SWOT Analysis of Method for Automatic Vectorization of Digital Photos Into 3D Model

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Abstract – Raster and vector are the two basic data structures for storing and manipulating images and graphics data on a computer. The conversion from vector to raster is easy and done automatically in seconds, but it is rather complicated to do an automatic conversion from raster to vector.

There has been extensive research efforts focused on this issue during the past decades.

This paper gives analysis of methods for creating 3D model out of digital photos, with emphasis on method of automatic vectorization and gives SWOT analysis for this method.

Keywords – Raster, rasterization, vector, vectorization.

I. INTRODUCTION

The two basic data structures for storing and manipulating images and graphics data on a computer are raster and vector. All of the major computer graphics software packages available today are primarily based on one of these two structures. They are either raster based or vector based, while they have some extended functions to support other data structures.

Raster images are presented in the form of bitmap (matrix) made from individual elements presenting the picture, where each individual element is defined by its position and color. These elements, which form the picture, are called pixels. In this case the file size is determent by the number of pixels forming the picture (resolution) and the number of bits used to define the color of each pixel. Raster data structures usually produce large file sizes.

Acquisition of raster images is easy and is done by using scanner or digital camera.

On the other hand, data structure of vector images comes in form of points and lines that are mathematically and geometrically associated. Points are stored using the coordinates in a two or three-dimensional space, and lines or curves are stored as a series of points that indicate line or curve.

In general vector data structure produce smaller file sizes then their raster equivalents.

Also topology among graphical objects is much easier to be represented using vector form instead of using raster form data structure.

Acquisition of images in vector data form is much more difficult to be done than raster image acquisition, because of its abstract data structure, topology between objects and associated attributes. Acquisition of vector data structures of images today is done by process of vectorization.

II. WHAT IS VECTORIZATION AND WHAT IS ITS USE

Vectorization basically means acquisition of vector data. Raster image acquisition, as mentioned before, is easy to perform using scanner or digital camera, but vector acquisition is much harder to be done.

Vectorization today has wide area of implementation like:
[1] Archaeology
[2] Architecture and preservation
[3] Accident reconstruction
[4] Creating digital terrain maps
[5] Film, Video, Animation
[6] Plant and mechanical engineering etc.

Because of its wide area of use there has been extensive research efforts focused on this issue during the past decades, especially automation of the process and 3D vectorization.

III. METHODS FOR VECTORIZATION

A. Manual vectorization

Manual vectorization is method that is mostly used in cases where there are limitations of quality of the taken pictures as well as in the possibilities of taking pictures from different angles. The method uses raster image as backdrop directly in the software and the line tracing is done manually by the operator. During the manual tracing there is great flexibility in the process, and different kind of adjustments can be implemented and realized.

The workflow of this method includes:
[1] Photographs acquisition
[2] Line tracing
[3] Creating the 3D model
[4] Texturing the surfaces

This method produces good quality vector model as well as good precision and accuracy, but it requires well skilled operator and most often can be very time consuming.

B. Semi-automatic vectorization

This is more powerful vectorization method, which requires pictures of higher quality. The whole idea of the process is to replace rather boring and very time consuming manual line tracing. In this case the actual tracing is done automatically,

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by the software that uses complex algorithms for line tracing, shape recognition, topology creation and attribute assignment.

After automated line tracing, the workflow is similar to the manual vectorization. The 3D model must be generated manually on the basis of traced images from different sides of the object; by extruding, revolving, sweeping, etc. traced 2D vector images.

This semi-automatic method produces 3D model with greater precision and is less time consuming than manual vectorization, but requires images of greater quality.

C. Automatic vectorization

Automatic vectorization is an efficient and effective method for modeling real world objects. 3DSOM's patented technology for model generation and sophisticated texturing technology allows 3D model to be created quickly and inexpensively while requiring low level of technical skill or expensive hardware platforms.

The workflow of this method is rather different from the previous methods. It requires larger amount of pictures (about 20) to be taken from different angels. The amount of photographs needed to create the 3D model is around 15 taken from lower angle and 3-7 taken from higher angle of horizontal centerline of the object, as well as some pictures from top and bottom perspective if needed. The quality of the photographs is the key element of this method so the photo session needs great deal of attention.

