Simplification of Rip Current Detection by Image Averaging Based on the Number of Wave Breaks

Ota Hamasuna[1], Leona Kimura[1], Satoshi Ikeda[1], Kaoru Ohe[1], Kenji Aoki[1], Amane Takei[1], Akihiro Kudo[2], Makoto Sakamoto[1*]
([1]Graduate School of Engineering, University of Miyazaki, Japan),
([2]National Institute of Technology, Tomakomai College, Japan)
[*]Corresponding Author
Email: saka2000@cc.miyazaki-u.ac.jp

Abstract

According to a National Police Agency report, there were 1,392 water accidents in 2023, with 368 victims (dead or missing) in the sea, mainly due to rip currents. Detecting rip currents is crucial, and past studies have used image averaging, often relying on fixed-point cameras or lengthy videos, making it difficult for individuals to apply. This study proposes using smartphone videos, with durations adjusted by the number of wave breaks, to enable easier rip current detection. To test this, smartphone footage was recorded at Hitotsuba Surf Point in Miyazaki Prefecture for analysis.

Keywords: Rip current, image averaging, image processing, wave breaking, SSIM

1. Introduction

According to a National Police Agency report [1], there were 1,392 water accidents in 2023, with 743 fatalities or missing persons. Furthermore, out of those 743 individuals, 368 were involved in water accidents at sea, with rip currents identified as a primary cause. In fact, in the author's hometown of Miyazaki Prefecture, an incident occurred on February 8, 2024, where a high school student was swept approximately 10 meters offshore at the Kaeda River mouth and drowned. Therefore, it is considered necessary to develop a system for detecting and visualizing rip currents. In addition, detecting and visualizing rip currents can provide benefits, such as helping anglers like the author find good casting points.

And as a method for detecting rip currents, "image averaging" is well-known (Fig. 1). This is a method for visualizing rip currents by converting video footage of the coastline into a sequence of images and averaging them into a single image. In previous studies, this method has been commonly used. However, most of them involve the use of fixed-point cameras or analyses that take a long time, which come with various constraints. Therefore, the purpose of this study is to propose a method that reduces the analysis time while also changing the video source from fixed-point cameras to handheld smartphone videos, enabling individuals to easily detect rip currents in various locations.

2. Rip Currents to Detect

Most previous studies have required long analysis times for image averaging. However, in the study by Shimada et al., "Investigation of Suitable Analysis Period of Time for Image Averaging to Detect Rip Current" [2], it was found that sudden rip currents can be detected in as little as 1 minute. Therefore, this study will focus on detecting these suddenly occurring rip currents.

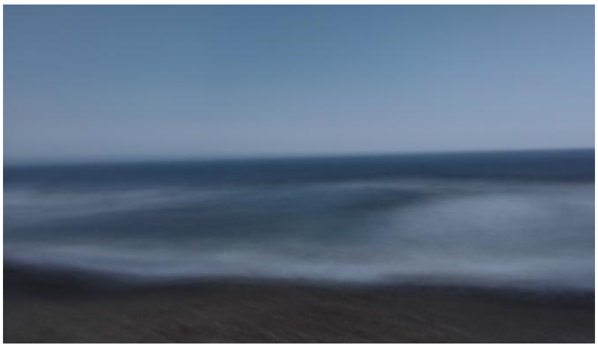
3. Proposed Method

We know that detection in 1 minute is possible through the work of Shimada et al. However, since the velocity of rip currents can reach 2 meters per second and we are assuming the use of hand-held videos from smart phones rather than fixed-point cameras, a shorter analysis time is required. Therefore, we propose a method to shorten the analysis time by using the number of wave breakings as the basis for the video used for image averaging, instead of simple time.

This proposal is based on the principle of detecting rip currents through image averaging. The reason why rip currents can be detected using image averaging lies in the characteristic that rip currents are less likely to cause wave breaking in the areas where they occur. When wave breaking does not occur, whitecaps are absent, and as a result, the pixel values in those areas become lower compared to the wave-breaking zones when image averaging is applied, creating vertical dark streaks (Fig. 2). Therefore, the number of wave breakings significantly impacts the results of image averaging. Based on this, we hypothesized that by setting the

Fig.1 Image averaging

analysis time according to the number of wave breakings, faster wave speeds could allow for shorter analysis times.



a. With rip current

b. Without rip current

Fig.2 Differences in the results of image averaging

4. Experiment

4.1. *Observation Sites and Dates*

Observations were conducted at the Hitotsuba Surf Point in Miyazaki Prefecture. This location is a high-risk area for water accidents, with frequent occurrences of rip currents (Fig. 3).

Observations were conducted a total of 108 times over four days, November 1st, 3rd, 5th, and 9th, 2024, regardless of the presence or absence of rip currents.

Fig.3 Hitotsuba Surf Point

4.2. *Experimental Environment*

The experimental environment is as shown in Table 1.

