Flow Measurement for Dynamic Behaviour of Heavy River Surface

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Abstract. *This paper shows the monitoring system of dynamic state (flow speed and direction) of river surface by using video image processing. This system is designed for estimation of dynamical behaviour of heavy river at natural disasters. The state of speed and direction estimated continuously from differential image flames. By monitoring the dynamic state, it is possible to find dangerous area and the dangerousness, predict the second water disaster and inform them to people and local/prefectural governments.*

Keywords: Disaster Monitoring, River Surface, Image Processing

1. Introduction

In Japan, rivers are short length and the vertical level of start and end points is high. Then after heavy rain and typhoon, the rivers change the state. The volume and speed of water flow are increasing. The surface becomes muddy and heavy. The water overs bank, sometimes breaks it at winding corners. The heavy river loses many lives and damages life infrastructures like road, houses, facilities, rice/vegetable fields, power lines and natures. The river disaster is dangerous and serious for people who live around it. By the reason, the monitoring system for heavy river flow is so importance for them. Some kinds of the system measure the water speed, force, direction and level of height directly by handy tools/instruments. But it is dangerous for measuring person to face the heavy river. And, standalone measuring system/instrument in river is broken easily at the heavy state of river. On the other hand, remote video monitoring system is safe and effective to measure the surface of heavy river. In this system, video camera takes the situation of river surface near the river. The image is transmitted to host system far from the river and analysed the speed and direction of river surface. By the image processing, dangerous area and level are always estimated, and it is possible to predict the second water disaster around the field.

2. Measurement System for Monitoring Dynamic State of River Surface

The river surface is recorded by video camera. The video is extracted by 7 image frames per second. Firstly, from neighbour two image frames, a differential image is calculated. And the differential image is divided evenly into 80*60 segments (Fig.1). By searching the most resemble segment around a ROI (Region of Interest) and make a vector between them, a couple of speed and direction of river flow is calculated. Repeating this processing to all segments, speed and direction distribution of river flow on a differential image is got (Fig.2).

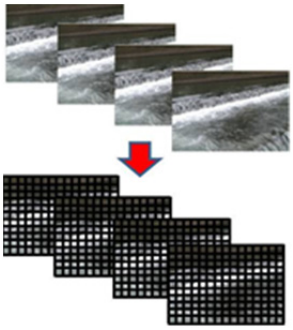


Fig.1 Segmentation of differential image

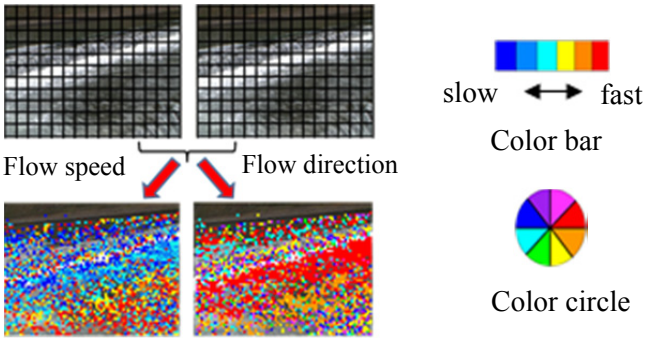


Fig.2 Flow speed and direction on a differential image

Fig.3 shows the definition of a vector to calculate flow speed and direction. On neighbour two differential frame images(DFI), by searching the most resemble segment on later frame image around a ROI on previous frame image and make a vector between their centers. The length expresses flow speed and the inclination angle shows flow direction. Each angle is denoted by a color(Table.1).

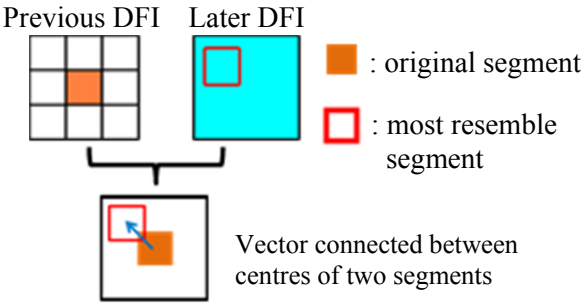


Fig.3 Vector to determine flow speed and direction

Table.1 Relation between directions and colors

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]

By the distribution of flow direction, the turbulent flow of river surface is estimated. Fig.4 shows direction numbers attached to each color. In Fig.5, all segments are numbered according with flow direction. 0 means no direction. Comparing a flow direction distribution with other one measured 1sec. (7 DFIs) ago, disturbance of river flow has been estimated. Firstly, a segment on flow direction distribution at 1 sec. (7 DFIs) ago is defined as ROI. Secondly, comparing numbers of surrounding 9 segments with the number of ROI, the difference of directions becomes obviously. If the difference is within 1, the segment is colored blue. If that is over 2, the segment is colored red (Fig.5). Counting these colors, if red segments are 5 more, it has been decided that the state of this area (colony of 9 segments) is disturbance. And if 4 less, the state is orderly.

