CO-308

INSET MAPPER: A TOOL FOR SCALE SELECTION AND INSET PLACING CONFIGURATION OF MULTIPLE INSETS IN ISLAND CARTOGRAPHY.

PAPAKONSTANTINOU A.(1), VARSAMIS D.(2), SOULAKELLIS N.(1), KYRIAKIDIS P.(1)

(1) University of the Aegean, MYTILENE, GREECE ; (2) Technological Educational Institute, SERRES, GREECE

ABSTRACT

Cartographic design is a process of scale selection, symbolization and placement of geographical information. In Island Cartography scientists are faced with a unique and special cartographic problem, that of land discontinuity, which arises when scientists want to visualize islands regions with multiple islands of significantly different size. The most efficient cartographic solution, in this situation is the creation of an inset map.

Cartographers typically use their judgment to determine the need of an inset. They visually inspect the map and subjectively identify the limits of areas which are "too crowded", "too small", 'too dense" or "too isolated". Inset maps should be created by cartographers following some specific cartographic rules for position and scale selection. Inset map placement is also influenced by the cartographer's artistic view.

The key factor for insetting in Island Cartography is the "complexity of land discontinuity" comprised of a number of islands that vary in size and shape creating a complex area surrounded by sea. It is very common for small and big size islands to coexist, thus rendering representation at the same scale problematic. The scale of the main map often causes small size islands not to be clearly visible by the map reader or not to be clearly drawn.

Inset Mapper is a software tool for automated place and scale selection for inset maps that overcomes these procedure difficulties. IM is developed in MATLAB, along with other pertinent cartographic functionalities. This software tool attempts to emulate the steps a cartographer takes when deciding where to place and in which scale within a map to inset. To meet these requirements, IM employs some new strategies of cartographic representation for the inset placement procedure, and for scale selection, in multiple inset maps.

Inset Mapper lays out the main and inset maps in four steps. At the first step the user selects the area of the map to inset, and chooses where IM to search for insets, either the quadrant the above selected area belongs into or the entire main map area. In the second step IM selects the appropriate scale of the inset map for the selected area. The choice of the parent scale determines both the size and place of the inset maps. in the third step IM renders colored boxed areas designating the proposed map placements within the main map. These preferred inset places depend on the number of natural groups of proposed insets. Finally, the user selects the preferred inset placement from those proposed by IM. This process can be repeated, so the cartographer is able to assign more than one insets in the same map.

This paper discusses the theory and application of the algorithms used to choose a map scale, detect areas suitable for the placement of inset maps and delineate the best inset. These algorithms apply a combination of cartographic principles and analysis of the represented data. IM employs data clustering algorithms to select and to propose the best inset place, from a large number of contiguous insets that can be placed on map. Data clustering is employed to identify natural groups of proposed inset places in the main map. At the end the inset is placed into the right location within the map using a number of rules and membership grades for each cluster group. Finally a case study is presented, with Inset Mapper results for multiple insets on three different maps selected to cover local, regional and continental geographic scales.

1. INTRODUCTION

Geographic visualization has an important role in geographic research as it provides a meaningful tool for geographical data representation. The increasing power of information technology permits to create more accurate and detailed geovisualizations in different scales. During the last decade scale issue has increasingly attracted the attention of scientists in different disciplines (Marceau and Hay 1999) as those using Geovisualisation in geographic research. The necessity to find appropriate linkages between different scales recognized as a serious problem in social and natural sciences (Marceau and Hay 1999, Marceau 1999).

Not only scale is a new issue but is concern restricted to geographic information scientists. Scale variations have long been known to constrain the detail with which information can be observed, represented, analyzed, and communicated. Changing the scale of data without first understanding the effects of such action can result in the representation of processes or patterns that are different from those intended (Turner et al 1989).

