DEVELOPMENT OF TSUNAMI INUNDATION SIMULATOR USING MOBILE MAPPING SYSTEM

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Abstract

Hazard maps in tsunamis and floods are created by many local towns and cities which has coast or river. However, they are not properly utilized by the citizens. One of the reasons is that many hazard maps are not enough to stimulate fear of tsunamis, since most of the them are shown in two dimension using the depth contour. Practical visualization of inundation is required to give the strong sense of danger.

In this study, the system is developed, in which the inundation can be shown in three dimension using the serial videos taken by all-around view camera. You can recognize inundation of the houses and buildings by CG. Although, it takes much cost to create CG in general, the elements such as the streets, houses and buildings which constitute the townscape can be easily converted to psuedo CG models in this system using the three-dimensional coordinates of the feature points in the video. Thus using the video and its information, the expression of the inundated condition in three dimension can be realized at dramatically low cost.

Keywords: education, disaster prevention, camera vector, CG

1. Introduction

2011 the Great East Japan Earthquake claimed near 20,000 lives. 90% of its cause was reported to be tsunamis. Many people failed to escape. Hazard maps of tsunamis had been created in the coastal area by many local towns and cities prior to the earthquake, though the low estimation of the inundation was one of the causes to enlarge the damage. However, the hazard maps were not properly utilized by the citizens, and it is the same today. Why is it that? One of the reasons is that many hazard maps are not enough to stimulate fear of tsunamis, since most of them are shown in two dimension using the depth contour. Practical visualization of inundation is required to give the strong sense of danger.

In this study, the system is developed, in which the inundation of tsunamis or floods can be shown in three dimension using the serial video taken by all-around view camera. You can recognize inundation of the houses and buildings by CG. In general, it takes much cost to create CG. However, the elements such as the streets, houses and buildings which constitute the townscape can be easily coverted to CG models in this system, since the feature points in the video have the three-dimensional coordinates. Thus using the video and its information, the expression of the inundated condition in three dimension can be realized at dramatically low cost.

2. MMS (Mobile Mapping System)

2.1 Hardware

MMS is the modular measurement system consisting of an all-around view camera, clinometer, GPS antenna, and their base units as shown in Fig. 1. Though this device has been used in the surveying, TSUJIHARA *et. al.* applied it to the visualization [1] of the simulation of evacuation [2]. Fig. 2 shows the camera. The multi-camera system Ladybug3 made by Point Grey Research Inc. is used. It has six 2 megapixel cameras which allow JPEG-compressed 12 megapixel resolution images to be streamed to disk at 15 frames per second. Fig.3 shows the way to use the camera in the measurement. In narrow paths, the cart or handy type is used. IMS (Iwane Mobile Mapping System) [3] is used in this study.

2.2 Software

2.2.1 Recording

The images shot by six cameras are recorded with the imformation of the location by GPS and the data of clinometer. Fig.4 shows a sample of the frames in which the composite image is shown. It contains all pictures recorded by six cameras. It is converted to Mercator projection as shown in Fig.5. Though only a part of the image in Fig.4 is visualized in Fig.5, the 360-degree surrounding image can be seen by rotating the mouse cursor on the movie window in Fig.5 by right-drag as shown in Fig.6.
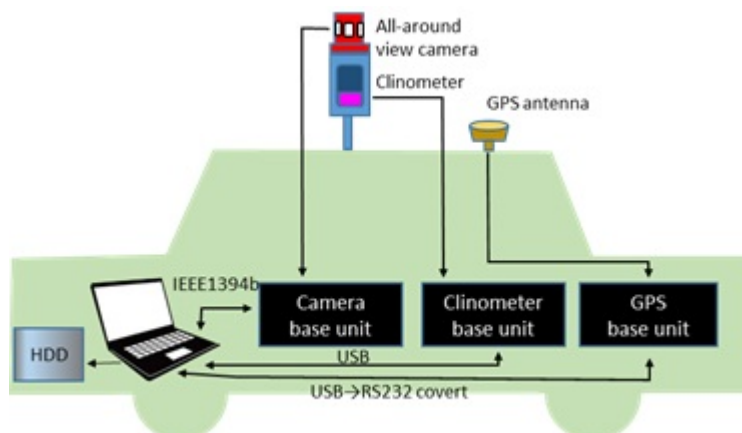

