Establishing Spatial Database for Slope Failure with GPS Digital Camera

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ABSTRACT: GIS (Geographical Information System) is one of useful tools for disaster prevention. Especially Web GIS based on Internet is a reliable system to collect information of many maps and the attribute data. And Web GIS will be very effective to exchange information. Therefore, the disaster prevention system with Web GIS is required.

The target of this study is to establish a system for collecting GIS data by using GPS digital camera. The image of GPS digital camera contains the coordinate of latitude and longitude in EXIF data. GIS data can be established by using the coordinate. However, the coordinate is just position of camera. The coordinate should be converted to point of the object in the taken image. Moreover, disaster area should be mapped on GIS.

In this study, converting method for coordinate of the object in GPS camera image will be developed using Digital Surface Model (15 meters grid). The skyline image on the camera point can be simulated using DSM. Direction of the camera can be calculated by image matching with the skyline. After that, disaster area will be mapped .

Field surveying with GPS digital camera was carried out for verification of this system. The correct ratio of skyline matching showed about 45%. A incorrect reason might be come from simple shape of skyline. Correct ratio may be raised by using high resolution DSM.

In future, correct ratio must be raised, and shape of slope disaster in taken picture is generated as GIS data.

KEY WORDS: Web GIS, GPS Digital Camera, Slope Disaster

1. BACKGROUND

GIS(Geographical Information System) is one of useful tools for disaster prevention. Especially Web GIS is a reliable system to collect information of many maps and the attribute data. And Web GIS will be very effective to exchange information. Therefore, the disaster prevention system with Web GIS is required.

Now image database on slope failure is establishing by using GPS digital camera. Mapserver is used to integrate database. The Mapserver was launched for Web GIS. The Mapserver was developed by Minnesota University, which is freeware. The GPS camera can take a coordinate of the place of camera. The coordinate can be stored in GIS data. However, the coordinate is just position of camera, which is view point. The coordinate should be converted to actual location information of slope failure area.

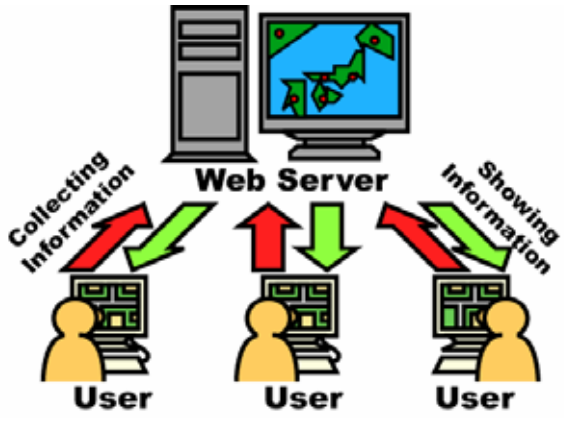

Figure1: Outline of Web GIS

2. OBJECTIVE

In this study, spatial database of slope failure with GPS camera will be established. Firstly, system for object point calculation from view point of GPS camera will be developed. Next, slope failure area in camera image will be converted as GIS data. Figure2 showed general idea of generating GIS data from shape of disaster in image. Finally, this system will be evaluated by field surveying.

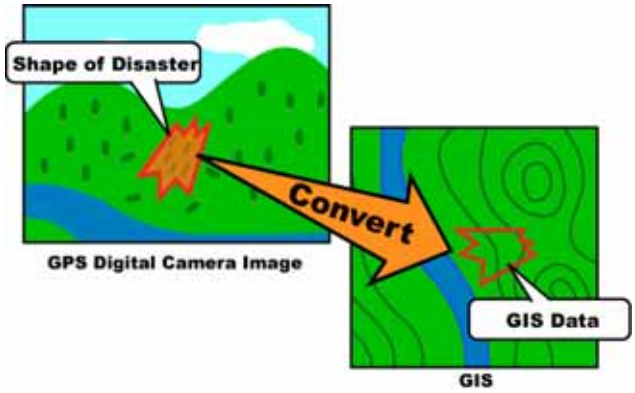

Figure2: General Idea of Generating GIS Data from Shape of Disaster in Image

3. SPECIFICATION OF GPS DIGITAL CAMERA

The image of GPS digital camera contains the coordinate of latitude and longitude in EXIF data. Figure3 and Table1 showed the appearance and the specification of GPS digital camera in this study.

