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Mobile application for data acquisition in integrated forest and land fires patrols

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Abstract. *Hotspot is one of the indicators of forest and land fires which is usually checked in the field through an integrated patrol program by a team formed by the Ministry of Environment and Forestry (MOEF). The findings from these patrol activities are usually reported through texts posted in the chat group media using the WhatsApp application. This method is, however, considered ineffective in presenting information queries from the patrol data. Therefore, this research aims to develop a mobile application to record data retrieved during forest and land fire patrols in the Sumatra region. The prototyping system development method was applied and this includes analyzing the needs of the user, designing and modeling the prototype, coding the system, testing the system, and system usage. Moreover, the Ionic 3 framework was employed in the system development through the application of the API from the back-end module. The application was integrated into the Google Maps Application Programming Interface (API) and the system was tested using the Blackbox method to show the features in the system function effectively.*

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INTRODUCTION

Indonesia has the most extensive tropical forests in the world, with several resources and diverse biodiversity. In 2013, 82 million hectares of Indonesia's land area were estimated to be covered by natural forests out of which 75% belong to Papua and Kalimantan (Purba *et al*., 2014). This forest area is, however, decreasing every year and one of the causative factors is forest and land fires (*karhutla*) which happens either naturally or through human actions, thereby, creating environmental damage through ecological, economic, socio-cultural, and political losses (Ministry of Forestry, 2016). It has also been reported that Sumatra and Kalimantan are the areas with the highest vulnerability to fires in the country. Moreover, several fire occurrences were recorded in 2015 on different islands in Indonesia, causing approximately 2 million hectares of forest and land to burn (BNPB, 2015). This caused the country to be covered in thick smoke, especially 80% of Sumatra and Kalimantan (Endrawati, 2016).

Therefore, the government has implemented several efforts to prevent forest and land fires using information technology by developing different information systems. An example related to early prevention efforts is the web-based monitoring system developed for forest and land fires on http://sipongi.menlhk.go.id/ by the Ministry of Environment and Forestry (SiPongi, 2015). This application presents real-time data on the distribution of daily hotspots throughout Indonesia, including the fire area, weekly hotspots, hotspot data in a monthly matrix per year, and CO_2 emissions (SiPongi, 2015). Another application is the Groundwater Level Monitoring System (TMAT) installed on peatlands in different locations in the country (SiMATAG-0.4m). SiMATAG-0.4m to monitor TMAT and rainfall in concession areas, progress on restoring the Peat Ecosystem in concession areas, and determine the company's compliance with the TMAT monitoring process. It also supports SiPPEG (Information System for the Protection and Management of Peat Ecosystems) in determining the Peat Ecosystem Quality Index (IKEG), calculating and monitoring water availability (water balance), as well as improving forest and land fire predictions (MOEF, 2019). Moreover, it is also possible to conduct Water Level Monitoring (TMA) using the Peatland Water Monitoring System (SIPALAGA) (Sipalaga, 2021), which was built by the Peatland Restoration Agency (BRG) supported by the Agency for the Assessment and Application of Technology (BPPT). This system is a real-time data monitoring platform produced from the TMA tool to measure peat soil moisture, rainfall levels, air temperature, humidity, and wind direction and speed (PTPSW-BPPT, 2019).

The 2015 case prompted the President of Indonesia to issue Presidential Instruction No. 11 of 2015 on the improvement of forest and land fire control. The policy was designed to improve the control of fire in the country based on three activities: prevention, suppression, and post-fire management. This led the Ministry of Environment and Forestry to implement a control policy that involves the immediate and proper conduct of prevention and mitigation efforts as well as the reduction of the number of hotspots used as fire indicators. Moreover, one of the preventive activities implemented in the area is fire patrol, defined in the Minister of Environment and Forestry Regulation No. P.32 March 2016 as "a monitoring activity carried out by Manggala Agni and all parties in the context of preventing and extinguishing forest and land fires" (MOEF, 2016). Therefore, integrated forest and land fire prevention team monitors hotspot locations, thus the data retrieved from the field observations are usually reported in the form of digital short messages sent to the operation leaders. These daily reports through the WhatsApp Group increase the data capacity of the forest and land fire prevention patrols, thereby making it difficult to search for specific information. Moreover, the submission of different report formats was observed to have led to the omission of some data, making it difficult to analyze the information. It is also important to note that data loss is possible when the user application used in storing the integrated report has any problem.

