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Research paper

Aedes Breeding Habitat Localization System

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Abstract

One of the main health issues Malaysia faced is dengue disease that is transmitted via Aedes mosquitos. The most prominence area of dengue cases in Malaysia is in urban area with construction site area reported the most. Till today, prevention and controlling methods are the only solution in combatting Aedes and dengue outbreak. The current aedes prevention approach via search and destroy involves manual searching of potential Aedes breeding habitat. The objective of this project is to develop an IoT based system called as the Aedes Breeding Habitat Localization System to locate watery areas, collect data and analyze data to improve understanding on potential Aedes breeding areas. The iterative and incremental prototyping approach has been used to develop prototype called ABLD. Also, an experiment for precision testing has been conducted to validate the system. Results found that time for data collection has been reduced tremendously and the collected data assist the health agencies improving data analytical process forecasting pattern and preventing future dengue outbreak.

Keywords: *Data mining, dengue disease, IoT, sensor.*

1. Introduction

Nowadays, dengue outbreak is very common in our society. The virus has shown increasing number of cases and has been a problem too many countries. As stated by [1], dengue virus contains flu-like disease that is transmit by female mosquitoes mainly the Aedes aegypti and Aedes albopictus. [2] stated that Aedes aegypti mosquito has been found to prefer urban habitats and breed in containers with stagnant water. Dengue usually occurs in tropical countries, where rainfall and temperature suit them. [3] suggested that analysis of three climatic factors such as rainfall, temperature and relative humidity were very important as these factors could affect the mosquito breeding activities. The amount of cases each year increases for every tropical country and serious action must be taken to prevent it. Emerging technologies in this current era has seen device application that are able to help our environment and community. Devices with the use of sensor helps us to gather data and meaningful information. Data collected such as humidity and temperature enable data analytical process to search for water present effectively and also to prevent and forecast future Aedes outbreak.

Therefore, the objective of this paper is to present an IOT based-project called AXIS that is developed to assist in the process of locating watery areas that leads to Aedes breeding ground.

The system consists of two modules: 1) AXIS - an IoT technology device as the localization device to locate potential watery area and collect all data; 2) Aedes Breeding Habitat Localization (ABHL) application system which is the mobile application with online software dashboard for data analytics.

1.1. Overview of Dengue Situation in Malaysia

Increasing number of dengue cases are reported every year [4] due to transmission from Aedes aegypti and Aedes albopictus and other factors [5]. The occurring of dengue is a worrying sign for a tropical country such as Malaysia particularly. These diseases cause Dengue Fever (DF) and Dengue Haemorrhagic Fever (DHF). A disease which causes one's body to feel pain such as joint, headache and even internal bleeding. According to [6], through the 51st week of 2016, Malaysia has reported a total of 100,028 dengue cases and 231 deaths. While as of June 2017, the number of dengue cases has increase significantly. The Crisis Preparedness Response Centre (CPRC) who are responsible in coordinating, monitoring and analyzing dengue outbreak and prevention, claims that for week 28 from 9th July 2017 to 15th July 2017 has shown an increase number or cases from the following weeks. An increase of 4.5% compared to week 27, (Figure 1). [7] has reported that as of week 28 for the year 2017, the number of dengue cases has total up to 48,092 cases with 107 deaths nationwide.

In Malaysia, the effort provided from various organization and government agencies included awareness campaign, search and destroy, fogging and visit from one house to another. Among the government agencies involves is the Crisis Preparedness and Response Centre (CPRC) which was founded under the 9th

Malaysia Plan (2005-2010) [8] as an effort to structure and organize management for disasters, outbreak, crisis or emergencies (DOCE) related to health issues.

