APPLICATION OF 3D VISUALISATION IN INDUSTRY

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1. SUMMARY

We have examined and used different 3D visualization techniques for the representation of some industrial activities, like Incremental Sheet Forming (ISF) and solving the Rubik's Cube with an industrial robot, as well as for interactive visualizations of sophisticated products of the furniture industry.

2. INTRODUCTION

Based on the rapid development of the graphical modeling tools, accurate modeling of complex systems became feasible. More advanced models require more sophisticated rendering techniques, as well. Three-dimensional visualization can supply the most realistic feeling in virtual environments. As a consequence of the advanced 3D technology considering both input and output devices, there is higher need for creating 3D models.

More and more powerful personal computers, graphic cards, and software tools make spatial representation of 3D models possible. Using the information highway for accessing those three-dimensional services, we can create state of the art applications on the web. We can directly use 3D tools via the Internet, and we can publish our results on three-dimensional web pages, too.

3. THREE-DIMENSIONAL VISUALISATION

Three-dimensional visualisation today is available not for special devices only, but for TV sets, for desktop and notebook computers, too. There are several methods of 3D representation, so let us have a brief look at some wide-spread techniques, especially at those that we used in our research.

Most of the techniques are based on producing two offset images, one for the left and one for the right eye. The two images represent two perspectives of the same view with the deviation as the two eyes can see it. The viewer technology of those images can be basically passive or active. The cheapest passive technology is the so called anaglyph method [1], where special glasses – in most of the cases with red and cyan

filters in front of the left and right eyes respectively should be used, and the colour modulated content will arrive dedicated to the left or right eye, which result 3D image in the brain. It doesn't require special monitor, or active devices, just very cheap, usually paper framed glasses. Viewing side-by-side images on active or passive monitors [2] requires special software that puts the images together and either filters the image to the left and right eye or controls the active 3D glasses that separate the images and causing 3D feeling.

4. INDUSTRIAL AREAS OF APPLICATIONS

We have applied three-dimensional visualization in different areas of industrial processes. We have shaped the 3D models of our industrial robot and its environment that accomplishes Incremental Sheet Forming, as well as that robot can solve the Rubik's Cube. We have used similar techniques for modeling multifunctional furniture for the furniture industry. After completing the 3D models we have connected them to the real processes in order to control them interactively.

4.1 Incremental Sheet Forming

Incremental Sheet Forming is a relatively cheap and fast 3D shaping procedure of metal or polymer sheets to make one-of-a-kind production, or rapid prototyping. Those applications would be very expensive and time consuming using the traditional die-sheet-die pressing technique [3].

ISF is based on a series of local deformations, created by a forming tool with a spherical head which is mounted on a CNC machine or on an industrial robot.

ISF doesn't require special equipment, because a simple tool moves over the surface of the sheet causing a highly limited deformation. Consequently a broad range of 3D profiles can be shaped by moving the tool along a properly calculated track. The advantage of ISF is the possibility of forming sheet material without dedicated dies, and to avoid huge pressing machines.

This is particularly profitable for small batch or customized production.

The automotive, aeronautic and space industry are interested in this new sheet forming technique [4], and experimental applications in medical aid manufacturing are also promising [5].

In the recently established robot laboratory in the Computer and Automation Research Institute of the Hungarian Academy of Sciences (MTA SZTAKI) an industrial robot (Fanuc S-430iF) has been set up, which has 6 degrees of freedom, it is able to lift up 130 kg, and has a approximately 2.5 meters horizontal reach. With that industrial robot we made several experiments in ISF (see Fig. 1) in order to found the optimal process parameters (like forming speed and force).

Figure 1.
Incremental Sheet Forming with Fanuc robot

4.2 Rubik's Cube

Rubik's Cube is a three-dimensional mechanical puzzle, where each six faces of the cube is divided by nine squares and covered by six different colours – one colour on each side (see Fig. 2). Those cubes are fixed to each other in a way, that one or two layers of the cubes can be turned around a central spindle by 90, 180 or 270 degrees. There are 8 cubes on the corners with 3-3 coloured surfaces, 12 have 2 colours each, and there is one little cube in the very middle with no visible surfaces. The rest 6 cubes on the middle of the 6 surfaces have one-one different colours. A special pivot mechanism makes possible to turn the sides of the cube independently.