Fig. 1 – Mobile Mapping System

Fig.2 – All around view camera

Fig.3 – MMS hardware mounted on car, cart and handy type

Fig.4 – Sample frame recorded by six cameras

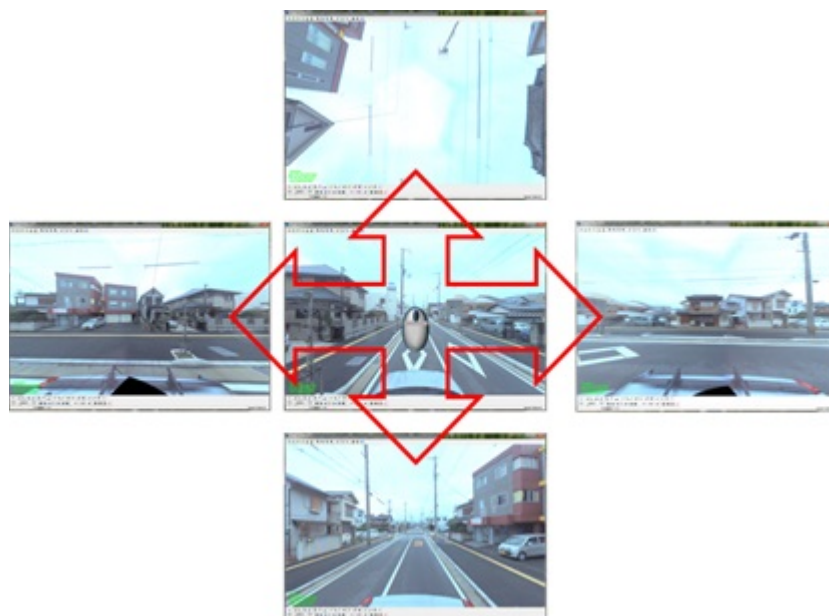Fig.5 – Sample frame in Mercator projection

Fig. 6 – View point control

2.2.2 Camera vector operation

The position and the posture of the camera can be derived only from the information contained in a moving image sequences. By calculating the trajectory of the camera in 3D space, the position of features within the source image sequence is described. Thus calculated or derived position of camera and features has relative value and the scale is relative. The absolute scale can be given by calibrating with the actual coordinates (GPS) . The feature points in the image are detected with sub-pixel accuracy using an edge, corner, contrast and other parameter detector. The points can be matched from one image to the next by choosing matches which have the highest cross-correlation of image intensity for regions surrounding the points.

2.2.3 Creation of moving image

The pictures captured by the camera system are converted to the moving image.   The global position of the frames in the image is given and the location can be shown in the map in parallel.

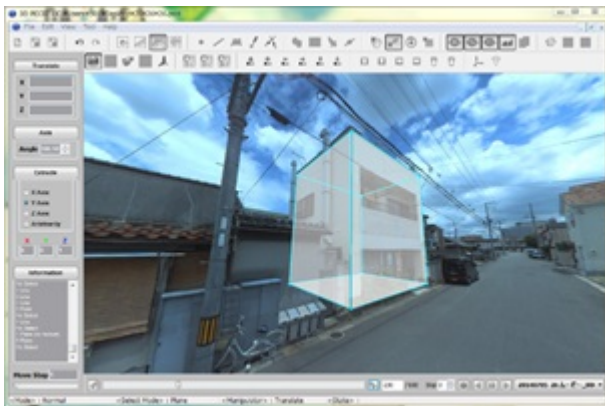## 3. Generation of 3D CG structure

This system enables the generation of 3D structure from 2D source image because the feature points has 3D coordinates.   However, the movie is just the sequence of 2D images, unless 3D CG strucures are generated and set.

