COMPUTER ASSISTED MILITARY TERRAIN INTERPRETATION AND ROUTE PLANNING

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This paper contains a short description of the Cross Country Movement Planning problem. This problem can be subdivided into two parts: 1. terrain interpretation and 2. route planning. Several possible forms of support using a GIS are given for the first subproblem. The research and prototype activities in this context are then outlined.

1 Introduction

Cross Country Movement (CCM) is a military operation directly related to the terrain. CCM relates to the movement across the terrain, based on a certain degree of 'terrain negotiability'. Using the interpreted terrain data, an 'optimum path' (or optimum route) to cross a certain area is to be determined. Note that the CCM-problem is very different from the more common linear route planning in a road network, because before the actual path planning, first the areas that are either easy or difficult to traverse must be identified, as must several types of obstacles. Further, in theory the number of possible moving directions is unlimited, which makes the planning itself more difficult.

The main motivations for the work described in this paper are: 1. limitations of current CCM paper maps; see Section 3; and 2. manual drawing overlays on topographic maps takes a lot of time (one hour). By combining data concerning the terrain (soil, obstacles, relief) with weather condition data, insight is provided in the terrain negotiability for a specific vehicle type. A prototype CCM system, which supports these tasks has been developed. The user is assisted trough a friendly GIS user interface, in CCM planning-tasks.

The following sections contains a short description of the CCM planning problem (Section 2), the data required (Section 3), and the forms of support using a GIS (Section 4). The last section gives an overview of the results and contains the conclusions.

2 The CCM Planning Problem

Many military operations are directly related to certain terrain conditions. A terrain consists of woods, sandy areas, rivers, hills, built-up areas, roads etc. Moreover, data concerning friendly forces, enemy forces (strength, armament, vehicles, deployment of formations etc.) as well as the weather conditions play a substantial role. The question as to what would be the most favorable course of action in view of the prevailing circumstances, is an extremely complex affair. One of the most important operations in this respect is CCM, the movement of deployed troops across a

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terrain. Since planning CCM-operations usually involves data of a spatial nature, a Geographic Information System (GIS) is likely to offer useful support.

CCM-planning relates to the movement of deployed troops across the terrain, based on a certain degree of *terrain negotiability*. Terrain negotiability is defined here as 'the degree of negotiability of terrain and soil types under various weather conditions'. With the help of the available data an *optimum path* (or optimum route) to cross a certain area is to be determined. In this case, the terms path or route do not necessarily denote existing roads, but refer to arbitrary movements across the terrain.

3 The Required Data

As mentioned before, information about the terrain to be crossed is essential for CCM-planning. Useful information can be found on a number of maps, which are discussed in this section. Also, field measurements are an important source of information. Further, a number of characteristics of the troops and the weather conditions are needed.

Current *CCM-maps* show, amongst other things, the following features of an area: soil composition (six classes), obstacles (watercourses, steep edges, vegetation, towns), natural relief, data concerning frost, snow, and groundwater level. These CCM-maps have the drawback that they are interpreted for wet conditions and combat tank only. Further, just old maps of parts of Europe are available.

The *Topographic Survey maps* contain features such as roads, rivers, towns, elevation, vegetation, etc. Although these maps are not specifically intended for CCM purposes they are nevertheless useful when determining the degree of negotiability and identifying obstacles. A high number of ditches for instance, indicates a high groundwater level (humidity). Topographic maps complement CCM-maps with more up-to-date data.

Soil maps are exceptionally well suited for determining surface negotiability, since these maps use a basic structure that strongly coincides with that of the CCM-map. Furthermore, Netherlands soil maps also indicate the averages of the highest and lowest groundwater levels. By combining groundwater level data with data concerning the soil, insight is provided in surface negotiability. Note that these interpretations differ from vehicle type to vehicle type.

4 GIS Support for CCM

Possible GIS support in the planning of CCM-operations may comprise several degrees of sophistication. Initially, the simplest situation is assumed, namely that a GIS only represents digitized CCM-maps, Topographic Survey maps and soil maps. This kind of functionality is, after digitizing and entering the map data, available in each and every GIS. Below, we describe various kinds of more advanced GIS-support for planning CCM-operations, that we have researched.

4.1 Terrain interpretation

For the implementation of a prototype 'terrain interpretation' function in a GIS, the following rules have been used:

1. For the soil interpretation, the 'Unified Soil Classification System' (USCS) with 17 soil types is applied to the Netherlands Soil map of the Staring Centre. Depending on the vehicle type/weight the important depths for the USCS soil type are 0/15/30/45 cm.
2. Based on the groundwater level, the USCS soil type, and the vehicle characteristics, the terrain negotiability percentage is computed with USCS formulas.

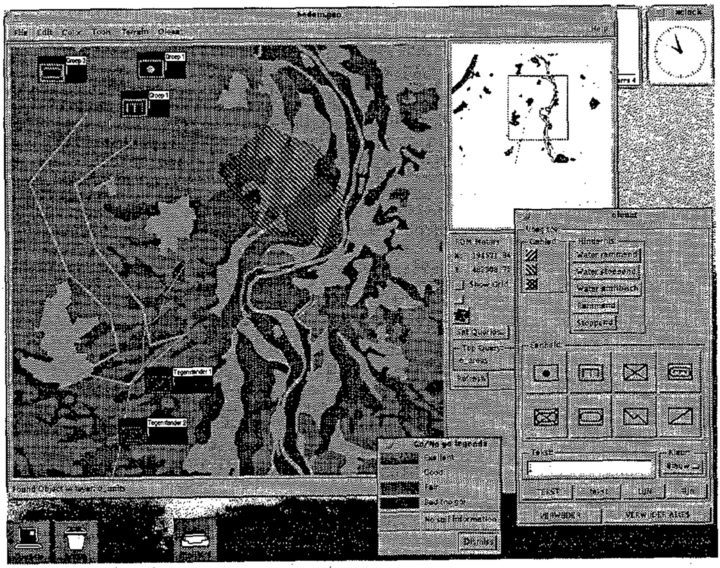

Fig. 1: Terrain interpretation: the GO/SLOW GO/NO GO areas

3. Selection of linear and area obstacles related to a certain vehicle type. Every vehicle possesses certain values expressing, for instance climbing capability, or the ability to overcome vertical obstacles of a certain maximum width.

