An Estimation Method of Coastal Ocean Debris Using Aerial Drone

Kazuo Ishii
Dept. of Human Intelligence Systems, Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka, 808-0196, Japan
E-mail: ishii@brain.kyutech.ac.jp

Kanako Shirahashi
Center for Socio-Robotic Synthesis, Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka, 808-0196, Japan
E-mail: y-nishida@brain.kyutech.ac.jp

Yuya Nishida
Dept. of Human Intelligence Systems, Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka, 808-0196, Japan
E-mail: ishii@brain.kyutech.ac.jp

Moeko Tominaga
Department of Integrated Systems Engineering, Nishinippon Institute of Technology
1-11 Aratsu, Kanda, Miyako, Fukuoka 800-0349, Japan

Yoshiki Tanaka
Dept. of Human Intelligence Systems, Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka, 808-0196, Japan
E-mail: ishii@brain.kyutech.ac.jp

Dominic B. Solpico
Dept. of Human Intelligence Systems, Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka, 808-0196, Japan
E-mail: ishii@brain.kyutech.ac.jp

Abstract

The actual situation of marine litter has not been measured accurately; however innumerable floating garbage are drifting in the ocean. Especially, non-perishable waste such as microplastics continues to grow and is damaging marine life, including endangered species, and some are washed ashore and causing pollution damage to coastal areas. Microplastics incorporated into marine organisms, Arctic Sea ice, and deep-sea seafloor sediments have also been detected. The Ellen MacArthur Foundation in the United Kingdom estimates that the total amount of marine debris exceeds 150 million tons, with more than 8 million tons of new inflow each year. We measured and compared the amount of ocean debris in coasts in Hirado and Matsuura cities, Nagasaki with manual count and an aerial drone observation.

Keywords: Ocean debris, Arial drone, Coastal cleaning

1. Introduction

United Nations had announced A/RES/70/1, Resolution adopted by the General Assembly on 2015 [1] on 17 Sustainable Development Goals (SDGs) with 169 associated targets which are integrated and indivisible to encourage world leaders pledged common actions into a broad and universal policy agenda. UN showed the path towards "sustainable development, devoting ourselves collectively to the pursuit of global development and of "win-win" cooperation which can bring huge gains to all countries and all parts of the world". In the 17 SDGs, the goal 14 describes on conserve and sustainably use of oceans, seas and marine resources for sustainable development. The goal 14.1 is set to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution by 2025, and the goal 14.2 is set to sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans by 2020.

In the G20 Osaka Leaders' Declaration [2], the meeting mentioned the importance of measures to address marine litter, especially marine plastic litter and microplastics, necessity to be taken nationally and internationally in order to encourages to swiftly take appropriate national actions for the prevention and significant reduction of discharges of plastic litter and microplastics to the oceans. as a common global vision, Japanese government proposed the "Osaka Blue Ocean Vision [3]" that aims to reduce additional pollution by marine plastic litter to zero by 2050 through a comprehensive life-cycle approach, which includes reducing the discharge of mismanaged plastic litter by improved waste management and innovative solutions while recognizing the important role of plastics for society.

Toward the "Osaka Bule Ocean Vision", Ministry of Foreign Affairs of Japan established an association, Japan's MARINE Initiative [4] to advance effective actions to combat marine plastic litter at a global scale focusing on **Ma**nagement of wastes, **R**ecovery of marine litter, **In**novation, and **E**mpowerment. Under the MARINE initiative, Japanese government started to support empowerment in developing countries to promote waste management, recovery of marine litter, and innovation.

As grass-roots movements, many researchers and groups have been working on the study of quantitative and qualitative observation of marine litters on coasts. Yamaguchi has investigated the marine litters quantitatively in a lot of Japanese coasts for long time [5]-[7]. In ref. [7], Yamaguchi discussed on the actual situation of coastal pollution by the drifted garbage in the Japan Island. They performed investigations of coastal environment at a large number of seashores in the Sakishima Is. (Okinawa), Honshu and Hokkaido districts, and counted the number of garbage drifted in seashore was counted, and the garbage was also categorized according to its type and nationality. It was pointed out that the problem of coastal pollution by the drifted garbage was a serious problem of environment in Japan and strongly requested both the prevention measure and the disposition method of the drifted garbage. And also they proposed a measurement method to quantitate the mount of microplastic on coast by sampling coastal soils.