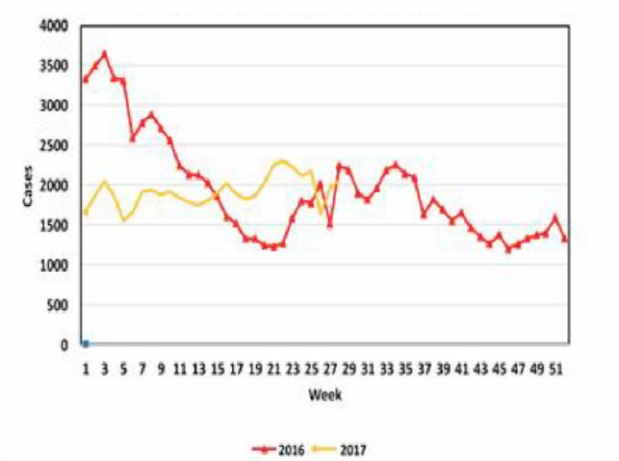

Fig. 1: Trend of Weekly Dengue Cases in Malaysia 2016 and 2017, Department of Health, Malaysia

Rapid industrial and economic development over the last two decades has brought massive infrastructure development and a very active construction sector for housing and commercial development, creating many manmade equipment, containers and tools which favors for Aedes mosquitoes as their breeding spot. It is identified that urban areas contribute to Aedes breeding ground are construction site and factories. These places contribute a significant percentage of Aedes breeding habitat totaling 14.4%. The reason for construction site being a concern is that they tend to provide the perfect condition for Aedes to breed, stagnant water areas in containers, barrels, leaking pipe source and others.

1.2. Big Data in Healthcare Industry

Information technology are now seen in every sector and has contribute in various industries. Among the changing sector that has drastically improved from the use of technology is the healthcare industry. The changing landscape of healthcare industry from technology is mainly from collecting large amount of data. These data help doctors and researchers to understand the situation of a problem better. They help to provide them with the ability to come out with curing diseases, analyses and predict epidemics, and improved life quality, and even avoid death. In the healthcare industry, the use of technology such as Big Data has help improve healthcare quality significantly. Modern healthcare agencies nowadays are provided with healthcare system that can manipulate data into meaningful information.

Through integration of cloud-based data and healthcare software, millions of patient's records can be access and identify patients that needs treatment and appointments. Another benefit from big data is the ability to have access of real-time patient data. Medical professionals are able to give more proactive care to their patients by continually checking and understanding real-time occurrences and vital signs. Large volume of electronic health data a recorded to monitor of patient's status. The information from these different screens can be analyzed in real time and alert patients, caretakers and medical professionals so that they are aware right away about changes in a patient's condition. Remotely monitor patients as well as interacting with the patient is made possible with such technology.

1.3. Predictive Analytics in Healthcare

Technology such as Data Mining, Data Warehouse and Big Data are all used to helps businesses identify patterns and analyze medical information needed. One of the application of business intelligence applied in healthcare is prevention of outbreak by forecasting potential areas of disease. Health related agencies, with analysing software can manipulate large volume of data to identify possibility where outbreak disease may occur next. Analysing the data to identify these kinds of patterns requires techniques and method of implementation. [9] stated that predictive analytics will help to enable detecting diseases at earlier stage and treatment can be done effectively, managing and detecting health care fraud more quickly and efficiently. In these day and age, the process of identifying manually outbreak areas a shifted towards computerize technology and locating future outbreak areas are done with the used of complex algorithms and advance technology. The computerize process to identify patterns for an outbreak involves algorithms are done with large amount of data collected. Data are crucial to future predict and prevent outbreaks of diseases. Among outbreak cases that uses the application of Business Intelligence is dengue prevention from Aedes mosquitoes.

1.4. Environmental Sensors in Our Daily Lives

Technology are now seen everywhere and are being implemented in our daily lives to continuously improve our quality of life. As we reach the era of advance technology, technology nowadays enable us to monitor surrounding environment and allow us to predict natural disasters, prevent diseases, provide health information and many others. Typically, this information is provided by sensors that collect surrounding environment data around us. A sensor device uses a small computer board powered by a power source, which connects to assortment of sensors for different kind of input data, such as light, temperature, humidity, shock, optical and many others. As for Malaysia, the healthcare sector deals with countless of disease cases, particularly on dengue. Increasing number of dengue cases every year requires solution and effective prevention methods.

