Three Dimensional Representation

for LANDSAT MSS Data

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ABSTRACT

National land information including elevation data is available to combine together with the geographically corrected LANDSAT MSS data. To represent LANDSAT MSS data three dimensionally, these data given as a function of three dimensional coordinates should be transformed to a plane by parallel or central projection through so-called hidden point processing.

This paper deals with methods of projective transformation and their subsequent processings which mainly consist of interpolation procedures.

Examples of three dimensional representation for LANDSAT imagery are shown in two areas. One is the mountainous Yarigatake area in central Japan including 240 by 200 data. The other is the Sagami River basin with Mt. Fuji including 1403 by 980 data. Further applications are shown for stereographs and animation.

INTRODUCTION

The advanced technology for geometrical and geographical correction for LANDSAT MSS data which has been developed by the authors, enables to combine these data with other data such as digital elevation data.

By the combination of LANDSAT MSS data with digital elevation data, LANDSAT MSS data given as a function of three dimensional coordinates could be transformed into a projective plane to represent these data three dimensionally.

Three dimensional representation for LANDSAT imagery would be effectively utilized to land form analysis, landscape planning, geologic structure analysis, forest inventory, snow resources and so on.

METHODS FOR THREE DIMENSIONAL REPRESENTATION

Three dimensional representation is carried out by the procedures as illustrated in Fig. 1. The preprocessing is to combine LANDSAT MSS data with digital elevation data. The projective transformation and the hidden point processing are main parts of these procedures. When an image in a specifed area such as a river basin or a state should be output, boundary data of the area should be prepared. The procedure following the projective transformation is to interpolate LANDSAT MSS data at regularly spaced grids on a projective plane.

a. Preprocessing

National land informations in Japan, including digital elevation data, are acquired in the national grid system with respect to longitude and latitude cooridnates. LANDSAT MSS data should be corrected geographically and resampled to the coordinate system. This geographic correction procedure has been already developped by the authors.

LANDSAT MSS data may be resampled at regularly spaced intervals of 50 or 100 meters in UTM system, while digital elevation data stored in national land informaion bank are sampled at regular grids of 7.5 seconds in latitude and 11.25 seconds in longitude which correspond to 280 by 230 meters

