# Coperion 3D – A Virtual Factory on the Tabletop

**Michael Zöllner (1), Jens Keil (1), Johannes Behr (1), Jan Gillich (2), Sebastian Gläser (2), Erich Schöls (2)**

(1) Fraunhofer IGD, (2) Design & Systems

Abstract

*This paper describes the development of a virtual factory application based on multi-touch interaction, high resolution projection technology and industry standards like X3D. The application is a presentation tool to describe hidden complex physical processes inside a plant for bulk material handling. We are covering the project objectives, the scene architecture and the CAD and physical simulation production pipelines.*

**Keywords**: Multi-touch, virtual factory, physical simulation, x3d, process visualisation

## 1 Introduction

Presenting products, values and competencies in an understandable and outstanding way is one important goal of companies' trade show performances. But how are complex and invisible aspects of a technology efficiently communicated in a limited time?
In this paper we are describing the development of a novel information visualisation approach for the industry based on large scale CAD data and multi-touch interaction technology.

*Figure 1. Multi-touch table*

Multi-touch technology "(Han, 2006)" is one of the most interesting developments in today's Human-Computer-Interface area. The interaction is simple and intuitive. For the Coperion 3D project we are using this approach in order to create a simple to use presentation tool to explain the complex processes in a plant for bulk material handling (Figure 1).

The Coperion Group is planning and producing plants and systems for the plastics industry. Since decades the company is well known for it's inventiveness and the management is always interested in new and innovative ideas. All the years before it was a hard thing for the salesmen to impart their know-how, because the knowledge of conveying and handling plastic pellets and powders normally take place in pipes, valves and diverters. With this multi-touch application

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Coperion now can easily demonstrate the core-competencies to the markets and they can also train their new employees as well.

*Figure 2. Presentation at Coperion's Booth*

The presentation at Coperion's booth (Figure 2) consisted of Fraunhofer IGD's multi-touch table and an impressive 8-meter wide high definition projection mirroring the table's image. The monolithic design of the table in combination with the projection's dimensions and its underlying advanced technology were unique at the trade fair.

## 2 Project Objectives

The challenge of the presentation was to demonstrate the complex processes in a plant for bulk material handling. The system makes invisible things visible in a very informative and didactical way (Figure 3). Thus the company can now demonstrate its competence, although the actual know-how is hidden within. The system is based on a 3D real time visualisation and every part and component of the plant can be functionally represented. All ranges of the giant tool can be "approached" interactively and each detail can be explored in a transparent view.

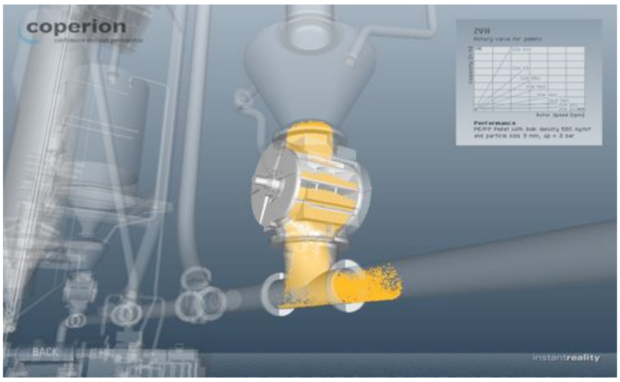


*Figure 3. Making invisible things visible*

One of the most important approaches was to adapt the information system as ideally as possible to a "normal" conversation. Therefore the multi-touch table was developed, because this intuitive interface works without additional devices. All inputs, inquiries or details can be made with the fingers directly at the represented object. Also untrained users or visitors can immediately and easily serve the system without further assistance.


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# 3 Technology

We decided to use the X3D format to implement Coperion 3D, since it is a well-known industry standard today, that most CAD and 3D author systems understand and provide.
Coperion 3D's visualization bases upon two integrated software parts and a custom interaction device developed at Fraunhofer IGD's Department for Virtual and Augmented Reality: instantreality framework “(Avalon, 2008)”, VisionLib and Fraunhofer IGD’s multi-touch table for both interaction and visualisation.

instantreality combines various components to provide a single and consistent interface for AR/VR developers. Those components have been developed at the Fraunhofer IGD and ZGDV in close cooperation with industrial partners over the last years “(Behr, 2004)”.
The framework offers a comprehensive set of features to support classic Virtual Reality and advanced Augmented Reality equally well. It provides a very simple application interface while still including the latest research results in the fields of high-realistic rendering, 3D user interaction and total-immersive display technology. It is also a very flexible system, that not only supports the X3D standards completely, but that also can be extended by special nodes.
VisionLib is a complementary tracking system for Augmented Reality and handles the complete finger-tracking process. It combines different tracking algorithms modular in order to create the ideal result in different scenes use cases. The multi-touch table's finger tracking VisiobLib's advances BlobTracking. VisionLib is integrated as instantvision in the instantreality framework. It enables the less experienced developer rapidly integrating advanced computer vision in X3D scenes.
To provide a better interchange between standard X3D nodes and the multi-touch capability of the table, new node types were developed “(Jung, 2008)” to feature multi-finger and multiuser interaction in X3D as well. The integration is very easy, due to the flexibility of the instantreality framework. Their implementation was also kept abstract enough to fit to more than only Coperion 3D’s interaction concept.