The daily report is always in the form of an unprocessed text file, which makes further analysis difficult. Therefore, a front-end module was developed in the webform by Ramdhany *et al*. (2021) to visualize the patrol results. The application's interface was built using HTML, and Javascript and the API from the back-end module were applied as the content manager. Moreover, the services and libraries provided by Google were used to support the functionality of the application. Meanwhile, this present study established a database to manage the forest and land fire patrol data obtained from text files and also developed an android mobile application to deal with problems associated with the daily recording of the team's field observations using a prototype method of the Representational State Transfer Application Programming Interface (REST API). Therefore, the findings of this research are expected to assist the field team of forest and land fire prevention patrols in recording daily data accurately, quickly, and uniformly to accelerate the reporting process as well as the decision-making analysis related to prevention.

METHOD

Research Data

This research used the data retrieved from the integrated patrols conducted to prevent forest and land fires in Sumatra and Kalimantan from February to April and June to December 2016 from the Ministry of Environment and Forestry. The daily reports of each operating area usually presented in WhatsApp groups were obtained and processed into Microsoft Word files with a total of 5 in February, 31 in March, 13 in April, 20 in June, 22 in July, 20 in August, 30 in September, 7 in October, 30 in November, and 2 files in

December. This means the total integrated patrol report file used in this research to determine the data type was 180 and the information obtained was in the form of patrol dates, provinces, areas of operation, target locations consisting of sub-districts and villages, results of patrol activities, and documentation.

The report was later converted into a spatial database with four entities. First, the patrol activity entity which contains information from the patrol team on its activities in a certain area and time. Second, the location entity involves information on the condition of the land used as the observation point. Third, the team member entity contains the personal data of the patrol team members. Fourth, the aerial location entity has the information on spatial data within the radius of the observation area. All these data were stored on the cloud hosting server in the form of a relational database, and the mobile application used in recording data on forest and land fire patrols was connected to a back-end module operating on the server-side to transmit information into the database.

Research Stages

A mobile application to record data on forest and land fire patrols was developed using the prototyping method as shown in Figure 1. This is due to the fact that prototyping has been reported to be the best software development method when the information obtained only has a general-purpose without identifying the detailed functions and features required for the software to be developed (Pressman, 2010). Therefore, the stages of this research are in line with the prototype system adopted (Pressman, 2010) include user needs analysis, rapid prototype design, and modeling, prototype construction to code the system, as well as delivery and feedback to evaluate previous prototypes to refine the specified requirements.

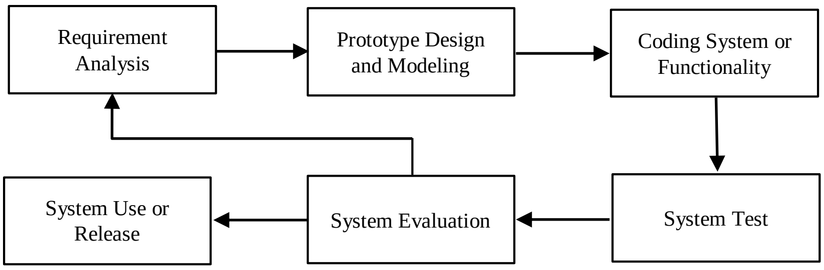


Figure 1 Research stages

Requirement Analysis

The entire system and the parameters or attributes in the forest and land fire patrol database are presented as Entity Relationship Diagram (ERD) in Figure 2.

