants to specify the density of random scatterers, K-distribution and Homodyned K-distribution can perform modeling an ultrasound wave, whereas Homodyned K-distributions is extended to be able to explain in the part of the coherent component. However, some distributions modulated parameters with some other distributions are proposed for modeling, i.e., Homodyned K-distributions, Generalized Kdistribution, Rician distribution with modulated inverse Gaussian distribution parameters, Nakagami distribution with modulated gamma distribution parameter, and Nakagami distribution with modulated generalized inverse Gaussian parameters. The mentioned distributions are able to describe an ultrasound wave model in the case of a specific density of random scatterers with the coherent component. The graphs of the relation between number parameters, σ , ε , α , λ , m or Ω and distribution parameters mean, variance, skewness, and kurtosis of the considered distributions perform that we can adjust the number parameters of some distribution to make its structure similar to another one's structure.



Conclusion

In our research, Nakagami distribution with modulated generalized inverse Gaussian parameters is the most generalized distribution which relates to the medical ultrasound image. The mentioned distribution is able to explain the physical phenomenon with the specification of the density of random scatterers and the coherent component. Also, its parameters are modulated by more generalized distribution, generalized inverse Gaussian distribution, which is an extended concept of gamma distribution and inverse Gaussian distribution.

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立体绿化城市环境绩效评价指标体系研究 THE INDEX SYSTEM OF ENVIRONMENTAL PERFORMANCE EVALUATION OF THREE-DIMENSIONAL GREENING CITY

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摘要

中文摘要: 立体绿化能对人和自然的关系产生一定影响, 探讨和实施立体绿化, 有助于充分利用城市土地资源、节能减排、降低热岛效应、净化空气、维护城市生态平衡、提升居民生活水平以及构建和谐社会, 有利于城市实现可持续发展, 从而提升城市管理绩效。本文通过梳理环境绩效的评价模型相关的文献, 分析适合用于评价立体绿化与环境关系的评价体系模型特征。并基于立体绿化相关理论基础下, 分析了 PSR 模型框架的适用性, 然后依照整体性、层次性、可获得性、可比性和客观原则性构建基于 PSR 模型的立体绿化与环境绩效评价的模型, 然后运用 spss 软件对构建的立体绿化与环境绩效评价指标体系进行了合理性分析。

关键词: 立体绿化; PSR 评价模型; 城市环境绩效

Abstract

Abstract: Three-dimensional greening can have an impact on the relationship between the man and nature, explore and implement vertical greening, helps to make full use of urban land resources, energy conservation and emissions reduction, to reduce the heat island effect, purify air, urban ecological balance maintenance, improve residents' living standard and the construction of a harmonious society, realizing urban sustainable development, so as to promote urban management performance. Based on the theory of three-dimensional greening, the applicability of PSR model framework is analyzed, and then the model of three-dimensional greening and environmental performance evaluation based on PSR model is constructed according to the principles of integrity, hierarchy, availability, comparability and objectivity. Then SPSS software is used to analyze the reliability of the three-dimensional greening and environmental performance evaluation index system.

Key words: three dimensional greening; concept of PSR; urban development; urban environmental optimization

引言

城市一方面是创造人类物质财富和精神财富的核心,另一方面也是改变生态格局、大量 消耗能源、资源、导致温室效应等问题的集中地(余荣,2011),根据联合国《世界都市化展望报 告》报道:2014年全球 54%的人口居住在都市中,到了 2050年,将有超过三分之二的人口居