(a) operation to generate a face

(b) operation to generate a box

(c) generated box

(d) texture mapped box

Fig.7 – Manner in generation of 3D CG structure

(a) source image

(b) image with CG of box

(c) image with transparent box

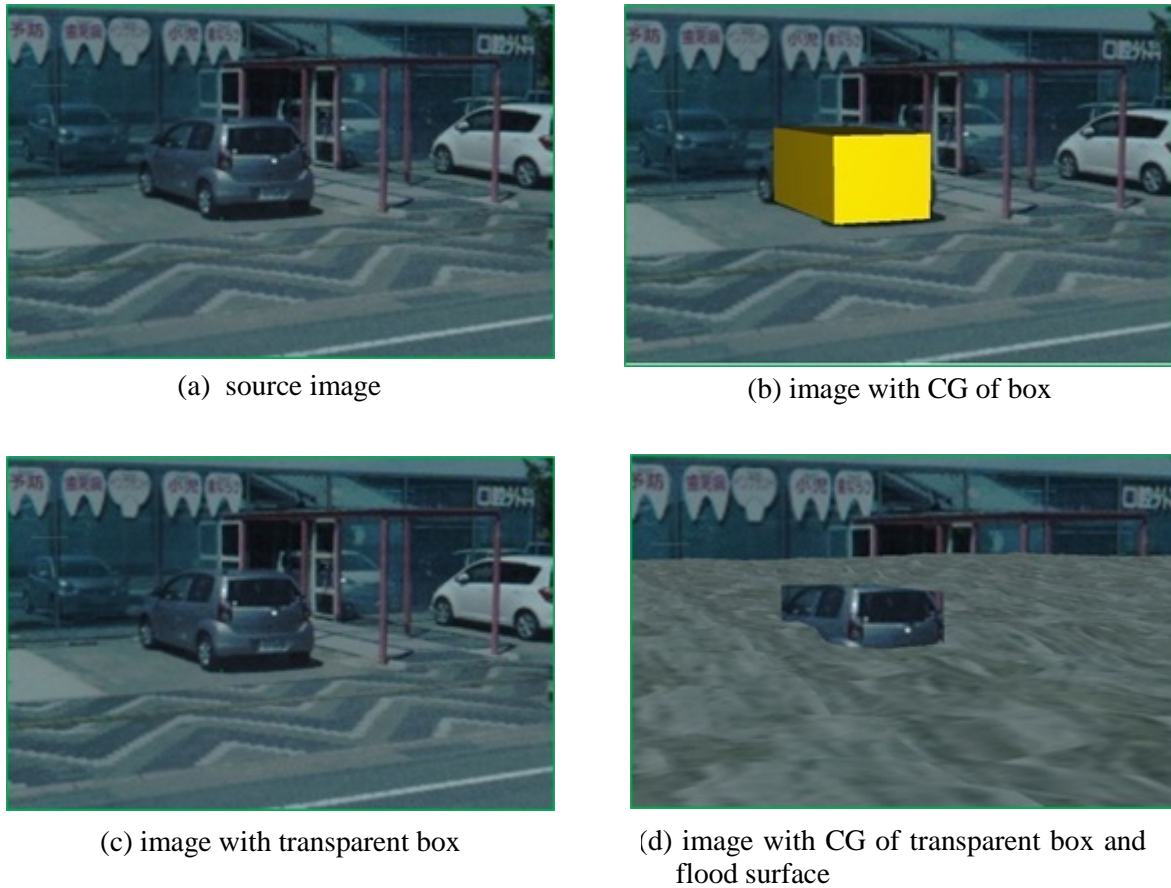(d) image with CG of transparent box and flood surface

Fig.8 – Simple way of generation of CG by pseudo-3D shape

In generation of 3D structure, pointing any two ends in the image by mouse, a line can be created. Graving the line and moving it as shown in Fig.7 (a), a face can be created. And pushing the face as shown in Fig.7 (b), a box can be created as shown in Fig.7 (c). Then, texture mapping can be done to the box as shown in Fig.7 (d). The corresponding texture in the source image is automatically mapped. Thus a 3D structure is set in the image and the construction of the area by 3D CG is possible in the same manner. Though the manner to generate a single structure is relatively easy as mentioned above, it takes much time to construct many structures. In this study, simpler manner is adopted to generate a 3D structure by CG at the expense of the accuracy, which is shown in the followings.