We had started the investigations of marine litters in a coast of Matsuura city (Fig.1, Coast (A) and (B)) and Hirado city (Fig.1, Coast (C)) using aerial a drone and compared with sampling, and report the results of the survey in this paper.

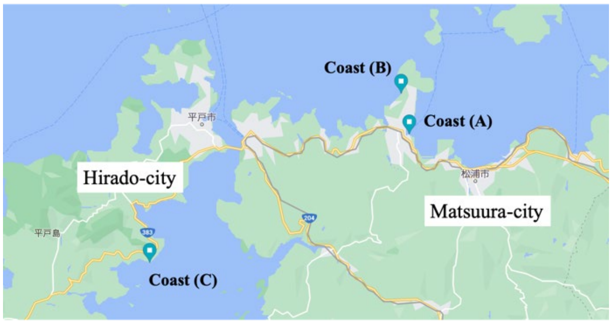


Fig. 1 The target coasts in Nagasaki, Kyushu Island. Coasts (A) and (B) are in Matsuura city and Coast (C) is in Hirado city. The coasts (A) and (B) direct for north direction, and coast (C) for south east. The basic map is from Google map.

2. Investigation of marine litter

2.1. *Coast of Matsuura city: Coast (A)*

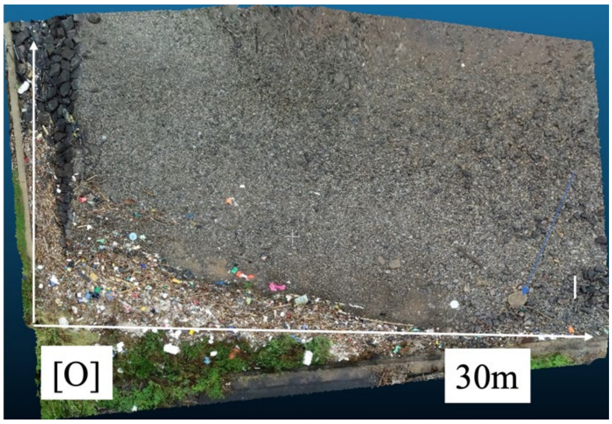
The first investigation of the target coast in Matsuura city: coast (A) in Fig.1 was performed on September 2020. The coast (A) is open for north direction and the garbage is drifting from Asian countries, especially a large amount of marine litter arrives in winter seasons. As shown in the photo of coast (A) in Fig. 2, the coast was covered by a large amount of garbage with many color and shape variations.

Firstly, the process to generate coastal map is introduced using Fig. 3. In this observation, a drone took a video from air, then the video is divided to 70 pictures so as to overlap 90% of each other of continuous pictures (Fig. 3(a)). The series of pictures are converged to a 3D-model (Fig. 3(b)) using Metashape v1.7 from Agisoft [8]. Agisoft Metashape [8] is a software product that performs photogrammetric processing of digital images and generates 3D spatial data to be used in GIS applications, cultural heritage documentation, and visual effects production as well as for indirect measurements of objects of various scales. The software calculates the feature points, generates a point cloud, make meshes and texture maps in 3D and its orthomosaic image. In the Fig. 3(b), we can see the stone area, garbage's area and walls with height in 3D. After the generation of 3D models, a free software CloudCompare [9] is used to evaluate and compare the maps. CloudCompare is a 3D point cloud

Fig. 2 The photo of coast (A) in Matsuura city, Sep./15th/2020. A large amount of marine litter arrived on the coast.

were used for the area of about 40m x 20m.

(b) The 3D-model of coast (A) using a software "Metashape" of Agisoft,.



(c) The obtained 3D model is adjusted using a free software CloudCompare based on reference points.

