



SPINKLAR-3D: Motion Capture, Interaction and Cooperation between People and Avatars in 3D Augmented reality and virtual reality

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Abstract

We present selected results from a recently established Future Technologies Laboratory for basic research in the field of interaction and cooperation aimed for augmented and virtual reality. The laboratory is being built around the Spinnstube system, which needs to be enhanced by devices that facilitate the interaction and mutual cooperation of humans and/or avatars with objects in virtual environments. The basic research question is how to optimize the communication among all involved entities. The outcome of this VEGA project is a concept of a laboratory suitable both for teaching and research.

Keywords:

motion capture, interaction, cooperation, augmented reality, virtual reality, avatar, virtual environments, laboratory, computer vision

CR Categories: I.3.7 [Computer Graphics] Three-Dimensional: Graphics and Realism – Virtual reality.

Abstrakt:

Uvádame vybrané výsledky z nového laboratória Future Technologies Laboratory na základný výskum interakcie a kooperácie pre rozšírenú a virtuálnu realitu. Dopĺňame už inštalovaný systém Spinnstube, ktorý sa dokompletuje o zariadenia na interakciu používateľa a/alebo avatara s objektami a vzájomnú kooperáciu vo virtuálnych prostrediach. Základná výskumná otázka je ako optimalizovať komunikačné situácie medzi všetkými zúčastnenými entitami. Výstupom projektu VEGA je prototyp laboratória, vhodného súčasne na výučbu aj výskum.

Kľúčové slová:

snímanie pohybu, interakcia, kooperácia, rozšírená realita, virtuálna realita, avatar, virtuálne prostredia, laboratórium, počítačové videnie

1. INTRODUCTION

This project research contributes, in general, in optimizing of data flows in augmented and virtual reality in the terms of speed and precision (as stated in the original preceding ARISE project – Spinnstube development, from this European project we obtained the virtual reality setup) [1]. A free-hand environment allows for the interaction and cooperation of adequate as well as unconventional objects. Following up the project ARISE mission and standard methodology [2], [6]. [11-14], we focus to more specific communication situations, more accurate motion capture, colors, and using more accurate methods for computer vision. We combine teaching with usage of the devices and research in progress. This way we get synergistic effect. We upgrade of autonomous agent, avatars and their communication possibilities with user, to examine for new ones. Partial results of our measurements and research are innovative by themselves for color processing, object reconstruction, communication scenarios and methodology for education in specific environment. We subdivided the research into the following research lines.

2. SPINKLAR-3D RESEARCH OUTLINE

2.1 We investigate optimal color representation for semantic information extraction from images/videos in three steps. Methods for perceptually equivalent gamut mapping and extraction/analysis of semantic information are synthesized within experiments with qualities/defects classification based on color information. We employed object color measurements and object/face recognition for image classification.

2.2 We aim to visualize an interactive city model using specialized VR environment and dedicated Spinnstube setup. For virtual reality education we developed tools and modules enabling students to program their own tasks. The ARISE targeted Spinnstube for elementary schools but our retargeting to university students and public exhibitions was welcome in both groups. We assumed ongoing system development for virtual cities and other complex objects for radical acceleration, scaling and more comfort usability, even for cellular automata based models development.

2.3 We study the possibilities of 3D display devices for the fields of Information Visualization and Scientific Visualization to achieve real-time rendering. We involved undergraduate students with bachelor and master theses for implementations and comparisons of selected visualization techniques.

2.4 A comparison of the 3D surface interpolations based on the radial basis functions on a scattered data and an implementation of Clough-Tocher method with normals computed using local interpolants was done.

2.5 Miniprojectors as new human-computer interaction tool (computer vision and new interactive methods) offer benefits over traditional methods. We consider real-life deployment scenarios now.

2.5 We work on integration of methods for construction, presentation, and evaluation of communication situations in VR, namely new prototypes of motion capture, extending the functionality of avatars and/or autonomous agents and analyze the transfer of animation standards for interaction and cooperation. This requires both the development of theory, e.g. reference models by Bimber-Raskar and Ignatiev, error and stability issues and practical incremental building of lab research, database of measurements.

