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Determination of Real-Time Flood Distribution using Flood Meter

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Abstract

Increase of flash flood occurring at unpredictable locations and at short durations of time are due to climate change, change in land use, channel flow disturbance and high amount of rainfall intensity. This cause difficult to identify the flood-prone area which is important in order to reduce the effect of flood and future sustainable land-use planning. Therefore, the use of suitable and applicable flood measurement for this specific flood type is important. This study aim to identify the effectiveness of a mobile application known as Flood Meter to measure the flood-prone area in a real-time situation. The accuracy in terms of coordinate, flood level, and distance between object reference and mobile were analyzed based on a flood event at Taman Universiti, Batu Pahat, Johor. The finding shows some highly inaccurate results, especially for flood level measurement at 270cm distance object reference from mobile. Several factors contribute to the accuracy of Flood Meter mainly due to the human error made by the user's inaccurate crop of a rectangle shape for object reference on mobile.

1. Introduction

Floods are a global problem, causing severe damage and economic losses [1]. In Canada, climate change has led to more frequent and severe flooding, resulting in significant costs and government aid. The United Kingdom is also experiencing high costs from flooding, which could worsen under climate change scenarios [2]. Adequate spending on flood defenses is necessary to maintain current protection levels. Australia experienced extensive damage from floods in 2010-2011, emphasizing the need for effective flood management and resilience measures [3]. In Malaysia between 1998 and 2018, approximately US$2 billion (RM8 billion) total damages were estimated due to 51 major disasters and flood is one of it [4]. Although most of flood in Malaysia are caused by long duration of high intensity of rainfall [5], flash flood which is usually in a short period of time also frequently occur [6]. This type of flood is mostly unpredictable and may also give a significant impact on the affected community [7]. Due to its characteristics, the flood distribution caused by flash flood is difficult to measure. Portable point measurement of flood level is potentially can be use as tool to measure flash flood and predict the size of flood distribution. This study aims to assess the accuracy of Flood Meter in real-time flood measurement including coordinate, flood levels, and distance between vehicle and mobile.

2. Methodology

Flood Meter is a mobile application used to measure a flood level at a specific location based on an image taken from the user's mobile [8]. The users need to manually highlight the vehicle in image taken from the mobile. Then, the application will measure the flood level and upload the information to the server together with the date, time, coordinate and distance between vehicle and mobile information. [8] explain the details of this mobile application with its accuracy. This study utilizes a case study approach in Taman Universiti, Batu Pahat, Johor by employs a Flood Meter and tape measurement to measure flood depth in the area. Six different areas and vehicles were selected to analyze the effectiveness of the Flood Meter. Data were collected on vehicle coordinates, flood level and distance between vehicle and mobile. The actual distance between vehicle and mobile were 270 cm, 300 cm, and 350 cm for each location.

Fig. 1 shows the coordinates of the actual location and 3 measurements from Flood Meter at 270cm, 300cm, and 350cm distance between vehicle and mobile. The coordinate accuracy was compared with Google Maps coordinates of the selected location. A common percentage error equation is used to measure the accuracy of Flood Meters in terms of flood level, distance between vehicle and mobile. It calculates the difference between the measured value obtained from the Flood Meter and the actual or expected value, expressed as a percentage of the actual or expected value. The formula for percentage error is:

Fig. 1 *Coordinate difference between actual location and Flood Meter for Proton Wira Aeroback*

3. Equations

In this equation, the "Measured Value" represents the value recorded by the Flood Meter, and the "Expected Value" represents the actual or expected value that the measurement should ideally correspond to. The difference between the measured and expected values is divided by the expected value and then multiplied by 100 to express the error as a percentage. By calculating the percentage error, Flood Meter can assess the accuracy of their measurements and determine the level of deviation from the expected values. This information is crucial for evaluating the performance and reliability of the Flood Meter and making necessary adjustments or improvements if needed.

$$Percentage\ Error = \left(\frac{|Measured\ Value - Expected\ Value|}{Expected\ Value}\right) X100 \quad (1)$$

