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RETRIEVAL OF SIMILAR TOPOGRAPHIC AREAS

Kokinou E.[1], Panagiotakis C.[2] and Kinigopoulos Th.[3]

[1] *Technological Educational Institute Crete, Department of Natural Resources & Environment, Chania, Crete, Greece, ekokinou@chania.teicrete.gr*

[2] *Technological Educational Institute Crete, Department of Commerce and Marketing, Ierapetra, Crete, Greece; cpanag@staff.teicrete.gr*

[3] *University of Crete, Department of Computer Science, Heraklion, Crete, Greece; kynigop@csd.uoc.gr*

Abstract

Image processing and understanding and further pattern recognition comprises a precious tool for the automatic extraction of information using digital topography. The aim of this work is the retrieval of areas with similar topography using digital elevation data. It can be applied to geomorphology, forestry, regional and urban planning, and many other applications for analyzing and managing natural resources. In specifics, the user selects the area of interest, navigating overhead a high resolution elevation image and determines two (3) parameters (step, number of local minima and display scale). Furthermore the regions with similar relief to the initial model are determined. Experimental results show high efficiency of the proposed scheme.
Key words: *Digital topography, pattern matching, content based image retrieval.*

Περίληψη

Η επεξεργασία και ερμηνεία της εικόνας και στην συνέχεια η αναγνώρισή της αποτελούν ένα πολύτιμο εργαλείο για την αυτόματη εξαγωγή πληροφορίας με χρήση τοπογραφικών δεδομένων. Στόχος της παρούσας εργασίας είναι η ανάπτυξη αλγόριθμου σε πλατφόρμα Matlab, ο οποίος χρησιμοποιεί ως είσοδο ψηφιακά τοπογραφικά δεδομένα και εξάγει τις περιοχές με παρόμοια τοπογραφία. Μπορεί να εφαρμοστεί στην γεωμορφολογία, στην δασονομία, στον περιφερειακό και αστικό σχεδιασμό, και σε πολλές άλλες εφαρμογές που σχετίζονται με την ανάλυση και διαχείριση των φυσικών πόρων.
Ο χρήστης έχει την ευχέρεια να επιλέξει την περιοχή που τον ενδιαφέρει, με πλοήγηση σε υψηλής ανάλυσης τοπογραφική εικόνα και να προσδιορίσει τρεις παραμέτρους (βήμα, αριθμό των τοπικών ελαχίστων και κλίμακα απεικόνισης). Στην συνέχεια εντοπίζονται αυτόματα οι περιοχές με παρόμοια τοπογραφικά χαρακτηριστικά. Τα πειραματικά δεδομένα δείχνουν υψηλή απόδοση του προτεινόμενου αλγόριθμου.
Λέξεις κλειδιά: *Ψηφιακή τοπογραφία, σύγκλιση προτύπων, ανάκτηση εικόνας βάσει περιεχομένου.*

1. Introduction

Elevation data are widely accepted as one of the most important tools in many scientific branches. Topographic maps contain various spatial and thematic information, providing an ideal data source for Geographic Information Systems (GIS). Simultaneously, GIS comprises a domain experiencin g a rapid growth of both computational power and quantity of information, making large spatial da ta archives available over the Internet (Ruiz et al., 2011). The interest to share this information bet ween different users is also increased. Automatic interpretation of digital topography was firstly ap plied in cadastral maps and/or raster-to-vector conversion (Ablameyko, 1993; Mayer, 1994) and fu rther in data fusion and remote sensing fields (Csathó and Schenk 1998, Lee and Shan 2003, Bartel s et al. 2006, Chen et al. 2008, Elaksher 2008), and mainly for urban areas (Cornet et al. 2001, Fan elli et al. 2001, Wald and Ranchin 2001).

The automatic enhancement and detection of structures on real and complex 2-D images are important tasks on various applications of computer vision, medical analysis, and geosciences (Panagiotakis et al. 2011). The present work aims to automatically detect areas that look alike, based on elevations of all points. Newsam et al. (2010) describe and demonstrate a web-based system for performing content-based image retrieval in large sets of high-resolution overhead images. The system provides a familiar Google Maps interface to navigate the images and select regions of interest. Xia et al., (2010) suggest a satellite image indexing method relying on topographic maps and a shape based image indexing scheme. The proposed approach contains both the textural and structural information of satellite images. Sırmaçek and Ünsalan (2011) propose a novel building detection method using local feature vectors and a probabilistic framework in order to detect buildings from very high resolution (VHR) aerial and satellite images. The following methodology was implemented using commercial and free software such as Matlab[1], Global Mapper[2] and ArcGIS 9.3[3].

