SCANNING OPTIONS AND CHOICES IN DIGITIZING HISTORIC MAPS

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ABSTRACT:

The introduction of modern digital imaging techniques in historical cartography, especially in documenting old map collections, meets the need for extending and complying image processing and relevant photogrammetric tools in the analysis of antique maps in the context that digital photogrammetry intersects the modern theories in digital treating of old maps.
In this paper we discuss some aspects in controlling the geometric features of the scanned images of antique maps in terms e.g. of linear, angular and areal deformation. Collateral effects influencing the scanned map image are also talked namely the statistics and the image quality of the output map images with respect to the original map and/or the "reference" digital best scanned image.

1. INTRODUCTION

In the modern era of mapping, photogrammetry was always interacting with cartography in the field of mapmaking. Since the first processing of aerial photographs in the framework of analog photogrammetry in the past century, maps became more precise depicting in all possible scales parts of the real world space. Modern technology using computers, digital photogrammetry (Schenk, 1999) and specialized hardware and software increased the above mentioned interaction and support the emertion of new domains of science and technology born from the intersection of already well founded fields as it is digital photogrammetry and cartography in all its folds, especially the digital one. Although historical maps are not of course based on photogrammetric information and at a first sight seems that there is no relevance at all between the two disciplines (at least for maps before the era of photogrammetric mapping), this paper will attempt to introduce a *new view and understanding* in how historical cartography and digital photogrammetry could meet and produce new products assisting the analysis and the interpretation of many hidden *mysteries* of old maps at least as far as their geometric content is concerned.

2. THE BASICS OF THE IDEA

Among the very special and particular characteristics of *old maps* one could pick the following, which are taken here in two groups for the shake of the example. The first concerns the degree of **alteration of the material** and the second the **geometric properties of the content**.
In the first group one should stress the fact that, generally speaking, old maps:

- Are indeed *sensitive* as material objects.
- They are often partially *damaged* in various ways and degrees.
- The *thickness* of the map-sheet in its different kinds is varying.
- In some cases are *not directly accessible*.
- ….

In the second group the following items can be assembled:

- The *map-scale*, usually small and loosely defined.
- The *drawing method*, the *projective properties* and the associated *map deformations*, which in most of the cases are veiled especially in the pre-scientific cartography.
- ….

All the above -and obviously some more to be identified or determined- led us to the idea that the use of photogrammetric methods and techniques are worth to be extensively tried and tested in **historical map processing**, mainly the digital counterpart, which is *a new trend* in modern cartographic culture (Livieratos and Myridis, 1999; Livieratos et al., 1999). Old maps cannot be treated just like any other hardcopy printed on paper or other relevant supporting material. Most of them are not well preserved and properly stored. This makes their *digital transformation* a not easy job since the conventional approach is not proper. In the conventional approach applied in modern map hardcopies, digitalisation is the result of a direct contact of the original with the scanning device without taking into account the overall technical specifications of the device. This is not the case for old maps due to the very concrete reasons mentioned above.
In order to face *the digital treatment of old maps* considering the particularities of the issue, the following scheme of actions could be attempted. The old map can be digitised in two modes:

- In the **traditional direct mode** (**DM**).
- In the **photogrammetry-prone indirect mode** (**IM**) involving an a-posteriori direct digression.

These two basic modes are in fact the *acquisition procedures* in order to store the **digital files of old maps** (**df**s) for the shake of their documentation and archiving but also for their further analysis and interpretation.

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3. THE ACQUISITION MODES

The **DM** is the case when the old map can be safely scanned with this mode. Depending on the size of the map, the supporting material and on the sensitivity of the drawing or printing, several types of high-resolution scanners can be used differing each time in:

- Format.
- Placement of the map and the type of the carrier motion; Mechanics of the moving sensor.
- Resolution; Sensor properties.
- Lighting type and intensity.
- Cost.
- ….

In cases **DM** is not applicable, the photogrammetry-prone indirect mode (**IM**) has to be implemented. Here, proper digital and / or analogue photo cameras can be used, **IM-dc** and/or **IM-ac** respectively, the latter requiring a further step, the a-posteriori external scanning (**IM-ac/d**).

In each mode, **df**s of the old map original are acquired using the following hardware:

- **DM**: Hard-copy scanners.
- **IM**:
  - **IM-dc**; digital cameras.
  - **IM-ac**; analogue cameras, provide film slides and film diapositives which can be then digitised using film scanners, **IM-ac/d**.