In Island Cartography, scientists are facing a unique and special cartographic problem; namely, the complexity of land discontinuity. This problem appears in cartography when scientists want to visualize islands regions where islands having different sizes co-exist nearby areas with much bigger size (Papakonstantinou 2010). In this case, it is a good practice to include one or more inset maps of broader scope. A clever trick and the most efficient cartographic solution is the creation of an inset map.(Arthur H. Robinson et al. 1995. Papakonstantinou. 2010). Where inset is a portion of the map at an enlarged scale in order to gain scale, to enlarge or to focus on a small section of the map.

Cartographers typically use their judgment to determine the need of an inset (Broome et al., 1987). They visually inspect the map and select areas which are "too crowded", "too small", 'too dense" (Jarvis 1995) or "too isolated" (Ormeling 2002) in order to represent them in insets. Inset maps should be created following some specific cartographic rules for position and scale selection (Thomson, 2009; Tyner, 2010; Krygier 2005). An already existing-and used software tool for automated inset map creation is the Census Automated Map Production System (CAMPS) (Thomson 2009; Martinez, 1989; Broome et al., 1987). This software tool applies cartographic logic and density analysis in order to create insets for areas of dense features (Thomson, 2009; Martinez, 1989; Broome et al., 1987). In this approach feature density is the key for the inset procedure and insets are always mapped on separate sheets never on into the parent map sheet (Broome et al., 1987).

In contrast, the key factor for insetting in Island Cartography is the "complexity of land discontinuity", whereby a number of islands with a big variety in size and shape create a complex area surrounded by sea, a fact that makes it difficult to represent them at the same scale. The main map scale sometimes causes small size islands not to be clearly viewed by the map reader or not to be clearly drawn.

In most Island cartography map projects were insets are used, areas with land discontinuity are represented in scales that have as a result to be drawn "too crowded", "too small", 'too dense" or "too isolated" from main map. These insets are selected by cartographers and placed into the map without any scientific justification as far as scale and position concerns.

There are no rules or software tools to help scientists to choose inset map placement position and scale selection according to their visualization demands and limitations. It is common that some times inset maps are represented in different scales than there are suitable to. That has as a result some of the insets to be more or less accurate as they should be. It is also viewed some insets to be misplaced within the main map, thus leads cartographers to the creation of unbalanced map design.

Such software does not exist in order to assist scientists to resolving problems as the above, problems that consists the "Inset scale and misplacement problems to the development of Inset Mapper which is a software tool for automated place and scale selection for inset maps that overcomes these procedure difficulties. IM is developed in MATLAB, along with other pertinent cartographic functionalities. This software tool attempts to emulate the steps a cartographer takes when deciding where to place and in which scale within a map to inset. To meet these requirements, IM employs some new strategies for the inset placement procedure, and for scale selection for multiple inset maps on the same main map.

This paper focuses on the results of the combined searching and cluster algorithms into IM software tool which implements all the appropriate methods and techniques enabling the user to interact and create multiple solutions for the scale and position of an inset map.

The paper is organized as follows: section 2 reviews theoretical frame of inset mapping, Section 3 presents a case study and section 4 concludes the paper and discusses future work.

2. INSET MAPPING THEORETICAL FRAME

This section reviews theoretical implementation of inset mapping procedure algorithms and cartographic rules used for the creation of IM software tool functionalities. Our effort motivated from the CENSUS CAMPS software (Thomson, 2009; Martinez, 1989; Broome et al., 1987) capabilities, to create software adapted to island cartography's restrictions. IM software tool tries to solve the "complexity of land discontinuity" problem in island geography visualizations using the appropriate rules. These rules are a combination of cartographic design principles and cluster analysis of the represented data in order to propose the appropriate scale and placement for multiple insets within the main map. The IM is a tool for the creation and placement of multiple insets that taking place in a paper map environment and also in digital display representations.

Our first consideration was that IM should reflect the cartographer's decision making process as far as inset scale and placement selection concerns. The most important and critical decision is the how an automated system should attempt to emulate cartographer decisions for insetting. Defining this procedure the quantitative definition of the cartographers reasoning process and the qualitative selection of cartographic principles used for insetting was the most important-critical step in the creation of the algorithms. Thus we tried to assemble a list that includes all these rules in order to "frame" insetting procedure.

