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# Web-Based Augmented Reality Mobile GIS for Disease Prevention and Control Programme

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**Abstract**

Abstract: This paper designs and develops a Malaysian geospatial dengue information sys-tem (MyGeoDIS) in Selangor using augmented reality and mobile web GIS technology towards enhancing the existing analytical functions and data management of dengue outbreak monitoring programme. The method utilised three stages to create the system, namely system design, system development, system testing and application. Datasets of local users' opinion, topographic map, contour, land use, rainfall, population, and dengue cases were collected ethically and pro-cessed using ArcGIS, QGIS, MapGuide, 000webhost and Wikitude. This pro-posed system has demonstrated common elements and functions of a beneficial disease information system according to the local health requirements. Start Window of the system offers both of authorised user or public user for ethically ac-cessing the system. The authorised user could manipulate the system for conducting spatial analysis. This interactive system also provides Home Window, Map Window, Management Window, Analysis Window, Sharing Window and General Info Window for a systematic guideline especially for non-geospatial back-ground users. The system is facilitated with a mobile-virtual reality apps for dis-playing real situations of the hotspots. This unique disease control prototype has been established with a minimal cost and an integrated geospatial capability including the data input, processing, management, analysis and information sharing geoinformation of the disease.

***Keywords:*** *Augmented Reality (AR), Dengue Disease, Mobile Apps, Web GIS, MyGeoDIS.*

## I. INTRODUCTION

Dengue is a vector disease caused by dengue viruses' serotypes which are transmitted to human by mosquito's dengue, Aedes aegypti species. The enormous number of dengue cases made it becomes the worldwide main problems. Reference [38], an estimated 50 million people are diseased with dengue and the quantity of cases will grow 100 million.

In Malaysia, dengue is one of the general health issues dependent on the cases number that it contributed every year [25]. The most influential Areas by dengue are the spots with fast urbanised region regions [4] such as Selangor, Johor, Melaka, Perak, Kuala Lumpur and Putrajaya where these states were recorded gigantic quantities of the cases. In 2013, an expected 43, 346 cases were analysed in 2012 only 21, 900 cases were accounted for the record. This shows to an expanding of 98% cases recorded in a year [30]

Geospatial technology plays main roles on monitoring of earth environmental condition to overcome this health problem, especially to improve the function of existing health information system. The technology such as geographical information

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system (GIS), Satellite remote sensing (RS) and global positioning system (GPS) can provide regional geoinformation and offer appropriate spatial analysis [42]. GIS is important tool as an information system to input, store, retrieve, manipulate, analyse and output geographically referenced data or spatial data.

Augmented reality (AR) technology is a significant tool that is a live direct or indirect view of a physical, real-world environment. AR enables users to collect the data of the objects of encompassing zones through telephone camera for thing such as café, Wi-Fi hot games, or houses available to be purchased. Despite the fact that the execution of AR innovation in the disease study is as yet not fully explored by re-searcher in dengue control programme, it can be used as geomapping system of dengue to disseminate the geoinformation to public for health awareness purpose.

These space-based technologies have great capacity to be incorporated with general disease applications because of its capability to integrate with spatial ecological issues. Mapping, spatial analysis, data information system and decision making are instruments given in GIS programming that can be utilized for mapping of disease, forecast new hazard region, store and information management, disperse data that are helpful for well-being and health departments in Malaysia during the epidemic episodes.

## II. GIS AND WEB BASED AUGMENTED REALITY AS DENGUE CONTROL PROGRAMMES

Dengue is an intricate medical issue to deal with because of a blend of elements shifting from biophysical to social and economic [16] Other than distinguishing and perceiving the principle factors that unequivocally add to the transmission of dengue epidemics. The disease is also required a medium which can be connected with open to disperse the news and to make the battle against dengue outbreak increasingly successful as concurred by Malaysia Minister of Health [30]. The implementation of new technologies and information system is also suggested by current researchers to prevent and control the disease creatively [21][19] such as applying cyberinfrastructure, big data and Internet of Things (IoT).