Figure3: GPS Digital Camera

Table1: Specification of GPS Digital Camera

Specification of Digital Camera (RICOH RDC-i700)	
Model Number	RDC-i700
Specification of Imaging Element	3.34Mega Pixel
File Format	Compress: JPEG (Exif2.1)
Specification of GPSReceiver (I-O DATA CFGPS2)	
Model Number	CFGPS2
Frequency of Receive	1575.42MHz (C/A code)
Formula of Receive	Multi Channel (12Channel)
Accurasy of Receive	below -140dBm
Land Surveying/A Coordinate System	Tokyo, WGS-84
Accuracy of Pinpointing	below 10m (2DRMS、SA OFF)
Accuracy of Speed	0.2m/sec(SA OFF)

4. METHODOROGY

4.1 Concept of Converting Method by Skyline Matching

Figure4 showed flowchart in this study. Convert system for shape of slope failure area in GPS digital camera image will be developed using skyline matching. The skyline simulation image at the view point can be generated using Digital Surface Model (DSM). DSM is one kind of elevation data including buildings or trees, which can be generated by satellite data or aerial photograph. Direction of the camera can be calculated by image matching between extracted skyline from GPS camera image and the simulated skyline. After calculating view direction, GIS data of slope failure area in the image can be generated by intersection on DSM and the vector from slope failure area in the image.

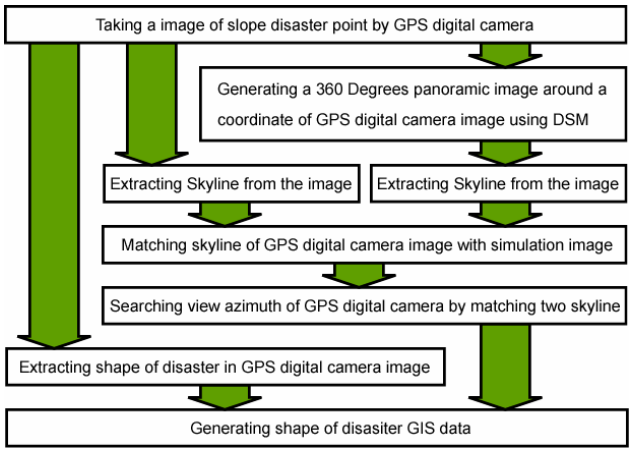

Figure4: Flowchart

4.2 Simulation Image of Skyline Using DSM

Figure5 showed general idea of skyline simulation program. DSM (15 meters grid) from satellite Terra ASTER VNIR was used in this study. The skyline simulation vector data can be generated from DSM. 360 degrees panoramic image should be generated. The panoramic image was generated based on cylindrical projection. The center of projection was set on position of GPS digital camera image. The size of cylindrical projection plane was calculated from focal length, CCD size of GPS digital camera. Figure6 showed generated simulation skyline vector data from DSM.