When designing insets in open form especially in Island cartography the scope is to render a portion of the map in smaller geographical scale in order to enlarge or to focus on a small section of the map of any of these that is hard for the reader to locate or to distinguish within the map. There are a few standards that followed for the creation of insets. In general the same design parameters-considerations that apply in the main map should be applied to the inset. The following cartographic rules are these that a cartographer should follow when deciding to create one or more insets within the primer-main map:

1. Should be a clear distinction between inset and main map using borders or an outline to separate insets from main map.

2. When the inset map scale is not the same as that of the main map should be therefore scale indicator (bar or text) should be provided (Peterson. 2009.).

3. Should use the same orientation with the main map else include an orientation indicator.

4. Should use balanced design between inset and main map content. . Its placement on the map should provide balance with the other map elements. That means the same features and feature styles in the primary map element need to be duplicate in the inset map element. (Peterson. 2009.)

5. Should abstain from cover other represented areas of the map including small islands areas providing less information. For this we can explicitly consider sea areas as the "white board" to place insets.(Papakonstantinou et al. 2010)

6. Inset map ratio should not exceed the one height to one sixteen the size of the primary map element. (Peterson. 2009.)

7. When using more than one (multiple) insets these should be placed under some restrictions (ex same quadrant) in order to avoid misplacement errors and unbalanced map design.

All these cartographic restrictions consist (compose) the theoretical frame in which Inset Mapper is placed in order to make insetting more efficient for cartographers. These rules where included to the algorithmic implementation of Inset Mapper software tool. They comprise a new approach in cartographic representation for the inset placement procedure and for scale selection, in multiple inset maps.

2.1. Insetting procedure

Insetting procedure takes place in four steps. At the first step the user selects the area of the map to inset, and chooses where the software to search for insets, either the quadrant the above selected area belongs into or the entire main map area. In the second step the software selects the appropriate scale of the inset map for the selected area. The choice of the parent scale determines both the size and place of the inset maps. In the third step colored boxed areas are rendered designating the proposed map placements within the main map. These preferred inset places depend on the number of natural groups of proposed insets. Finally, the user selects the preferred inset placement from those proposed by software. This process can be repeated, so the cartographer is able to assign more than one insets in the same map.

2.2. Selecting inset's scale

A primary consideration in the selection of inset scale is the relationship between main and inset map dimensions. Also scale selection it is crucial to the success of the insetting procedure encountering that areas selected for inset be clearly viewed.

As far as inset dimensions concerns these can be defined with the use of algorithms created especially for this procedure. These algorithms calculate the ratio between main and selected to inset area dimensions and areas. From these ratios the algorithm calculates the larger enough scale that meets the required cartographic principles as they specified above.

Scale selection algorithms are devised to explicitly consider sea areas as the "white board" to place insets. The analysis of the parent and the configuration of inset map desirable scale relationship is realized with the use of serial-sequential inquiry algorithms. These algorithms scan the parent map for sea areas that are large enough to hold-get in the inset with the appropriate scale. The decision for the appropriate scale is taking using restrictions based on 5-6-7-8 cartographic rules mentioned above.

The objective of scale calculation is to calculate an ideal scale for each of the selected for insetting areas where the placed inset keeps the proportions of the area selected. The ideal scale is the one at which the inset is placed on the map using as more as possible sea area to overlap with the inset.

We should underline that before the insetting procedure the user defines three parameters. Firstly is importing to the software the main map layout, secondly is selecting the area to represent as an inset. And finally is choosing the area into which the calculation will take place, this area can be the entire map or the quadrant that the selected for insetting area belongs. We have to point out that the parent map is divided into four equal areas quadrants.

The scale selection procedure has as a result very large number of contiguous inset placement areas that cover-accomplish scale selection criterion.

