# REAL-TIME AUTOMATED DAMAGE ESTIMATION USING INFORMATION TECHNOLOGY AND SPATIAL IMAGERY

**Jae-Hyun Shim**
*National Institute for Disaster Prevention, Korea*[1]

**Ji-Tae Kim**
*National Institute for Disaster Prevention, Korea*[2]

**Woo-Jung Choi**
*National Institute for Disaster Prevention, Korea*[3]

**Kyeong-Hyeok Jin**
*National Institute for Disaster Prevention, Korea*[4]

**Keywords:**

Automated damage estimation system, information technology, spatial imagery, efficient disaster recovery

## Abstract

Recently, large scale natural disasters such as floods and typhoons due to climate change have been occurring all over the world causing severe damages. Among the various efforts to reduce and recover damages, recently, advanced information technology and remote sensing techniques are applied in disaster management. In this study, a real-time automated damage estimation system using information technology and spatial imagery was developed to accomplish prompt and accurate disaster damage estimation. This system is able to estimate the damage amounts of public facilities such as roads, rivers, bridges automatically through spatial imageries including ground based digital images. Based on these spatial images, the damage amounts are analyzed in the Web-GIS based analysis system. Consequently, the digital damage reports such as digital disaster information sheets and damage maps can be made promptly and accurately. This system can be a useful tool to carry out prompt disaster damage estimation and efficient disaster recovery.

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[1] 253-42, 6th Floor, Gongdeok-Dong, Mapo-Gu, Seoul, Tel : +82-(0)2-3271-3220, e-mail:shim1001@nema.go.kr
[2] 253-42, 6th Floor, Gongdeok-Dong, Mapo-Gu, Seoul, Tel : +82-(0)2-3271-3230, e-mail:jtkim77@nema.go.kr
[3] 253-42, 6th Floor, Gongdeok-Dong, Mapo-Gu, Seoul, Tel : +82-(0)2-3271-3221, e-mail:choiwj@nema.go.kr
[4] 253-42, 6th Floor, Gongdeok-Dong, Mapo-Gu, Seoul, Tel : +82-(0)2-3271-3231, e-mail:tom51@nema.go.kr

## Introduction

In the past few years, catastrophic disasters such as large-scale typhoons, torrential downpours causing serious damage have been increasing due to climate change. In Korea, July 14-20, 2006, a torrential downpour which occurred at Inje and Pyeongchang city in Kangwon province caused nearly $1,418 million of property damage, 29 dead. Typhoon Maemi in 2003 caused $4,222 million of property damage, 131 dead, 61,800 displace and Typhoon RUSA in 2002 caused $5,147 million damages, 246 dead, 63,000 displaced.

When a large scale disaster happens, the officials of relevant local governments are evacuating residents in disaster area to shelters, supplying relief goods to victims and reporting damage information from disasters to the central administrative organizations and agencies. In case of emergency with disaster, the central organizations need damage information from disaster for estimation of a recovery budget but there are problems with precise estimation of damage because the officials of local governments are concentrating on the safety of residents, temporary recovery, and the report of damage situation from disaster.

For the reasons mentioned above, it is necessary to utilize IT technologies such as wireless communication, portable computers, GIS (Geography Information System), Remote Sensing. We developed the system for the prompt investigation of damage from disaster using IT technologies, terrestrial photogrammetry, aerial photos, and satellite images with the project 'The automated damage assessment using spatial imagery' from 2004. The purpose of this project is to reduce a term of damage assessment and to raise efficiency of recovery budget through objective estimation of the amount of damaged facilities, especially for roads, embankments, bridges.

The system is able to estimate the damage amounts of public facilities automatically through spatial images including ground based digital images, aerial photos, satellite images of disaster sites. Based on these spatial imageries, the damage amounts are analyzed in the portable computer and Web-GIS based analysis system.

## Real-time ground based investigation system

In case of road and embankment breaking from disasters, the officials of local governments have been reporting damage information (length, area and amount of damage) to the central organizations and agencies by fax and inputting that information to NDMS (National Disaster Management System). In the existing disaster management system, this quantitative information of damaged facilities is estimated by eye or tape measurement at the response stage. However, although this process could be suitable method for the approximate report to prepare a recovery process, the precise investigation of damaged facilities is essential for official approval of damage information reported by fax and NDMS.