However, the research of all above outlined questions is limited by funding shortage.

3. SELECTED RESULTS

In the following, we survey five selected particular achievements.

3.1 *Crowd simulation in an exhibition environment*

We introduce a novel grid based method of presenting participants in a crowd [3]. We propose a psychological approach in the special case scenario in the exhibition environment. For this environment we use 3D approach for emotions, that is widely used in psychology. We map context-specific axes to achieve better emotional control for our specific environment. Moreover, we discuss also possibilities of low level behavioral control, collision detection. We extend the pedestrians movement methods with our novel behavior model for the setup.

3.2 *Automated usability measurement of arbitrary desktop application with eyetracking*

Nowadays, in software development process more attention is paid to the final usability of the product. To achieve such usability we use various methods from user centered design up to the usability evaluation methods, requiring much attention from usability experts. The presense of these experts are needed both during capturing and analysing usability data, which eventually costs too much. We propose a tool for automated data capturing during user tests as well as a captured data analysis in order to evaluate the recorded interaction and guide the attention of software developers. Furthermore, we provide a simple statistics of user tests as well as a means to browse recorded data with the interaction context extended with eye tracking data [4].

3.3 *Skeleton Texture Mapping*

A novel way of mapping of textures onto a surface of 3D model is introduced [9]. Our technique is based on two interlocking mappings. The first one maps surface vertices onto a computed skeleton and the second one maps the surrounding area of each skeleton segment into a rectangle with size based on the surface properties around the segment. Furthermore, these rectangles are packed into a squared texture – skeleton texture map (STM) by approximately solving a palette loading problem. Our technique enables the mapping of a texture onto the surface without necessity to store texture coordinates with the model data and it is also suitable for surfaces with a topology non-homotopic to a sphere with higher order genus and unlimited structure branching.

3.4 *Computer graphics education from high school to university*

We analyze the introductory courses of computer graphics [10], having two goals in mind. First, we studied how computer graphics ideas in another context are taught before entering university, at high school level. Second, what is the content of introductory courses and how connected it with previous knowledge. Our findings are summarized into three stages of knowledge, and five levels of education. We described the educational process by analogy with selected models and theories – the reference model for computer graphics, mathematic language ruptures by Kvasz, Piaget's development theory, and a cognitive process of mathematic by M. Hejny.

3.5 *Terrain Models for Mass Movement Erosion*

We present a particle-based method for large scale long time progressive simulation of terrain erosion containing wet granular particles [7]. The wetting process and the propagation through granular material is based on defining the wetness value for each particle representing the amount of water absorbed by granular particles and stored between them, as was originally proposed by Rungjiratananon. We extend this model by adding a non homogeneous material to

simulate differences between different types of soil-like granular material, based on physical constants like stability, plasticity and wetness. With this approach we can create a physical animation of erosion process like mass movement or mass wasting.

▀ 3.6 Scalable Multifunctional Indoor Scanning System

The main goal of this work was to extend the system SMISS functionality. It is a scanning system for automatic 3D reconstruction in metric space. It works on a triangulation principle, using structured light from digital projector to spatially code the space. For the data acquisition, the system uses a digital camera. We address the problem of low dynamic range of similar systems and propose a novel approach, first of its kind, to solve the problem using simple additional hardware and designed algorithms. Our solution, in form of extension HDR SMISS is also a powerful and flexible tool for future improvements. We also introduce a deeper study of methods, which use structured light for coding the scanning space. We contemplate the possible usage of 3D reconstruction in different fields of human life. Moreover, we offer a way to visualize the captured data in form of a view dependent stereo vision. While solving the problems, we care about choosing physically correct approaches and we solve the problems using combination of hardware and software. Therefore we introduce descriptions of prototypes built for specific purposes and for international propagation.



Fig. 1 – Results of 3D reconstructions

Project SPINKLAR has supported the Master Thesis “Scalable Multifunctional Indoor Scanning System”, which received Rector’s Award and 2nd place in best IT Master thesis competition ACM-SPY in Czech-Slovak region. SPINKLAR project allowed the student to use advance technology to present his work to professionals and general public [8].

