VTT SYMPOSIUM 269

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Current and Future Perspectives of Virtual Reality, Augmented Reality and Mixed Reality: Industrial and Poster Track

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Preface

The Joint Virtual Reality Conference (JVRC2011) of euroVR and EGVE is an international event which brings together people from industry and research including end-users, developers, suppliers and all those interested in virtual reality (VR), augmented reality (AR), mixed reality (MR) and 3D user interfaces (3DUI). This continues a successful collaboration between the 8th Conference and Exhibition of the European Association of Virtual Reality and Augmented Reality (euroVR) and the 17th Eurographics Symposium on Virtual Environments (EGVE). This year it was held in the UK in Nottingham hosted by the Human Factors Research Group (HFRG) and the Mixed Reality Lab (MRL) at the University of Nottingham.

The aim of JVRC2011 is to provide an opportunity for all to exchange knowledge and share experiences of new results and applications, interact with live demonstrations of current and emerging technologies, and form collaborations for future work. This publication is a collection of the industrial papers and poster presentations at the conference. It provides an interesting perspective into current and future industrial applications of VR/AR/MR. The industrial Track is an opportunity for industry to tell the research and development communities what they use the technologies for, what they really think, and their needs now and in the future. There are presentations from large and small industries from all over Europe. The Poster Track is an opportunity for the research community to describe current and completed work or unimplemented and/or unusual systems or applications. Here we have presentations from around the world.

We would like to thank warmly the industrial and poster chairs for their great support and commitment to the conference.

Industrial chairs

- Angelos Amditis (ICCS-NTUA, Greece)
- Dennis Saluäär (Volvo, Sweden)
- Harshada Patel (University of Nottingham, UK)
- James Ritchie (Heriot-Watt University, UK)
- Kaj Helin (VTT, Finland).

Poster chairs

- Anatole Lécuyer (INRIA, France)
- Angelica de Antonio (Universidad Politécnica de Madrid, Spain)
- Marco Sacco (ITIA-CNR, Italy)
- Sue Cobb (University of Nottingham, UK).

Special thanks go to Kaj Helin (VTT) for organising the sponsorship of this publication.

We hope that all the participants of the JVRC2011 have enjoyed their experience, learnt something new and met some interesting people.

Mirabelle D'Cruz, Roland Blach, John Wilson, Chris Greenhalgh
JVRC2011 General Chairs

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Poster Papers

Customer Requirements Validation with VR Technologie – Case Metso Minerals

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Abstract

The aim of this study is to explain how VR technologies are used in validation process and its objectives in general. This paper is not able to present the actual results as they will be available in September 2011 (earliest).

1. Introduction

Metso Minerals is a leading supplier of equipment and services for mining and construction industries. Since 2006 the company has studied VR/AR technologies for improving the efficiency of product development and productization related activities. In 2006–2009 the company participated to a VR/AR research project 'Virvo' (www.vtt.fi/proj/virvo). The project was lead by VTT (Technology Research Centre of Finland). In this project Metso's case study was focused on certain critical maintenance tasks of a new crusher model. However because of the novelty of VR technologies it was not possible to get clear benefit from using the new tools as the product development project had to keep the schedule. For Metso Minerals the most important outcome of the Virvo project was the understanding of how VR can support different product development related reviews and how 3D-model information can be used in various systems efficiently.

This study is a related to EC project ManuVAR (www.manuvar.eu). The project has started in May 2009 and it has more than 20 European participants. The main focus of the project is the use of VR&AR technologies for supporting manual work in different lifecycle phases of the product/system. In ManuVAR project Metso Minerals is the case company of Cluster 5 lead by VTT. So far Metso's cases have been concentrated mainly to productization related reviews (assembly work, ergonomics, safety etc.).

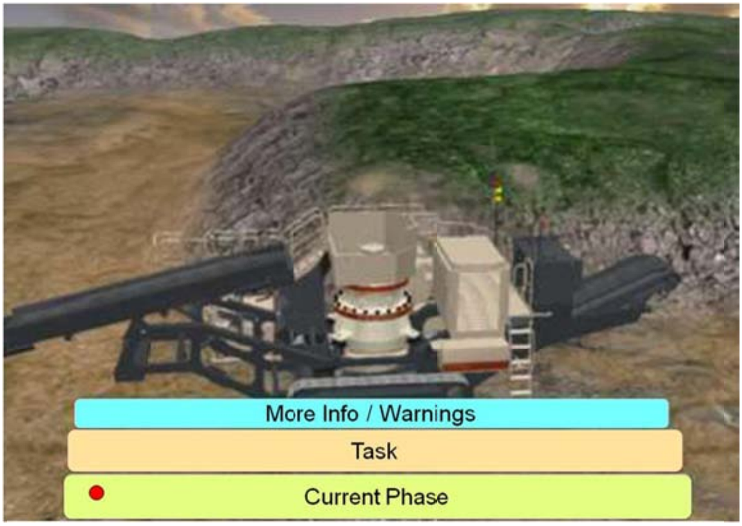

Figure 1. Maintenance task simulation system developed in Virvo project 2009.

2. Case Description

In early 2011 Metso Minerals started a new product development project which aims to find improved solutions for reducing noise and dust related problems that are typical for crushing and screening processes. From the customer perspective noise and dust is not only an HSE issue but also a serious economical issue due the fact that these problems will make it difficult to get permissions for their operations from the authorities. Typically this means reduced working times and other limitations.

The project is cooperating with the company's Finnish construction segment customers. Customer requirements have been collected via interviews and meetings. Based on the feasibility and idea collection phases of the project first prototype solutions are currently being built. However these prototypes will be used for test and verification purposes only. At the same time the actual concept development phase will seek for solutions that are accepted by the customers.

The main challenge for this customer validation is to make sure that the customer is able to understand the concept correctly and give feedback about the details easily.

2.1 Requirements Collection

The primary target for the project is to develop new improved solutions for reducing noise and dust problems related to crushing and screening processes. The project will concentrate on track mounted crushing and screening units (known as Lokotrack™-concept). However most of the solutions to be developed should be adoptable for traditional crushing plants as well.

Figure 2. Track mounted crushing unit, Metso LT110.

As already mentioned the project is cooperating deeply with some key customers in Finland. Selecting of Finnish customers as partners in this project is not only due to near location from the R&D organization point of view. The Finnish construction segment is the most experienced users of mobile crushing concept. In addition they need to operate in quite varying conditions (especially temperatures -30 to +30 Celsius). From customer point of view the requirements are quite obvious and can be simplified as follows:

1) The solution must be effective (noise or dust).
2) The solution must fit to existing machinery because these will be used typically at least 10–15 years.
3) The solution must be detachable due to transportability requirements and the fact that not all crushing sites require using it.

4) The solution must be easy to install (after the transport to the new site).
5) The solution must enable performing routine maintenance tasks easily.
6) The solution must enable clearing any process problems easily.
7) The solution must be durable and work in all weather conditions.
8) The installation and operation of the solution must be easy and safe.

In addition Metso Minerals needs to define how to create modular solutions so that same parts can be reused with as many product models as possible (due to cost requirements). However this is not dominant requirement from the concept evaluation point of view.

Many of the requirements above will result further technical (design) requirements. Also the product (mobile crusher) will set a range of boundary conditions which needs to be taken into account in the concept design.

2.2 Verification & Validation

The purpose of verification and validation tasks is to make sure that both the technical requirements and the customer expectations will be met. However in the concept development phase of the project more emphasis is put on finding a solution principle that is most valued by the customer.

In this case technical verification is used for ensuring that solution proposals are feasible and effective. For instance a noise reducing solution prototype was developed by using a combination of simulation and measurements. Based on this iteration a physical prototype was designed and built. This prototype is mainly used for verifying the noise simulation results.

In conceptual design phase the customer validation is used for selecting best solution alternatives for further development. The feedback from customers is very useful for this development and could even result totally new solution alternatives. VR technology enables improved visual experience for the reviewers (customers) which support communication between R&D and customers.

VR models should support the validation of the most critical customer requirements – mainly assembly/disassembly phases, routine maintenance tasks (accessibility) and clearing of process problems.

3. Virtual Environment Systems

In this study, a VE system in VTT Tampere, Finland was used for demonstrations. The VE system (Figure) consists of several subsystems:

- visualisation
- user interface devices
- audio system
- physics simulation
- recording system.

The calculation of the physics, visualisation and device management were distributed over three computers. Communication between subsystems was handled throughout by the Virtual Reality Peripheral Network (VRPN). Also real devices were connected via the VRPN to this VE system. These devices included:

- Tracking system
- Input devices like joysticks
- Motion platform
- Haptic devices
- Data gloves, etc.

Figure 3. Virtual Environment system used onsite at VTT.

The fundamental idea behind the established VE system was that it was relatively low cost, easily re-configurable, and the immersion level was reasonable enough for, for example, designing a cabin.

The visualisation system includes three 2.7 x 2.05 metre screens, three video-projectors and shutter glasses. The system enables a stereographic view to be portrayed in all four screens. Optical motion tracking enables the calculation of movements of the user's head and the correct viewing angle in the VE, as well as the control of the movements of the digital human model, which can be utilised in various HF analyses. The UI configuration is flexible, i.e. it is possible to connect different type of UI devices into the system. The devices can be real control instruments of mobile machines, or they can be, for example, gaming devices. Haptic UI devices enable the "touching" of virtual UIs. Also 5DT's data gloves can be used with this system. The calculation of physics, visualisation and device management are distributed in three computers. The functions and physics of the mobile machine can be simulated in real-time. Some actions of the users can be recorded in order to analyse human factors.

4. Summary

In previous VR/AR projects Metso Minerals and VTT have been working together in order to find out how these simulation tools could be used in product development. These tasks have been performed in “practicing mode” i.e. lot of time and efforts have been used in transforming 3D-data and planning tasks. Now in August–September 2011 we are finally using these systems in real life. This means that there will be maximum of week or maybe two available for preparing VR models for the demonstrations and at the same time engineering will make final design adjustments to the solution alternatives.

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Evaluating a modular virtual reality platform for high-skilled, high-value manual tasks in real industrial cases

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Abstract

This paper details the development and design of a Human Factors (HF) evaluation study being used to inform development iterations of the ManuVAR solution – a modular virtual reality platform to be used to support high-value manual work throughout the product lifecycle in 5 different industrial areas: terrestrial satellite assembly, assembly line design, remote maintenance of trains, inspection and maintenance of power plants, and large machine assembly process design.

1. Introduction

The ManuVAR project is a response to changes in the European manual-labour market and aims to harness the potential of VR (virtual reality) and AR (augmented reality) to develop a technology platform and a framework to support cost-effective high-value, high-knowledge manual work in Europe taking into account the entire product lifecycle [1]. The goals of ManuVAR are to: (i) identify industrial problems – targeting real issues for real organisations; (ii) develop innovative VR and AR solutions to these issues; (iii) demonstrate value for European industry; and (iv) produce a commercial tool to assist more European industries to address outsourcing. This paper gives an overview of the project, the development of the evaluation study design, the methods used, and some preliminary results on the effectiveness of the approach.

2. The industrial Areas

The industrial areas defined in the project were allocated into five clusters. Cluster 1 uses VR and AR to assist experienced technicians to plan and prepare procedures in the **assembly of space probes and spacecraft**. Cluster 2 involves **ergonomic workstation design and assessment using VR tracking.** Cluster 3 uses AR to provide **remote on-line support for railyway maintenance** by enabling maintenance experts from a remote location to guide the operators through tasks and to easily exchange useful information in real-time. Cluster 4 uses VR to provide **procedural and motor skills training** to inspection and maitenance engineers of nuclear power plants. Cluster 5 uses VR and AR to improve the **design of manual assembly and maintenance tasks** in the mining, minerals processing, and civil engineering fields and to support the Product Lifecycle Management (PLM) process.

3. Evaluation study design

The evaluation of iterative developments of the ManuVAR solution was challenging as it included various people from designers to factory workers, operators, maintenance personnel, and end-users – all spread across the whole system life-cycle and located in diverse industries. A user-centered participatory design approach was adopted. This actively involves the relevant stakeholders in the design and evaluation process [2] and ensures that the cases developed are socially valid and that the technology matches the needs of the user. The ManuVAR project involved the HF research team from the outset in the gathering of requirements from the industrial partner organisations and the specification of the solutions for each cluster's requirements.

There were four levels of trials, each successively more complex than the last and incorporating more features to support the industrial partners in achieving their goals of improving efficiency and productivity in manual work. The trial method applied was compliant with the ‘test (using demonstration)’ from the ECCS Standard for Verification in Space Engineering [3].

Evaluation Methods used

1. Symptoms check-list – Self-complete user checklist for sickness symptoms and comfort before and after the trial.
2. Observation Protocol – Structured around the following areas: Setting up the task, Performing the task, Display of task progress, Accessing and storing data, Visualising the data, General issues.
3. Interview – Questions requested feedback on the following: Suggestions for improvement in the application, Cost effectiveness of the application, Efficiency of the application, Application training required, Organizational restrictions for using the application, Real world transfer.
4. Questionnaire – Covering the same areas as the observation protocol.

4. Example of HF impact in design

Between Trial 1 and Trial 2 the number of elements that were rated as having a ‘*major usability problem’* fell from 40% to 15% (results from non-functional and HF elements of the observation protocol and corroborated by interview results). This serves to highlight the way in which the evaluation framework is serving to make the ManuVAR tools more usable as the iterative development continues. Taking the example of **Cluster 2** we can see how this works in practice:

“Setting up the task”
Average rating Trial 1: 3 (major usability problem)
Average rating Trial 2: 2 (minor usability problem)

Improvements: After trial 1 it was pointed out to the developer the need to allow the user to see and modify guidelines to be used for assessment, scope of the assessment. In Trial 2 the input page was introduced following this suggestion. Remaining features are now in the process of being implemented for the next trial (Trial 3) however the tool has already shown major improvement.

"Visualising the data"
Average rating Trial 1: 3 (major usability problem)
Average rating Trial 2: 2 (minor usability problem)

Improvements: As a result of the suggestions made at Trial 1 and the subsequent development work the Trial 2 application provided the user with the ability to query the "red" values (the ergonomic analysis uses a traffic light metaphor – green, orange, red) to explain why a value of red or orange has been obtained. For example, the reason for a red value might be a combination of an angle of work, repetition, and task duration. However some improvements are still needed and proposed now as a result of Trial 2 to be improved for Trial 3.

5. Achievements

Notwithstanding the fact that the final trial (Trial 3) remains to be analysed, it is clear from the data that have been gathered that a number of achievements have been made as a result of the incorporation of a comprehensive evaluation framework into the design-develop cycles. Chief amongst these achievements are: a systematic and uniform trial plan and evaluation process across system generations; the verification of the requirements; the evaluation of the HF aspects across the system generations; the assessment of the gaps and Lifecycle coverage and technological advancements; and high user acceptance.

6. Acknowledgements

Funded by the European Commission's Seventh Framework Programme FP7/2007–2013 under grant agreement 211548 "ManuVAR" (www.manuvar.eu).

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Immersive training in oil & gas industries

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Abstract

The process industry always requires research and exploration of new ways to reduce costs, increase revenue and improve security. In the oil and gas industry this need is even greater given the large capital investment, high operating costs, and the serious impact that accidents can have.

The VRSim project allows advanced simulation in virtual reality environments such as entire power plants and refineries. The system consists of stereoscopic 3D interface that allows the exploration of the system with photo quality and a chemical-physical simulator that provides a real-time model of the plant.

The system was successfully tested in important companies in the energy sector. The use of VRSim allows the validation of operational procedures of the systems, optimization of startup and shutdown sequences of lines, the immersive training of operators and the following evaluation of results achieved, the simulation of faults and failures and their management.

1. Introduction

The chemical-physical simulators are usually applied in the process industry. Among the various industrial sectors, the simulation in the oil and gas sector has a role of particular importance for several reasons:

– Large amounts of capital invested in the industry: refineries, LNG (Liquefied Natural Gas), GTL (gas to liquid), IGCC power stations (Integrated Gasification Combined Cycle) are examples of systems for which the investment frequently reaches the billions of euros.

- High operational costs are related to the particular technology, maintenance costs and downtime.
- Safety: serious adverse events in this area may lead to loss of lives and environmental disasters, with costs of hundreds of millions of euros.

Search and explore ways to reduce costs, increase revenue and improve security can lead to significant increases in profits.

This is actually already done, largely, with the use of chemical-physical simulators, used for the engineering design of the plant, in which the component of stereoscopic virtual reality is not present or is present just at the component level to allow the designer to display the prototype of the component (es. AnSys, Honeywell, Siemens).

3DVRS Platform Suite and the VRSim pilot project allow to interface a chemical-physical simulator (in this case that of the company Invensys) to a stereoscopic virtual reality 3D interface, while extending the use of immersive training simulation also to the field operators. In this case the simulation is not only of the failures but also their management by the field operators.

The VRSim pilot project, contained in Kiosk and EyeSim [3, 4] products marketed by Invensys, is a milestone in the field of advanced simulation in 3D stereoscopic virtual reality and augmented reality, while the platform 3DVRS Suite (in progress) is beyond the state of the art for the development of similar simulators.

2. VRSim

The VRSim product was the first simulation engine in 3D stereoscopic immersive virtual reality implemented by VRMMP. The oil & gas has been chosen as field of application thanks to the partnership with Invensys, which has provided its Dynsim chemical & physical simulator.

