

## DYNAMIC FLOW MEASUREMENT TO MONITOR THE BEHAVIOR OF RIVER SURFACE

*Taiki Tomoo, Shigeru Takayama,*

Department of Electrical & Electronic Engineering, Science & engineering  
 Ritsumeikan University, BKC, Shiga, JAPAN, [re006076@ed.ritsumei.ac.jp](mailto:re006076@ed.ritsumei.ac.jp)

**Abstract:** This paper shows the monitoring system of dynamic state of river surface by using video image. The dynamic state is estimated by the flow speed and direction of micro blocks distinguished evenly on a frame of video. By the dynamic state of river surface, water behavior and dangerous area will be distinguished. Aim of this study is to clear the dangerous area, presume disasters, inform them to local/national government and alarm them to people.

**Keywords:** River surface, Disaster monitoring, Image processing.

### 1. INTRODUCTION

Every year, Japanese people have faced many kinds of natural disasters (landslide, muddy river flow) caused by heavy rain and typhoon. They have taken many lives and damaged our life infrastructure which are traffic routes, private houses, public facilities, energy network and food supply. Water damage by heavy rain and typhoon is the most careful disaster for the people who live at around river. The present observation system for a river should proceed to the site by the person and observes or make the river touch directly by the measurement hardware. However, there cause accident and the measurement hardware due to swelling of a river are damaged, and the loss. It is high concern for the people to know the dynamic state of river surface by using video image. The dynamic state is estimated by the flow speed and direction of micro blocks distinguished evenly on a frame of video. By the dynamic state of river surface, water behaviour and dangerous area will be distinguished. Aim of this study is to clear the dangerous area, presume disasters, inform them to local/national government and alarm those people.

### 2. MEASUREMENT SYSTEM FOR MONITORING DYNAMIC STATE OF RIVER SURFACE

Fig.1 and Fig.2 shows the measurement system to monitor dynamic state of river surface. The situation of river has been recorded by video camera. Extracts frame images by every 7 frames image. After distinguished each select frame image evenly with small square areas, the set of image segments on each select frame image is formed. An image segment is ROI (Region of Interest). (Fig.1) By comparing a ROI with neighbour segment, flow speed and

direction have been estimated. Fig.2 shows the image frame noted them. Color bar shows the flow speed level. Color circle shows the flow direction of ROI.

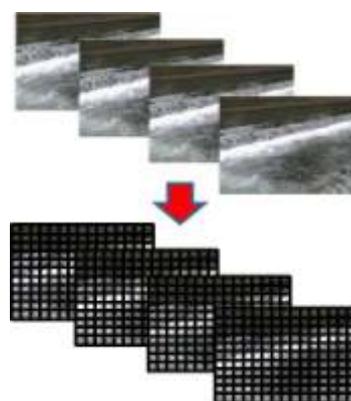


Fig.1 Segmentation of differential image calculated from series of image frame

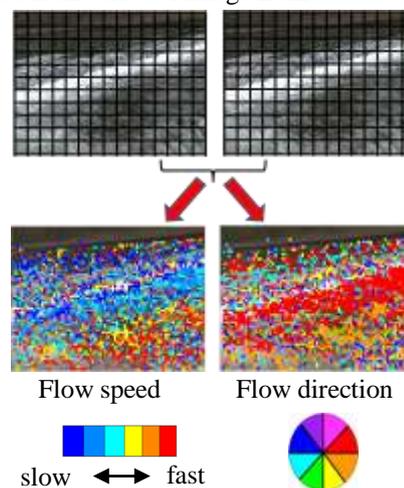


Fig.2 Notation of flow speed and direction on a differential image frame.

Fig.3 shows the determination method of flow speed and direction. The block by which the luminosity value matched the original block most is looked for from the search range of 9 blocks of circumferences obtained from the picture of seven frames after. Original block and most match block are connected with a line, and a vector is acquired. The vector length shows flow speed. The vector angle shows flow direction. These are denoted by a color, respectively. Table.1

shows direction to color conversion. The flow chart of flow speed and direction observation processing is shown in Fig.4.

