Third Central European Multimedia and Virtual Reality Conference

Eger, Hungary
6-8 November 2006

Pannonian University Press

PEK

Central European Multimedia and Virtual Reality Conference (2006)
C. Sik Lányi (Editor)

The flying Seahorse Project – How to build a digital entity for visual effects

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Abstract

A well known application of VR is a computer animated film, but also computer animated parts of a feature film. Mythical creatures, who comes to life with computer animation in films like „Herr der Diebe" you can not design with a CAD-system. The designer is an artist, aesthetics is very important for him. In producing the model he wants to be in physical interaction, his way is to produce a sculpture or to carve it. The created work of art is digitized with a 3D-scanner. Every 3D-scan gives us a range image in an own object coordinate system. There is to compute series of points of about one million points from one scan. The point coordinates have to compute in a common coordinate system. Efficient and robust algorithms are necessary, to come quickly to a valid triangle mesh describing the surface in high quality. This computer model is like a digital double and can be used in computer software to animate it and to produce visual effects. We will show this way considering as example the seahorse from "Herr der Diebe".

Categories and Subject Descriptors (according to ACM CCS) I.4.5 [Image Processing and Computer Vision]: Surface Reconstruction

1. The Idea

First you start with the scenario. To illustrate the sequence of events you needs both: painted graphic and computer graphic. A story board (Figure 1) suggests actions and spirits.

Figure 1: *Story Board*

Animatics (Figure 2) are the „keys" for the „visual effects", the computer generated parts of a film.

We will show the way to produce the computer model. The designer feels like an artist, he doesn't like to use a computer to design the figure. Lightpen, computer mouse and keyboard are inapplicable tools, he likes to interact intuitively with a physical exemplar, see also [GrHa06]. So the first step is a model of clay (Figure 3).

Figure 2: *Animatics*

Figure 3: *Model of clay*

Next step is a model of wood in full-scale.

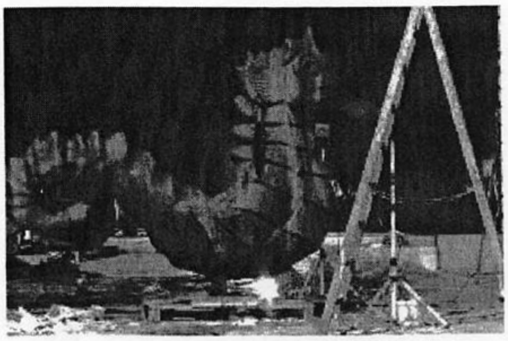


Figure 4: *Model of wood*

The computer model is generated from the model of clay. Both - the model of wood and the computer model – will be actors in the film. They have to be indistinguishable. You can say, the computer model is the "digital double".

2. From physical model to points – 3D scan

The model of clay is scanned with a 3D-scanner. There are different methods to come to a range image.
Picture 5 shows the used technique with camera and projector.

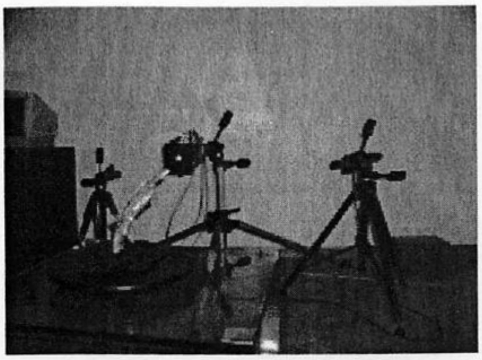
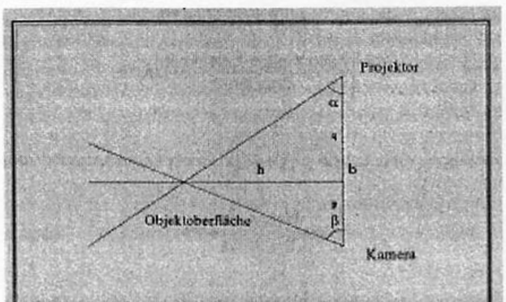


Figure 5: *3D Scan – technique*



If you know α, β, b you can compute

$$h = b\frac{\tan\alpha + \tan\beta}{\tan\alpha \cdot \tan\beta}$$

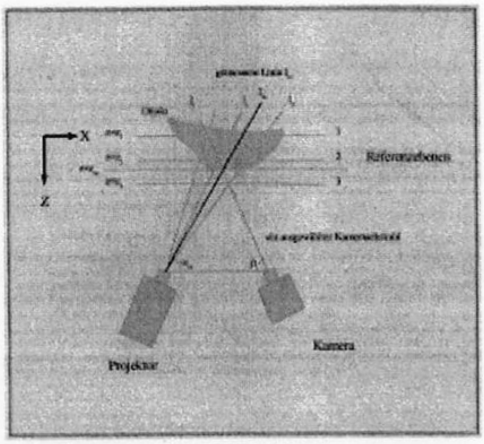


Figure 6: *3D scan – measuring method*

The result of a 3D scan is a range image (Figure 7). In a range image a pixel is connected with a 3D point measured on the surface of the 3D object. But there is no 1-1 correspondence from pixel to point!