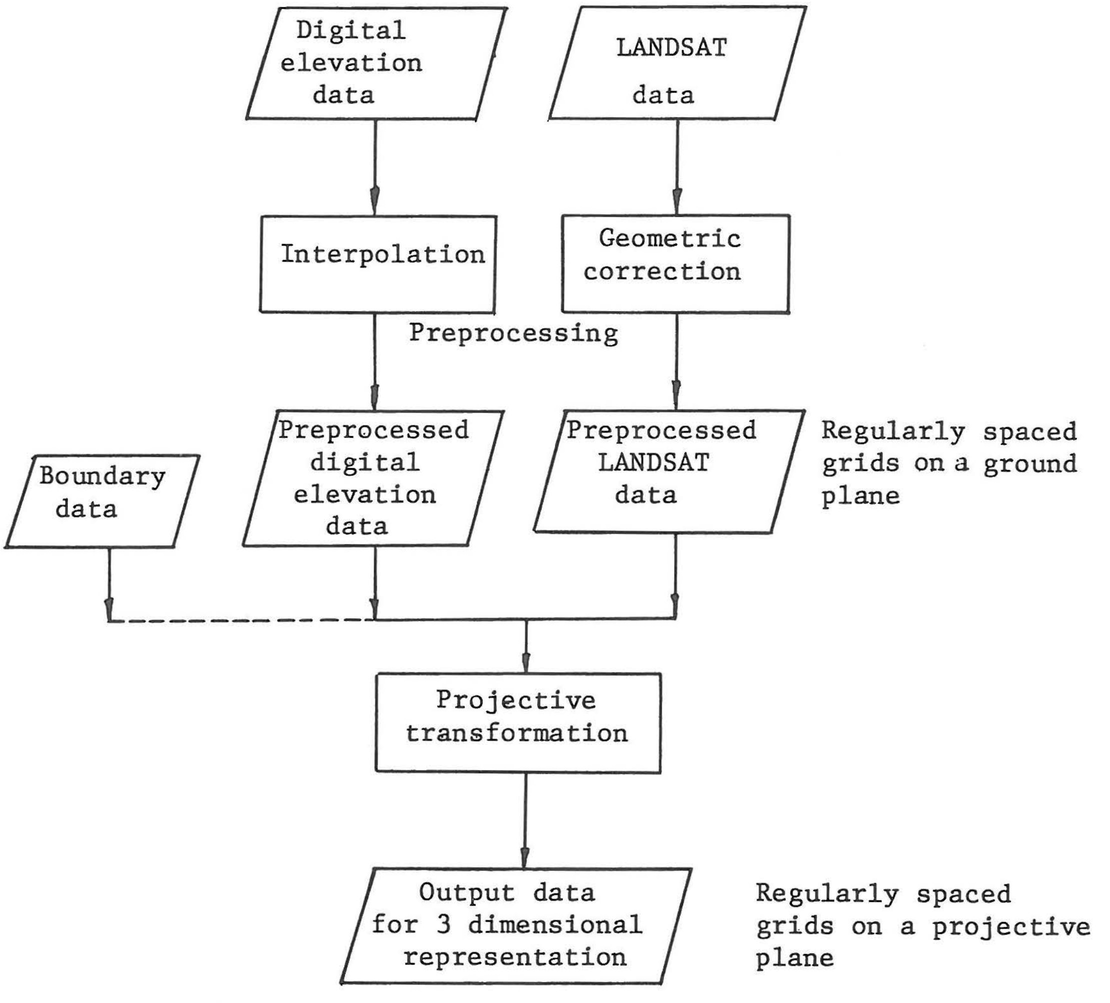


Fig. 1 Procedures for Three Dimensional Representation

rectangulars in Japan. Therefore digital elevation data should be interpolated to the same grids as the resampled LANDSAT MSS data.

For this interpolation, a piecewise interpolation using third order polymonials was exceuted, pixel by pixel.

b. Projective transformation and hidden point processing

Two projective transformations were dealt with in this study that is parallel projection and central projection.

Fig. 2 shows the method of parallel projection including hidden point processing.

Hidden point processing is based on the principle that those points which are projected at higher position than the subsequest points in a projective plane, are visible when those terrain data are transformed in the order of far distance. For the example shown in Fig. 2, points of 1, 4, 5 and 6 are visible, while points of 2 and 3 are hidden because these two points can not keep higher position than the subsequsent point of 4 on the '1' line in the 'k' section.

Fig. 3 and Fig. 4 show the two types of method of central projection including hidden point processing.

The hidden point processing by radial line method shown in Fig. 3 is based on the same principle as that in Fig. 2. A large memory area in a computer is required for the interpolation for central projection, because the projective transformation should be carried out for each radial lines.