2. Methodology

This project employed the iterative and incremental model approach for its prototype development. The iterative and incremental model composed of seven (7) main phases, which are planning, requirement, implementation, testing, evaluation, iteration release and deployment as shown in Figure 2.

Each phase helps the project to identify objectives and distribute tasks ensuring better result for the project. Each iteration function will undergo requirement, development, testing and evaluation. The reason for choosing the Iterative and incremental model is that is suits complex and huge amount of information that needs to be gathered. The Iterative and incremental model help to focus on each iteration to meet its goal. The model helps to continuously improved understanding, improve functionalities, speedup process and reduce paperwork.

Fig. 2: Iterative and incremental development model

Each iteration focuses on the functionalities and is later review by the stakeholders to meet requirements. This also means frequent amount of testing is done in agile manner. Frequent testing is done as per requirement on each iteration which helps reduce risk and time of testing in big bulk function of the system. For the ABHL system, there will be three iterations conducted which is based on the objectives of the project as shown in Table 1.

Table 1: Iteration Functionalities table

Iteration	Functionalities
1st iteration	On/off device, Connect Smartphone
2nd iteration	LED Indicator (Device), Search Area (Device display reading, Alert sound (Device),
3rd iteration	Display Reading output (Smartphone), Save Reading output (Smartphone)

An experiment approach also has been conducted to test and validate the precision level of the IoT device. The main aim of the experiment test was to identify the rate of evaporation change for the humidity and the temperature changes.

3. AHBD and AXIS Design

3.1. Hardware and Software

This section provides the details of the proposed design of the ABHL system as well as the AXIS device. As of hardware, Arduino Uno R3, LED 5mm Red/Green, AM2315, HC-05 Bluetooth module. Piezo Buzzer, LCD, Lenovo Tab3 7 Essential have been chosen to be used. Table 2 list all the hardware and its intended usage in developing AHBD system.
As of software, Arduino IDE 1.8.3, Android Studio, Power BI, Google sheets, Win Automation have been selected. In addition, Java nd C++ are the two programming languages used.

Table 2: Hardware and its usage in the ABHL system

Hardware	Description
Arduino Uno R3	The Arduino will be coded to provide instruction to the device sensors and electrical components to operate and function with specific instruction process.
Led 5mm	Indicate humidity and temperature for watery areas by
Red/Green	blinking and changing colors from green to red when the condition of a Aedes breeding habitat is located.
AM2315	Able to detect and collect humidity and temperature data and later by using complex algorithm formula and data mining techniques coded to analyze and identify watery areas.
HC-05 Bluetooth Module	Connect device to an android smartphone via Bluetooth and transfer data of temperature and humidity reading and other relevant data.
Piezo Buzzer (5V)	Produce a beep sound done by coding that alerts and notify user when the condition of a Aedes breeding habitat is located.
Basic 16x2 Character LCD	Display the reading of temperature and humidity obtain from the sensors.
Lenovo Tab3 7 Essential	Connect to the device, develop and install mobile application and display reading.

3.2. ABHL System Architecture

The following Figure 3 shows the overall architecture of the ABHL system and the AXIS device and ABHL apps in a construction site area. The AXIS device will be turn on, to enable sensors to detect the humidity and temperature of the surrounding areas. The AXIS will use complex algorithm to determine and identify possible wet areas for Aedes to breed. The device will then alert user with beep sound and blinking LED and a display message when the area meets the condition for Aedes to breed. The device also can be connected to a smartphone via Bluetooth through ABHL app to provide dashboard data to view, analyze and display reading, with an option to also store the data.