4. Results and Discussion

Fig. 2 shows the accuracy of Flood Meter coordinate measurements obtained manually versus data from apps. The study reveals that coordinates in the apps are generally inaccurate compared to the manual measurements conducted on Google Maps with an average distance between the actual coordinate and Flood Meter coordinate are 48.3m, 14.6m, and 50.7m for the distance between vehicle and mobile 270cm, 300cm, and 350cm respectively. Various factors contribute to this inaccuracy, including poor internet connection during app usage, which affects the precise pinpointing of coordinates. Additionally, users may not perform the calibration technique correctly in real-time flood events, further diminishing coordinate accuracy. Furthermore, the study highlights the main influence on app coordinates to be the mobile phone's GPS. As different devices have their own GPS systems, which are not centralized, the coordinates obtained through the Flood Meter app can vary

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based on the device's location. In this era of technology, despite the availability of GPS in most mobile phones and electronic devices, achieving consistent and accurate coordinates remains a challenge for Flood Meter apps.

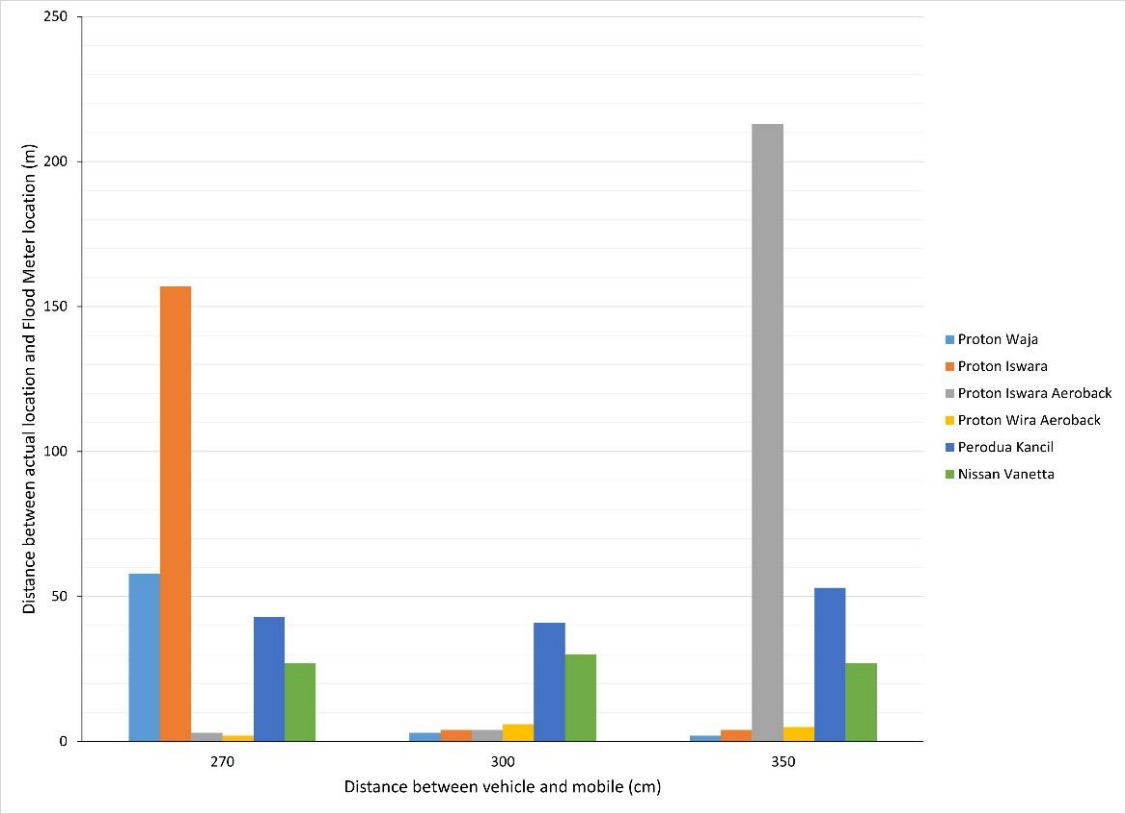

Fig. 2 *Coordinate accuracy*

Fig. 3 shows the Flood Meter accuracy in term of flood level. The study includes recordings of six vehicle types: Proton Waja, Proton Iswara, Proton Iswara Aeroback, Proton Wira Aeroback, Perodua Kancil, and Nissan Vanetta. Each vehicle type was observed at distances of 270cm, 300cm, and 350cm. The findings reveal that the Perodua Kancil and Proton Iswara positioned at 270cm, exhibited the largest error, indicating a significant deviation from the actual flood level data. The average accuracy of flood level is 252.1%, 42.9% and 46.9% for the distance vehicle from mobile 270cm, 300cm, and 350cm respectively. Factors contributing to the app's inaccuracies include inaccurate cropping of object references and app-related errors. To enhance accuracy, it is recommended that the developer collaborate with vehicle companies to integrate Flood Meter app sensors, thereby improving the precision of flood level measurements. Careful consideration of feasibility, cost-effectiveness, and user acceptance is necessary before implementing such changes. Further investigation into the causes of errors and potential solutions would also be beneficial.

