

## AUTOMATIC RECOGNITION OF LINEAR FEATURES, SYMBOLS AND TEXTURED AREAS WITHIN MAPS

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### *Abstract*

This paper describes advances in methods for the segmentation of linear features, such as grids, roads, contours and rivers, symbols and textured areas within binary map images. Due to the high level of complexity and occlusion within binary map data, the automatic classification of small non-linear components discussed in the paper, shows remarkable progress towards a completely automatic map recognition system.

### **1. Introduction**

The need for total automation in capturing digitised map data has primarily been driven by the needs of urban planning and public utility companies, such as gas, electricity and water. Automatic recognition of map components offers dramatic benefits in planning and maintaining the data used by such companies since their databases are context dependent upon map information. A recent interesting application at Nottingham University has been the capture of terrain dates for virtual reality systems.

Our approach to the problem is to scan in a paper-based map, thus producing a raster image, convert the image to a vectorised format, and then attempt to extract or segment similar structured components within the map image into various layers or strata. However, maps are a source of extremely complex binary images due to the intense occlusion incurred by the constituent components. For this reason the task of automatic recognition of all classes of pattern within such documents remains a difficult one to solve.

The layout of the paper includes an overall categorisation of the map data used, followed by a description of the model by which the data is extracted, along with results showing lines and areas successfully extracted and classified, and concludes with a summary of some of the benefits this system offers in relation to previous work carried out in the field.

### **2. Overall Categorisation of Map Data**

The highly complex binary images, produced as a result of digitisation of geographical maps, reflects the abundant amount of intricate detail these documents contain. UK Ordnance Survey Landranger Series map with a scale of 1:50 000 may typically illustrate eleven main categories of constituents within its key. However, a category may include upto twenty five different sub-classes. Sometimes there is only a subtle distinction in structure between these. With the aid of colour, these subtle differences are easily distinguishable, but when presented in binary form, a hierarchical model must be constructed to identify each class.

In our system, map data from the Ordnance Survey Landranger Series ( 1:50000 scale ) has been taken. The categories within the map legends have been sorted into a hierarchical model to illustrate the structure of the various constituent classes. This is summarised within figure 1.

### **3. Model for Segmentation**

The detection and extraction of textured areas and long linear structures, such as the grid lines, roads, railway lines and some contour lines, are carried out in different ways. The schematic approach used, is to detect and extract all the grid lines, then remove all other long linear structures, and finally detect textured areas by their enclosed symbols. The following sections outline the mechanisms by which these components are segmented from a binary map image.

#### **3.1 Segmentation of Grid Lines**

Grid Lines are segmented from the binary image based on the properties of equi-distance and straightness of vectors within the map. Horizontal grid lines are detected independently of vertical grid lines, although the principle behind both sets is the same. Considering the detection of grid lines in one of the two axes, the first stage involves the graphical

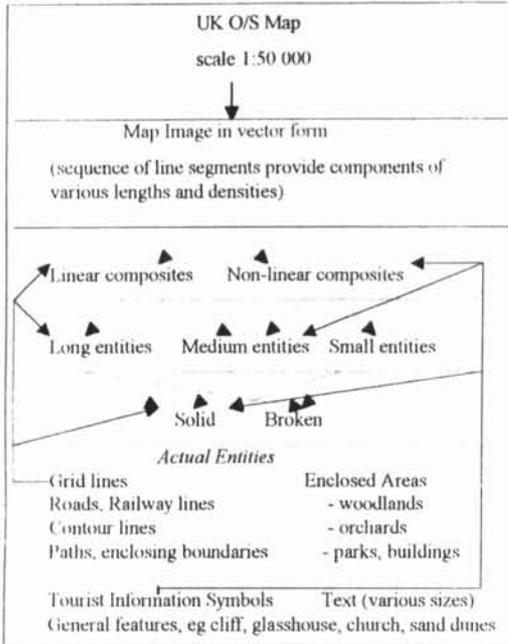


Figure 1: Map Data Categorisation

analysis of map vector lengths passing through each value in the axis. This is shown in figure 2 as exemplified with the vertical lines only. A "Mexican hat" type filter is then applied to emphasise the peaks and reduce the noise in this graph. The mode, or highest peak, of the graph is assumed to represent one of the grid lines in the axis considered. Constraint upon the graph values allow only the weighted means of areas (the middle point of each area) from readings that exceed twice the mean value of the entire graph, as shown in figure 3. The result is a list of values in the axis that are represented by the large peaks of the graph.