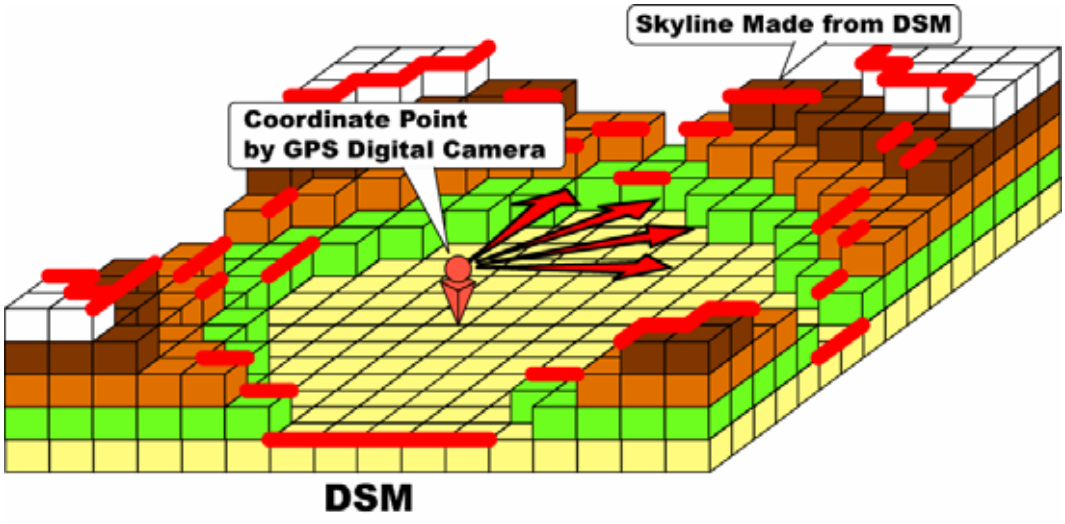

Figure5: General Idea of Skyline Simulation Program

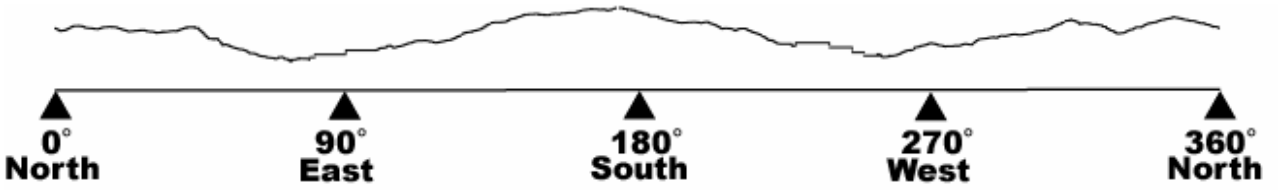

Figure6: Generated Simulation Skyline Vector Data with DSM

Figure7: GPS Digital Camera Image

4.3 Extraction of Skyline from GPS Digital Camera

The skyline can be also extracted from GPS digital camera image. The skyline in the image was located where difference of pixel value was very wide in vertical direction. Figure7 showed sample of taken image with GPS digital camera. Figure8 showed extracted skyline from GPS digital camera image.

4.4 Skyline Matching

Figure9 showed outline of skyline matching. First, the skyline vector data extracted from GPS digital camera image was compared with the 360 degrees skyline vector data made from simulation image. After that, the least of total error is searched for matching. Total error can be calculated by distance between each skyline vector data.