住在都市(IPCC2014)。报告并且指出:到 2030年人口 1000万以上的巨型都市会有 41 个。 显示国际人口持续大量移居都市,且都市的范围将越来越大。随着都市化迅速扩张,数量及规 模庞大的楼房建筑以及如蜘蛛网笼罩着城市的生硬水泥道路及高架桥导致城市绿化面积越来越 少(冉帆,2015)。不可否认,城市化进程能够带来巨大的综合效益,但是它对人居环境造成 的负面影响令人堪忧。维持城市生态系统平衡,有限的平面绿化量已远远不足。人口激增、资 源锐减、生态失衡、大气污染、水污染、噪音污染、"热岛效应"造成区域气候炽热、酸雨和 臭氧层损耗等各种各样的环境问题一直影响着城市的发展。尤其是近几年城市总是被雾霾笼罩, 人们逐渐意识到良好的生态环境对人类的生存与发展意义重大(凤凰空间•上海,2012)。我 们意识到地面上有限的绿地面积已经不能满足生活环境中生态平衡的绿化要求和节能要求。如 何找到一个科学的方法已成为全社会共同关注和努力的目标,城市的低碳化和生态化良性发展 正是解决问题的根本途径之一(张爽&林建群,2011),也是优化城市环境管理绩效的根本之路。

1. 立体绿化概念

立体绿化是指充分利用城市地面上的各种不同立地条件,选择各类适宜植物,栽植 于人工改造的环境中,使绿色植物覆盖地面以上的各类建筑物、构筑物及其他空间的结构的表 面,利用植物向空间发展的绿化方式(罗舒雅,2015)。

建筑立体绿化主要针对于建筑而言,包括建筑的内外墙面、阳台、屋顶、棚架、柱 子等实施人工所创造的绿化的方式。它是改善城市生态环境最积极有效的方法之一,在不增加 城市绿化用地的基础上,最大限度扩大绿地面积、提高绿化覆盖率是建设低碳节能城市的一项 重要内容。立体绿化技术将城市绿化建设从二维空间扩展到了三维空间,为低碳节能城市的建 设发展提供了新思路,为改善城市环境,减少建筑能耗等方面做出了贡献。城市热环境的恶化 对城市空间使用以及城市建筑能耗都有显著负面影响:室外公共空间由于气温、辐射温度和风 速的变化造成城市微气候的变化,对使用者而言,热舒适度的降低将直接导致使用率下降,从 而影响城市空间活力和社会层面的可持续性;同时,室外气温升高将提升空调能耗;美国环境 保护署(EPA)的研究表明,夏季气温每升高 1oF(0.6oC)导致用电峰值荷载上升 1.5%~2% (U.S Environmental Protection Agency (EPA), 2012)。因此,改善城市热环境对建筑节能和提高城市 空间利用率、倡导健康的户外生活方式都有重要意义。

2. 立体绿化建设能带来的好处

 生态效益,包括降温增湿、缓和周边小气候、缓解热岛效应,改善城市空气质量, 创降低噪音,造城市内的生物生息空间,以及保证特定范围内居住环境的生态平衡 3 个方面;

2) 经济效益,包括保护建筑物、节省能源和具有储水功能 3 个方面;

3) 社会效益,包括合理利用和分配城市上层空间,美化城市高层建筑周围环境, 创造与周围环境协调的城市景观,软化硬质建筑线条给人带来的烦躁感,使城市更自然、更人 性化,以及为人们开拓更多的休闲空间。(黄志贵,2018)

但是在全世界没有一家权威的立体绿化研究机构。正如一家顶级设计公司的景观设 计师所言,"立体绿化在业内是一个很时尚、很热门的话题,但是问题的关键是,除了在杂志 上偶尔看到过立体绿化在案例之外,我们对其所知甚少"。并且立体绿化应用没有统一的权威 的标准、规范。基本上都属于"挂羊头,卖狗肉",简单的花盆摆放也称为立体绿化,应用比 较混乱,这样对行业的发展极为不利。

纵观国际外立体绿化研究,在理论上现有文献只有立体绿化的技术、养护,绿植选择等方面进行了研究,立体绿化对于环境绩效影响的原因没有进行动态关系分析。导致立体绿 化可以改变城市环境的重大作用理论支撑不足。



研究目的

立体绿化能对人和自然的关系产生一定影响,探讨和实施立体绿化,有助于充分利 用城市土地资源、节能减排、降低热岛效应、净化空气、维护城市生态平衡、提升居民生活水 平以及构建和谐社会,有利于城市实现可持续发展,从而提升城市管理绩效。