# 4 Content Optimization Pipeline

Plants for plastic manufacturing are very large and complex systems, which require a hundred thousand cubic meters space of piping, silos and all sorts of different process components
(Figure 4). Right from the start one of the project's challenge was the preparation, structuring and optimisation of 3 Gigabytes of CAD content for real time rendering. In the first step a reduced, but significant model system had to be sketched in close cooperation with the plant-engineers. Most of the models were already available in a CAD format. Apart from a skeletal structure of pipes and irrelevant parts, all components had to be exported separately to VRML, because they had to be individually addressable within the application.

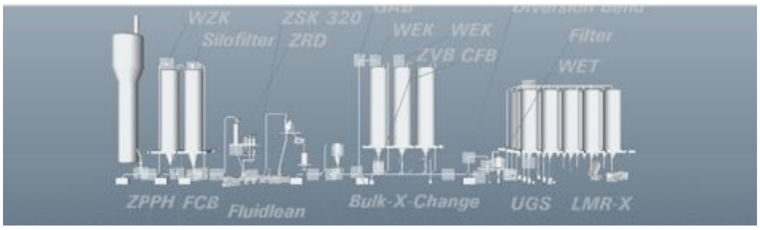


*Figure 4. Plant's component overview*


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The individual VRML files' polygons had to be reduced in order to achieve a slim and fast rendering model with undistorted meshes in a nearby view. We assured this by exporting three different resolutions with different levels of detail (LOD).

In the final optimization up to 400 individual files were converted by instantreality's optimizer tool "aopt" into binary X3DB format. To a large extent this process was automated with the help of a python script. In the end we achieved a reduction of memory requirement from 3 GB of the original files to about 100 MB in binary X3DB format. It improved the loading time of the scene and its stability. This memory reduction enabled the rendering on a standard 32-bit PC.
The X3DB files were included into the X3D scene via Inline nodes. Some animated components, which were exported with a zeroized position beforehand, now had to be repositioned manually to the correct position in the scene. For the overview perspective, where no direct interaction was needed, we merged all the single components into one small X3DB file.

## 5 X3D Scene Design

The virtual factory had to be planned with regard to future expansion. Therefore the X3D "(Web3D Consortium, 2008)" scene was optimised for today's high-end graphics computer systems. The goal was to ensure on the one hand a minimum of rendered triangles and used memory and on the other hand a continuously high visual quality of the rendering.

The scene uses level of detail (LOD) to provide 3 different resolutions depending on the distance between user and geometry. In the overview the scene consists of three very low-resolution production lines each with its own bindable global viewpoint (Figure 5). A production line can be approached by touching them on the tabletop. Each production line consists of a merged static skeletal structure and numbers of interactive and animated components (Figure 5). Touching a component is followed by a smooth camera movement to a close-up. The component switches to a transparent appearance and its internal parts and processes become visible (Figure 3).

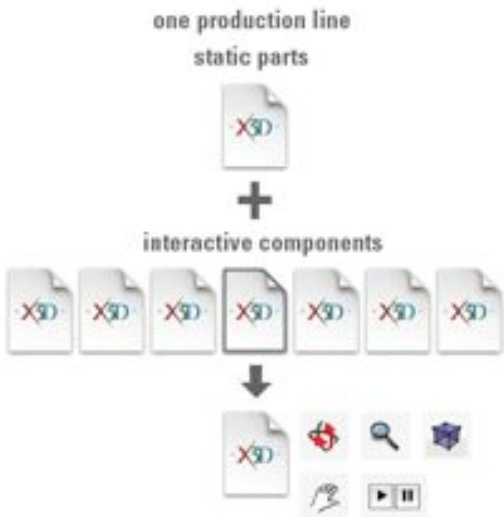


*Figure 5. X3D scene design*

Interactive components are rotated, zoomed and manipulated by a combination of standard X3D pointing sensors and instantreality's HyperSurfaceSensor "(Jung, 2008)" multi-touch pointing sensor. Manipulations include animations' and simulation's speed adjustment and switching different visualisation states.

# 6 Physical Simulations

For the correct physical representation of the transported plastic granulate and powder in the rotary-valves we developed a solution which permits a maximum number of simultaneous drawn particles with a physically correct behaviour in this real time application.