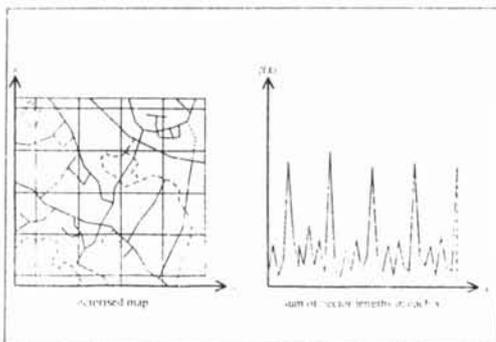


Figure 2 : Detection of Grid lines

Frequency of the grid lines complete their detection. For each pair of peaks in the original graph, a value is added to a new graph at a point corresponding to the distance between the two peaks. The value that

is added is the smaller height of the two peaks. The graph is smoothed in order to combine very close values. The mode of this graph is assumed to represent the regular interval between vertical grid lines on the map.

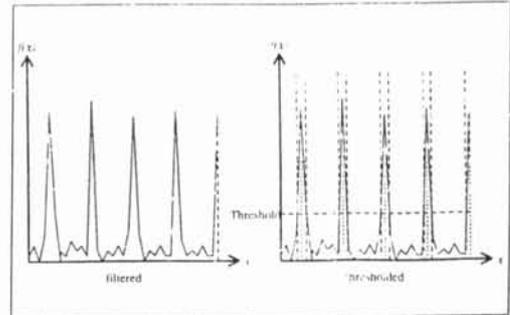


Figure 3 : Detection of Grid lines

The known x- or the y-coordinate of one grid line, and the determined interval between grid lines now enable a perfect set of grid line, in the axis considered, to be constructed. So in the original map, any line that fulfils both of the following conditions is then removed as being part of a grid line:

- Is nearly vertical.
- Centres near a position at an integer multiple of the calculated interval from the known vertical grid line.

### 3.2 Removal of long linear structures

All the individual lines that make up the map are grouped into objects. A line is in the same object as another line if the shortest distance between them is within a certain fixed tolerance, or they are connected via other lines in this way. The shortest distance between two lines is determined according to the properties of the lines. An object's size is considered equal to the largest distance between any pair of line endpoints within that object. Thus, objects comprising the map may be separated according to an arbitrary size threshold. For example, small objects will include map symbols, text, textured areas and dotted lines, and long spaghetti-like objects will include roads and contour lines.

### 3.3 Segmentation of Textured Areas

Textured areas are distinguished by the presence of a cluster of identically structured symbols. So, in order to detect such areas, the detection of the cluster is essential. Using the vector information of a map, under the assumption that all long lines have been successfully removed, a textured area is

determined in the following manner. Firstly, detection of known symbols for such areas is carried out, initially on the basis of component size, but further supported by feature information of the pattern, such as number of end points, degree of complexity and density of line segments within the pattern. Each detected symbol is then labelled by its type and centre of gravity location in the map image. This process accounts for the majority of discriminations between symbols and similar sized map components, such as text. However, a small percentage of symbols, overlapping with similar sized map components may be categorised at a later stage of the map segmentation system, when labelled areas may also be updated.

The second stage towards extraction involves determining if symbols, labelled with the same type, form a cluster in the image, and if so, how many symbols contribute to the same cluster. This clustering information is obtained by using a 3-Nearest Neighbour algorithm on each of the symbols of the same type.

The boundary of a textured area is not always displayed as a solid line. Sometimes it is represented by dashed lines, and sometimes there are no lines around the area. For this reason, the boundary is determined using the co-ordinate locations of symbols on the edge of a cluster.