2.1 Features

The VRSim main purpose is to improve plant safety through appropriate training aimed at:

- Improve knowledge of the system: the exploration of the system in the virtual environment leads to learn procedures and skills that can be re-used in the real field.
- Reduce errors: for example, in operations carried out rarely for maintenance.
- To manage potentially dangerous situations: through the simulation of different types of accidents such as gas leaks, explosions, fires etc.

The use of VRSim allows to conduct analysis to improve operational management. The optimization procedure leads to the reduction of time and costs for common tasks like startup and shutdown of equipment. Through the effects of augmented reality you can keep under control the main parameters of the system, such as temperature and pressure versus time, and check the effect of the operations on the dynamics of the system.

Training in virtual environment can be performed by a single operator or by an entire operators team with a supervisor. VRSim allows training on specific scenarios with the help of a tutorial. After the learning session, with the same application can be assessed the level of expertise achieved. Periodic assessment sessions can contribute to the maintenance of the knowledge acquired over time.

2.2 Architecture

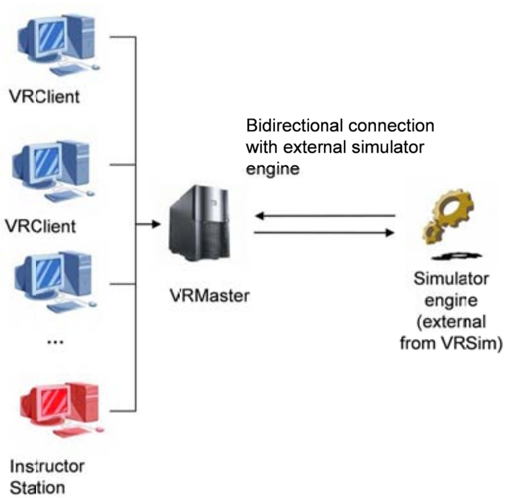
VRSim is based on the Delta3D [2] simulation engine. Among other open source technologies used there are: OpenSceneGraph, OpenGL, OpenAL and nVidia Physx. VRSim is intendend to be used on a Windows workstation with a standard 32-bit or 64-bit architecture, nVidia Quadro graphics cards and nVidia 3DVision kit for stereoscopic vision.

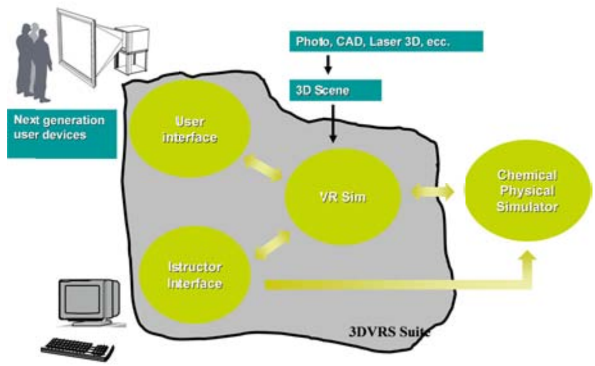
The architecture of the simulator VRSim includes the following modules:

- VRMaster: is the server application that handles communication between all other modules. Users never interact directly with the server. This component communicates in real time, in both directions, with the external physical-chemical simulator.
- VRClient: is the application that allows the user to become a field operator in the virtual world. Multiple clients can participate in the same simulation.

– Instructor Station: is the supervision application that allows the instructor to monitor the simulation. Through the instructor station is possible to locate the various actors in the simulated environment, check the weather conditions of the scene, drive failure events, record a simulation session and present it again in playback.

– VRViewer: is the application to navigate the virtual environment in a standalone way disconnected from VRMaster.





3. 3DVRS Suite

The implementation of VRSim has showed the need to have a platform and a development suite for more efficient realizations and generalization of the idea. This suite, through a graphical user interface, will make possible to implement new 3D simulators in a fast and efficient manner, potentially also in areas other than oil&gas, and interfaced with various chemical-physical simulators.

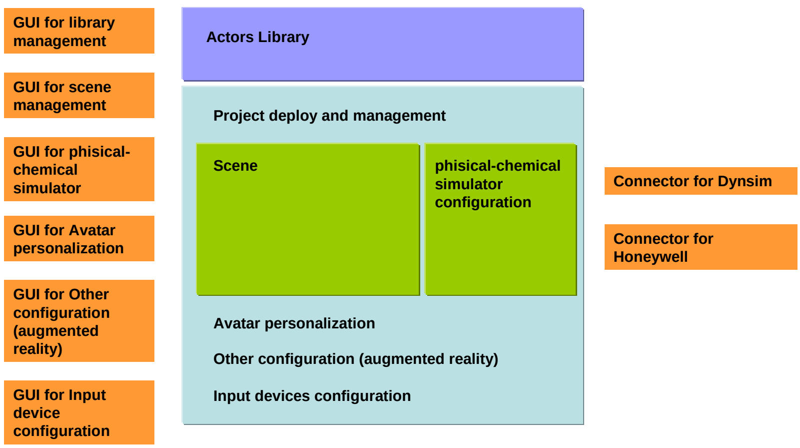
VRSim's experience has served to crystallize the general architecture of the simulator, while research into the development of a standard production pipeline and development of a graphical suite that limits the need to write code is currently work in progress with the creation of the suite 3DVRSSuite.

3.1 Features

The platform 3DVRS Suite allows you to create 3D virtual reality simulators of which VRSim is an example. Who uses the platform, in a very simple GUI environment, can build new simulators for various types of industrial plants.

The platform provides a set of graphical tools with which:

- manage the content library for creating the scene
- create the scene to simulate the overall system
- customize the interface to a chemical-physical simulator; the 3DVRS platform is open to different types of chemical-physical simulator
- change the appearance of the avatar in the scene
- prepare the final installer simulator.



4. Saving obtained with VRSim and 3DVRSSuite

EyeSim, which uses VRSim as 3D immersive interface, allows you to completely change the methodology of training, replacing the field training with classroom training, with significant cost savings and increased efficiency.

Similarly, the Kiosk product, still using VRSim, allows the execution of assessment test giving the possibility to assess the capabilities of operators (also in danger situations) with much lower costs.

Typical savings of first customers that adopt VRSim technology include:

- Saved 30 to 40% on time and cost for job training.
- Reduced time of startups/shutdowns by 15% to 20%.
- Saved 1 to 3% on maintenance budgets.

The platform 3DVRS Suite, according to our estimates and our experience in developing VRSim, will allow to implement new simulators with reduced cost and time.

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MESH – Mise en scène Helper

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Abstract

Real-time 3D computer graphics environments have become widespread in several fields, such as film previsualization, edutainment applications, simulation-based training, multimedia installations. This paper presents the software environment MESH (Mise-En-Scène Helper), thatprovidesa simplified computer graphics environment for scene layout and action schedule, and a local desktop + web-based 3D player, that can visualize/auralize the scene (also on the web). MESH was employed in a number of projects of film pre-visualizations, linear video productions, and multimedia installations.

1. Introduction

The relevance of real-time computer graphics is multimedia authoring is acknowledged in several areas of production, ranging from pre-visualization to virtual cinematography to the development of interactive applications.

Pre-visualization, that is the practice to visualize a film before actually shooting it [2], has been mostly addressed with real-time 3D graphics, starting from the work with high-end programs such as Maya (and Motionbuilder), 3D Studio Max, Softimage XSI, and Poser. The final result is delivered as a video showing the complete shooting set and a number of technical prints to organize the set at the best for the optimization of resources.In addition, a number of specific programs have emerged, that are marketed for pre-visualization and production in

"Machinima" (i.e., Machine cinema) style [5], respectively. Known examples are iClone, FrameForge and Moviestorm[1]. All of them provide suitable interfaces for the mise-en-scène of events in virtual sets, the definition of multiple virtual camera shootings, and the staging of virtual characters, usually equipped with a set of basic animations. GoogleSketchUpwidens the view of such graphical editors to architectural planning, urban design, house furnishing, scenario editing, also offering the possibility of downloadingfreeuser-built 3D models from the Google Warehouse.

In general, such real-time graphics has its basics in game technology [6], augmented with recording tools to produce high-quality pre-production visualizations. To this goal, a number of real-time game engines have provided own editors, scripting tools, and exporters for content to be used with the engine. The Unreal engine, for example, provides a package for Machinima productions. The visualization of happenings with multimedia installations or architectural designs is an immediate extension to pre-visualization and Machinima production. We can refer to 4D CAD technology (i.e. 3D plus time as fourth dimension on CAD software), used by designers and engineers to analyze and visualize construction projects in order to take decisions on design, plan construction operations, analyze the feasibility of a project, estimate the costs, manage the resource allocation, and communicate with customers and stakeholders [4]. Moreover, the virtual simulation approach is unavoidable in the case of re-constructions of works from the past, such as in the case of [3], where the virtual reconstruction employs 3D real-time-time graphics and spatialized audio to deliver a sense of the original space.

A shift of attention for real-time 3D graphics, from a pre-visualization tool to a production tool has been recently acknowledged and promoted also by Autodesk [1], with the introduction of a pipeline called Virtual Moviemaking. In this pipeline, the pre-production, production, and post-production phases becomes a continuous refinement cycle in the real-time graphics environment, with the possibility of integrating live shooting and CG content on-the-fly, and anticipating most of the integration/compositing process, with greater creativity freedom for the artists involved.

The MESH program contributes to the real-time production paradigm by proposing an open-source platform, with a simplified graphic interface that provides

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[1] http://www.reallusion.com, http://www.frameforge3d.com, http://www.moviestorm.co.uk, respectively.

the controls of the scene layouting and dynamics, respectively, and the possibility of delivering the player as a Java Applet fro the web. MESH has been successfully applied to a number of target areas (pre-visualization for film, architecture, and exhibitions, video production, documentation of cultural heritage).

2. The MESH platformand applications

The MESH software architecture (see Figure 1) consists in a core platform, called Enthusiasm, that includes the high-level graphic framework Tarta4D, the Sound Manager, and the graphic interface Director Studio, with the associated Control Score Player.

The core of the scene rendering is the Tarta4D Framework, a rendering library and 3D engine that offers high-level functionalities: import of 3D objects authored with the most popular 3D authoring tools (including SketchUp); real–time 3D rendering, animation and automated blending; spatialized 3D audio; rigid bodies physical simulation; multi-platform support (Windows, Linux, MacOS X), simplified scene management (with Input/Output support), multi-thread support, C++ and Java APIs, effortless integration in Java AWT/Swing interfaces, GUI for scene authoring. For these functionalities, Tarta4D relies on a number of open-source libraries: Ogre3D, for real-time 3D visual rendering; Open Dynamics Engine (ODE), for rigid-body physical simulation; OpenAL, for real-time spatialized audio; TinyXML, to store and retrieve 3D scenes description in an XML format; SWIG, for the Java interface of Tarta4D; the IKAN package for inverse kinematics in character animation; the OggVorbis library for audio decoding and streaming.

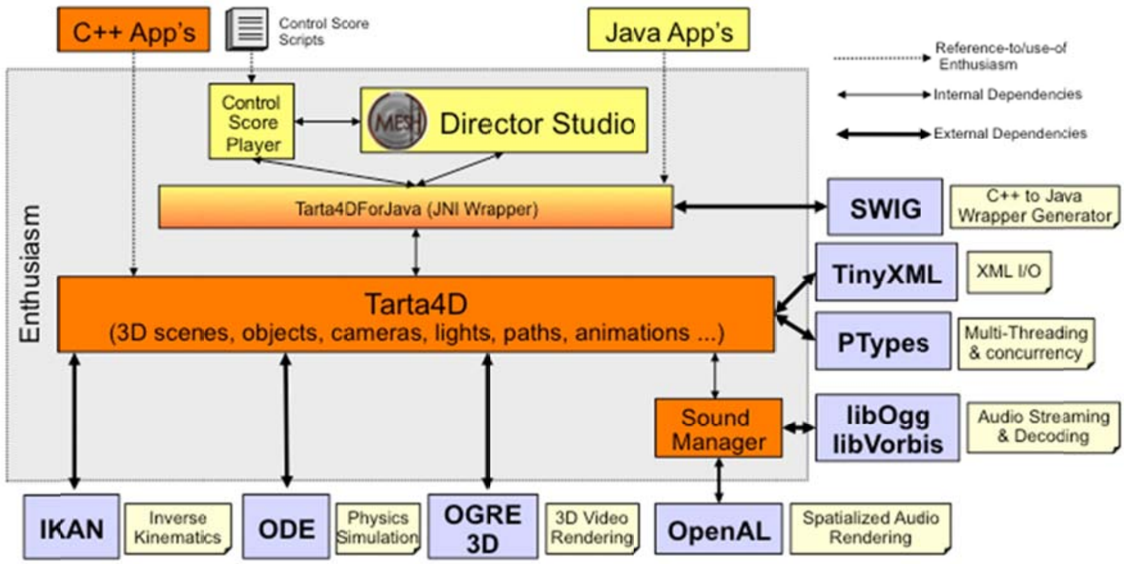

Figure 1. The MESH architecture, with the Enthusiasm platform and the Tarta4D framework. Yellow/lighter modules are written in Java; orange/darker modules are written in C++.

The Director Studio is a set of windows that allows the author to control the initial layout and the dynamic behaviour of all the elements of a scene, namely object instances, cameras, lights, animated characters, paths for the displacement of cameras and characters. As for the majority of authoring tools, the elements are arranged onto a hierarchy.The Director Studio also provides the capability of publishing a content, that is to capture the dynamics of a scene in a video that depends on the action sequence spanning the timeline in the control score, and edited according to the camera switching commands.

The work methodology with MESH, assessed in a number of case studies setting, is to start from sketches and textual descriptions to build a 3D scene of the situation; given the final output, set lights and cameras, elaborate textural and shader-based materials, with more or less sophistication; then, elaborate a control score of the scene dynamics, capture the scene executed and published in the required format, alternatively, produce a delivery of an interactive application.

The MESH platform, though at a development stage, has been already employed in a number of projects. Actually, we can say that the development of most of MESH features relies upon the requirements posed by the applicative projects we have carried out. In this section, we describe a few significant projects that have contributed to mould the workflow described above. Their diversity has accounted for a balanced development of the MESH program, with features useful in many design and production areas. We think of providing some customization in the future, in order to specialize the authoring process in some restricted domains, such as, e.g., filmmaking and architectural visualization.

In the case of previsualization (Figure 2, left), MESH was employed for preparing a virtual set for shooting scenes. Beyond scenographic and character elements, MESH provides several standard camera optics for shooting simulation and staff members to position in the set for appreciating the actual structure of the shooting set and organize the shooting activity at best. MESH allows directors and producers to avoid set design errors and save time in mise-en-scène.

Figure 2. (Left) Pre-visualization of a fictional story and the actual shooting ("Eva Kant", IlariaChiesa, independent, 2009); (center) Reconstruction of a mountain area during Pleistocenes (Turin: history of the city, Jalla/Donadio, Fondazione Torino Musei, 2011); (right) Video for a new incinerator (TRM, 2011).

MESH was also used for two video productions: the firsttold the realization of a multimedia exhibition and has required the modeling of the building from scratch as well asof the dynamic installations therein; the second was about the natural landscape through geological eras (Figure 2, center). The latter video has required the integration, into the pipeline, of a commercial software for the generation of terrains (World Machine 2[2]).Finally, MESH wasusedin acouple of projectsofarchitecturalrenderings (in Figure 2, right, anewincinerator). Here the challengewas to adapt the CAD model to be rendered in real–time in a suggestive mood.

[2]http://www.world-machine.com

3. Conclusions

In this paper, we have presented MESH (Mise-En-Scène Helper), an open–source software tool for multimedia authoring, based on real–time 3D graphics, also delivered as a Java Applet for the web. The renderings can be captured with an integrated recording module.

We wish to thank the CIRMA centre of the University of Torino, for bringing its competence in storytelling and mise-en-scène into the MESH project, and the Chamber of Commerce of Turin for its support to the development of MESH. We also thank Elisa Busca, Enrico De Palo, Fabio Cacciatori and Franco Bevione for their help.

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Mixed reality system and objective ergonomics evaluation for designing work stations in manufacturing industry

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Abstract

Due to shorter productlife cycles in manufacturing industry there is a lot of pressure on the process of designing new work systems. Early attention for human factors would lower the costs compared to changes at a later stage. Low cost tools for workstations design could help especially small to medium sized assembly enterprises. However, these tools are not always available in the form needed by the companies. A promising technology is a mixed reality solution called Ergomix wherein real human operators and virtual work system objects are mixed together. This solution offers a number of advantages, low cost, fast and active participation of engineers, operators and management. However, it does not incorporate an objective evaluation of ergonomics of the workstation yet. This will be available in near future.

1. Introduction

Market forces continuously drive manufacturing enterprises to optimize their operational processes. These also put pressure on the process of designing new work systems and work stations. For flexibility purposes, human operators are still present in many manufacturing operations and therefore, one of the challenges here is the inclusion of human factors in an early stage of the design process [1]. Early attention for human factors would lower the costs compared to retrofitting changes for human factors reasons at a later stage [2]. Moreover, the participation of human factors experts and company representatives like process engineers, production managers or operators is crucial in this stage for reasons that have been extensively indicated and discussed in previous papers on participatory ergonomics [3, 4].

