DeMaMech Exchange Program 2006

A Student's Report by Konstantin Priesnitz

Personal Data

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Home University
Name: Technische Universität Berlin
Faculty: Mechanical Engineering and Transport Systems
Supervisor: Prof. Dr. Blessing

Host University
Name: University of Tokyo
Institute: Research Center for Advanced Science and Technology
Laboratory: Fine Digital Engineering
Supervisor: Prof. Dr. Suzuki

Flight Schedule

Towards Japan

April 5, 2006	Berlin – London
April 5/6, 2006	London – Tokyo

Towards Germany

September 19, 2006	Tokyo – London
September 19, 2006	London – Berlin

Executive Summary

I started thinking about studying abroad right after my undergraduate study. In 2005 I began to gather information about exchange programs offered at my home university. The DeMaMech Exchange Program interested me the most. It provides the opportunity not only to study abroad but also to live in a country with totally different cultural roots. I applied and was happy to be accepted at Professor Suzuki's laboratory of "Fine Digital Engineering" at the University of Tokyo.
In August 2005 I participated in the DeMaMech workshop at my home university in Berlin. We heard lectures about Japanese culture and history and got an intensive course in Japanese language. Those two weeks were a good chance to get in contact to the other exchange students and to become prepared for the upcoming journey.

In the beginning of 2006 Professor Suzuki arranged my accommodation in the Komaba International Lodge. Therefore I could concentrate on other paperwork. Sincere thanks to him.
The first weeks in Japan were both exciting and exhausting. A lot of formalities had to be done, many orientation meetings had to be visited. The jet lag and the humid climate made their contribution to tiredness. Nevertheless, curiosity for meeting my lab members and other exchange students and for the Japanese culture saved me from overcoming fatigue.

I first had to become acquainted to "lab life" in Japan. But all my lab members were welcoming and friendly. They patiently forgave me my lack of knowledge about Japanese behavioural rules in the beginning and helped me out when I asked for support.

My research topic was new terrain for me. I spent quite a period of time on studying fundamentals like basic image analysis, the CT scanning process and standard data structures in computer vision. Challenging was also the programming. Each algorithm had to be tested carefully for storage and runtime efficiency since even test files were huge amounts of data.

In the beginning of the term I attended a Japanese language class. That appeared to be really helpful. The teacher was a native Japanese speaker but was also able to describe all details in very good English. In the end, my time consuming research project forced me to give this class up. That is why my Japanese is still low-level. A fact I regret now, but there is no reasonable chance to learn speaking Japanese fluently in five months anyway.

In September 2006 I left Japan. I had learnt a lot about a new culture, about myself and about computer science.

Research Summary

Introduction

At the laboratory "Fine Digital Engineering" research is conducted into the field of reverse engineering using industrial x-ray CT (Computed Tomography) scanners.
Most of a product's designing process is done by using digital engineering systems like CAD (Computer Aided Design). Since the real physical object differs from its virtual model, it is important to receive information about the product's behaviour in reality. This feedback can be obtained by using modern scanning technologies such as x-ray CT scanners.
Besides the advantages of a CT scan like being non-destructive, the acquired data has to be transformed in order to allow a comparison to a CAD-model.