2. Methodology

Elevation Data

Global Mapper free software was used to download the elevation data, elaborated in Matlab in the context of the present work. The pre-mentioned software offers access in a variety of spatial datasets and supports a wide range of formats. The onshore Crete area (Fig. 1) was selected as the comparison area and an area located in the western part of Heraklion as the initial testing area. That is, the algorithm developed in this work, will search the entire Crete in order to find areas of similar topographic relief with the region, located west of Heraklion. Elevation data of the above areas is exported from Global Mapper in .xyz format corresponding to longitude, latitude and elevation.

Geographic Information System (GIS)

GIS techniques were used for mapping and estimate the topographic features of the initial testing area, located west of Heraklion. Scope of this approximation, using GIS techniques, was to have a detailed view of the topography corresponding to the initial for testing area and better control of the expected results.

Topographic visualisation (Goldfinger, 1994; Goldfinger et al., 1997) presents several basic forms: shaded relief plots, contour plots, and wire-frame plots. Deformation patterns are better revealed using shaded relief plots (Oguchi et al., 2003). The basic parameter of the hillshade tool is the illumination angle (Kennely, 2008), important to make plots with several angles and combine

[1] http://www.mathworks.com/products/matlab/
[2] http://www.globalmapper.com/
[3] http://www.esri.com/software/arcgis

interpretations. Additionally, GIS systems can generate many useful derivative datasets from topography. Two useful products for studying the topography are slope and aspect maps (Brewer and Marlow, 1993). A slope map assigns colours to the slope angle of each pixel of the elevation grid. This type of image can be used to isolate ranges of topographic slope angles for statistical treatment, predictive capabilities of slope stability, or outcrop exposure. Similarly, an aspect map assigns colours to the azimuth of the slope direction.

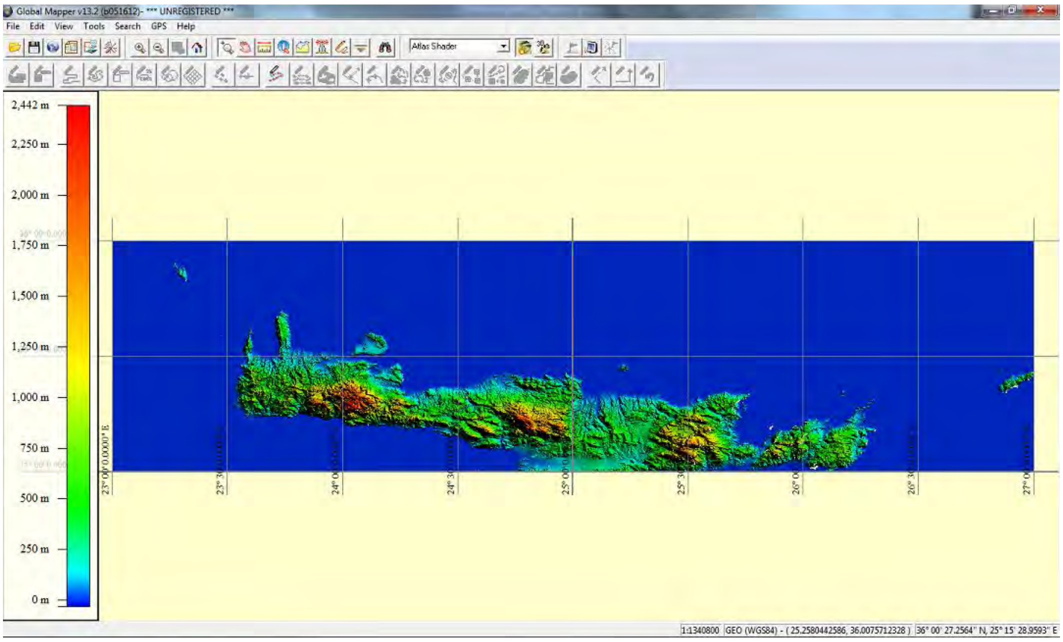

Figure 1 - Onshore Crete (from Global Mapper) was selected to be the comparison area.