In the case of grid line method shown in Fig. 4, trans-

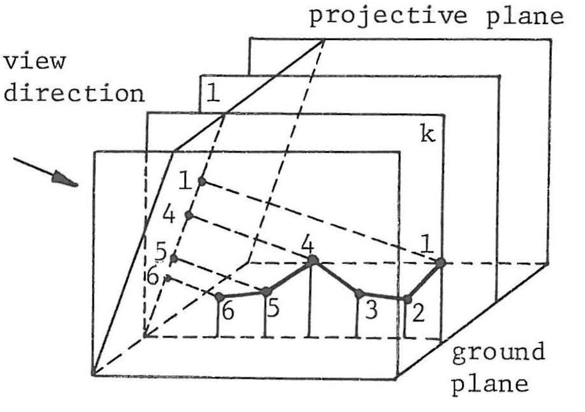


Fig. 2 Parallel Projection

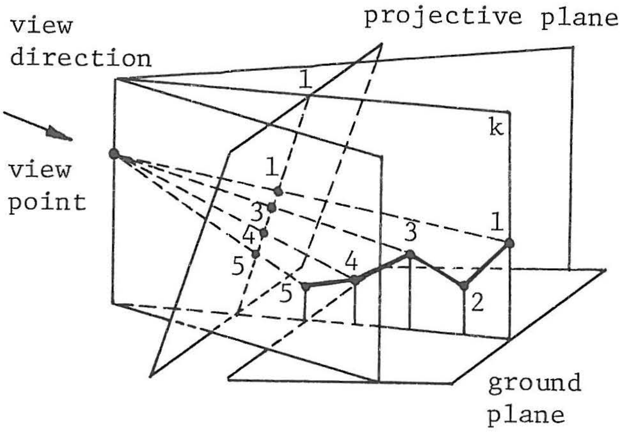


Fig. 3 Central Projection by Radial Line Method

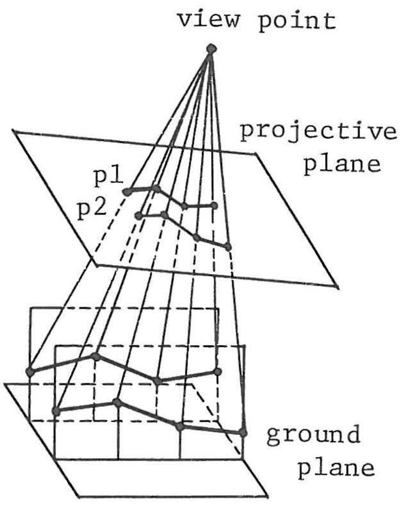


Fig. 4 Central Projection by Grid Line Method

formation is carried out line by line in the ground coordinate system. The hidden point processing in this case is carried out for each polygonal lines (p1, p2, etc., in Fig. 4) on the projective plane.

c. Interpolation through projective transformation

Fig. 5 shows the configuration of the data structure before and after transformation. Finally all data for output must be interpolated into square grids, which coincide with output picture elements. Interpolation should be carried out in the processes as symboled as 'A3', 'B1', 'B3' and 'C3' in Fig. 5. The interpolation for 'A3' does not need a large size of memory because of linear interpolation, line by line, while the others such as 'B1', 'B3' and 'C3' need much memory in a computer, because two dimensional interpolation is required.

