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ONSITE MEASUREMENT SYSTEM FOR DYNAMIC CHARACTERISTIC EVALUATION OF RIVER FLOW

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Abstract - This paper shows the dynamic characteristic evaluation system to monitor muddy river flow by video image. The dynamic character is evaluated by the flow speed and direction in each small block distinguished evenly on a video frame. By evaluating dynamic character of river surface, water behavior and dangerous area will be distinguished. Aim of this study is to discover the dangerous area, to presume disasters and to inform local or national government and alarm people.

Keywords: River flow, 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 like 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.

These days, the state of such river flow is observed by human eye far from the river and measurement instrument dropped into the river directly. But in these observations, dangerous like losts of human lives and measurement instruments are occurred.

On the other hand, such river flow measurement by video image processing is so safety method. By using tablet PC, it becomes very convenience to observe the dynamic state of river flow. Water behavior and dangerous area will be distinguished.

These information is so useful to predict water disasters and to give the information to local/national governments and people living around the river

2. MEASURMENT SYSTEM FOR MONITORING DYNAMIC STATE OF RIVER SURFACE

The situation of river flow has been recorded by video camera. The frame rate is 30 fps. The resolution is VGA (640pixel*480pixel).

To find the dynamics of river flow, each image are distinguished small square areas (8pixel*8pixel). Fig.1 shows the segmentation. An image segment block becomes Region of Interest (ROI). The dynamics of river flow is estimated by the movement of those ROIs.

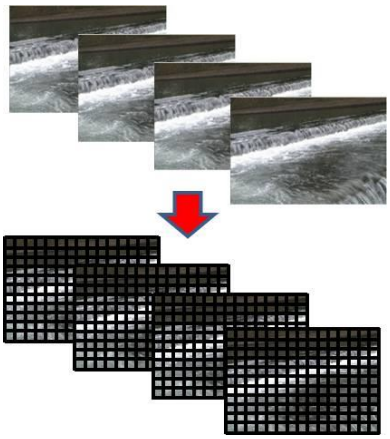


Fig.1. Segmentation of image frame

Fig.2 shows how to find the movement of ROI blocks. To find the movement of an original ROI block in an image frame, correlation to blocks in next image frame is calculated. The searched range is 24pixel*24pixel centered a same position with the original ROI block in previous image frame. Connecting the original block and the most resemble block detected by the scanning, a movement vector is got. By repeating the scanning on all ROI blocks in an image frame, finally a set of vectors is got.

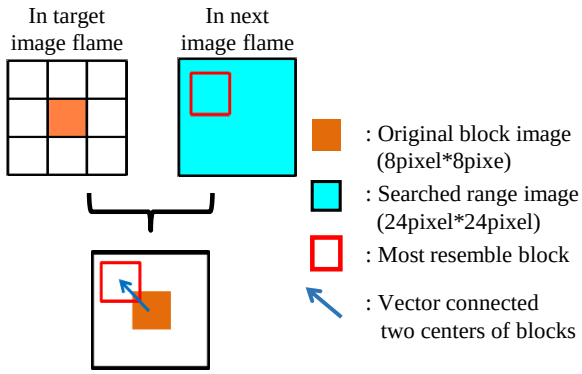
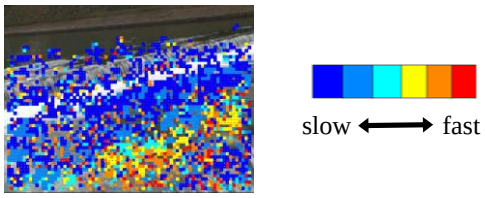


Fig.2. Generation of a movement vector of a ROI block

By the vector, the flow speed and direction of the original ROI block are estimated. As the length of vector is

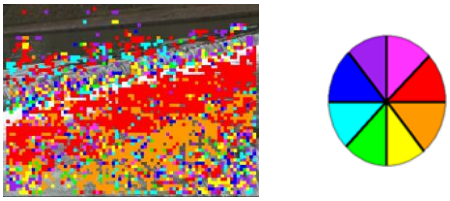
related to movement distance, the flow speed is estimated by the length. Fig.3 (a) shows the distribution of flow speed each blocks. The level of flow speed is expressed by block color shown in Fig.3 (b).