A GIS is one of big data devices which has ability to interrelate and tackle spatial issues. GIS is a computer system for decision making platform, which allows people to process, analyse, and display spatial data for intentions. GIS has been known as powerful toolset and have ability to be implemented in public health sector based on the number of studies that have been conducted in this sector. This geospatial technique has benefits in term of spatio-temporal analysis for disease mapping, and management as conducted by John Snow for cholera mapping in 1845. GIS application offers geospatial analysis tools for analysing patterns, mapping and measuring geographical distributions of dengue which can be used to address public health problems and can improve health condition level [5][9][10][14][ [20][22][32][42][29][23][31][37].

The functions of GIS can be enhanced from customary single programming to-wards various programming or machine processing by utilizing web-based GIS and augmented reality (AR) mobile application. This application can be classified as web or online GIS because of its association with web browser. Past analysts have utilised the application as a tool for quick geographical information sharing and compelling spatial observing reason [3][15][18][24][26][27][35]. Web GIS empower clients to see, get, question, translate, envision and screen the study of disease transmission from various perspectives to uncover the relationship and patterns map on a standard internet browser.

However, most research related to GIS in epidemiology are often limits for general spatial analysis and mapping only [12][13][17][20][32][39][40][41]. Besides this, there are just a few previous studies that focusing on implementation or use of GIS in development of an epidemiology information system [28]. This indicates that the use of GIS in this field is still new for GIS users especially in developing countries and due to a

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lack of expertise since it involves and requires multi-disciplinary fields.

In the context of Malaysia, most of the studies or researchers related to the use of GIS in the field of epidemiology also more focus on spatial analysis and mapping [1][2] [5][6][16]. However, there is a local system that developed by Malaysia remote sensing agency, I-Dengue, which used in Malaysia. In the initial stage, the system just focusing on information sharing, this intends to disseminate the news and the in-formation of dengue outbreak to the public [7].

Therefore, the integration between GIS, visualisation, epidemiology, especially dengue information system can convey contemporary era for GIS, and it can also expand its usage. This integrated innovation can be beneficial in the dengue control programme in developing a proposed Malaysian Geospatial Dengue Information System (MyGeoDIS) to improve and enhance dengue surveillance systems for effec-tive and efficient way to control and prevent dengue outbreak. MyGeoDIS is expected to cover the functional elements of data management, processing, and information sharing of dengue geography.

## III. DATA AND METHODS

### A. Research Framework (Data, Software and Techniques)

The main methodology applied for development of MyGeoDIS involved three phases mainly planning, system design and development and system testing as stated in a standard Software Development Life Cycle (SDLC) (see in Fig 1) [34]. Selangor is selected as a study area due to its the highest cases and deaths of dengue in Malaysia [36].

User requirement (semi-structured interview) of the proposed system was carried out in 2013 and 2014 among the 44 officers from Selangor Health Department (JKNS) to determine their preferences on the system design and development. This method helps determine the needs of users, current work practices and new ideas for the development of the proposed system. The proposed system was developed using open source software (Quantum GIS, MapGuide, 000webhost and Wikitude) with a few combinations with desktop software (ArcGIS, and Microsoft Access). The main data used in this development is shapefiles data in vector data format that were formed in personal geodatabase.

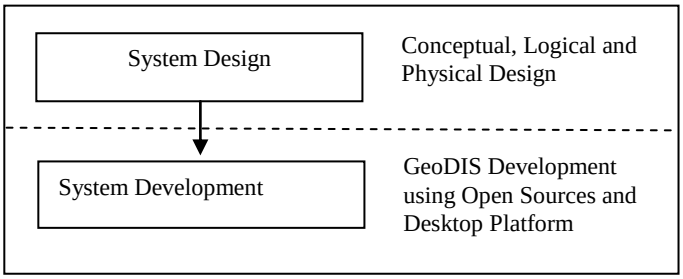


**Fig 1.** Research Methodology of MyGeoDIS

Geographical Weighted Regression (GWR) is also one of the functions provided in the system. The analysis was focused on the relationship between dengue cases and selected parameters that contributed to the local dengue outbreak in 2010 such as rainfall, temperature and population. GWR constructs these separate equations by incorporating the dependent and explanatory variables of features falling within the bandwidth (such as Kernel and Number of neighbours parameters) of each target feature [8]. The user input of parameters has one restriction: when the number of neighbouring features would exceed 1000, only the closest 1000 are incorporated into each local equation.