These areas are within the main map or into specific quadrants and their number some times outreach-outmatch the one thousand solutions. Figure 2 presents the calculation results for the map of Samos Island in Aegean Archipelago with two insets. After the calculation the first inset has 774 proposed placement solutions and the second inset has 1669. It is clearly viewed that the numbers of the proposed solutions make the inset placement not as accurate as a common user want from software to provide. To make scale selection and placement procedure more efficient and more accurate is to search for clusters of the proposed insets. The next paragraph discusses how these clusters are detected and how cluster analysis reduces the number of proposed insets.

2.3. Detecting Clusters for defining Inset Positions

IM employs data clustering algorithms to select and to propose the best inset place, from a large number of contiguous insets that can be placed on map. Data clustering is employed to identify natural groups of proposed inset places in the main map. Finally the inset is placed into the right location within the map using a number of rules and membership grades for each cluster group.

The purpose of clustering is to identify natural groupings of data from a large data set to produce a concise representation of the proposed insets. Clusters are formed in such a way that objects in the same cluster are very similar and objects in different clusters are very distinct. In our study is used as a way to examine similarities and dissimilarities of proposed insets These often fall naturally into groups where the characteristic of placement in the same cluster is similar and the characteristics of placement in different clusters are dissimilar. To define these similarities and dissimilarities the k-means clustering algorithm is used.

The K-means algorithm has been selected because is commonly used in computer vision as a form of image segmentation. The results of the segmentation are used to aid border detection and object recognition. (Shapiro and Stockman. 2001). K-means clustering is a partitioning method that treats observations in our data as objects having locations and distances from each other. It partitions the objects into K mutually exclusive clusters, such that objects within each cluster are as close to each other as possible, and as far from objects in other clusters as possible. Each cluster is characterized by its centroid, or center point. This centred point in our case is the proposed inset place. In figure 2 selection of an area to inset was shown and the proposed placement solutions create two natural groups (cluster 1 and cluster 2).

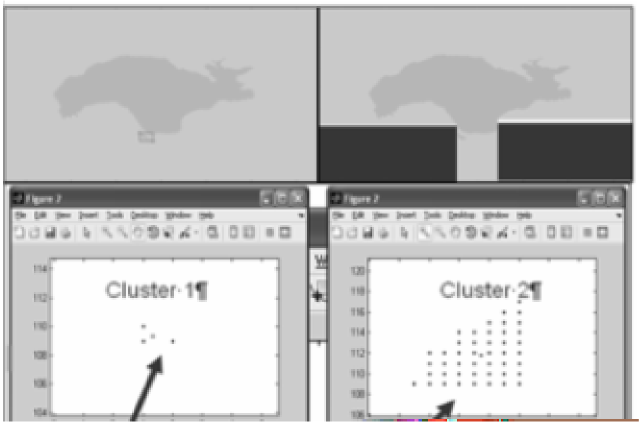

Figure 1: Clusters Natural groups. Local scale case study.

Once software has designated the analysis features using the above algorithms creating each group of proposed solutions the next step is to render the final inset (see figure 2).

Before this, cartographer should define the preferable inset within the proposed by software cluster in order the software to draw the boundaries separating the inset from the parent map. The results of placing insets to the right location into main map using scales and proposed by software are represented in our case study.

3. CASE STUDY

To exemplify how scale and placement positions are calculating, three different areas were selected as a case study in order to cover local, regional and continental geographic scales. For each area two insets are placed and the result was evaluated according the following parameters:

a) The total number of insets within all the main map.

b) The total number of insets within the quadrant that selected area belongs.

c) The final number of insets proposed by software- The total cluster number (natural groups).

d) The main map area.

e) The selected area to inset.

Realizing our case study we select the island of Samos in the Aegean Archipelago for the local scale, the area of Peloponnese in the South of Greece as regional scale, and finally Europe as the representation for continental scale. For all datasets we used the same resolution in order to avoid errors in the proposed insets. We have to point out that the scale selection algorithm is reading the imported maps in GeoTiff format. Thus the main map dpi resolution affects the calculation time and the total number of proposed insets (Papakonstantinou 2010).