In this way, three main types of **df**s of the same old map can be generated by:

- The **DM,**
- the **IM-dc** and the
- **IM-ac/d.**

Attention should be focused on the results obtained from the use of different types of **df**s-generating scanning devices in the **DM** case, from the technical specifications of the digital and/or analogue cameras in the **IM** case and from the use of different types of **df**s-generating scanning devices in the **IM-ac/d** subcase.

4. THE INDIRECT MODE

The nature of the old map implies that in the most of the cases it is proper to use the **IM** image capturing procedure. In this case, both **IM-dc** and **IM-ac** lead to the very need of applying photogrammetric methods and techniques. The **IM-ac/d** variant introduces some additional issues related to the scanning process. Due to the state of the art in digital photography, the **IM-dc** case needs rather high cost investment and it still requires skills, which are not yet the common case in the every-day life of professional photography. In this context **IM-ac** seems to be the prosaic case and the indeed main stream in old map documentation. The generation of the relevant **df**s is an a-posteriori process associated to the **IM-ac/d**.

It is needless to say that not only the **IM** procedures but also the **DM** counterpart, introduce a variety of errors and image alterations that need to be first identified and then removed before final expert analyses are performed on the "restored" map image. A typical example is the well-known image distortions due to the inherent in any photo acquisition procedure central projection. These distortions are present in any map image derived by either **IM-dc** or **IM-ac** together with other errors, which should be removed in order to obtain an *ortho* projection of the map's image, which can be easily done using off the shelf rectification software applications.

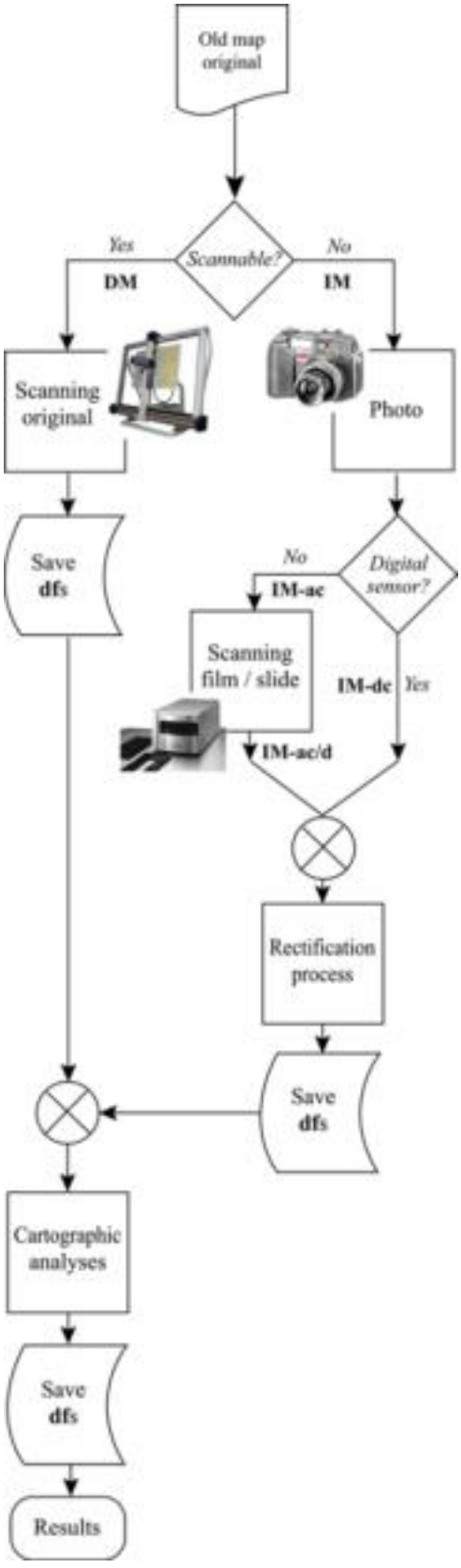

Figure 1. The proposed flowchart for old maps scanning and unified photo/carto digital processing.

5. THE PROPOSED FLOWCHART

5.1 The image acquisition

As it is already stated, the flowchart of the new proposal (Figure 1) concerns the transformation in digital form of old maps that are real artefacts parts of our "recent" cultural heritage. This type of artefacts because of their intrinsic and extrinsic properties should be treated in a careful and delicate manner. Especially the generation of their **df**s require the development of a new know-how based on concrete theory, targeting at the same time to Low Cost with Optimal Response (LCOR) management models because the worldwide possessors of old maps are not only wealthy maplibraries and prosperous individuals but also many institutions and collectors with less available resources.

