THE AUTOMATIC SELECTION SYSTEM OF TRANSMISSION LINE ROUTES BASED ON DTM

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Abstract:

The ultra high voltage nuclear plants are constructed at remote area for the electric power development. The transmission line routes shall be extended through mountainous regions. Detailed study concerning new transmission line routes to be constructed in a wide area shall require tremendous amount of manpower.

We, therefore, developed a Computer-Aided Transmission Line Route Selection System to conduct a rapid investigation on leading and economical routes. The system is based on DTM and topographic information. This report shall inform you of the summarized results of the Route Selection System to be originated in Japan.

1. OUTLINE OF ROUTE SELECTION SYSTEM

The transmission line route is to be so selected that its cost should be minimum in general consideration of the natural and social environments as well as its construction and maintenance. The restrictions on society to be taken into account in the selection include such technical ones as geographical features of the site, the steel towers which bear the line and surrounding conditions of location.

In this system we have therefore been preparing, as data base in the form of grids or polygons, the geographical space information considered to be necessary for the selection of routes in all the areas in order to evaluate the conditions of location. Further a computer-aided model simulation based on the standards of transmission line is performed for the points and spans where the steel towers can be constructed, the combinations of which allow us to select the most economic routes.

Figure 1 represents the general flowchart of this system. The data are the information groups of the points, lines and planes transcribed on topographic maps from aerial photographs, other geographic maps and other data that were measured by analytical plotter "PLANICOMP C-100" and digitizer. These data are compiled into the grid information that can be easily processed by computer when simulated. The output we obtain in this system are route maps, longitudinal profiles, route ledgers that permit us to confirm the details of the routes as selected in a same way as the conventional route selection.

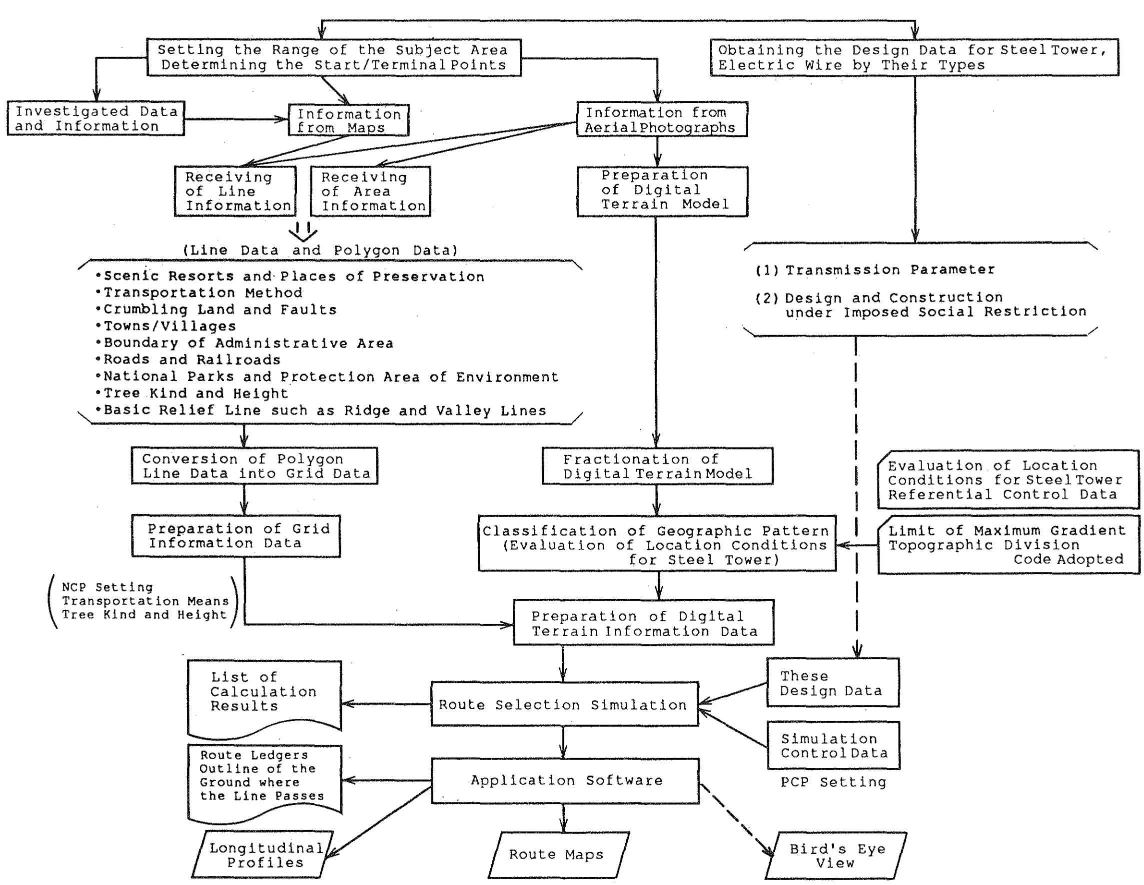


Figure 1 Flowchart of Route Selection Simulation

2. RECOGNITION OF GEOGRAPHICAL SPACE INFORMATION AND TOPOGRAPHY

The geographic space information includes the points to be positively selected as sites of transmission line (Positive Control Point; PCP) and those considered not suitable for passage of the lines (Negative Control Point; NCP) as well as the areas to be selected.