The start position of the game is a mixture of colours on the sides, while in the goal position each side must consist of one of the six colours. Theoretically, we can turn the first corner of the cube to 8 places in three positions, the second corner to 7 places in 3 positions etc. [6].

Solving the Rubik's Cube with our industrial robot was a great challenge, in spite of the fact that there are several similar applications. Most of the Rubik's Cube solver robots are dedicated to this special task, with special gripping and turning methods (see e.g. [7]) or on the other hand they are general, but even very efficient application, like the world's fastest cube solver using Lego's Mindstorm NXT powered by a Samsung Galaxy S II (see [8]). There are existing solutions with industrial robots, too, see e.g. [9] or [10].

We wanted to test the precious movements, acceleration, retardation, change of direction of our robot, so for these purposes this application seemed to be ideal. The solving algorithm that can turn the cube into the final state in maximum 21 steps was developed by the author of [7], while the mechanical extension and actual movements of the robot were developed in our laboratory (see Fig. 2).
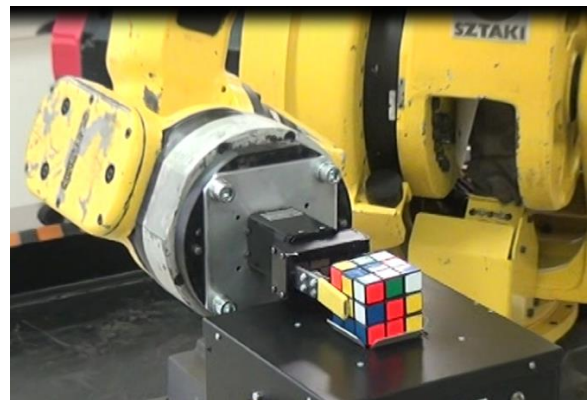

Figure 2.
Fanuc robot solving the Rubik's Cube

4.3 Multifunctional furniture

There is a special segment of the furniture industry, which produces sophisticated multifunctional pieces of furniture, like wing-chair with movable footrest, versatile sofa with adjustable backrest etc. In the more expensive implementation of that type of furniture these movements are performed by electric motors and precious control.

Traditional printed flyers can hardly demonstrate all the features of this type of furniture, so new,

3D virtual methods are required to convince the customers. Our laboratory undertook the task of creating 3D models of multifunctional furniture, and making them alive in a virtual environment.

For modeling purposes we have selected two sets of furniture of a multinational company. One was a sofa, which has electrically adjustable footrest and backrest that can be turned to a cup holder in its horizontal position (see Fig. 3). The other model includes a footrest that can be turned manually under a coffee table made of glass. The armrest and headrest of this model can be adjusted manually, too.

Figure 3.
Modelled multifunctional furniture

5. APPLIED SIMULATION AND MODELING TOOLS

We have developed the three-dimensional models of the components (robots, metal sheets, Rubik's cube, furniture etc. and their environment) and after that we have simulated their operation in a three-dimensional Virtual Reality environment called VirCA [11]. After the validation of those models we can use them either for following the real movements in the virtual environment or for direct control of the real systems from the model.

5.1 VirCA

The Cognitive Informatics Group of our Institute developed the Virtual Collaboration Arena (VirCA) [12], that has been used for the modeling and control of our applications. VirCA is a component based, distributed, interactive virtual reality manager system for connecting, as well as displaying and manipulating virtual and real objects, realizing collaboration that way. VirCA handles real, physical as well as virtual spaces in order to realize distributed, interactive collaboration.

The innovation of the VirCA system on the other hand is the connection of virtual and real physical devices. The user can see and manipulate the different, usually distant devices together. With the help of the virtual objects, the cooperation of such real devices far from each other can be tested without the development of a simulator.

