Web Crowdsourcing for Coastal Flood Prevention and Management

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Abstract. Coastal floods have been causing massive casualties and economic loss to human societies. To better understand and manage coastal floods, existing research has comprehensively studied their physical processes, but we still face the challenges of inaccurate predictions, insufficient information, and imprecise management. Web crowdsourcing has emerged as an effective tool to collect and leverage crowd intelligence. However, there is a research gap in terms of using web crowdsourcing to aid flood disaster prevention and management. Therefore, in this poster, we present a crowdsourcing design that uses various web applications and technologies, to improve flood prediction, collect necessary information, and help in management optimization.

1 Introduction

Coastal disasters, such as floods, storms, and tsunamis, can have extremely negative impacts on human beings living in coastal regions. People suffer from these disasters because we lack an understanding of their consequences. Since we cannot accurately predict their consequences and cannot comprehensively obtain social reactions, it is difficult to make precise management strategies for people in danger in response to the emergency. Therefore, for both research institutes and emergency departments, there is an urgent need for precisely predicting the disaster, collecting social information, and organizing scientific management.

Researchers have proposed plenty of ocean models to predict coastal floods and other ocean disasters [5, 2]. However, there are unaddressed challenges in terms of applying such models in supporting effective management during coastal flood disasters. We categorize the challenges into three aspects: 1) Inaccurate predictions. While state-of-the-art ocean models can produce accurate predictions in the ocean, the prediction of how they impact the land, particularly the coastal cities, needs to be corrected. Particularly, environmental factors could be more complex in cities and towns considering human activities. 2) Insufficient information. Even if ocean models can make accurate predictions, it is necessary to collect sufficient information in terms of the reaction of society, people's opinions, and physical/mental wellness. Such subjective data could play a dominant role in decision-making. 3) Imprecise management. Traditional management strategies

are not designed specifically for flood disasters. Therefore, they are usually costly and imprecise. A good management strategy should truly satisfy people's needs, and be optimized to reduce the casualty, economic loss, and waste of resources simultaneously.

We noticed that crowdsourcing, featuring high flexibility and scalability, shows great potential in aggregating human intelligence during disasters. To tackle the above-mentioned challenges, in this poster, we propose a crowdsourcing design to achieve three goals: 1) leveraging human intelligence to improve the state-of-the-art coastal flood models, 2) comprehensively collecting subjective information related to disasters, and 3) acquiring people's needs and accordingly optimizing management strategies. We anticipate that web crowdsourcing for coastal flood prevention and management will provide valuable insights in the future.

2 Crowdsourcing Framework Design

To address the challenges with regard to inaccurate predictions, insufficient information, and imprecise management respectively, we propose a framework integrating crowdsourced flood model improvement, social information collection, and management strategy optimization, as shown in Figure 1.

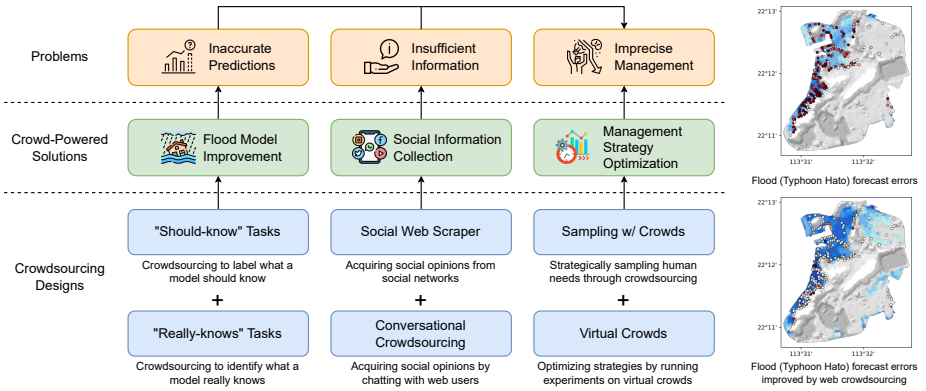

Fig. 1. An overview of the crowdsourcing framework. We also show an example of forecasts of the flood event induced by Typhoon Hato improved by web crowdsourcing [11].

Flood Model Improvement. Inspired by the previous crowdsourcing design [10], the flood model improvement method consists of two crowdsourcing tasks – the "should-know" task and the "really-knows" task. The "should-knows" task requires workers to label important elements that a flood disaster should particularly pay attention to (elements that could lead to bad model performances), on street-level imagery of disaster zones. The "really-knows" task asks

workers to make comparisons between model outputs with observational data, to understand what a model really knows and where it makes mistakes. Observational data can be acquired via mobile crowdsensing, which assigns data-collecting tasks to workers via mobile web applications. Furthermore, web-based crowd-mapping is an effective task design to let workers complete tasks remotely (not in the disaster regions) [8, 1]. Online workers can use map applications equipped with street-level imagery (e.g., Google Map), to acquire high-quality geographic/environmental information, so as to label important factors that the model should know or really knows. After "should-know" and "really-knows" tasks, we could understand why and where a flood prediction model makes mistakes. For different types of model drawbacks, the model could be improved through while-/gray-/black-box system identification methods, which are well-studied in the field of control science and cybernetics.

