RAPIDLY FLOOD EXTENT MAPPING SERVER DESIGN AND EXPERIMENT USING MATHEMATICAL MORPHOLOGY RECOGNITION AND COOPERATED DISASTER INFORMATION SERVERS ON THE INTERNET

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ABSTRACT:

Mathematical morphology operations and directional filters provide image feature measurements. Terrain feature recognition for SAR imagery combines both target's physical property and morphological image processing. This method should be adopted in order to solve the problem how to distinguish paddy fields from flood inundated areas by using the conventional SAR signal intensity change method. For example, if the Levee of paddy fields is above the inundated water surface, the paddy fields should be almost without damages in the consolidated farm lands. If the region of the low backscattering intensity level occupy large area, that can be most likely large water surface, flood-inundated areas. These calculations require only a snapshot of SAR image. This image processing procedure will have advantage over the flood disaster monitoring using SAR satellite data. The authors plan to make rapidly flood extent mapping server on the Internet for the early warning system of regional and agricultural flood damage. The analyzed satellite images showing flood extent superimposed on a geographic global map should be converted to an appropriative format image and stored into image database. The authors installed web server such as windows2000 server IIS, the ColdFusionMX as a web application server and the MapGuide server as a web map generator, the ImageWebServer as a swiftly showing tool bridged from the image database and the MapGuide server. The users of such web map only should prepare a web browser. They can see the flood extent image and global maps in the same browser. The SAR data should be the useful tool for risk management as monitoring change or disaster in the first situation. Recently, as web mapping standard is preparing, distributed map server design and its experiment is planning among JIRCAS, AIT and PDC.

1. INTRODUCTION

There are many kinds of agricultural disaster, such as cool summer damage of paddy rice crop, drought damage, flood damage, etc. In the big river downstream regions of tropical areas, flood is not unusual thing. But the life style among the people living in such regions and the way of rice crop production was changed. (Farmers cultivate less floating rice.) The flood influences both their daily life and rice crop production. The water level usually rises several centimeters per day during flood in such areas. Then satellite SAR, which recurrent time is rather long period, can detect flood extent. Addition to that, the next Japanese satellite, ALOS has PALSAR sensor and one of the mission of ALOS is the disaster monitoring.

Natural disaster can happen anywhere on the earth, but the organizations, which can analyze satellite data, will be

limited. And the flood water depth or the necessary information on regional base is not easily acquired by the remote sensing data. Then it should be very convenient that the above mentioned information can be uploaded into the web servers which exist at hand, but the client of disaster information unconsciously and seamlessly can access such kind data on the distributed and cooperated web servers through the Internet. Recently, the discussion of the international standard for such distributed and cooperated server design is progressing at ISO, OGC, etc.

Mathematical morphology procedure should be suitable for the method of SAR data analysis for such kind of disaster data server. Because this image processing procedure will have advantage over the flood disaster monitoring using SAR satellite data in some points.

The authors plan to make rapidly flood extent mapping server on the Internet for the early warning system of regional and agricultural flood damage.

2. FLOOD EXTENT MAPPING METHOD IN PADDY FIELD AREAS

2.1 Interaction between SAR data and ground features

Computational mathematical morphology operations, such as erosion, dilation, opening, closing and directional filters, provide image feature measurements. By using conventional method, they can detect the flood extent from the low backscattering value of each pixel for the water surface. But it will be very difficult to distinguish the flood areas from the ordinary paddy fields especially in the early growing stage of rice plants. But SAR signal intensity for each pixel includes some interactive information between microwave and terrain feature on the ground. Then morphological processing procedures are one of the methods for detecting such spatial information. For example, if the Levee of paddy fields is above the inundated water surface, the paddy fields should be almost without damages in the consolidated farm lands. If the region of the low backscattering intensity level occupy large area, that can be most likely large water surface, flood-inundated areas. These calculations require only a snapshot of SAR image.

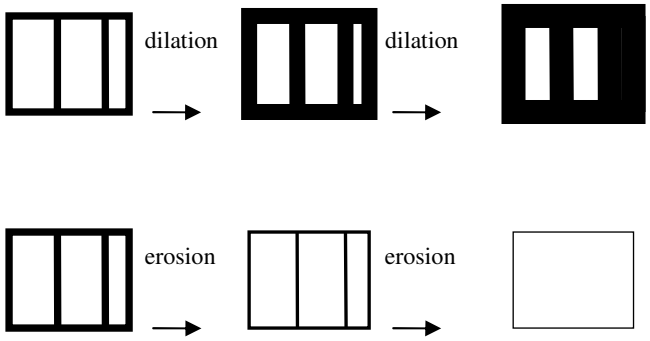

Fig.1 The results of dilation and erosion

□Morphological operators

S # B = {z: B + z # S} ; erosion operation

S @ B = #{B + x : x # S} ; dilation operation

S $ B = (S # B) @ B ; opening operation

S ¥ B = [S @ (-B)] # (-B) ; closing operation

2.2 Terrain feature recognition method for SAR imagery in paddy field areas during flood

If the farm lane or levee is above the water surface otherwise it is an ordinary inundation or flood, the flood damage to paddy rice is assumed as no damage. Because usually, paddy fields have the water surface of its swamp and the water level is under the top of the levee or farm lane.