In this project, we adopted wireless communication technology for real-time disaster information transmission and ground based photogrammetry system which could estimate the amount of damage length, area through stereo images.

## Ground-based investigation system

The ground-based investigation system is able to estimate the amount of damage using stereo images of damaged facility based on ground photogrammetry. This system is composed of stereo imaging system, UMPC(ultra mobile PC), GPS receiver, and the amount estimation software. For the estimation of recovery expenditure, the unit cost of each facility is pre-inputted in the database. Figure 1 shows the ground-based investigation system. Two digital cameras are fixed at a certain distance on tripod and UMPC is located between two cameras.

At the first step, stereo images taken by two digital cameras are stored in UMPC and length and area of the damaged facility estimated through software. And then that damage information including the amount of damage and images are transmitted in real time by HSDPA (High Speed Downlink Packet Access) modem to a web server.

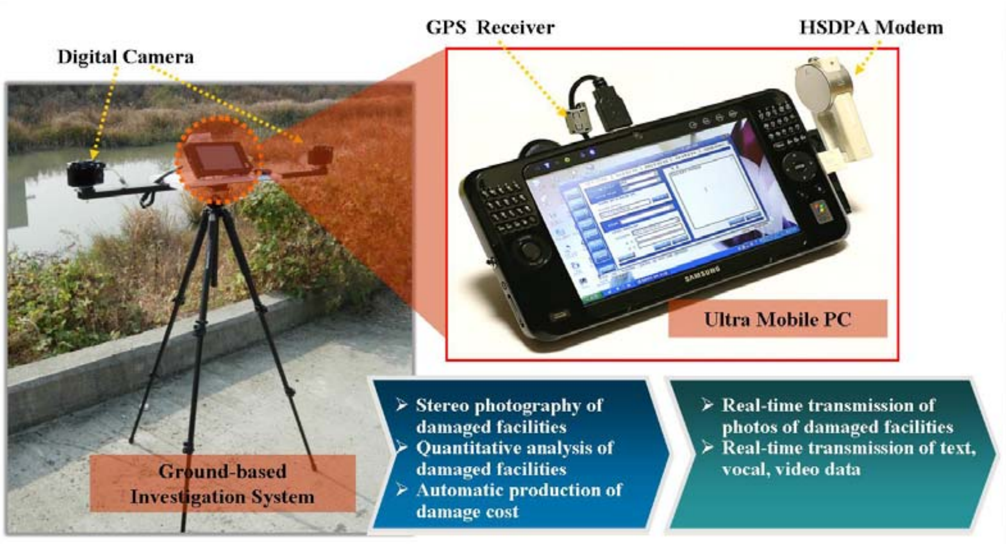


Figure 1. Real-time ground based investigation system

## 1) Softwares

In this study, we developed software that could estimate amount of damage from stereo images and transmit damage information in real time to a web server. Figure 2 shows the software for estimation of amount of damage by public facilities, which programmed by Microsoft Visual Basic. Figure 3 is the real-time transmission software of damage information with photos and quantitative information based on C# program language.


Figure 2. Software for estimation and management of damage

Figure 3. Software for real-time transmission of disaster damage

## 2) Accuracy verification by distance

Accuracy verification of the system by distance from 10m to 100m was performed comparing measurement of a target with process results of the system developed in this study. The results of accuracy verification indicated that the more distance between the camera and a target increases the more errors increase. Table 1 shows the results of accuracy verification.

Table 1. Results of accuracy verification by distance

| Distance | X, Y | Measurements(m) | Results(m) | Error(m) |
|---|---|---|---|---|
| 10m | X | 7.56 | 7.42 | 0.14 |
| | Y | 2.56 | 2.52 | 0.04 |
| 20m | X | 7.56 | 7.29 | 0.27 |
| | Y | 2.56 | 2.50 | 0.06 |
| 30m | X | 7.56 | 7.11 | 0.45 |
| | Y | 2.56 | 2.42 | 0.14 |
| 40m | X | 7.56 | 6.95 | 0.61 |
| | Y | 2.56 | 2.41 | 0.15 |
| 50m | X | 7.56 | 6.78 | 0.78 |
| | Y | 2.56 | 2.38 | 0.18 |
| 60m | X | 7.56 | 6.74 | 0.82 |
| | Y | 2.56 | 2.25 | 0.31 |
| 70m | X | 7.56 | 6.53 | 1.03 |
| | Y | 2.56 | 2.21 | 0.35 |
| 80m | X | 7.56 | 6.19 | 1.37 |
| | Y | 2.56 | 2.17 | 0.39 |

