EUROGRAPHICS '0x / M. Ioannides, D. Arnold, F. Niccolucci, K. Mania (Editors)

Volume 0 (*2006*), *Number 0*

A Toolbox For Movable Books Digitization

Paper 1060

Abstract

Nowadays, scanning and diffusing fac-similes are well studied and known tasks. However digitizing movable books addresses new issues. In this paper, we describe preliminary results about a software that eases the rebuilding of moving systems of such books. This tool computes, in a semi-automatic way, the reassembling of the system's texture, the detection of the system's shape, its rebuilding into a 3D object and its final texturing. Such 3D object can then be imported and animated in a 3D reading environment.

Categories and Subject Descriptors (according to ACM CCS): I.7.5 [Document and Text Processing]: Graphics recognition and interpretation, Scanning H.3.7 [Information Storage and Retrieval]: User Issues

1. Motivations and Background

The first movable books were scientific books [Hai79] in which moving parts made of paper were added in order to illustrate authors' theories. Such books are very fragile and are often damaged and weakened by time and repeated handling. They are also usually forbidden for general public because they are kept in private places where only some researchers can have access. Generally, the digitization of ancient books allows, on one hand, to increase their accessibility towards all kind of public and, on the other hand, to ensure their conservation via an un-damageable medium. The digitization of classic (i.e. flat) books is well known and allows nowadays to ensure their accessibility and their safeguarding. But this process is limited to books with usual dimensions and characteristics. The specificities of movable books make them impossible to be digitized with traditional methods.

Digitization must take into account that a page of a movable book is a volume whereas a page of a traditional book is a surface. The digitization of a three dimensional (3D) object is not a simple task [CHT04]. It is even more difficult when the object's configuration changes with time. In addition to the usual textual and graphical contents, a movable book proposes to the reader an interactive experience by the handling of the moving parts on its pages [CDT05]. Some parts of some pages are thus hidden by moving systems and require a special handling to be acquired at the digitization step.

Our aim is to obtain a virtual reconstruction of a movable book that an user can manipulate and read in a 3D environment. We use as model of book the one proposed in [CST02]. The environment is based on a 3D scene specified with a set of OpenGL functions. We identified three stages in the digitization process: the texture reconstitution, the mesh building and its texturing. These various stages will be detailed in this order in the next sections. For each, we will describe the corresponding functionalities of the application that we have developed.

2. The Digitization Step

The main problem comes from the texture occlusions. It mainly happens with rotating systems (discs, indexes). Depending on the position in which they are, the occlusion will concern a more or less wide area of systems located below. The image of these partially hidden systems cannot thus be obtained directly. We developed a tool which allows to recompose with a set of images, a single image without hidden parts. For a given system, the user must take snapshots, each of them showing a different position of the moving part (i.e. showing a previously hidden area). The idea is to obtain with this set of pictures all data needed to recompose the final picture of the system. For the various pictures, shooting conditions must be very stable in terms of lighting and framing. This last condition makes it possible to obtain better results. Fig.1 shows a set of 2 pictures. There is no limitation for the number of pictures in the starting set. The implemented algorithm uses all pictures and processes them by couple in the following way.

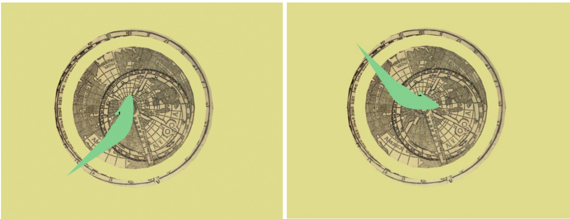

Figure 1: *The initial set of 2 pictures. The mobile part occupies two different positions*

First, the user must manually select two points (by their coordinates) on the mobile part on an image and give the corresponding points on the second image. Then the images are converted into greyscale pictures. The application will then try to identify the moving part by analysing differences between both images. In the case of a perfect point of view (no movement from one image to another), the corresponding pixels will be drawn in black. But in facts, two pictures are never taken without an even small displacement of the camera. In this case, the system has to determine the quantity of this motion, in order to compare the right corresponding pixels. Then, the homography between the two points of view is computed and is included for the computation of the mask building. We have implemented the RANSAC resolution for the homography computation [FB81]. The non black part of the result is the part where there is difference between the two images. This stage leads to the creation of a single greyscale image, in which all the non black points belong to the moving part, in one or the other of its initial positions (Fig.2).

Figure 2: *The two computed masks*

We know that the mobile part moves with a geometrical transformation. In our case, it will necessary be a rotation or a translation. It is computed by the application by using the points given previously by the user. This is the reason why only two pairs of points are enough. From the mask obtained previously, there is a set of points likely to belong to the mobile in the first image. By applying the identified transformation to this set of points, one can determine which part of the mask corresponds to the part of the system on the first image. Indeed, the points that belong to the mobile in this image will have as an image a non black point in the preceding mask. The black points or those that have a black image are ignored (Fig.2) The remaining points are replaced by those of the second picture (Fig.3).