> 本研究基于 PSR 概念下构建立体绿化对城市环境优化的绩效评价体系验证其适用性。 **文献综述**

3. 基于 PSR 概念下立体绿化对城市环境优化的绩效评价体系构建

3.1 指标体系的构建原则

立体绿化城市的标准(目标)是定性的、抽象的描述,它区别于一切局部的、单 项的内容,充分体现了它的整体性、相关件和综合性。因此,有必要建立一套立体绿化城市发 展目标的具体指标体系,以便能进行定性定量的衡量、评价,构建评价的综合指标体系是其关 键。指标体系实际上是内若干指标构成的指标库,它能否准确、全面反映生态城市的内涵,指 标选择至关重要。因此在建立指标时要遵循五方面的原则:

1) 全面性与完整性相结合原则

城市的生态环境是一个有机联系的整体,某一地区的环境管理失效,可能 会给周边地区带来严重的生态环境问题。在对城市进行环境绩效时,在讲求社会效益和经济效 益统一的同时,要更加注重社会效益和生态效益。坚持经济效益、社会效益和生态效益三者的 相互结合,才能全面推进环境绩效的全面发展。除此之外,在构建环境绩效评价指标体系时, 要注重绩效与公平相结合。政府利用资源的效率与效果是绩效问题,不同主体的利益分配是公 平问题。

2) 简明性原则和可操作性原则

简明性原则是指选择具有代表性,能够准确清楚地反映问题的指标。由于 立体绿化城市环境绩效评价涉及的领域非常广泛,评价指标虽然要求多,但并不是越多越好。 如果多,资料难易获取,综合分析过程也很困难,同时也不能兼顾到实际应用上来,而且又大 大地增加了复杂性和冗余度。所选指标变量如果过少,就有可能不足以或不能充分代表立体绿 化城市的标准。所选指标的设置要有针对性地加以选择,每个指标的含义要求明确,代表特征 要求清楚,无互相交叉重叠现象。

可操作性原则是指环境绩效评价标准必须简明、具体、易懂,便于评价人 员进行分析,易于判断被评价对象绩效的好坏,有利于信息使用者的理解。此外,评价标准还 应充分考虑客观因素,并从实际情况出发,对被评价单位的可控制因素进行评价。

3) 定性分析与定量分析相结合的原则

环境绩效包括经济效益、社会效益和生态环境效益等多个不同层面。经济 效益和绝大数的生态环境效益可以借助数学模型进行定量分析,但社会效益和少数生态环境效 益因其特殊的性质很难进行数量上的计算与分析。所以,在对立体绿化城市进行环境绩效评价 中,对环境绩效的评价必须采用定量分析与定性分析相结合的方式来进行。

4)科学性和规范性

评价指标建立要建立在科学分析的基础上,能够客观地反映立体绿化城市 的最本质特征和它的复杂性,能反映生态城市的质量水平、每个指标必须概念清晰,科学涵义 明确,指标之间既要有内在联系,又要避免重复。指标的选择应遵循使用国际公认、常见的指 标及计算方法或单位的原则,指标符合相应的国际相关规范、标准要求,避免使用不常用、难 于统汁的指标,使指标标准化、规范化,易于在实际中找到适当的代表值,并使数据资料易得、



计算方法简单,也便于横向、纵向比较。

3.2 立体绿化对城市环境优化的绩效评价体系的构建

3.2.1 PSR 模型内涵

为了更有效地筛选可以清晰反应立体绿化对城市环境污染治理中社会、 自然和经济有影响的逻辑因素指标,研究将依据更权威且有针对性的方法构建环境绩效评价体 系中的指标体系。

PSR 评价体系模型使用"压力一状态一响应"(Pressure-State-Response) 思维逻辑,由加拿大统计学家 Rapport 与 Friend 首次提出(1979)。从指标产生机理方面构建 指标评价体系,充分体现了环境可持续发展调控过程中,人类与环境的相互影响、相互作用的 关系,广泛地应用于环境资源指标体系研究中,成为一种常见的成熟的环境评价模型。