Prototype Design and Modeling

This was initiated by producing the prototype of the mobile display to be created and adapted to the system requirements defined in the previous stage. The design includes an overview of the system interface as well as the required inputs and outputs to be generated.

Coding System or Functionality

This stage involves the process of writing code using the Ionic 3 framework, which is usually used to develop cross-platform applications to ensure they can run on different mobile operating systems such as Android, iOS, and Windows Phone (Cheng, 2017). Furthermore, Angular programming language was also used to handle application logic, while Cordova was applied as the cross-platform application framework to compile the program code for its installation in mobile devices (Justin and Jude, 2017).

The Ionic 3 framework uses Hypertext Markup Language (HTML) supported by Cascading Style Sheets (CSS) as a display controller (customization) on the mobile application interface. Moreover, the HTML code created in the previous stage was included in its functionality using the Typescript programming language. The integration process was also implemented at this stage using the Google Maps API and the back-end module for the forest and land patrol application. The Google Maps API was used to input coordinates for the forest and land fires observation area while the data obtained were processed through an array of Javascript Object Notation (JSON) after which they were sent to the database through the back-end module of the application.

System Test

This was conducted using the Blackbox method which allows the users to test all existing functions with different inputs and compare the output with expectations. The experiment was, however, conducted several times up to when the results needed were produced.

System Evaluation

At this stage, the system was evaluated based on the desired requirements and a good result indicates it is fit to be passed to the release or public use stage. Meanwhile, unfavorable results mean there is going to be a return to the coding stage where the unfulfilled functions are to be added or repaired.

System Use or Release

The final stage of developing the mobile application is its release to Playstore to be downloaded publicly. This was, however, conducted after the API provider back-end module associated with this application has been successfully released.