Contents

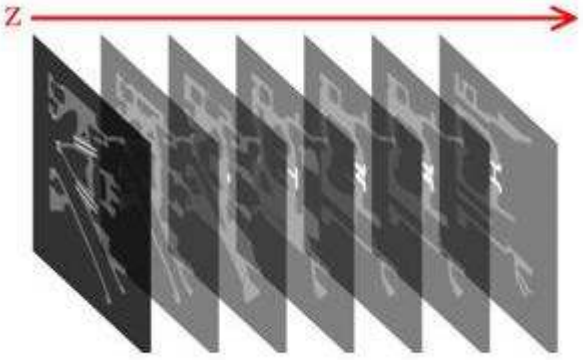

Figure 1: Constructing a volumetric image

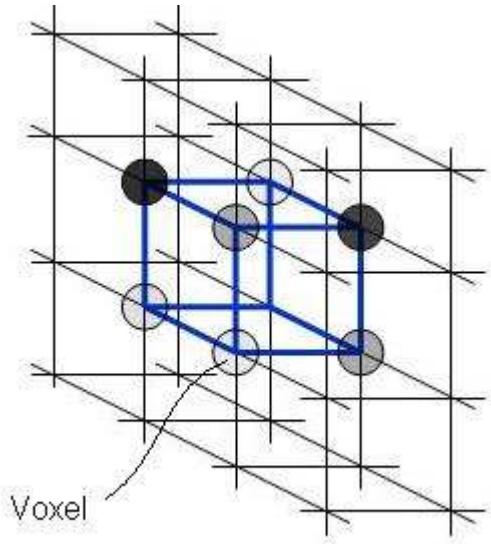

Figure 2: Volumetric model

A CT scan provides a two-dimensional image of a cross section of an object. This picture consists of picture elements or pixels in short. The grey value of a pixel represents the density of the object. Performing the scan on several parallel planes a volumetric image of the object can be reconstructed (see figure 1). One may think of a volumetric image as a three-dimensional orthogonal grid where each grid vertex is associated with a grey level value which represents the density of the object in this point. These vertices are also called volume elements or voxels in short. Figure 2 illustrates this idea.

Figure 3: From a CT system to a CAD system

Such a volumetric model is not ready for being integrated in a CAD system. As shown in figure 3, the next step to a CAD model is to create a surface mesh model. In general, with the "Marching Cubes Algorithm" we are able to separate an object from its background by generating a triangular mesh which defines the border of the object.

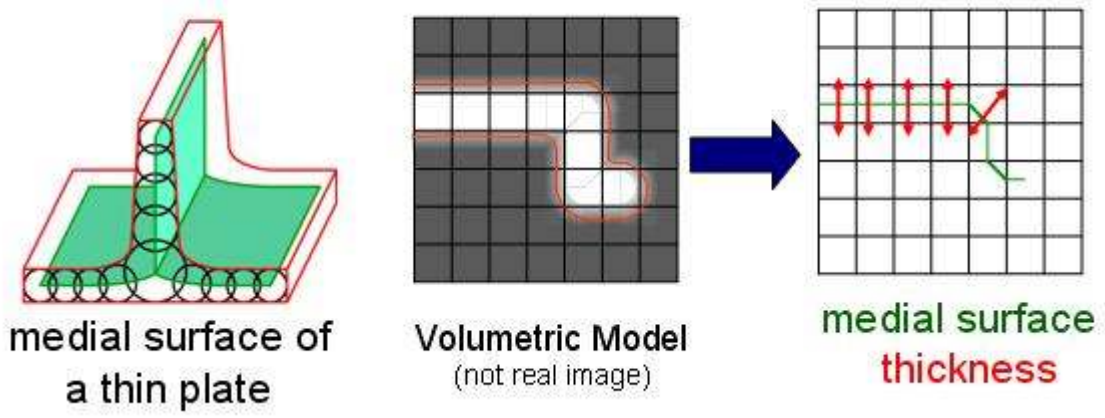

Figure 4: Extraction of a medial surface

Unfortunately, when designing thin plate structures, as car body shells for example, in CAD systems their shape is represented by surface models associated with their thickness values, i.e. such models do not have a volume.
Therefore, a so called medial surface has to be extracted from previous models. The idea of this method is shown in figure 4.
Today's algorithms do not work satisfyingly in this case. If you define a medial surface point as a point having the same distance to two or more different borders of the object then the output image will have branches where no branches are (see figure 5).

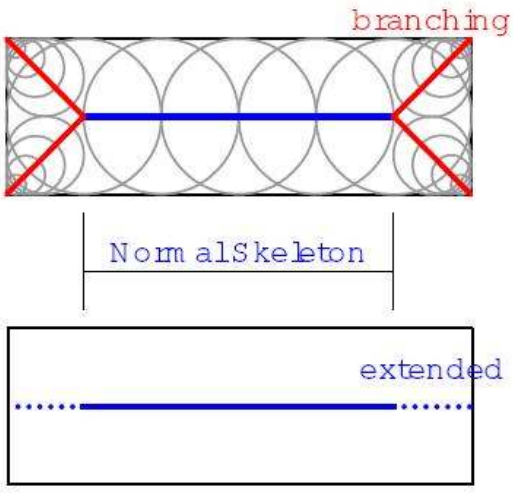

Figure 5: Problems in medial surface extraction

If you define a the medial surface point as a point which has the maximum distance to the border of the object then you will receive the blue line shown in figure 5. This leads to a shrinking of the object at edges.