Fig. 3 The map of coast (A) is generated based on pictures obtain by a drone. To merge the pictures, a software Metashaps and CloudCompare are used.

(and triangular mesh) processing software, which has been originally designed to perform comparison between two dense 3D points clouds or between a point cloud and a triangular mesh. It relies on a specific octree structure dedicated to this task, and extended to a more generic point cloud processing software, including many advanced algorithms such as registration, resampling, color/normal/scalar fields handling, statistics computation, sensor management, interactive or automatic segmentation, display enhancement and so on.

Figure 4 shows an example of analysis using CloudCompare. The height from the plain surface which is based on stone area is visualized by colors. The marine litter drifted and mounted on the red-colored area. The 3D models are adjusted in the sizes, translation and angles of rotation transform matrix. Figure 5 is the 3D model after garbage clean up. By comparing the models of Fig. 3(c) and Fig. 5, the change of volume is estimated.

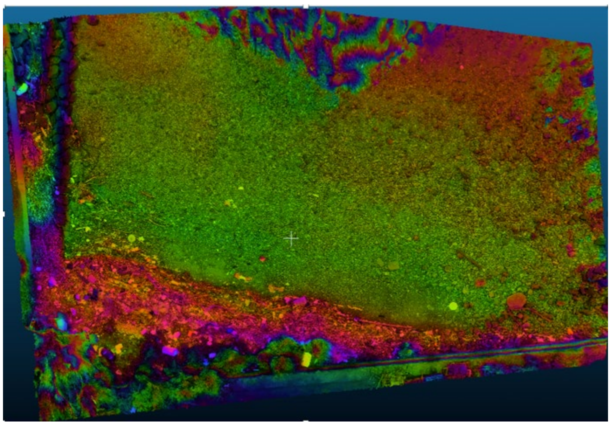


Fig. 4 An example of analysis using CloudCompare. The height from the plain surface is visualized by colors. The marine litter drifted and mounted on the red-colored area.

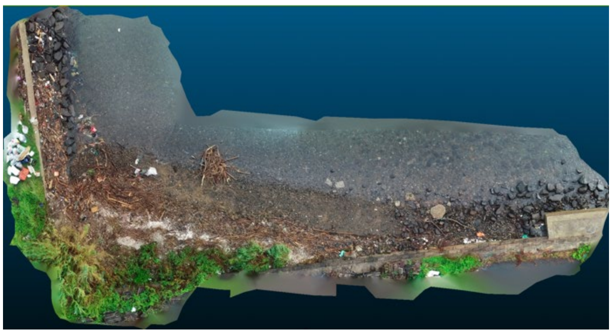


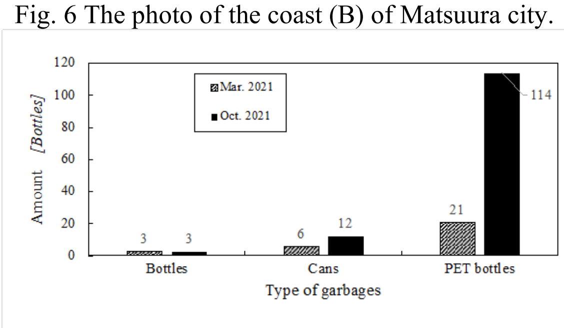
Fig. 5 The 3D model after clean up the coast. By comparing with the model in Fig. 3, the volume difference can be estimated.

This kind of analysis is utilized in the research of civil engineering to compare the soil volume and change after constructions [10].

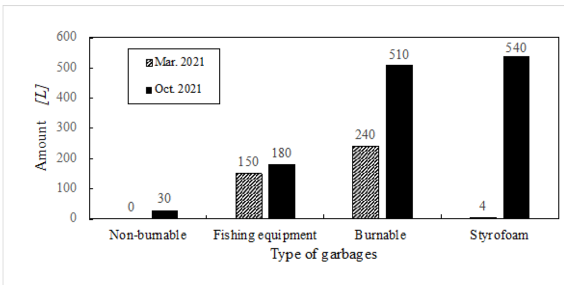
2.2. *Coast of Matsuura city: Coast (B)*

Figure 6 the photo of the target coast (B) in Matsuura city. We set 3 areas with 10m x 10m square and removed marine litters and count the number of bottles, plastics, fisher tools, Styrofoam. The left bars are results in the

Fig. 6 The photo of the coast (B) of Matsuura city.