Proposed Algorithm

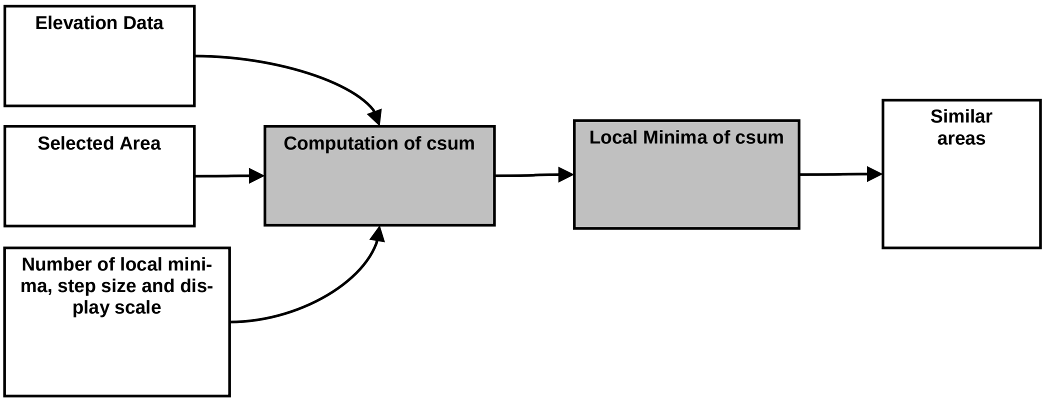

Figure 2 - The scheme of the proposed algorithm.

Figure 2 illustrates the scheme of the proposed algorithm. The input of the method is the given elevation data, the selected area, the step size, the number of local minima (N) that the algorithm will compute and the display scale. The output of the method is the N most similar areas with the initial selected area. Hereafter, we present the proposed method with details.

The present algorithm is executed in three steps as follows:

- Load files, initial variables, create arrays in the format used in the procedure. Input files are loaded in MATLAB in .xyz format that is in the form of tables with 3 columns corresponding to the longitude, the latitude and the altitude of each point. Then by using the command input the user is prompted to give three parameters as inputs and is checked so that when the user gives a non-positive value is requested to login again. These parameters are:

1. The step size, defining the neighborhoods that will be searched for local minimal. This parameter is used at the last part of the method (in local minima computation).

2. The number of local minimal (N) and therefore the number of related (similar) areas.

3. Scaling used to divide the map for better result in displaying.

- Create array (csum) for sum for each sub-region (z1) of the initial image (c) matched in the dimensions of the selected for comparison area (h). The sum of the absolute differences of all sub- regions (z1) in comparison with the original selected region (h) and placement in a new array (csum) of dimensions (s-s1) x (dd-dd1).

```
for i=1:s-s1
   for j=1:dd-dd1+1
         z1= c(i:i+s1-1,j:j+dd1-1)
         d= abs(z1-h)
         sd= abs(sum(sum(d)))
         csum(i,j)=sd
     end
end
```

- Finally, according to the step size we find the local minima of csum array and we print the retrieval results. The local minima are computed in ascending order (starting with the global minimum). The step size defines the minimum distance between two local minima. So, when a local minimum is computed we ignore all possible local minima in a squared region of size equal to step size.

The step size is the only parameter that affects the results of the algorithm. If this parameter is zero then it is possible that the algorithm will yield local minima in the same region. A default value of this parameter is the size of the initial selected area.

3. Experimental Results

In this work, Matlab and ArcGIS 9.3 were combined to ensure the reliability of the algorithm developed. Figure 3(a), (b) present the elevation of the initial testing area, located west of Heraklion, using the display tools of the pre-mentioned software programs. In the majority of this area, the elevation is ranging between 0-200 m and only in the south-western part increases up to 300 m. Figure 3 (c)-(e) show the hillshade, aspect and slope maps, respectively. Generally, prevailing aspects are east, southeast, west and northwest. The relief of the study area is mainly hilly. Steep slopes (>45%) prevail in the south-western part of this area.