### B. System Design

System design can be resolved as a primer thought regarding the new framework and how it will function to meet the client needs [33]. This study utilized the framework structure that incorporates three fundamental steps; conceptual design, logical design and physical design. This step has been recommended the most potential stage and language that can convey the proposed framework capacity and interface of a standard system. Designing of Selangor Dengue Information System (SDIS) is a step to create storyboards of graphical user interface (GUI) for MyGeoDIS.

### C. System Development and Application

System development of MyGeoDIS involved three

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steps which are data preparation, designing of GeoDIS and development of GeoDIS. After collecting the data, the data were processed and analysed to generate a GIS base map of the study. Quan-tum GIS, MapGuide (QGIS) and geographically weighted regression analysis are main platforms used to map and identify the dengue spatial pattern. Afterwards, designing of MyGeoDIS was carried out as a framework or storyboard of MyGeoDIS as illustrated in Fig. 2. Functions, tabs and buttons of MyGeoDIS were created in this phase as well.

Development of MyGeoDIS is next phase conducted to develop the physical system of MyGeoDIS using 000webhost. The main functions established in the system included the main homepage, dengue information, dengue control programmes and other related menus to the state dengue input and requirement.


**Fig 2.** System Storyboard of MyGeoDIS

## IV. RESULTS AND DISCUSSION

### A. User Feedbacks on the Proposed System

Sixty-one per cent (61%) of the 44 respondents answered the organisation has been applying a computer-based system and most of them in a digital form. This system is carried out in combinations of manual and digital based system such as hardcopy and digital map, file system, and text-based system (such as Microsoft office excel). The other methods include digital (27%), manual (7%) and some of them have also no idea (5%) on what specific method have

been used in this organisation, Overall, only 52% of the respondents who are satisfied with the current system performance due to there are still insufficient aspects need to be improved in the system.

Thus, the elements that are recommended by the respondents in the system are system functions need an easy to use interface, completed dengue map, dengue risk factors, completed database, relevant spatial analysis, updating dengue information, easy to access and surveillance system development. Interestingly, it is also found out that 100% of respondents agreed with the implementation of GIS in the state because they believed that this technology is helpful to improve the current frame-work restriction and staff imperatives, particularly in directing a superior spatial investigation and sharing data. From this user inclinations, it very well may be utilized as a framework to create the MyGeoDIS or other related disease matter in the country.

B. System Framework and Implementation

*Framework and Main Tiers of User.* Fig. 3 demonstrates the Entity Relationship Diagram (ERD) which otherwise called as a conceptual data model for the proposed SDIS. This design is utilized as the structure for planning the database for MyGeoDIS to avoid data redundancy. Conceptual design represents the entities, relationship and how they are identified with one another, for example, numerous passwords can enrol numerous patients and every patient can have one changeless location and worker address.

The development of MyGeoDIS is not only focusses on the information sharing or dissemination but also covers data analysis and management to enhance the dengue control programme in the state. MyGeoDIS is developed with two tiers of user i.e. staff of Selangor State Health Department (registered user) and public (public user) as shown in Fig 4. Public users allow to retrieve the information provided by MyGeoDIS while Selangor State Health Department staff has responsibilities to perform data manipulation, analysis and management. In general, the public can use the system for displaying the dengue distribution and risk areas for health awareness, education and promotion.