PSR 模型概念框架是依据因果关系的逻辑基础将指标分为了三类,即压力指标、状态指标和响应指标。大自然为人类的生存与发展提供各种必需的资源,而由于人类活动过度的开采和消费导致自然界的资源储量与质量急剧下跌;同时生态环境的改变又会制约社会的发展,因而面对如此的改变,人们则会通过改变自己的行为意识来适应以上的变化。如此往复,人类与环境之间形成压力一状态一响应循环关系,其影响结构如图1所示。





来源:吴腾飞. (2018). 基于 psr 模型的大气污染治理绩效审计评价体系研究. 市场周刊(理论研究)(04), 124-125.

由图可知,压力、状态和响应三个独立层面包含人类活动对社会经济环境的具体影响因素,是为解决环境问题制定决策提供依据,满足政府对于环境污染治理、生态管理监测等问题的需求。

3.2.2 PSR 模型的适用性

PSR 模型框架适用于立体绿化对城市环境优化的绩效的评价体系的构建 是由其本身蕴含的意义本质所决定的,是为解决环境绩效问题所'量身定制'的模型框架。OECD 经合组织将环境问题大致概括为13个方面包含其废物、有毒污染、酸化、森林资源、气候变化、 臭氧层破坏、水资源、渔业资源、生物多样性与景观、沙漠化与侵蚀和其他不能归结为特定问 题等的环境问题。"经济合作与发展组织(简称经合组织)针对上述每一个环境问题,都归纳 了压力、状态、响应指标"(李春瑜,2016)。所以,压力一状态一响应(PSR)模型特别之 处在于可以识别人类活动对于生态环境施加的所有压力,而不仅局限于某层面活动带来的自然 资源污染问题。基于社会、自然生态环境状态的变化感知和对产生压力的人类活动之间的因果 逻辑关系,通过模型假设,采取适当的响应措施,预防压力产生的影响效果。所以,应用 PSR



模型(压力--状态-响应)的思维框架对指标进行不同层面的分类从而构建的框架评价体系, 具有较强的逻辑性与系统性,将该模型应用于立体绿化对城市环境优化绩效的评价体系的研究 具有一定的可行性和实际操作性。

3.3 指标体系构建思路

评价体系中的指标是指能够反映总体现象的具体数值和特定的概念,由指标名称和指标数值组成。指标表明研究对象在数值方面的科学概念,是质与量的结合与统一。依据不同的原则,将统计指标归为不同类型,本文主要采用描述性指标与评价性指标。

本节的整体思路大致如下,首先确立评价体系的总目标;其次,将指标依据压力、状态和响应三个层面进行分类;最后依据要素层的分类选取具体与立体绿化优化城市环境相关的指标,构建自上到下的级阶梯状结构的评价体系,详见图2立体绿化对城市环境优化的 绩效评价研究框架。



图 2: 立体绿化对城市环境优化的绩效评价研究框架

研究方法

4. 指标选取及评价体系构成

4.1 指标选取依据

环境绩效评价指标的选取要依据法律法规,结合环境特点,国家、国情,社会 经济特以及环境状况等具体情况具体分析。在保证指标数据的可获得性前提下,多角度、多层 次全方位的对指标内容进行选取。(刘丽敏等,2007)

1)国际标准 ISO14031 · ·

在设置环境绩效评价指标体系时应以国际通用标准作为对标。ISO14031 是 国际标准化组织(ISO)关于 ISO14000 的进一步深化发展。国际标准化组织(ISO)不仅是国 际标准化领域中一个十分重要的组织,也是一个全球性的非政府组织。ISO14000 的推出主要借 鉴了在同年欧盟发起的一个用于企业和其他组织进行评估、报告和促进其环境绩效的管理工具, 可以真实地报告其可持续活动的工具 EMAS(Eco-Management and Audit),以及英国在 1992