(a) Flow speed image (b) Color chart of flow speed

Fig.3. Distribution of flow speed on a differential image frame

As the angle of vector is related to movement direction, the flow direction is estimated by the angle. Fig.4 (a) shows the distribution of flow direction each blocks. The flow direction is expressed by block color shown in Fig.4 (b) and Table.1.



(a) Flow speed image (b) Color chart of flow direction

Fig.4. Distribution of flow direction on a differential image frame

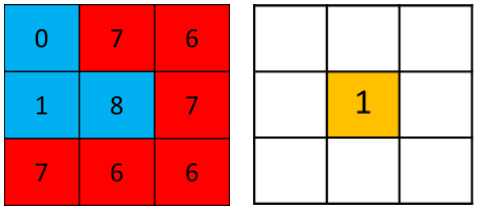
Table.1. Direction to color conversion table

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

To evaluate dangerous area of river surface, it is necessary to estimate the dynamic state of the turbulence of river flow. The turbulence is estimated by the relation of flow directions.

Fig.5 shows how to estimate the turbulent flow by counting different directions among neighbor blocks. Number in each block shows the direction assigned in Fig.6. 0 means no vector in the block.

Fig.5 (a) shows the distribution of flow directions of nine blocks in previous image frame. Fig.5 (b) shows the flow direction of target block which is the center block in same nine blocks in present image flame. Comparing two kinds of distributions, flows of two blocks assigned 1, 8 are same and adjacent direction to the target block. On the other hand, flows of six blocks assigned 6, 7 are different directions to the target block. These blocks becomes positive factors to cause the turbulent flow at the target block. When the number of these blocks are six or more, it is estimated that turbulent flow is occurred at the target block in present image frame.



(a) Distribution of flow direction in previous image frame

(b) Flow direction of target block in present image flame

:Block not to caused different direction

:Block to cause different direction

Fig.5. Estimation of turbulent flow

Fig.6. Numbering to direction color

Dangerousness of river surface is estimated by the relation between the flow speed and the turbulence of flow direction. (Fig.7)

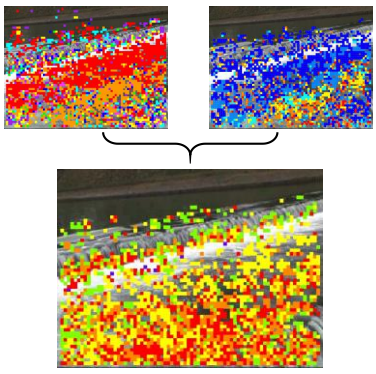


Fig.7. Estimation of dangerous block by flow speed and turbulence of flow direction

Table.2 shows the relation. The flow speed is distinguished to three levels. They are “Extremely high speed”, “High speed” and “Low speed”. The turbulence is also distinguished to three levels. They are “Turbulent flow”, “Normal flow” and “Orderly flow”. By these level divisions, the dangerous level is classified into 5 modes. Mode1 expresses the most dangerous state in a ROI block. Mode1 is depended to “Extremely high speed”. Mode2 expresses the dangerous state relatively in a ROI block. Mode2 is depended to “High speed” and without in case of “Orderly flow”. Mode3 expresses the careful state in a ROI block. Mode4 by “Normal flow” and “Low speed” expresses the calm state in s ROI block. Mode0 by “Orderly flow” and

"Low speed" expresses the safe state in a ROI block. These dangerous levels are estimated each ROI blocks.

Table.2. Classification of dangerous level

	Turbulent Flow	Normal Flow	Orderly Flow
Extremely High Speed	Mode1	Mode1	Mode1
High Speed	Mode2	Mode2	Mode3
Low Speed	Mode3	Mode4	Mode0

Then, emphasized high density area of ROI blocks, the characteristic area is specified each mode. Fig.8 shows the emphasis high density area as an example of Mode1. Fig.9 shows the specification of characteristic area each mode.

