Extracting ruins in Angkor region Using satellite image data

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ABSTRACT

The ancient Khmer civilization had existed in Cambodia, northern Thailand, and Vietnam through 9th to 13th century. Many of those buildings of Khmer constructed in these periods are still existing today. These ruins are one of the largest ruins in the world, and many studies and surveys had been done so far. Some have been surveyed and the positions are known, but there are still many more ruins which have not been surveyed nor found. The location of the ruins are tend to be in a backcountry region, it is necessary to have an accurate position of them to have an effective survey. The purpose of this research is to have a basic study of grasping the ruin distributions and their positions by using satellite images. Angkor ruins are picked up as an object. Since they are the most famous ruins group in the region for its scale and beauty. (especially, Angkor Wat is known as world heritage defined by UNESCO). There are many data such as maps, books, and plans about this ruins group, which makes it appropriate to start the basic study. It is possible to project objects on the ground by using different spectral reflection that the satellite images give. In this research, we used Landsat-5/TM image as well as JERS-1/SAR image. Landsat-5/TM image has 7 different band of spectrum images, and by changing those combinations of the spectral images, it is possible to extract the required object. JERS-1/SAR image is taken by the active sensor. This sensor is tend to reflect the feature of the shape and the texture of land. By using characteristics of these two kinds of satellite images, the extraction of the ruins was attempted, and calibrated against the known ruin maps.

1.INTRODUCTION

The Angkor ruin group is located in Siem Reap region, Cambodia. The ruin group is consisted of more than 100 ruins, existed in a vast area (30square KM). There are difficulties to have a survey in Cambodia, because of deep rainforests, remaining mines from the internal conflicts since 1970's, and unstable political situations. There are still many ruins existing in the jungle, which are keys for the study of Angkor, and Khmer histories. If we can pinpoint these ruins, and identify their chronology with their cultural propagation, it would contribute to the archaeological study of Khmer civilization. It is also intended to study relationship of ruin distribution to the geographical features. From the standpoint of the cultural assets conservation, it is said that many of the ruins have already been collapsed and immediate reconstruction is required.At least, it is necessary to have a survey on these ruins and take a record of them before they completely collapse. To have a survey on some ruins which location is uncertain, the way to decide the accurate location of ruins should be required.

Satellite remote sensing is known as an effective method to grasp the characteristic of the place where it is difficult to have a field survey. This study is to apply its capability to the archaeological field.
In this research, the extraction against the ruins which location is already known has been attempted as a basic study.

2.FEATURE OF THE ANGKOR RUINS

Khmer had their unique vision of the world from their religion. They constructed their temples in their vision, and almost all the ruins have a similar appearance as a result. Basically, ruins are consisted of temples, surrounding walls, and the water moat. The material of the ruins is mainly sandstone and laterite, which was comparatively soft and easy to handle ,but it made the ruin weak.

Tab.1 Used data in this research

Satellite Name	Data Type	Date	Ground Resolution	Path / Row
Landsat-5	TM	1995/1/31	30m	127/051
JERS-1	SAR	1997/1/15	18m	120/278

Referred Data	Source	Notes
GIS data	Integrated Resource Information Center(IRIC)	Coverage data of the Angkor region
Maps	Department of Angkor Conservation	The rough position can be known
GCP	Angkor field survey	GCP taken by GPS survey
Ground truth data	Angkor field survey	The accurate land cover can be known