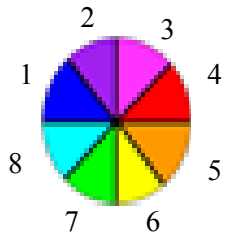


Fig.4 Direction number

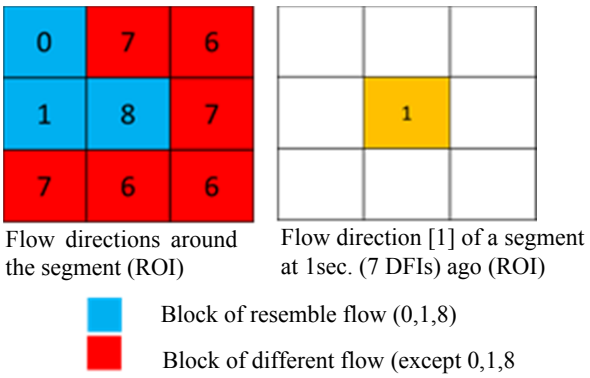


Fig.5 Example of distinction of flow directions

Using the flow speed and disturbance of river flow, the characteristics of dangerousness of river flow is decided (Fig.6). Kinds of the dangerousness are distinguished by relations between the flow speed and disturbance of river flow (Table 2). When the flow speed is high and turbulent flow, the level of dangerousness of segment is “High”. In Fig.6, the segments are colored red. When the flow speed is low and turbulent flow, the level of dangerousness of segment is “Middel”. The segments are colored orange. When the flow speed is high and orderly flow, the level of dangerousness of segment is “Low”. The segments are colored green. When the flow speed is low and orderly flow, the level of dangerousness of segment is “None”. The segments are no color. Fig.7 shows three kinds of dangerous segments distinguished by “High”, “Middle” and “Low” level. In the 1st stage, the distribution of

segments is shown. In the 2nd stage, the distribution of colonies is shown. In the 3rd stage, the distribution of areas is shown. Fig.8 shows the formation of colonies by plural segments. The colonies are surrounded by red lines. Green boxes show local set of colonies. When the box is large enough, it is shown by blue circle instead of green box that the area is dangerous intuitively.

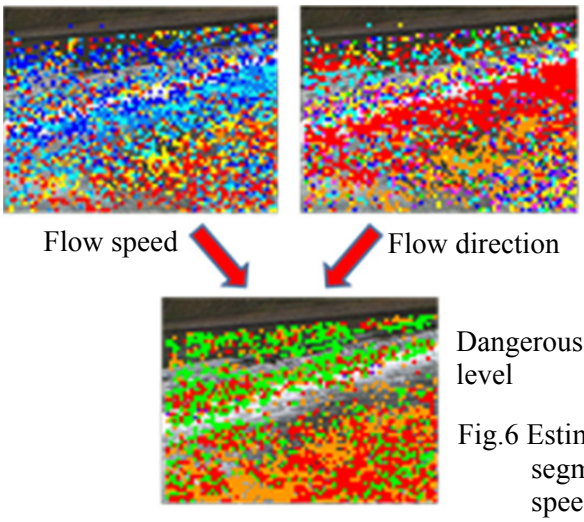


Fig.6 Estimation of dangerous segments and level by flow speed and turbulent flow