#### 4 Results

The following set of figures illustrate the extraction of grid lines, long linear structures, "textured" areas and symbols from a map image scanned at 300dpi. The original image is shown in figure 4

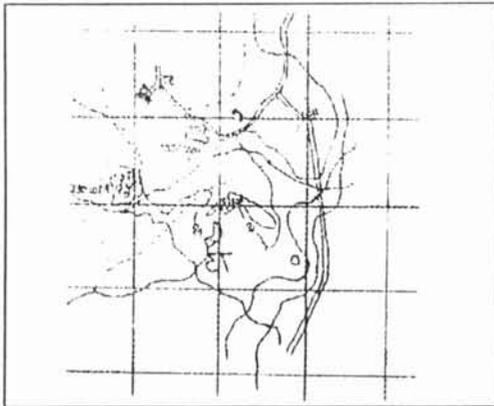


Figure 4 : ORIGINAL IMAGE

The segmentation process identifies grid lines as shown in figure 5. Although the segmentation is not

perfect, it is more than adequate to identify the position and spacing of the grids as well as the skew angle which has been calculated in this instance to be 0.32 degrees. The very small circles scattered in the figure are "noise".

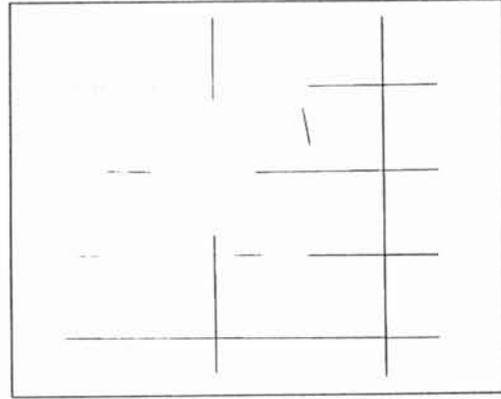


Figure 5 : GRID LINES



Figure 6 : LONG LINES

Figure 6 shows the extracted long vectors which correspond to features such as roads, contours and railway lines.

Finally, text and other symbol-sized components are segmented as shown in figure 7, while "textured" areas, such as woodland regions, are extracted as illustrated in figure 8.



Figure 7: SYMBOLES

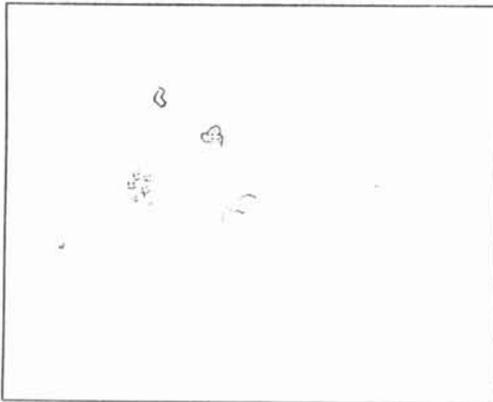


Figure 8: WOODLAND REGIONS

## 5 Conclusions

Most map recognition systems have focused upon specific components within confined areas of a map, or in maps of lesser complexity than those used in this work. Cadastral maps<sup>1</sup> are a prime target for automatic recognition, since their use has such a great impact on urban planning [BOA92]. However, it is acknowledged that the approach in [BOA92] fails when symbols touch or overlap lines, which is a feature commonly found within land register maps. Many systems have concentrated upon numerical text within maps. One such application of number recognition has been to investigate the depth soundings within Hydrographic field sheets [MEL91]. Although, the number identification approach carried out is very similar to that in [COS90], the the problem occurring between digits attached to neighbouring linework is addressed. Linework in maps have received a fair amount of

attention [NAG90][SUZ87]. The foundations of a system called MARIS<sup>2</sup> [SUZ90] show that lines remaining in a binary image may be distinguished by criteria of thickness of line, periodicity in pattern shapes and a general process of elimination. General character recognition within maps [RAF89] is by far a more difficult task, as text is presented in various sizes, fonts and orientations

Due to the high proportion of touching and occluded patterns, the segmentation of specific map components is a problem that has been evaded or approached with many constraints [INA92][EJI90]. The work presented in this paper has shown an approach towards full segmentation of components within binary images of fairly complex maps with minimal constraints.

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<sup>1</sup> These maps, also known as land register maps, describe the geometry of land properties and buildings in a geographical context.

<sup>2</sup> MAp Recognition Input System