Krassi et al. [5] evaluated the most prominent problems facing modern manufacturing industry today. Two of these are: an ineffective design process and the low acceptance of new technology especially in the small to medium sized enterprises. Low cost activating tools for workstations design could help especially small to medium sized assembly enterprises to both optimize the assembly workstations and involve their workers. However, these tools are not always available in the form needed by the companies. Relevant technologies to address the human factor in early design in this respect are VR simulators or Digital Human Modeling, but these tools are often too complicated and too costly [6]. A promising technology is the mixed reality solution called Ergomix, which can be used to create environments wherein real human operators and virtual work system objects are presented together in one environment [4]. This solution offers a number of advantages, such as rapid availability, low development cost and active participation of engineers, operators and production management [7]. However, it does not incorporate an objective evaluation of the ergonomics of the workstation yet. Moreover, a transition to a mobile form may increase the range of application.

In this paper five implemented case studies of manufacturing ergonomic situations using Ergomix are evaluated and future developments for further improvements are described.

2. Methods

In the case studies the Ergomix is used as part of a larger, more comprehensive participatory ergonomics approach. Goals of this approach are involvement of assembly workers and managers, lead time reduction, increase of productivity and flexibility and an improvement of the assembly tasks in an ergonomic sense. The main elements of the approach are the active participation of the company, the integration of two basic disciplines: assembly engineering and ergonomics, and its stepwise nature. The main steps are: 1. analysis of the assembly process, 2. analysis of bottle necks in flow and ergonomics; 3. design of new assembly system and flow line; 4. design and evaluation of new assembly workstation as part of the system, and 5. implementation and evaluation of the whole new system and workstations. The fourth step in the process has often been performed using the mixed-reality workplace simulation called Ergomix [8]. In the Ergomix, a real assembly-line worker is placed in a virtual workstation, represented as a picture or drawing (see Figure 1).

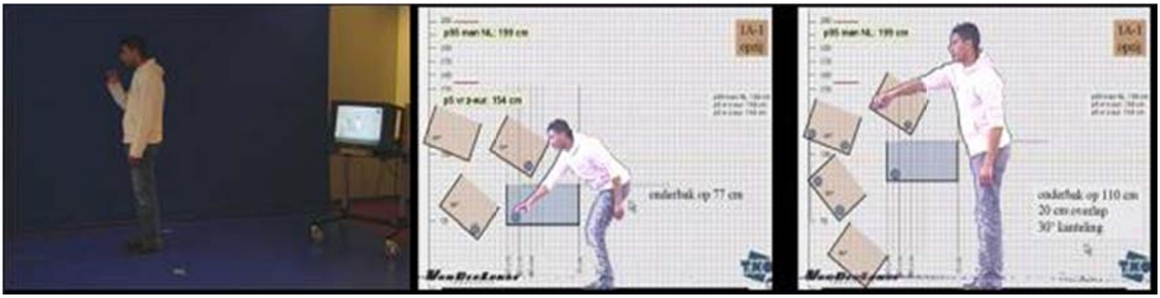

Figure 1. In Ergomix a real worker is placed in a drawing of the workstation.

Workers are the actors in their own "virtual" workstation and are asked to perform their usual assembly activities. The chromakey technology allows the employees to be shown in workplace sketches or CAD drawings in which their normal working behavior is simulated and made directly visible to themselves and others. The working height and reach in the drawings can be immediately adjusted so that the right work posture is obtained. The whole scene "scaled" such that a worker can represent a larger or smaller worker within that workspace. In these sessions, the ergonomist leading the Ergomix session works with the employees, engineers, and management, as well as outside constructors of the workplace equipment.

3. Results

To examine the utility of the mixed-reality system, five case studies on (re)designing manufacturing lines were analyzed. The results of these cases are shown in Table 1.

Table 1: Summary of the 5 Ergomix case studies.

Case	**Risk assessment before Ergomix**	**Risk assessment after Ergomix**	**Ergomix outcomes**	**Impact of total project improving productivity and ergonomics.**
Producer of handling systems	Static and repetitive arm lifting: red Trunk bending: red	Static and repetitive arm lifting: green Trunk bending: yellow	One level high-capacity compact order picking workstation	Sustained performance for a period of 4 hours, no increase in locally perceived discomfort, energetic loading, muscle fatigue in the fore arms and hand and no increase in perceived mental exertion
Producer of shavers	Applied finger force: red Static arm lifting: red	Applied finger force: green Static arm lifting: green	Volume flexible packaging line for sitting and standing working	Operators satisfied with their new workstations, work content was reduced by 50%
Producer of envelop inserting machines	Static arm lifting: red Lifting and carrying: yellow	Static arm lifting: green Lifting and carrying: green	Healthy component locations and ergonomic racks	85% of employees assessed workplace layout as much better, 93% assess the supply of plate material as better, 75% felt new racks improved
Producer of coffee machines	Lifting: red Static and repetitive arm lifting: red	Sitting + standing working posture; reduction of arm lifting	Flexible production line with height adjustable workstations	Increase of production 15%, 300% increase in through-put, floor space reduction 26%, Work in progress decreased 75%
Producer of roof systems)	Static and repetitive arm lifting: red	Reduction of arm lifting	Reduced height and distance	Increase of awareness on ergonomics

4. Conclusions and future work

From these five case studies, it can be demonstrated that Ergomix simulation of the workstations allows relatively fast and easy ergonomic intervention early in the design process. Other achievements for the five case studies demonstrate that all new designs resulting from the Ergomix session reduced the musculoskeletal risk factors.

Ergomix is a medium fidelity MR simulation solution somewhere along the continuum between a paper-prototype/checklist and the traditional human modeling/CAD programs or full VR simulations. Ergomix costs are a fraction as much as the more traditional human modeling CAD system and similar evaluations take much less time than the traditional modeling, with no lengthy programming required [9]. The greatest advantage of the Ergomix is the ability to change the parameters in real time while the end-users and other participants are present.

One drawback of the system is the limited accuracy. Specific effects of changes of less than a few mm cannot be studied with this system. Also, the Ergomix simulation is only physical, not cognitive and if there is no physical mock-up employed in the simulation, there is no haptic feedback [4]. In addition, no 2-D or even 3-D force modeling software is currently integrated with this mixed-reality simulation system; currently, the most awkward postures/ highest force or lifting cases are modeled in other software and guidelines (e.g. [10, 11] which is not integrated with the Ergomix. Unlike mathematical simulation models, but like most DHM software and VR technologies, the Ergomix cannot evaluate time aspects like (sustained) performance over a time period, frequency or pacing or perform thousands of repetitions with random variation and different inputs. The Ergomix is not applicable in all situations of production line improvement. For instance, for more complex or detailed engineering other systems like a VR cave or complex CAD models are more appropriate, with the latter to study the effects on musculoskeletal loading, or the best fidelity is to perform experiments with real adapted production lines and instrumented workers.

To overcome some of the shortcomings mentioned above some new developments were started to improve the Ergomix system. These new developments in the past year constitute of four elements:

1. An upgraded, digital and mobile Ergomix system.
2. A mobile system for motion capturing, i.e a sensor suit capturing.
3. A fully automated software module translating the captured kinematic data into the input required for the application of the most relevant risk assessment guidelines.
4. Fully automated risk assessment of the health risk in a traffic light manner (red, yellow or green). The objective evaluation is experienced as a main improvement, since the subjective experiences of the worker in the Ergomix environment are now ‘supported’ by objective

evaluations of the health risks related to repetitive movements and static body postures.

The developed connections across mixed reality, human motion capturing systems and ergonomic guidelines could make the system more valuable to be able to show the effects on the whole body in an early design phase. These connections may be useful to close the gap between low end and high end users without losing the flexibility and user acceptance of the already existing level of use.

Acknowledgement

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Remote Maintenance Support in the Railway Industry

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Abstract

Railway vehicles are complex systems that contain elements associated with a complete range of engineering disciplines. From the workings of a modern traction motor to the dynamics of vehicle suspension, to the control systems for signalling and train safety, different expertise is required to address and solve maintenance issues repair faults and prevent them reoccurring. This paper describes how augmented reality (AR) technology has been developed to address the need to assist maintenance staff at a remote location faced with a system fault, and where expert advice is sought either from co-workers at the maintenance headquarters, or from the system supplier. The collaborative work achieved so far by Tecnalia and NEM Solutions, within the EU funded project ManuVAR [1], demonstrates how time and resource dedication to maintenance tasks can be reduced through the use of AR technology, asset availability can be increased, and in addition AR footage can be used at a later date for training purposes or for feedback into the product or system lifecycle.

1. Introduction

1.1 Stakeholders

NEM Solutions (NEM) is a company dedicated to improving the effectiveness and efficiency of maintenance activities. It works with asset maintainers for the transport and energy markets in order to achieve savings in maintenance and lifecycle costs, whilst ensuring or improving asset reliability, availability and safety. NEM Solutions develops both hardware products and software applications that are provided as a service to enhance business performance and to meet the high expectations of the end user.

TECNALIA Research & Innovation (TECNALIA) is a private, non-profit research organisation resulting from the merge of eight research centres: Cidemco, ESI, EUVE, Fatronik, Inasmet, Labein, Leia and Robotiker. It is the leading private research and technology entity in Spain and the fifth largest in Europe. TECNALIA operates in: Industry and Transport, ICT, Sustainable Development, Innovation Systems and Health and Quality of Life. TECNALIA is very active in FP7, participating in 170 projects and coordinating 38 of them. Tecnalia has a strong market orientation and it contributes to management and social development, transferring new technologies to companies, or promoting the creation of new management activities.

TECNALIA has worked on a number of projects with NEM Solutions to provide advanced product development to meet the demands of maintainers and to bring technology to the forefront of what often is seen as an industry based on tradition and past working practices. The work presented in this paper forms part of the EU funded project ManuVAR [1].

1.2 Demands on current working practices

Train fleets are expected to have an operational service life of 20–30 years during which preventive and corrective maintenance must be undertaken to ensure that trains are reliable (i.e. they will not breakdown during service), they have high availability (i.e. there is a high proportion of the fleet available for service when required) and that high safety standards are met or surpassed.

As customer expectations of passenger services increase and as many countries open the railway industry to the competitive private sector, there is an ever increasing demand on maintainers to provide a high quality throughput at low cost.

Corrective maintenance is unplanned and must be undertaken swiftly to ensure that the train is available for service as soon as required. This may often have to be undertaken outside of the main depot, either on open track, at a station, or an alternative less-equipped depot. It often takes place on equipment mounted in a confined space, where parts are often hidden to view, and it is often difficult for the maintainer to have documents and drawings close at hand when attending the faulty equipment [2].

As corrective maintenance cannot be planned, the time and cost involved in repairing faults is significant and difficult to predict and control. Furthermore, maintenance staff must be made available to travel to the site of the train failure. They may not be specifically qualified in the equipment or system that has failed and they can only hope that they take with them the correct information, tools and spare parts required. Once at the scene, remote support is often given over the phone from an expert, but does not prove a good effective medium for diagnosing faults and instructing the onsite worker. Often the expert is required to travel to the site of the train.

In order to reduce the time taken in both diagnosing faults and determining corrective actions, a method of providing real-time audio and visual support together with information fed from engineering models, equipment condition data and historical maintenance records is required.

2. Objectives of the Augmented Reality application tool

The principal objectives of the work undertaken can be summarised as follows:

- To reduce the cost incurred in unplanned maintenance by reducing the time and resources required for accurate fault diagnosis and in the planning and execution of corrective maintenance actions
- To capture knowledge and provide ‘first-hand’ feedback of maintenance activities to those involved at different stages of the product lifecycle in order that future improvements can be made to people, processes and products.

Working in close collaboration with maintainers and system developers, a solution was proposed and a set of user requirements defined.

3. Current development and description of AR application tool

The solution under development consists of using a pair of augmented reality goggles and video streaming over the internet to connect the onsite worker with a central location, or 'hub'. The concept of the application is shown in Figure 1.

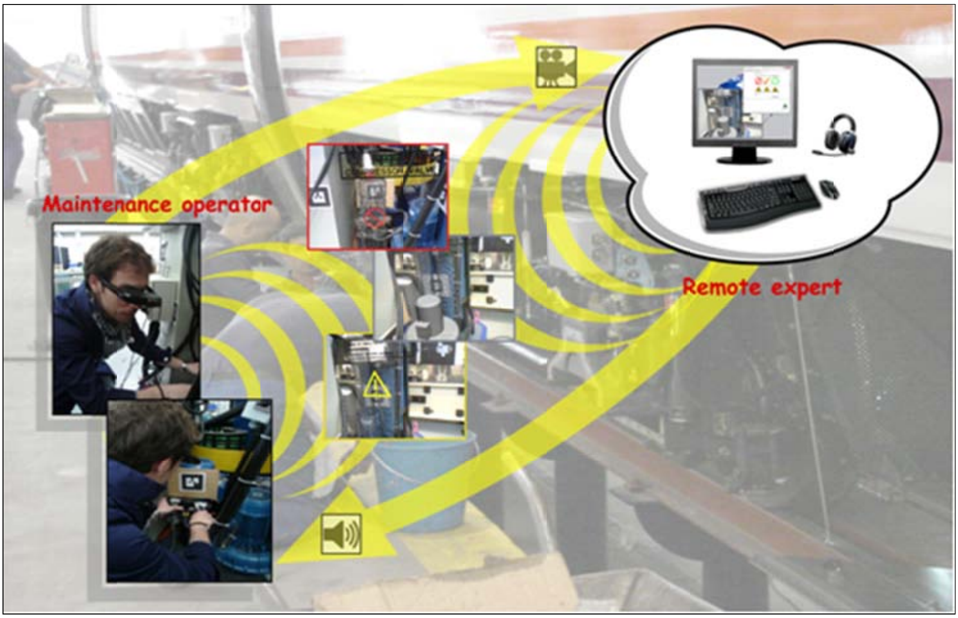

Figure 1. Concept of AR based remote maintenance support.

A brief description of the main components that are part of the application is given below:

– Pro Mobile Display iWear VR920 from Vuzix[1]: augmented reality goggles used to offer a combined and smart view of the reality and the virtual objects

1 http://www.vuzix.com/home

- ALVAR library[2]: ALVAR is a suite of products and libraries for creating virtual and augmented reality applications, developed by the VTT Technical Research Center of Finland and used to perform marker based recognition and tracking of the virtual objects
- LibVLC[3]: the external programming interface of the VLC media player to provide video & audio streaming among involved actors.

Thus, virtual representations of the equipment, together with useful information provided by the hub worker for diagnostics can be shown to the onsite worker (Figure 2) through a pair of augmented reality goggles.

Figure 2. Example of 3D objects that are overlaid through the use of AR goggles.

Maintenance information directly available to the hub worker can be channelled to the onsite worker through the AR system. This can extend from recent asset condition information (e.g. oil quality, pressure/temperature readings, power rating) through to asset history details (maintenance task history, operational hours, wear parameters, next programmed maintenance, etc) and maintenance task procedures. The AR overlay of this information could be configured, depending on the size and format required to be shown and whether it is to be tracked to specific locations.

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[2] http://virtual.vtt.fi/virtual/proj2/multimedia/alvar.html
[3] http://wiki.videolan.org/LibVLC

4. Benefits of using the AR application tool

The 3D model overlaid on the real video image seen through the worker's goggles, allows the expert to guide the onsite worker to perform tasks by signalling specific components or features, giving instructions and giving visual warnings of safety hazards.

This enables the worker through audio and visual interaction with their colleague, to quickly focus on determining the cause of equipment failure and decide on which corrective maintenance actions to undertake.

Expected cost savings are achieved by:

- Significant reduction in the time required by workers to diagnose fault and decide appropriate actions
- Elimination of need for expert to travel to site (both cost and time savings)
- Only key staff are involved in the task
- Lower financial penalties imposed due to reduced impact on asset operation and availability.

Additionally, the recorded video including the 3D model overlay, can later be used for training purposes, or to highlight areas for improvement in equipment design and manufacture, and to suggest ways to increase its maintainability.

The AR video when used in training is a mixture of a classroom and practical approach; trainees learn the theoretical syllabus while observing annotated examples of real tasks being performed in their actual environment. In this way, savings are made in being able to provide more effective training to staff.

With respect to design, issues such as fatigue problems, component wear, dynamic instability etc can be captured in a video and later shown to equipment designers and integrators. Manufacturing and instalation issues such as poor material quality, or tolerance problems can be viewed. The ease or difficulty of undertaking repair work can be highlighted, for example in confined space (or interference) to undo fastenings, or poor visibility to check structural integrity etc.

5. Future Work and Deployment

A number of issues are currently being worked on in order to improve the current performance and functionality of the application. The fact that the worker's distance from train equipment varies from over 2m down to 20cm requires careful calibration and positioning of markers and advanced tracking. TECNALIA is working at present to provide a markerless or hybrid tracking system to avoid the need to position temporary markers onto the train.

Future work will be focussed towards increasing the user engagement with the 3D model and information displayed through the AR goggles. This will increase the ability of the onsite worker and hub worker to diagnose faults quicker through improved interaction of computer generated imagery and text.

The application tool will be demonstrated and evaluated by potential users in the railway vehicle maintenance sector at the end of the year and during the first quarter of 2012.