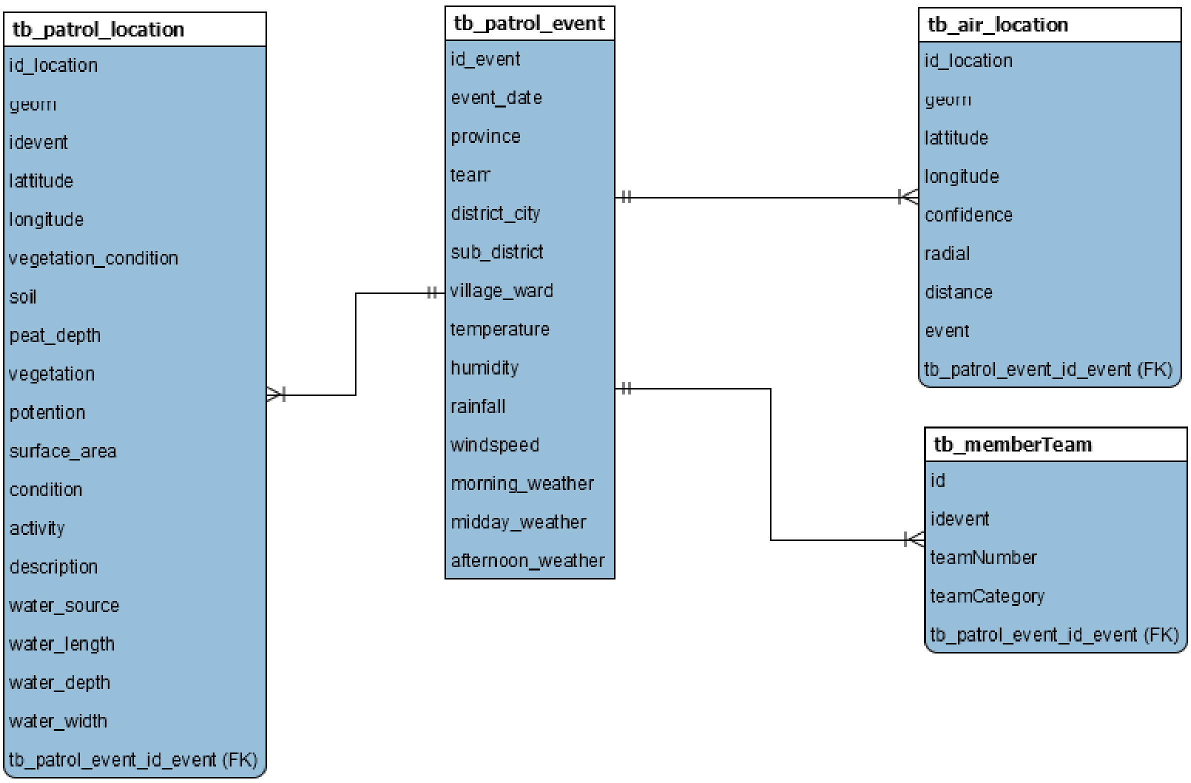


Figure 2 ERD in forest and land fire patrol database

RESULTS AND DISCUSSION

The process of developing the mobile application started in November 2018 using the Pressman Prototyping method (Pressman, 2010) which was modified according to system requirements. The development activities were divided into 6 stages which include the analysis of users' needs, rapid design and modeling of the prototype, construction of the coding the system, delivery and feedback to evaluate the prototypes, feedback on the modifications to improve the required specifications, and the usage of the prototypes to obtain direct feedback for further development.

User Needs Analysis

The needs analysis was conducted throughout the system through the examination of previous research and communication with stakeholders with the focus on the parameters used in recording the data on forest and land fire patrols. The stakeholders communicated with include the Head of the Center for Climate Change as well as Forest and Land Fire Control in the Sumatera Region. Their responses showed the need for a system to collect or record patrol data through a website and mobile device which has the ability to print documents into softcopy.

This study, therefore, focused on developing a platform to collect or record uniform data on forest and land fire patrol using a mobile application. It was discovered that there was no similar application to achieve this except for the SIPONGI mobile application developed to detect hotspot points while data are being recorded manually with different formats on WhatsApp Groups. Moreover, the users were found from the communication to include a patrol officer named Manggala Agni and other parties associated with the prevention and elimination of forest and land fires making observations in the field. The stakeholders want a data acquisition process which produces the same and uniform format and parameters. This, therefore, led to the development of a platform to make reports using web applications in this research.

Prototype Design and Modeling

This stage involved describing the business processes using case diagrams while the system function process flow was described using activity diagrams to determine the functions of the proposed application based on the user needs as shown in Figure 3.