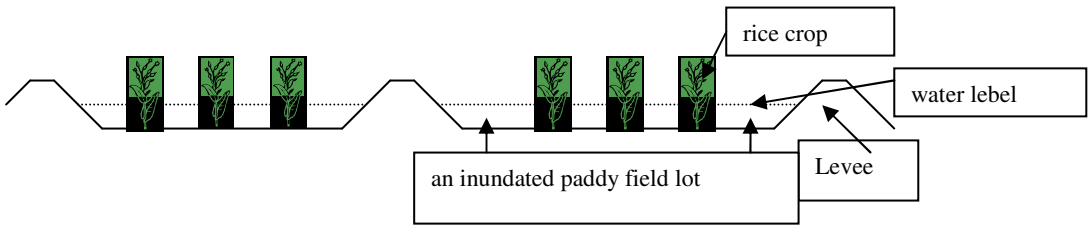

Fig.2 Cross section of paddy fields

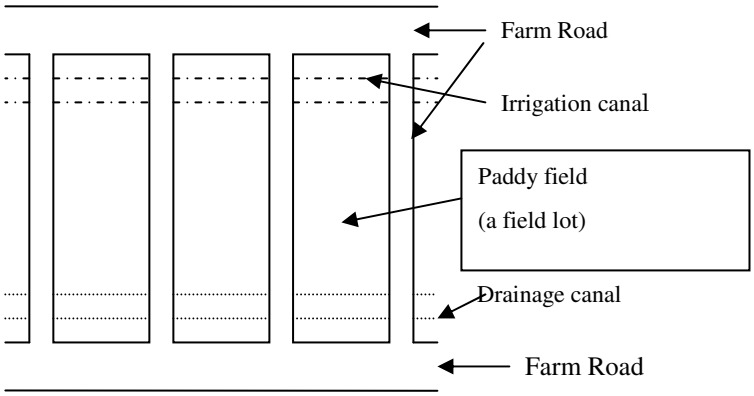

Fig.3 Plane figure of paddy rice fields after farm land improvement

2.3 Terrain feature candidates decision making rule

- Paddy field almost without damages

Levee of paddy fields should be above the inundated water surface. Then after cutting the SAR data off at the threshold of appropriate value and making binary images, some dilation operations are performed for filling the interval areas of levees in improved paddy fields as non-damaged fields. The number of iteration should depend upon the width of the paddy fields, because the land-improved paddy field has the shape of rectangle. And the levee, farm lane, will run along the long side of the rectangle.

- Most likely flooded water surface

The region of the low backscattering intensity level can be most likely large water surface. This time, threshold method is adopted for getting the candidate of large water surface.

3. CASE STUDY IN THAILAND

3.1 The proposing method of terrain feature recognition for SAR imagery employing spatial attributes of targets

The combination of dilations after erosions is called an "opening" operation. Another combination of dilations followed by erosions is a "closing" operation. "Open operation" has the effects of removing pixel noise. "Closing" used to bury small holes or narrow dents and to connect together with the broken connected components (river or something).

SAR signal intensity for each pixel includes some interactive information between microwave and terrain feature on the ground. Then we can examine SAR images applying to morphological processing procedures above mentioned.

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3.3 Procedure of case study in Thailand

The following picture, Fig.4, shows the flow chart of the computational method of flood extent detection.