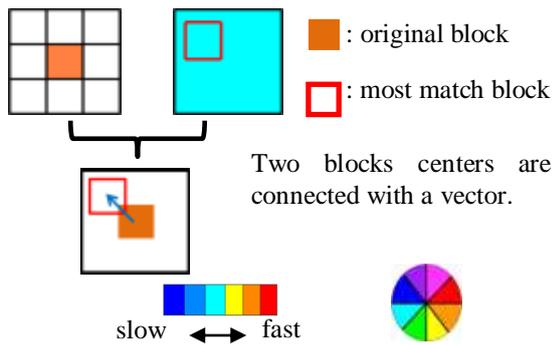


Fig.3 the determination method of flow speed and flow direction

Table.1 direction to color conversion table

- direction: 0 to +45 [degree]
- direction: +45 to +90 [degree]
- direction: +90 to +135 [degree]
- direction: +135 to +180 [degree]
- direction: 0 to -45 [degree]
- direction: -45 to -90 [degree]
- direction: -90 to -135 [degree]
- direction: -135 to -180 [degree]

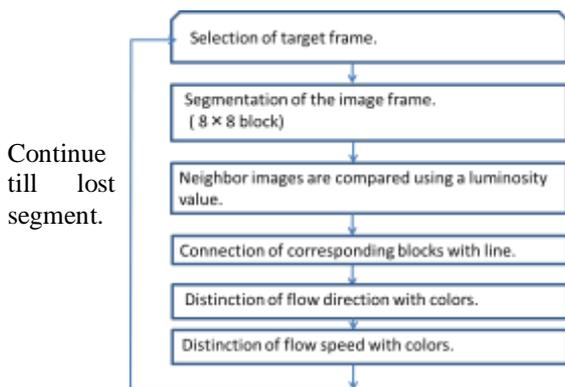


Fig.4 Flow chart of content of flow speed and direction observation processing

Next search turbulent flow blocks using flow direction. First a number is assigned all blocks according to a direction. (Fig.5) 0 is assigned to the block without a direction.



Fig.5 Flow direction corresponding to a number

Second compares with 9 blocks of circumferences of the seven frames ago and frame under processing. Same flow direction block, flow direction of the adjacent range in color circle block and non-flow direction block are judged not leading to a turbulent flow blocks. Other flow direction blocks are judged leading to a turbulent flow blocks. When a number of leading to a turbulent flow blocks are five or

more, in the center block of the frame under processing, it is judged that the turbulent flow has occurred. (Fig.6)

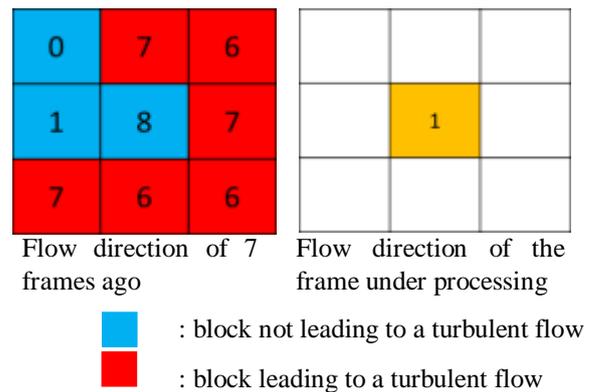


Fig.6 The example of a turbulent flow judging

After by combines flow speed data and turbulent flow direction data, dangerous level and blocks have been estimated. (fig.7) The block in which it is fast flow speed and the turbulent flow has occurred judges it as dangerous level high, and it smears it away red. The block in which it is fast flow speed and the turbulent flow has not occurred judges it as dangerous level middle, and it smears it away orange. The block in which it is slow flow speed and the turbulent flow has occurred judges it as dangerous level low, and it smears it away green. The block in which it is slow flow speed and the turbulent flow has not occurred judges it as dangerous level nothing, and it not smears it away. The flow chart of dangerous level and blocks have been estimated processing is shown in Fig.8.

