The Development of SaaS for Quantifying the Amount of Drifted Debris on the Coast

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Abstract

In the process of collecting drifted debris along a coastal area, it has been required to quantify the collection results. This study introduced a Software as a Service (SaaS) equipped with image processing capabilities for the detection and identification of debris in photographs. The SaaS was developed to facilitate the automated weighing of the collected debris. In the beach cleanup event in June 2023, 317 images capturing debris found during the coastal cleanup were gathered on a cloud server from 90 participants via this SaaS. These images were subsequently analyzed by object recognition AI executed on a cloud server, leading to the detection and identification of 954 instances of debris. This result represents the actual amount of debris collected during this cleanup event, and indicates that the achievements of the event were quantified via the SaaS.

Keywords: Coastal environment, Cloud edge, SaaS, AWS

1. Introduction

The impact of marine debris is a global issue [1]. The familiar scenery of the beach can be destroyed by a large amount of debris drifting to the coast after being carried from urban areas through rivers. In Japan, an island nation surrounded by the sea, this is a significant problem that needs to be addressed as soon as possible. In recent years, much research has been conducted on quantifying the amount of beach-drifted debris. Especially, methods based on high-resolution images acquired from UAVs or satellites have been developed [2], [3], [4]. In both proposed methods, deep learning has been actively utilized, and certain results have been achieved for a local region of the beach. These methods can quantify the physical situation of the debris spread on the beach compared to human-powered methods. However, these image processing-based methods have not been implemented in an actual field. It is estimated that people engaged in cleanup tasks may not consider utilizing such technologies to improve the effectiveness of cleanup. Additionally, these latest technologies have not been widely disseminated to the public.

In this study, considering this situation, it is estimated that a system that can be used with already familiar devices is needed for non-engineers or general consumers participating in the quantifying work of debris. In other words, a method that can be completed with only a smartphone and its operation method is important to promote a quantitative understanding of waste. The performance of smartphones equipped with high-resolution cameras has been increasing year by year. Furthermore, the advancement of AI through cloud computing, which is a core technology in Digital Transformation (DX), has created a social situation where high-performance PCs are not needed for individuals. In this study, while utilizing image processing-based litter detection and identification methods similar to previous studies, an attempt has been made to widely establish the work of quantifying debris by developing a Software as a Service (SaaS) to provide users with functions related to image analysis and information collection on the cloud. Users are required to take a photo containing the debris found on the beach during the beach cleanup, and the identification process of the debris category and the quantification process for each category are completed on the cloud. The SaaS implemented with such functions has been developed. In this paper, to socially implement the proposed method, the verification results are reported.

2. Proposed method

2.1. *Beach debris quantifying though cloud service*

In this study, an application integrating AI and cloud services has been developed to facilitate the quantitative assessment of beach-drifted debris. Fig. 1 represents a use case of the application. Users of this application are participants in a beach cleanup event. Typically, they explore the beach, find debris, and pick it up. In the proposed method, users are expected to take a photo capturing the found debris. After finishing the cleanup work (or during the cleanup), these photos will be uploaded to cloud storage via the internet. Subsequently, the photos will be analyzed by AI upon upload. Finally, the information needed to quantify the debris, such as the type of debris and the quantity of each type, will be gathered as a database on the cloud. As for the expectation of this proposed method, the event that originally gathered labor to collect debris would transform into an initiative constructing a large-scale database focusing on the physical situation of the drifted debris. This database will be provided to the participants or organizers of the event, and it can be used for evaluating the results of the executed event or planning the schedule for the next event.

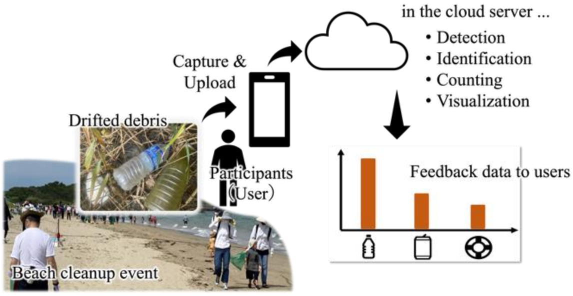

Fig. 1 Usecase of the application in the proposed method

2.2. *Design of the application*

To achieve the usecase as shown in Fig. 1, the application has been designed as follows:

- Users can upload images without depending on a specific location.
- The images will be uploaded to cloud storage and automatically analyzed by AI upon upload.
- AI detects all debris in the image, classifies them, and quantifies the number of each debris type. These results are then gathered in cloud storage for easy access.
- Users can review the data analyzed by AI through the application.

In this study, a web application with a graphical user interface (GUI) has been selected and developed to meet the previously specified requirements. Cloud storage and CPU resources on the cloud have been utilized to automate image processing. By leveraging cloud computing, a large amount of information about the debris can be collected through smartphones owned by individuals.

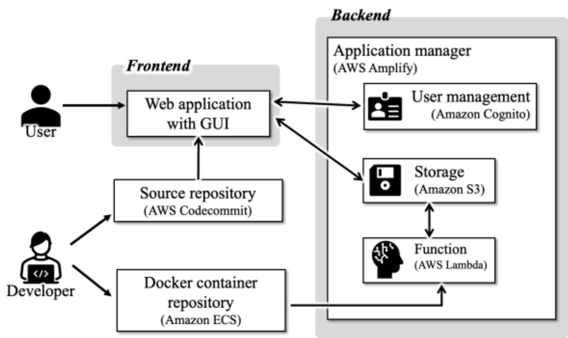

Fig. 2 The system structure and network resources

3. Developed web application

3.1. *Amazon Web Service (AWS)*

In developing the web application, Amazon Web Services (AWS) was chosen as the platform for constructing its network infrastructure. AWS, the cloud computing service provided by Amazon Web Services Inc., has been offering services, including network infrastructure. By integrating various services within AWS, the web application developer can rapidly create an application with extensibility and robustness.