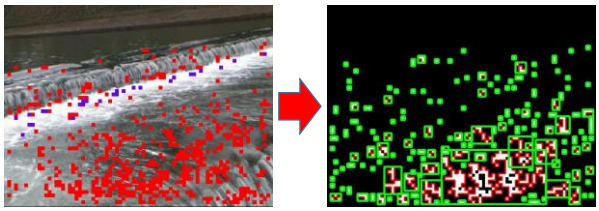


Fig.8. Specification of characteristic of Mode1

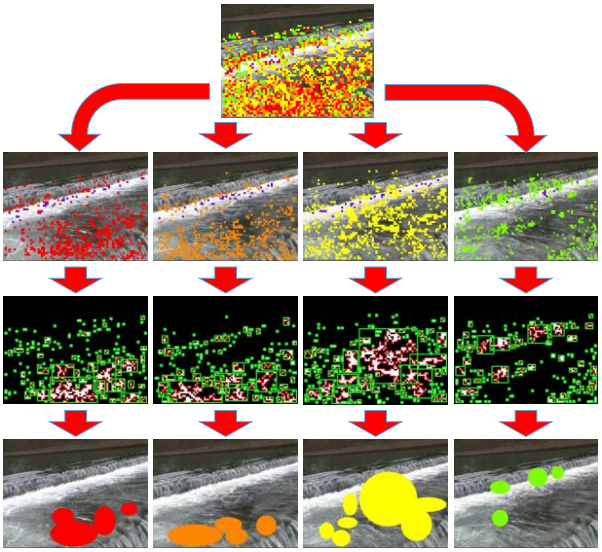


Fig.9. Specification of characteristic area each modes

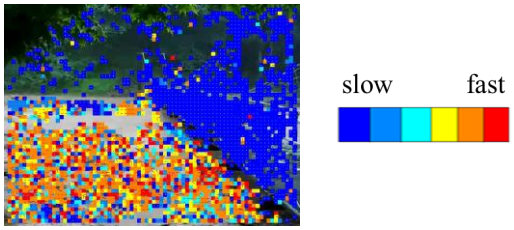
3. EVALUATION RESULT OF FLOW SPEED AND DIRECTION OF SURFACE

3.1. Processing result of muddy river flow

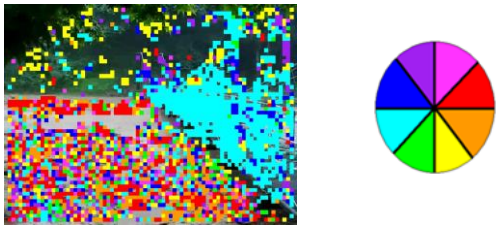
First, muddy river flow video has estimated. Fig.10 is original image.

Fig.10. Original image of muddy river flow

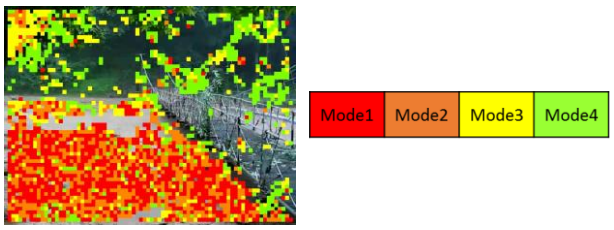
Fig.11 shows processed the image processing of flow speed, flow direction and dangerous level. Flow speed is judged very fast around river surface (Fig.11 (a)). Moreover, flow direction is judged different direction (Fig.11 (c)). Movement of leaves and bridge around upper/right side are also estimated. In Fig.11 (e), dynamic state of river surface is evaluated in mode1 and mode2.



(a) Flow speed image (b) Color chart of flow speed



(c) Flow direction image (d) Color chart of flow direction



(e) Dangerous level image (f) Color chart of each mode

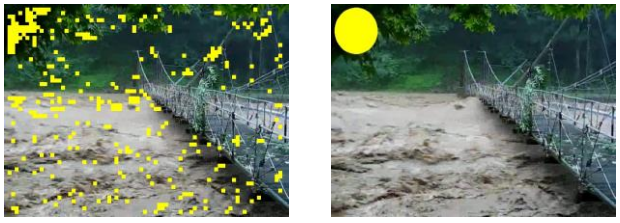
Fig.11. Estimation of muddy river

Fig.12 shows dangerous area image in each mode. In Fig.12 (a), almost of all blocks are judged mode1 on river surface. Dangerous area of mode1 spread on river surface mostly (Fig.12 (b)). The blocks in mode2 are also spread on

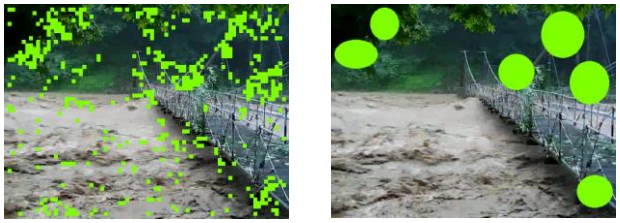
river surface (Fig12 (c)). Dangerous area of mode2 is distributed around front side in Fig.12 (d). The blocks in mode3 or mode4 are so few (Fig.12 (e), (g)) Dangerous area of mode3 or mode4 is not expressed on river surface (Fig.12 (f), (h)). From these results, this muddy river is evaluated clearly danger.

