Making of Weihnachtkarte 2009

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1. Introduction

The Institute of Computer Graphics and Algorithms of the Vienna University of Technology (VUT) produces every year a Christmas card. Copies of this card are sent to former employees and friends of the institute. The design of the Christmas card is on behold of a current employee and always deals with a topic in computer graphics. This year the Christmas card shows a scene that is made up of laser scanned objects. The objects are intentionally not rendered in the best possible quality, but show the geometric primitives they are made of. The models were ad hoc scanned for the Christmas card, as no suitable models were available.

Generating the models required a suitable laser scanning device. The device should be capable of scanning complex geometry in a reasonable time frame. The intention was to use existing technology, not only for the scanning process, but also for the post-processing of the resulting data. Searching for a suitable laser scanning device led to a small survey of available laser scanners at the VUT. To the knowledge of the author there are currently 4 laser scanning devices at different institutes at the VUT. The available laser scanning devices are the following:

- Metris MCA 3600 M7 Portable Coordinate measuring Arm (Institute of Art and Design[2]). This is an articulated laser scanning arm. The mounted laser scanning head uses a triangulation based scanning technique. The measurement precision is beyond 1 mm. Since the position of the mounted laser scanning head is always known during scanning, no registration of the scanned points is necessary when several measurements of one object are taken.
- Minolta VIVID 900 with Rotary Stage Isle RF1 (Institute of Geometric Modeling and Industrial Geometry). This is a triangulation based scanner combined with a rotary stage. The measurement precision is beyond 1 mm. Scanning of complex geometry is a bit more involved than with the scanning arm, because the single scans have to be registered afterwards. This can become tedious when many scan positions are required to completely cover an object.
- Riegl LMS Z420i (Department of Spatial Development, Infrastructure, Environmental Planning). This Time-of-Flight (ToF) scanner is capable of scanning objects as far as 1 km away. The resolution of this device in the distance measurement is ± 1 cm. While the resolution is sufficient when scanning buildings or other large structures, it is not quite enough for objects that have a size in the decimeter range.
- Zoller + Fröhlich IMAGER 5006i (Institute of Photogrammetry and Remote Sensing). This is a phase-based laser scanner, giving sub-millimeter precision in the distance measurement at small distances. The measurement distance goes up to some 80 m.

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The scanning resolution would be sufficient, but here also the registration of single scans of an object becomes tedious.

For the purpose of the Christmas card the Metris articulated laser scanning arm was chosen, as the measurement precision is adequate for the size of the models to be scanned, and the registration of single scans is not necessary.

2. Models

For the Christmas card 3 objects were chosen that should be scanned (see Figure 1). The objects are of increased difficulty to scan (from left to right).

The first object, a cylindrical Santa Claus, is a 31.5 cm tall figure made of unglazed ceramic, and colored by a diffuse paint. The geometry is quite easy to scan, except for the areas beyond the mustache and the gloves. Otherwise there are no difficulties to expect. The color is also easy to capture for a laser scanner, as the reflections are somewhat uniform. The surface reflection properties differ at the white beard and the dark gloves compared to the other areas, but overall the reflection properties are well behaved.

Figure 1 The three scanned models. From left to right they are a cylindrical Santa Claus made from unglazed ceramic, a small house also made from unglazed ceramic, and a deer („Bambi") made from Styropor with colored straw applied to it.

The second object, a small house with a height of 21 cm and standing on snow with a Santa Claus and a conifer in front of it, is also made from unglazed ceramic. The paint is somewhat more specular, especially the white paint. This means that the model cannot be scanned with just one intensity of the laser scanners beam, but the intensity has to be adjusted depending on the scanned area. The geometry of the object is also somewhat more complicated, as the roof has small cracks in it and it is also standing off the wall. This means that this ledge has to be scanned from the top and from underneath.

The third object is a young deer made from Styropor with a height of 51 cm. It is the most difficult object to scan as it has a rough surface due to the straw applied to it on the surface. It has highly reflective areas around the white snout and inside the ears, and very dark areas at the hooves, so it cannot be scanned with one laser intensity. It has tinsel applied to the straw, which gives it a sparkling effect, but also makes scanning even more challenging.