Table 2 Distinction of dangerous level by flow speed and turbulent flow

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

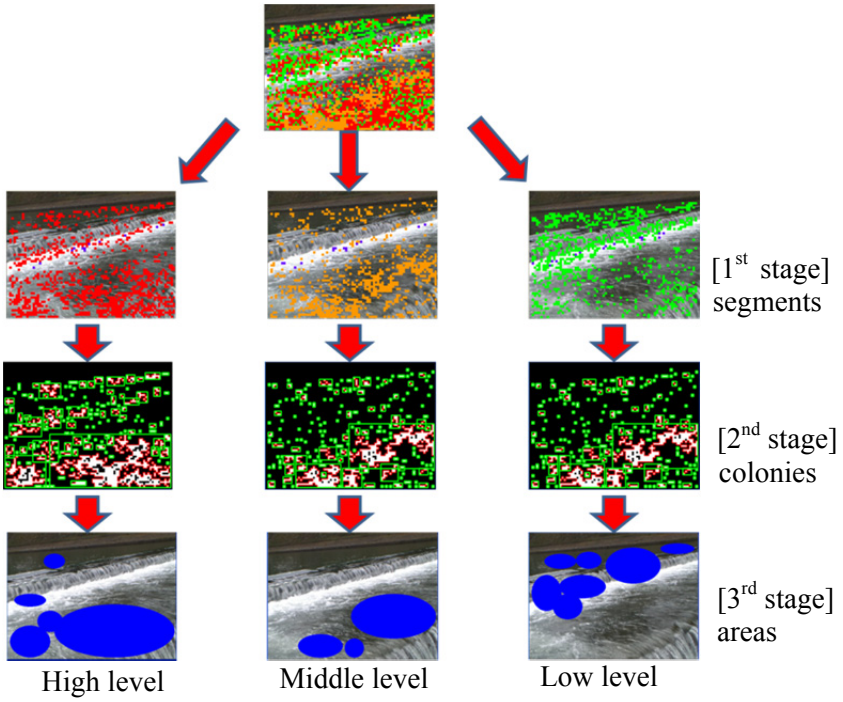


Fig.7 Dangerous segments, colonies and areas distinguished by three kinds of level

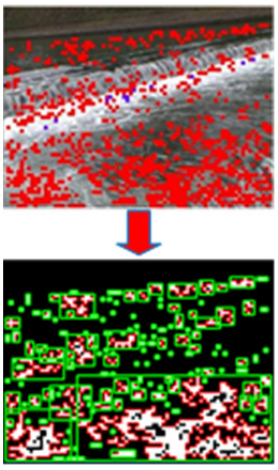
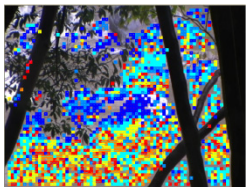


Fig.8 Formation of dangerous colonies

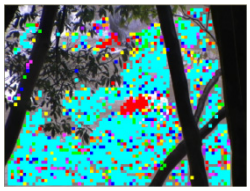
3. Measurement of Flow speed, Direction and Dangerous Level of River Surface

Fig.9 shows an example of measurement result of flow speed, direction and dangerous level of river surface. The flow speed in Fig.9 (b) is shown by the color defined in Fig.9 (c). The flow direction in Fig.9 (d) is shown by the color in Fig.9 (e). The dangerous level Fig.9 (f) is shown by the color in Fig.9 (g). Fig.10 shows dangerous area divided by three kinds of levels. Fig.10 (a) and (b) show the segments and areas in high dangerous level. Fig.10 (c) and (d) show the segments and areas in middle dangerous level. Fig.10 (e) and (f) show the segments and areas in low dangerous level. In Fig.9(b) and (f), no area is confirmed as dangerous area.

(a) Original image



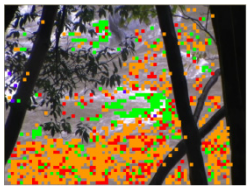
(b) Distribution of flow speed



(d) Distribution of flow speed

(c) Flow speed level

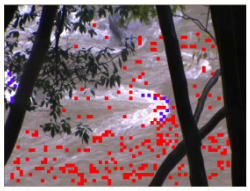
(e) Color circle for direction



(f) Distribution of dangerous level

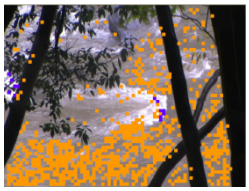
(g) Dangerous level

Fig.9 An example of measurement result of flow speed, direction and dangerous level of river flow



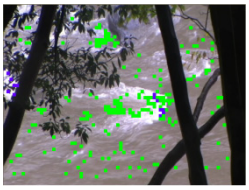
(a) Segments of high dangerous level

(b) No area of high dangerous level



(c) Segments of middle dangerous level

(d) Areas of middle dangerous level



(e) Segments of low dangerous level

(f) No area of low dangerous level

Fig.10 Dangerous segments and area divided by three kinds of level

4. Conclusions

To estimate dynamic state of river, the flow speed and direction of river surface are measured by image processing of video. By these parameters, it has been possible to estimate turbulence and dangerous area on the river surface. These parameters will be so useful to inform the dangerousness to people and to predict future disasters around the river.

References

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