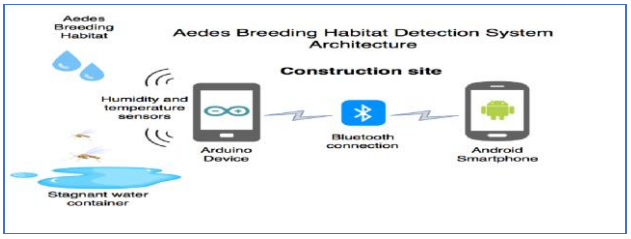

Fig. 3: ABHL System Architecture

3.3. System Flow

The activity diagram had been developed to demonstrate the system flow of the ABHL and AXIS clearly. As shown in Figure 4, the process includes three swim lanes that represents the safety officer or inspector, construction site and smartphone. The process starts when the safety officers turn on the AXIS device. The safety officer will then connect the AXIS device to the smartphone (ABHL app). Upon successful connection with the device AXIS, the device is able to search area for watery areas and display reading on both the device and the smartphone application. The safety officer will have the option able to save the reading display. If condition is met for watery areas, a buzzer sound and LED will blink to indicate watery areas in that area. The device is then turn of when is not in used.

3.4. Comparison of Current Localization System vs ABHL System

In view to identify the effectiveness of the AXIS system compared to the current process of Aedes prevention, a comparative study is done. The study helps to compare the current method of Aedes prevention and control and the AXIS system by comparing the time taken, effectiveness and limitation of each method. The following Table 3 presents the comparison between the two methods of Dengue prevention, Search and Destroy (manually) and the ABHL System.

Table 3: Comparative study between current approach with ABHL system

Comparison	Search and Destroy	Aedes Breeding Habitat Localization (ABHL) System
Description	Locate and eliminate Aedes breeding ground by searching manually with community effort.	Helps to locate Aedes breeding ground area by sound notification and LED alert indicator when watery areas presences detected using sensors.
Time taken	The process to locate watery areas for Aedes breeding ground is time consuming as each surrounding area needs to be manually search.	The time taken is locate watery areas that are potential for Aedes breeding ground is quickly located with the help of using by sensors.
Effectiveness	Effective in large group and commitment.	Provide instantaneous alert, notification though sound and blink indication.
Limitation	Needs large number of people and community involvement to locate Aedes breeding ground.	Rely on power source to power the device, and the device price is costly.

The Search and Destroy controlling method is a campaign initiated by government and health agencies with the aimed to archive zero dengue cases in city areas. The campaign usually involves community engagement as to locate manually their residential areas for watery areas for Aedes breeding habitat. According to Parkash and Shueb (2015), this method is done in a top-down approach where people were instructed on how to prevent mosquitoes from breeding in and around their home and thousands of inspectors were sent to check individual house holds, and enforce the anti-mosquito breeding laws. While the AXIS device is an automated locator process which helps to locate areas, which suits Aedes breeding condition though the use of sensors and hardware component. In terms of the time taken, the manual process involves long time period and commitment to eliminate Aedes breeding areas, while the AXIS device can improve the time to locate it. The effectiveness of the Search and Destroy method relies on manpower and commitment. The automated process using the device will provide much real-time indicator and notification when a watery area is located. The drawback of the manual method is that large number of people and effort is needed to identify Aedes breeding areas. On the other hand, the automated method ABHL system rely on a power source and the device is costly to be implemented.

4. Result and Discussion

The prototype of the AXIS device was developed for detecting water presence nearby the radius of the device. For the experiment, the setup will consist of the device AXIS, water tray, water, stopwatch. The experiment conducted was done at an open environment to stimulate a construction site scenarios. For validation purpose, the experiment was conducted at two (2) distinct locations with different date and time, weather condition, with variable distance of AXIS device to water source and also evaporation time. A test case was produced to report the test result.