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Abstract

COSE (**CO**llaborative **S**ystem **E**ngineering) Centre is a multimedia centre which has been started by Thales Alenia Space Italia (TAS-I) taking advantage of an EU/FP5 project called "VIEW of the future" (Virtual and Interactive Environment for Workplaces of the Future).

The Centre is supported by its Technology Research Office (TRO), in cooperation with local universities, hosting the development of a VE platform called VERITAS (Virtual Environment Research in Thales Alenia Space), based on open-source components. Synergies with other domains have been investigated and contacts have been established with other domains, such as aeronautics, railway transportation, energy production, astrophysics and civil protection. The utilisation of the Centre brings positive results improving the relations with Customers and Suppliers because it allows reducing the time normally required for results evaluation/assessment by the programme teams usually composed by many different and multidisciplinary experts.

1. Introduction

TAS-I is actively participating to the vision that should enhance dramatically the use of virtual product technologies, following two main branches: the user interaction with the virtual product, and the data production and exchange by engineering teams. In the first case the research is centred in virtual reality technologies, driven by the advances in the entertainment and games domains which represent nowadays most of the worldwide technological push. In the second case the focus is the system data modelling, the data exchange between system and engineering disciplines so to build a Model-Base System Engineering (MBSE) methodology using also the current enhancements of SW developments process. The final goal is to have a multidisciplinary (functional and physical) representation of the system, built up concurrently, with enhanced 3D and 2D (e.g. using SysML notation), desktop or immersive, user-interaction. Therefore the user is considered as centre and objective of the development, through the research on web-based collaboration, immersive virtual reality and use of interaction devices (e.g. haptic devices).

2. The COSE Centre

The TAS-I COSE Centre is utilized as a tool to support on demand project activities. The Centre includes a Virtual Reality Laboratory (VR-Lab), a Collaborative Room and a Technology Research Office (see Figure 1). The collaborative room follows space Agencies [2] related R&T and European Cooperation for Space Standardisation (ECSS) rules/activities thus the VR-LAB is mainly developed thanks to TAS-I collaboration in EU projects.

Figure 1. Torino COSE Centre.

2.1 VR-LAB

TAS-I Virtual Reality Laboratory (VR-LAB) is aimed to the study of VR applications to design and development activities of complex systems, including training & educations. The application of the facility has been already partially extended towards all system and subsystem engineering disciplines, such as integration and testing, and the interactions among them in the concurrent design definition and verification processes. Thanks to Tecnology Research Office (TRO) experts, VERITAS is used on requests by programmes and continuously maintained/improved according to the users' requests. Many programmes and astronauts already tested VR-LAB contributing to its requirements definitions.

2.1.1 VERITAS

VERITAS (Virtual Environment Research In Thales Alenia Space) is a VE (Virtual Environment) based on open-source components platform which allows simulating different 4D scenes from 1 to 6 screens. It is a multi-software and scalable platform that allows VR stereoscopic immersive visualization and that contains specific applications developed on the basis of the real need to represent data e.g. during reviews at System level. VERITAS main technical achievements are especially:

– The various innovative interaction devices (i.e. Mouse, Keyboard, Nintendo Wiimote + Nunchuck, Data Gloves, Haptic Device for force feedback, Tracking System, Motion Capture Suits).
– The solution to precision problems: it supports a multi-steps rendering in order to supply floating point lack of precision.
– The possibility to be interfaced off-line (using ASCII files) or run-time (using TCP or UDP connections) with other software such as Tracking System ART (for optical/infrared motion tracking), Siemens Jack (virtual mannequin application) and other Aerospace Engineering Discipline tools.
– Scalability: a VERITAS application can be rapidly configured to run on different hardware configurations (i.e. single PC, multi PC with stereoscopic visualization (3D Monitor), multi PC with immersive stereoscopic visualization (CAVE)).

– The main output is a 3D simulation of a scene which can be located in the Universe (spacecraft trajectory simulation and Universe exploration), a planetary surface (Earth or Mars, for example), or in a generic virtual space (for example a scene with a spacecraft or any kind of 3D model to analyze it). It is also possible to capture screenshots, create videos, export 3D models and modified scenes.

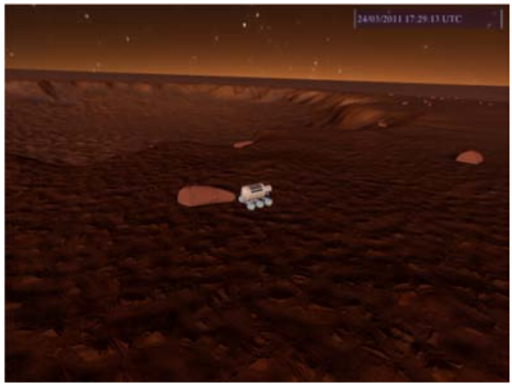
Upon VERITAS platform several applications prototypes have been developed (or are in development) to support:

– Trajectory Visualization: in collaboration with astrophisics scientists it is used for Solar System and Universe exploration, and for trajectory visualization.
– Cargo Accomodation: used to test rack and bags allocation in a S/C module (in xG).
– Radiation Visualisation: used to show radiations around the Earth and dose on a spacecraft.
– Design Review: used for design review and to virtual mock-up analysis.
– Rover Simulation: used to simulate designed rover behaviours on a planetary surface [4].
– Lander Simulation: used to simulate a lander arriving on a planetary surface.
– Tracked data analyser: used to log S/C vibrations during test [3].
– Haptic simulation: used to receive force feedback during critical procedures immersive simulations.
– Natural phenomena simulation: used to simulate natural phenomena (melting glaciers, landslides, etc.). Under developments.
– Inverse kinematics scenario: allow the visualization of a scene with a virtual mannequin and see it moving according to a Motion Capture Suit or to Siemens Jack® software.

Currently in VERITAS the product data is derived from the CAD Model and the environment data are coming from dedicated databases, catalogues and multivariate analysis results. The current internal research and development of a distributed environment for space systems engineering data modelling, integration and collaboration (called DEVICE) considers VERITAS as the best front-end for the end user, both for product structure and behaviour data visualization. Examples of applications in VERITAS.

In the following are described two of the latest applications that TAS-I is developing in VERITAS.

Rover Simulator: is an application used to show a rover moving on a planetary surface. Most of the personalization lies into the loaded scene file. The user can control a rover by interfacing with an external program that sends to the application the torque to be applied to the rover motors. In the present TAS-I scenario the rover moves on the surface of Mars where physical laws such as gravity, frictions, dust behaviour and collision detection are simulated. The user can move the rover throught the accelerometers of two Nintento Wiimote controllers.



ario.

Motion Capture Suit Scenario: is used to evaluate the accessibility/reachability and user's movements in a spacecraft. The user wears Optitrack Motion Capture Suit and the 8 IR cameras get the position of the markers on the suit. The position of a virtual mannequin is processed by the Optitrack SW that communicates with VERITAS through an adapter SW. This allows moving the virtual mannequin in the VE according to the user's movements.

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Using virtual reality for the training of the Metallographic Replica technique used to inspect power plants by TECNATOM S.A.

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Abstract

TECNATOM S.A., an engineering services company which uses the metallographic replica technique in their maintenance procedures within industrial facilities and industrial power plants, is using Virtual Reality (VR) along with haptic feedback to test how these technologies could potentially improve safety and risks management and be a cost efficient way of training and planning of this technique. The paper presents how VR has been used to support this process as part of an EU funded project ManuVAR (http://www.manuvar.eu) and concludes with a discussion on some of the perceived benefits and future requirements of the technologies.

1. Introduction

TECNATOM S.A. is an engineering services company that provides training and assistance in safety issues within industrial facilities and electrical power plants. As part of the evaluation of the structural integrity of the major components within the plant, Tecnatom regularly performs the inspections and tests required by the applicable standards. In many cases, these activities are carried out with high levels of radiation and contamination and in places that are difficult to access. The scope of the activities includes a wide range of inspection techniques, combining the use of remotely-controlled robot-operated equipment and manual tasks carried out in-situ.

2. The Metallographic Replica technique

One test performed by TECNATOM is the metallographic replica which is a non-destructive sampling technique used to measure and analyse the obsolescence of the inner material of structures such as valves, pumps and pipes. The metallographic replica technique is a long and precise process involving several steps that include: preparing the surface of the pipe by grinding, polishing and chemical etching before the Replica application takes place. Some of these steps are performed many times under hazardous conditions in areas with high levels of radiation and contamination and in regions that are difficult to access. In addition, the accurate planning of the Metallographic Replica activity can be complicated due to the lack of up to date information.

Efficient training on Metallographic Replica task is mainly performed in situ and can be undertaken at three different levels (motor skills, procedural and managing hazardous situations). The consequence of this is that workers spend more time on the power plant site and risk being exposed to radiation and other toxic conditions. There is no software solution to support efficient training and task analysis at the laboratory. Task planning is commonly based on obsolete 2D representations of power plant pipe displayed on paper supports.

3. VR training of the Metallographic Replica technique

TECNATOM in collaboration with AARBA, the University of Malaga and the University of Nottingham are developing a methodological and technological framework to support procedural and motor-skills training in VR for the performance of a Metallographic Replica task in a real environment under industrial conditions using a haptic device, as part of the EU funded project ManuVAR [1]. The haptic interaction technique is presented to be of great interest for motor-skills training and has already been included in a large number of commercial and non-commercial Virtual Reality (VR) applications, implicated in educational [2] and industrial [3] domains.

In both procedural and motor skills training cases, the ManuVAR architecture [4] fully supports and manages technological implementations. The Application Tool Specific Logic (ATSL) dedicated to manual work training management in an industrial environment performs necessary mathematical calculations to support users training effort evaluation, and handles communication between all technological components connected to the ManuVAR platform.

Procedural training implementation is based on a Precision Teaching (PT) method. PT is a learning paradigm, developed by Lindsley in the field of Behaviour Analysis [5]. It consists of "basing educational decisions on changes in continuous self-monitored performance frequencies displayed on standard celeration charts". Trainers may monitor performance through a performance analyzer, embedded in the Lesson Runner module, which manages the learning rules. This module shows a chart displaying the behaviour fluency (i.e., accuracy and frequency of his/her training sessions calculated as right answers per minute).Training items are displayed through a 2D graphical user interface (GUI).

Motor-skills training consists of a Sensable Technologies Phantom haptic interface that provides information on the user´s hand position and orientation with 6 Degrees of Freedom (DOF) onto a stereoscopic display supported by Virtools 5.0 VR player, and supplies moderate force feedback with 3 DOF. It is implemented in two applications: the training program, which focuses on the transfer of motor skills such as motion, angle and force, and the simulator, which is used to train the metallographic replica polishing stage. Both applications include real-time and step information feedback related to task performance

The motor skill training program also includes the PT method which divides learning into small steps allowing the trainee to improve his/her skills. The simulator takes on a holistic approach. The trainee has to complete one of the steps of the polishing task and the system estimates how well the task has been performed at every single point on the surface being polished, providing feedback at the end of the simulation in the form of a colour map, representing the level of completeness of the polished surface.

4. Potential benefits of using VR

One of the main benefits perceived by TECNATOM for using VR for training is to improve safety as well as communication between workers and maintenance engineers. It could also help in minimizing asociated risks and execution costs. Other potential benefits of VR Metallographic Replica Training include:

- a low cost training solution compared to the real world training carried out in situ, which is not always possible and affordable
- training in different situations and locations with possible display of relevant aspects of the working area, such as radiological map or hot spots
- an unlimited possibility for retrieving training sessions as much as possible without any inconvenience to the workers
- creation of scenarios within the same virtual environment to simulate different operational situations with the aim of training workers under different conditions.

In addition better and more efficient planning of the task within VR/AR in advance of the works would allow the workers to plan their activities, consequently reducing task completion, radiation exposure and stressful situations. It could also show relevant aspects of the working area as well as, classifying the tasks depending on their potential risk. This could help to minimize the risk of radioactive contamination.

5. Future work

The next phase of this work is to demonstrate the potential of the VR Metallographic Replica training system within TECNATOM facilities for improving training and task planning. The system will be installed in the organisation to be assessed by the real workers. An evaluation study including qualitative and quantitative analysis, and experimental tests performed by senior experts and junior workers will capture information regarding the costs and benefits of the application from a technological, methodological and business view point.

Acknowledgements

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Virtual Reality for planning and validating spacecraft integrating procedures in Thales Alenia Space Italia

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Abstract

Thales Alenia Space Italia (TAS-I) aims at developing and supporting the implementation of procedures using Virtual Reality (VR) and Augmented Reality (AR) overcoming difficulties in the work carried out in its integration facilities. In these facilities experienced technicians integrate "one-of-a-kind" spacecrafts by hand. To automate this activity, apart from being right-on impossible, would be to ignore the flexibility, adaptability and resourcefulness of the human worker. Human capabilities are essential in this quasi-artisan spacecrafts assembling, and since product 100% of reliability must be guaranteed means to properly support the human in avoiding errors are vital. Within ManuVAR [1] (Manual Work Support throughout System Lifecycle by Exploiting Virtual and Augmented Reality) TAS-I has revised its product lifecycle identifying how to exploit the features of this innovative platform and framework to increase efficiency and effectiveness of manual work.

1. Introduction

TAS-I represents a worldwide standard for space development: from navigation to telecommunications, from meteorology to environmental monitoring, from defence to science and observation and constantly has to deal with multivariate data coming from different fields that need to be analyzed and represented. Prime contractor for most of the Italian Space Agency (ASI) programmes and for some of the major programmes of the European Space Agency (ESA), TAS-I is also taking a significant role in many international joint projects, especially those of bilateral co-operation between ASI and NASA, as well as in commercial programmers. TAS-I has a vast experience in the conception, development, integration, testing, verification, and delivery of Space Systems and Space Vehicles. Activities cover the design, development and construction of complete space systems: manned and unmanned orbital space infrastructures; telecommunication satellites and ground stations; remote sensing, meteorological and scientific satellites; and launch, transport and re-entry systems. TAS-I has built over 150 satellites and a number of important orbital infrastructures, in particular over 50% of the habitable structures of the International Space Station (ISS). The TAS-I extensive involvement and responsibility, among others, on ISS related manned systems and re-entry vehicles studies/technologies provides a solid experience both on design and development of transportation systems (with emphasis on system, configuration and thermo-mechanical architecture).

Thus target of TAS-I participation to ManuVAR was to develop supporting tools for planning and preparing procedures as well as making them easily accessible to the integration activities exploiting ManuVAR innovative platform and framework. This to allow tackling existing industrial gaps such as communication throughout the lifecycle, poor user interfaces, physical and cognitive stresses and human work low productivity and propensity to error.

2. VR/AR/MR in TAS-I

Designing for human space exploration and the other TAS-I fields of application represent a challenging task for various reasons, first the design for the hostile environments, second consider the different gravity laws, then prepare the system for either some time unknown or unpredictable phenomena which need ad hoc technological solutions and finally to put together one unique product for the first and last time without making mistakes. In this context, Virtual Reality (VR) techniques can help industry and especially space industry to improve the quality in design and integration; its main advantages are to allow realistic digital mock-ups representation, to enable collaborative multidisciplinary engineering tasks, simulation of critical ground and flight operations, real-time interactivity, costs reduction and time sparing.

TAS-I believed almost immediately in 4D systems and started to experiment them from the beginning of 2003, year in which the COSE (Collaborative System Engineering) Centre [2] VR-LAB was born with the purpose to support all the project design and integration phases. For this reason, TAS-I developed a Virtual Reality Framework called VERITAS (Virtual Environment Research In Thales Alenia Space) that allow simulations and displaying multivariate data in a 4D environment. The stereoscopic visualization makes possible to project the scene loaded in VERITAS in the CAVE in 3D, while the user–scene interaction can be accomplished with several innovative devices such as Nintendo WiiMote and Nunchuck, Data Gloves, Haptic Device, Tracking System, Motion Capture Suit, etc. Moreover VERITAS can import and export 3D models and can be interfaced on-line or off-line with other software.

Virtual Reality allows executing the normal review activities in an innovative way, reducing dramatically the time needed by the project teams for baseline awareness, problems evaluations and solutions discussion and decision. The idea beside VERITAS was to integrate in the Virtual Environment (VE) data from the various Engineering disciplines without intervening in the way they were produced (from excel file to sophisticated calculation algorithms), but integrating the obtained data directly in the product virtual representation in a sort of "*what you see is what you get*" approach. VERITAS can be used not only for complex systems design and development activities, including training, but now with ManuVAR tools also to connect and enhance the quality of collaboration of engineering disciplines with the integration and testing teams allowing the interactions among them in the concurrent system lifecycle. VERITAS is in principle a multi-domains engine.

The VR-main audiences are:

– engineering: for decision making or for analysing and simulating data and for example understanding the possibilities of system integration (ManuVAR)
– management: for engineering options presentation and support to decision making
– users: support to astronauts but also AIT people training and operations performances
– science: research data presentation and dissemination
– generic public: mainly for education & training.