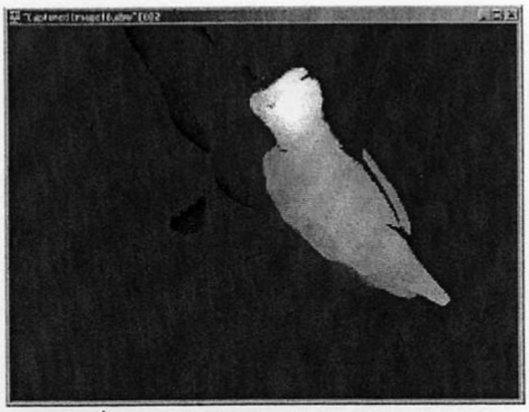


Figure 7: *Range image*

First step is **Preprocessing.** In this step the points of background are removed, background pixels are pixels without correspondence.

You need more than one range image to describe the complete surface.

Every range image has an own object coordinate system. The step to compute coordinates in a common coordinate system is called **Registration.** The result is a point cloud of 3D points.

3. From point cloud to surface

The points are not the model we need for visualization or animation. Therefore we have to compute a triangle mesh. A valid triangle mesh are series of knots, connected to triangles. The surface has to be an oriented manifold without self intersections, see [HD*92], [Hop94],[LoCl87].

Figure 8: *Point cloud – part of the object*

The process to generate the representation of the surface – the triangle mesh – is the **Integration.** This step is the most important step. After this step **Post processing** follows. In this step the net will be optimized [SZL92].

There are a lot of integration methods, they are heuristic ones. There important parameters are computing time, memory, how to deal with measuring inaccuracy, possibility to take into account additional range images, robustness, accuracy, restrictions of topology or ability to close holes.

At first we show some effects which appear. Picture 9 shows the triangle mesh of one part. There are false triangles, so called spikes. They have to remove before connecting the parts.

Figure 9: *Triangle mesh with spikes*

Figure 10: *Triangle mesh after removing the spikes*

Another problem is overlapping of meshes. You have to merge the parts mesh 1 and mesh 2 to create a new valid mesh.

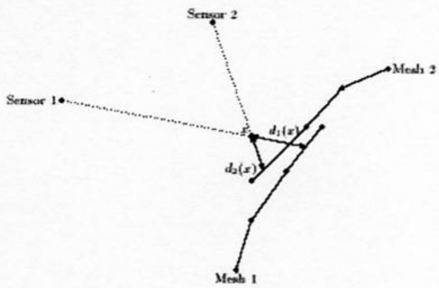


Figure 11: *Overlapping meshes from different scans*

This technique is called **Mesh Zippering** (Picture 12), see [TuLe94]

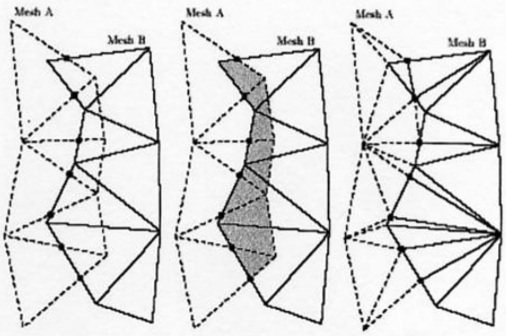


Figure 12: *Mesh Zippering*

The used algorithm in the vimotion software to create a triangle mesh is done with view to the method of Neumann [Neu01]. This is a special marching Cube – algorithm.

The steps are:

- From the range images a real function is defined. This distance function computes for every point near the surface the distance point-surface.

  This function is defined with help of all range images with use of weighting functions:

  $I_k, 1 \le k \le n$ ...range image nr. k, n...number of scans

  $d_k : IR^3 \to IR$, distance function nr. k

  $w_k : IR^3 \to IR^+$, weighting function nr. k

  $$d(x) \quad = \quad \frac{\sum_{k=1}^{n} w_k(x) \cdot d_k(x)}{\sum_{k=1}^{n} w_k(x)}$$

  ... distance function, x...3D point

- Sample this function at a regular grid. You will get a discrete distance function in a voxel model.
- Compute the triangle mesh. This mesh will generated from all zero points of the distance function. This is done with the marching cubes-algorithm.