Fig.1 Laboratory for photo session

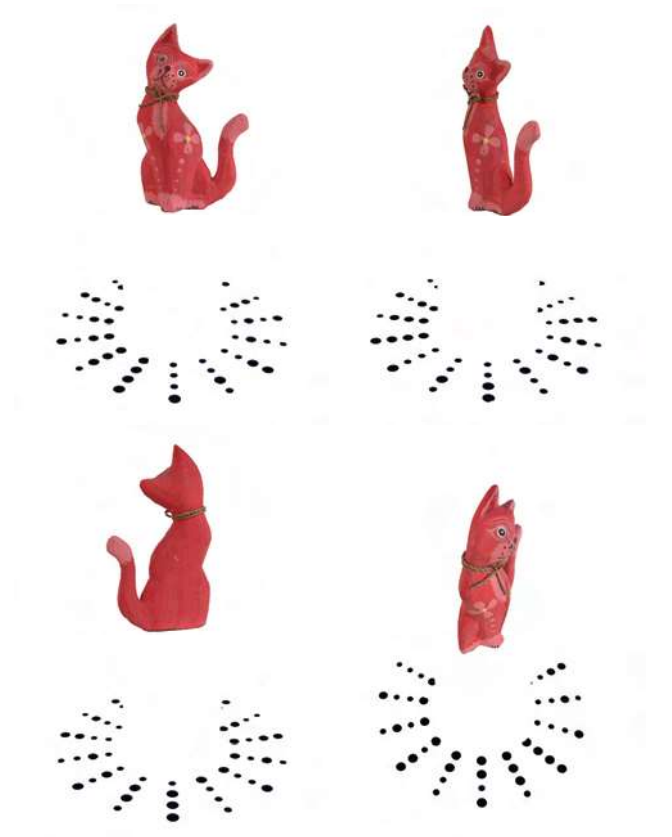Fig.2 Position of the model for photo session

Fig. 3 Some of the total 19 taken pictures for vectorization of this model (toy – cat)

After the pictures are imported in the software the next step is automatic masking of the images what means cutting of the background. A mask is created to identify the outline or silhouette of the object, as seen from the camera's point of view.
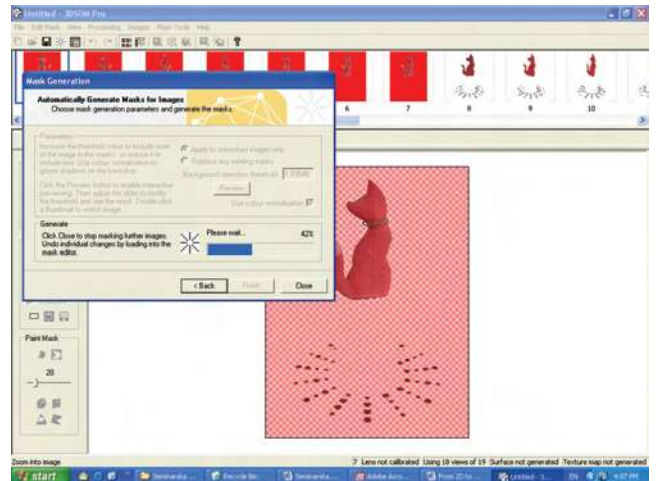

Fig. 4 Process of masking of imported pictures

The "Generate Wireframe" process that constructs the 3D model can be represented as a sculptor taking a block of clay and projecting each image mask onto it from the viewpoint of the camera. Wherever the projected mask appears on the clay, the clay is sliced away until the model's silhouette matches