A new know-how in this direction is required for the rational generation of **df**s from old map originals. Scanners that are used in **DM** to create **df**s of printed old map documents -or even worse, of manuscript old maps- may produce severe damage on them, which is an impermissible situation in our cartographic heritage documentation and management. On the other hand taking snapshots of old maps in the frame of **IM** (**IM-dc, IM-ac/d**) photogrammetric skills are a prerequisite in order to avoid misuses in reducing the map images properly.

For all the above reasons a careful implementation of a per-se scheme is necessary requiring the testing of all possible image acquisition modes concerning the transformation of old maps in **df**s.

5.2 The processing

The testing of the relevant **df**s acquired in **DM** or **IM** (**IM-dc, IM-ac/d**) is the processing step of the proposed scheme. Images of different **df**s of the same old map (or versions of it) are treated in a quantitative environment by applying a variety of comparative studies of a manifold of geometric and non-geometric (radiometric, etc.) features. The processing can be based on:

- Conventional and non-conventional *transformations* giving point-wise and areal measures of **df**s differences, for further elaborations.
- The *cartometric* analyses and the connections of the old map **df**s with modern relevant **df**s, which is the cartographic component of the overall scheme.

The latter opens a huge domain of research coupling digital image processing of old maps with modern digital cartography and allows a direct interaction between raster and vector cartographic processing.

In this processing context, it is clear that a new multidisciplinary area of research and implementation is emerging relating historical cartography with image processing, photogrammetry and cartography plus digital numerical analyses.

5.3 The LCOR concept

The final part of the new scheme proposed here, is the articulation of a *protocol* addressed to the possessors of old maps aspiring digital outlooks. The basic concern for this *protocol* is to keep a reasonable balance between a Low Cost in **df**s acquisition and relevant processing and an Optimal Response for outputs that meet the basics not only of the cartographic heritage requirements but also the interest for modern cartographic research on old maps.

6. THE CARTOGRAPHIC INSIGHTS

Research on the digital treatment of old maps and their properly derived images was one of the targets of the EC-DG X **CartoTech** project (Livieratos and Myridis, 1999, see also, e.g., Guerra et al., 1999; Boutoura, 2000; Balletti and Boutoura, 2001). In order to illustrate the proposed method some examples are given from the digital documentation of old maps. Two 300 dpi **df**s of the same old map (Laurenberg, 1656, *Collection: Holy Mt Athos Map Library by the Hellenic National Map Library*) have been obtained in two different modes:

- Applying the **DM**
- Applying the **IM-ac/d.**

The two **df**s have been conformally best fitted in order to eliminate the small rotation and scale differences without alteration of the form of the map. From the two images a detail was cropped (the island of *Limnos*). In Figure 2 the detail is shown from the **df** derived by the **DM** and in Figure 3 the counterpart from the **df** derived by the **IM-ac/d**.

Figure 2. A detail of Laurenberg's map *Insularum Archipelagi Septentrionalis,* 1665 (here the island of Limnos) derived by **DM** scanning the original.

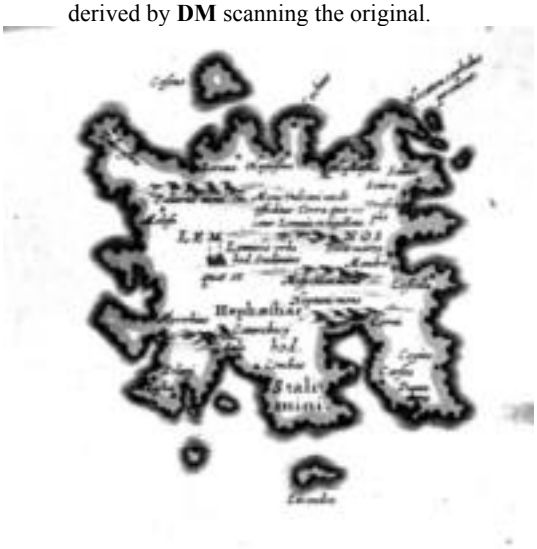

Figure 3. The same detail derived by **IM-ac/d** after a conformal best fitting to the image of Figure 2.