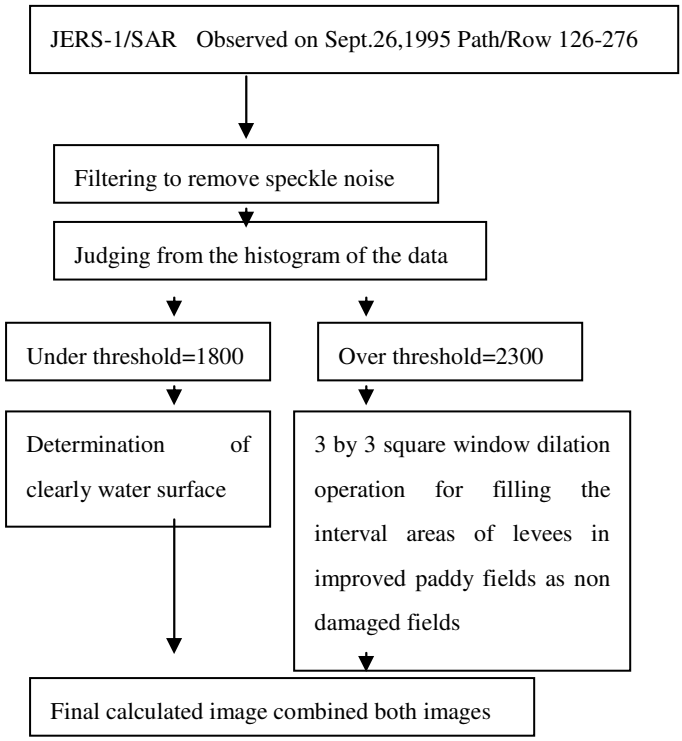
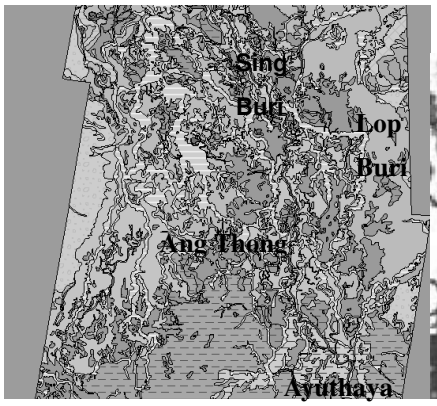


Fig.4 Flow chart of the computational method of flood detection

Fig.5 indicates the location of this analysis, around Ayuthaya to Lop Buri, Ang Thong in the Central Plain of Thailand along the Chao Phraya river. This area is over the JERS-1/SAR scene of path-row/127-276, September 26, 1995. The flood of 1995 was started in the end of August, 1995 and reached the peak depth of water at the end of September in this region. The flood-inundated period was very long.



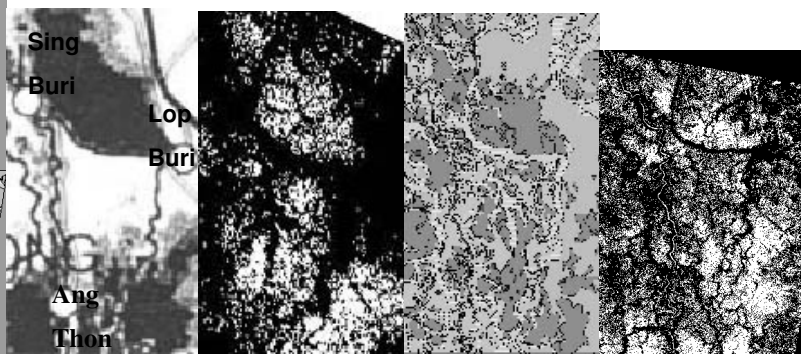


Fig.5 micro-geomorphological survey map (around Ayuthaya to Lop Buri)

Fig.6 Fig. 7 Fig.8 Fig.9

Fig.6 is a part of the reported inundation map (gray color) around Lop Buri. Fig.7 is the result of morphological image processing. (white color) Fig.8 shows a part of the micro-geo-morphological survey map. Fig.9 indicates the flood-damaged areas in paddy fields using the conventional analytical method.

The conventional method employs the SAR signal intensity change to the correspondent pixels in plural images. But it is rather difficult to distinguish flood-inundated areas from paddy fields (Fig.9), because ordinary paddy fields have water surface. The image by mathematical morphology (Fig.7) is similar to the flood report (Fig.6). The analytical method requires only snapshot SAR image, quick calculation and little hardware resources. This is advantage over the conventional

method. But there are some points in dispute about this scene. To compare Fig.6 to Fig.7, the center of the Fig.6 is not flood-inundated area, but the same part of Fig.7 is flood area. Addition to that, though the region near Ang Thong is floating rice growing area, it seems that the report says flood damaged area. Then we must do ground truth to make sure these points.

3.4 Ground truth

The result of the ground truth, that is field study, shows the satellite data analysis fully corresponds to the flood report.

4. DISASTER INFORMATION WEB SERVER

4.1 NASA/Raytheon Synergy Project

NASA started "NASA/Raytheon Synergy Project" with several universities, intended for the effort of the enhancement of potential satellite data application since 2000. In that program, it is included to make Web-based distributed server, "Infomarts" using Open GIS Consortium criteria and the recent web technologies in the disaster monitoring research field.