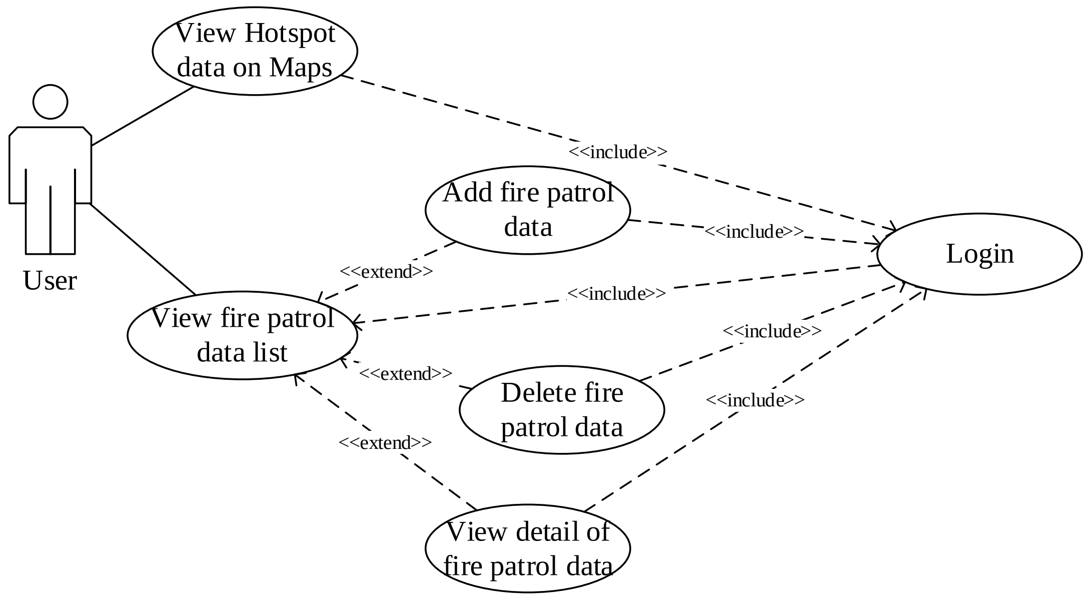


Figure 3 The case diagram of the mobile application to record forest and land fire patrol data

Figure 3 shows the functions of the proposed mobile application include the following: (1) The application is accessible by logging in using the username and password registered in the WEB application; (2) The application has the ability to detect the hotspot points obtained from the SIPONGI website; (3) The application can create, view, modify, and delete the recorded data. The modification and deletion are, however, only allowed when the current date matches the patrol data date and the hour does not exceed 19:00 local area.

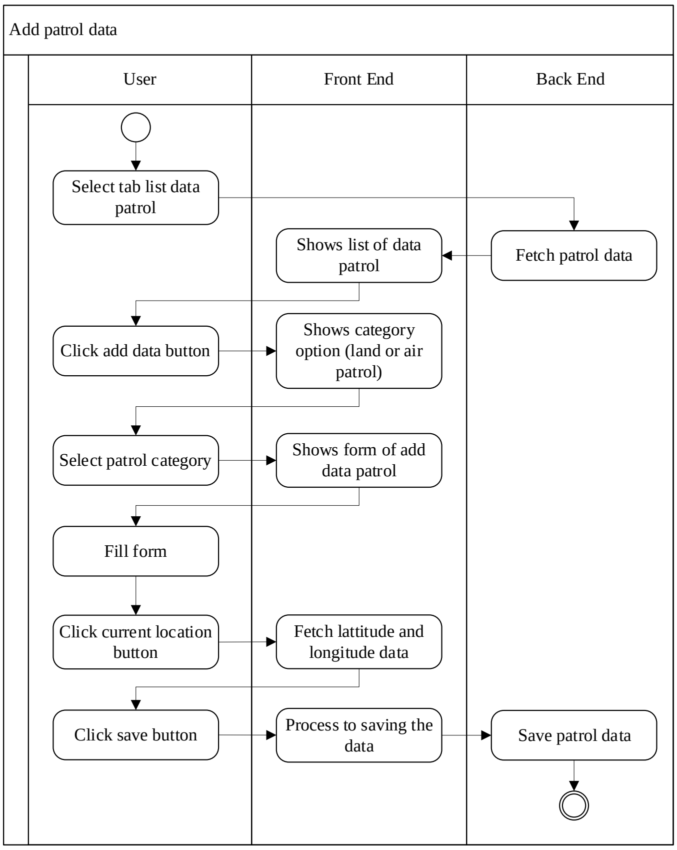
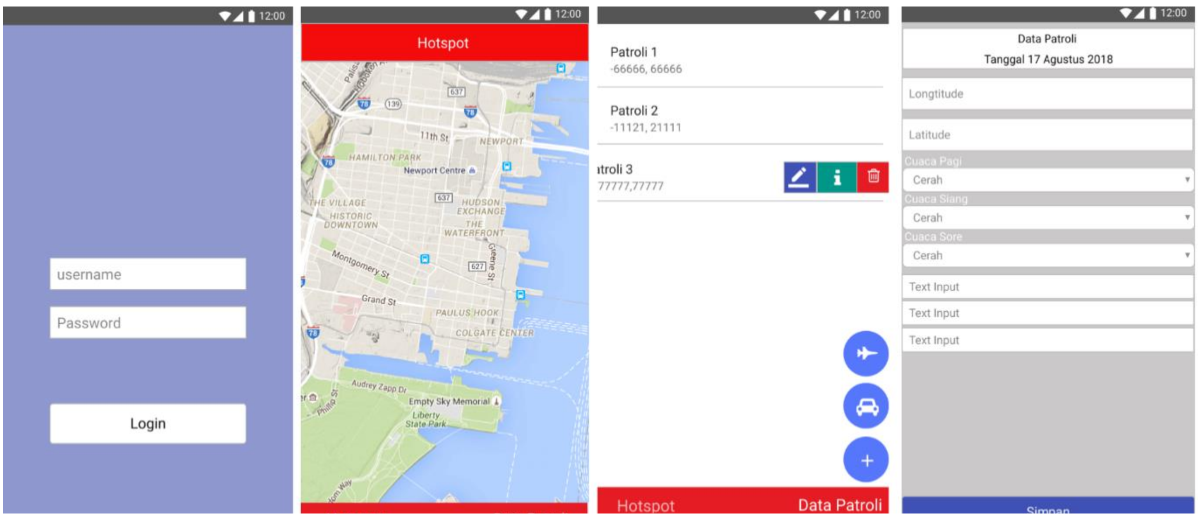