3. Scanning Process

The scanning took place at the laboratory of the Institute of Art and Design where the scanner is standing. The 3600 mm long articulated arm of the laser scanner allows for scanning objects up to the size of the Bambi. The objects are placed on a table at some distance to the scanner, so that the operator can move around the table. There is still enough space between the table and the scanner, so that the operator is not hindered by the scanner (see Figure 2). The scanner is attached to a laptop that runs the software for displaying the models and controlling the scanners operation (see Figure 3). The laptop is equipped with 4 GB of main memory.

Figure 2 The setup of the scanning arm at the laboratory of the Institute of Art and Design at the VUT.

After calibrating the scanner by a standard procedure, at first the Santa Claus was scanned to test the capabilities of the scanner. The scanning head has to be moved by the operator at a distance of about 5 – 10 cm from the object to get a valid distance measurement. The result can be directly viewed on the laptop attached to the scanner. This makes identification of areas where more scans are needed easy. The model was easy to scan, no change of the laser beam intensity was necessary and almost the whole geometry has been captured. One problem arose at the end of the scanning process when some refinement scans should be taken. At this time already some 16 million points had been scanned. The attached laptop gave an error that not enough memory could be reserved, so 16 million points seem to be maximum number of points for a single scanning procedure.

Figure 3 The laptop with the raw point cloud after scanning and the scanned model aside of it.

When scanning the house the laser beam had to be adjusted to a low intensity for the white areas and to a high intensity for the black boots and the brown roof. At the back of the house is an opening (to place a candle into the house) and inside this opening it was not possible to capture the whole geometry. During scanning the model was shifted about 0.5 cm due to some kind of accident. This shift is visible in the resulting point cloud as some points do not fit to the surface. Most of the points are on the correct positions. Scanning was stopped when 16 million points were reached.

The Bambi was scanned to get an idea how the laser scanner behaves when an object with a rough and shiny surface is scanned. During scanning the intensity of the laser beam again had to be adjusted. Once for the white, highly reflective areas, once for the black hooves, and once for the rest of the surface. The scanning went quite well and the resulting point cloud is still recognizable as a deer. The physical size of the Bambi is quite on the limit of what the laser scanning arm can cope with, as during scanning the joints of the scanning arm were often moved as far as they would go. The Bambi consist of some 13 million points.

4. Results

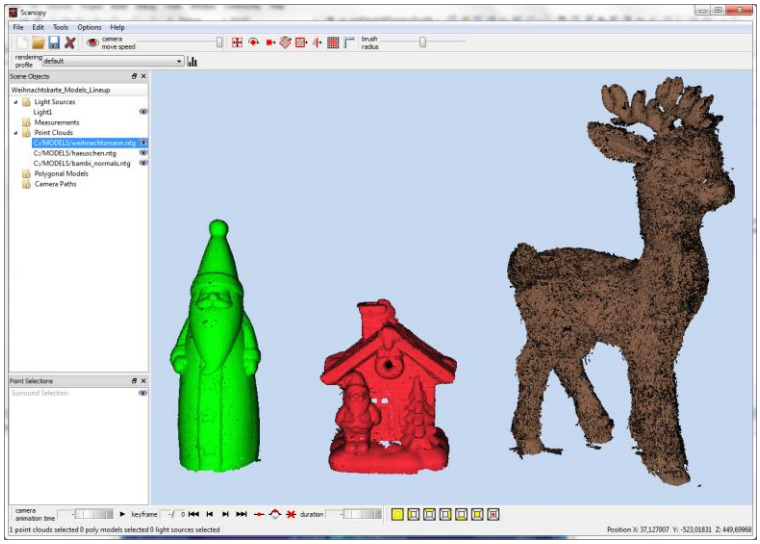

Figure 4 The resulting 3 point-based model lined up in Scanopy. The colorization of the point clouds was done after scanning and is arbitrarily chosen.

Figure 4 shows the resulting point-based models lined up in Scanopy. The total number of points for all 3 models combined is 45458793. The normals for the models were calculated on the fly by the scanner software. Even the Bambi model has some valid normals, as it is shaded in some areas when a light source is moved in front of it.

The scanning alone took 5 hours. Together with the preparation time and the post-processing time of the models the making of the Christmas card took about 5 working days.

Merry Christmas 2009 and a Happy New Year 2010!