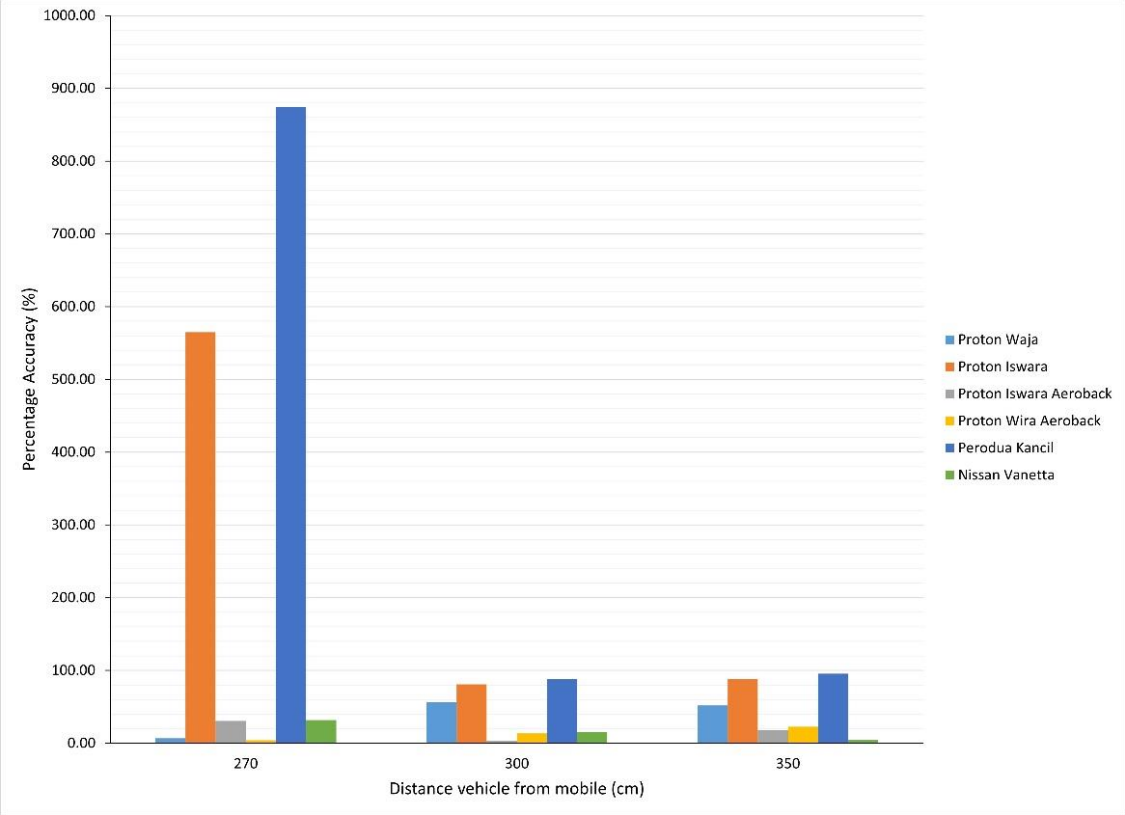

Fig. 3 *Flood level accuracy*

Fig. 4 show the average accuracy are 6.3%, 9.6% and 16.7% for 270cm, 300cm and 350cm distance vehicle from mobile respectively. The distance vehicle from the mobile is 270cm shows the ideal distance to get a the most accurate result from the apps Flood Meter. It is because when the vehicle captured on 270 cm the differences of the result come out with zero (0) differences and the result from the apps are same with the actual data in real event (except Nissan Vanetta), but when the distance goes to 300cm and 350cm from object reference the result from the apps have an error and not accurate with an actual distance in real time. From this study and result obtained, were concluded that there are several factors that effected the result come out from the apps which is it could be that error made from the users while crop into a rectangle shape on vehicle. Moreover, the user may not take the distance correctly in manual measurement and affects the result from the apps. Last but not least, as [8] study was conducted with one object references, so the data come out from the apps are more accurate compared with several numbers of object reference data.