Figure 4 Activity diagram to add patrol data



(a) (b) (c) (d)

Figure 5 Interface modeling; (a) login page, (b) main page, (c) data patrol list page, (d) add/edit data page

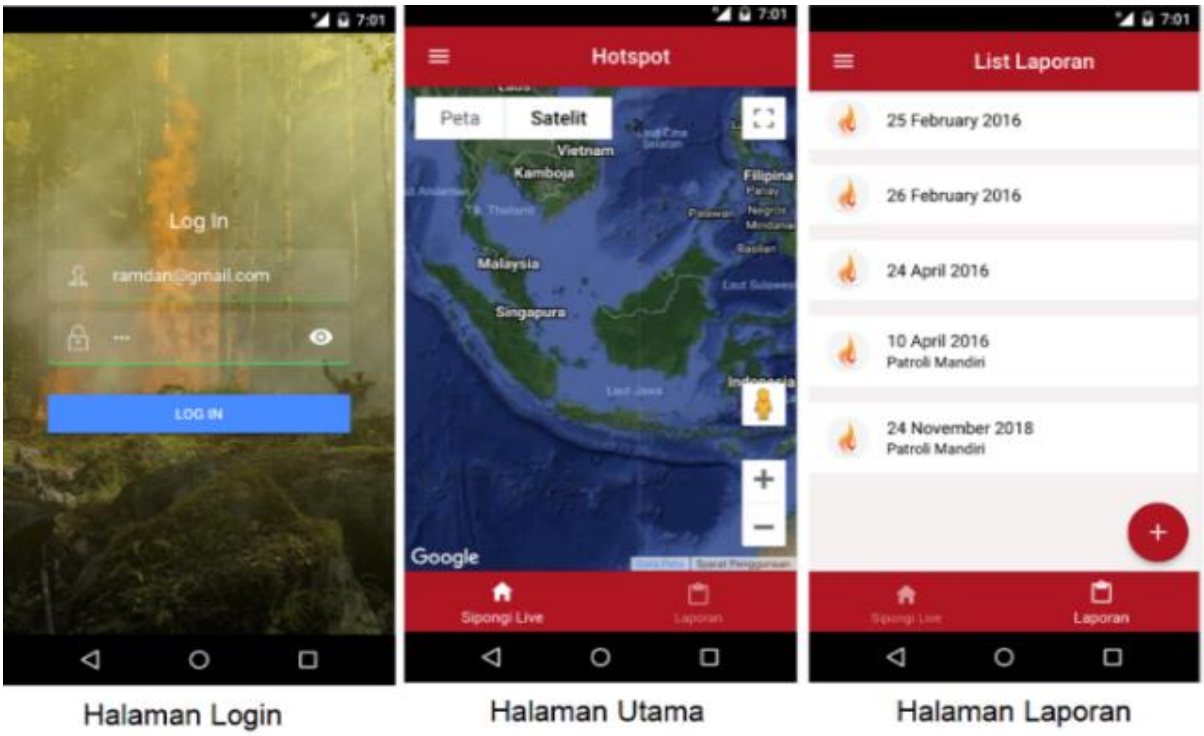
The case diagrams were converted into a system design using activity diagrams which connected the components including the user, front end, and back end. The activity diagram to add patrol data was, therefore, designed as presented in Figure 4 with the user discovered to have the ability to perform two main activities which include viewing the list of patrol data and adding patrol data. The data addition option allows the user to include the field observations of the team by filling out the form and pressing the 'add' button and also to save the data to the database by pressing the 'save' button.