Figure8: Extracted Skyline from GPS Digital

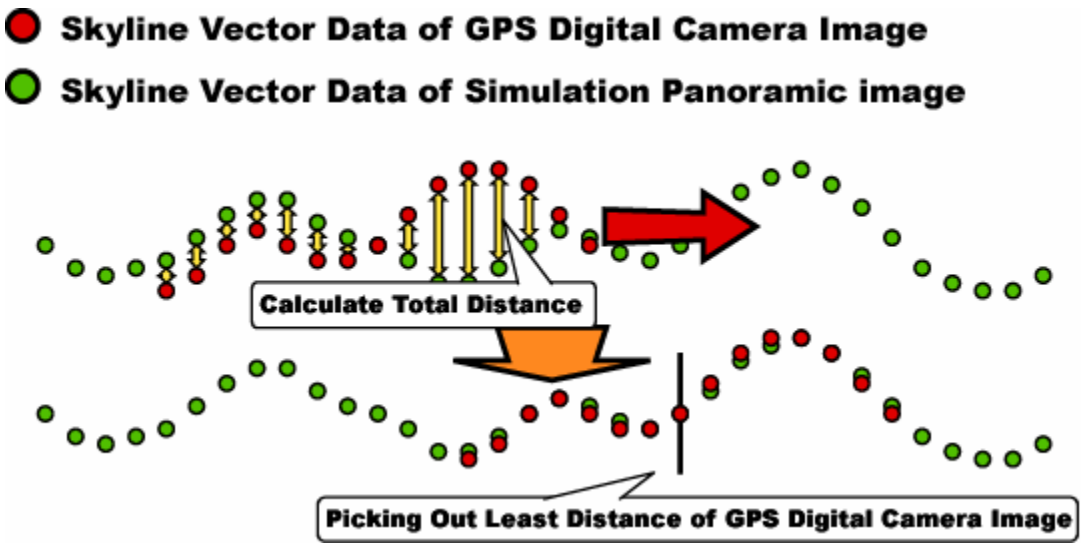

Figure9: Outline of Skyline Matching

4.5 Calculating Ground Coordinates of Slope Failure Area

Figure10 showed shape of disaster on GPS digital camera image. Figure11 showed general idea of calculating ground coordinates of slope failure area. First, direction of GPS digital camera image is calculated by skyline matching. Next, the vectors to slope failure area on image is calculated from camera direction. After that, ground coordinates of slope failure area can be extracted from intersection point of DSM and the vectors to slope failure area on the image. Finally, shape of slope failure area as GIS data is generated in ground coordinates.

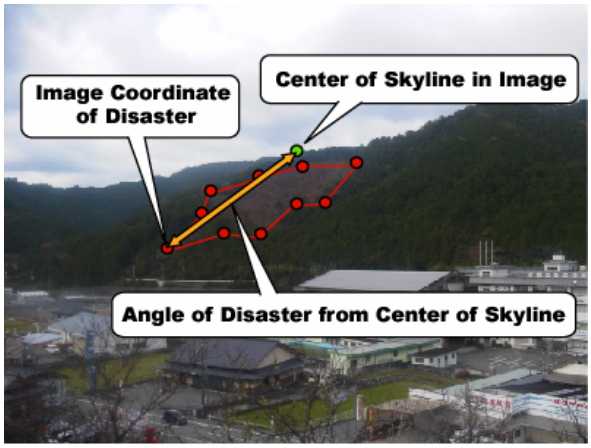

Figure10: Shape of Disaster on GPS Digital Camera Image

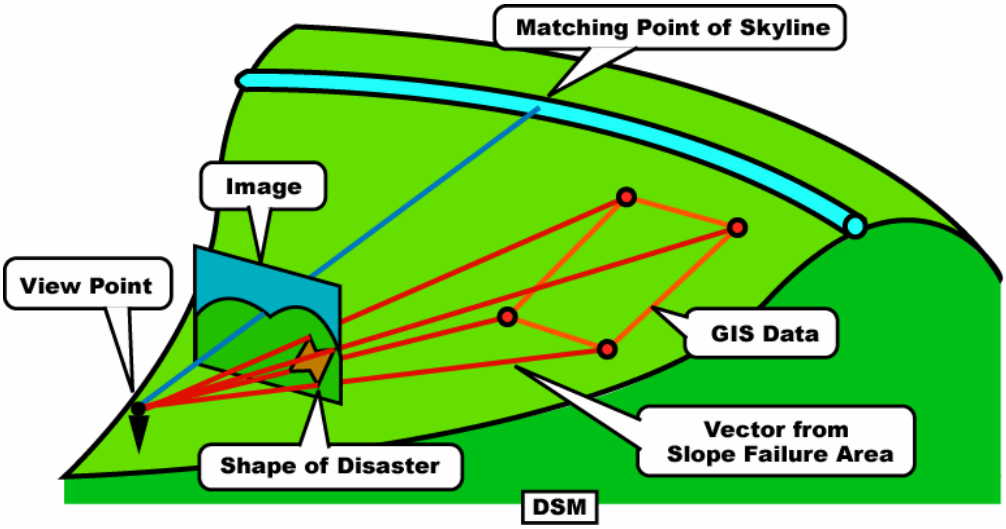

Figure11: General Idea of Calculating Ground Coordinates of Slope Failure Area

Figure12 showed result of extracted disaster on GIS software.