Besides keep improving the already existing scenarios and functionalities, TAS-I is constantly searching for new and innovative idea to support the company various potential audiences. This was the purpose of the TAS-I participation in ManuVAR project whose objective is to develop an innovative technological platform and a framework to support high value manual work throughout the product lifecycle. ManuVAR innovative idea foresees a bi-directional communication throughout the Lifecycle (LC) where a Virtual Model (VM) is used as a communication mediator that means a single access point to the variety of data, information and models on the system for all the actors in the LC. In such a way the real data and information are stored in the company PDM/PLM while all the data communication is handled through the VM that contains only references (no data stored inside the VM). This solution is ideal to support TAS-I unique model concept realize achieved within Virtual Spacecraft Design (VSD) project. The objective of this study is to develop and apply the virtual design and verification technology in the context of the spacecraft development process with the aim of reducing its duration and rendering it more cost-effective, facilitating the control of costs and risks. The approach is to develop a digital or “virtual” model of the spacecraft already in early phases to support the specification and definition activities, and to evolve it to support Design, Verification, MAIT and Operations in all the spacecraft lifecycle [3].

Within ManuVAR, TAS-I mainly focused on two utilisation scenarios:

1. Developing and validating critical integration procedures in VR.
2. Providing on-site integration support through AR instructions guiding the user in performing the required tasks.

The implementation of the above scenario is allowing to cover the definition phase (1) and the integration (usage) phase (2) of TAS-I products lifecycle.

3. Potential benefits of ManuVAR results exploitation in TAS-I

To properly perform critical integrations activities the integration team needs easy access to procedures that are previously thoroughly tested. This to avoid potentially dangerous or improper integration actions or late identification of design faults that may lead to engineering or workmanship Non Conformances (NC) that will lead to increase the project costs.

Presently TAS-I integration procedures are generated using existing CAD models and assembly drawings printed on paper or reviewed on a PC screen. These procedures are written by the Integration Team with the contribution of the Engineering Team in charge for the design & development of the product. The procedures are then validated by discussion between the various actors without any specific support and then used by the worker in the integration room. During integration, because of the high quality standards required, the worker has to carefully implement the instruction: any deviation either generated by the worker him/herself or by the impossibility of performing the action generates an NC. The critical engineering /integration issues concern the capability to: evaluate accessibility, envisage the correct sequence of actions, evaluate human posture, estimate the time needed to perform the task and need for design modifications and at the same time increasing the collaboration between the Integration and Engineering teams. Those issues often lead to costly rescheduling and sometimes improper assembly.

Exploiting ManuVAR platform and the implemented methodologies, the procedures are generated using a Hierarchical Task Analysis (HTA) tool linked to the VE from where is able to obtain models and other data, throughout the VM. In such a way it is possible to define each procedure step and the related documents, screenshots, videos that can be associated. Moreover the force feedback felt with Haptic Device allows evaluating the involved mass (so for example being able to understand if the action can be implemented vertically or the spacecraft has to be tilted to allow proper integration of the selected part) and the collision detection (so for example identifying the collision risks and protections needed). Procedures created in virtual reality (VR) can be validated and made more easily available using augmented reality (AR) format so that to guide hands-free assembly task execution, moreover innovative procedures formats more user oriented can be developed. The instructions are displayed to the integrating worker through goggles or Head Mounted Display (HMD) over imposed on the real hardware. Consequently it should be possible to reduce NC number and impact, i.e. time and effort for NC control and late modification in design or procedures. The expected saving are both in term of reduction in delivery time or in personnel costs. If these savings are

translated in costs TAS-I expects a reduction in the order of 0.4–0.6% of the overall program costs. Usually the cost of our products is ranged between 30–50 MEuro. This can produce a double effect either the increase of margin or a more competitive selling price; in general it will increase TAS-I confidence in costs evaluation in the proposal phase.

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A Virtual Environment for Rugby Skills Training

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Abstract

The Virtual Environment Rugby Skills Trainer (VERST) is an on-going collaborative project between Bangor University's Schools of Computer Science, Sports Health and Education Sciences and Psychology, together with Rugby Innovations Ltd., to create an accessible training tool that will help professional rugby players improve certain skills. It is said that it takes 10,000 hours of learning to fully grasp a skill; VERST will reduce the waiting time during practices and allow players to train individually. Although similar projects are being developed for lineouts and defensive strategy, as a first step in our implementation we have chosen to focus on passing the ball; an accurate passing technique is more difficult to achieve than many realize, and is a truly vital base skill. Using a motion capture suite and other tracking hardware, the players' and ball's movements are digitized so to allow them to interact with the virtual environment in a natural way. Physical modelling and simulating the motion of a virtual ball under real-game conditions preserve the accuracy of the environment. Wales is characterized as a nation that loves rugby, but no one really uses this for marketing – a project from the heartland might be what Wales needs to win the world cup!

1. Related Work

There have been a few projects that use virtual environments for sports applications e.g. [1], but very few that address rugby [2, 3]. The improvement in computer graphics, tracking, and display technologies currently provide an opportunity for a high fidelity rugby skills simulator to be created.

2. Implementation

2.1.1 Physical System of Motion for a Rugby Ball in Flight

The physical motion of the ball is being modelled on the following aerodynamic principles: the trajectory is a straight line unless external forces intervene; the initial velocity depends on the launch angle; on ascent, weight and drag act together, on descent the forces have opposite signs; any external side forces like wind or rain are added to the lift. Drag or lift can be experimentally determined by throwing the ball at a measured speed through two points, after which the information can be used to simulate the ball's flight. A simple low fidelity implementation based on Newton's Laws of Motion has been completed; a more complex model is currently being prototyped. In practice, the ball's flight is a complex motion of a solid object through a constantly moving but slow paced fluid. Any changes in the physical parameters of the fluid (viscosity, density, internal pressure) due to weather conditions change the resistance force that acts on the ball during flight. Hence, in order to increase the simulation's accuracy, the air is modelled as a Newtonian fluid with variable viscosity depending on velocity and temperature. The interaction between solid and fluid is time dependent. During flight, the ball rotation is a very complex (three rotation axes similar to an aeroplane), depending on the initial throw conditions and the motion stability in its entirety. All these aspects are considered for an accurate simulation rugby ball flight model.

2.1.2 Example Simulation Scenario

The player's motion is tracked, and they can optionally wear stereoscopic glasses as they look at the virtual world. The Personal Space Tacker captures the ball speed and position as it leaves the player, then flight properties of the virtual ball are calculated. The real ball is tethered to player's hands; the player throws, a virtual ball is animated, and statistics given to help the player understand how to improve technique.

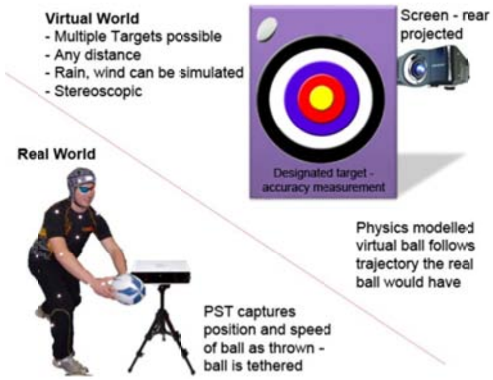

Figure 1. Example scenario of VERST System.

3. Conclusion

VERST is currently in development but early results argue well for the utility of this tool. As we complete the build of the first prototype, we will investigate the visual space perception issues involved in its use. Validation tests will be carried out in collaboration with local rugby teams. There are many other skills in this complex sport that we intend to tackle in future work.

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Adaptive Guiding for Fluvial Navigation Training in Informed Virtual Environment

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Abstract

We propose a training system for fluvial navigation which can automatically guide learners by displaying multimodal feedbacks according to their performance. A decision-making module, based on the Dempster-Shafer theory, determines the most appropriate aids according to the learner's performance. This system allows relieving the trainer from controlling the whole training simulation.

1. A pedagogical tool for adaptive training

The purpose of the OSE project, funded by the European Union and Picardie region, is to add a pedagogical aspect to a fluvial-navigation training simulator called SimNav. We built a model called GULLIVER (GUiding by visuaLization metaphors for fluviaL navigation training in Informed Virtual EnviRonment) to propose an adaptive training based on the existing simulator SimNav. GULLIVER allows automatically guiding the learner by displaying multimodal feedbacks (visual and audio aids) according to his/her performance. The system gathers various data about the learner (risks taken, stress level, cognitive load, etc.) and makes a decision about the most appropriate feedbacks to display.

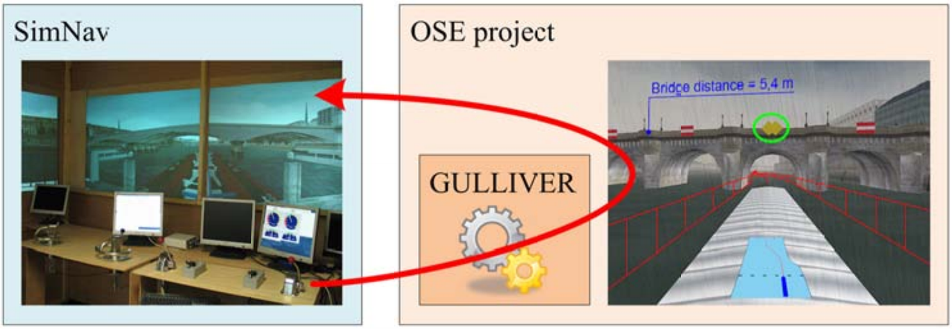

Figure 1. Model of the system.

2. GULLIVER: model of an adaptive training system

GULLIVER is composed of three modules: the user's activity detection module, the user's state recognition module and the decision-making module. The first module is in charge of detecting the mistakes made by the learner and the risks taken from data about learner's steering and gestures. The second module recognizes the learner's state (stress level, cognitive load, etc.) thanks to data coming from physiological sensors (heart variability sensor, etc.). From the learner's state, his/her mistakes, the risks taken and his/her profiles (learner's level and usage history), the third module activates the right aids to guide the learner. The Dempster-Shafer theory is used for the fusion of these data about the learner. This brings a new approach in the informed virtual environments by allowing a strong coupling between the user and the virtual environment. Our approach presents the advantages to have a better adaptation to the trainee and to propose an adaptive guiding in complex situations with uncertain data about the learner.

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Alleviating cybersickness in VR helmets using Jedi training

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Abstract

Cybersickness experienced after prolonged use of Head-Mounted Displays prevents wider use of this technology. One proposed cause of cybersickness is the discrepancy between visual and vestibular input. To alleviate this, the scene can be blurred during fast head rotations. The effectiveness of this solution was assessed in a questionnaire-based experiment, using a spatial tracking task, inspired by the Jedi training routine from Star Wars movie. The results of the first stage were inconclusive. The next planned stage will implement a more elaborate blurring algorithm and an improved testing protocol.

1. Introduction

Cybersickness is a common problem found in many VR applications [1]. It includes symptoms of nausea and disorientation after prolonged use, preventing wider use of promising immersive technology. One proposed cause of cybersickness is the discrepancy between visual and vestibular input (ibid.). In simulations using Head-Mounted Displays (aka VR helmets), this discrepancy is especially noticeable during fast head rotations, where the relatively low framerate results in a noticeable 'jerkiness' of the scene which is at odds with the smooth vestibular sensation.

An under-researched solution is to alter the rendering in the HMD to conform to the perceptual features of fast-moving scenes [2], i.e. to blur the scene during fast head rotations, making the visual sensation smoother and thus closer to the vestibular one. We present a work in progress investigating this solution.

2. Method

At the first stage a simple square blur algorithm was implemented using DirectX 9 fragment shader. The blur was only introduced to the scene if angular head rotation speed exceeded a predefined threshold. The scene was presented in stereo using a NVIS-SX60 Head-Mounted Display, with position and orientation tracked with an InterSense IS-900 head tracker.

The efectiveness of this solution was assessed using a task that required users to perform numerous fast head rotations, thus presenting a high number of potentially cybersickness-inducing stimuli. The task consisted of tracking a small object in a virtual scene; the object randomly changed position around the viewer every 1–2 seconds. Every participant performed the task twice, with and without blur, and then filled a short questionnaire reporting the subjective task difficulty and levels of nausea perceived during and after the task, for each condition, on a five-point Likert-type scale.

3. Results and Conclusions

Twelve participants (2f/10m, mean age 22) took part in this study. The results of the first stage are summarised in Table 1. As can be seen from the t-test p-values, the results were inconclusive. This is most probably due to a short testing time for each participant (one minute for each condition) which was not sufficient to develop significant cybersickness symptoms. That conjecture is supported by relatively low reported nausea levels across the board (1.16 to 1.75 on a 1 to 5 scale).

Table 1. Summary of results from questionnaire analysis.

Questionnaire variable	**Mean response (Blur)**	**Mean response (No Blur)**	**T-test *p***
Tracking difficulty	2.5	2.416	0.72
Nausea during trial	1.66	1.75	0.75
Nausea after trial	1.16	1.33	0.44

The next stage, currently in development, implements a more elaborate blurring algorithm and uses an improved testing protocol. The algorithm is angular motion blur, and the testing protocol will involve longer trials, more in-depth questionnaires, and more participants.

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Automated Design Knowledge Capture and Representation in an Immersive Virtual Reality Environment

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1. Introduction

The capture of engineering design processes and associated knowledge has traditionally been extremely difficult due to the high overhead associated with current intrusive and time-consuming manual methods used in industry, usually involving interruption of the designer during the design task and relying on them to remember how a design solution was developed after the event. This research demonstrates how the detailed logging and analysis of an individual designer's actions in a cable harness virtual reality (VR) design and manufacturing system has allowed design knowledge to be automatically captured and extracted.

2. COSTAR

The experimental platform developed for this research, called COSTAR (Cable Organisation System Through Alternative Reality), comprises an SGI® Onyx4™, V8 stereo head-mounted display, Flock of Birds® magnetic tracking system and Pinch® data gloves.

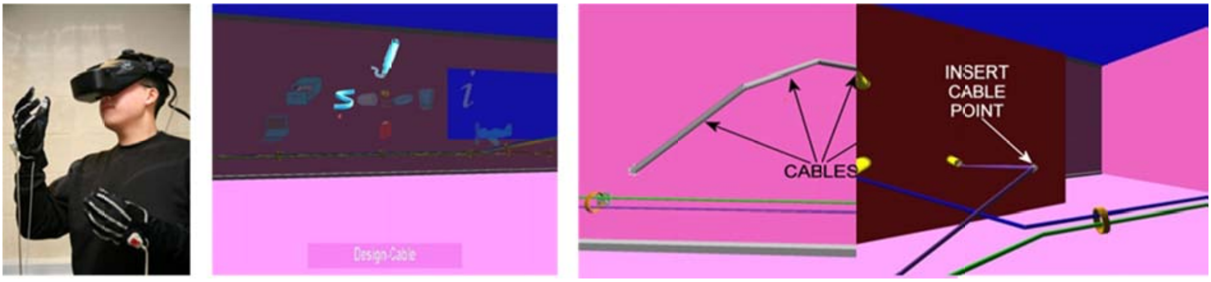

Figure 1. VR Apparatus & Cable Harness Design Functionality.

3. Knowledge Capture & Analysis

By automatically analysing the logged data and extracting the important design knowledge embedded in a log file, design knowledge has been formally represented using several established formats, which include PSL (Process Specification Language), XML (eXtensible Markup Language), English descriptive syntax, IDEF0 (Integration DEFinition) diagrams, DRed (Design Rationale editor) graphs and storyboard representations. In addition to these, annotated video clips of engineering processes have been automatically generated. By utilising the captured design and manufacturing knowledge, a novel interactive online help design information 'push' system to aid users during a design task has been demonstrated. This system will not only instruct users on how to correctly carry out a task but should also help improve the efficiency of future designs. User trials involving industrial engineers were carried out to evaluate the various design knowledge representations.

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  </costar_events>
```

```
(activity CableDragDrop)
(subactivity PickCable CableDragDrop)
(subactivity DragCable CableDragDrop)
(subactivity ReleaseCable CableDragDrop)
(cablepointname A01H01C01S01P02 currentcable)
(occurrence_of ElectricalInterference)
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Figure 2. XML (top) & PSL (bottom).

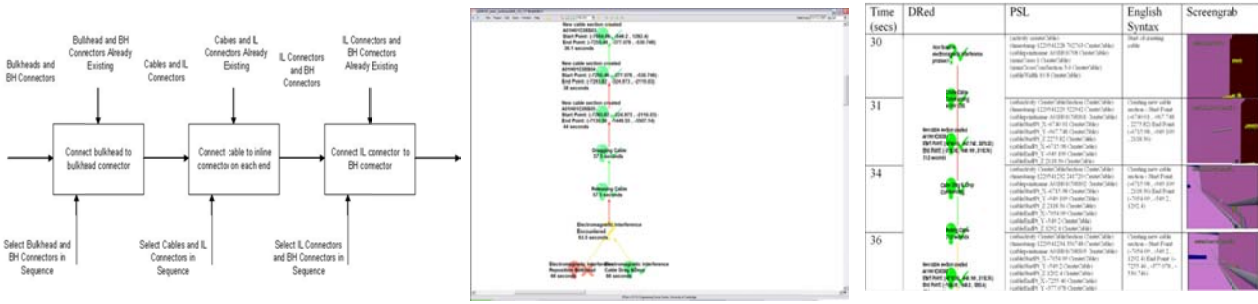

Figure 3. IDEF0 Diagram (left), DRed Graph (centre), Storyboard (right).