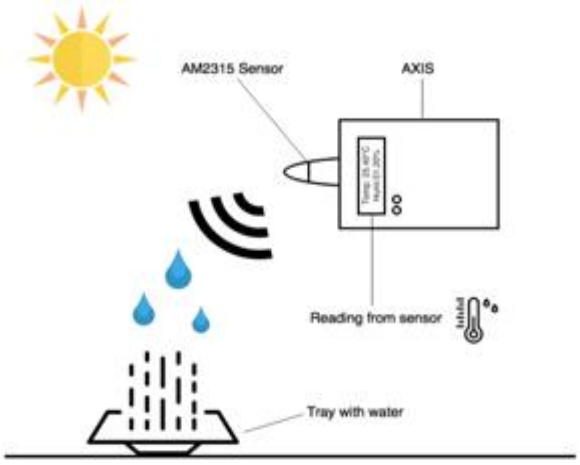

Fig. 5: Illustration of conducted experiment

Figure 5 presents the illustration of the conducted experiment. The purpose of this experiment test is to identify the rate of evaporation B. Test 2 Result – Ipoh (Cloudy) change for the humidity and temperature changes once water is presence in a sunny temperature condition (Seri Iskandar) and cloudy condition (Ipoh). The precision testing of data collected from the AM2315 Sensor is determine. All the experiment was conducted at an open area. The experiment will use 200ml distill water. While the AXIS device distance between the water will be between 0.5 to 1.5-meter range.

4.1. Test 1 Result – Seri Iskandar (Sunny Weather)

The graph as shown in Figure 6 shows that the rate of humidity change is significant and increase in all of the time duration given. The duration for the one (1) minute experience the highest change of value as it is expose the longest towards the water tray.

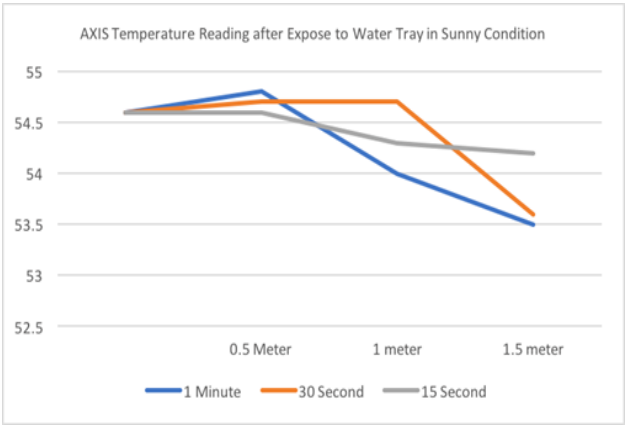

Fig. 6: Comparison between duration and distance on temperature on a sunny day

The following graph shows that the rate of humidity change is significant and increase in all of the time duration given. The duration for the one (1) minute experience the highest change of value as it is expose the longest towards the water tray.

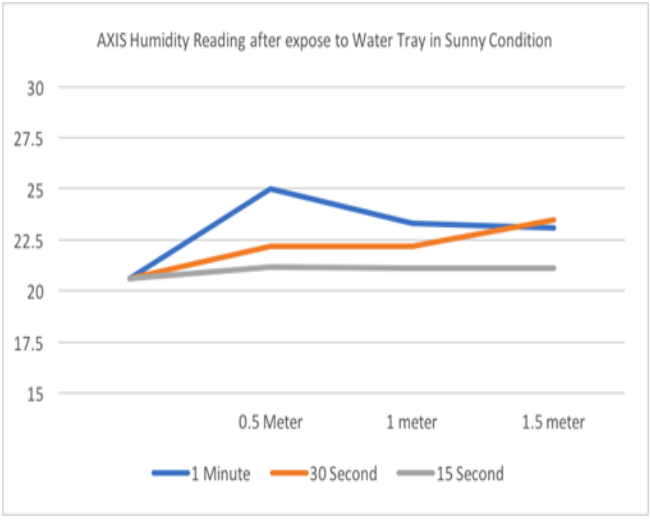

Fig. 7: Comparison between duration and distance on humanity on a sunny day

From test 1, it has been found out that the rate of evaporation for the water tray, increase drastically when the water tray is at a sunny and hot condition with high temperature. The rate of evaporation increases substantially rapidly increasing the humidity value. However, the temperature value fluctuates normally, without any change of value despite the water presence.