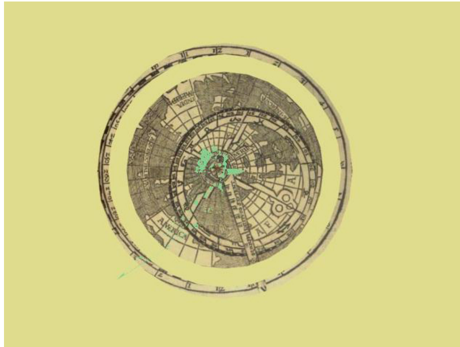

Figure 3: *The reconstructed texture for a 2 pictures initial set*

3. The Modelisation Step

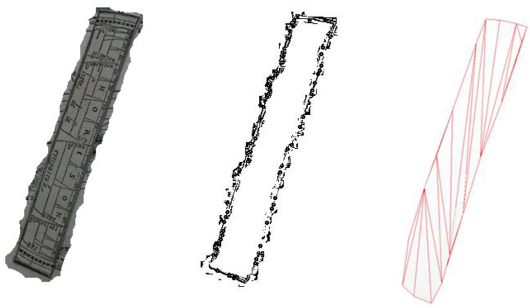

Figure 4: *The initial mobile part(a), the contour detection stage(b) and the 3D mesh(c)*

Once the image of the system recomposed, the application builds a virtual model. With our 3D book model, it is not necessary to have a thickness. For that reason, a simple 2D surface is created. In some particular cases, the simplest ones, the mobiles have basic geometrical forms (circular or rectangular). It is then easy, using a 3D modeler, to recreate the corresponding part. However, two arguments led us to develop our system. The first came from realizing that the majority of the encountered systems have very particular forms. The second came from a librarian, seen as a potential user, who couldn't imagine herself using a 3D modeler. Both motivated us to improve the automation of this process. Our software thus takes as an input the picture of the system to be modelled. It must be prepared in a image-editing software (like imaging or the gimp): the user has to coarsely erase the picture's areas which do not belong to the mobile.

Once done, the application will detect the contour of the mobile part using the Sobel method [Sob70]. It can be divided into two steps: firstly, we compute the picture gradient and secondly, we can extract the interest points by a thresholding. This spline is carried out by a genetic algorithm which gives the contour segmentation. Once this perimeter defined, we rebuild a 2D surface (i.e. the triangles inside the curve). This stage is carried out automatically thanks to Delaunay's triangulation [Che93] applied to a set of points taken from the previous contour. This stage ends with the surface texturing. We can directly make it from the input picture because we modified neither the scale, nor the positions of the points at the time of the re-creation of the shape. The textured object is shown on Fig.5.

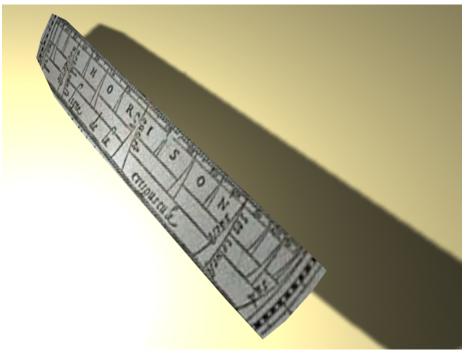

Figure 5: *The textured mesh in a 3D scene*

4. Conclusion and Future Work

We presented a system for the automation of the various stages of the digitization of a movable book system. It makes it possible to reconstitute a single image of a system starting from partial pictures of it. It rebuilds the corresponding 3D model, by performing the contour detection, the spline computation and the surface generation, based on a Delaunay triangulation. The model texturing finishes this digitization. Some aspects still need to be improved. We will optimize our texture rebuilding algorithm that can be, for the dense textured systems, more effective. We would like to exempt the user of any intervention in the process and automating at least the designation of the pairs of points on the mobile. A good start would be to look at the landmark matching algorithms developed in the computer vision domain. Lastly, the integration of this tool in a more global environment for rebuilding digital models of books is in hand.

References

[CDT05] CUBAUD P., DUPIRE J., TOPOL A.: Digitization and 3d modeling of movable books. In *JCDL '05: Proceedings of the 5th ACM/IEEE-CS joint conference on Digital libraries* (New York, NY, USA, 2005), ACM Press, pp. 244–245.

[Che93] CHEW L. P.: Guaranteed-quality mesh generation for curved surfaces. In *SCG '93: Proceedings of the ninth annual symposium on Computational geometry* (New York, NY, USA, 1993), ACM Press, pp. 274–280.

[CHT04] CUBAUD P., HAAS J.-F., TOPOL A.: Numérisation 3d de documents par photogrammétrie. In *CIFED'04: Actes du Colloque International Francophone sur l'Ecrit et le Document* (2004).

[CST02] CUBAUD P., STOKOWSKI P., TOPOL A.: Binding browsing and reading activities in a 3d digital library. In *JCDL '02: Proceedings of the 2nd ACM/IEEE-CS joint conference on Digital libraries* (New York, NY, USA, 2002), ACM Press, pp. 281–282.

[FB81] FISCHLER M. A., BOLLES R. C.: Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography. *Commun. ACM 24*, 6 (1981), 381–395.

[Hai79] HAINING P.: *Movable books, an illustrated history*. New English Library, 1979.

[Sob70] SOBEL I.: *Camera models and machine perception*. 1970.