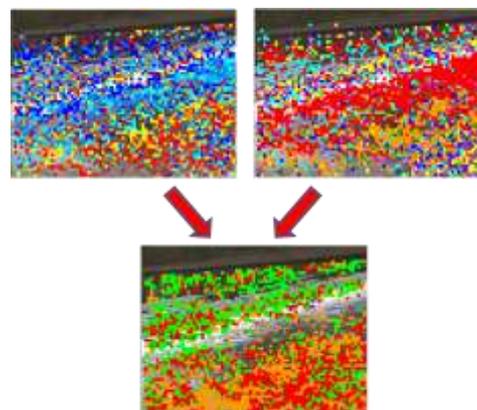


Fig.7 Estimate to dangerous block and level using by flow speed data and turbulent flow data.

Table.2 Dangerous level conversion table

	High speed	Low speed
turbulent flow	High	middle
orderly flow	low	nothing

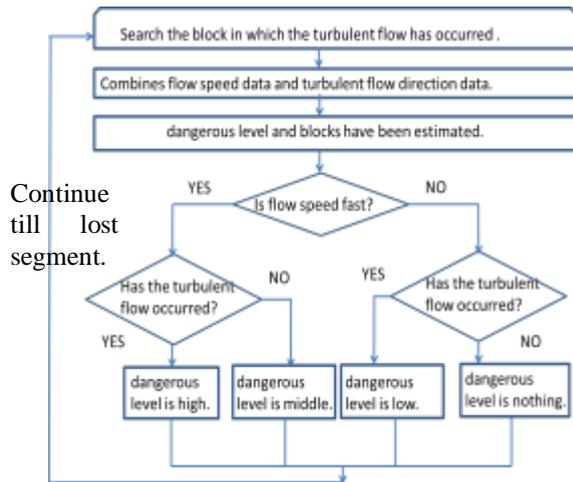


Fig.8 Flow chart of dangerous level and blocks have been estimated processing

Fig.9 shows dangerous area divided by three kinds of levels. The outline and area of dangerous blocks are surrounded with red line. If the size is sufficient, the circle inscribed in a circumscription rectangle is painted with blue.

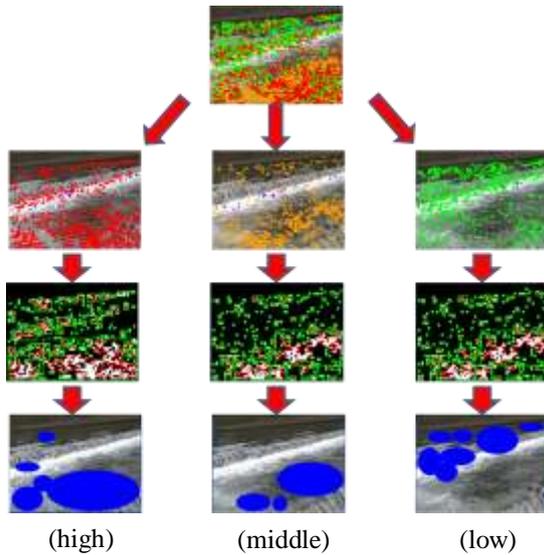


Fig.9 Dangerous areas divided by three kinds of levels

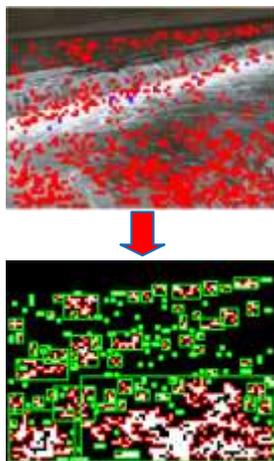


Fig.10 Dangerous areas out line and circumscribe squares.