年提出的致力于改善环境状况的 BS 7750 (Britain Standard 7750)标准(孟志华, 2011)。其共同 目的是为了改善环境,规范组织的环境管理操作,并使环境绩效评价有据可依。·

根据 ISO14031: 2013《环境管理环境绩效评价指南》指出: "对不同地区 国家的环境状况信息进行反馈是环境状况指标的一个特性;指标涵盖的内容与范围会随着时间、 空间的转移而改变; 也会因为多样性的环境类别而具有可以反映能力或者利益相关影响因素的 功能"(黄进, 2015)。

2) 可持续发展指标体系.

1996 年,由联合国政策协调和可持续发展部(Department for Policy Coordination and Sustainable Development, DPCSD)与联合国可持续发展委员会(Commission Sustainable Development, CSD)主办会议上,结合"社会、环境、经济与组织机构"概念模型、《21世纪议程》核心章节内容和 PSR 概念框架共同建立了核心指标的可持续发展的框架 雏形。

联合国统计局(UNSTAT)针对联合国的"建立环境统计的框架"加以修改,不以传统的划分标准为主,而是根据《21世纪议程》章节主题内容分类成可持续发展指标框架(Framework for Indicators of Sustainable Development, FISD)框架(Badrinath, S. D.& Raman, N. S., 1995)。

此外,国际上经合组织 OECD 设定的指标体系以及英国等国际上现有的指标评价体系应用也较为广泛。

4.2 评价体系构成

本文基于 PSR 概念框架的原理对投入产出指标的要求,严格遵循评价指标的 选取原则,较为充分的整理了国内外较为成熟的评价标准体系,以国外较为成熟的环境绩效评 价指标体系为参照,并基于中国国情主要参考和借鉴了中国政策和学者的研究成果,结合研究 区域的特点及立体绿化特征,建立了立体绿化对城市环境优化的绩效评价指标体系。指标的筛 选过程如下:

1) 压力指标

该类型指标主要反映人类的哪些经济活动对大气环境产生压力以及压力程度。设置的指标包括两部分:一部分是反映与大气污染有关的经济发展及资源利用状况的指标。由于大气污染的产生与区域人均 GDP 水平、工业类型及工业化程度以及能源利用率等方面有着紧密的联系(魏巍贤等,2015),因此设置的指标包括人均 GDP、第二产业产值比重、单位 GDP 能耗。另一部分是更直观地反映污染物排放情况及经济发展"绿色程度"的指标,主要包括单位 GDP 二氧化硫排放量、单位 GDP 氮氧化物排放量、单位 GDP 烟(粉)尘排放量。

2) 状态指标

该类型指标主要反映空气质量状况及立体绿化对居民的工作环境及生活改善程度。由于空气质量状况可以直接通过监测污染物的种类以及污染的严重程度予以反映,因此在设置该部分指标时参考了我国的《空气质量标准》(陈涛等,2019)。居民的工作环境及生活改善程度可以通过问卷调查、走访等方式获得相关数据。相关指标主要包括单位空间可吸入颗粒物(PM10)浓度、单位空间细颗粒物(PM2.5)浓度等空气质量指标以及居民工作环境及生活改善满意度、居民空气质量满意度。

3) 响应指标

在响应指标体系下,本文将环境治理投资占 GDP 比重和工业废气治理费用 纳人二级指标体系中。在 2013 年,国务院印发《大气污染防治行动计划》中明确了未来五年大



气污染的治理目标,明确规定了工业废气排放的消减目标。本文在大气污染的响应指标体系中,纳人工业废气治理费用来衡量其响应和努力的程度,并纳人环境治理投资占 GDP 比,以考察地方对环境的重视程度(樊博等,2017)。

