MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 6 No. 1 (2025) 41-46
https://publisher.uthm.edu.my/periodicals/index.php/mari

Experimental Study on the Interaction Between Image and Static Vehicle on the Flood Level Measurement

Ooi Zi Quan, Tan Mu Xian, Ahmad Saufi Sujali, Muhammad Azraie Abdul Kadir*

Neo Environmental Technology, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, 84600 Panchor, Johor, MALAYSIA

*Corresponding Author: mazraie@uthm.edu.my
DOI: https://doi.org/10.30880/mari.2025.06.01.007

Article Info

Received: 1 October 2024
Accepted: 30 November 2024
Available online: 15 January 2025

Keywords

Static Vehicle, Flood Measurement, Experiment, Mobile Camera, 3D Printer

Abstract

Flooding has become a widespread, increasingly severe problem in Malaysia in the past few years and causes problems for calculating the water level because flash floods occur quickly, and the position is uncertain. The aim of this study is to optimize the similarity equation between an image and a static vehicle. This paper suggests and uses an experiment using a 3D printed vehicle model and a mobile image to address these issues. Before conducting the experiment, the model was designed and manufactured using a 3D printer. A clear aquarium tank filled with water was prepared and placed the vehicle model into the tank. Water levels were incrementally adjusted to simulate different flood stages. Mobile camera was used to capture images of the water surface and the vehicle model at each water level with ensuring consistent camera positioning for accurate comparison. Lastly, water levels was measured and recorded using a ruler, as well as the corresponding images or video frames for each level. After conducting the experiment, this study has collected all the data for optimization using the similarity equation. Model 1 has an average accuracy of 98.28%, model 2 has 98.16%, model 3 has 98.19% and model 4 has 98.52% after optimized the similarity equation and 1.1% increases in average accuracy. This finding could greatly contribute to future flood observing systems and the use of this application can significantly enhance the ability to respond to and mitigate the impacts of flooding.

1. Introduction

In the past few years, flooding has become a widespread and increasingly severe problem in Malaysia. This issue has had a devastating impact on human life and property, displacing hundreds of thousands of people and causing billions of dollars in damage. It has caused the loss of lives and destruction of properties [1]. It is one of the natural disasters that prevents the development of a country [2]. Floods, particularly flash floods, are among the most devastating and unpredictable natural disasters that pose significant threats to human life, property, and infrastructure. Flash floods usually occur in areas with rapid development by a rapid rise in water level, high velocity, and large amounts of debris. According to previous research [3], thunderstorms may be extremely devastating because of the heavy rainfall that happens in short bursts, frequently resulting in flash floods. This type of flood is mostly unpredictable and may also give a significant impact on the affected community [4]. As climate change increases the frequency of extreme rainfall events [5], it is expected that the frequency and intensity of flash floods will also increase. Existing water level measurement methods generally include float-type gauge, bubble gauge, pressure type, and mobile image, according to specific application scenarios. However, in practical application, these methods are easily restricted by external factors such as water quality, temperature, and sediment concentration, resulting in limitations in use, installation, and daily maintenance [6][7][8][9]. Flash floods occur quickly and the position is uncertain which causes problems for calculating the water level. The frequent occurrence of flash floods presents a critical challenge in accurately measuring water levels during these rapid and unpredictable events. The existing methods for water level measurement struggle to provide real-time and precise measurements due to the uncertainty in the flood's position and its swift onset. Consequently, there is an urgent need to develop an innovative approach that leverages the synergy between images and strategically positioned static vehicles. The aim of this research is to optimize a similarity equation of water level measurement using the interaction between an image and a static vehicle by simulate water level using static vehicle experiment.

2. Research Methodology

In the development of a vehicle prototype using a 3D printer, the chosen "Ender" 3D Printer, known for its precision, utilizes fused deposition modeling. The "Ultimaker Cura Software" then transforms these images into detailed 3D models, which are scaled and formatted for printing. Each iteration of the printed prototype undergoes careful inspection, with adjustments made to software or printer parameters to achieve an accurate reproduction of the original model. The experiment is set up in an aquarium, simulating flood conditions by adjusting water levels around the 3D-printed car. To stimulate realistic flood scenarios, precise water level measurements are taken, and a high-resolution camera captures images at different distances. Controlled flood simulations are conducted in a purpose-built tank, monitoring water flow, vehicle stability, and water dispersion. Data collection involves recording water level measurements and corresponding photos or video frames, utilizing both manual measurements and computer vision algorithms. In this experiment, image measurements of vehicle width, vehicle height, image size of height and width were obtained by cropping the image of the model using 'FloodMeter' application [10]. Fig. 1 shows the interface of 'FloodMeter' application, Fig. 1 (a) shows the main interface of 'FloodMeter' application and Fig. 1 (b) shows the flood level measurement. The final step involves optimizing the similarity equation by identifying key variables and expressing their relationships mathematically, ensuring the equation adheres to relevant principles and includes coefficients or constants.

