METHODS TO LEAD THE USER TO SIGNIFICANT PROCESSES IN A 3D MATERIAL FLOW SIMULATION

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OBJECTIVES

Simulation of material flow process and the visualization are quite common tools to improve the planning of new plants or the reworking of existing processes. 3D-visualisations of such simulation runs are more and more common. This allows a faster understanding and better communication of the processes. However, up to now this analysis process is carried out unguided. A user does not now where he has to look in a virtual environment. For this, we developed a set of helping tools to support the user during the analyzing process (like not synchronized cycle times). We are detecting processes that are going wrong and being good candidates for taking more attention of the user. After this detection, we try to show the user these candidates and give him the option to get guidance to the processes with automatically generated additional elements in the 3D environment.

STATE OF THE ART

Today many material flow simulation tools offer integrated 3D-modules (Klingstam and Gullander 1999 or Mueck and Dittmann 2003). Examples are simulation tools such as QUEST by Deneb, Taylor ED by Enterprise Dynamics (Nordgren 2001), eM-plant by Technomatix or Automod with integrated virtual environments. The user can build a model, see, and analyze it in a 3D environment. However, an active support for the user does not take place. If the viewer moves in the relevant system, he cannot experience critical processes that take place in his back. They are not visible for him. User guidance to significant points is unknown. The locating of critical objects is thus left to the experience of the viewer or based on random.

SIGNIFICANT PROCESSES

If a material flow process is sketched and modeled, a simulation run can be used to find out processes, which are not quite well balanced. E.g., a machine runs empty of incoming parts, a machine breaks down or a stock is much too big. Like this, several other rules for “not well balanced behavior” can be defined. If something like this happens, it could have a huge influence on the simulation run and especially on the key production figures like parts in process or throughput time. If a change of a process leads to a fast changing production figure, we call the process significant. So our significance is based on a dynamic process. In addition, the level of significance can change during the simulation run.

If the user wants to improve these production figures, the significant processes are the processes he should take care of. In our approach, we detect these processes automatically and help the user to solve potential problems.

Each significant process belongs to a machine, a stock or any other static part of the simulation model. If we talk in this paper about a significant machine, we also include all the other cases.

VISUALISATION OF SIGNIFICANT OBJECTS

Significant processes have a high influence on the key production figures. Therefore, they are important for the user to watch. However, typically the user is not standing direct in front of these processes. The chances are not too bad that some other machines are hiding the significant process. In this case, the user has at least to be notified, where significant processes occur. It would be better, if he can see them directly.

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Columns on Top of Significant Processes

Typically, the user is walking through his production hall. Moreover, he cannot see very far. Machines surround him. Nevertheless, he can look over the machines. In this approach, the machines belonging to significant processes are getting columns on top. Theses columns are high enough that the user can see them from every point of the scene. Because all columns have the same wide, the user can easily see which are close to him. Additional captions on the columns can show the name of the significant machine.

Semitransparent Visualization

If the user is close to a significant process but an object hides the process, parts of the object will be visualized semitransparent in this approach. Therefore, the user can see the significant process through a hole in the object (c.p. Figure 1). If the user is moving, the hole is following (in the object) him.

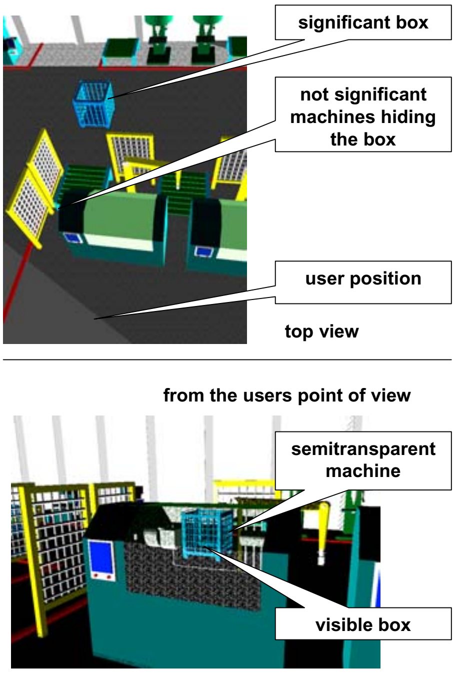

Figure 1: Machine is hiding the box. Parts of the machine will be visualized semitransparent.

For significant processes that are close to the user this is working fine. However, if there are too many objects between them, semi transparency does not work, because several semitransparent objects are leading to a non-transparency. With a complete transparency, the user cannot see the machine direct in front of him. The visualization cannot separate where the user is looking at. Therefore, it must be possible to see everything.

Arrows Pointing to Nearby Significant Processes

Columns on the top of significant objects works well for far away objects. If the user is nearby the object, columns on the top are too high above the objects. The user cannot identify the significant object, because the column of the nearby significant object is difficult to distinguish from the columns of far away significant objects. Therefore, we use another means to point to nearby significant objects. We highlight significant objects in the scene by red arrows that are placed at the top of a significant object (see Figure 2 for an example), similar to the arrows suggested by Darken and Peterson (Darken and Peterson 2002)). Thus, the user can easily get a visual overview which of the machines is significant. The visual detection of significant machines works faster than a text message.