The results for these three cartographical scales are represented in the following paragraphs.

I) Local scale

Samos is a Greek island in the eastern Aegean Sea, south of Chios, north of Patmos and the Dodecanese, and off the coast of Asia Minor. As for areas to inset as first area Samiopoula (inset 1) and the peninsula close to the capital of Samos (inset 2) was selected. Samiopoula is an islet located on the south of Samos Island and at a distance of 0.85 km and is ideal to represent as an inset. Running the software for this two areas the results for insets are the following (table 1).

LOCAL SCALE	Map Area km^2	Selected Area km^2	Map Scale	Proposed Scale	Total N° Insets	Quadrant N° Insets	N° Clusters	Proposed Insets
Main Map	3146		1:393562	-	-	-	-	-
Inset 1	-	5.6	-	1:57038	1669	74	2	2
Inset 2	-	11.2	-	1:78712	774	6	2	2

Table 1: Local scale inset mapping results.

As we can see in this case the total inset number that can be placed within the map is 1669 for inset 1 and 774 for inset 2. In contrary the proposed by software after the use of clustering algorithms are reduced in two positions for each inset.

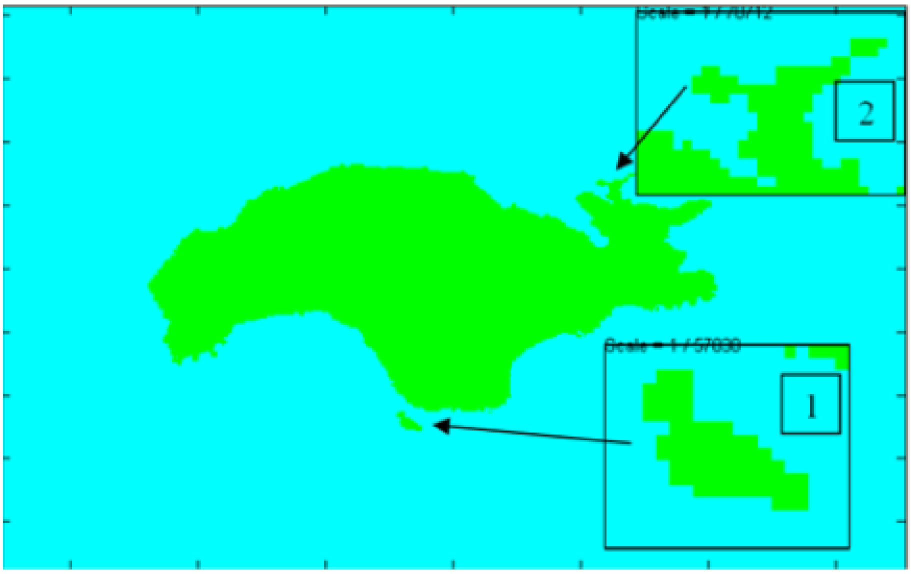

Figure 2: Insets 1 and 2 rendered in same map.

After the selection of the proposed insets for local scale the main map representation overlapped with the two insets is showing in figure 2

II) Regional Scale

Peloponnese is a large peninsula in southern Greece, forming the part of the country south of the Gulf of Corinth. The Peloponnese covers an area of 21,549.6 km² (8,320 square miles) and constitutes the southernmost part of mainland Greece. While technically it may be considered an island since the construction of the Corinth Canal in 1893 it is rarely, if ever, referred to as an "island". This unique shape leads us to the selection of Peloponnese. More specific as areas to inset the island of Anticythera (inset 1) and the islands of Sapientza and Schiza (inset 2) in the southwestern coast of the Peloponnese were selected. The inset procedure has as a result the following table.