▀ 3.7 Interactive Bivariate Mode Trees for Visual Structure Analysis

The number of modes in a kernel density estimation of a certain data distribution strongly depends on the chosen scale parameter. We present an interactive mode tree visualization that allows to visually analyze the modality structure of a data distribution. Due to the branched structure of the bivariate mode tree, composed of many curved arcs in 3D, we need to utilize advanced techniques, including clutter removal through transparency, on demand outlier suppression or preservation, and best views, to improve the visualization mapping [5].

▀ 4. OTHER ACTIVITIES

▀ 4.1 CESCOG 2012

The student conference CESCOG 2012 took place in Smolenice Castle in Slovak Republic. The paper HDR SMISS was presented with the hardware support of the SPINKLAR project. The work received best presentation and second best paper award.



Fig. 2 – Results of 3D reconstructions and installation setup at CESC 2012

4.2 Noc Výskumníkov 2012



Fig. 3 – 3D reconstruction at the exhibition “Noc Výskumníkov“

The exhibition “Noc Vyskumníkov” is European Union project on popularisation of Science. One of the the exhibited scientific project was face scanning using structured light. This system, called SMISS is developed at the Comenius University and is capable of geometrical face reconstruction. These data are then visualised. We use our developed solution to track user eyes and register the real and space, so that, we are able to project the face scan on a 3D display (supplied by SPINKLAR project). This projection creates illusion than the object is registered in volume and looks realistic. This technique is called view dependent stereoscopic vision.

4.3 Virtuálny Svet 2012

The exhibition “Virtuálny Svet 2012“ took place in AVION Shopping Center, which is located in Bratislava. The event was organized by Faculty of mathematics, physics and informatics of the Comenius University. The main idea of the exhibition was to present new ideas and the study at the University.

4.3.1 3D Scanner

The project SPINKLAR-3D supported the part of the exhibition by supplying the hardware for visualization. The 3D scanning solution was available to general public for one month. Every visitor of the shopping center was allowed to scan his face by simply sitting in the chair. The system in realtime and automatically recognized human face and started voice communication. After instruction has been said by the system, the system executed the scanning process and reconstructed the visitor’s face. The result was then projected to supply 3D TV screen.



Fig. 4 – 3D reconstructions setup at the exhibition “Virtuálny svet 2012”

4.3.2 Information Kiosks

The project SPINKLAR-3D supported renovation of the hardware and software setup for the kiosk. The kiosk was created as a part of a project “Považské múzeum 3D online” to motivate people to visit the museum „Považské múzeum“ personally.



Fig. 5 – Kiosk and it’s instalations (exhibition “Virtuálny svet 2012“, FMPH UK)

But now the kiosks are used as information center for many other projects created by working group on Faculty of Mathematics, Physics and Informatics and anybody touching the screen can access these projects and play with them partly when the kiosk is offline and fully when the kiosk is online.

4.4 Spektrum Vedy – Virtuálne Svety 2012

A part of television documentary about science in Slovak Republic. This part, named Virtual Worlds, was dedicated to 4 different research projects from FMFI of Comenius University. The already mentioned project SMISS was presented in this documentary and it was broadcasted by Slovak National Television.



Fig. 6 - A part of television documentary about 3D reconstruction

5. CONCLUSION

By support of the project SPINKLAR-3D and as one of the main goals of this project was to create also a Besides the support of the VEGA project SPINKLAR-3D, the laboratory is also supported by Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava. By public voting we named this laboratory “Future Technologies Laboratory”. The mission of this laboratory is dealing further with the fertile research fields of computer vision, computer graphics, augmented reality and virtual reality. For more about FTlab, visit, please, its webpage at www.ftlab.sk. The complete results and outcomes can be found at [15], resp. [16].



Fig. 7 - Logo of the laboratory

ACKNOWLEDGEMENTS

All projects, publications and activities mentioned in this paper are supported by Project SPINKLAR-3D -Project VEGA No. 1/1106/11. We thank to CVUT Prague team for noble-minded donation of the Spinnstube prototype.

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