	准则层	指标层
	压力指标	X1 人均 GDP
		X2 第二产业产值比重
		X3 单位 GDP 能耗
		X4 单位 GDP 二氧化硫排放量
		X5 单位 GDP 氮氧化物排放量
立体得化对城市环境优化的建筑亚价		X6 单位 GDP 烟(粉)尘排放量
立冲球化对弧印环境优化的须双片仍	状态指标	X7 单位空间可吸入颗粒物(PM10)浓度
		X8 单位空间细颗粒物(PM _{2.5})浓度
		X9 居民工作环境及生活改善满意度
		X10 居民空气质量满意度
	响应指标	X11 环境治理投资占 GDP 比重
		X12 工业废气冶理费用

表1: 评价体系层级构建

研究结果

5. 研究设计

5.1 指标合理性分析

本文通过对调查问卷(附件 1)的完善,对比分析各项数据发现其中存在 3 个 潜变量,12 个测量题项。由此可以推出本次发放的调查问卷中有 60 份之上可以被收回,如果 不能保证收回的调查问卷在 60 份以上,那么研究得出的结果可靠性就会降低,所以本次发放调 查问卷共计 200 份,完全可以保证收回的有效调查问卷在 60 份以上,确保研究数据的客观真实, 研究结果的合理科学。本研究在回收问卷时进行初步整理,将作答规律明显或缺失项过多的问 卷视作无效的问卷进行剔除,有效的问卷共计 188 份,有效回收率为 94%,数量达到了要求。

样本具有的特征分析。通过对数据的整理收集,完成立体绿化城市环境绩效评 价一级指标之间的关系,完善现有的研究体系,筛选出代表性的指标作为调查问卷的设置元素, 设置数值代表对观点的认可程度,数值从小打到依次排列,调查结果均值达到平均数 3.0 以上 表示研究具有意义。表 2 说明 12 个测量题项的均值都在 3.0 以上,说明样本的研究对象具有意 义,得到调查对象的认同。



	个案数	最小值	最大值	平均值	标准差
Q1	188	2.00	5.00	3.2979	.60884
Q2	188	1.00	5.00	3.2074	.68173
Q3	188	2.00	5.00	3.3936	.68939
Q4	188	2.00	5.00	3.3936	.75598
Q5	188	1.00	5.00	3.3670	.81324
Q6	188	1.00	5.00	3.1489	.85227
Q7	188	2.00	5.00	3.3085	.81466
Q8	188	2.00	5.00	3.3989	.71306
Q9	188	2.00	5.00	3.3138	.81590
Q10	188	2.00	5.00	3.3830	.71060
Q11	188	2.00	5.00	3.5266	.91004
Q12	188	2.00	5.00	3.4681	.82348
有效个案数(成列)	188				

表 2: 描述统计

指标的信度分析本文采用 SPSS2 软件进行计算,主要来说明设计的指标是否具 有可靠性和稳定性。指标的信度分析,主要来说明设计的指标是否具有可靠性和稳定性。管理 学中一般采用 Cronbach Alpha 系数 α 进行检验, α 系数在 0-1 之间进行变化,一般而言, α 大于 0.6,则指标的信度是可以接受的,总的来说, α 越接近于 1,那么就表明该指标题项的可信度 越高。因此,本研究中的各个指标的克隆巴赫系数值如表 3 所示。

表 3: 各个指标的信度分析

	删除项后的标	删除项后的	修正后的项与	删除项后的克隆	各个二级指标克	整体克隆巴
	度平均值	标度方差	总计相关性	巴赫 Alpha	隆巴赫 Alpha	赫 Alpha
X1	37.4300	28.106	.418	.802	.831	.811
X2	37.4800	28.030	.355	.806		
X3	37.2900	28.390	.314	.809		
X4	37.2100	25.642	.565	.788		
X5	37.1500	27.098	.480	.796		
X6	37.1300	26.074	.544	.790		
X7	37.5900	27.093	.416	.801	.747	
X8	37.5900	26.123	.493	.795		
X9	37.5000	26.596	.453	.798		
X10	37.6600	25.277	.518	.792		
X11	37.5000	26.273	.443	.800	.874	
X12	37.6000	25.636	.510	.793		