REGIONAL SCALE	Map Area km²	Selected Area km²	Map Scale	Proposed Scale	Total Nº Insets	Quadrant Nº Insets	Nº Clusters	Proposed Insets
Main Map	103652	-	1:2445847	-	-	-	-	-
Inset 1	-	358	-	1:555874	2014	4	2	2
Inset 2	-	171	-	1:301956	7	7	1	1

Table 2: Anticythera (inset 1), Sapientza and Schiza (inset 2) inset mapping results.

In the Peloponnese map the total inset number that can be placed for the Anticythera island (inset 1) within the map is 2014 and 74 for inset 2. In contrary the proposed by software after the use of clustering algorithms are reduced in two positions for each inset in 2 and 1 for each one.

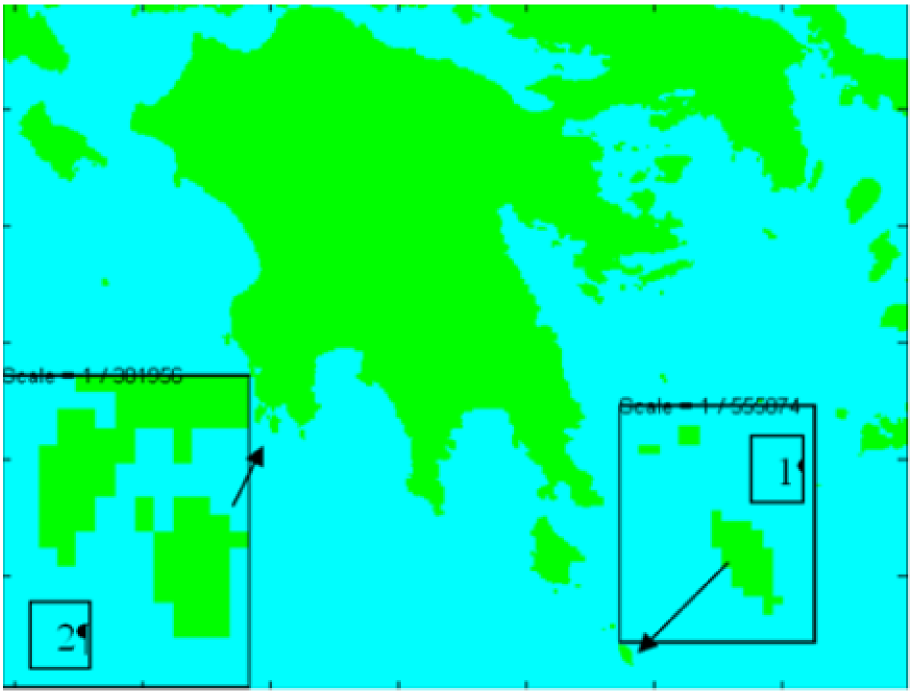

Figure 3: Peloponnese map with the two insets.

Figure 3 shows the Peloponnese map with the island of Anticythera as an inset (1) in the right corner of the map in bigger scale as so as the islands of Sapientza and Schiza (2) in the left corner.

III) Continental scale

The evaluation procedure for continental scale was realized even if the main map area (Europe) cannot be comprised as an Island area. For our insetting evaluation procedure we select the island Jan Mayden (inset 1) and the Azores group of islands (inset 2) as areas to inset. In order to establish distinctive results we use a dataset of that represents the European continent without any of the other continents that is abut on her.

CONTINENTAL SCALE	Map Area km^2	Selected Area km^2	Map Scale	Proposed Scale	Total N° Insets	Quadrant N° Insets	N° Clusters	Proposed Insets
Main Map	40023622		1:40023622					
Inset 1	-	15576	-	1:2948567	68	68	1	1
Inset 2	-	279710	-	1:11722353	21	0	1	1

Table 3: Continental scale inset mapping results.

For continental scale the total inset number for the island Jan Mayden (inset 1) are 68 when the proposed by software is 1. As for the Azores (inset 2) the number of insets is 21 when the proposed is also 1. Is obvious that the software is reducing the outnumbered insets using the clustering algorithm.