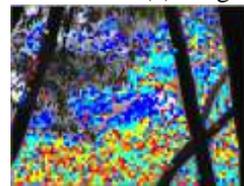
### 3. MEASUREMENT RESULTS OF FLOW SPEED, DIRECTION AND DANGEROUS LEVEL OF RIVER SURFACE

#### 3.1 View of processing result.

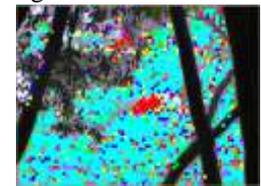
Fig.11 shows measurement result of flow speed, direction and dangerous level of river surface. The flow speed in Fig.11 (b) is shown by colour. The color is defined by colour bar in Fig. (c). Fig.11 (c) is shown that blue is the slowest, and red is the fastest. The flow direction in Fig.11 (d) is shown by color. The color is defined by color circle in Fig.11 (e). The dangerous level Fig.11 (f) is shown color. Dangerous level is determined by flow speed and direction. Dangerous level conversion table show Fig.11 (g).



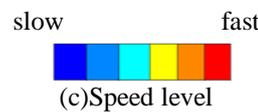
(a) Original image



(b) Distribution of flow speed



(d) Distribution of flow direction



(c) Speed level



(e) Color vector circle



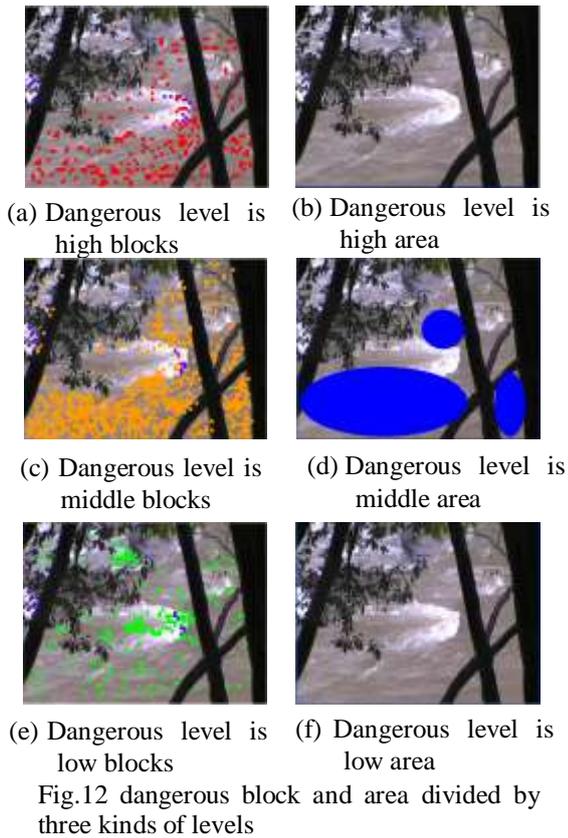
(f) Distribution of dangerous level



(g) Dangerous level

Fig.11 Measurement result of flow speed, direction and dangerous level of river flow

Fig.12 shows dangerous area divided by three kinds of levels. Fig.12 (a) and (b) show dangerous level is high blocks and area. Fig.12 (c) and (d) show dangerous level is middle blocks and area. Fig.12 (e) and (f) show dangerous level is low blocks and area.



### 3.2 Information that can be read from various processing results

#### 3.2.1 Processing results of slow speed and curving river flow

Fig.13 shows processing results of curving river flow. It is understood that the flow speed is slow when paying attention Fig.13 (b). Moreover, it is understood that many kind of flow direction exist after the curve paying attention Fig.13 (d). It is surmised whether the flow which has flowed directly, and the flow reflected in the shore strike, and that this occurred. Therefore, after a curve, it can be judged that the turbulent flow has occurred. It can guess that after curving river flow's dangerous level is low from Fig.13 (b) and (d). (Fig.14) The processing results of Fig.13 (f), Fig.15 (e) and (f) show that this a guess and a processing result are in agreement. It can be judged that the flow of this river is safe from these results.