Figure 4 (a) and (b) show the initial selected area that is located west of Heraklion and the most similar area with the initial selected area according to the proposed method. Figure (5) shows the result of the proposed method, depicting the most similar area with the initial selected area using as similarity measure the elevation and comparing the morphology of both areas mainly based on the slope and the aspect. The most similar area is located in the northwestern part of the Chania prefecture (Relevant Area No1). Other less similar to the Relevant Area No1 were respectively detected in the Rethymno prefecture and in the Lasithi prefecture. It holds that both initial selected area and Relevant Area No1 present not only similar elevations but also similar morphological characteristics.

The above methodology is important for data fusion or map conflation concerning the extraction of the best-fit geometry data applied in geospatial databases as well as the most suitable data from existing datasets (Stankute and Asche (2009)). The problem of feature type matching comprises an aspect of data fusion, a process that requires specific rules for automating the matching and fusion step. In the present case the elevation was used as attribute for matching areas of similar topography. Furthermore the morphological attributes of both areas were included in order to check the results of the applied algorithm.

4. Conclusions

In the context of the present work an algorithm was developed aiming to automatically detect topographically similar area(s) to an initial selected area. The similarity search is performed against a target dataset using as similarity measure the elevation. The morphology of both initial and relevant areas was included to check the results.

The proposed method is simple and it can be easily applied under different metrics and type of input data. Experimental results show high efficiency of the proposed scheme. An extension of this work may include the retrieval of places that have similar topographic maps in the sense of shape, invariant rotation, translation and scaling transforms.

As demonstrated by this approach, the above methodology aids the automation of feature conflation and contributes towards developing other applications of pattern recognition and data analysis.

5. Acknowledgements

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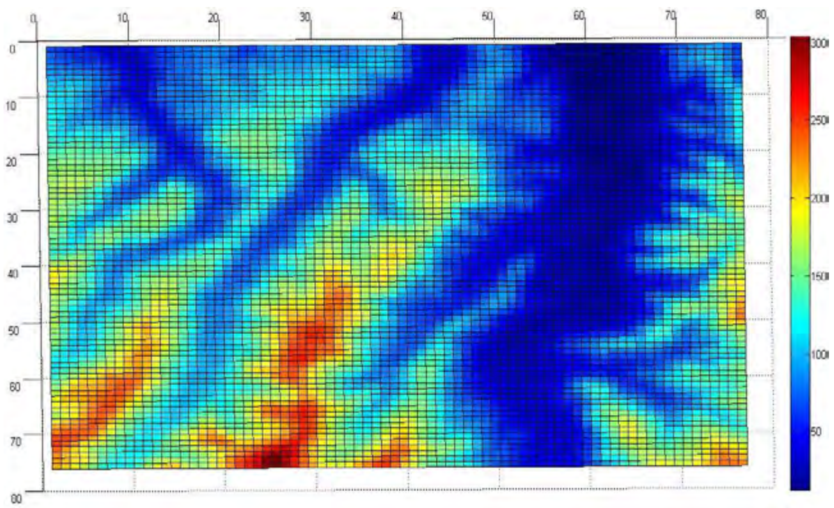
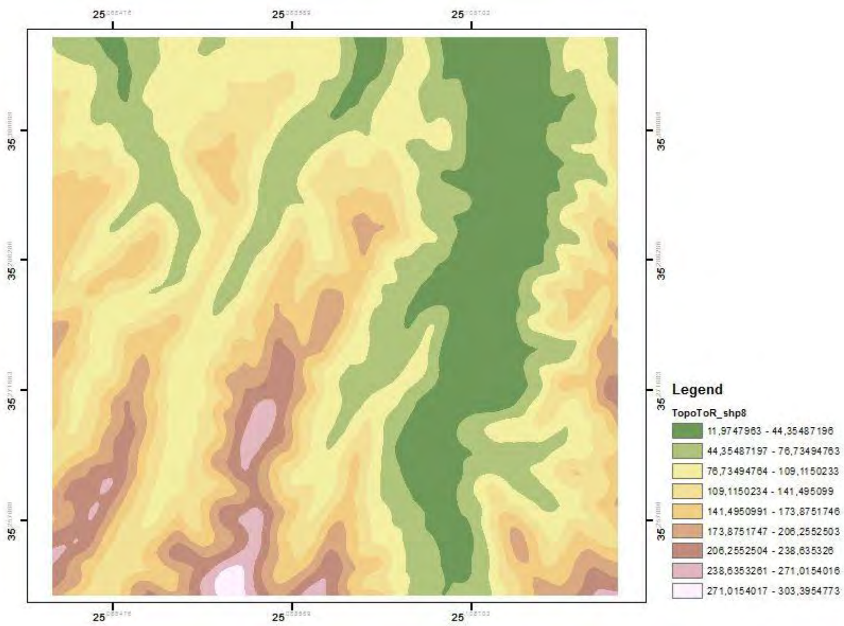
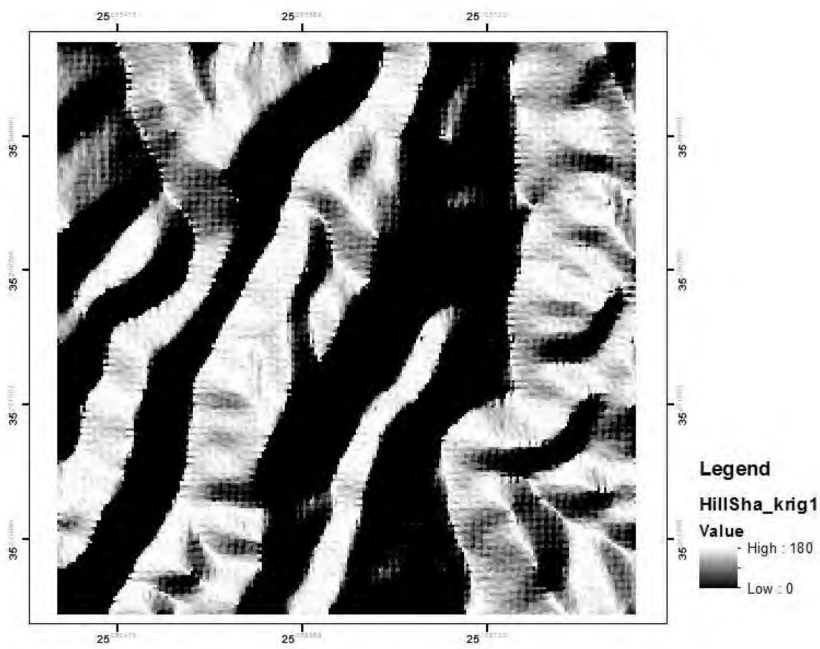