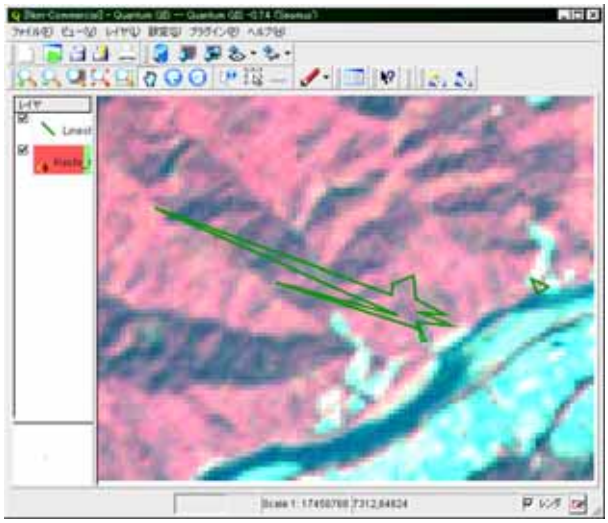

Figure12: Shape of Disaster GIS Data on GIS Software

5. VALIDATION BY FIELD SURVEY

Field surveying with GPS digital camera was carried out for verification of this system. In 29 points, GPS digital camera images had taken. Accuracy of skyline matching is verified by comparing vector azimuth of view point to center of generated GIS data and measured azimuth with compass. Table2 showed results of skyline matching. Number of correct areas were showed 13 areas. The correct answer means less than 10 degrees difference.

Table2: Results of succeeded skyline matching

Point	Surveyed Disaster Area Azimuth from North	Calculated Disaster Area Azimuth from North	Difference of Surveyed Azimuth and Calculated Azimuth
A	300	291.47	8.53
B	330	326.93	3.07
C	20	23.55	3.55
D	78	63.63	14.37
E	31	55.26	24.26
F	78	75.05	2.95
G	91	91.26	0.26
H	177	172.00	5.00
I	44	28.56	15.44
J	69	62.71	6.29
K	112	82.82	29.18
L	315	75.93	239.07
M	350	344.98	5.02
N	80	316.80	236.80
O	345	290.17	54.83
P	285	274.01	10.99
Q	23	293.62	270.62
R	85	304.61	219.61
S	175	306.61	131.61
T	268	256.53	11.47
U	322	319.02	2.98
V	350	343.75	6.25
W	40	48.79	8.79
X	85	85.50	0.50
Y	125	112.11	12.89
Z	115	143.99	28.99
AA	35	32.69	2.31
AB	325	264.65	60.35
AC	280	324.91	44.91

Figure13 showed GPS camera image in correct matching point (Point G). The skyline in this image had very characteristic shape.

Figure13: GPS camera image in correct matching point (Point G)

Figure14 showed GPS camera image in failure matching point (Point L). The skyline of this image had very simple shape. Probably, skyline matching is easy to fail in case of shape of the skyline is simple.

Figure14: GPS camera image in failure matching point (Point L)

These problems may be influenced by accuracy of DSM and actual skyline will be changed by weather condition.

6. CONCLUSIONS

The system of converting slope disaster area in image to GIS data with skyline matching was developed. However, the accuracy of skyline matching is not so good. A reason of miss matching might be come from accuracy of DSM and weather condition.

Correct ratio may be raised by using high resolution DSM. The panoramic image should be generated by considering visibility of image for using by weather condition.

This system takes time for about 30 minutes to calculate. In future, this problem must be also solved.

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