Table 1. Experimental environment

Smartphone	Redmi Note 10T
Handheld video	width : 1280px height : 720px fps : 30
Programming language	Python
Library	OpenCV
Program	convert.py : Video-to-Image Conversion ave.py : Image Averaging
Laptop	LAPTOP-LRONCBM2 OS : Windows 10

4.3. *Experimental Method and Evaluation Method*

A one-minute video was recorded at various points in the Hitotsuba Surf Point a total of 108 times. Afterward, each video was divided based on the number of wave breakings, and image averaging was performed on each segment.

The evaluation method utilized SSIM (Structural Similarity Index Measure) (Eq. (1) and (2)). The SSIM guidelines are established by JIMA (Japan Internet Media Association) [3]. The guidelines are shown in Table 2.

$$\mathrm{SSIM}(x,y)=\frac{(2\mu_x\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_x^2+\sigma_y^2+C_2)} \quad (1)$$

$$\underset{\text{Mean}}{\overset{\text{Luminance}}{\frac{2\mu_x\mu_y+C_1}{\mu_x^2+\mu_y^2+C_1}}} \times \underset{\text{Standard Deviation}}{\overset{\text{Contrast}}{\frac{2\sigma_x\sigma_y+C_2}{\sigma_x^2+\sigma_y^2+C_2}}} \times \underset{\text{Covariance}}{\overset{\text{Structure}}{\frac{\sigma_{xy}+C_2/2}{\sigma_x\sigma_y+C_2/2}}} \quad (2)$$

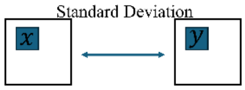


Table 2. Guidelines for SSIM

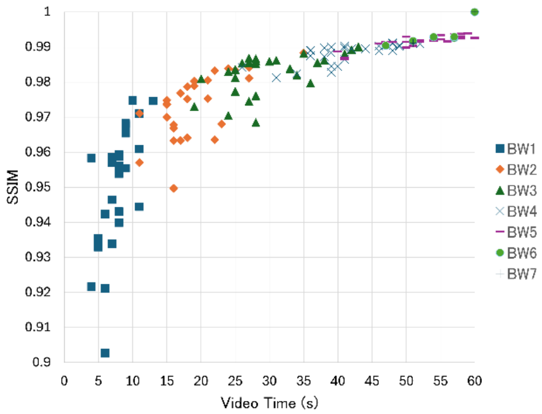
SSIM	Subjective Evaluation
0.98 ~	The original image and the compressed image are indistinguishable.
0.90 ~ 0.98	The degradation is noticeable when zoomed in.
~ 0.90	The degradation is clearly noticeable.

In this study, we aim to conclude with the number of wave breakings that reached a value close to 0.98.

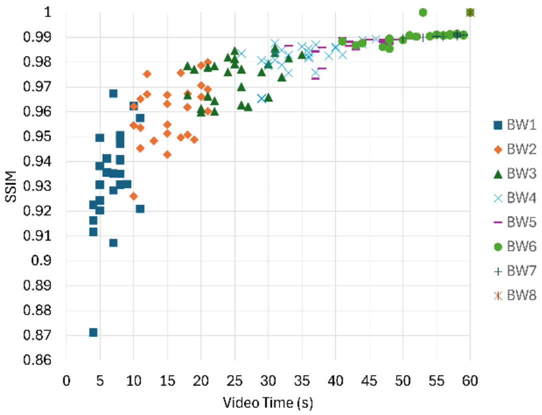
5. Results and Discussion

5.1. *SSIM Results for 108 Observations*

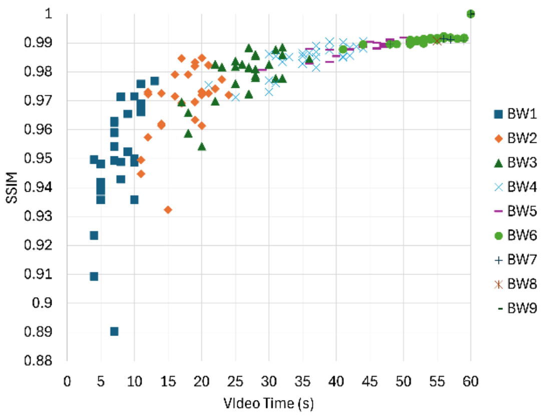
The results of 108 observations are shown in Fig. 4.



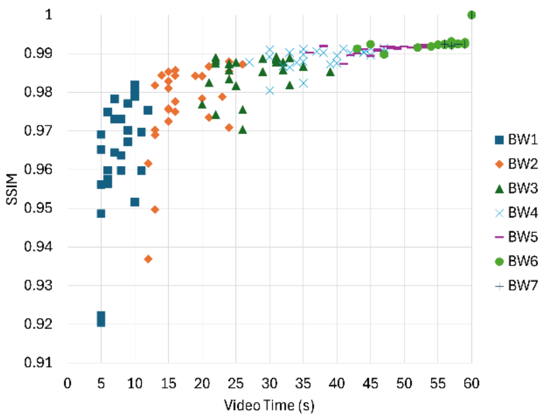
a. 2024/11/01



b. 2024/11/03



c. 2024/11/05



d. 2024/11/09

Fig.4 SSIM results

Fig. 4 a-d , it can be seen that the SSIM approaches 0.98 when the wave breaking count is 4. The average video duration for 4 wave breakings on November 1, 2024, was 41.2 seconds. Similarly, on November 3, 2024, the average video duration was 34.9 seconds, on November 5, 2024, it was 35.9 seconds, and on November 9, 2024, it was 38.1 seconds. And the total average duration was 37.5 seconds. This means a reduction of about 22 seconds compared to the conventional method.