(a) Dangerous blocks of mode1 (b) Dangerous area of mode1

(c) Dangerous blocks of mode2 (d) Dangerous area of mode2



(e) Dangerous blocks of mode3 (f) Dangerous area of mode3



(g) Dangerous blocks of mode4 (h) Dangerous area of mode4

Fig.12. Dangerous blocks and area of muddy river flow

On the other hand, observer estimates dangerous are by human sense shown in Fig.13. Comparing Fig.12 (a) and Fig.13, their dangerous areas have become same place. Then, it has been shown that this estimation is correct.

3.2. Processing result of calm river flow

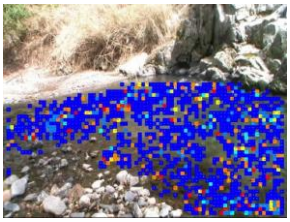
Second, calm river video has estimated. Fig.14 is original image.

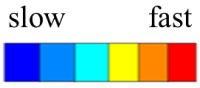
Fig.15 shows the image processing of flow speed, flow direction and dangerous level. Flow speed is judged slow (Fig.15 (a)). Moreover, various flow directions exist after the curve (Fig.15 (c)). The river flow is reflected by opposite

Fig.13 Dangerous area of muddy river which people estimated by human sense

Fig.14. Original image of calm river flow

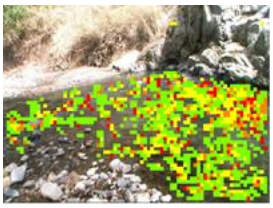
shore around curve. The river flow is turbulent at the area. In Fig.15 (e), dynamical state of river surface is evaluated in mode3 or mode4.





(a) Flow speed image (b) Color chart of flow speed

(c) Flow direction image (d) Color chart of flow direction



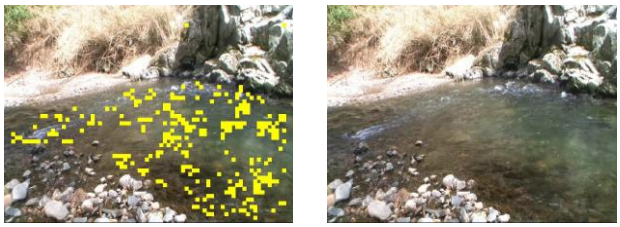
(e) Dangerous level image (f) Color chart of each mode

Fig.15. Estimation of calm river flow

Fig.16 shows dangerous area image in each modes. The blocks in mode1, mode2 and mode3 are so few (Fig.16 (a), (c), (e)) Dangerous area of mode1, mode2 and mode3 are not expressed on river surface (Fig.16 (b), (d), (f)). The blocks in mode4 are spread (Fig.16 (g)). Dangerous area of mode4 is spread on river surface after the curve (Fig.16 (h)). From these results, this slow speed and curving river is evaluated calm.

(a) Dangerous blocks of mode1 (b) Dangerous area of mode1

(c) Dangerous blocks of mode2 (d) Dangerous area of mode2



(e) Dangerous blocks of mode3 (f) Dangerous area of mode3

(g) Dangerous blocks of mode4 (h) Dangerous area of mode4

Fig.16. Dangerous block and area of calm river flow

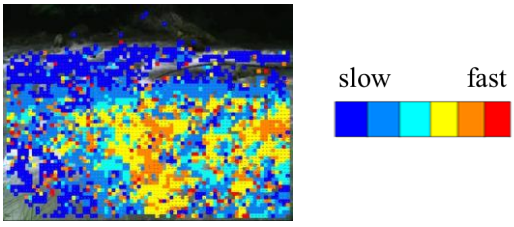
On the other hand, observer estimates no dangerous area. In Fig.16, dangerous area of mode1, mode2 and mode3 are not expressed. Then, it has been shown that this estimation is correct.

3.3. Processing result of rapid flow.

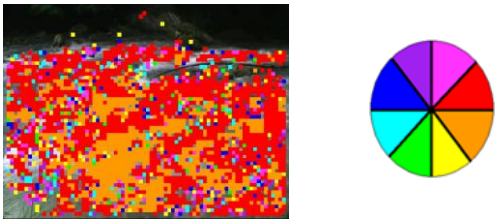
Third, processed rapid flow river video. Fig17 is original image.