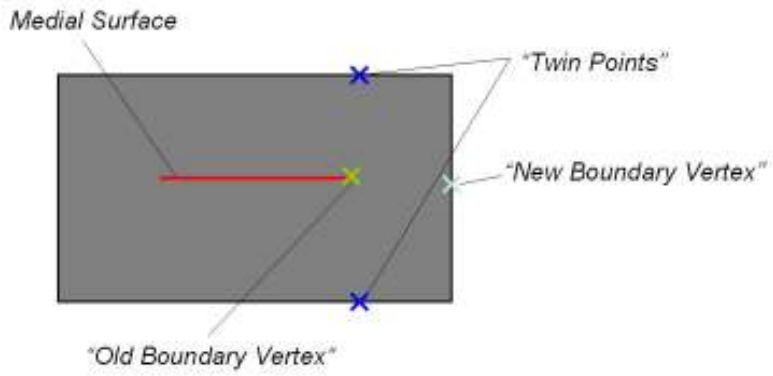

Figure 6: "Twin points" used to receive "new boundary vertices"

I worked on the development of an improved method to provide extended medial surfaces accurate for use in CAD systems.
To validate and test my methods I implemented a software prototype that executes the new algorithm. It is based on the established data structure “winged edge” and written in Java. Since a visual quality check is essential this package uses the Java3D engine for viewing the three-dimensional objects.
The basic idea of my approach is to use the boundary vertices of the shortened medial surface to calculate new boundary vertices. Then, the old and new boundary vertices can be used to create the extension part of the medial surface. There are algorithms which are capable of creating a triangulated mesh from those boundary vertices. I developed criteria to define “twin points” as I call them (see figure 6). Obtaining new boundary vertices from those twin points appeared to be challenging. The plan was to define the new boundary vertex by the middle of the shortest path between the according two twin points. A simple shortest path algorithm does not work sufficiently since it is dependent on the structure of edges and vertices of the solid boundary surface. I therefore implemented a routine which crosses facets (polygons) in order the find the shortest path. This led to better results. Nevertheless, there are still problems which often occur in standard objects. The edges of T-junctions for instance caused much trouble. For those special cases future work has to be done.

Exchange Student Life

Having a room in the Komaba International Lodge was a piece of luck to me. It took me two minutes to my lab. So I did not have to spend money frequently for metro tickets. If I forgot my purse or my laptop in my room I could quickly go home and get it. Even after a long night in the lab I did not have to care about how to come home (or to think about staying in the lab over night).
The room I lived in was quite small. I had my own folding bed, my own folding desk and even my own folding bathroom (the basin could be folded over the toilet). A washing machine was on the floor. Since I did not spend much time in my room it was absolutely sufficient.
The common room was a meeting spot especially during the Soccer World Cup 2006. Sometimes when I came home from lab late at night I saw a crowd of students sitting in front of the TV and cheering for their teams. Since plenty of nationalities were present in the dorm that was not something of a rarity.
In the dormitory I also got acquainted with many other foreign students. There were always barbecues or birthday parties where you met your friends or made new contacts. It was a lot of fun to hang around with guys from all over the world.

My lab members were quite reserved. Their English was a bit limited. So they were afraid of starting talking to me. Nevertheless there were some nights when we went out for a drink and karaoke. After some glasses of beer they realized that even there worst karaoke singing could not be as bad as what those foreign guys performed. In the end they became more and more open had as much fun as I had.

Going out in Tokyo normally started in an izakaya, a place where you can enjoy delicious Japanese food at a cup of sake. Afterwards clubs or karaoke bars were the places to go. This could last all night long. Fortunately, the lodge was on walking distance from Shibuya metro station, one of the centers of night life in Tokyo. That saved us several times from the overfilled last/first trains at the evening or in the morning or for expensive taxi rides.

The work in my lab was quite time consuming. Therefore I did not have much time for travelling around in Japan. I visited Fuji-san and did sightseeing in Kamakura and other places in and around Tokyo with some friends.
All in all, life as an exchange student at the University of Tokyo was an exciting and enjoyable experience to me. I can only recommend the DeMaMech exchange program warmly to all students who think about studying abroad.

Summary

Five months in a foreign country like Japan is not enough to become acquainted with each facet of life there. Although I learnt new things about the Japanese way of life almost every day, there is so much more to explore and so much more to see. Of course, not all aspects were positive (I enjoyed watching the sun rise on Mount Fuji as much as I suffered while climbing the mountain). But all in all, I will keep Japan in mind as a fantastic part of my life, an experience I would not want to miss.