4.2. Test 2 Result – Ipoh (Cloudy)

The following graph shows that the rate of temperature change is significant increase only at a shorter distance which is 0.5 meter. The other range shows decrease value in all time period the device is expose towards the water tray.

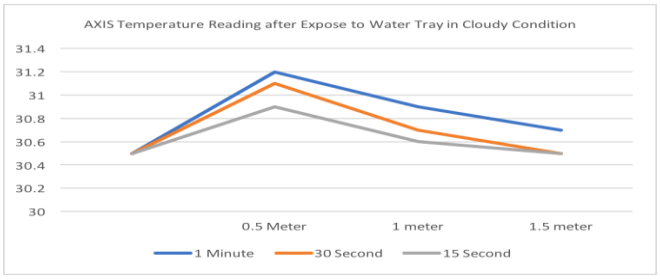

Fig. 9: Comparison between duration and distance on humanity on a cloudy day

The graph above shows that the rate of humidity change is increase significant only at a shorter distance which is 0.5 meter. The humidity value is only seen to be increased rapidly at shorter ranger while the remaining distance shows decrease and reading value.
From test 2, it has been found out that the rate of evaporation for the water tray is slow. When the water tray is at a cloudy and breezing condition. The rate of evaporation increases the temperature and humidity value when the AXIS device is being place at a shorter distance of 0.5 meter. Additionally, the temperature value and humidity values decrease when the AXIS device is place further the then 0.5 meter. This shows the that the high temperature condition effects humidity value and the rapid or drastic change that can be seen when a water is presence.

5. Power BI

All the gather data will be transferred from AXIS to the connected smartphone via the ABHL mobile app. The data gathered will then be stored into an excel file and send into Power BI for analytical purposes. The ABHL sensor data retrieve from the excel file and uploaded form the excel sheet will be able to display graphical charts and dashboards with meaningful data that will help data analyst, healthcare agencies and experts to prevent and forecast future Aedes Outbreak.

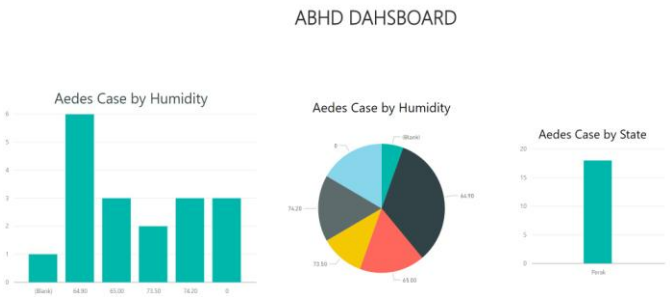

Fig. 10: ABHL dashboard using Power BI

6. Conclusion and Future Works

The AXIS together with the ABHL will prove crucial in combating Aedes Outbreak especially in tropical countries such as Malaysia. The ability to locate watery areas much faster and data collection will be beneficial to improve understanding on the effects of temperature and humidity plays in Aedes prevention. The significant advantage AXIS provides is locating watery areas in terms of the time taken compared to locating it by manually searching watery areas. AXIS can be used by construction workers, safety officers and relevant health environment agencies, government agencies to stop Aedes from breeding by identifying possible Aedes breeding places easily with the use of AXIS. It can also improve the rate of success in locating Aedes breeding ground as well as reducing the millions of costs need to spend on combating Aedes that the government in currently doing. This also help construction site developers to improve their approach efficiently so that they will be more engaging together in the effort to combat Aedes as well as avoid them from being compound due to legislation offences. Furthermore, the data obtain from AXIS, together with the ABHL system can be used by health agencies to improve the data analytical process and forecast and prevent future outbreak. The ABHL app and Power BI dashboard will provide reports and statistic that are significant and can help determine an Aedes Outbreak.
The further improvement and recommendation of the AXIS prototype is to improve in terms of its accuracy. To improve that, the use of an additional sensor which is an Infrared Thermal Camera will be equip to the AXIS. This will help to identify and display contrast values between high temperature and humidity with low temperature and humidity, thus further improving accuracy.

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