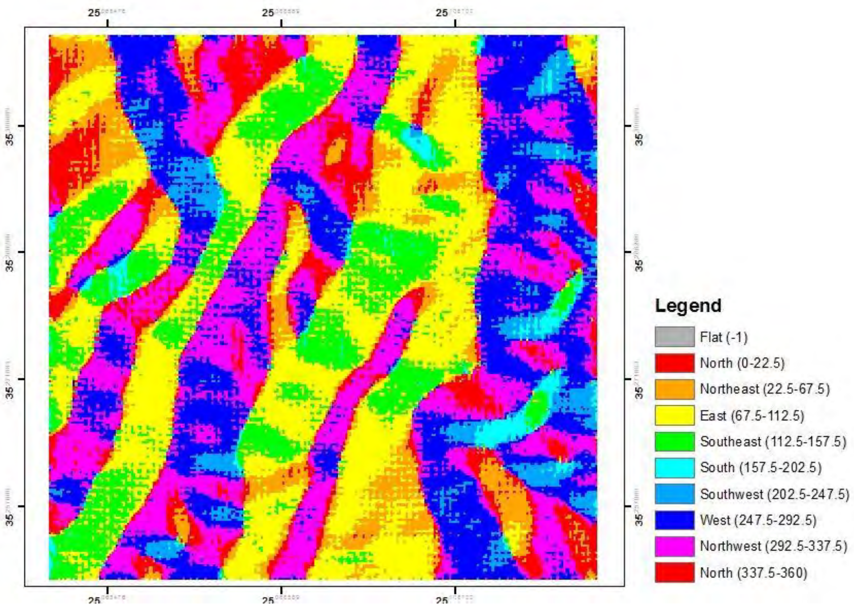
(a)