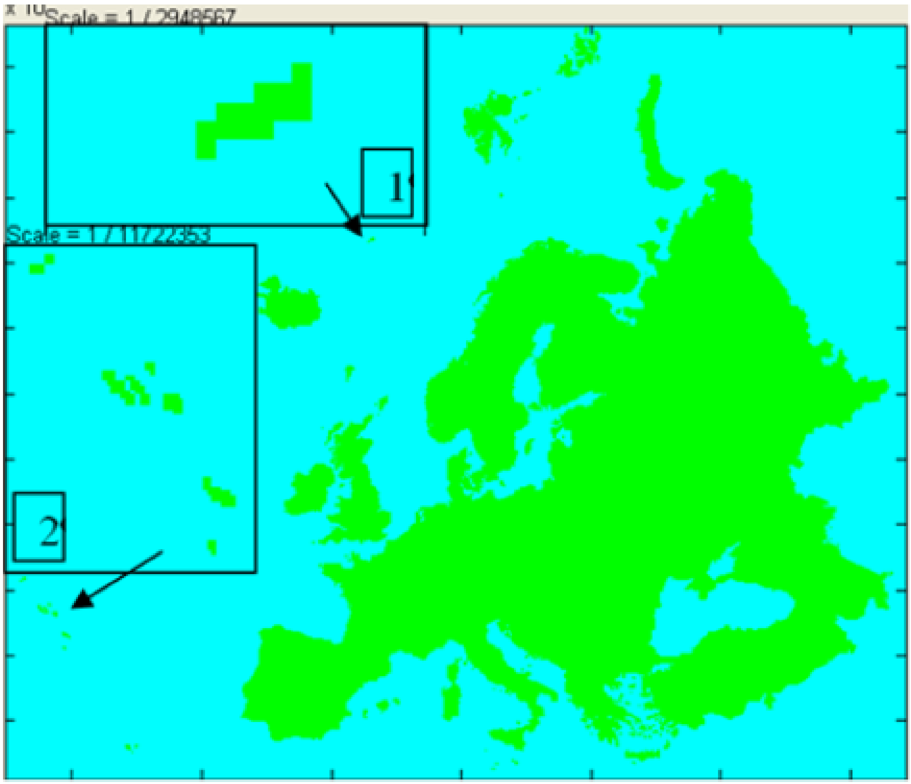

Figure 4: Continental Scale Jan Mayden island (1) and Azores (2) as insets.

From this case study we may draw some simple conclusions:

i. The proposed insets by the searching algorithm is significantly greater that the finally proposed after clustering.

ii. The numbers of proposed insets are equal with the number of clusters which varies for the most cases from one to two. This lead from the cartographer to an easiest inset selection between a very small number of inset placement positions.

4. CONCLUSIONS AND FEATURE WORK

In this paper we presented the theory and the algorithms implemented into IM software tool, which is a tool for assisting cartographers to select scales and placement positions for insets. This software tool includes cartographic rules and cluster analysis algorithms to detect scales and areas suitable for the visualization of multiple insets.

It is blending cartographic rules and cluster analysis algorithms in order to provide to the cartographers and inexperienced user an easy way to represent multiple insets within the main map. These follow cartographic rules and consist and represent an effective visualization of areas which are too small or to dense in the parent map scale. In addition the software assists users to save preprocessing time when dealing with geovisualisations that have land discontinuity problem.

Our case study covering three geographic scales local, regional and continental was presented, showing that our software can be considered a valuable tool in the field of cartography and more specific in insetting procedure.

Feature work will focus on the development of new more efficient and timeless algorithms for scale and placement selection. Also there should be an improvement of clustering algorithms with the enrichment of rules and membership grades defining each cluster group. In addition the plan for future software development includes configuration of new mapping projects developed to study areas with land discontinuity problem. As cartographic projects are using this tool the evaluation procedure comes up and new issues are revealing. Over all we will work to modify and to shape the software in order to imitate as close as possible the cartographers resourcefulness.

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