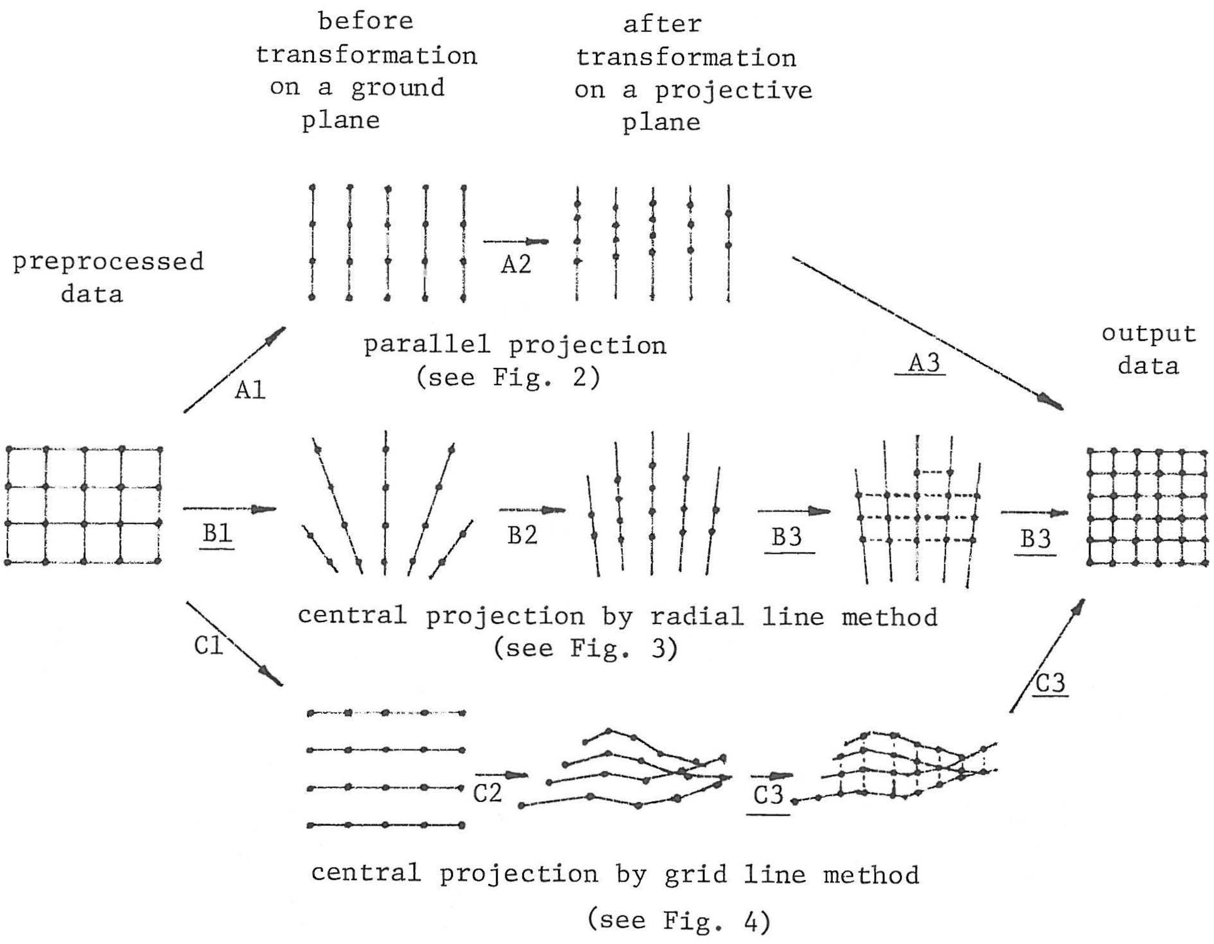


Fig. 5 Configuration of Data Structure

APPLICATIONS

a. Representation for small size of data

The mountainous test area of 17 km by 15 km with 240 by 200 preprocessed data was used in the case of parallel projection. The wider area including the above test area of 23 km by 18 km with 160 by 80 original data was used in the case of central projection. The following examples of three dimensional representation for LANDSAT MSS data were genrated by color TV monitor.

(1) LANDSAT MSS 7 by parallel projection from south. (See Fig. 6)
(2) LANDSAT MSS 7 by central projection of radial line method from north-east. (See Fig. 7)
(3) LANDSAT MSS 7 by central projection by radial line method from east. (See Fig. 8)