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the masked silhouette obtained from the object's photo taken from that perspective.
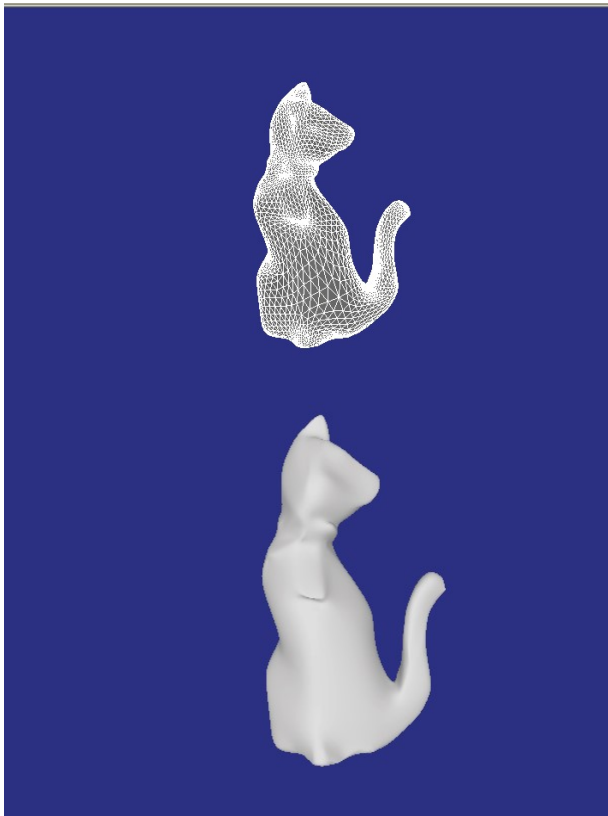

Fig. 5 Look of the model after applying techniques Generate Wireframe and Mesh Optimization

Mesh optimization and texturing are also done automatically in matter of seconds what puts this method ahead of previous two methods.
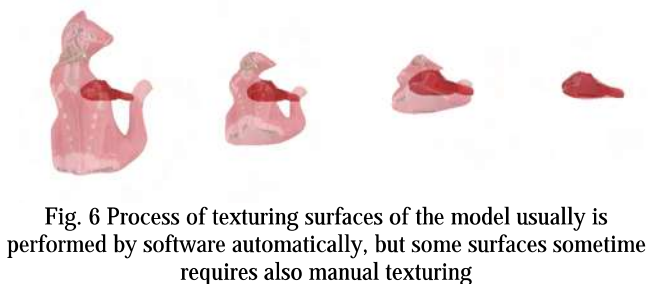

Fig. 6 Process of texturing surfaces of the model usually is performed by software automatically, but some surfaces sometime requires also manual texturing
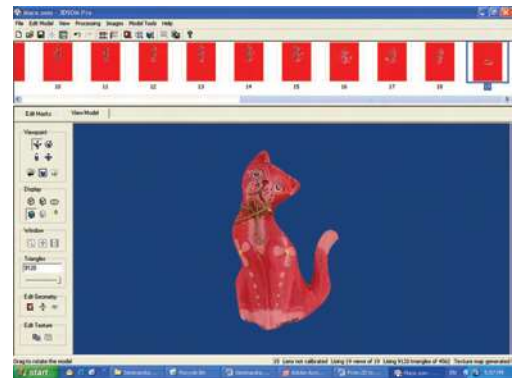

Fig.7 Final look of the 3D vector model after applying technique of texturing its surfaces

The limitations of this method are consisted in following: it can be used only for small size objects and it is complicated to vectorize transparent objects or objects with large holes like coffee cup.

IV. SWOT ANALYSIS

Table I – SWOT analysis of manual vectorization

Strengths	Weaknesses
- Good quality of the created 3D model - Line tracing flexibility - Greater control of the operator	- Very time consuming - Medium level of accuracy and precision
Opportunities	Threats
- 3D model construction from low quality pictures - Unavailability of multiple photos from different angles	- Automation of the process of vectorization - Complexity of the object being vectorized - Operators skills

Table II – SWOT analysis of semi-automatic vectorization

Strengths	Weaknesses
- Greater precision of the created model - Time consumption	- Requires photos of greater quality
Opportunities	Threats
- Small amount of photos but	- Automation of the process - Unavailability of photos from different angles - Manual optimization and texturing

Table III – SWOT analysis of automatic vectorization

Strengths	Weaknesses
- Great precision of the 3D model created - Exceptionally low time consuming - Low requirements regarding of operator skills	- Requirement of greater number of high quality pictures - Large objects - Transparent objects and objects with larger holes (eg. coffee cup)
Opportunities	Threats
- Creating a model of complex real world objects	- Unavailability of photos from different angles

V. CONCLUSION

From this analysis can be concluded that for vectorization of larger objects and objects that can not be easily photographed more convenient are the first two methods, but for smaller objects the more appropriate choice is the automatic vectorization which can be used mostly in the fields of preservation of historical and cultural heritage, as well as for 3D representation of real objects in animation industry.

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