数据分析结果显示,总体信度为 0.811,说明该指标体系具有较高的可信度,可以进行下一步的研究。

5.2 问卷效度分析

效度常用来表示结果的准确性或者测量结果的科学性和合理性。所以效度系数 的大小关系到研究的价值,所以这里将效度系数设为较大值。

研究中的 KMO 样本测度和 Bartlett 球形检验如表 4-3 所示。

表 4: KMO 和巴特利特检验

KMO 取样适切性量数	(o	.612
巴特利特球形度检验	近似卡方	1404.476
	自由度	66
	显著性	.000

根据上述分析得出, KMO 样本测度数值为 0.612, 同时在 Bartlett 球形检验中的数值显示为 0.000, 说明通过 Bartlett 球形检验。所以得出结论且可以进行探索性因子分析, 首先提取研究所需的公因子,接着对提取的因子进行正交旋转处理,获取因子负荷矩阵,通过 对表格数据的对比分析得出只有测度项与对应因子的相关度在 0.5 以上,是符合研究条件的。

	初始特征值		提取载荷平方和			巅	旋转载荷平方和		
成分	总计	方差百分比	累积 %	总计	方差百分比	累积 %	总计	方差百分比	累积 %
1	4.215	35.129	35.129	4.215	35.129	35.129	3.148	26.233	26.233
2	2.314	19.285	54.414	2.314	19.285	54.414	2.920	24.334	50.566
3	1.290	10.754	65.168	1.290	10.754	65.168	1.752	14.602	65.168
4	.978	8.153	73.321						
5	.897	7.471	80.792						
6	.677	5.642	86.434						
7	.554	4.620	91.053						
8	.383	3.193	94.246						
9	.298	2.482	96.727						
10	.217	1.807	98.534						
11	.146	1.216	99.750						
12	.030	.250	100.000						
提取方法	去: 主成分	·分析法。							

表 5: 总方差解释

从表 5 可见,大于 1 的特征值共有 3 个,也就是说 12 个指标中共包含 3 个公共 因子。累计方差贡献率达到 65.168%,即原始变量中的 65.168%保存在了该主成因模型中,同 时 3 个公共因子的特征值>1。由此可见,选取这 3 个因子的方式是可行的。但是初始荷载矩阵



中 3 个公共因子的典型代表变量并非都很突出,没有达到对因子很好的解释,因此对因子荷载 矩阵进行旋转是非常具有必要性的。旋转后的荷载值显示 3 个公共因子对系统的方差贡献率分 别达到了 35.129%、19.285%、10.754%,累计平方和载入仍然为 65.168%。



图1: 碎石图

		成分	
	1	2	3
Q1	.639	.126	.206
Q2	.714	.056	.251
Q3	.601	.168	.294
Q4	.767	.016	133
Q5	.788	103	.215
Q6	.699	.368	047
Q7	.197	.890	064
Q8	.044	.723	.449
Q9	.137	.887	083
Q10	036	.745	.427
Q11	.113	.252	.758
Q12	.315	089	.724
提取方法: 主成分分	分析法。		
旋转方法:凯撒正	态化最大方差法。		
a. 旋转在 6 次迭代	后已收敛。		

表 6: 旋转后的成分矩阵 ª



通过以上分析可以得出:根据因子分析法的解释总方差和碎石图可以判定应将 12个指标分为3个。3个变量的各个测量题项的因子负荷都达到0.5以上,故保留这些测量题 项。通过以上探索性因子分析,可知问卷结构良好。

总结

立体绿化对未来城市环境有独特的优化作用,在城市环境优化评价过程中,绩效评价是 重要环节,通过进行绩效评价总结性的说明环境绩效的优劣,科学完整的评价体系是开展城市 环境绩效评价的基础,直接关系到绩效评价活动的实质开展(房巧玲等,2010)。