A cubic box can be set at any location. Fig.8 (b) shows the box which is put in the image of Fig.8 (a) as to surround the car with adjusting the size. Then by clearing the color of the box, the car is covered with a box of transparency as shown in Fig.8 (c). The generated structure is indistinguishable to the eye. But, the car has pseudo-3D shape, although the detail is different. Fig.8 (d) shows the synthesis of the image of movie with CG of flood surface. If the car does not have the 3D shape, it is submerged completely under the flood surface.

If the CG is required to be generated in detail, some fundamental shapes can be used to generate a complex structure. For example, the fence is modeled in Fig.9 (a). The yellow thin box is put so as to cover a part of the fence in the source image. Fig.9 (b) shows the image in which color of the box is cleared and CG of flood surface is set on it. The problem is that the grass in the rice field on the back is seen. Actually, it should not be seen, since the rice field is submerged. The reason of this problem is only one box is used to express the fence which has some rods at intervals. The structure of the fence including the backward grass is generated. Fig.10 (a) shows the CG structure in which the bar and each rod of the fence are modeled using the shape of

cylinder.   Fig.10 (b) shows the image in which the color of cylinders is cleared and CG of flood surface is set on it.   The flood surface is seen properly through the gap between the rods of fence.

4. Inundation simulation

Inundation simulation is carried out using the image recorded by MMS.   Fig.11 shows the source image near a railway station.   Fig.12 shows the CG models which are generated in the source image.   The structures such as the station, building, car, lamppost, road fence and person are modeled.   With a little practice, this degree of CG can be created in less than about 30 minutes.   Figs.13 and 14 show the images with the flood surface of 1.5 m and 3.0 m height, respectively.   Thus, the inundation simulation can be carried out in the relatively easy way using the source image captured by MMS.   The image which is created in this way may helps the instinctive understandings of inundation in tsunamis or floods estimated in the area.

5. Conclusions

In this study, the system is developed in which the inundation of tsunamis or floods can be shown in three dimension using the serial video taken by all-around view camera.   Fundametal shapes of CG such as box and cylinder are put so as to cover the structures in the source image and then the color of them are cleared.   Thus pesudo-3D structures are generated, althogh it looks like there is no change in the image.   By setting the CG of flood surfce to it, inundation is expressed.

It is important to get the accurate data on the lacation of the camera in MMS, since it effects on the accuracy of CG very much.