(a) Original image

Fig.13 Measurement result of flow speed, direction and dangerous level of river flow

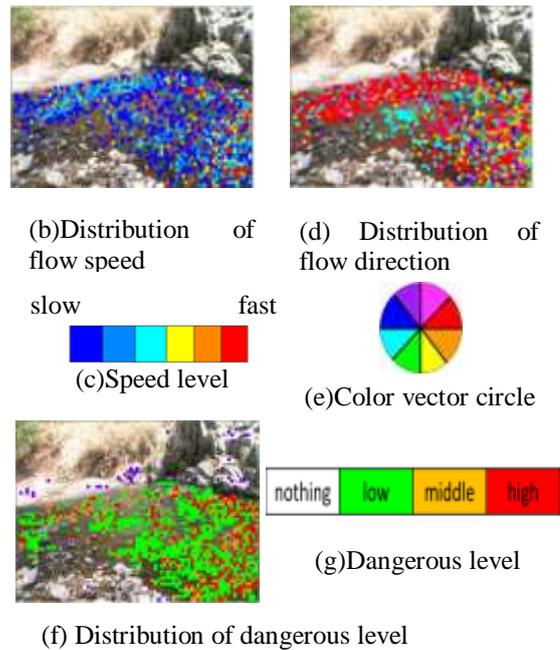


Fig.13 Measurement result of flow speed, direction and dangerous level of river flow



Fig.14 The dangerous area and dangerous level which people guess by one's sense

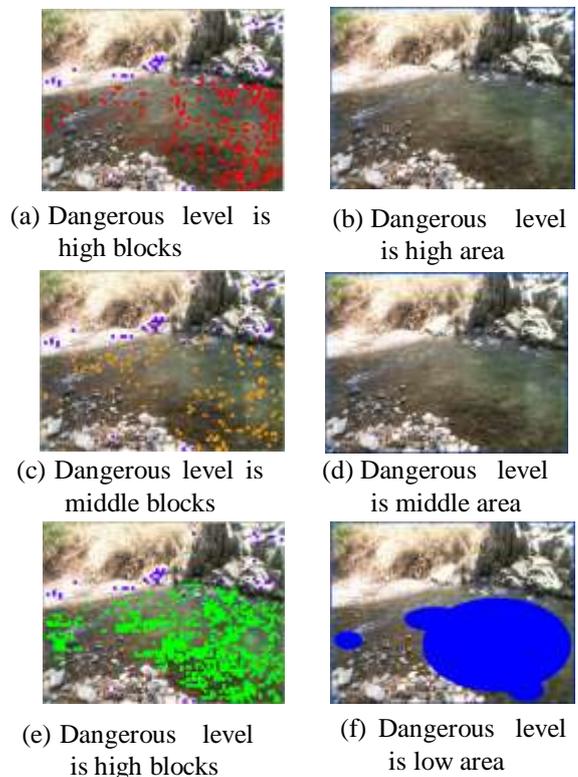


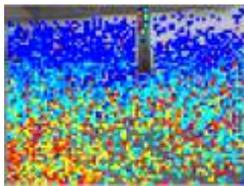
Fig.15 dangerous block and area divided by three kinds of levels

### 3.2.2 Processing results of fast speed and straight river flow

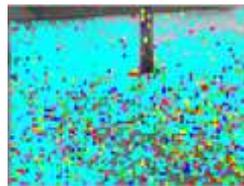
Fig.16 shows processing results of straight river flow. It is understood that the flow of the part in the lower left of figure speed is fast when paying attention Fig.16 (b). It is understood that flow direction is orderly direction of the lower left when paying attention Fig.16 (d). It can guess that the dangerous level is middle at the lower left of a figure. (Fig.17) The processing results of Fig.16 (f), Fig.18 (c) and (d) show that this guess is right. The result it was not able to be expected that paying attention to Fig. 18 (a) and (b) can be seen. These results show that the gap is caused by turbulent flow judging between people's feeling and processing of system. It can be judged from these results that the flow of this river needs to be warned.