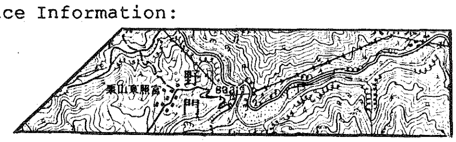
Figure 2 gives an example of these respective factors. PCP are line start/terminal points and intermediate fixed points, while NCP includes the points that do not allow the construction of tower nor passage of line and those that allow only the passage.

The present system incorporates these judgment codes into the grid data. From the topographic viewpoints it is recommended to select such locations as stable mountaintops, crest lines and slopes that allow to have a distance of electric wire from ground (a certain restriction existing for the clearance between the wire and the ground) and reduce the height of the tower.

This system has therefore developed and adopted a method to evaluate the locations of towers classifying the topographic patterns by elevation data of the grids. The method consists in classifying the topography into 15 groups by the ratios and combinations of the collection vector (C) and deluge vector (D) which can be obtained from the differential elevation of given points with the surrounding grid intersections. (See Figure 3).

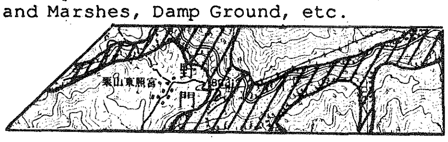
It is so designed that suitable topographic geometry can be selected in response to the steepness of slope and distribution of the subject areas by assigning the code number and the maximum gradient when simulating. Figure 4 shows up an exemplary distribution at a selectable point.

Geographic Space Information:



Natural Conditions:

Crumbling Land, Steep Mountainous Areas, Faults, Streams, Lakes and Marshes, Damp Ground, etc.



Social and Living Environmental Conditions:

Towns/Villages, Establishments/Facilities, Temples and Shrines, Communication Facilities and Sightseeing Areas

Rules and Regulations:

National Parks, Planned Areas and Environmental Protection Areas

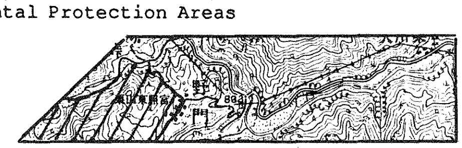


Figure 2 Classification of Restrictions (NCP)

Code No.	Topographic pattern: Classification	Topographic pattern: Sub-classification	Geometric shape in drawing	Sectional geometry	Remarks
14	Mountain top	Summit			Gradient < 55°
13		Ridge			
12		Saddle			
11	Convex slope (plane figure)	Convex sectional slope			Gradient < 55°
10		Slopes with certain indication			
9		Concave sectional slope			
8	Concave slope (plane figure)	Convex sectional slope			
7		Slopes with certain indication			
6		Concave sectional slope			

Figure 3 Topographic Division

3. HOW TO DECIDE THE OPTIMAL ROUTE

This system uses principally the minimum weight of tower as an index of the optimal route. The weight of tower has the following restrictions from the designing standpoints.

1. The tower installed at point "i" as shown in Figure 5 has relative horizontal (θ_i) and vertical angles (h/s) to the upstream and downstream towers. These two factors determine the tower type.
2. There is a minimum distance determined between the electric wire and the ground. Securing this distance and the minimum sum of the towers including the upstream and downstream ones permit us to decide the tower height.
3. The tower type and height thus decided allow to have the tower weight desired (w_i).