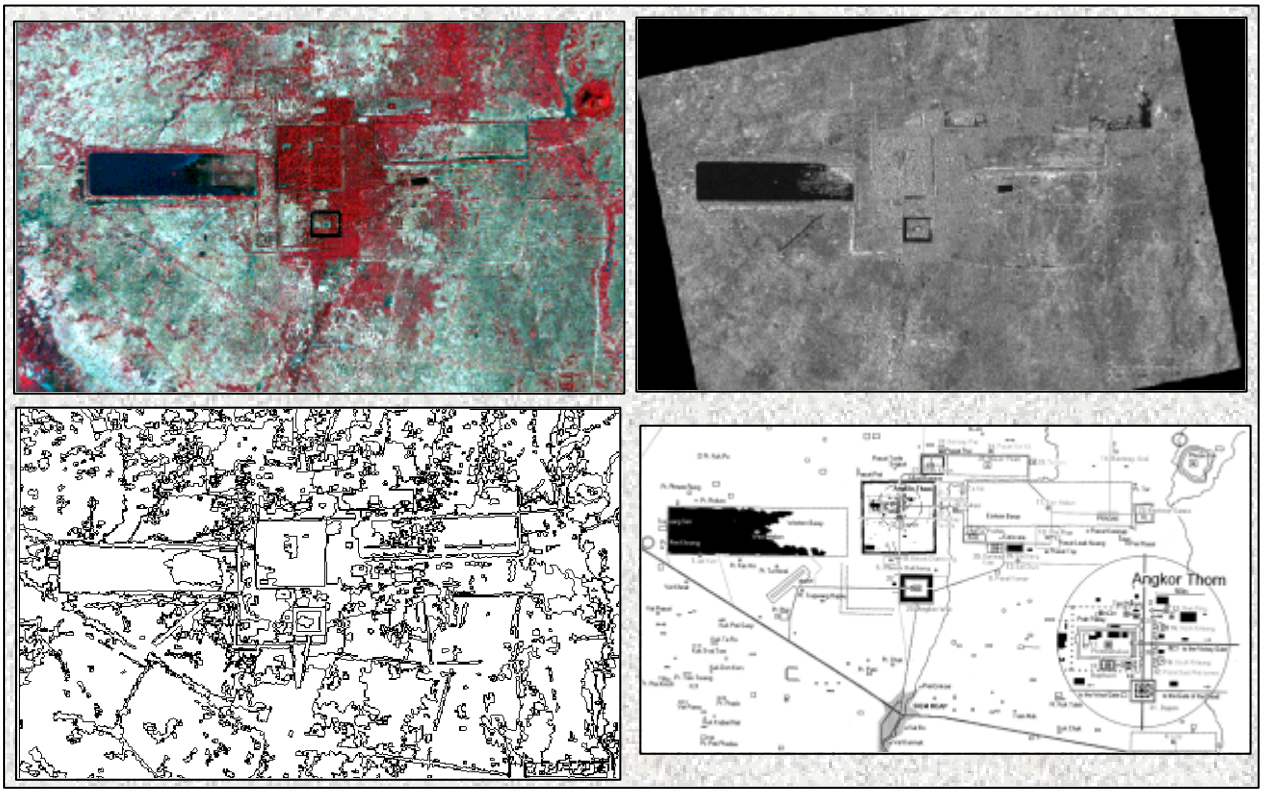

Fig.1 Ruin of Angkor (Angkor Wat)

Fig.2 Upper left: Landsat-5/TM, Upper right: JERS-1/SAR, Lower left: GIS data, Lower right: map