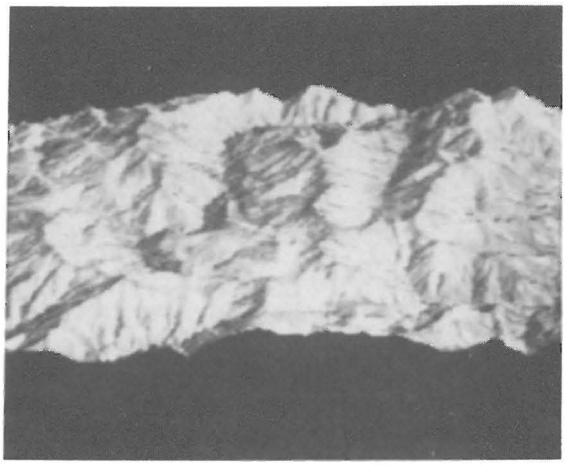


Fig. 6 LANDSAT MSS 7 by Parallel Projection

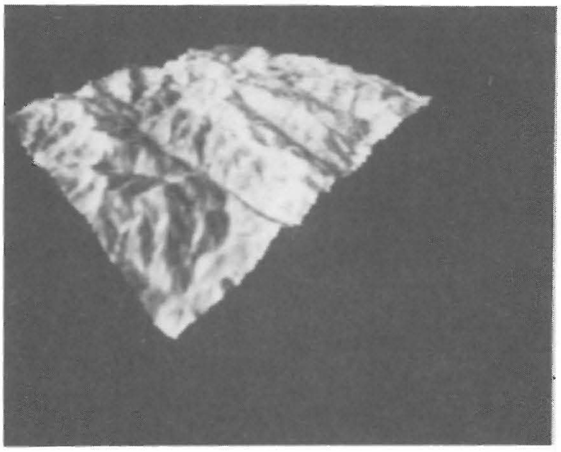


Fig. 7 LANDSAT MSS 7 by Central Projection from North-East

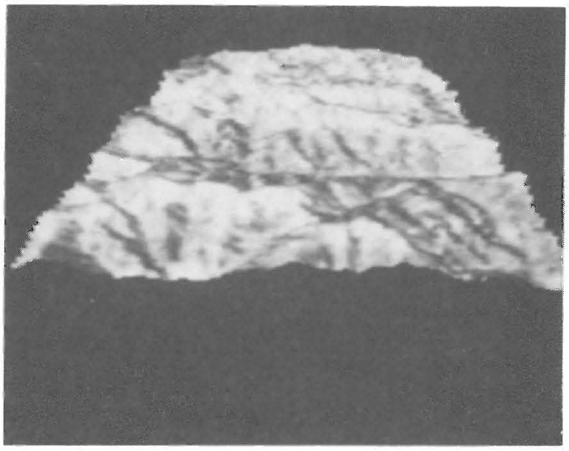


Fig. 8 LANDSAT MSS 7 by Central Projection from East

b. Representation for large size of data

The test area including Mt. Fuji of 82 km by 55 km with 1400 by 980 preprocessed data was used. The following examples were examined.

(1) LANDSAT MSS 5 by parallel projection.(See Fig. 9)
(2) LANDSAT MSS 5 by parallel projection only in the river basin. (See Fig. 10)
(3) LANDSAT MSS 5 by parallel projection with 3 times of vertical scale.(See Fig. 11)