4. Conclusions

- Logging of user activity in virtual design environment to capture design knowledge
- Captured design knowledge automatically formalised using various knowledge representations
- User trials carried out involving industrial engineers to validate knowledge representations
- Results indicate engineers prefer visual knowledge representations such as annotated video clips and DRed graphs.

Calibrating the Kinect with a 3D projector to create a Tangible Tabletop Interface

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Abstract

In this poster we present a portable and easy to calibrate 3D tabletop display enabling easy understanding of complex datasets and simulations by providing a visualization environment with natural interaction. This table enables users to interact with complex datasets in a natural way and engenders group and collaborative interaction. We also demonstrate the use of the display with an example environmental visualization tool, designed for stake holder engagement.

1. Introduction

In previous work, we presented a 3D tabletop display [1], which used a 3D projector to turn a desk into a 3D immersive display. This display used a Kinect interface to provide basic interaction within an immersive environment. However this set-up relied upon the accurate alignment between both the projector and Kinect, and both being directly overhead. We have extended our software to allow the Kinect to be calibrated to the tabletop from any arbitrary position.

2. Method

In order to calibrate the view the user must initially select the four corners of the tabletop display from within the Depth View seen from the Kinect. As it can be assumed that the 3D position of the corners are coplanar, the defined surface is split into two triangles and an average gradient calculated for the surface, as shown in figure 1(b). The surface is considered as ground zero, and by subtracting the gradient from the depth map the models that are on the surface can be segmented. The volume is scaled to the corners to give us a final calculation of where the objects are on the tabletop, as shown in figure 1(c).

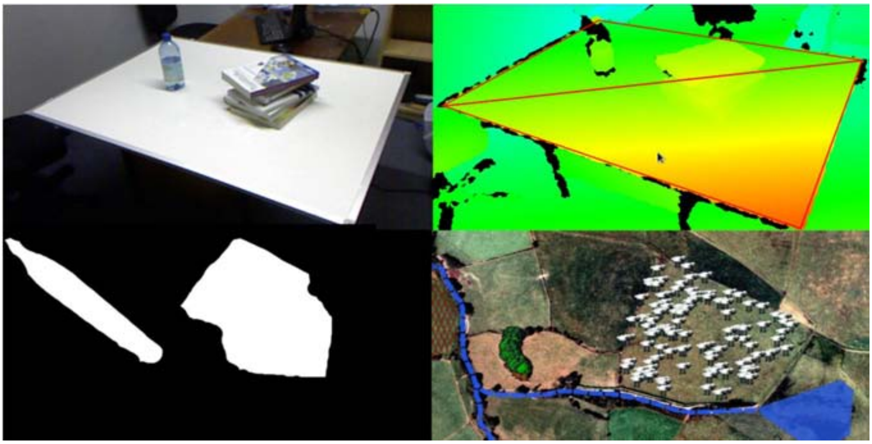

Figure 1. (a, top left) View from the Kinect's perspective, (b, top right) the depth map showing defined tabletop region, (c, bottom left) the estimated position of models on the tabletop; (d, bottom right) an example environmental flooding application.

3. Conclusions

In our poster we demonstrate our tabletop display using example application, which is designed for interacting with stakeholders by demonstrating the affects agriculture can have on the environment, as shown in figure 1(d). We have used the table with our flood management and stakeholder engagement tool. Here, stakeholders can explore the simulated environment by adding objects onto the table to control different parameters, to (say) increase the numbers of sheep or trees in that area, to explore different flood mitigation scenarios.

Although our calibration provides a good estimate of objects above the surface the Kinect requires an unobscured view of the table to prevent occlusion.

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Characteristics of a Tactile Rendering Algorithm

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Abstract

During active exploration of a virtual surface, a tactile renderer specifies drive signals for a 24-channel tactile display on the fingertip. Characteristics of these drive signals indicates that the renderer offers a wide range of touch sensations to the user, providing a basis for discrimination of different surfaces.

1. Introduction

The skin is populated by four types of touch receptors that can be divided into two groups: Pacinian receptors, which respond mainly to higher frequencies (100–400 Hz), and non-Pacinian receptors which provide sensitivity at lower frequencies. In this study a 24-contactor tactile display is used to produce spatio-temporal patterns of virtual touch sensation on the fingertip by stimulating these two groups of receptors in the fingertip.

Two of the authors were previously involved in the EU-funded HAPTEX project [1] in which a virtual touch system was developed to create the sensation of exploring the surface of a textile. The present study involves hardware and software based on that from the HAPTEX project, but with a number of improvements and modifications. The emphasis here is on the characteristics of the tactile-rendering algorithm – work which was beyond the scope of the HAPTEX project.

2. Hardware and Software

The present study involves hardware and software based on that from the HAPTEX project, but with a number of improvements and modifications. The tactile display is an array of 24 contactors covering 1 cm^2 on the fingertip (figure 1) which are driven by piezoelectric bimorphs that convert the signals from the drive electronics to mechanical movement of the contactors. The display moves with the user's finger during active exploration of a virtual surface with a graphics tablet providing the position and velocity information of the user's finger.

The renderer software runs in real time on a standard PC, calculating the data to specify the 24 drive signals for the display. The drive signal to each contactor in the display is a combination of a 40 Hz sine wave and a 320 Hz sine wave, addressing the non-Pacinian and Pacinian touch receptors, respectively. The amplitudes of these sine waves, A_{40} and A_{320}, are calculated separately for each contactor every 25 ms, based on local Fourier transforms of the surface profile, at the location of the contactor on the textile surface, as well as information on the position and velocity of the tactile display and band-pass filter functions H_{40} and H_{320}, centred on 40 Hz and 320 Hz, based on tactile detection thresholds [2].

3. Characteristics

Information on surface texture is provided to the user as time-varying patterns of A_{40} and A_{320}, distributed over the 24 contactors of the tactile display (left panel, figure 1). The center and right panels in figure 1 indicate that the renderer offers a wide range of texture information to the user, providing a basis for discrimination of different textiles.

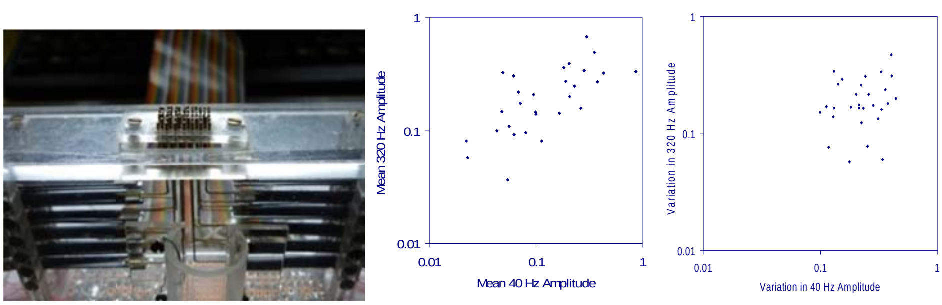

Figure 1. The tactile display (left panel), with 24 contactors each driven by a piezoelectric element, with the mean values (center panel) and coefficient of variation (right panel) of A_{40} and A_{320} during exploration of the textile surface at 10 cm s^{-1}, for 29 different textiles.

4. Conclusions and Future Work

By generating signals that stimulate the two groups of touch receptors in the skin, this virtual touch system attempts to recreate the tactile sensation of exploring a surface. The renderer can provide a wide range of touch sensations to the user. In future, a comparison will be made between the virtual sensation and the real sensation of exploring the textile surface, to test the fidelity of the system. This system was used in January of 2011 at the National Museum of Scotland to recreate the sensation of exploring the surface of an artefact.

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Cybersickness and Anxiety in Virtual Environments

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Abstract

The question whether feelings of anxiety are confounded with cybersickness in studies on virtual reality exposure therapy (VRET) was raised since the questionnaires used to measure them contain overlapping items. In the experiment, 88 participants were asked to talk in front of a virtual audience. Previous research has shown that this task may induce feelings of anxiety [1]. A significant correlation between levels of experienced anxiety and the nausea subscale of the Simulator Sickness Questionnaire was found for people who reported no cybersickness in a virtual neutral world. Therefore it must be concluded that when cybersickness is measured in VRET experiments, the results may partly be explained by feelings of anxiety rather than cybersickness per se.

1. Introduction

The Simulator Sickness Questionnaire (SSQ) [2] is an extensively used protocol for measuring cybersickness in virtual environments. However, symptoms included in the SSQ questionnaire are quite similar to symptoms commonly found when people experience anxiety. Since the aim of VRET is eliciting anxiety in patients, there is a concern that the SSQ measurements are not ‘purely’ measuring *cybersickness* when used in the context of VRET, but that they are confounded with feelings of anxiety. Earlier studies already reported significant correlation between anxiety and cybersickness [3, 4] Some VRET treatments even found a decrease in SSQ from pre- to post measurement [5, 3]. Participants were relieved rather distressed after the therapy which might have affected their SSQ score. So whether the participants' reported cybersickness is affected by their anxiety or not needs to be tested.

2. Method and results

Eighty-eight volunteers, i.e. 35 females and 53 males, from the Delft University of Technology participated in the experiment. Their age ranged from 18 to 70 years old (M = 28 years old, SD = 6.3). Two participants were removed from the data set because they did not perform the task according to instructions. Participants were naive with respect to our hypotheses. Written informed consent forms were obtained from all the participants and they received a gift for their contributions. The virtual worlds were shown via an eMagin Z800 head mounted display. The participants' head position was tracked at 125 Hz update speed. Sounds were played through desk mounted speakers. Participants were first immersed in a neutral room [3] and then in the virtual public speaking world twice: once with stereoscopic rendering and once without stereoscopic rendering, in a counterbalanced order. The participants were asked to give a 5min talk in each public speaking world. The SSQ questionnaire developed by Kennedy et al. [2] was used to evaluate cybersickness after viewing each virtual world. A modified version of the Personal Report of Confidence as a Public Speaker (MPRCS) was used to measure participants' anxiety after their talk [6]. The MPRCS consisted of 16 items, and a higher score meant a higher level of anxiety.

Participants who reported no cybersickness in the virtual neutral world were selected to test the anxiety effect on SSQ in the virtual public speaking world. This selection resulted in only 14 participants (7 males, 7 females; M = 30 years old, SD = 6.2). For these participants, we calculated the correlations between the MPRCS and the SSQ scores and its three subscores: nausea, oculomotor and disorientation. A significant positive correlation was found between nausea and MPRCS in both viewing conditions ($r = .77$, $p = .001$ & $r = .58$, $p = .029$ for non-stereoscopic and stereoscopic viewing respectively). The results thus suggest that reported cybersickness is affected by people's anxiety in the virtual public speaking world. No significant ($p > .05$) correlation was found between the MPRCS and any of the SSQ (sub)scores for the other participants, who did report cybersickness in the neutral world.

3. Conclusion

For participants who reported no cybersickness in a neutral virtual environment, the reported cybersickness in the virtual public speaking environment seems to be affected by their anxiety. To limit the bias of anxiety in scoring cybersickness, a new method seems required. Further, caution is advised in interpreting the results on cybersickness in studies involving anxiety, and vice verse in interpreting the results on anxiety in studies that are susceptible to inducing cybersickness in participants.

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Display-less Augmented Reality with Image Projection Techniques

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Abstract

We propose a novel augmented reality technique without additional display devices, like a HMD used for mixing real and virtual. Our proposal is based on a dynamic luminance correction technique, which can project arbitrary images correctly on physical colored materials in real-time.

1. Introduction

Augmented Reality (AR) techniques are only provided through some additional display like a HMD or SmartPhone, and they are huge limitation for making an immersive feeling of virtual environments. In this research, we aim to achieve the AR effects in projection-based virtual environments which can be seen through no display devices. We project overlapped images on real moving objects, and provide new appearance of them.

2. Dynamic luminance correction

In usual projection on the real objects, projected images are strongly affected by various colors of the objects. In order to remove the effects, we introduce a dynamic luminance correction technique [1]. This technique enables us to use real objects as screens, and we can change the appearance of the real objects even though they are actively moving. That is to say, we can achieve the AR effects in the real-world through no display devices.

In our basic strategy, we estimate the response function of the projector at a point as a reference, and also, we get the luminance-ratio (L_{map}) of each pixel toward the reference point [2]. The basic shape of the response function (F_{resp}) is unique for the projector, and the difference at each pixel is represented with the luminance ratio. Thus, the luminance (L) projected at this coordinate (s, t) for input $i(r, g, b)$ is given by the following equation.

$$L(s, t, i) = F_{resp}(s_0, t_0, i) \times L_{map}(s, t)$$
$$= \{ (W_0 - B_0) \times (i/255)^{\gamma} \times L_{map}(s, t) \} + (B_0 + E_0) \times L_{map}(s, t)$$

In this equation, W_0 is maximum luminance of 100% white projection, and B_0 is minimum luminance of projector's black offset. E_0 is environment light. γ is well-known response property of the projector. L_{map} depends on a material of targets. If someone stands in front of the projector, L_{map} is also changed. So, L_{map} is frequently measured and updated for the next overwriting.

We show the process flow of our proposal and some results in Figure 1. In these results, actual color of target clothes are canceled, and overwritten by virtual images and clothes. (Supported by KDDI Foundation Grant Program)

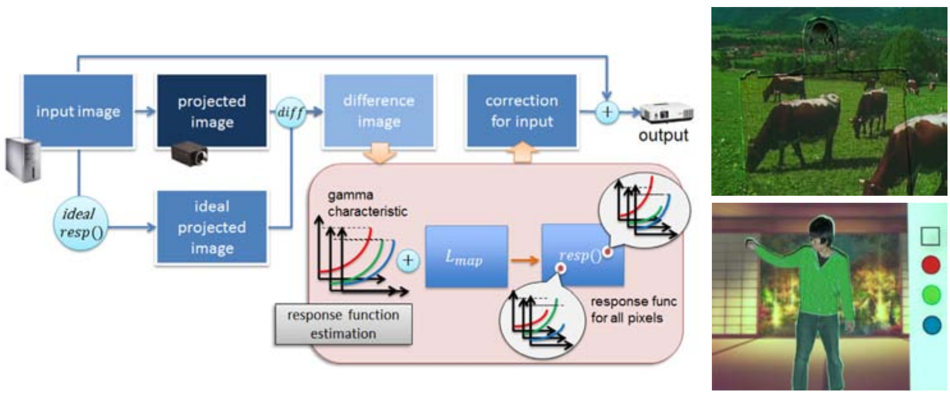

Figure 1. The process flow of our proposal and its results (Invisible-man embedded in projected images and virtual dress-up system with virtual clothes)

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HDR Display with a Composite Response Function

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Abstract

To build a high dynamic range (HDR) display by multiple projections, this paper explains how input images to the projectors are provided from a raw image based on a composite response function of the HDR display. Our HDR display could linearly present 1024 gradations and succeeded in making higher dynamic range in high luminance intensity regions.

1. Introduction

In providing larger HDR display, multiple projections have been studied. HDR display using two projectors has been reported which uses two photographed images with long and short exposures as inputs. However, it is not clear how output luminance intensities projected from these input images are related each other. This study proposes a HDR display that is an overlaid projected plane from four projectors, as shown in Fig. 1. We design all output luminance intensities projected from the four projectors to follow a composite response function of the HDR display, and compose four input images by adjusting HDR output luminance intensities pixel by pixel.

2. HDR Display Algorithm

In this study, a 10-bit raw image is used as the input of our HDR display (Fig. 1). Hence, the response function of the HDR display has the input range [0–1023], and the relation between the input and output of the HDR display is ideally linear because the raw image represents the luminance intensity itself.

With the linearity of the response function and the output luminance intensity range of the HDR display, we compute the HDR output luminance intensity for every input raw value. To realize the HDR output luminance intensity, we determine the best combination of the four projectors' output luminance intensities whose total output luminance intensity the closest to the HDR output intensity, and define a feasible composite response function. Note that because the luminance intensity distribution is not uniform on the projected plane, the determination of the combination is required pixel by pixel. Then, for every pixel of the HDR display, the input values to the four projectors of the best combination are recorded in order to compose input images to the projectors.

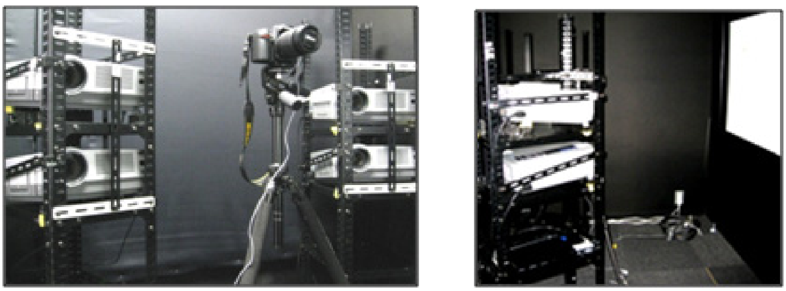

Figure 1. Our HDR display.

3. Results and Discussions

We measured the output luminance intensity at the center of our HDR display. In Fig. 2, all the measured output points lie linearly. We can confirm that when displaying a raw image, our HDR display can present 1024 gradations along the linear HDR response function. Fig. 3 is two output photos of our HDR display. The photo with the shutter speed of 1/100 [sec] is the closest to what we actually saw, though it includes some blackouts and whiteouts. The shutter speed of 1/500 [sec] produces the least blackouts and whiteouts in high luminance intensity regions such as the sky. This photo shows a successful result of making higher dynamic range in these regions. In conclusion, higher dynamic range and more graduations by our HDR display algorithm make it possible for us to enjoy more realistic VR systems.