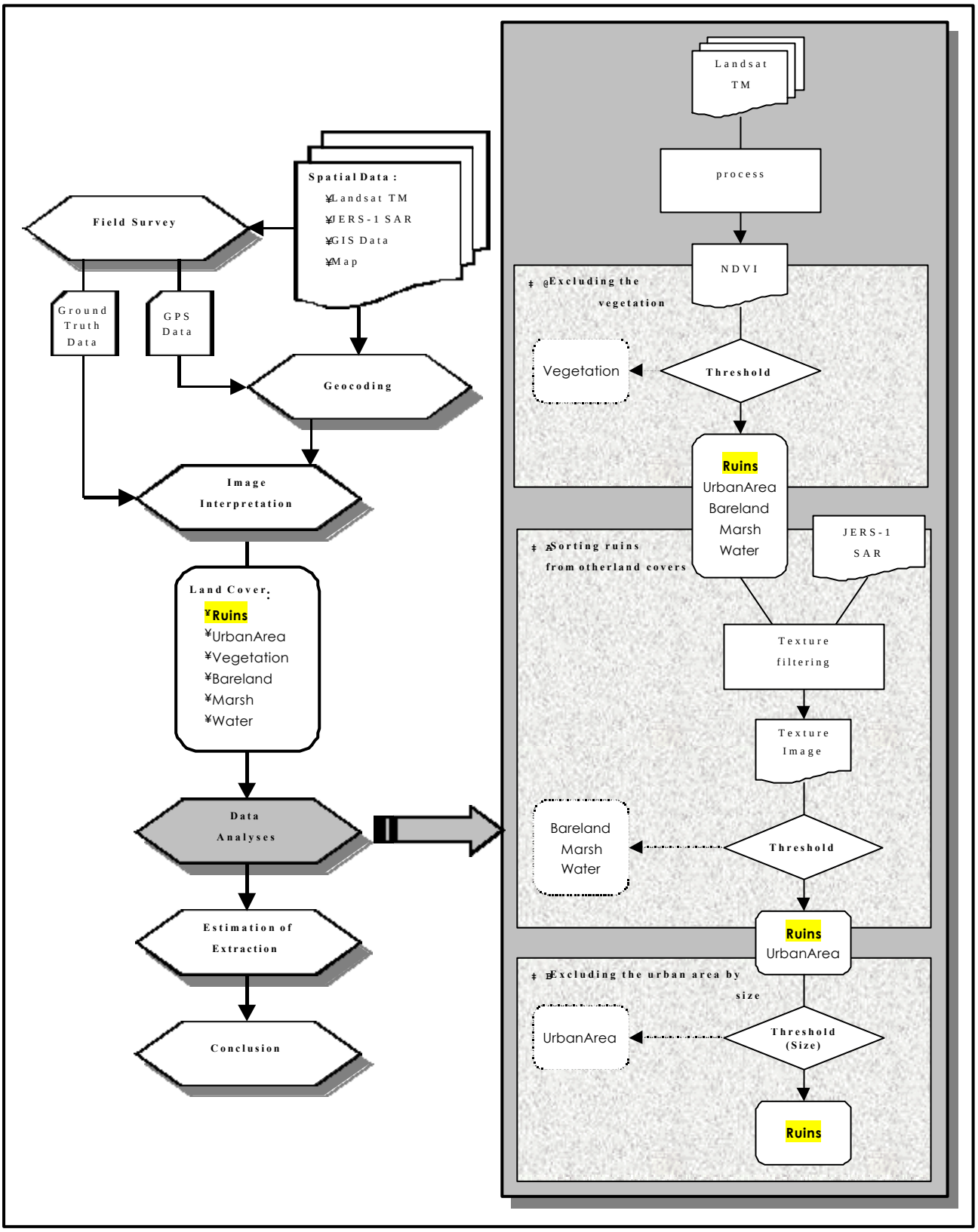

Fig.3 The flow of this research

3.FLOW OF THIS RESEARCH

The data used in this research was as Tab.1, Fig.2. This research was processed as the Fig.3. The interpretation was done by the Tab.1, Fig.2 data, especially according to the ground truth data. The Land cover which was not sure by maps and GIS data was observed.

4.FIELD SURVEY AND GEOCODING

The field survey in Angkor ruins were done by using the GPS and the Satellite image. Ground Control Point (GCP) was taken in the field survey in the Angkor region by means of Real Time Differential Global Positioning System (RD-GPS) survey. The accuracy is 1meter, and the number of the surveyed point is about 100points. The GCP was used for geometric correction.

5.IMAGE INTERPRETATION

The image interpretation was done by using ground truth data taken by field survey. The research area are consisted of 5 types of land cover as follow.

- ruins
- urban area
- bareland
- marsh
- water

6.DATA ANALYSES

The uneven appearance and the rough texture of the surface are the most characteristic factors of the ruins. It is known that SAR images can be useful for these types of characteristics. In SAR image, the uneven texture of the land covers are reflected vividly. So it is necessary to exclude the point where indicates a strong scattering except ruins. In the Angkor region, the vegetation tends to indicate a strong scattering in the SAR image, which may be confusing when having discrimination. For this reason, the exclusion of the vegetation was done by using the TM image. By processing the SAR image which scattering has been emphasized by the filter with processed TM image, it was able to exclude almost all of the flat land cover in the image. In short, there are three processes for extracting the ruins such as 1) Excluding the vegetated land cover by using the spectral characteristics of the Landsat-5/TM image, 2) Separating ruins and urban area from other land cover using characteristics of the texture known by JERS-1/SAR image. 3)Sorting the ruins from other by sizes of the grouped pixels.

