User project Report
MATEMASYS2

Title: Design of a Virtual Reality Environment for MAintainability TEsts and MAnufacturing Systems Simulations

Access provider: Operation Excellence Institute

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End date of the User project (end of the experiments on the infrastructure): 24/10/2014

Challenge: An original VR architecture (MATEMASYS2) in order to create a unique environment whose features are able to satisfy requirements for Virtual Maintenance and Virtual Manufacturing tasks is conceived. The architecture is based on complex hardware and software technologies available at the Operations Excellence laboratory at Cranfield. A case study to be realized in MATEMASYS2, regarding the maintainability of complex assemblies is proposed.

Work description: VR ARCHITECTURE: MATEMASYS

The realization, in an immersive virtual environment, of maintainability tests and manufacturing systems simulations, above introduced, needs specific requirements:

• A powerful graphic and calculus system able to manage a great amount of data;

• A large screen able to visualize complex systems in full scale;

• Input devices allowing the protagonist of the virtual experience to easily navigate and interact with the virtual scene and other members of the design team to share such experience and review the design;

• software tools for collision detection, motion programming, kinematics simulation, 3D distance measurements, virtual markup, path recording;

• 3D audio output device increasing the immersion in the virtual environment.

In order to satisfy these requirements an original VR architecture, named 'MATEMASYS2' (acronymous for MAintainability TEsts and MAnufacturing SYstems Simulations) has been conceived (Figure1).

The platform used as Simulation Manager is Visionary Render 2: it is an extensive tool containing many functions for product development, from the creation of virtual environment to the assembly simulation or ergonomics analysis. Since VR software does not offer, to date, standard characteristics to perform engineering applications, in particular maintainability tests and manufacturing systems simulation, Visionary Render was chosen as it provides Application Programming Interfaces used to customize the MATEMASYS Simulation Manager.

This platform gives the possibility of interfacing with a wide range of input/output devices, such as those available at the Operation Excellence laboratory. The software allows designers to manage all the input and output devices used for the visualization, navigation and interaction with the scene. Due to the chosen approach, based on the direct manual interaction, the devices implemented in Visionary render, in particular for navigation and manipulation, have been:

- flystick for the activation of actions by means the events associated to the eight keys;
- system of six cameras for tracking position and orientation of the sensors attached to head, hand and other characteristic human body points, in order to transfer the real movements to the virtual scene.

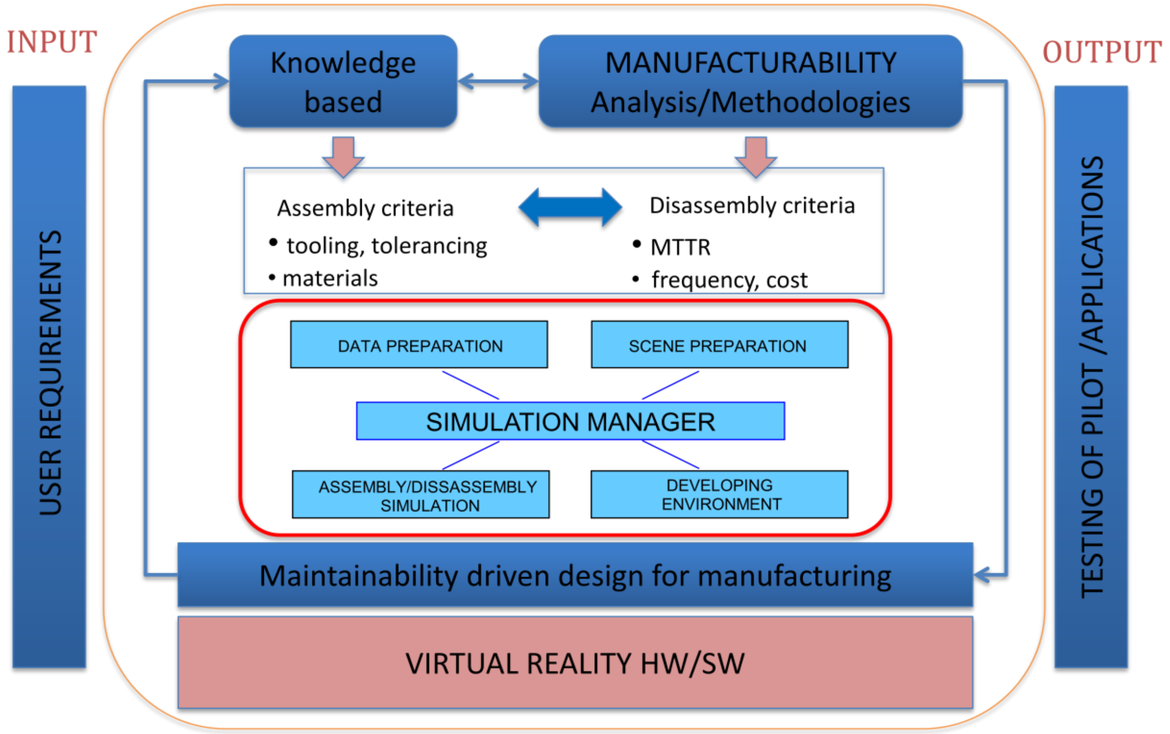

Figure1: VR architecture: *MATEMASYS2*.