Fig. 1 (a) Main Interface

Fig. 1 (b) Flood level measurement

Fig. 1 Interface of 'FloodMeter' Application

2.1 Experiment Setup

The process begins with acquiring a physical model of the car, where Nissan GTR R34 used with scale 0.074m width, 0.192m length and 0.058m height for model 1, while 0.055m width, 0.147m length and 0.043m height for model 2, model 3 has 0.046m width, 0.123m length and 0.037m height and model 4 has 0.025m width, 0.066m length and 0.019m height. Besides, model 1 has a scale size of 23 compared to original scale, model 2 has scale size of 31, model 3 has 37 while model 4 has 71 which is the smallest scale. This experiment is set to develop in the area using an aquarium with size 30cm length x 20cm width x 20cm height. First, it is a must to place the aquarium on a stable surface to ensure water level. After that, fill the clear aquarium tank with water to simulate flood conditions. Place the 3D model into the water and set the water level at different levels, then capture images of the water surface at different water levels using the mobile camera and measure the water level. The color of the vehicle and the water are different to avoid vision disruption. Fig. 2 shows the experiment setup.

Fig. 2 Experiment Setup

3. Result and Discussion

All the the experiment were carried out by doing a simulation and using a model that have be choose. This experiment also has been conducted at Kolej Kediaman Pagoh due to the accessibility of the appropriate apparatus and equipment. Fig. 3 (a)(b)(c) show the water level relationship for 0.2m, 0.25m and 0.3m distance between camera and vehicle while Fig. 3 shows the graph of water level relationship between camera and vehicle. These graph effectively shows the optimized similarity equation in accurately measuring water levels using 'FloodMeter'. Based on Fig. 3 (a)(b), there is only 0.015m and 0.01m is completed in the graph because these two water levels are the most consistently measured across all model types. Other water levels are not completed because the model is too light as the model will float on the water and cause the inaccuracy of result. But the optimized similarity equation appears to prioritize water levels of 0.02m and 0.015m as they are in the centre of the result and show the most consistent and reliable measurements across all water level. Graph in Fig. 3 (c) is not completed because model 4 has achieved minimum measurement when cropping the image in 'FloodMeter'. Before optimizing the similarity equation, model 1 has an average accuracy of 95.87%, model 2 has 96.93%, model 3 has 97.25% and model 4 has 98.72%. After optimizing the similarity equation, model 1 has an average accuracy of 98.28%, model 2 has 98.16%, model 3 has 98.19% and model 4 has 98.52%. This relationship forms the basis for using static vehicles and image analysis to measure flood levels accurately.