1)EXCLUDING THE VEGETATION

Most of research area is covered by vegetation, which is consisted of agricultural land (rice field, farm), grove (shrub, palm), water plants and the rain forest. It is difficult to distinguish vegetation from ruins by JERS-1/SAR image because the appearance according to their rough texture resembles to the ruins. The vegetation was excluded by using the method of Normalized Differential Vegetation Index (NDVI). Comparing NDVI image with the ground truth data, the threshold of making the binary image is decided. According to the binary image, The vegetation in the TM image has been excluded.

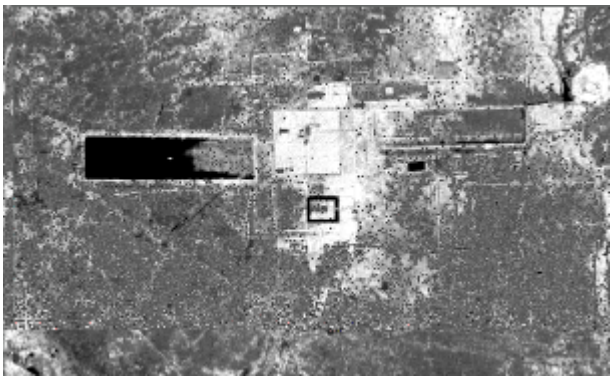

Fig.4 NDVI image

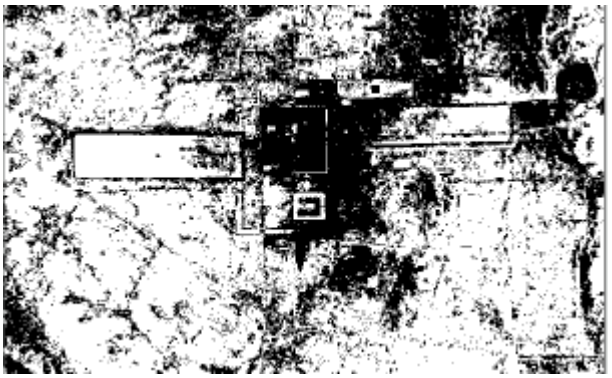

Fig.5 Threshold image after excluding vegetation

2)SORTING RUINS FROM OTHER LAND COVER

Excluding the vegetation by processing the TM image, the land cover which is remained with strong scattering is distinguished ruins and urban area. Because of the shape, ruins and houses of urban area are likely to form the corner reflector, which makes the scattering stronger in the image. In fact, as is observed in the following chart, the scattering of texture between ruins and other flat land cover is a different.

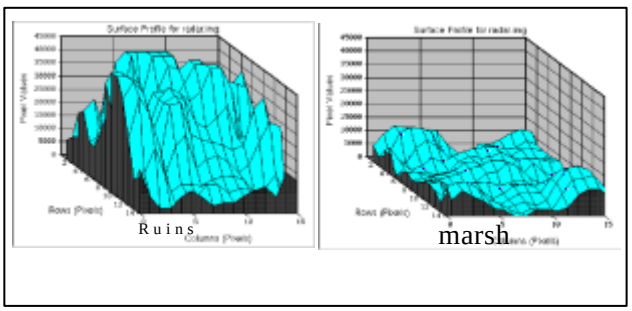

Fig.6 The graph of scatters (For example)

By using the filter that calculate the standard deviation (SD) of the scattering inside the 15 × 15 pixels (Fig.6), the part which has high scattering has been emphasized. The scale of the filter was determined from the scale of Angkor Wat which is considered to be the biggest ruin in the area. After emphasizing these features by the filter, the binary image was made by using the threshold. The exclusion against the land cover with flat texture was operated using the binary image.