(a) Original image



(b) Distribution of flow speed



(d) Distribution of flow direction

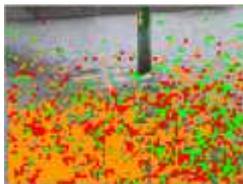
slow fast



(c) Speed level



(e) Color vector circle



(f) Distribution of dangerous level



(g) Dangerous level

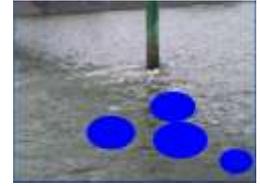
Fig.16 Measurement result of flow speed, direction and dangerous level of river flow



Fig.17 The dangerous area and dangerous level which people guess by one's sense



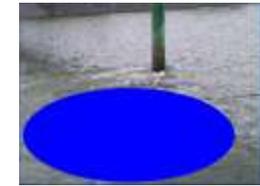
(a) Dangerous level is high blocks



(b) Dangerous level is high area



(c) Dangerous level is high blocks



(d) Dangerous level is high area



(e) Dangerous level is high blocks



(f) Dangerous level is high area

Fig.18 dangerous block and area divided by three kinds of levels

### 3.2.3 Processing results of caused disaster river flow

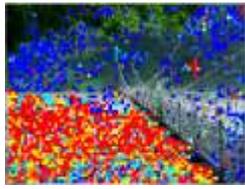
Fig.19 shows processing results of caused disaster river flow. It turns out that it is being displayed that the information on places other than the flow of a river also paying attention to a Fig.19. These pieces of displayed information are observed the swing of the trees or a bridge by a storm. When its attention is paid to a Fig.19 (b) and (d) based on this thing, it turns out that the flow of a river is fast and the turbulent flow has also occurred

Therefore, it is presumed that the dangerous level of the whole river is high. (Fig.20) The processing results of Fig.21 (a) and (b) show that this a guess and a processing result are in agreement. However, it indicates that the dangerous level of the whole screen is low by Fig.21 (e) and (f). This is caused by two of the determination technique of dangerous area and information other than a river being included. It can be judged from these results that it is necessary from it to take refuge immediately since the flow of this river is dangerous.

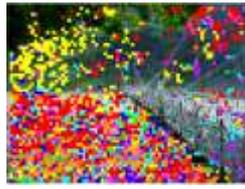


(a) Original image

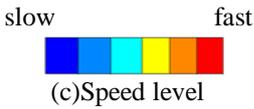
Fig.19 Measurement result of flow speed, direction and dangerous level of river flow



(b) Distribution of flow speed



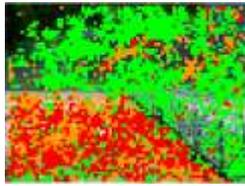
(d) Distribution of flow direction



(c) Speed level



(e) Color vector circle



(f) Distribution of dangerous level



(g) Dangerous level

Fig.19 Measurement result of flow speed, direction and dangerous level of river flow



Fig.20 The dangerous area and dangerous level which people guess by one's sense



(a) Dangerous level is high blocks



(b) Dangerous level is high area



(c) Dangerous level is middle blocks

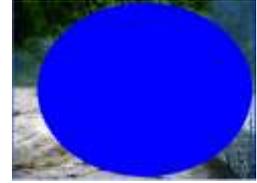


(d) Dangerous level is middle area

Fig.21 dangerous block and area divided by three kinds of levels



(e) Dangerous level is low blocks



(f) Dangerous level is low area

Fig.21 dangerous block and area divided by three kinds of levels

## 4. CONCLUSION

To estimate dynamic state of river, the flow speed and direction of river surface are measured by image processing of video. And, a dangerous area comes to be able to be discovered, and to be forecast from the river speed data and turbulent flow data. Make future tasks are that, the processing result of a system should accord with people's feeling.

## 5. REFERENCES

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