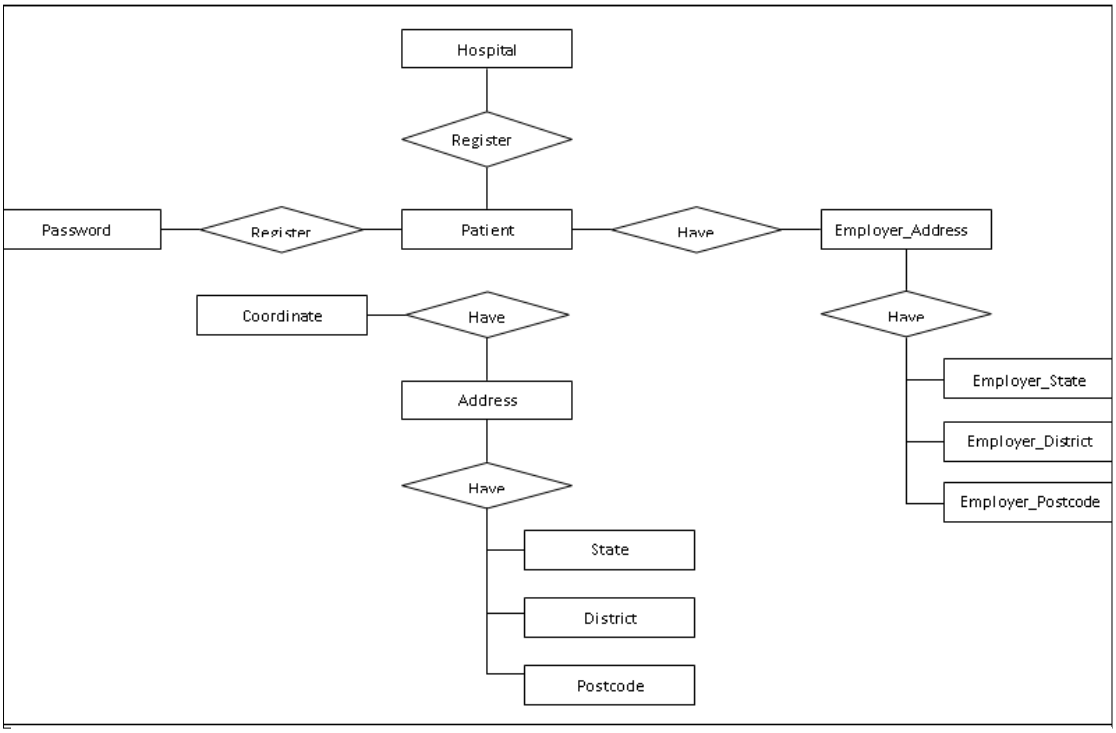


**Fig 3.** The Entity-Relationship Diagram in MyGeoDIS

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*System Functions*. Overall, the system provides the main important functions as a standard disease system such as Home window, integrated data, map and analysis window, publications on the disease, activities window and contact window, data manipulation and analysis, and mobile applications. Introduction or Home window introduces users with the system and GIS technology and dengue information. In the context of this study, the system is also called as Selangor Dengue Information System (SDIS) as the study conducted in this state.

Window of database, map and analysis are also included in the system for centralised Database Management System (DBMS) and providing users with high risk map of dengue areas in Selangor such as to analyse the dengue pattern and to determine possible relationships with other risk factors. Publication window acted as a library to store all publication paper and journal, while Activities Window is intended to update and announce all control activities of Selangor State Health Department related to dengue programmes. MyGeoDIS is facilitated with Contact Window so that the user can do mail for any enquiry.

Spatial data manipulation and analysis could be also conducted in the system (see in Fig. 5). Geographical Weighted Regression (GWR) was concentrated on the correlation between dengue cases and selected variables that contributed to dengue epidemics such as land use, rainfall, and population. This spatial modelling showed that Hulu Langat is the most risk area with dengue due to high of standard residual (1.5 - 2.5) following by Gombak and Sabak Bernam which both of these districts were standard residual recorded between 0.5 – 1.5. The low risk areas in Selangor are Se-pang, Petaling, Klang and Hulu Selangor which had standard residual below -0.5. There have also four possible areas which have the potential to be affected by den-gue outbreak, including Petaling, Hulu Langat, Gombak and Klang.