Legend
TopoToR_shp8
11,9747963 - 44,35487196
44,35487197 - 76,73494763
76,73494764 - 109,1150233
109,1150234 - 141,495099
141,4950991 - 173,8751746
173,8751747 - 206,2552503
206,2552504 - 238,635326
238,6353261 - 271,0154016
271,0154017 - 303,3954773

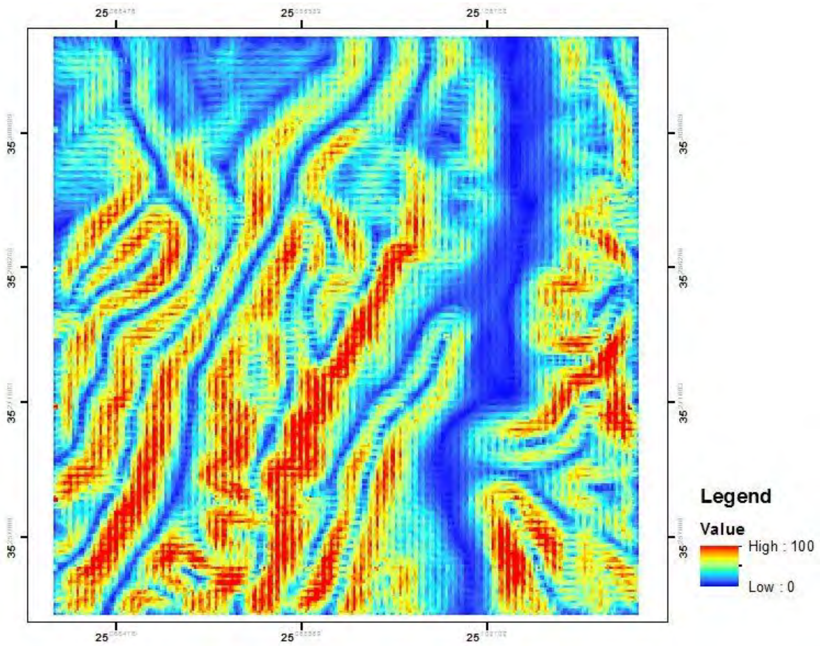
(b)


Legend
HillSha_krig1
Value
High : 180
Low : 0

(c)

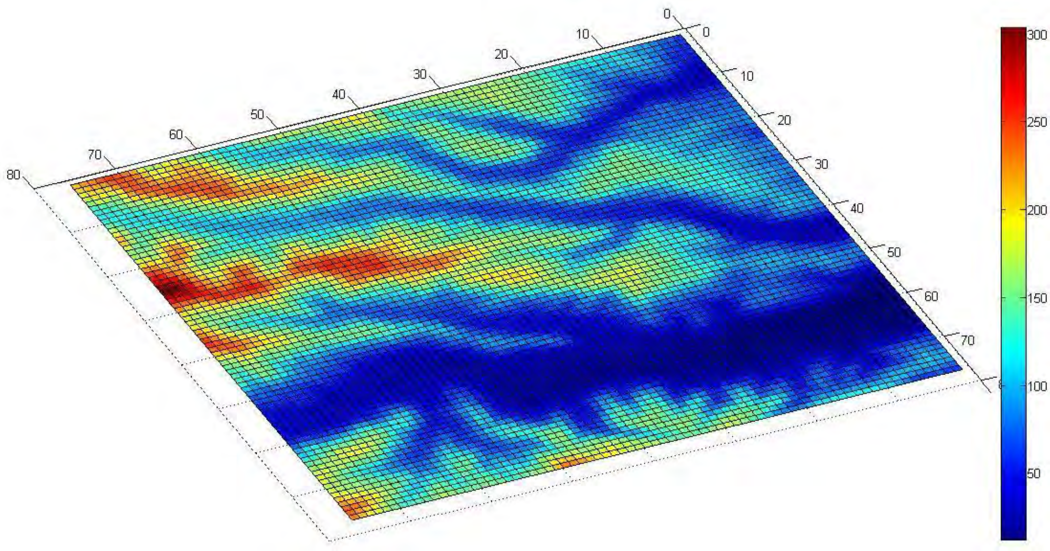


(d)