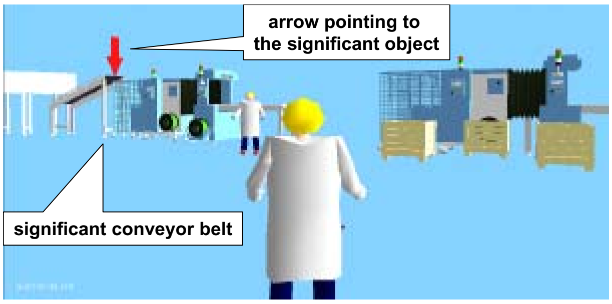

Figure 2: The conveyor belt is significant. The red arrow points to the significant object.

GUIDANCE OF USER TO SIGNIFICANT POINTS

In traditional 3D simulation environments, the user is walking through his process. The way he is walking is in best case based on experience and some expectations. However, in many cases his way is also influence by luck. This is not structured and efficient. In our approach, the user should be guided to the significant processes. For these we developed two visualization techniques (Guidance by Lines and guidance with signs). For a better overlook, orientation, and to avoid a disorientation of the user, we implemented a minimap that shows a top view of the scene.

Guidance by Lines

In this approach the way between the significant processes and the user are shown with lines on the ground. If the user wants to go to significant process, he only has to follow these lines. Figure 3 shows an example for this. It also shows what is happening if two or more processes are significant. In this figure, the different ways are carrying captions, which contain the name of the process. This is difficult to realize for the user. In further steps, we will work with different colored lines. Each color represents one process and the lines will be shown side by side.

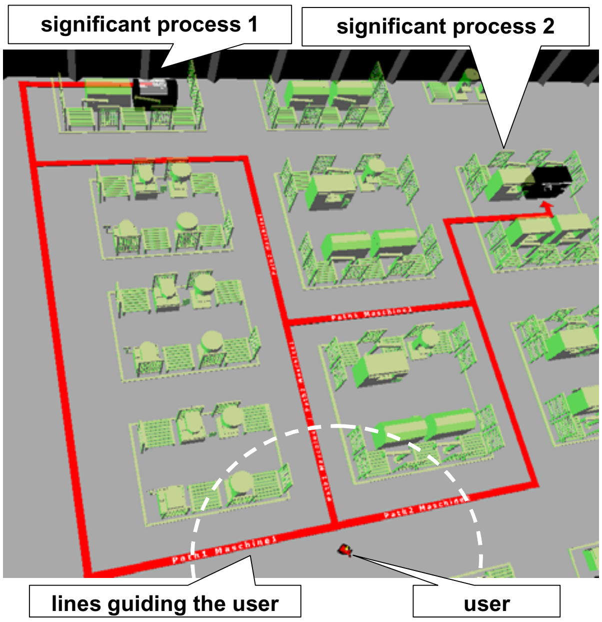

Figure 3: Lines on the ground are visualizing the shortest path to the significant processes

Guidance with Signs

In the first approach, the user has to look on the floor. This is not where he is typically looking. He also only needs information about the way on junctions. Therefore, we developed 3D signs that guide the user to the significant processes. On each junction, these signs or arrows are showing the shortest way to the most significant points to the user (cp. Figure 4). Like traffic signs, they can show more information than the direction and the name of the process. Therefore, it is possible to provide the user with additional information (e.g. the distance or the level of significance).

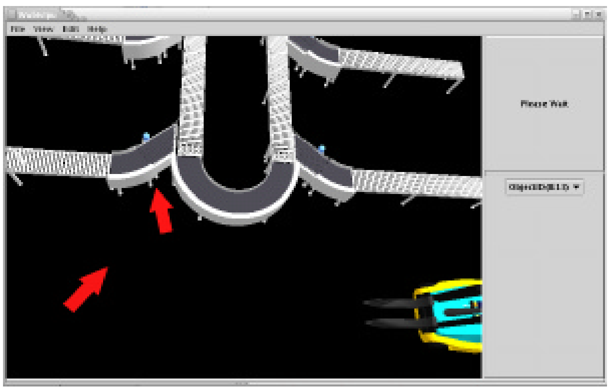

Figure 4: Arrows showing the user the way to a significant process

Both approaches (guidance by lines and guidance by signs) are implemented in our software. However, the effects for the user are not yet fully analyzed. Especially the speed measurements for the orientation of the user have to be made in the close future.

Overall View to Orientate the User

A typical problem of 3D environments is the orientation in the virtual world. Especially in environments of material flow processes, e.g., in a large factory hall, the area is large, and during the planning process, often changes so the user can loose his way and orientation. To prevent disorientation, the user must concentrate on finding the right way to the wanted destination. However, the purpose of the 3D visualization is to observe and analyze processes and not to waste time with finding and exploring a way through the scene. Therefore, the system must make the orientation as easily as possible.