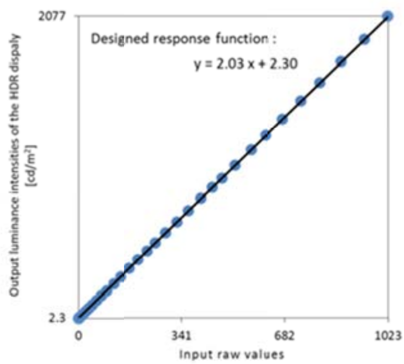

Figure 2. Measured output luminance intensity points with the linear HDR response function.

Figure 3. Two output photos of our HDR display with a scenery raw image as an input. (Left: shutter speed of 1/100 [sec], Right: shutter speed of 1/500 [sec])

Heterophoria changes, visual discomfort and 3D stereoscopic displays

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Abstract

Changes in heterophoria and visual discomfort were compared in 19 participants who played a 2D and a 3D stereoscopic version of the same computer game. The prediction was made that the latter would produce a more exophoric adaptation. This *was* found [$p < 0.03$]. It was also predicted that (contrary to current theory) lower levels of asthenopic symptoms would occur, because less convergence would be required. This was not found, and *higher* levels were seen.

1. Introduction

3D stereoscopic displays are ubiquitous, and cinema, television and computer games are all now available in this format. However, many people have reported experiencing discomfort when viewing this kind of stimulus. At present, although the differences between the visual stimulus presented by these virtual displays and that of the real world are known, the relative effect of each is not yet established [1].

In this study, we carried out an investigation into physiological changes in the visual system during the playing of a computer game, chosen because it would be unlikely to produce visually-induced motion sickness. This investigation consisted of an examination of the changes in the resting eye position ("heterophoria") and changes in comfort over the course of the game. The comparison was made between the changes seen when a 2D version of the game was played, and when a 3D stereoscopic version producing only crossed disparities was played.

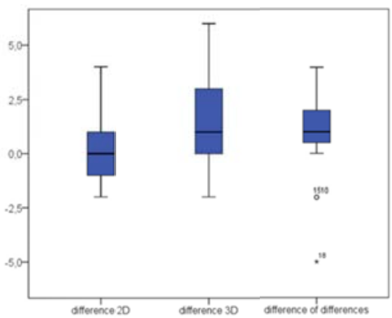
2. Method

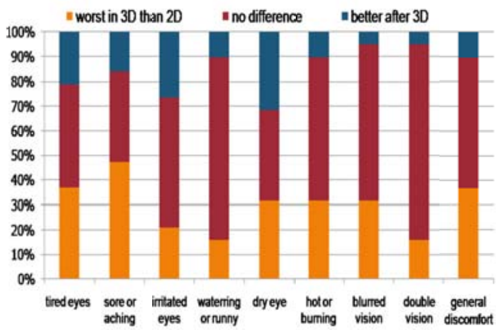
Nineteen participants (aged 19 to 45 yrs) played the same puzzle-based, vection-free computer game ('Ziro' by Kokakiki LLC) in a 3D and a 2D condition for 20 minutes on different days. None of the participants had any reported visual abnormalities, and all wore any necessary refractive correction.

To measure heterophoria at the correct distance the left eye viewed a scale (graduated in prism Dioptres) displayed on the screen. A red Maddox rod was introduced in front of the right eye, which then saw a vertical red line, and the measurement was the value on the scale at which the line crossed it.

To evaluate visual discomfort, a standard questionnaire was used, which participants completed before and after the trial, allowing evaluation of the change.

3. Results





The left figure shows the change in heterophoria for the 2D (left) and the 3D (middle) conditions, and the difference between them (right). The change in the 3D condition was more exophoric than in the 2 D condition ($P < 0.03$), as predicted. However, although visual discomfort changed in both conditions, the changes were greater in the 3D condition than the 2D condition. However, no correlation was found between the heterophoria differences and the discomfort differences, indicating the lack of a causal relationship.

Reference

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How to improve group performances on collocated synchronous manipulation tasks?

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Abstract

Previous studies on Collaborative Virtual Environments (CVE) investigate various features of synchroneous CVE. However, they focus on configurations involving mainly 2 users. This paper proposes to compare a standard collaboration approach, involving 2 participants, with a more complex collaborative structure, involving 4 participants. The results show that groups of 4 participants are more efficient than pairs only if they plan their actions during a brainstorming step.

1. Objectives

With recent advances in Information and Communications Technology (ICT) and reduction of communication delays between remote sites, several applications presetting closely coupled interactions in Collaborative Virtual Environments (CVE) were explored. Basdogan *et al.* are among the first to study the simultaneous manipulation of shared artefacts with the haptic feedback 0. Sallnas *et al.* 0 carry out several experimentations to understand the role of the haptic feedback to improve the presence and the awareness of partners in a CVE. More recently, Iglesias *et al.* 0 propose a complete system with haptic feedback for the collaborative assembly of 3D CAD models. If these works explore with relevance closely coupled interactions for configurations involving 2 partners, only few studies investigate configurations requiring more users. Chan *et al.* 0 are among the first to investigate complex group dynamic for collaborative interaction on a custom turn-taking protocol to improve the communication.

In this paper, we propose to explore closely coupled interactions in a CVE with groups of 4 participants and to compare this configuration with pairs. The objective of this study is to highlight the evolution of working efficiency, collaborative interactions, and communication processes. The context of the proposed study is the real-time deformation of huge molecules. We propose to investigate the procedure of molecular deformation. This task requires the management of several constraints (kinematic, physical, *etc.*), and involves the simultaneous manipulations of the different shared artefacts (atoms, residues, structures, *etc.*).

2. Experimental study

2.1 Hardware setup and apparatus

Experiments were conducted on a collaborative platform coupling standard desktop workstations and providing shared view on a large screen display (see Figure 1). The software platform is based on the VMD visualization software coupled with NAMD and IMD for the molecular simulation. 4 haptic tools (PHANToM Omni) enable the interaction with the molecular simulation through VRPN client/server system. The shared view is supported with a beamer and a large display screen.

2.2 Method

16 participants were involved in the experiments. Two main independent variables were investigated: 1) the number of participants ("2" *vs.* "4") and 2) the possibility to do or not a brainstorming before experiments ("brainstorm" *vs.* "no brainstorm"). To compare the two collaborative strategies, we consider the following measures: 1) the completion time to achieve the task, 2) the number of selections and 3) the number of verbal intervention of participants. During the experiment, participants are asked to deform the molecule, with haptic arms, to reach a targeted conformation displayed with transparency. The similarity between the manipulated molecule and the target molecule are evaluated by the RMSD (displayed on the main view). The experiment begins with a short period of training of 10 mn.

2.3 Results and analysis

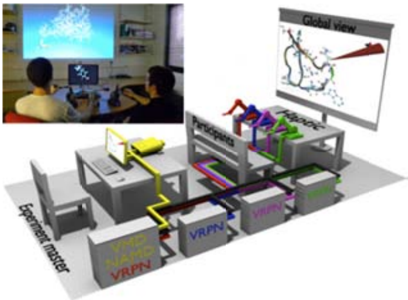

Figure 1. Illustration of the platform.

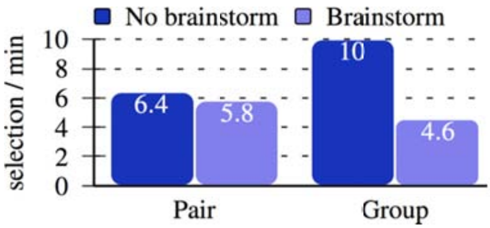

Figure 2. Number of selections results.

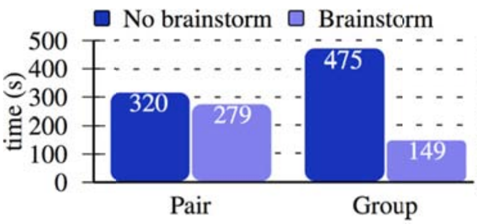

Figure 3. Completion time results.

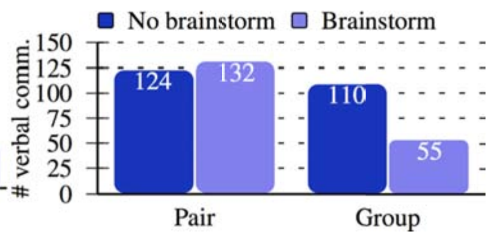

Figure 4. Verbal communication results.

Figure 2 and Figure 3 show respectively the mean completion time and the mean number of selection according to the possibility to have or not a brainstorming and according the number of participants. Groups (4 users) who plan their actions greatly decrease the completion time (decrease of 69% with $\chi^2(1) = 3$, $p = 0.083$) while pairs do not present a significant decrease (decrease of 13% with $\chi^2(1) = 0.224$, $p = 0.636$). The measure of the number of selections follows the same evolution. Groups with actions planning greatly decrease the number of selections (decrease of 54% with $\chi^2(1) = 5.333$, $p = 0.021$) while pairs do not present a significant decrease (decrease of 9% with $\chi^2(1) = 0.893$, $p = 0.345$). Figure 4 shows the total number of communications request according to the possibility to do or not a brainstorming and to the number of participants. Groups with actions planning greatly decrease the number of selections (decrease of 50%) while pairs do not present a significant increase (increase of 6%). These results show that the brainstorming session mainly improves the effectiveness of the group (4 users) but have not effect on pairs. In fact, the group configuration presents an important level of inter-subjects interaction (up to 3) while pairs configuration enables the interaction with one partner at most. Thus, during the progress of the task, subjects in groups can simultaneously collaborate effectively with some partners and come into conflicts with other partners leading to an important communication level. The brainstorming enables the avoidance of such conflicting situations (which greatly decrease the verbal communication) since the tasks and the working spaces are partitioned.

3. Conclusion

This study highlights the role of the brainstorming step for the organization of collaborative tasks of large groups. Beyond the improvement of the working performance, the brainstorming step enables the regulation of communication.

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Interactive Binocular Therapy (I-BiT™) for treatment of lazy eye (amblyopia)

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Abstract

I-BiT™ is a Wellcome Trust funded 3 year project to develop a virtual reality based system to treat amblyopia. The treatment is delivered via specially designed computer games. This poster presents an overview of the system hardware and software developed in phase one. Multi-centre clinical trial studies will be conducted in phase two of the project.

1. Introduction

Amblyopia is abnormal visual development in the brain during childhood causing poor vision in one eye. It affects 2–3% of the population and leads to restrictions in employment and increased risk of blindness. Conventional treatment involves patching the "good" eye for many hours each day but has a detrimental effect on the child's ability to use their eyes together. Patching affects quality of life and poor compliance results in poor visual outcome; overall results are mediocre. Excessive patching can be harmful, so treatment has to be supervised [1]. The novel I-BiT™ system stimulates both eyes simultaneously and preliminary clinical studies show very encouraging results with dramatically reduced treatment times. Proof of concept was gained in 2003 and a patent application to protect the technology has progressed into national phase (application number WO/2003/092482). Preliminary clinical trials and statistical analyses showed that I-BiT™ therapy significantly outperformed conventional patching, with increases in vision in some children after only six weeks of treatment.

2. Technology development

The overall aim of the project is to develop the I-BiT system and determine if virtual reality videogames effectively treat amblyopia. The project proposal describes three main phases of research to be carried out over the duration of the project. Phase I defines the development of the I-BiT™ software and hardware components. During this phase a feasibility study has been undertaken to establish that these new technologies perform in the same way as the original I-BiT™ prototype. The current project will complete technical development of the I-BiT™ system, complete clinical trials, analyse data and prepare material to demonstrate the clinical value of I-BiT™.

2.1 Software development

A range of 3D interactive games have been designed along with a clinicians' interface to allow configuration of the game display to each eye and patient data management (fig. 1).

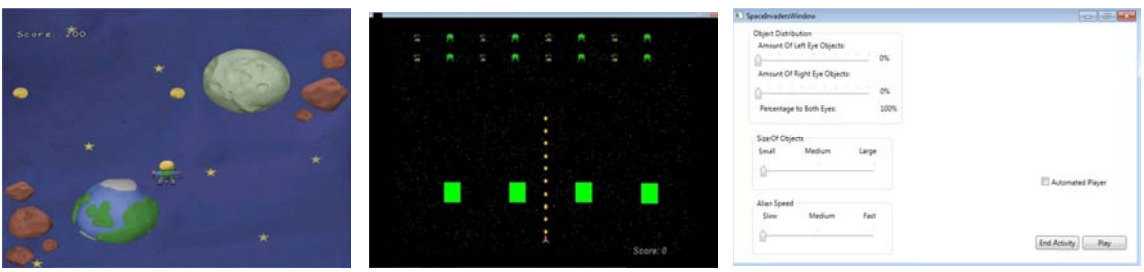

Figure 1. Two of the developed games and the clinician interface.

2.3 System hardware and display development

Two display systems are implemented. Shutter-glasses can be used to treat patients without a squint. For patients with a squint, we have developed a mirror system that will allow the clinician to change the viewing angle and therefore compensate for the angle of squint (fig.2).

Figure 2. The shutter-glasses system and two iterations of the mirror system development.

3. Clinical trials

In the next phase of the project we will conduct clinical trials to evaluate the effectiveness of the I-BiT™ system for amblyopia treatment and determine optimum dose-reponse.

4. Acknowledgements

This project is funded by a Wellcome Trust Translation Award and is funded from April 2010 until April 2013.

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Low Cost Tracking

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Abstract

In order to increase the immersion in virtual reality applications, optical tracking of movements is a common interaction method. However, professional optical tracking systems are very expensive and often proprietary. Therefore we introduce an open source based solution for pupils and students with the intention to enhance their understanding and usage of 3D optical tracking systems.

1. Introduction

In 2005 Reutlingen University has begun to set up an immersive virtual environment system with the objective to have a hands-on VR setting for learning and teaching. However installing a professional system is expensive and therefore cannot be used as a demonstration object for schools and student laboratories. With the current work we present a low cost way to establish tracking systems for virtual environments for educational purposes.

2. Our Approach

We work just with two comparatively cheap webcams with modified filters. Without infrared filters and additional infrared bandpass filters the accuracy of the tracking system is increased. This also improves the results of simple thresholding for image segmentation and in the broader sense blob detection. The equivalent to Bouguet's Camera Calibration Toolkit implemented in OpenCV [1] is used to calibrate, undistort and rectify the camera images as described in [2]. Since we want to track infrared markers we need to track blobs of light in the images and find their correspondences. We use methods of the OpenCV Library for image segmentation and blob detection. For blob tracking and correspondence finding we implemented our own algorithms based on epipolar geometry.

For better maintainability and understanding of our tracking system by students, our system is implemented in C# rather than in C++. Therefore we use EmguCV [3] as wrapper for OpenCV. Additionally the system uses VRPN [4] as interface so the tracking data can be used by client applications.

3. Conclusions

So far our work has shown the feasibility of the approach. It shows that the understanding of computer vision by students can be improved in contrast to those that never had any practical experience working with such a system. Before extending the system the next step is to evaluate the system with regard to its accuracy, reliability, and later to its performance. Another point of future work will be advanced research into ways to automate the calibration process.

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Participant representation in use of collaborative virtual environments for conversation with children on the autism spectrum

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Abstract

This study examines the influence of computer mediation and participant avatar representation for supporting children with autism spectrum conditions (ASC) in answering interview questions about the design of computer games. Preliminary results suggest that conducting the interview in a collaborative virtual enviro-ment (CVE) is more successful than face-to-face and that children prefer video avatar representation of participants than computer-generated avatars.

1. Introduction

Children with ASC often find it difficult to communicate with others face-to-face. Virtual reality offers a platform in which children can communicate in a safe and predictable environment where face-to-face communication is not necessary. The Reev-You Room is a collaborative virtual environment that has been designed specifically for children with autism spectrum conditions (ASC). In this study it is used as a meeting space in which a researcher conducts interviews with children to find out their views on computer game design. A child and researcher enter the virtual room from separate laptops and are represented by either an avatar or via video technology.

2. Evaluation study

A school-based study is currently being conducted to evaluate the Reev-You room as a computer-mediated resource to facilitate interview discussion between the researcher and students. 24 students have been recruited to the study; 12 on the autism spectrum and 12 typically developing students.

Each student participates in three 30–45 minute sessions, comprising the following activities: Playing a commercially available computer game for 10 minutes; Interview discussion with the researcher answering questions about design features of the game just played and ideas for development of a new game.

The interview plan was prepared with the help of specialist teachers.For each session a different game is reviewed and the interview is conducted under one of the study conditions (in balanced-order study design) shown in Figure 1.

Condition 1: Reev-You Room with avatars	Condition 2: Reev-You Room with video pods	Condition 3: Non-computer mediated interview

Figure 1. Three study conditions applied.

3. Results

To date, thirteen students have completed all three sessions (7 students with ASC and 6 typically developing students). Preliminary results indicate a preference for talking to a researcher using the virtual environment. No students said that they would prefer talking to a researcher in a face-to-face setting. Overall, 8 students stated that they preferred the video pods condition and 5 students preferred the avatar condition.