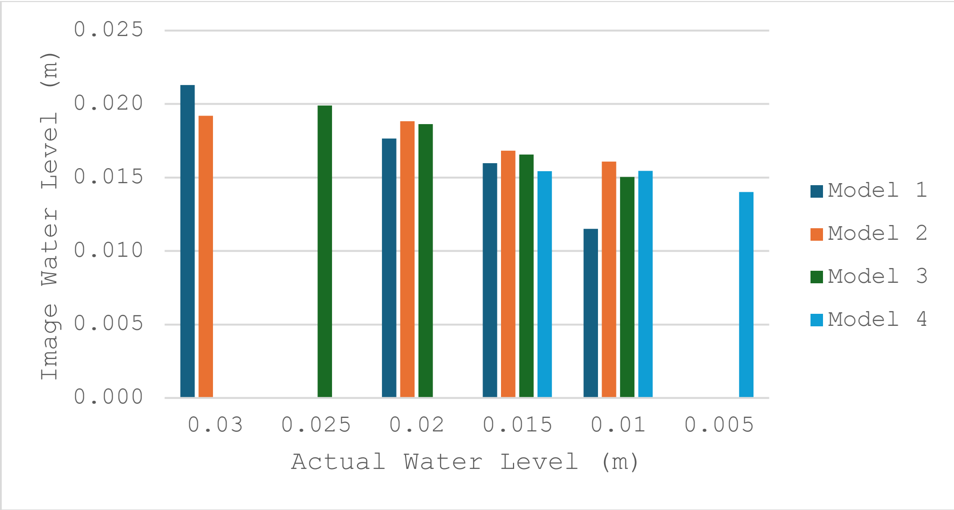

Fig. 3 (a) Water level relationship for 0.2m distance between camera and vehicle

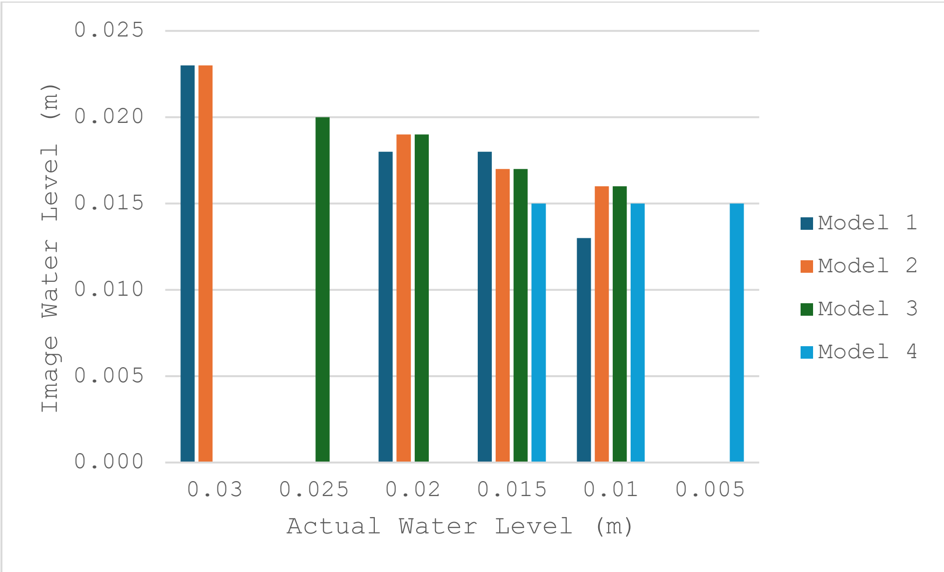

Fig. 3 (b) Water level relationship for 0.25m distance between camera and vehicle

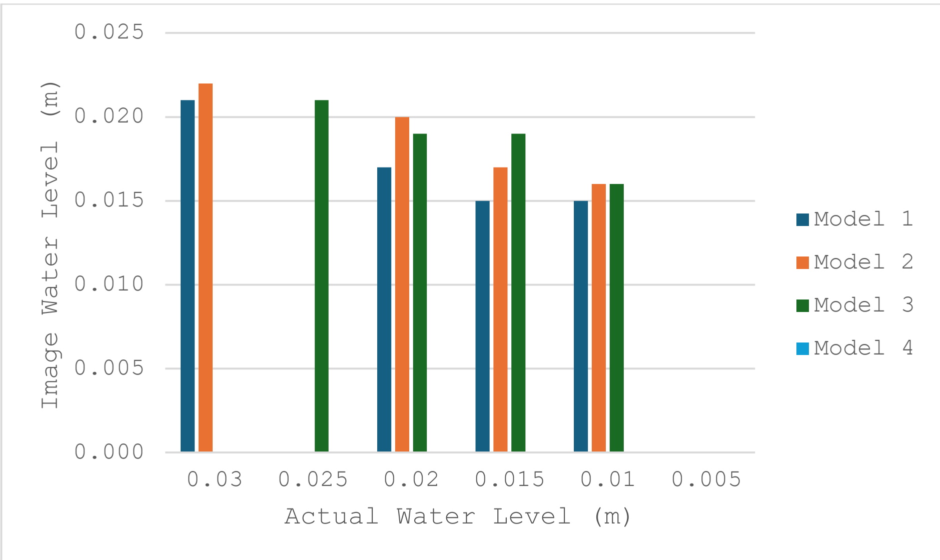

Fig. 3 (c) Water level relationship for 0.3m distance between camera and vehicle

The effect of difference in model size is probably the accuracy and consistency of water level measurement. In this experiment, it has been found that larger size of model can be measured more accurately because they are more consistent compared to the smaller size with their greater visibility, stability and range of applicable water levels. Besides, the effect of difference in distance camera is also the accuracy and image resolution. For instance, model 4 in 0.3m distance between camera and vehicle has reached minimum measurement because it is too far to the model and failed to crop. Lastly, the effect of difference in water level is accuracy and calibration. Different water levels require recalibration of measurement systems to ensure precise readings with standard measurement. At first, this experiment uses a ruler to measure the dimensions and the water level. However, the ruler is not as accurate as vernier caliper because it allows to measure smaller increments. Therefore, vernier caliper is used as a measuring tool to measure the dimensions of 3D model and water level. Before optimizing the similarity equation, the average accuracy of all models was 97.19%. After optimizing the similarity equation, the average accuracy of all models is 98.29%. Overall, the result is acceptable after optimized as the average accuracy increases. These results underscore the difficulty of precisely measuring water levels with interaction between image and static vehicle methods, highlighting the necessity of more methodological improvement, but careful consideration of potential distortions and measurement limitations is crucial for achieving high precision and reliability.