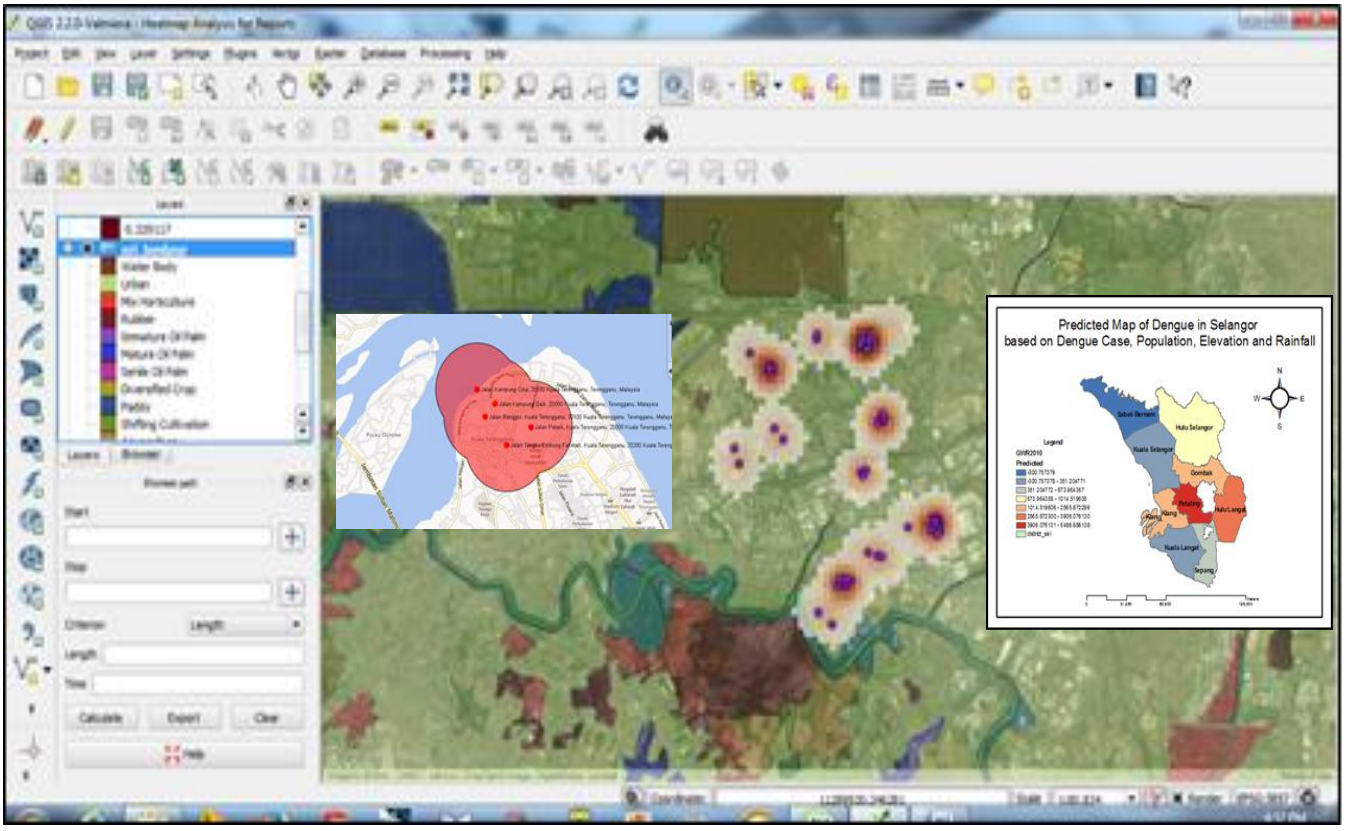


**Fig 5.** Spatial Data Manipulation and Analysis in the System

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The system also offers users to conduct spatial analysis function to identify and analyse the spatial pattern of the disease. This function is only available for registered users such as officers from Selangor State Health Department and the district health offices. The point locations of the disease allow the users to view and under-stand the exact and possible patterns of the high-risk areas. In terms of analysis, the basic analyses include buffer, query, and calculate distance and area. For example, buffering areas between the hotspot locations of dengue and the nearest built environmental elements are important analyses to determine their spatial correlations.