| | | | | |
|---|---|---|---|---|
| 90m | X | 7.56 | 6.01 | 1.55 |
| | Y | 2.56 | 2.13 | 0.43 |
| 100m | X | 7.56 | 5.81 | 1.75 |
| | Y | 2.56 | 2.06 | 0.50 |

As shown in Table 1. the accuracy decrease as the distance to target increases. This tendency can be explained that the resolution of the image decreases as the distance increase by containing detection and distance errors.

### 3) **Accuracy verification by angle**

Accuracy verification by angle from 0° to 90° between a target and the camera was performed comparing measurement of a target with process results of the system. The results of accuracy verification by angle indicated that the errors changing angle between camera and a target are similar and magnitude of errors is very little and error tendency by angle was not proportional to angle. It is clear that this error is caused by mismatching of damaged facility in stereo images when estimating length or area of damaged facilities.

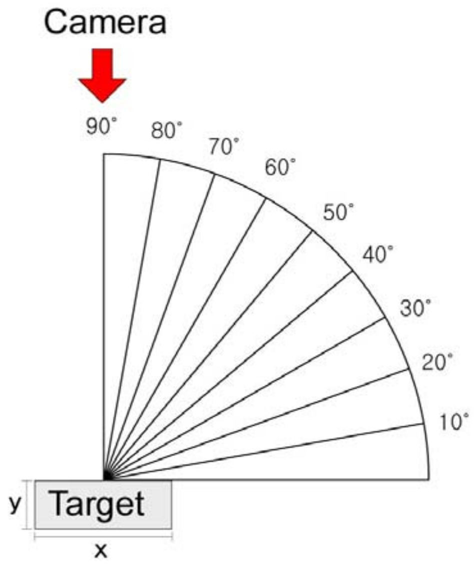


Figure 4. Changing of angle for accuracy verification by angle

Table 2. Results of accuracy verification by angle

| Angle(deg) | X, Y | Measurement(m) | Result(m) | Erros(m) |
|---|---|---|---|---|
| 90 | X | 2.54 | 2.47 | 0.07 |
| | Y | 0.90 | 0.89 | 0.01 |
| 80 | X | 2.54 | 2.45 | 0.09 |
| | Y | 0.90 | 0.87 | 0.03 |
| 70 | X | 2.54 | 2.48 | 0.06 |
| | Y | 0.90 | 0.86 | 0.04 |
| 60 | X | 2.54 | 2.45 | 0.09 |

| | | | | |
|---|---|---|---|---|
| | Y | 0.90 | 0.85 | 0.05 |
| 50 | X | 2.54 | 2.50 | 0.04 |
| | Y | 0.90 | 0.89 | 0.01 |
| 40 | X | 2.54 | 2.41 | 0.13 |
| | Y | 0.90 | 0.88 | 0.02 |
| 30 | X | 2.54 | 2.45 | 0.09 |
| | Y | 0.90 | 0.89 | 0.01 |
| 20 | X | 2.54 | 2.52 | 0.02 |
| | Y | 0.90 | 0.89 | 0.01 |
| 10 | X | 2.54 | 2.51 | 0.03 |
| | Y | 0.90 | 0.86 | 0.04 |

As shown in Table 2. the errors by angle are small and constant. This indicate that the system is not affected by angle and could be applying to estimate information of damaged facilities with not being a perpendicular line between the camera and a target.

## Website for management of disaster information

Disaster damage information acquired from the ground-based investigation system are stored in the database system and processed by web application program and then expressed on the web system like Figure 5. In main page of the website, the recent information list of disaster damage, official announcement, and question/answer are displayed and designed to move to detailed information page clicking button 'more'. Especially, the digital disaster information sheets are created using photos on disaster site, quantitative damage information, and each GIS information (X, Y coordination of damage area or facilities). Users can get disaster information through the website.