4.2 Web Application Server

The WWW(World Wide Web) server on the Microsoft windows operating system is IIS(Internet Information Server). It provides HTML or XML documents to the Internet. The "Macromedia ColdFusion" software or else a JAVA Servlet engine (a servlet container and a created servlet) can be used as the Web application server between database and the web server. (Of course, JavaServer Pages or else JavaBeans or Perl scripts can also be used for this purpose) The "AutoDesk MapGuide Server" is a kind of a GIS map data server from map database to the Web server through a Map Agent like CGI (Common Gateway Interface). The MapGuide server provides GIS map data, otherwise vector type map's components, such as point, line and polygon features or raster type maps at an arbitrary map coordinate. The Web server gets the map data from the MapGuide server. The client can open maps on his web browser with an appropriate coordinate system and he can move it or magnify it or get the x, y coordinates and it's distance. He can make references of the map attributes database and he can renew the data using the ColdFusion. But he doesn't recognize it, because it works background of the web server. The ImageWebServer is used as a swiftly showing tool bridged from the image database and the MapGuide server. The client can see the heavy image without stress through the Internet. The authors intend to use DCW (Digital chart of the world) or the global map (by International Steering Committee of Global Map) as the world map for this server.

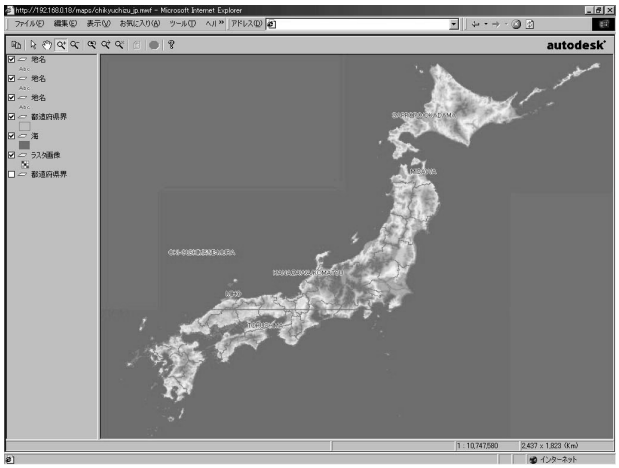
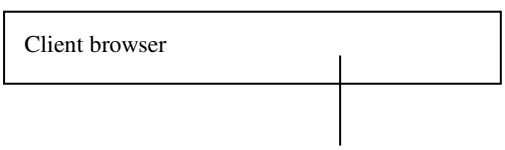


Fig. 15. a part of the Global Map on a client browser



4.3 Distribution of Flood Extent Image

After the computational mathematical morphology operation to SAR images, we can obtain the image of the potential areas of the flood extent in such region in less than several hours after getting Level 2.1 products of JERS-1/ SAR for example. It will store the database on the server, after converting the image file type. The client can see the images overlaid on a low scale map on his web browser.

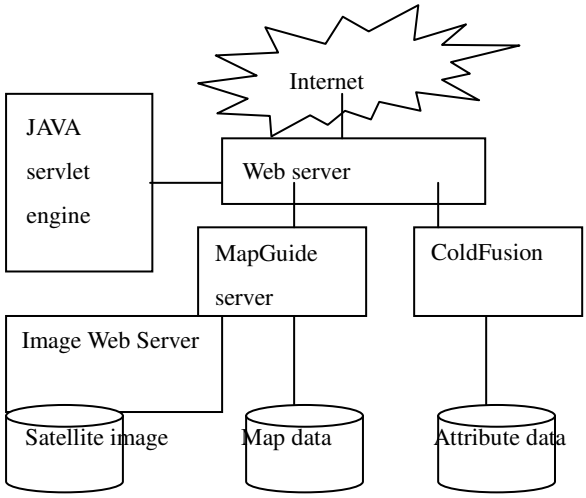


Fig. 16 The concept of this server

4.4 Future possibilities and discussion

GML (Geography Markup Language) will be prescribed for the standard language of the GIS world by ISO in the near future. Then the distributed web based GIS server, Geo-Web can be made as for the disaster mapping system. Office for Outer Space Affairs, United Nations Office at Vienna already makes some efforts to establish regional partnerships as for disaster management and assessment. The rapidly flood extent map server system in this paper will contribute to this kind efforts.

5. CONCLUSIONS

The computational new method of combining the terrain feature and mathematical morphology will provide the flood extent mapping procedure in paddy field areas. This kind procedure requires small machine power and they can quickly obtain the result. Then it can be used for rapidly flood extent mapping for the early warning system of regional and agricultural flood damages. Recently, as web mapping standard is preparing, distributed map server design and its experiment is planning among JIRCAS, AIT and PDC.

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