Our system supports an easy orientation by the implementation of a minimap that shows an overlook of the scene. The upper image of Figure 5 shows the 3D scene and the lower image shows the corresponding minimap. The overlook of the minimap consists of a two-dimensional floor plan of the scene, e.g., the factory floor. Additionally, we draw the skeletal silhouettes of all static objects such as machines and conveyor belts, and of all moving objects such as forklifts and users. The users are rendered as thumbnails in the minimap.

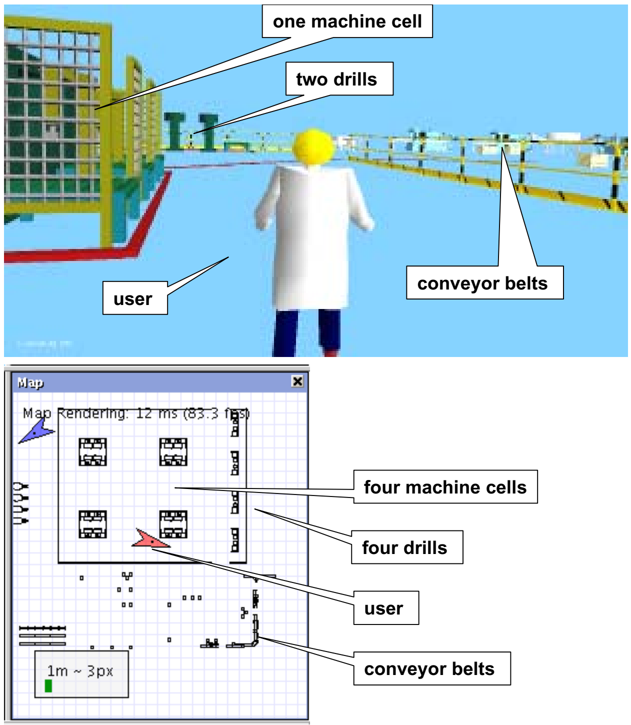

Figure 5: A user navigates through a 3D scene of a manufacturing facility seeing only one machine cell and two drills. A minimap show the skeleton of four machine cells and four drills.

In the example rendering of Figure 5, the user sees one machine cell and two drills. On the minimap, he sees his neighborhood including all occluded objects. Therefore, he sees four machine cells and four drills. Thus, a user can easily find a way to neighbored machines that are occluded by large machines or other objects. Without a minimap, the user would waste his time by searching a way as in a labyrinth. Our minimap supports in an easy manner:

- to find a way to the destination,
- to explore the factory and environment,
- to find neighboring users.

Currently we use arrows, which look like compass needles, as thumbnails for the users. The compass needle shows the line of sight of the user. This supports an easier orientation in the scene.

CONCLUSION

This paper describes several methods to support a user during his analyze of a material flow process. For this first process of potential interest for the user have to be detected. This has been done on the base of performance measurements. We call these processes significant processes. The developed tool is only a supporting system. We cannot detect everything the user might be interested in. Therefore, we offer our significant processes to the user and give him the option to take a closer look on them. For this, some methods to show him the location of the processes and the way to the processes have been discussed in this paper.

Such methods are quite new to material flow simulations. The developed methods do not claim that they are optimal or even complete. Especially measurements of the speed up of the work with and without our methods are still missing (we are planning to do this in the near future). If it is possible to find problems faster with these visualization techniques, this could reduce the efforts and the costs for analyzing material flow simulations.

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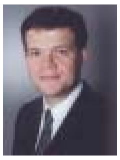
AUTHOR BIOGRAPHIES

Wilhelm Dangelmaier was director and head of the Department for Cooperate Planning and Control at the Fraunhofer-Institute for Manufacturing. In 1990 he became Professor for Facility Planning and Production Scheduling at the University of Stuttgart. In 1991, Dr. Dangelmaier has become Professor for Business informatics at the HEINZ NIXDORF INSTITUTE; University of Paderborn, Germany. 1996, Prof. Dangelmaier founded the Fraunhofer-Anwendungszentrum für Logistikorientierte Betriebswirtschaft.

Bengt Mueck studied computer science at the University of Paderborn, Germany. Since 1999 he is a research assistant at the group of Prof. Dangelmaier, Business Computing, esp. CIM at the HEINZ NIXDORF INSTITUTE of the University of Paderborn. At the end of 2004 he recieved his phd in the area of discrete materialflow simulations. His main research interests are logistics systems and tools to simulate those systems.



Matthias Fischer studied computer science at the University of Paderborn, Germany. Since 1995 he is a research assistant at the Heinz Nixdorf Institute. In 2005, he received a PhD for his work on distributed virtual environments. His main research interests are computer graphics, real-time rendering algorithms, and distributed computing.

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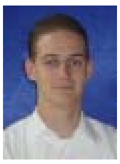

Christoph Laroque studied business computing at the University of Paderborn, Germany. Since 2003 he is PHD student in the graduate school of dynamic intelligent systems and research assistant at the group of Prof. Dangelmaier, Business Computing, esp. CIM. He is mainly interested in material flow simulation models and the “digital factory”.