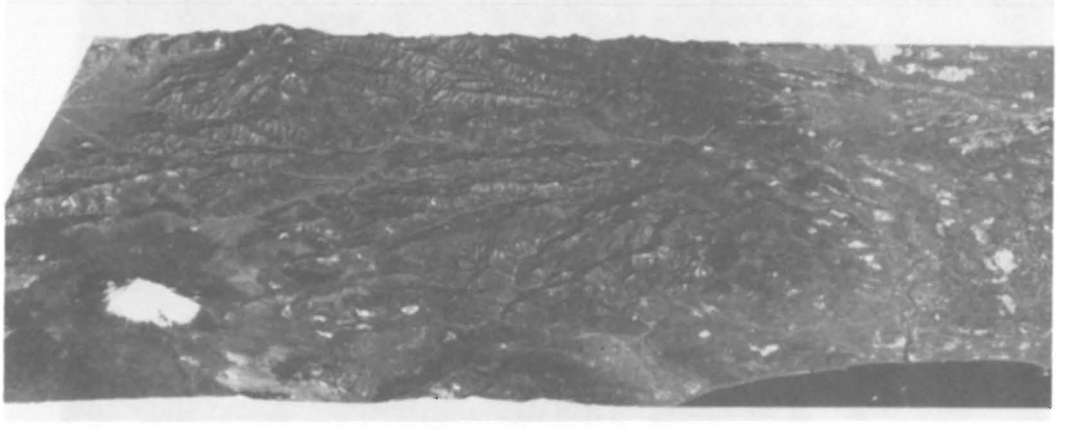


Fig.9 LANDSAT MSS 5 by Parallel Projection

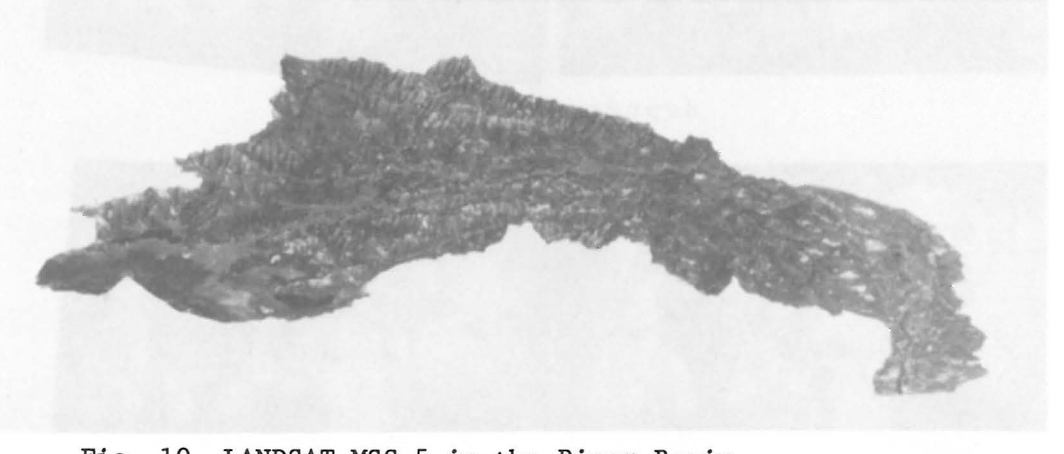


Fig. 10 LANDSAT MSS 5 in the River Basin

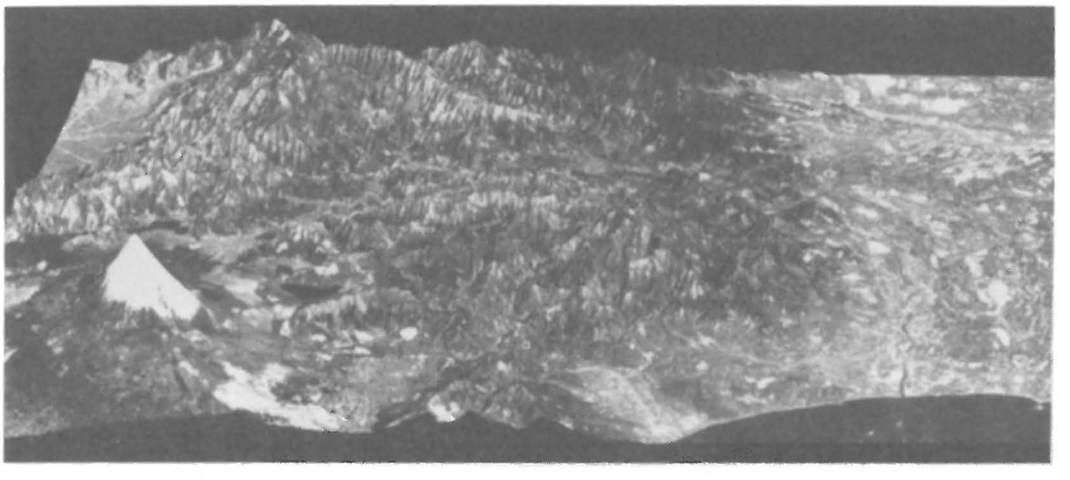
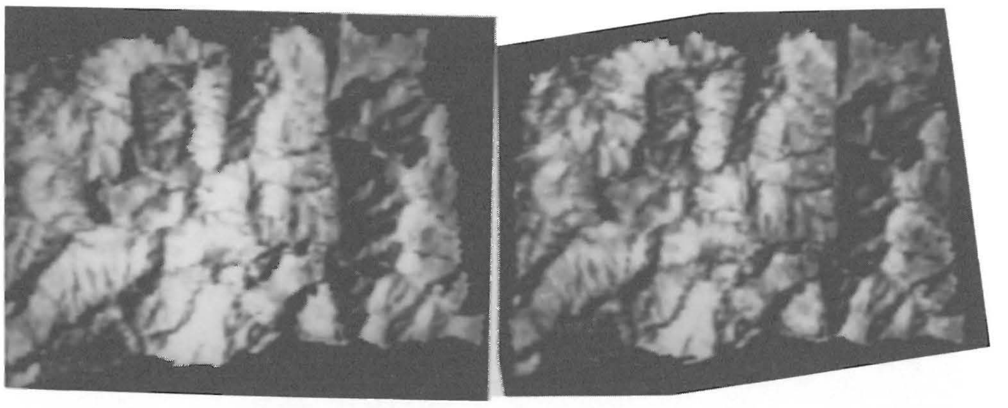
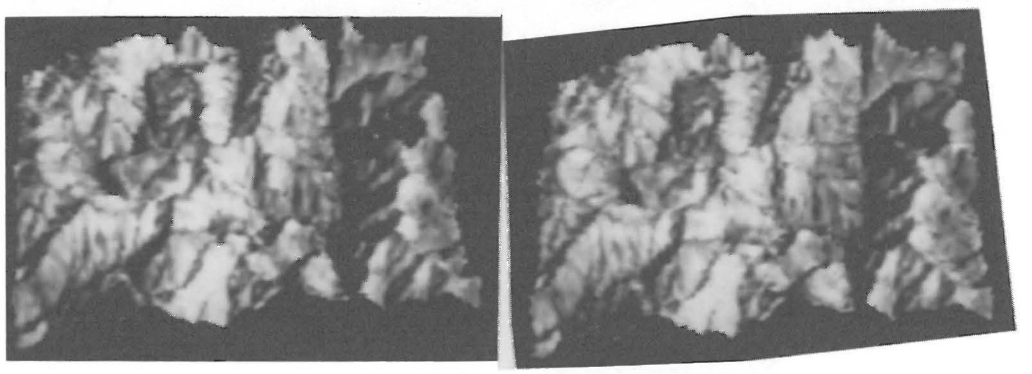