3.2. *The system structure*

Fig. 2 shows the structure of the system (as the web application). As mentioned above, resources such as storage for data or image processing have been implemented by integrating services provided by AWS (e.g., AWS Amplify, S3, AWS Lambda, etc.). The system can be divided into two subsystems: a frontend and a backend. The frontend is software that can be executed on a web browser, essentially a web page including a GUI. The resources required to implement the functions of the application are referred to as the backend, and they exist on the cloud.

In this study, the frontend was designed as a web page with a file browser UI, allowing users to choose images and buttons to initiate the upload of the selected image. On the backend side, the implementation included (1) User identification and management functions, (2) The storage region on the cloud, and (3) Virtual CPU executing inferencing process. Particularly, the details of the inference processing are explained in the next section in this paper.

Fig. 3 Captured debris by user

Fig. 4 Example of detection and identification debris by the SaaS: Right side was identified “Styrofoam”. Left side was identified “Other plastics”.

3.3. *Inference process based on DNN*

In this study, a DNN-based inference is used to detect captured debris in an uploaded image and classify its category. In this process, *mmdetection* [5] was used as the DNN framework, and *Mask-RCNN* [6] was employed as the neural network architecture for detection of debris. And, *TACO dataset* [7], it is large dataset for garbage was utilized as the annotated data. In this study, the dataset was classified by eleven categories as below:

- Plastic bottle
- Can
- Glass
- Metal
- Tabaco
- Rubber
- Rope & String
- Styrofoam
- Paper
- Other plastics
- Others

Fig. 3 shows an example of input image including the actual beach-drifted debris, and Fig. 4 shows example of inference result of Fig. 3 image.

4. Experiment in actual environment

The developed system has been implemented in an actual beach cleanup event and verified. The event, held in June 2023 at Hokuto-mizukumi Park (Munakata, Fukuoka, Japan), aimed to have participants use the system. In this cleanup activity, approximately 70 individuals from 30 families participated, spending one hour cleaning up the beach. It is estimated that 30 to 40 smartphones were used to utilize the system. The participants were instructed to upload images capturing the found debris after finished the cleanup activity. The total number of gathered images was 317, and AI's identification processing detected 954 beach-drifted debris. Fig. 5 represents the numbers for each category of debris, with the majority falling under "Other plastics," including plastic fragments and buoys used in fisheries. As shown in Fig. 5, plastics were detected significantly more than other categories. Fig. 6 shows examples of results where debris identified as "Other plastics.". From these results, it was confirmed that:

- There were instances of misidentifying shells or colored natural objects as plastics.
- Single plastic objects were occasionally detected as multiple plastic objects.

So it will suggest (1) participants could easily spot plastics on the beach, leading to intensive collection, and

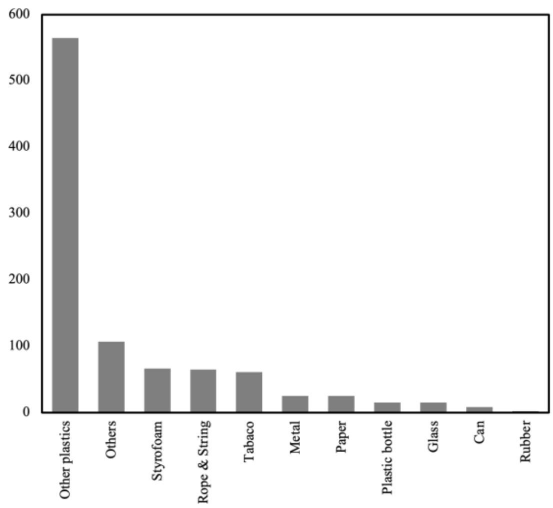

Fig. 5 The result of number of each category of detected debris

(2) to enhance object detection accuracy, reconstruction of the learning dataset for debris is necessary.

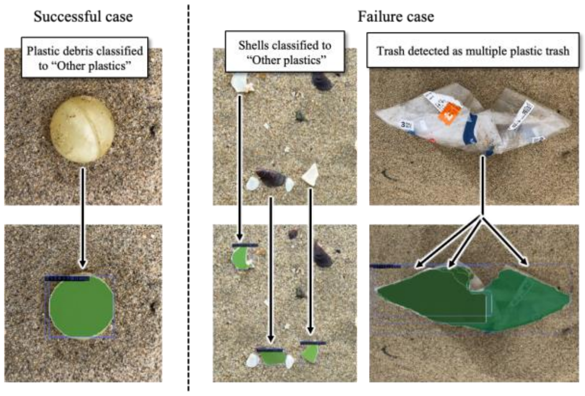

Fig. 6 Example of the input and detected "Other plastics"

5. Conclusion

In this study, a cloud service-based web application was developed to promote the quantification of beach-drifted debris. This web application, which can be used from a smartphone, aims to gather a large-scale beach debris dataset through beach cleanup events. One advantage of this proposal is that many people can easily participate in debris quantification work. In the case of experimental verification, the system successfully collected over 300 images capturing debris and detected over 900 debris with the participation of about 70 cleanup event participants. In the future, efforts will be made to enhance the usability of the application, making it less stressful for users. Additionally, long-term verification, spanning months or even years, will be conducted to address and improve the physical situation of beach-drifted debris.

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