Ruled Line Projection System for Paper Layout Assistance

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Abstract

This paper reports an evaluation experiment using our prototype system which dynamically projects ruled lines on a sheet of paper to support a user in layout design. The system projects lines at proper positions depending on shape and state of the sheet detected from camera images. In the experiment, we compared two sets of lines drawn by a subject with and without ruled lines. It was observed that the difference between these two conditions was significantly large, suggesting the feasibility of the proposed system.

1. Prototype system for evaluation

Our proposed system [1] assumes that computers and other people do not know what task a user is drawing or writing for. This is an absolutely different point from typical augmented reality (AR) system such as a remote assistance system [2] and AR modelling system [3]. Displaying ruled lines on paper has large potential to support for various tasks. This section describes hardware and software configurations of the prototype system.

The prototype system consists of a table with a transparent top board (50cm in diameter), a USB camera (Buffelo Kokuyo Supply Inc. BSW13K05HBK, 640x480 px. 30fps), a LCD projector (3M MP160, 640x480) and a standard PC

(CPU: Intel Core2 2.66GHz, RAM: 2.94GB) shown in Fig. 1. The projector is fixed under the table for avoiding occlusions of user's hands.

This system projects ruled lines parallel to each edge of a sheet. To detect four edges, it computes binarization, labelling, edge detection, Hough transformation and rectangle determination, in order. In the rectangle determination, the optimal combination of four lines is selected from more than ten lines by minimizing an error. The error is a ratio of the number of points in two false regions to the number of all the points randomly sampled in the whole frame. The two regions are false positive and false negative regions between the detected sheet region and a hypothesized rectangle. The optimal combination having minimum error is found by a round robin.

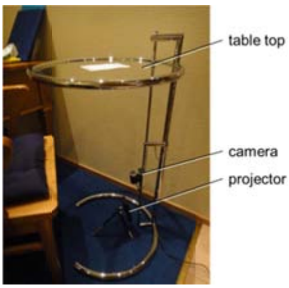

Figure 1. Appearance of the prototype system.

Figure 2. Notepads with (left) and without (right) ruled line projection.

2. Effectiveness of assistance

This experiment shows effectivity of assistance with projected lines shown in Fig. 2. We compared two sets of lines drawn by a subject with and without projection, as two conditions. For each condition, the subject was instructed to draw ten horizontal lines around the projected lines as straight as possible.

The acquired twelve drawn lines were compared with two measures computed in linear regression. The first measure (1) is average R-squared value, which represents linearity of each line. The second (2) is variance of gradients which represents uniformity among multiple lines.

In the case with ruled line projection, the variance of gradients was $2.77\text{x}10^{-4}$ and the average R-squared value 0.82. In the case without ruled line projection, the variance of gradients was $2.84\text{x}10^{-4}$ and the average R-squared value 0.44. We found that the differences of the measure (1) and (2) are significant large by unpaired t-test ($p < 0.05$) and F-test ($p < 0.1$), respectively. These results suggest the feasibility of the projected ruled lines.

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SivinaRia 4D+1: an interactive web environment about the history of navigation in Bilbao

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Abstract

The project SIVINARIA 4D+1 is an interactive system aimed at the spatial and temporal visualization of an image database about the shipping industry of the Bilbao River Mouth. It has been developed in an advanced graphic engine that connects with a historical database through scripting language files. This database contains geo-referenced multimedia data. ICT applications are on their way to becoming one of the most powerful means for the dissemination of cultural heritage.

1. Introduction

The activity in the Bilbao River Mouth relied historically upon many factors that determine the historical evolution of it. The extensive and in depth study of these relationships, as well as their representation through virtual reality constitute a complex enterprise.

SIVINARIA 4D+1 is a web-base application which scripts are the responsible to react to the interaction events of the users with the application. It shows complex database contents through a 3D environment. The database management is made from within the application, and the access based profiling allows us to give permissions to some people to manage it. The graphic engine reads from this database all the interest points and according to the location information that it picks, generates the new hotspots icons like a new 3D model. Navigational interface consists of various controls: a menu, a manual navigation helm and two buttons to control the type of view (a “free walk” and an “automatic walk”).

2. Goals of the project

The main goal of the project was to develop a product which is meaningful both for local and foreign audiences. We wanted purposefully to avoid the passivity of traditional video recordings, as well as the lack of engagement of object-oriented databases with verbal query engines. On the contrary, we pretended to allow users become actors in (their) History thanks to a virtual interactive 4D reconstruction [1] endowed with the unquestionable value of the living witness, that it, of oral transmission, which was the traditional way to preserve the collective memory (Fig. 1).

Figure 1. Screenshot of an interest point within the application.

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Social Competence Training for Children on the Autism Spectrum Disorder Using Multi-Touch Tabletop Surface: A Usability Study

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1. Introduction

Autism Spectrum Disorder (ASD) is a neurological disorder that affects behavior and the ability to communicate and interact socially. Social competence, entailing a child's capacity to integrate behavioral, cognitive and affective skills in order to adapt flexibly to diverse social contexts is one of the core skills impaired in children with high functioning (HF) ASD [1].

A variety of technologies have been used to train social competence of children with ASD [2]. To date, well-established practices for the design of technology to support interventions for these children are lacking [3]. In recent years, an additional technology, multi-touch table top surfaces have become available. These are large touch-screens placed horizontally that can be operated simultaneously by more than one user via multi-user "cooperative gestures" [4]. We have developed a new application, the Join-In Suite, designed to implement social competence training based on Cognitive-Behavioral Therapy (CBT) which views social competence as a multidimensional concept and assumes reciprocity between the ways an individual thinks, feels, and behaves in social situations [5]. Although using technology for children with ASD has been shown to have great potential, there have, thus far, been no attempts to explore the ways in which CBT can be implemented via technology. This work is part of a European Union project, COSPATIAL (http://cospatial.fbk.eu). We present the results of a usability study of the application's prototype.

2. Method

Eight boys with HFASD, aged 9–13 years, participated in the study. All were enrolled in special education classes (Grades 2–5) within a mainstream elementary school. They were moderate to frequent users of video games and had used a multi-touch table previously. The intervention sessions were provided by two experienced occupational therapists who work with these children at their school.

The Join-In Suite is a 3-user, touch-based application implemented via the DiamondTouch (http://www.circletwelve.com), which uses the multi-user capabilities to foster collaboration between pairs of children. Also it provides ways for a teacher/therapist to control the pace and process of the interaction. The design of the application explored different types of collaborative interaction patterns in a multi-user context that supported CBT techniques. The three games – "Bridge", "Apple Orchard" and "Save the Alien" – are composed of two tightly integrated parts: a learning part, which realizes a structured version of the CBT social problem solving technique, and an experience part based on the CBT behavioral reinforcement technique.

We used four questionnaires. *The Scenario Experience Feedback Questionnaire* (SEFQ) to query the children's enjoyment, understanding, ease of use, and other usability issues, *the Scenario Learning Feedback Questionnaire* (SLFQ) to query how well the children understood and felt about the problem and solution part in each game, and *the Intrinsic Motivation Inventory* (IMI) task evaluation questionnaire to assess a user's interest in and enjoyment of the task, perceived competence, perceived choice and feelings of tension while doing the task. It was administered at the end of all three scenarios. At the end of the session, the children were asked to rate the games in order of *preference and effort*.

3. Results and Conclusions

The results show that *Bridge* was the most enjoyable for the children, followed by *Save the Alien*, and then by the *Apple Orchard*. In terms of ease of use, *Bridge* was the easiest game for the children, followed by *Apple Orchard* and then *Save the Alien.*

We also found that the ratings for the *Apple Orchard* were lower in all the experience categories but all three prototypes were rated similarly for the learning part (very positive for all). *Bridge* and *Save the Alien* were rated very similarly to each other and were very positive for all categories of the experience part. The cooperation components for *Bridge* and *Save the Alien* were particularly high. For the IMI the results show that the children were very interested in the task, felt very competent doing it, perceived that they could make choices during the task, and felt minimal tension while doing the task. A number of key changes were made to the prototypes as result of this pilot feedback.

In conclusion, the results of the current study have helped to ensure that the Join-In Suite is a usable and enjoyable application, and suitable to achieve its therapeutic goals. We are now poised to run a formal evaluation study in which the effectiveness of the Join-In Suite will be tested.

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The Analysis of Design and Manufacturing Tasks Using Haptics

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1. Introduction

The HAMMS (Haptic Assembly, Manufacturing and Machining System) was developed as a test bed to investigate and measure user interactions and response while performing various engineering tasks in a virtual environment. The systems' architecture is presented in Figure 1 and comprises a haptics interface (Sensable OpenHaptics® Toolkit and Phantom Desktop), graphics interface (Visualization ToolKit) and physics interface (Nvidia PhysX™).

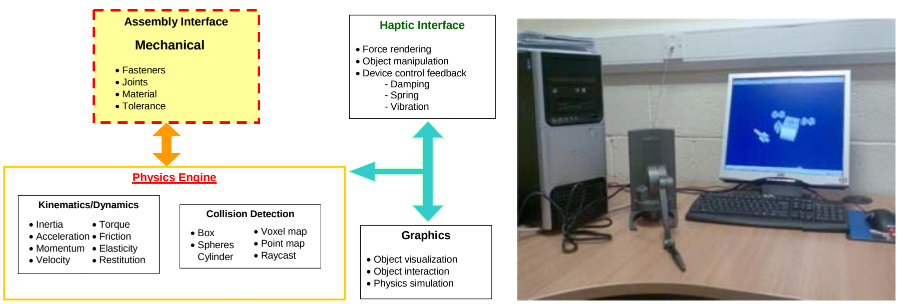

Figure 1. HAMMS Architecture (left) and the Apparatus (right).

2. Assembly Plan Generation

Experiments were carried out that involved users assembling a pump assembly in the haptic environment whilst their activities were logged automatically in the background. The logged data can be parsed to extract assembly instructions shown in the Table 1.

3. Motion Study

Assembly planning remains an important and active area of research. As advances in technology allows for more complex geometries to be manufactured, so too has the degree of complexities increased when assembling components. In order to automate assembly procedures, it is useful to understand the cognitive insight of the human operator. A method that allows for such analysis is to track user-object interaction. The data obtained can then be plotted as a time-dependent profile, called chronocyclegraphs, describing motion together with position, orientation and velocity. (left-hand side of Figure 2). Various yhysical and mental assembly processes, known as Therbligs, can also be automatically assigned to various assembly tasks in the HAMMS environment, as shown on the right-hand side of Figure 2.

Table 1. Assembly Sequence Plan.

HAMMS TRIAL ASSEMBLY PLAN

Op Num	W/Centre	Assembly Instruction	Tooling	Assembly Time Virtual (s)	Assembly Time Real (s)
10	Assy Station	Assemble Housing Pos(52.1973300,132.374680,303.486660), Ori(-27.223383,78.0677630,81.9269930)	Hand Assembly	9.563	2.5
20	Assy Station	Assemble Bushing Pos(34.1373200,136.032850,262.600090), Ori(-30.080830,90.2299300,91.6540300)	Hand Assembly	14.625	2.75
30	Assy Station	Assemble Large Cog Pos(36.0329300,5.65438850,198.074030), Ori(-79.139830,47.3445400,48.3960930)	Hand Assembly	15.156	3.35
40	Assy Station	Assemble Small Cog Pos(87.9126700,17.4170450,275.344170), Ori(15.4471330,95.0802830,90.5356330)	Hand Assembly	28.859	12.0
50	Assy Station	Assemble Bushing Pos(35.5983700,82.9755150,241.834560), Ori(-30.403610,94.2829200,91.7849300)	Hand Assembly	16.906	3.6

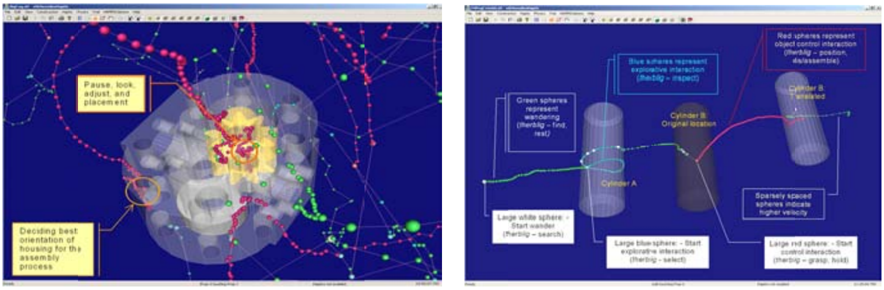

Figure 2. Chronocyclegraph (left) and Therbligs (right) for Assembly Task.

4. Conclusions

- Successfully used a haptic free-form assembly environment with which to generate assembly plans, associated times, chronocyclegraphs and therblig information.
- By logging user motion in the manner shown and outputting an interaction pattern over a task, the derived chronocyclegraph can be used to pinpoint areas of where and how decisions are made.
- Provision of auditory cues could also further enhance a users experience and provide clues on how the human sensory system synchronizes and process sound inputs with tacit and visual signals.

VR Interactive Environments for the Blind: Preliminary Comparative Studies

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Leicester, UK

Abstract

People living with impaired vision rely upon other sensory inputs in order to learn the configuration of a new space. This research project asks 2 questions: what types of acoustic cues are used to mentally represent a given environment without the visual channel? And is it possible to accurately model these cues computationally [in a Virtual Reality (VR) space] to provide an easy mechanism for someone with visual impairment to learn the configuration of a new environment in advance of being introduced to it? In this poster, three preliminary comparative studies are presented which focus on the ability of blind and sighted individuals to detect walls and obstacles within an environment, relying only on the auditory sense.

1. Introduction

Standard interactive VR systems (e.g. gaming applications) are usually created for sighted people, and are visually-oriented. Other sensory feedback (audio, haptic, etc.) may be present in these applications, but is not modelled precisely enough to, for example, play the game blindfolded. Whilst a large body of research has been undertaken to understand spatial audio perception, this has been primarily conducted with sighted people; specific studies on visually impaired are limited, and have only recently begun to emerge in the literature [1, 2, 3]Further advancing this understanding is a fundamental component of this research.

As an example, in order to be able to localize a sound source in a reverberant environment, the human hearing system directionally analyzes only the first signal that reaches the ear, i.e. the signal that comes directly from the sound source. It does not consider the localisation of other signals resulting from reflections from walls, ceiling, floor etc. that arrive within a certain delay from the first signal. For this reason, and to reduce the number of computationally expensive calculations, when simulating 3D soundscapes the directional resolution of the acoustic reflections is often approximated. However, it is an accepted dogma that people living with visual impairment make extensive use of these reflections to understand their local environment, although robust scientific evidence for this is lacking. The ability to analyse directionally the early reflection components of a sound is not thought to be common in sighted individuals. If VR and 3D sound applications are to be used effectively by the visually impaired, they need to be customised to give a better representation of the real world soundscape.

2. Preliminary comparative tests

Aiming at identifying and quantifying the differences in terms of environmental auditory perception between sighted and blind individuals, three pilot studies have been recently carried out.

An obstacle/wall detection test was carried out, in which the ability of localizing an obstacle/wall using only sound reflections was compared between sighted and blind individuals. While a frontal sound source was reproducing speech signals, a baffle was placed at different positions and distances around the participant, who had to localize it using only the auditory stimulus. The results for the two groups of people (visually impaired and sighted) were then compared: neither group seemed to have an advantage over the other, while it was shown that age played the most important factor.

Another test was carried out in which the detection threshold for distance was measured comparatively between sighted and blind individuals. Using a setup similar to the one of the previous experiment, a baffle was positioned at different distances from the participant (5 cm distance steps between 2 m and 20 cm). Blind individuals were found to be able to localize the baffle when this was located up to 2 metres away, while for sighted individuals this value was reduced to 0.9–1 metre.

A final test focused on comparing the ability of blind and sighted individuals when discriminating room size and shape with the exclusive use of the auditory sensory channel. Binaural audio recordings were made in a variety of rooms and presented to test subjects in the context of a “forced choice” test; subjects were asked to evaluate the recordings using a set of scale models, representing the rooms in which the recordings were made, and to identify the room which they felt each recording was made in. On average, the blind group showed greater accuracy in performing this task compared to the sighted group, although a broad and differing range of abilities was recorded for both sighted and visually impaired individuals.

3. Conclusions

The results of the preliminary tests described in the previous sections seem to underline the correct direction of this research, and need for further sudies in the field.

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Title

Joint VR Conference of euroVR and EGVE, 2011

Current and Future Perspectives of Virtual Reality, Augmented Reality and Mixed Reality: Industrial and Poster Track

Abstract

The Joint Virtual Reality Conference (JVRC2011) of euroVR and EGVE is an international event which brings together people from industry and research including end-users, developers, suppliers and all those interested in virtual reality (VR), augmented reality (AR), mixed reality (MR) and 3D user interfaces (3DUI). This year it was held in the UK in Nottingham hosted by the Human Factors Research Group (HFRG) and the Mixed Reality Lab (MRL) at the University of Nottingham.

This publication is a collection of the industrial papers and poster presentations at the conference. It provides an interesting perspective into current and future industrial applications of VR/AR/MR. The industrial Track is an opportunity for industry to tell the research and development communities what they use the technologies for, what they really think, and their needs now and in the future. The Poster Track is an opportunity for the research community to describe current and completed work or unimplemented and/or unusual systems or applications. Here we have presentations from around the world.

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