(a) Rough model of fence   (b) CG of fence and flood surface

Fig.9 – Image with CG of roughly modeled fence and flood surface

(a) Detailed model of fence   (b) CG of fence and flood surface

Fig.10 – Image with CG of fence modeled in detail and flood surface

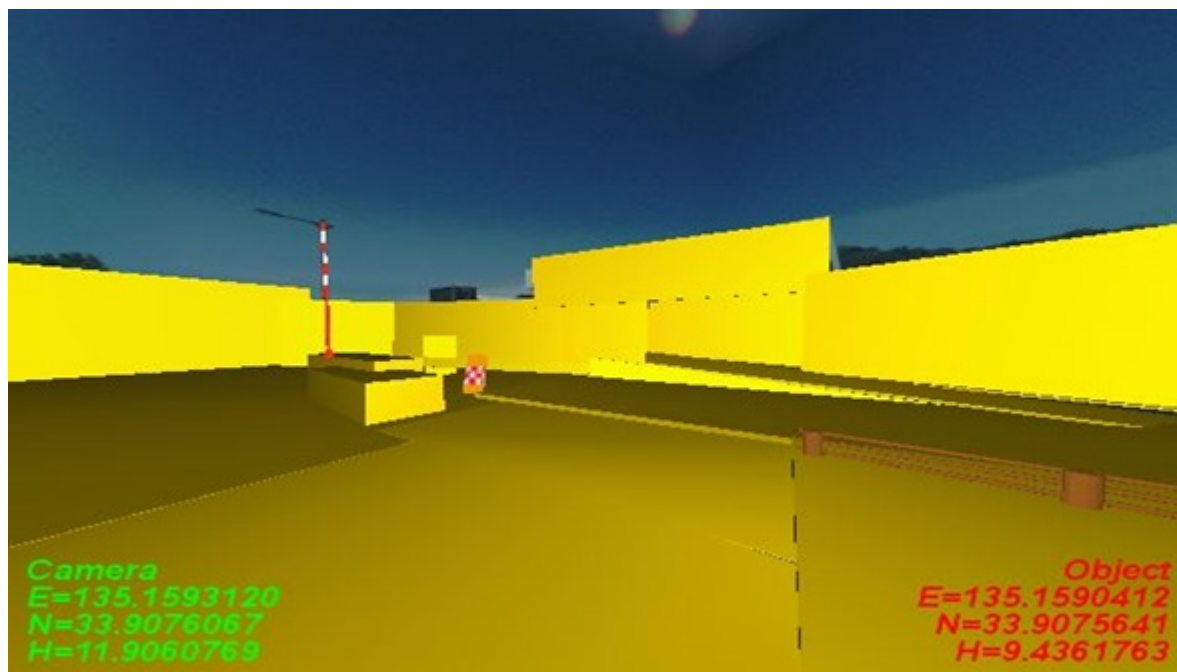Fig.11 – Source image near a railway station

Fig.12 – CG models generated in the source image

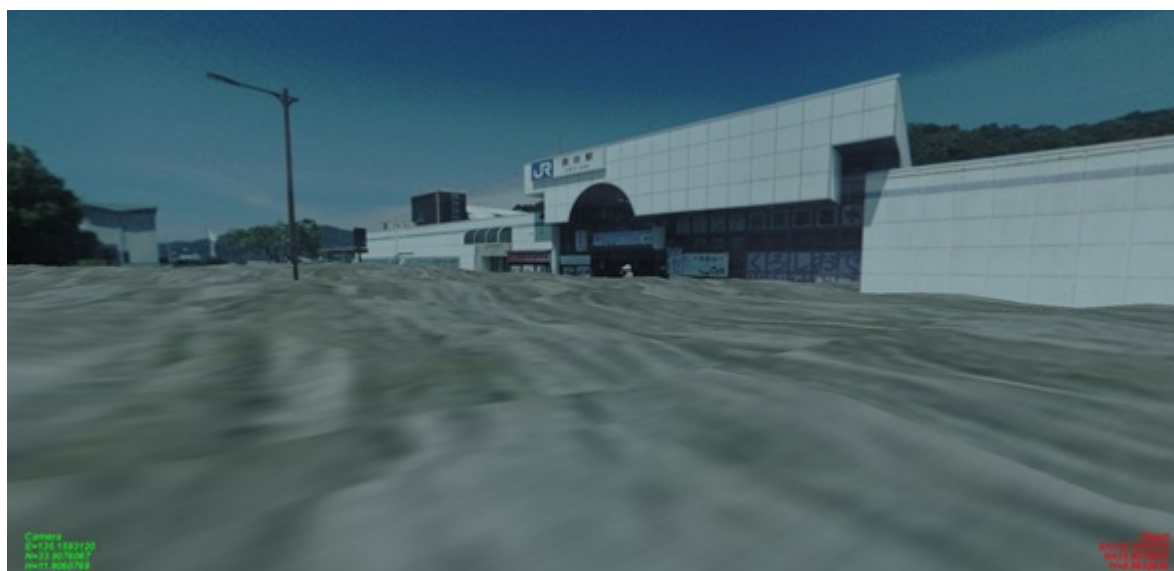Fig.13 – 1.5 m height inundation

Fig.14 – 3.0 m height inundation

Acknowledgements

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