4. Conclusion

The size of the model significantly influences water level readings in the Flood Meter application, with larger models tending to overestimate and smaller models underestimating water levels. The average percentage deviations indicate that using different scaled models results in inconsistent measurements, making their use unacceptable due to fluctuating readings. Consistency in model scale is crucial to prevent errors and inaccuracies, and it is advised to standardize the model size for practical application to minimize errors. Despite various scaled models providing insights, their notable disparities highlight the need for a uniform model scale for accurate flood monitoring. Regarding the uncertainty due to distance from the camera, the distance does not affect water level image data, as each model type consistent with all models with respect to the camera-vehicle distance. To achieve a more consistent graph, additional values should be added to the existing equation, such as addition or subtraction processes, to obtain optimized results. This adjustment may counteract inherent biases or errors in the calculation process, thereby improving the data and graph. Based on the results, model 1 has 2.41% increases in average accuracy, model 2 has 1.23% increases, model 3 has 0.94% increases, while model 4 has 0.2% decreases in average accuracy. However, the average accuracy among all the vehicle increases by 1.1% showing an increase in accuracy and making the optimized outcomes acceptable. This comprehensive methodology provides a solid foundation for subsequent studies and assessments within the scope of the experiment.

Acknowledgement

The authors would like to thank the Centre for Diploma Studies, University Tun Hussein Onn Malaysia for its support.

Conflict of Interest

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

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Ooi Zi Quan, Tan Mu Xian, Ahmad Saufi Sujali;* ***data collection:*** *Ooi Zi Quan, Tan Mu Xian, Ahmad Saufi Sujali;* ***analysis and interpretation of results:*** *Ooi Zi Quan, Tan Mu Xian, Ahmad Saufi Sujali, Muhammad Azraie Abdul Kadir;* ***draft manuscript preparation:*** *Ooi Zi Quan, Tan Mu Xian, Ahmad Saufi Sujali All authors reviewed the results and approved the final version of the manuscript.*

References

[1] N.N. Kourgialas, G.P. Karatzas, "*Flood management and a GIS modelling method to assess flood- hazard areas-A case study,"* Hydrological Sciences Journal, vol. 56, no. 2, pp. 212- 225, Mar 2011.

[2] Z. Elias, Z. Hamin, M.B. Othman, "*Sustainable management of flood risks in Malaysia: Some lessons from the legislation in England and Wales*," Procedia-Social and Behavioral Sciences, vol. 105, no. 1, pp. 491-497, Dec 2013.

[3] C., Price, M. Kohn, E. Galanti, K. Lagouvardos, V. Kotroni, "*Nowcasting thunderstorms in the Mediterranean region using lightning data,*" Atmos. Res., vol. 100, no. 4, pp. 489–502, Jun 2011.

[4] T. R. Bhuiyan, A. C. Er, N. Muhamad, J. J. Pereira, "*Evaluating the cumulative costs of small-scale*

flash floods in Kuala Lumpur, Malaysia," Journal of Hydrology, vol. 612, pp. 128181, Sep 2022.

[5] A. Lavell, M. Oppenheimer, C. Diop, J. Hess, R. Lempert, J. Li, et al., "*Managing the risks of extreme events and disasters to advance climate change adaptation,*" A special report of working groups I and II of the intergovernmental panel on climate change (IPCC), vol. 3, pp. 25-64, 2012.

[6] G. Zheng, H. Zong, X. Zhuan, L. Wang, "*High-accuracy surfaceperceiving water level gauge with self-calibration for hydrography,"* IEEE Sens. J. vol. 10, no. 12, pp. 1893–1900, Aug 2009.

[7] K. Chetpattananondh, T. Tapoanoi, P. Phukpattaranont, N. Jindapetch, "*A selfcalibration water level measurement using an interdigital capacitive sensor,"* Sens. Actuators A, vol. 209, 175–182, March 2014.

[8] Z. Zhang, Y. Zhou, H. Liu, L. Zhang, H. Wang, "*Visual measurement of water level under complex illumination conditions*," Sensors, vol. 19, no. 19, pp. 4141, Sep 2019.

[9] Z. Zhang, Y. Zhou, H. Liu, H. Gao, "*In-situ water level measurement using NIRimaging video camera,"* Flow Meas. Instrum, vol. 67, pp. 95–106, Jun 2019.

[10] M. S. M. Osman, A. I. S. Rizal, A. Z. W. A. Zaini, M. A. A. Kadir, M. Kaamin, "*An alternative flood measurement approach: Flood Meter*," In IOP Conference Series: Earth and Environmental Science, vol. 1205, no. 1, pp. 012015, Jun 2023.