Fig.17. Original image of rapid flow river

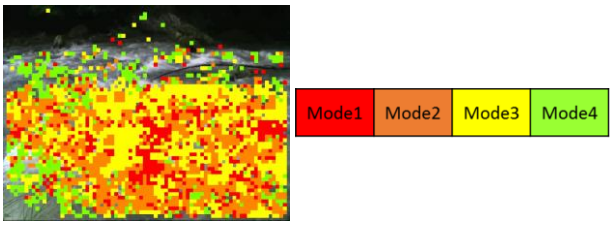
Fig.18 shows image processing of flow speed, flow direction and dangerous level. Flow speed is judged fast around center and right side center (Fig.18 (a)). Moreover, flow direction is judged right direction flow mostly (Fig.18 (c)). However, there is various direction left side center. The river flow is turbulent at the area. In Fig.18 (e), the block in all modes are spread.



(a) Flow speed image (b) Color chart of flow speed



(c) Flow direction image (d) Color chart of flow direction



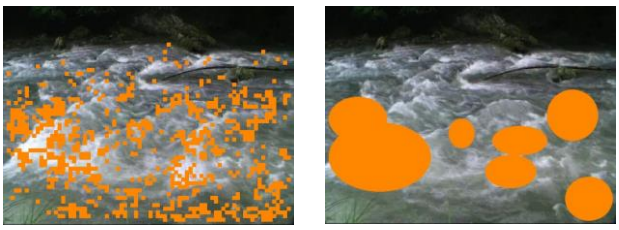
(e) Dangerous block image (f) Color chart of each mode

Fig.18. Estimation of rapid river

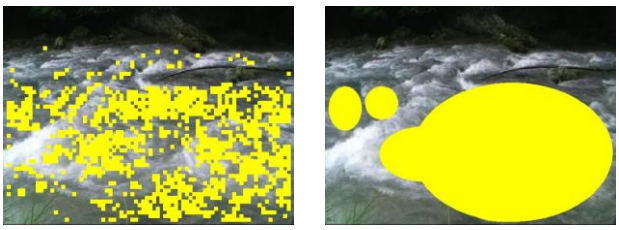
Fig.19 is dangerous area image in each mode. The blocks in mode1 block concentrates around center and right side center (Fig.19 (a)). Dangerous area of mode1 is distributed at the same position (Fig.19 (b)). The blocks in mode2 is spread on left side river surface (Fig.19 (c)). Dangerous area of mode2 is distributed at the same position and left side in Fig.19 (d). The blocks in mode3 is spread widely (Fig.19 (e)). Dangerous area of mode3 is also distributed widely (Fig.19 (f)). The blocks in mode4 are spread around upper and lower sides in Fig.19 (g) but

dangerous area of mode4 is not expressed (Fig.19 (h)). From these results, this river is evaluated danger.

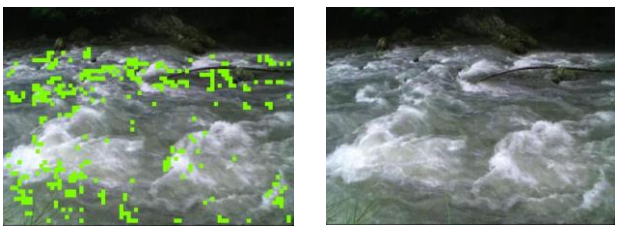
(a) Dangerous blocks of mode1 (b) Dangerous area of mode1



(c) Dangerous blocks of mode2 (d) Dangerous area of mode2



(e) Dangerous blocks of mode3 (f) Dangerous area of mode3



(g) Dangerous blocks of mode4 (h) Dangerous area of mode4

Fig.19. Dangerous block and area of rapid river flow

On the other hand, observer estimates dangerous are by human sense shown in Fig.20. Comparing Fig.19 (d) and Fig.20, their dangerous areas have become same place. Then, it has been shown that this estimation is correct.

Fig.20 Dangerous area of rapid flow river which people estimated by human sense

4. CONCLUSION

To estimate dynamic state of river, the flow speed and direction of river surface are measured by video image processing. The dangerous area and water behaviour is distinguished by the dynamic state of river flow. Make future tasks are that, the processing result of this program should accord with much more people's feeling and inform people who lives around river and remote place.

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