CONSTRUCTION OF GIS FOR THE RESTORATION SUPPORT BY IMAGE PROCESSING AND AD HOC NETWORKING IN A DISASTER

Kazutaka IWASAKI, Takashi WATANABE, and Keiichi ABE

Faculty of Information, Shizuoka University
3-5-1 Johoku, Hamamatsu-shi, Shizuoka-ken, 432-8011 Japan
iwasaki@inf.shizuoka.ac.jp, watanabe@inf.shizuoka.ac.jp, abe @inf.shizuoka.ac.jp

ABSTRACT:

Earthquake disaster frequently happens in Shizuoka Prefecture and it is commonly predicted that a giant earthquake(Tokai Earthquake) could occur in the near future. When a giant earthquake happens, extensive damage of lifelines will be expected. It is considered that the collection of damage information and the establishment of a communication network system are very important in order to restore lifelines quickly. And geographic information system(GIS) might play a very important role to grasp the spatial information of lifeline damage in a natural disaster.

The authors' group had a research project to study a lifeline restoration support system with image processing and ad hoc networking in a natural disaster. The objectives of this presentation are to introduce our project and to show some results of our study. The authors finally constructed the GIS for the integration of damage information acquired by image processing and ad hoc networking.

KEY WORDS: GIS, Tokai Earthquake, Image processing, Ad hoc network, Disaster restoration

1. INTRODUCTION

Hamamatsu City is located in the central part of Japan and in the west of Shizuoka Prefecture(Figure1).

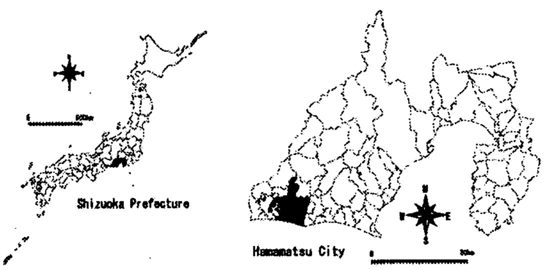

Figure 1. Location of Hamamatsu City

It is commonly predicted that a giant earthquake could occur in and around Shizuoka Prefecture in the near future. Due to the urgent need in developing a system that prevents a secondary disaster we started a project whose goal is to develop a restoration support system in a disaster by image processing and information gathering by ad hoc networking.

The project has 3 subprojects, i.e.,

(1) Global damage information gathering by aerial photograph images or high resolution satellite images.

(2) Local information gathering by wireless ad hoc networks.

(3) Combining the two information database to support effective restoration planning.

2. IMAGE PROCESSING

The authors tried to detect areas of collapsed buildings from a single aerial image taken after an earthquake using color information and edge information.

As for color information, an important point is that damage areas usually look brown. It is the color of the ground as well as the color of lumbers, main materials of Japanese houses. Such areas are detected by thresholding the hue image with specified brown ranges.

As for edge information, the distribution of edge directions is more important than edge intensities. In the damaged area of collapsed buildings, the edges have short lengths and random directions. On the other hand, in the non-damaged area of railroad tracks or buildings, the edges point to mostly one direction or the direction perpendicular to it.

Figure 2 shows Original aerial image, Figure 3 shows the detected damage area by color information, Figure 4 shows the detected damage area by edge information and Figure 5 shows the final image of detected damage area. The result of this method is shown in Table 1.

Table 1. Result of image processing

	Detection ratio	Exactness ratio
Area damaged by fire	49.3 %	77.7 %
Area damaged by destruction	11.5 %	35.9 %

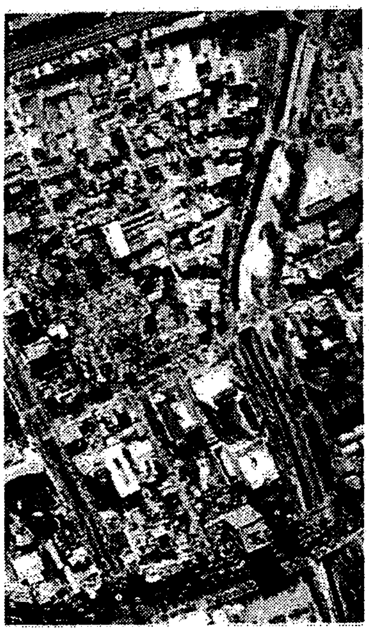

Figure 2. Original aerial image

Figure 3. Detected damage area by color information

Figure 4. Detected damage area by edge information

Figure 5. Final image of detected damage area

3. AN AD-HOC NETWORKING SCHEME IN CELLULAR NETWORKS FOR DISASTER COMMUNICATIONS

In a natural disaster or emergencies, it is a critical matter to maintain accessibility and connectivity for emergency services and for collecting damage assessment information. A centralized network operating in polling mode is suited well to acquire data effectively without communication congestion as shown in Figure 6 nad 7. However, the network is linked with single paths. In the event that a disaster happens, propagation conditions of the wireless channels may get worse by damage to an antenna or other interruptions, resulting in disconnection of the links between BS and terminals. Meanwhile, technologies of ad hoc networks conduct infrastructure-less networking; it has no fixed line, and all nodes discover and build a route dynamically. When transmitting data, the source node tries to discover a route to the destination by multihopping. Even if an ad hoc link may get damage and cannot maintain the link, the node is capable of rebuilding an alternative connection. Links of ad hoc networks, however, are vulnerable due to not only movement but also simple equipments of transceivers, furthermore due to some issues such as interferences from hidden terminals. In conditions where the number of multihopping increases, the connectivity may deteriorate, besides, the end-to-end delay increases in proportion to the hops. Consequently, the reliability of the network degrades by the multihopping. Those drawbacks hamper to introduce ad hoc networks to the system for disaster communications.