Social Information Collection. Social information collection uses crowdsourcing to acquire sufficient information from social media to assist in disaster management. Particularly, subjective social information such as perceived disaster risks, people's opinions, and their wellness could play an important role in disaster management [3]. Information could be collected from posts and comments on existing social applications such as Twitter and TikTok, by publishing crowdsourcing tasks to crowd workers, or by using AI scrapers. Conversational crowdsourcing is a feasible way to directly collect information related to disasters [7]. To collect such information, conversational agents could be applied to have task-oriented conversations with people either physically in disaster zones or remotely online. Such agents have been proven to be effective in making crowd workers more engaged in expressing their opinions [7]. The key is to design appropriate crowdsourcing microtasks or AI agents, to effectively collect data from various sources and detect malicious/fake information from crowds.

Management Strategy Optimization. In traditional ways, management strategies are usually made simply according to the decision-maker's subjective experience. We argue that the management of flood disasters needs to well reflect people's needs, and decisions need to be adequately optimized through computational experiments. To accurately understand the people's needs and the overall situation, we suggest that crowdsourcing-based sampling methods (e.g., Monte Carlo Markov Chain with people and Gibbs sampling with people) need to be carried out [9, 4], so as to estimate the risk of different coastal areas and to know the needs of local residents. To optimize management strategies, we highlight the importance of building a crowdsourcing simulation system [6]. Through iterative computational experiments with virtual crowds in a parallel artificial society [6, 12], prevention measures and management strategies could be optimized, to achieve minimum casualty and economic loss.

3 Conclusions

In this work, we show how crowdsourcing could assist in coastal flood prevention and management. Specifically, we provide a few web-based crowdsourcing

designs with regard to improving flood models, collecting flood-related social information, and optimizing management strategies.

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References

1. van Alphen, G., Qiu, S., Bozzon, A., Houben, G.J.: Analyzing workers performance in online mapping tasks across web, mobile, and virtual reality platforms. In: Proceedings of the AAAI Conference on Human Computation and Crowdsourcing. vol. 8, pp. 141–149 (2020)
2. Dong, W., Feng, Y., Chen, C., Wu, Z., Xu, D., Li, S., Xu, Q., Wang, L., Beardsley, R.C., Lin, H., et al.: Observational and modeling studies of oceanic responses and feedbacks to typhoons hato and mangkhut over the northern shelf of the south china sea. Progress in Oceanography **191**, 102507 (2021)
3. Gao, H., Barbier, G., Goolsby, R.: Harnessing the crowdsourcing power of social media for disaster relief. IEEE intelligent systems **26**(3), 10–14 (2011)
4. Harrison, P., Marjieh, R., Adolfi, F., van Rijn, P., Anglada-Tort, M., Tchernichovski, O., Larrouy-Maestri, P., Jacoby, N.: Gibbs sampling with people. In: Larochelle, H., Ranzato, M., Hadsell, R., Balcan, M., Lin, H. (eds.) Advances in Neural Information Processing Systems. vol. 33, pp. 10659–10671. Curran Associates, Inc. (2020)
5. Luettich, R.A., Westerink, J.J.: Formulation and numerical implementation of the 2D/3D ADCIRC finite element model version 44, vol. 20. R. Luettich Chapel Hill, NC, USA (2004)
6. Qiu, S., Bozzon, A., Houben, G.J.: Virtualcrowd: A simulation platform for microtask crowdsourcing campaigns. In: Companion Proceedings of the Web Conference 2020. p. 222–225. WWW '20, Association for Computing Machinery, New York, NY, USA (2020). https://doi.org/10.1145/3366424.3383546
7. Qiu, S., Gadiraju, U., Bozzon, A.: Improving worker engagement through conversational microtask crowdsourcing. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. pp. 1–12 (2020)
8. Qiu, S., Psyllidis, A., Bozzon, A., Houben, G.J.: Crowd-mapping urban objects from street-level imagery. In: The World Wide Web Conference. pp. 1521–1531 (2019)
9. Sanborn, A., Griffiths, T.: Markov chain monte carlo with people. In: Platt, J., Koller, D., Singer, Y., Roweis, S. (eds.) Advances in Neural Information Processing Systems. vol. 20. Curran Associates, Inc. (2007)
10. Sharifi Noorian, S., Qiu, S., Gadiraju, U., Yang, J., Bozzon, A.: What should you know? a human-in-the-loop approach to unknown unknowns characterization in image recognition. In: Proceedings of the ACM Web Conference 2022. pp. 882–892 (2022)
11. Wang, X., Dao, F., Ji, Y., Qiu, S., Zhu, X., Dong, W., Wang, H., Zhang, W., Zheng, X.: Crowdsourcing intelligence for improving disaster forecasts. The Innovation (2024)
12. Zhu, Z., Chen, B., Chen, H., Qiu, S., Fan, C., Zhao, Y., Guo, R., Ai, C., Liu, Z., Zhao, Z., Fang, L., Lu, X.: Strategy evaluation and optimization with an artificial society toward a pareto optimum. The Innovation **3**(5), 100274 (2022). https://doi.org/10.1016/j.xinn.2022.100274