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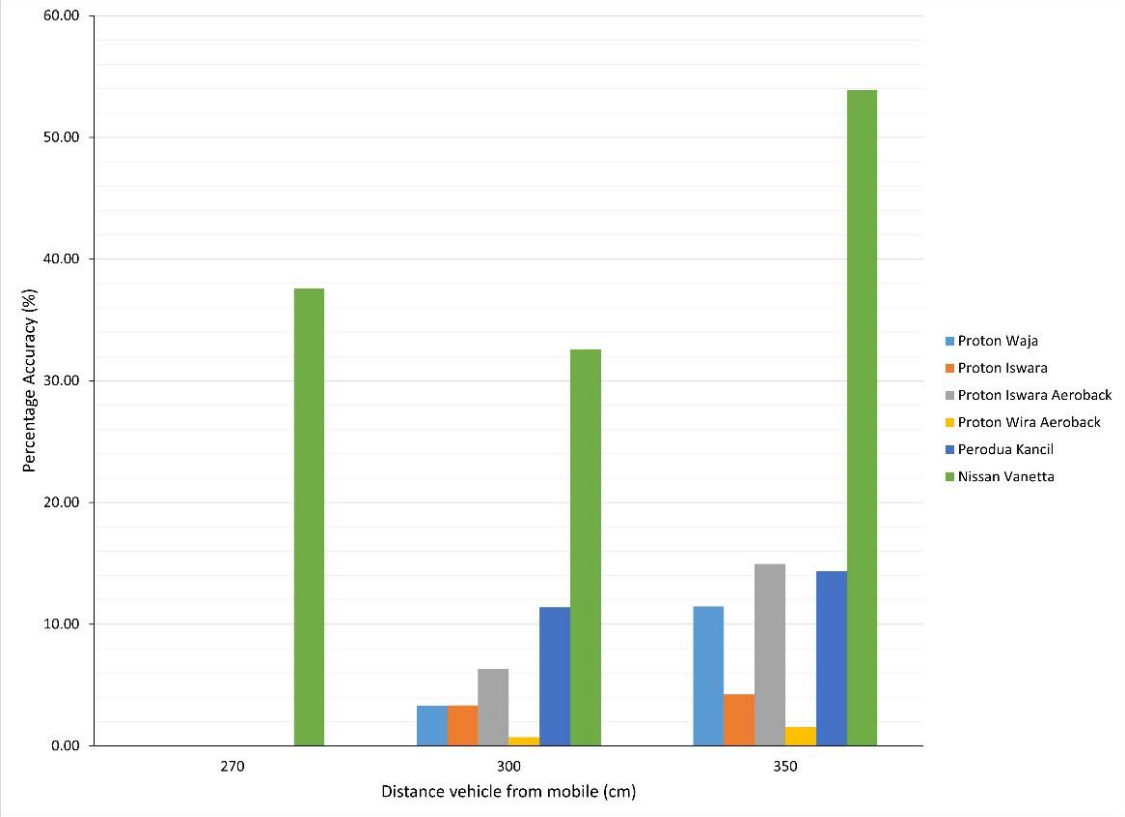

Fig. 4 *Distance between vehicle and mobile accuracy*

5. Conclusion

Flood Meter was recently developed to identify the real-time flood situation. However, the capability of this mobile application is still limited. This study analyzes the effectiveness of Flood Meter to identify the coordinate, flood level and distance between vehicles and mobile for Taman Universiti, Batu Pahat, Johor flood event. The analysis shows some highly inaccurate results, especially for flood level measurement at 270cm distance vehicle from mobile. Several factors contribute to the accuracy of Flood Meter mainly due to the human error made by the user's inaccurate crop of a rectangle shape for object reference. Further work recommended that users of the application must possess proficient techniques and knowledge in order to achieve optimal results. These techniques include capturing the object with proper framing and precision, performing calibration prior to image capture, and consistently using the same object reference within the application before recording the actual events occurring at the site location. By adhering to these guidelines, users can enhance the accuracy and effectiveness of the application in practical scenarios.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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