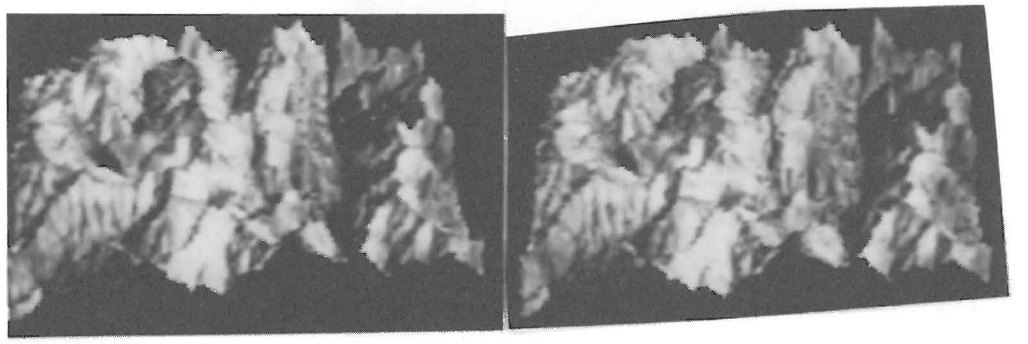
Fig. 11 LANDSAT MSS 5 with 3 Times of Vertical Scale



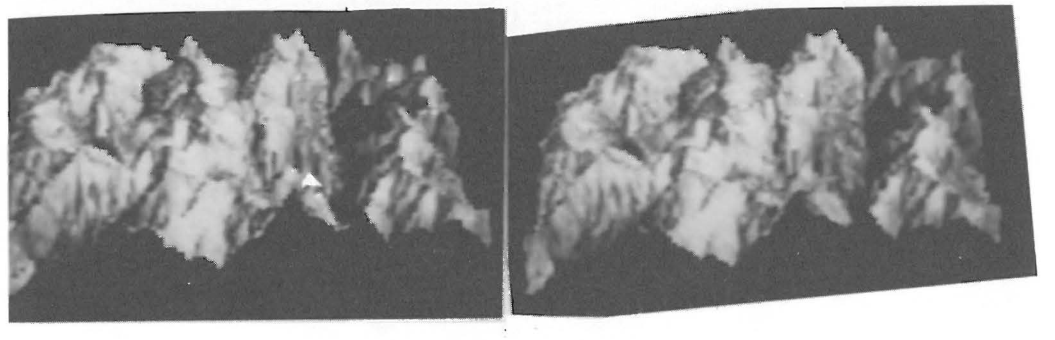
depression angle 65°



depression angle 55°



depression angle 45°



depression angle 35°

Fig. 12 Stereographs of LANDSAT MSS 7
with Change of Depression Angles

c. Further applications for stereographs and animation

The same test area of 23 by 18 km with 160 by 80 data as in the case of a., were utilized.

Fig. 12 is the examples by central projection of radial line method looking from the view points with the base length of 7.6km, and the distance of 76 km, in the direction from south to north. The altitude of the elevation data is emphasized 3 times vertically. The depression angles were varied from 65 degrees to 35 degrees at the interval of 10 degrees. Each pairs between rigth and left photographs, or between up and down photographs in Fig. 12 can be seen stereoscopically. If the depression angles are varied continuously, or a very small interval, three dimensional representation by animation would be possible.

CONCLUSIONS

a. The high accuracy geometrical correction for LANDSAT MSS data enables to represent LANDSAT MSS data three dimensionally by combination of these data with digital elevation data.

b. The methods for three dimensional represenataion have been developed both for parallel projection and by central projection. In the case of parallel projection, even large size of data such as 2000 by 2000 data could be processed without keeping a big size of core memory by the program which has been developed by the authors. However, it can be said that samll size of data, such as 200 by 200 data which can be stored in core memory can be processed for central projection, while large size of data such as 2000 by 2000 data which can not be stored in core memory, can not be efficiently processed. The method of central projection for large data should be further developed.

c. Additional products, such as computer generated stereographs of LANDSAT images and their animation could be obtained in this study.

References

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