Now the two **df**s are ready to be compared in a one-to-one correspondence in order to depict graphically the overall statistical geometric differences due the different acquisition methods ap-

plied, the **DM** and the **IM-ac/d**. For the better visual perception of the differences, the overlay of an orthogonal equidistant grid was applied on the **IM-ac/d** map detail as in Figure 4.

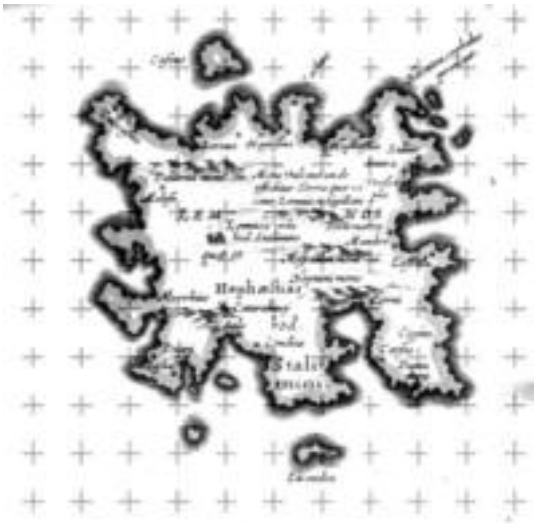

Figure 4. The grid overlay on the image of Figure 3.

Finally, the gridded **df** is now optimally fitted to the **df** as in Figure 2, applying a fifth-degree polynomial. The transformed **df** is depicted in Figure 5.

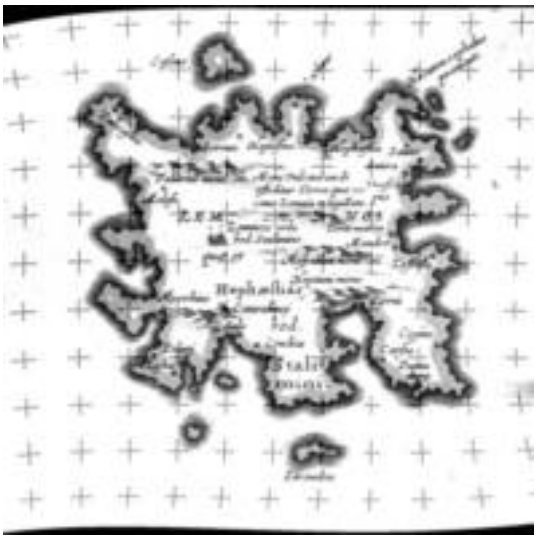

Figure 5. The best fitted **IM-ac/d** image to the **DM** initial image applying a fifth-degree polynomial.

The image in Figure 5 summarises the surface differences induced by the two modes of image acquisition the **DM** and the **IM-ac/d**. Here, all possible types of distortions due to the particular modes used are included in a *global* sense. Knowing the dimensions of the original map it is possible to compute **linear, angular and areal deformations** induced by the acquisition modes. Studying these deformations one could arrive in some indeed significant results, which will contribute in the development of the intended *protocols* concerning the LCOR concept as mentioned in the paragraph 5.3.
The real challenge here is to develop a model or the identification and the classification of the distortions.

7. CONCLUDING REMARKS

In this paper we have introduced the idea to combine digital photogrammetry and digital cartography with modern research in historical cartography. In this procedure, scanning of old maps, i.e. the acquisition of relevant **df**s, is of vital importance since the overall scheme is operating totally in digital domain.
A special flowchart has been designed for the implementation of the idea and two research by-products are formulated:

- The articulation of a *protocol* for a Low Cost with an Optimal Response digitalisation of old maps **for the introduction of cartographic heritage in the digital era**.
- The strengthening of the research on the analysis of the geometric and projective properties of old maps by using digital analyses and interpretations.

In paragraph 6 a general example illustrated the second by-product of the proposed scheme. For the shake of the example we presented the image of the global differences (Figure 5) between the **df** derived by the **DM** and the counterpart derived by the **IM-ac/d** after some reasonable initial corrections in fitting the **df**s preserving the conformality of the images (Figures 2, 3). Of course the advancement should be the meticulous analysis of the contributing distortions either by identifying the sources for this or by studying the effects in a phenomenological manner applying e.g. deformation analyses (Boutoura and Livieratos, 1986). Both cases, as well as issues related to the first by-product as stated above, are subject of on-going research.

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