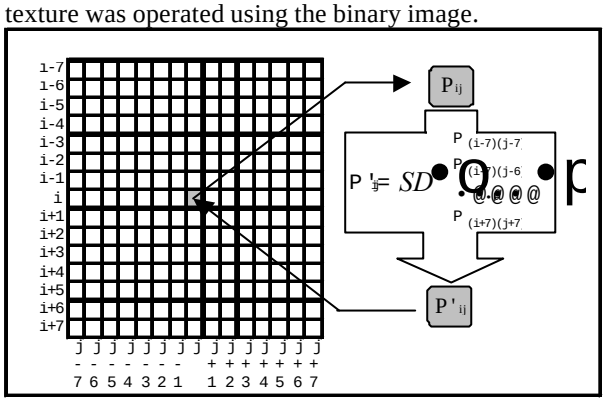

Fig.7 The filter to emphasize the scattering

Fig.9 Threshold image of Fig.8

3)EXCLUDING THE URBAN AREA BY SIZE

The urban area is seen in the lower part of the Fig.9. As it can be observed, urban Area tends to organize a large scaled group of pixel comparing with other. the biggest size of the ruins in Angkor ruins group is the Angkor Wat. The scale of Angkor wat is about 300m × 300m, which appears in the image as a group of about 10×10 pixels. Angkor wat may be one of the biggest ruins compared with the others. On the other hand, urban area has a larger extension compared with the ruins, and which appears in the image as a group of more than 10×10 pixels. Filtering by the difference of size of the grouped pixels, it is able to exclude the urban area from the ruins. By converting the raster image into vector image, the area of the object can be calculated. By calculating the area, the area bigger than the ruins were excluded.

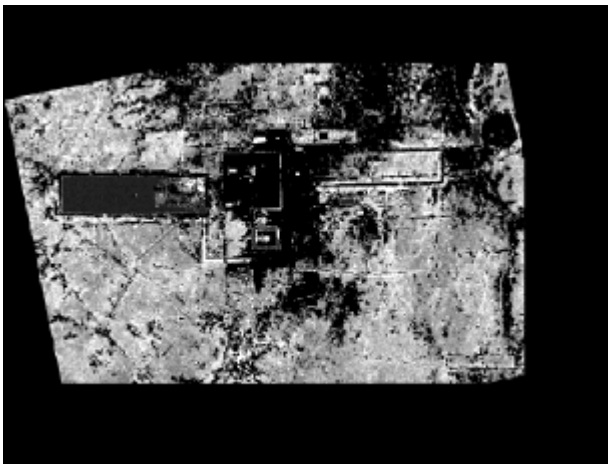

Fig.8 Image which scattering has been emphasized

Fig.10 Extracted ruins (zoomed)

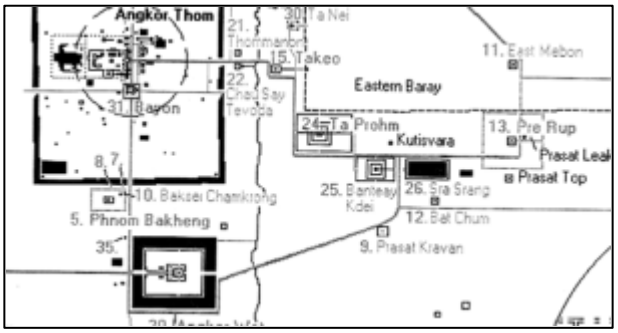

Fig.11 The map corresponding to Fig.10

7.ESTIMATE

According to the interpretation of those data, the research has concluded in a satisfying result about the comparatively large scaled ruins.

8.CONCLUSION

The method established by this research is to exclude the objects by using the difference of the scattering between ruins and the other objects. The separation of the ruins and the others were done by using the filters which emphasize the trend of those characteristics. The important point of this research was how to distinguish the ruins from other objects after extracting the emphasized scatter objects. As mentioned before, excluding the vegetation which has strong scattering by using NDVI appeared to be an effective way. Before this operation, the scattering was emphasized by the filter. The separation of ruins and urban area was operated by the difference of the area of those pixels which are consisting the objects. The accuracy of the extraction was confirmed by referring to the maps and the GIS data.

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REFERENCES

JSPRS,1998.GOUSEI KAIKOU RADAR GAZOU HANDBOOK, Asakura, pp80-115

ERSDAC,1995.SHIGEN REMOTE SENSING GAIRON,ERSDAC

ERSDAC,1992.GOUSEI KAIKOU RADAR(SAR),ERSDAC

NASDA,1982.CHIKYUU KANSOKU DATA RIYOU HANDBOOK, NASDA

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