Figure 4 Distribution of Selectable Locations of Tower

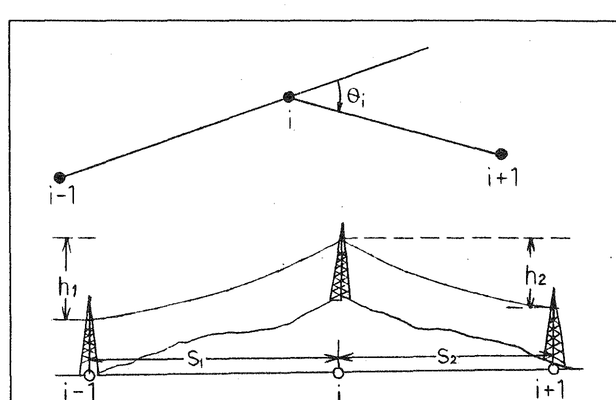


Figure 5 Relationship between the Towers

The optimal route of the transmission line may be determined by selecting such a route as minimizes the total weight of the steel towers so combined as connecting the given distance between starting and terminating points in due consideration of the above conditions as:

$$J = \sum_{i=1}^{n} w_i = (w_1 + w_2 + \dots\dots + w_n) \rightarrow \text{Minimum} \quad (1)$$

4. HOW TO SEEK AFTER THE ROUTE

The model simulation of the route of transmission line is performed on a digital terrain information model on the basis of the design values in Figure 1.

Then we seek after the location of steel tower in the following sequential order on the conditions of search angle (α) as against the line joining the starting and terminating points as set, the maximum span (S_{max}), and minimum span (S_{min}) and the distance from the ground.

1. First, points are to be selected out of a sector as enclosed by the search angle and minimum/maximum spans (Figure 6).
2. Deliberations for determining if the transmission line can pass between the points as defined.
3. Determination of tower types in terms of the horizontal and vertical angles.
4. A topographic sectional geometry is to be obtained from DTM.
5. Catenary is calculated on the basis of design values.
6. Checking the distance between the electric wire and the ground.
7. Determining the optimal tower height that ensures the required distance.
8. Computation of the tower weight and storing the information relating to the tower site.

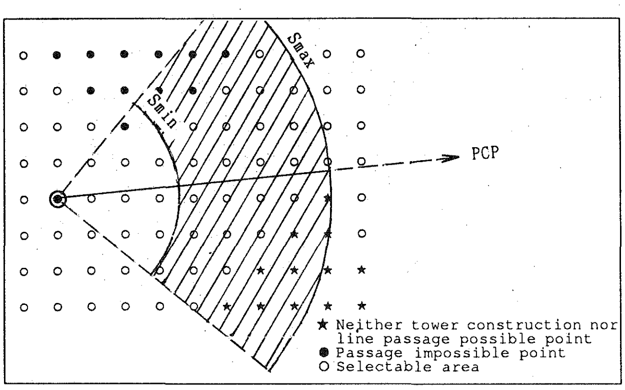


Figure 6 Search for Neighboring Points

The discussions as above shall be made for all the points in the sector to thus repeat the search in selection branch form. When the routes arriving at their terminal points reach a certain number, the simulation is terminated to have an optimal route from the smallest tower weight.

We have thus far performed about 1 million discussions with the PCP distance of 30 km and ±70° search angle.

5. CONCLUSION

Thus far we have worked out some simulations as several areas as our case studies to improve the software through verifications on site.

The topographic division based on DTM gave us a good result as the object of selection of steel tower locations. The clearance under the electric wire as calculated from DTM showed a good accord with the actual topographic conditions.

We consider that there are few cases of large areas as treated in three dimensions with only small-scale applications of DTM to the engineering field by computer, due to difficult data collection, too small capacity of the computers that is against process the valuable application and sufficient data.

In the cases we performed this time it is possible to process total distance of 50 km and width 10 km. Since further we have adopted a processing system of topographic pattern by recognizing it from DTM with software, we should be free from any cumbersome data preparation.

We would like to express our deep thanks to the engineers of TEPCO who gave us many useful advices and indications at the stage of the preparation of this system.

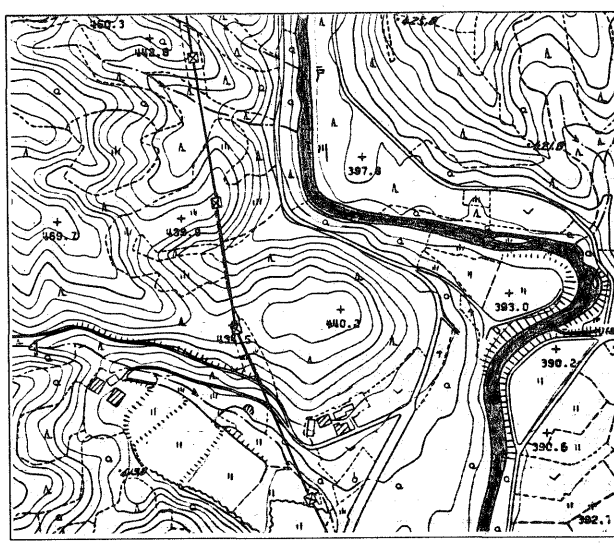


Figure 7 Maps Describing a Route of Transmission Line on the Contour

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