(a) Amount of bottles



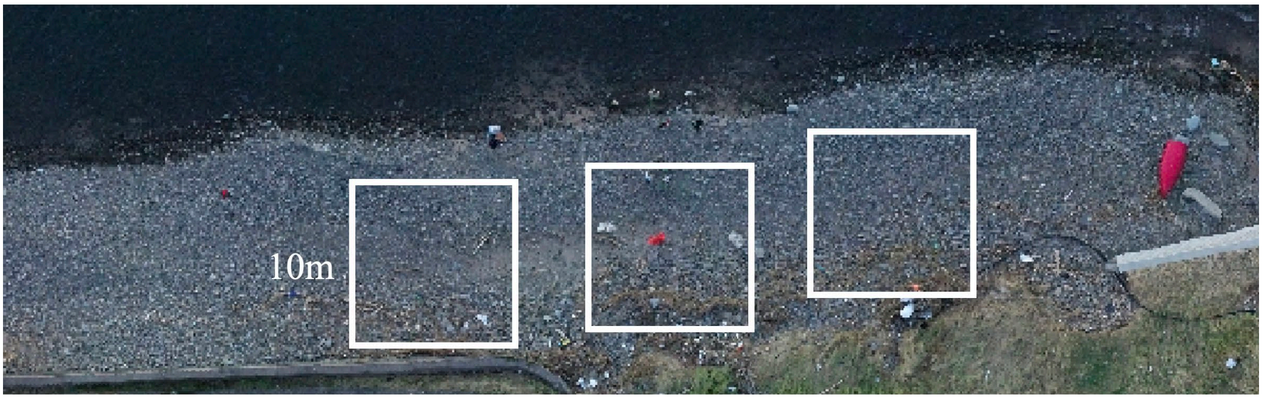
(b) Other garbage

Fig. 7 Types of bottled garbage washed ashore on the coast of Matsuura

March 2021 and the right October 2021. Figure 7(a) shows the numbers by categorizing bottles, cans and pet bottles and (b) are the non-burnable garbage, fishing equipment, burnable garbage, and Styrofoam measured in volume [L].

2.3. *Coast of Hirado city: Coast (C)*

The target coast (C) in Hirado city was also recorded by a drone and the 3D models before and after clean up are compared using the same software. The marine litter is measured in the 3 square areas by 10m x 10m in sizes. Comparing with the coasts of Matsuura city, the coast (C)



(a) Before clean up the coast

(b) After clean up the coast

Fig. 8 The photo of the coast (C) of Hirado city.

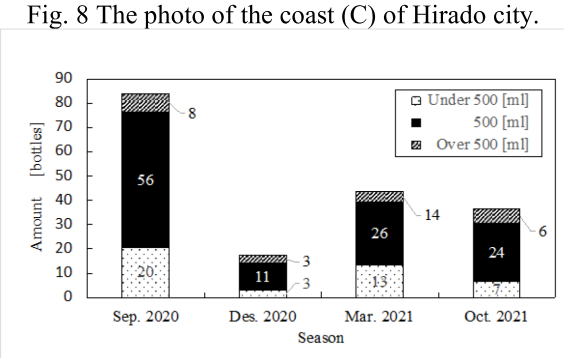


Fig. 9 Types of marine litter in the coast (C) Hirado city. The survey on Sep./2020 was after the typhoon, so that a large amount of garbage was on the coast.

directs in south east and the amount of marine litter is fewer than those of (A) and (B). Figure 8 shows the 3D models for comparison before and after clean up the coast.

3. Conclusions

We had started the investigations of marine litters in the coasts of Matsuura city and Hirado city using an aerial drone and compared with manual sampling. In order to make garbage maps of the coasts, we introduced the drone and measured the coast from air, and made 3D models using the software Metashape and CloudCompare. Japan is surrounded by ocean and huge amount of marine litter has arrived on the coasts. We should develop methods to visualize, digitize and quantilize the conditions of marine pollution.