Digital disaster information sheets include a report number, cause of damage, type, area, information of damaged facilities, photos, video, sound information and reliable information for estimation of amount of damage (Figure 6). Through this website central government officials can understand disaster damage situation and information without access to disaster area and generate disaster damage maps easily


Figure 5. Website for disaster information management (http://host.datapcs.co.kr/NIDP)

Figure 6. Digital disaster information sheet

For disaster information management, this website includes GIS system in linking coordination of disaster area or facilities with maps. Web-GIS system is composed of layer tree, menu, information expression, maps. Base map of this system is satellite image of IKONS with spatial resolution 1m and digital maps with 1:1,000 and 1:5,000 which divided into administrative districts, contours, rivers, hydrographic layers, facilities, roads, buildings (Figure 7).

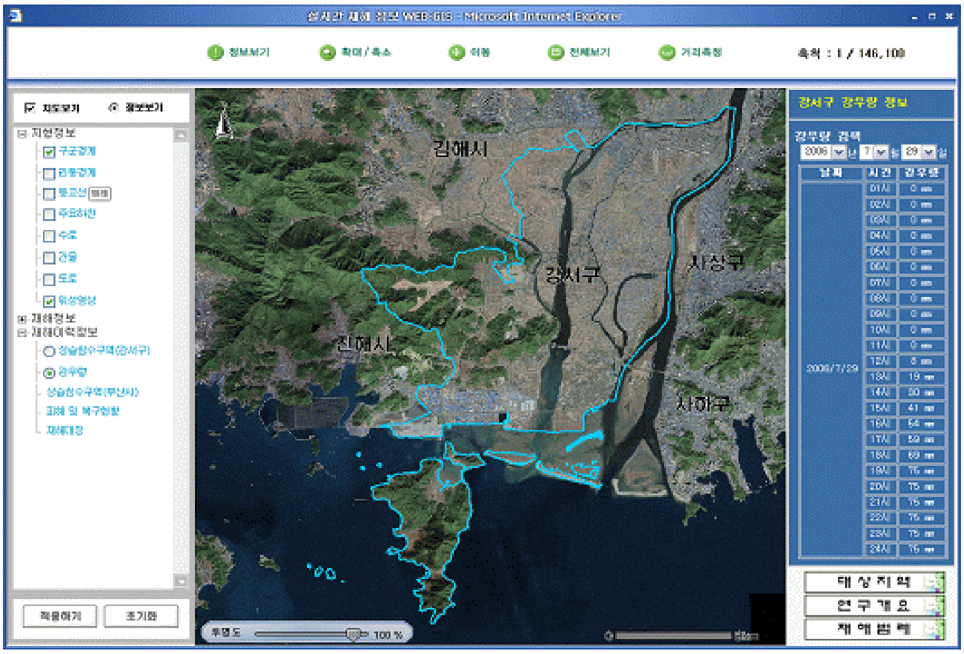


Figure 7. Web-GIS based disaster information management system

## Conclusions

The results of an accuracy test have shown that the major error of the system is caused not by angle but by distance from the camera to an object. To increase the feasibility of the system, separate software and system need to be integrated. And the real-time communication system between damage site and relevant agency is proven to be needed to make this system more effective. When this ground-based investigation system is linked with aerial photos of satellite images, it is expected that more accurate, prompt and efficient damage estimation can be achieved.

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## Author Biography

Jae-Hyun Shim had a Ph.D in Hydrology at Yonsei University in Korea. Since 1997, he has been working at National Institute for Disaster Prevention and a leader of research planning team. He has been the superintendent of this project since 2004.

Ji-Tae Kim had a Ph.D in Hydrology at Yonsei University in Korea. Since 1998, he has been working at National Institute for Disaster Prevention and a leader of disaster information & analysis center. He has been researching about disaster information management and generation for analysis of disaster.

Woo-Jung Choi had a Ph.D in Hydrology at Kukmin University in Korea. Since 1999, he has been working at National Institute for Disaster Prevention and a member of research planning team. He has been researching about a policy of disaster management and the system developed in this project.

Kyeong-Hyeok Jin have been working at National Institute for Disaster Prevention and a member of disaster information & analysis center. He has been researching about application GIS and spatial imagery such satellite image and aerial photo to disaster management