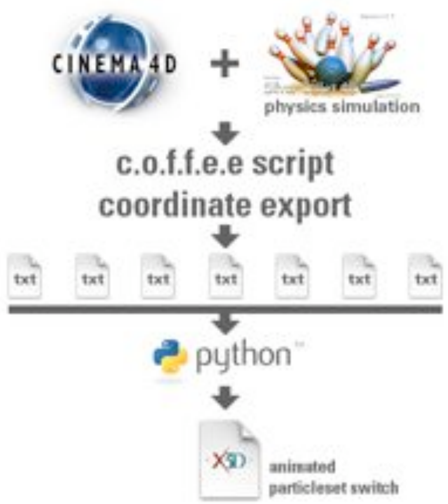


*Figure 6. Pre-calculated physical simulations*

Smaller particle simulations were realised with instantreality's ParticleSystem (Simulation) and ParticleSet (Visualisation) and thus can be manipulated in real time. The only possibility for complex flow simulations was an offline simulation and a pre-calculation of the respective particle coordinates (Figure 6). We used the physics simulation plug-in SilverBullet4D in Maxon's Cinema 4D. Via a C.O.F.F.E.E. script we exported the particle's coordinates per frame into text files. These 3D scatter plots were converted into a X3D file via a python script. It contained a TimeSensor driven Switch node with one ParticleSet for each frame. This had to be synchronised in its rate with other turning parts of the components. Thanks to the pre-calculation we could achieve an absolutely smooth performance of high complex physical behaviours.

# 7 Usability

One intention of the application was to enable inexperienced users to navigate and manipulate complex three-dimensional scenes with simple gestures. Therefore we had to focus on the needed navigation and manipulation in order to eliminate the unessential ones and thus to avoid errors and confusion.

The visualisation's and navigation's core principle is that a selected object is always in the center of the scene. Only this object and its information are rendered visible. The peripherals are rendered transparent. This is an imitation and intensification of the way our perception works. Thus the user's concentration is focused on the point of interest and not distracted by the


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environment. Only interaction and manipulation of one selected object at a time is possible. Hence making an error by picking the wrong object is avoided "(Schroeter, 2004)" Jef Raskin described this principle of perception as Locus of Attention "(Raskin, 2000)".
By centring and limiting the freedom of navigation and focusing it on the active element we are avoiding common irritations of 6 degrees of freedom (DOF) environments like CAD and 3D modelling applications. Untrained users are often getting lost and have to reset the view and start over. A presentation tool needs less degrees of freedom than a construction tool. Furthermore it demands less if it should work in fast moving situations like trade fairs and museums.

Navigation to the single components was very straight and fast, too. In order to get from the overview aspect to the very detail of a component it takes two tips. In the overview one of the three plant sections is selected: manufacturing, compounding, processing. After the camera zoomed on the section all components of interest are highlighted. Tipping on one or its textual description enables a camera flight to the close-up and reveals the components internal processes.

*Figure 7. Engineers presenting application*

This approach was proven and documented while Coperion's performance at K trade fair. Surrounded by visitors and customers engineers and sales people presented complex processes inside the plant with their fingertips (Figure 7). Even older people without lifelong computer experience illustrated their descriptions by jumping and zooming through the 3D plant.

# 8 References

## 8.1 Books:

Raskin, J. (2000): *The Humane Interface.* Addison-Wesley Longman, Amsterdam.

## 8.2 Journal Articles:

Schroeter, P. von, Juergensen, B., Zoellner, M. (2004): Cercon Move - A Navigation Aid for Dental CAD Applications. *International Journal of Computerized Dentistry 7, 4, 371-377.*

## 8.3 Conference Proceedings:

Behr, J., Daehne, P., Roth, M. (2004): Utilizing X3D for immersive environments. In *Web3D '04: Proc. of the ninth int. conf. on 3D Web technology*, ACM Press, NY, USA, 71–78.
Behr, J., Daehne, P., Jung, Y., Webel, S. (2007): Beyond the Web Browser - X3D and Immersive VR. In *IEEE Computer Society u.a.: IEEE Virtual Reality 2007. VR Tutorial and Workshop Proceedings [CD-ROM]: IEEE Symposium on 3D User Interfaces*. Piscataway, NJ : IEEE Service Center, 2007, 5 p.
Han, J. Y. (2005): Low-cost multi-touch sensing through frustrated total internal reflection. In *UIST '05: Proceedings of the 18th annual ACM symposium on User interface software and technology*, ACM, NY, USA, 115–118.


ISBN-978-960-89028-7-9

Han, J. Y. (2006). Multi-touch interaction wall. In *SIGGRAPH '06: ACM SIGGRAPH 2006 Emerging technologies*, ACM, NY, USA, 25.

Jung, Yvonne; Keil, Jens; Behr, Johannes; Webel, Sabine; Zoellner, Michael; Engelke, Timo; Wuest, Harald; Becker, Mario (2008): Adapting X3D for Multi-touch Environments. In *Spencer, Stephen N. (Ed.); ACM SIGGRAPH u.a.: Proceedings WEB3D 2008 : 13th International Conference on 3D Web Technology. New York*. ACM Press, 2008, pp. 27-30.

### 8.4 Internet Sources:

Avalon, 2008.
http://www.instantreality.org
Web3D Consortium. 2008. Extensible 3D (X3D).
http://www.web3d.org/x3d/specifications/ISO-IEC-FDIS-19775-1.2/index.html

### 8.5 Computer Programs:

Fraunhofer IGD, Darmstadt, Germany (2007): instantplayer [Linux, version beta 4].
Maxon Computer, Friedrichsdorf, Germany (2007): Cinema 4D R10 [Mac OS X, version R10].
Remotion4D, Andernach, Germany (2007): SilverBullet4DPlus [Mac OS X Intel].


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