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4. References

1. Resolution adopted by the General Assembly on 25 September 2015, United Nations A/RES/70/1, 2015.
2. G20 Osaka Leaders' Declaration, on 28-29 June 2019.
3. Toward Osaka Blue Ocean Vision, https://g20mpl.org in Jan. 20th/2022.
4. Japan's "MARINE Initiative" toward Realization of the Osaka Blue Ocean Vision, https://www.mofa.go.jp/ic/ge/page25e_000317.html in Jan. 20th/2022
5. Hareyuki YAMAGUCHI, Coastal Pollution by Foreign Drifted Gabages, JSCE, Vol.83 (3), pp.60-62, 1998
6. Yamaguchi, H., Pongpo, Thunyawit, "Coastal Pollution by Drifted Garbage in Japan Island, Proceedings of the Symposium on Global Environment, 2000, Volume 8, Pages 111-120, 2011 (in Japanese)
7. Yamaguchi, H., "A large amount of microplastics verified in coastal areas where microplastic pollution is becoming more serious ",Proceedings of the 25th Symposium of Global Environment, pp.23-28, 2017 (in Japanese)
8. Metashape, https://www.agisoft.com
9. CloudCompare, http://www.cloudcompare.org
10. Lague, D., Brodu, N. and Leroux, J., "Accurate 3D comparison of complex topography with terrestrial laser scanner: Application to the Rangitikei canyon (N-Z)," ISPRE Journal of Photogrammetry and Remote Sensing, 82, pp. 10-26, 2013.

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Authors Introduction

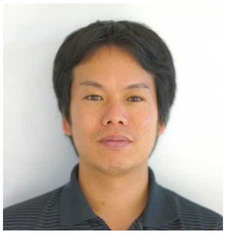
Prof. Kazuo Ishii

He is currently a Professor at the Department of Human Intelligence Systems of Kyushu Institute of Technology, Japan. He obtained his M. S. degree in 1993 and his D. Eng. degree in 1996 at The University of Tokyo. His research interests are in the fields of Underwater Robotics, Field Robotics, Neural Networks and Intelligent Systems.

Ms. Kanako Shirahashi

She belongs to the Center for Socio-Robotic Synthesis (CSRS), Kyushu Institute of Technology. She supports and manages the projects of CSRS, such as Tomato-Harvesting Robot Cometition, Underwater Robot Comepition, Ksrp Ekiden Tournament. Etc.

Dr. Yuya Nishida



He is an Associate Professor at Graduate School of Life Science and System Engineering, Kyushu Institute of Technology, Japan. His research area is about filed robotics, its application, and data processing.

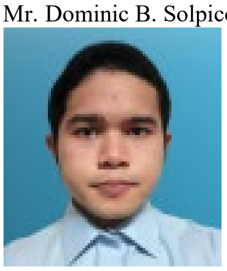
Dr. Moeko Tominaga

She received Ph.D. degree from Kyushu Institute of Technology, Japan in 2021 and now she is working as an Assistant Professor at Nishinippon Institute of Technology, in Japan. Her research area is about robotics and machine learning. In particular, she is interested in inter-agent cooperation in multi-agent systems.

Mr. Yoshiki Tanaka

He received his master's degree from Department of Human Intelligence Systems, Kyushu Institute of Technology, Japan, in 2019. He is pursuing the PhD at Kyushu Institute of Technology, Department of Life and Systems Engineering, under the supervision of Prof. Kazuo Ishii. His research area is underwater robots, its application.

Mr. Dominic B. Solpico



Mr. Solpico obtained his M. S. degree in Electronics Engineering at the Ateneo de Manila University, Philippines in 2015. He is currently taking his Doctoral degree course at Kyushu Institute of Technology, Japan. His research interests are in the fields of Intelligent Aquaculture, Wireless Sensor Networks (WSNs), and Field Robotics.