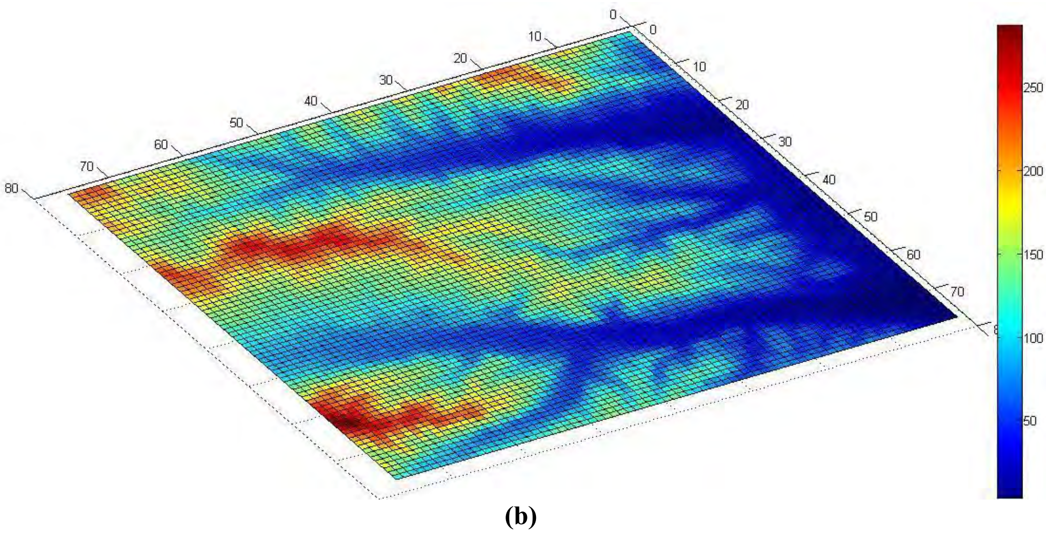


(e)

Figure 3 - (a): Selected area plotted using Matlab (scale represents the elevation in m), (b): the same area plotted using ARCGIS), (c): hillshade map of the same area, (d): aspect map, (e): slope map (%).



(a)



(b)

Figure 4 - (a) Initial selected area, (b): area with similar topographic characteristics detected using the algorithm developed in this work, (scale represents the elevation in m).

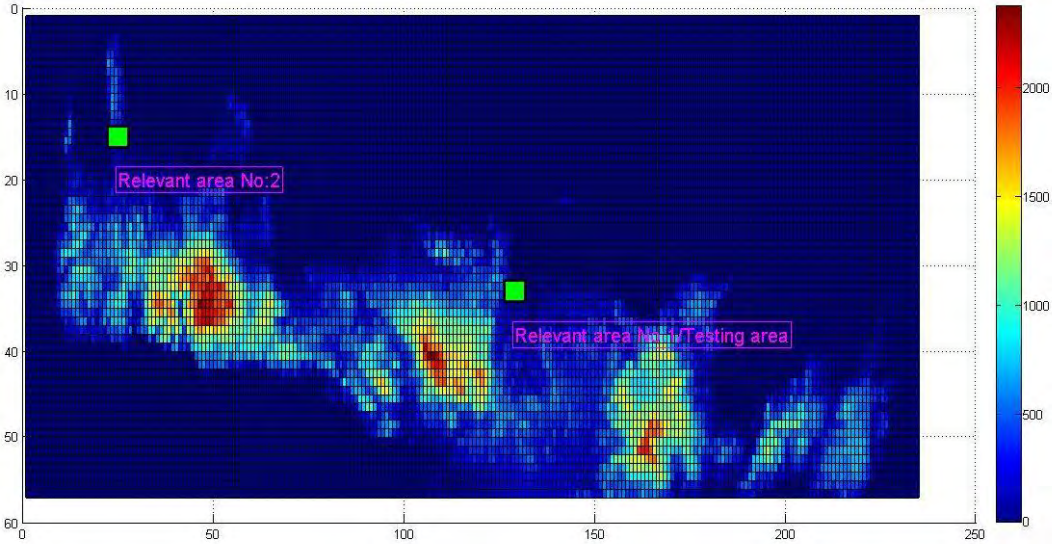


Figure 5 - Map of Crete showing two areas with similar topography, (scale represents the elevation in m).

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