5.2. *Results for Rip Currents Only*

The results based only on images showing rip currents among the 108 observations are shown in Fig. 5. There were 31 images that showed rip currents.

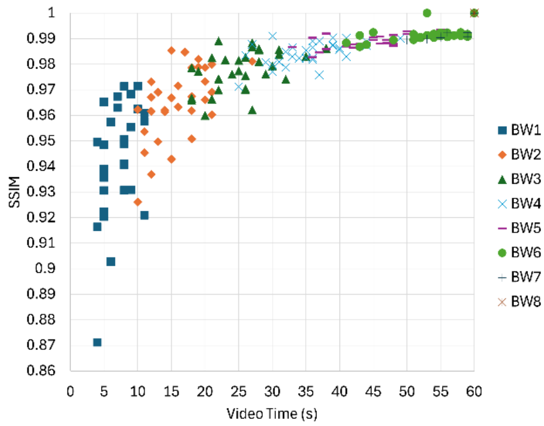


Fig.5 Rip currents only

The results for rip currents only, as shown in Fig. 5, also indicate that the SSIM approaches 0.98 when the wave breaking count is 4. And the average video duration for a wave breaking count of 4 was 35.4 seconds. This means a reduction of about 24 seconds compared to the conventional method.

6. Conclusion

We proposed a rip current detection method using image averaging with videos based on the number of wave breakings. As a result of 108 observations and experiments conducted at Hitotsuba Surf Point, it was found that the results obtained with 4 wave breakings were nearly equivalent to those obtained using the conventional 1-minute method. When considering the video duration, this method allows for a time reduction of approximately 22 to 24 seconds.

Appendix

The author is an angler. In this study, the points where rip currents were detected were recorded, and fishing was conducted around those points. Although the conditions were different, the catch was 2.4 times higher compared to last year. In particular, I was able to catch fish-eaters such as flatfish (Fig. 6) and Lateolabrax latus (Fig. 7). Rip currents tend to gather bait in their vicinity, making it an ideal casting point. Detecting rip currents can provide such benefits as well.

Fig.6 Flatfish

Fig.7 Lateolabrax latus

References

1. National Police Agency, "令和 5 年における水難の概況等"[online](accessed:2024/12/22).
2. R. Shimada, T. Ishikawa and T. Komine, "Investigation of Suitable Analysis Period of Time for Image Averaging to Detect Rip Current", Journal of Japan Society of Civil Engineers Ser B2, vol. 76, no.2 pp.I_1339-I_1344, 2020.
3. JIMA, "電子化文書の画像圧縮ガイドライン"[online] (accessed:2024/12/22)

Authors Introduction

Mr. Ota Hamasuna

He is a master student at Department of Computer Science and System Engineering, University of Miyazaki. His current research interests are rip currents, augmented reality, computer graphics, and so on.

Ms. Leona Kimura

She is a master student at Department of Computer Science and System Engineering, University of Miyazaki. His current research interests are image processing, machine learning, and so on.

Dr. Satoshi Ikeda

He received PhD degree from Hiroshima University. He is an associate professor in the Faculty of Engineering, University of Miyazaki. His research interest includes graph theory, probabilistic algorithm, fractal geometry and measure theory.

Prof. Kaoru Ohe

She received her Ph.D. degrees from University of Miyazaki, Japan, in 2014. Currently she is an Associate Professor of the Center for Science and Engineering Education, Faculty of Engineering. Her research is separation engineering especially adsorption hazardous heavy metals and oxyanions

Dr. Kenji Aoki

He received Ph.D. of Engineering from Kagoshima University in 2010. He is currently working in Information Technology Center at University of Miyazaki as Associate Professor, since 2010. His research interests include bio-informatics, evolutionary computation, information system and Intelligent systems. He is a member of IPSJ and JSET.

Dr. Amane Takei

He is working as a professor for Department of Electrical and systems Engineering, University of Miyazaki. His research interest includes high performance computing for computational electromagnetism, iterative methods for the solution of sparse linear systems, domain decomposition methods for large-scale problems. Prof. Takei is a member of IEEE, an expert advisor of IEIC, a delegate of Kyushu branch of IEEJ, a director of JSST.

Prof. Akihiro Kudo

He received Ph.D. degree from Nagaoka University of Technology He is a professor in the Department of engineering for innovation , National Institute of Technology, Tomakomai college. He is a member of Acoustical society of Japan, Information and Communication Engineers (IEICE).

Prof. Makoto Sakamoto

He is presently a professor in the Faculty of Engineering, University of Miyazaki. His first interests lay in hydrodynamics and time series analysis, especially the directional wave spectrum. He is a theoretical computer scientist, and his current main research interests are automata theory, languages and computation. He is also interested in digital geometry, digital image processing, computer vision, computer graphics, etc.