5.2 Creation of 3D Models

We have created the 3D models of our system and its environment (see Fig. 4) using 3D designer programs, first of all Google SketchUp 8 [13]. Some of the original 3D visual components have been created in other graphic modeler programs (e.g. SolidWorks, or Solid Edge) using different file formats (e.g. STEP, DAE) that have been imported to Google SketchUp. In some cases Autodesk 3ds Max has been used for transforming original files to 3DS format that has been imported to Google SketchUp, too.
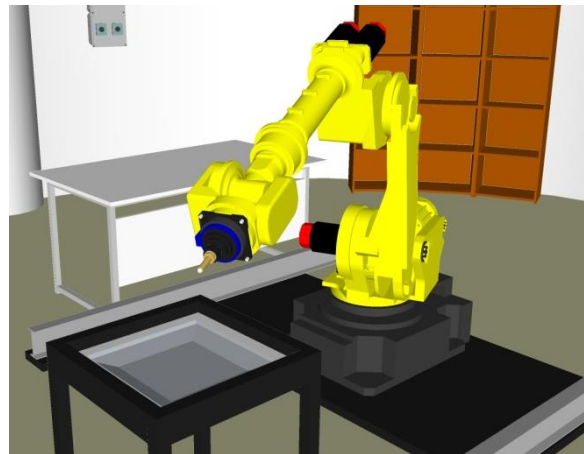

Figure 4.
Model of the Fanuc robot and its environment

In case of modeling multifunctional furniture Google SketchUp didn't seem to be a suitable tool, because it was not accurate enough in the representation of smooth edges and corners. Therefore we used Blender for modeling sophisticated furniture, and we have imported the Blender files to Google SketchUp for further conversions to the graphic engine of VirCA.

In order to make the components of our models moved, and provide interactivity we used the previously mentioned VirCA system. This way our 3D models become dynamic and alive in the cyber space, and we can synchronize and control the real processes with their virtual representation for test, training and remote control purposes.

Since the graphic engine of VirCA is Ogre [14], therefore the visual components of all models

have been supplied in Ogre (mesh and material files) format. The mesh and material files have been exported from Google SketchUp, using "SketchUp to Ogre Exporter" plug-in.

6. 3D MODELLING AND VISUALISATION EXPERIMENTS

6.1 Operation of the 3D models

The VirCA environment allows us to be in a virtual environment and interact with it knowing that all the actions can be also done in the real system. This way several parameters, as well as the model of the industrial applications (ISF, Rubik's Cube, and multifunctional furniture) can be examined both in the virtual and in the real system (see Fig. 5).
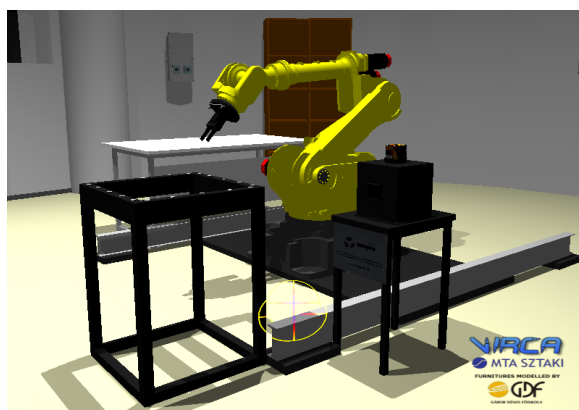

Figure 5.
Fanuc robot in VirCA

A special web based tool [15] supports the connection of the different programs with the proper interfaces, and activates the whole system via the Internet. It controls the states and connections of all the affected components; even they might be available from the different parts of the world.

We have been established a live serial port connection between the Fanuc robot controller and its cyber device in VirCA. It means that the movements of the real robot can be seen in the model simultaneously, as well as the movements of the robot model can be directly executed on the real robot.

In case of the multifunctional furniture (see Fig. 6) there is no choice for data input with which the real movements can be controlled from outside. In other words there is no interface between the virtual objects and the real system, therefore communication between the real system and VirCA is not possible in this case.

Based on that all movements in VirCA are pre-programmed in a so-called wired-in way.

Figure 6.
Multifunctional furniture in VirCA

7. CONCLUSIONS AND FUTURE PLANS

In this paper interactive 3D visualization of different industrial applications have been introduced. We have discussed the creation of the 3D models of these industrial processes and the applied modeling tools. The models were operated in the interactive virtual 3D environment of VirCA that helped in the integration of the components, too.

We have connected and synchronized all the components of the VirCA models with the real industrial systems, similarly as we have done in our two-machine-based ISF configuration [20].

Later on by moving the robot in the virtual space using different sensors and control tools (voice recognition, Kinect sensor [16] and Wii controller [17]), the real robot can be controlled through the model via the Internet even from a far distance. This way tele-presence and tele-operation tasks can be performed, too.

Our results have been presented in our three-dimensional websites (http://robotmodell3d.hu, and http://3dweb.hu) where we used different 3D rendering techniques.

8. ACKNOWLEDGEMENT

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