The terrain negotiability percentage is mapped to the well-known categories: NO GO/SLOW GO/GO and can be presented to the user; see Fig. 1. The whole interpretation can be done in a few minutes, which is a huge time gain compared to the manual interpretation using paper maps and an overlay.

4.2 3D Terrain analyses

The terrain negotiability percentage is also the basis for automated planning and/or user-specified path evaluation. For this purpose, an other important factor is relief, which has a number of effects:

- it influences moving possibilities for certain vehicle types due to climbing/descending limitations, note that is direction dependent;
- it influences the 'vehicle visibility' together with the terrain elements;
- the path length as seen on the projected map.

The CCM-prototype system has the capability to store and visualize 3D data; see Fig. 2. In addition to this it is also possible to perform 3D analyses; e.g. the *viewshed* (indicates which areas are visible from a give location; see Fig. 3) and the *visibility index* (indicates the 'overall' visibility of locations; in Fig. 4 dark means a high visibility) can be computed.

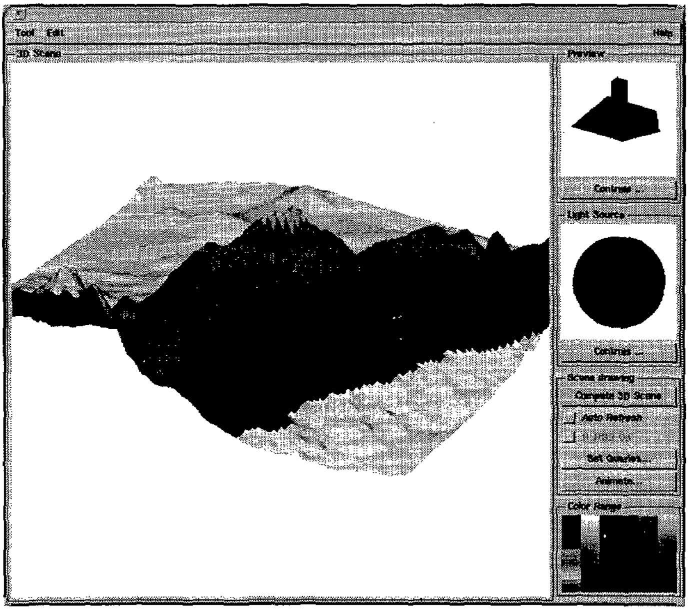

Fig. 2: 3D data visualized in our GIS (elevation contours)

Fig. 3: Viewshed for a given location

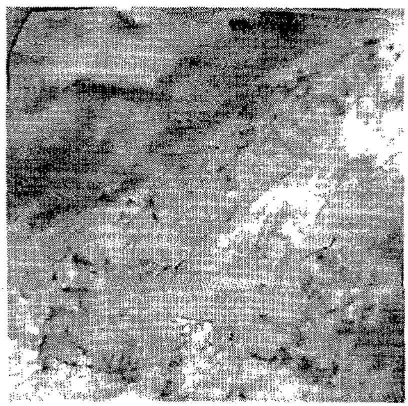

Fig. 4: Visibility index on terrain.

4.3 Analysis and Planning Functions

Algorithms for computing the optimal CCM path from a given source to a given destination have been described in another paper [2]. The determination and representation of the optimal route across the terrain, is based upon the vehicle types of the unit to be moved, and the previously determined terrain negotiability; this may include the following variants: 1. indicating complete lines or areas rather than specific (starting and finishing) points; 2. indicating compulsory waypoints along a route, allowing the user to generate various alternative paths; 3. specifying multiple sources and/or destinations (finishing points, lines or areas), e.g. water supplies;

Besides drawing the optimal path, the computation can also generate a iso-time diagram map, i.e. a diagram indicating how far one can travel within a certain period of time starting from a certain point using a certain vehicle. The functionality mentioned above has been developed for both the 2D and the '2.5D' (one z value on every (x, y) location) situations, in which height differences are also taken into account.

5 Conclusion

The prototype implementation has been carried out with the help of the advanced GIS GEO++ [3]. GEO++ is based upon Postgres [1], because this DBMS offers many advantages as a basis of an integrated GIS, particularly because Postgres allows the use of a spatial index. Postgres also offers the possibility to store and manipulate spatial objects, such as points, lines and areas. All this makes GEO++, based on Postgres, a flexible and extensible system and as such very suitable for developing and integrating new applications. The following CCM support functions have been implemented: – Many map visualizations (CCM-map, soil-map, topographic map, ...); – Support of DIGEST A (ISO 8211) and DIGEST C (VPF) data input; – terrain interpretation; – Evaluation of a user specified route; – Conversion of vector maps (result of terrain interpretation) to raster maps (as input for the raster route planning); – Several automatic raster-based CCM algorithms with a prototype interface; – 3D module for integrated storage of elevation data; – 3D visualization (with shading, arbitrary view-angle, hidden-line/ hidden-surface, feature selection); – An automatic vector-based CCM algorithm (without GUI); – Constrained (Delaunay) triangulation (basis of many 3D applications and also of the vector-based CCM algorithm).

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