CASE STUDY

Maintainability of an aircraft carriage

MATEMASYS2 architecture has been used to simulate maintainability tests of an aircraft carriage. The study has been directed to the disassembly analysis of some components, chosen from the list of the maintenance activities. In particular, in the following is described one of this simulation, regarding the disassembly of the brake plates (Figure 2).

The 3D model of the boogie has been designed with ProEngineer (PTC) and imported in Visionary Render, after prepared the scene and the geometries. Then, light sources were introduced and different materials were associated to each part, by means of colours and textures, in order to improve the realistic effect of the scene. A small table were positioned near the bogie where the tools used in the simulation have been placed.

For the disassembly of the brake plates it is necessary to remove the two bolts that fix it to the chassis of the carriage. The digital model of the tool used for this maintenance task was introduced in the virtual environment. The preliminary phase of the study has been focused on the accessibility of the tools. In particular, the presence of the prescribed volume of access has been verified to allow the operator unscrewing the bolts.
The simulation in VR allows the operator to collect all the necessary information for the compilation of the maintenance chart, providing a positive outcome for the feasibility of the whole operation. In particular, detachability, accessibility, and manipulability were verified.

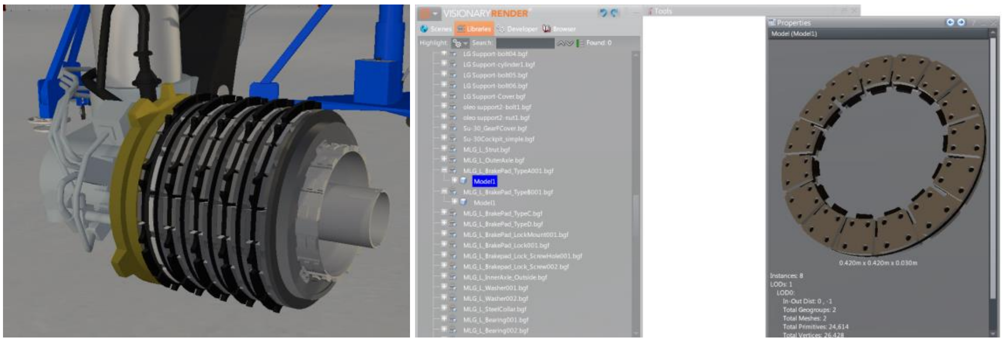

Figure 2: Disassembly of the brake plates of an aircraft carriage.

The simulation can be conducted by an unskilled operator and the employment of only one operator is sufficient for the whole task. The mean total time for the execution was about four minutes.

Result and future works

The present work wants to demonstrate the important potentialities offered from VR techniques in industrial applications, in particular, for maintainability tests on complex assemblies and for the simulation of manufacturing systems.
Obtained results not only provide a valid answer to the design questions in the field of maintenance and manufacturing systems simulation, but they make objective the effective applicability of the proposed methodology: in spite of the subjective character of the approach to the simulation, based on the direct manual interaction, the information collected in the case studies, allow to grant the feasibility of tasks and to individualize the design parameters on which operating to better answer the functional requirements and, finally, to improve the design.
After each design modification, a new phase of simulation follows in order to verify the effective satisfaction of the requirements. In particular, the virtual simulation is important also for the training of the staff assigned to the maintenance and manufacturing activities.
The analysed case studies have highlighted that the proposed MATEMASYS architecture satisfies all the requirements needed to perform maintainability tests and manufacturing systems simulations. Nevertheless future works have to be focused on the implementation of more grasping conditions of the virtual objects, in order to increase the realism of the simulation, reproducing the natural posture of the hand assumed in the manipulation of the objects. Also the possibility to introduce a virtual reproduction of the wrist, the forearm and the arm of the operator, represents an interesting objective,

in order to increase the sense of immersion into the scene and to make more precise and concrete the results of the simulation.

Moreover, a future interesting task will be to implement algorithms for the automatic calculation of assembly/disassembly paths, starting from the initial and final position of the components: obtaining the theoretical collision free path, the simulation can allow the operator to reproduce the previously calculated trajectory. Finally the introduction of shadow effects on the examined system would increase the realism of the scene, in order to improve the perception of distances and volumes between virtual hand, tools and components.