*System Uniqueness.* The system is also advanced with online, mobile and augmented reality applications (see in Fig 6). The mobile application was created by utilizing Google Map and Wikitude technology. Data planning being developed of the mobile application is a procedure for preparing, appropriating and altering of dengue cases into Google Map and to trade the information into kml position for utilizations being developed of MyGeoDIS Mobile application phase utilized Augmented Reality technique. This is a vital step for sharing the hotspots maps of dengue cases to the public for health awareness campaigns.

C. MyGeoDIS as a Dengue Surveillance System

MyGeoDIS is proposed to enhance the existing dengue surveillance system. This reported dengue cases tool would geocode, analyse and process the cases to identify the high-risk areas of dengue, trends and patterns. This data also would store in database. The information's such as dengue high risk areas, trends and patterns would be used for arrangement of dengue control and prevents activities to overcome the outbreak.

Moreover, the system would be disseminated to public through web-based and mobile application. The implementation of MyGeoDIS in JKNS could reduce and eliminate dengue outbreak in Selangor regions through functions provided in the system such as spatial analysis which acts a decision making for prediction purpose of dengue outbreak. Besides this, the database management system could make the data management of dengue data more efficient and effective, and lastly information sharing through web-based and mobile application could improve level of awareness amongst public users on the disease.

MyGeoDIS mobile application is one of innovative method which using augmented reality technique to share the map and info of dengue cases in Selangor to the public. The application of Open Wikitude browser in the system is done by selecting the chosen Point of Interest (POI) of dengue cases to display the information. Then Map button is clicked to switch to map function. After that "route me there" button is chosen to navigate to the selected dengue cases as shown in Fig. 6.

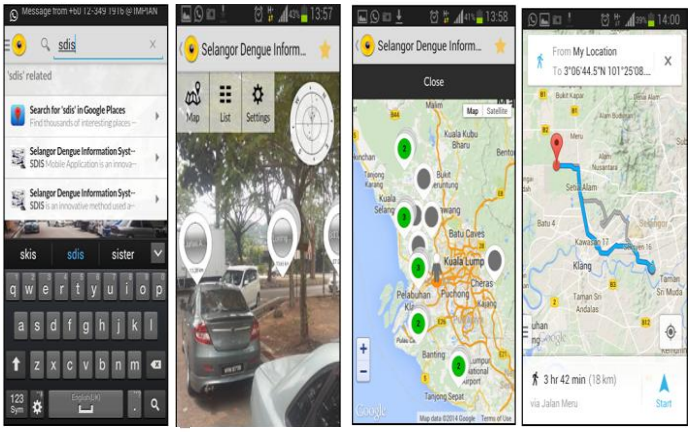


**Fig 6.** Augmented Reality Based Mobile Applications in MyGeoDIS

## V. CONCLUSION

This paper has demonstrated the capabilities of Web GIS and Augmented Reality (AR) technology to develop an integrated geographical-based Dengue Information System (GeoDIS) in Selangor. The system was created by assimilating open source software such as QGIS, MapGuide, 000webhost and ArcGIS in three main phases of research methodology: data preparation, designing of the system interface and development. GIS and AR are powerful technology for managing and visualizing geoinformation of the epidemiological datasets since the technology provides valuable functions such as database system, mapping and visualization, data

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processing, data analysis, data modelling and predictive simulation, and development of dengue surveillance system. The proposed system of MyGeoDISin this study is beneficial to enhance the local dengue control programme through promoting the public aware-ness among the public especially in endemic and remote areas. The AR mobile based apps offers the local health department with efficient database management system (DBMS) which intend to record all the dengue cases or patients. Interactive dengue maps allow users in identifying patterns, trends and distribution of dengue outbreak in the state, and disseminating the epidemic information to public through web-based and mobile applications.

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