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A study on Integration of Technologies of Image Processing and a Geometric Methods in GIS

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We use various maps in our daily life. Each map has its own application. What we are calling maps are theme maps made for different purposes (theme). By the development of digital mapping technology, the technology of creating theme maps has been realized by connecting terrain information and attribute information of objects on terrain data as one data and using it.

In recent years, these processing are established as a Geographic Information System (GIS). GIS is getting a lot of attention in many fields with different scales. Although GIS is very useful, GIS has not been applied for private use. The difficulty comes from computational load by the huge size of data sets to be treated in GIS. Therefore it is necessary to invent a new method by carefully considering the speed and accuracy of GIS. In this study we discuss about improvement of performance and accuracy of imaging in GIS from viewpoints of algorithm and data structure. We are interested in the geometrical transformation of terrain data. Terrain data are supplied in a raster data structure just like image data. Therefore, one color value is assigned to each of grids (addresses) on image data. Each grid on terrain data has one altitude value. It is common to apply geometric transformation in image processing to terrain data. However, since this method puts the highest priority on locations of grids and interpolation is based on image feature that image pixels are smoothly arranged, the original data are destroyed.

For instance, as is seen in reduction, if we apply a simple method for reduction geographic feature may disappear according to reduction ratio by the influence of aliasing and averaging. To make matters worse, it happens memorably relative to reduction size. This suggests how to improve the way of application of geometrical transformation of image data for terrain data.

In this study, we propose a new concept of geometrical transformation considering accuracy of location and altitude by the integration of geometrical transformation of

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image data and the feature that is extracted from terrain data. As the feature of terrain data, we determine the four features: "ridges", "volleys", "hollows", and "tops". There are many studies on extraction of features from terrain data. In most of them global sets of grids are regarded as free surfaces to extract these features by their shapes. However, it takes much processing time and it is also difficult to implement.

Although an algorithm which is relatively easy to implement is proposed for detection of running water lines using flood-style algorithm, it is difficult to extract features when considering the relation between ridges. Dislike the common processes for raster data described above we take a different approach in this study. In this approach we transform raster data to vector data and change evaluation from points to edges. First, we form a regular triangulated network on terrain data by triangulating terrain data. Next, we form an irregular triangulated network (TIN) by removing those vertices whose errors are within a fixed range by using Delaunay triangulation and drop heuristics. TIN can be computed in O(log n) by using Lee's algorithm. It is easy to access to edges, faces and vertices because a minimum constituent element is a triangle. It is also excellent in the data analysis. After constructing TIN, we compute a cost of each edge of TIN as feature extraction by three viewpoints. They are "connectedness of vertices", "degree of two faces that adjoins an edge", and "curvature of partial area considering topological distance". After computing costs of all edges of TIN, we extract those edges within a predetermined threshold. The feature data extracted in this way are stored into a file in a flag form after raster-vector transformation as a feature extraction mode. In this way we can perform processes utilizing common methods in image processing and in addition features and accuracy of geometric shapes of a terrain.

In the end of the study, we have implemented a program based on our new concept, and we experiments to compare the existing reduction method using geometric transformation and our reduction method in the same scale. Thanks to the software library of LEDA, it was easy to implement algorithms in constructing various data structures such as graphs and lists.

As mentioned above, in this study we have taken our approaches both from theory and practice (implementation) for the task of solving problems in GIS and devising a practically efficient processing. Automatic feature extraction was left as a future subject. Especially how to determine parameters of the cost function is an important subject to be resolved.