The mobile application interface of the prototype was modeled based on previous designs. It was designed to be used on touch screens to suit the Android-based operating systems requirement with each activity to be performed described. This means the interface modeling was used to show the display to be used by users and to facilitate the development of the display using code as indicated in Figure 5.

Coding System or Functionality

This stage involved coding the system based on the information obtained starting from the user requirements analysis to the prototype design and modeling stage. It is important to note that the proposed mobile application is client-server-based with the client being an android mobile device while the server is a web directly connected to the database. Moreover, Android devices need to be connected to a web server to perform data communication, therefore, the proposed mobile application uses an HTTP connection to send and receive response data from the webserver. The process to request data uses HTTP post or HTTP get while the data receiving process uses the HTTP response. It is important to note that the data sent by the web server and received by the client is in JavaScript Object Notation (JSON) format and this means it will be easier to parse.

The modeled interface was implemented into HTML form in accordance with the rules of the Ionic 3 framework by considering the characteristics and requirements of the system. The results of the code written for the application using the Ionic 3 Framework are, therefore, presented in Figure 6.



(a) (b) (c)

Figure 6 Application display; (a) login page, (b) main page, (c) report page

System Testing, Evaluation, and Usage or Release

This involved testing and evaluation of the system using the Blackbox method with the focus on the functionality of the mobile application as the test scenario. The aim of this process was to evaluate the ability of the system's functions to run according to requirements. The scenarios and test results are, therefore, presented in Table 1.

Table 1 System functional test

Test	Scenario	Expected results	Test results
Login	Entering a username and password that does not exist	An error message showing the inability to login	Success
	Entering the username and password in the database	User enters the main page	Success
Hotspot from SIPONGI	Displaying hotspots of SIPONGI with Google Maps	Displays Google Maps with hotspot points	Success
Patrol Data List	Displaying a list of patrol data	Displays a page in the form of a list of patrol data	Success
Take a photo	Taking photos using the mobile camera	Displays photos that have been taken using the camera	Success
Take the current coordinates	Retrieving the coordinates of the current location using Google Maps.	Displays the current coordinates of the point.	Success
Add patrol data	Entering patrol data into the add data form	Data stored in the database	Success
Delete patrol data	Deleting patrol data by id	Data deleted from the database	Success

CONCLUSION

This study succeeded in building a mobile application to record data on forest and land fire patrols using the Android platform. The mobile app is capable of displaying hotspot information from the SIPONGI website and manipulating forest fire patrol data. Moreover, the maps in the application were integrated using Google Maps and this can be used in determining different positions. The test results also showed that the features of the application function properly according to user needs. The next design, therefore, needs to add or improve several things such as the design of the display for the added patrol data on the mobile application.

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