This paper has proposed a hybrid wireless network scheme, ECCA(Enhanced Communication scheme combining Centralized and Ad hoc networks), combining ad hoc networking with a centralized network to satisfy the requirement of maintaining connectivity for disaster communications as shown in Figure 8.

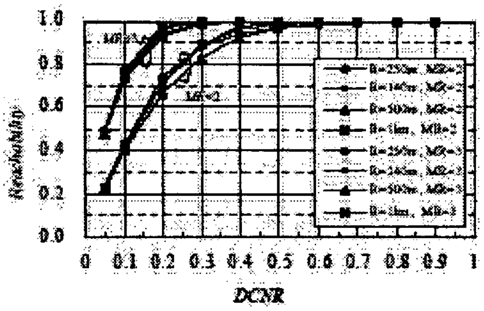

Figure 6. Impact of cell size in reachability

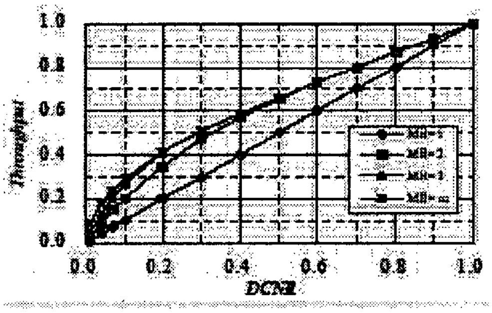

Figure 7. Average throughput as a function of DCNR

The routing protocol of ECCA allows a terminal to discover an route to the base station by multihopping with neighboring communications monitoring. Experiments showed that 90% of terminals reach the base station within three hops by multihopping even if only 20% of nodes are directly accessible to the base station. Simulation results of delay indicated that the network is capable of transmitting a packet in a short delay. We expect that the proposed network work sufficiently without communication congestion even in disaster circumstances. Further study is under way to investigate the total performances of the network by way of modeling with probability process.

Retransmission control is also under way to improve throughput of the network.

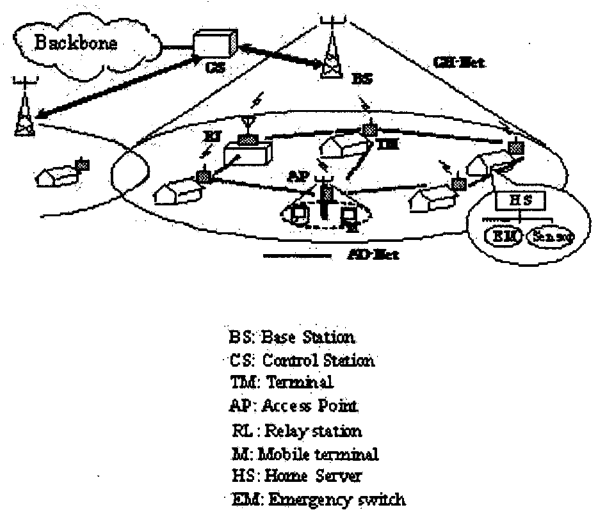

Figure 8. Concept of wireless networks combining ad hoc networking with a centralized hierarchical network

4. INTEGRATING ON GIS

Various digital maps of Hamamatsu City is collected at first, to develop the GIS of Hamamatsu City. The middle scale map of boundaries of small statistical units of Hamamatsu City is collected to sum up the damage area and topographic map of large scale digital map to register each house or building in the image to geographic space.

Traditionally, the coordinate system of large scale(1:25,00 or larger) maps is different from that of middle scale(from 1:50,000 through 1:10,000) maps. The middle scale maps use the UTM coordinate system, but the large scale maps use the Japanese original modified UTM coordinate system. This coordinate system is called the Plane Rectangular Coordinate system(PRC system) in Japan. PRC system is based on the transverse Mercator's projection and divides Japan into 19 blocks. The origin of the coordinates of each block is designed so that one prefecture is located within the same block. The map unit of PRC system is meter just like UTM coordinate system, but PRC system has no false Easting or Northing.

The city planning basic maps are usually 1:2,500 scale ones and based on PRC system. The large scale digital maps are usually digitized from the city planning basic map but the middle scale digital maps are usually digitized from the Japanese standard topographic map of UTM projection. When the maps of different scale are overlaid, the elements of the maps do not perfectly correspond with each other. The errors usually result from the middle scale digital maps, but sometimes result from the inaccuracy of large scale digital map, because the coordinates of city planning basic map are not authorized by the Geographical Survey Institute of Japan.

As the images of damaged areas should be rapidly processed, and precisely registered to geographical coordinate system, we have to compare several large scale digital maps and decide the bast map as the basic map of this project.

5. CONCLUSION

The authors' group had a research project to study a lifeline restoration support system with image processing and ad hoc networking in a natural disaster. The authors introduced our project and showed some results of our study. The authors finally constructed the GIS for the integration of damage information acquired by image processing and ad hoc networking.