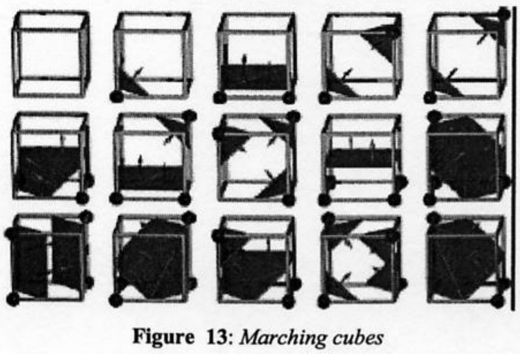


Figure 13: *Marching cubes*

- The last step is to optimize the net. Picture 14 shows this optimized model.

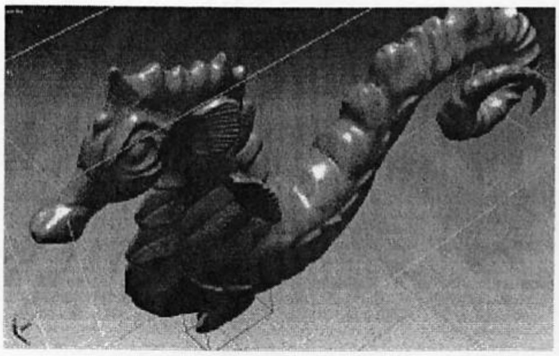


Figure 14 : *Computer model*

With the marching cube method we get the "pure" surface, we also have to generate the attributes. This is done with textures taken from the real model of wood.

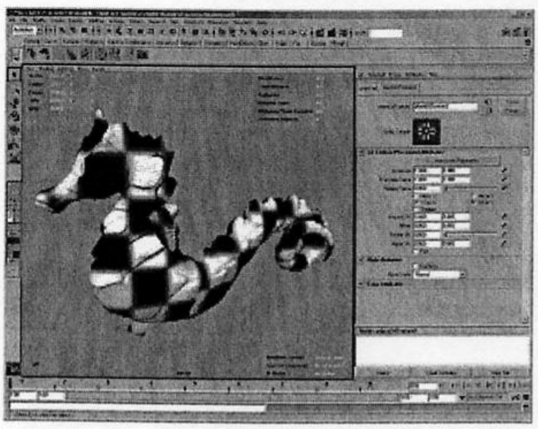


Figure 15: *The texture coordinate system*

Figure 16: *Projection of a texture*

This seahorse is living in a virtual world. It is a double for the wood-seahorse (the real actor) acting in scenes with special effects. You can see it in a scene flying through time and space.

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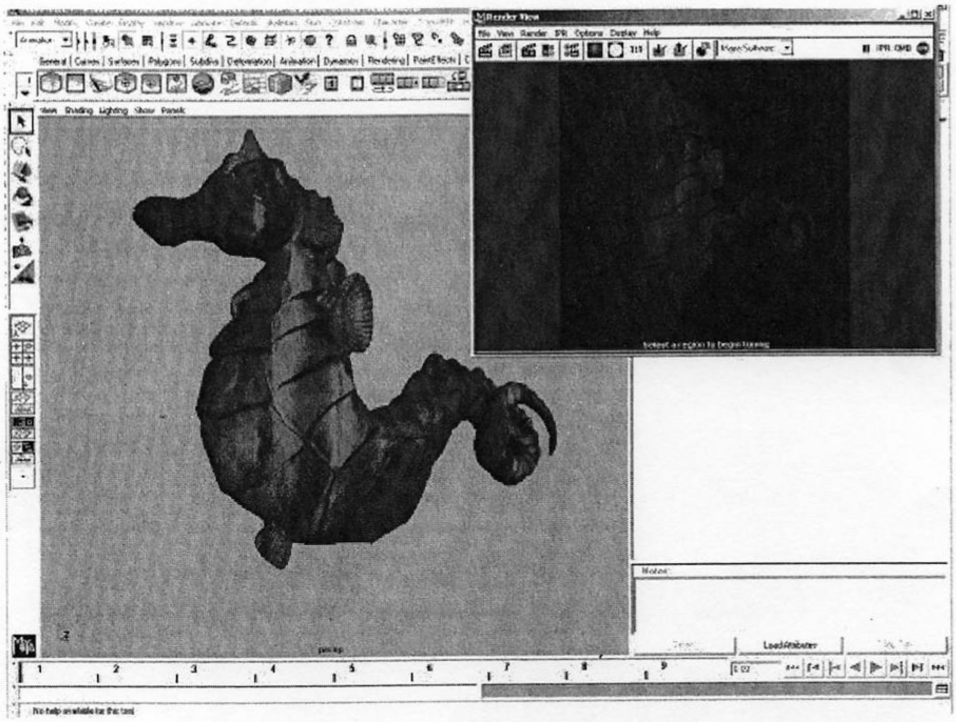

Figure 17: *Seahorse model as „Digital Entity"*