讨论

建立立体绿化对城市环境的绩效评价体系验证合理性后,应进一步研究其指标赋权,确 定权重,完善其评分体系,构建完整的立体绿化对城市环境优化的绩效评价体系,为立体绿化 产业的发展提出有效建议。

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附件1

立体绿化对城市环境优化的绩效评价研究调查问卷

尊敬的女士/先生:

您好,衷心感谢您在百忙之中参加本次问卷调查。该调查问卷的目的是对立体绿化对城 市环境优化的绩效评价研究并提供参考、启示及建议。特借此问卷获取您的宝贵意见,您填写 的内容将只用于学术研究,不会用于个案分析。我们将会对您提供的数据信息予以严格保密! 敬请放心填写。

此次问卷将占用您宝贵的几分钟时间,请您放心并尽可能客观作答。您对问题的真实客 观回答将对我们的数据分析与研究结论产生重要的影响。因此,诚请您根据您所在企业的实际 情况和自身真实感受逐项回答下列问题,同时对您的支持表示感谢。

第一部分 基本信息

-1-		
1.	您的性别:	
2.	您的学历:	
	A. 本科及以下	B. 研究生及以上
3.	被访者任职年数()	
	A. <3 年	B. >3 年
4.	职务()	
	A. 工作人员	B. 管理人员

第二部分 立体绿化对城市环境优化的绩效评价指标

(填写说明:以下的各个题项是对立体绿化对城市环境优化的绩效评价研究各指标的描述,请您根据各个题项的要求及您所在单位的实际情况,选出对应的选项,并打"√"。其中 1-5 依次表示被调研对象对立体绿化对城市环境优化的绩效指标评价的真实感受由非常不同意 向非常同意过渡)

1.	您是否认为人均	GDP 可以影响	成市环境优化	的绩效	
	○ 非常不同意	○ 不同意	○ 適中	○ 同意	○ 非常同意
2.	您是否认为第二产	^亡 业产值比重可	以影响城市环	下境优化的绩效	
	○ 非常不同意	○ 不同意	○ 適中	○ 同意	○ 非常同意
3.	您是否认为单位	GDP 能耗可以影	影响城市环境	优化的绩效	
	○ 非常不同意	○ 不同意	○ 適中	○ 同意	○ 非常同意
4.	您是否认为单位	GDP 二氧化硫	非放量可以影	响城市环境优化	的绩效
	○ 非常不同意	〇 不同意	○ 適中	○ 同意	○ 非常同意
5.	您是否认为单位	GDP 氮氧化物	非放量可以影	响城市环境优化	的绩效
	○ 非常不同意	〇 不同意	○ 適中	○ 同意	○ 非常同意
6.	您是否认为单位	GDP 烟(粉)尘排	İ放量可以影响	向城市环境优化的	的绩效
	○ 非常不同意	〇 不同意	○ 適中	○ 同意	○ 非常同意
7.	您是否认为单位。	它间可吸入颗粒	物(PM10)浓度	度可以影响城市理	不境优化的绩效
	○ 非常不同意	〇 不同意	○ 適中	○ 同意	○ 非常同意
8.	您是否认为单位。	空间细颗粒物(P	M2.5)浓度可	以影响城市环境	优化的绩效
	○ 非常不同意	○ 不同意	○ 適中	○ 同意	○ 非常同意



9.	您是否认为居民工作环境及生活改善满意度可以影响城市环境优化的绩效					
	○ 非常不同意	〇 不同意	○ 適中	○ 同意	○ 非常同意	
10.	您是否认为居民空	气质量满意度可	可以影响城市环	境优化的绩效		
	○ 非常不同意	〇 不同意	○ 適中	〇 同意	〇 非常同意	
11.	您是否认为环境冶	理投资占 GDP	比重可以影响却	成市环境优化的	绩效	
	○ 非常不同意	〇 不同意	○ 適中	〇 同意	○ 非常同意	
12.	您是否认为工业废	气冶理费用可以	以影响城市环境	优化的绩效		
	○ 非常不同意	〇 不同意	○ 適中	〇 同意	○ 非常同意	