VOXAR Labs

augmenting experiences for a better life

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***Abstract*—The VOXAR Labs is a research group with the mission of developing people by augmenting experiences. It develops and transfers technology related to visualization, tracking and natural interaction techniques focusing augmented reality in multi-disciplinary application domains. The laboratory has several ongoing projects including an international cooperation, projects with the industry, involving energy and military ones, as well as research and academic projects. VOXAR Labs is part of the Informatics Center of the Federal University of Pernambuco, located in Recife – Pernambuco, Brazil.**

Keywords: Augmented reality; tracking; visualization; interaction

I. VOXAR LABS

The VOXAR Labs finds its inspiration in areas studying the three-dimensional space, being the voxel –or volumetric pixel– the key element of the lab's name. The concept of voxel also refers to how the world is constructed, how it can be understood and rebuilt to achieve a better one. This idea is strongly connected to the core research focus of the group, augmented reality. This way, the lab's name was coined.

The laboratory is located at the Informatics Center – CIn building at the Recife campus of the Federal University of Pernambuco – UFPE. Detailed information about the VOXAR Labs can be found at www.cin.ufpe.br/voxarlabs. Fig. 1 shows part of its team on a meeting.

Figure 1. VOXAR Labs visualization team on a meeting.

Recife is a beautiful tropical city in the northeast of Brazil. It is one of the most important technology pools in the country, having the so called Porto Digital (in English, Digital Harbor) with anchor institutions like CIn UFPE and CESAR, and companies such as IBM, Motorola and Ogilvy. More than 26.000 students study in the UFPE, and CIn is evaluated by the Ministry of Education – MEC as one of the top 5 information technology centers in Brazil.

II. HISTORY AND MISSION

In 1998 the CIn began to perform research in the so called advanced human-computer interfaces area, exploring technologies such as virtual reality. In 1999 the first MSc dissertation related to this subject was finished, followed in 2004 by the first PhD thesis. Since then not only the number of students performing research related to human-computer interfaces has grown in CIn, but an important team of professors with diverse related expertise joined the institution, leading to the creation of the Media & Interaction research area, in 2007.

Since 2005 a group of researchers with common interests has been investigating virtual reality and augmented reality technologies at CIn, leading recently to the creation of the VOXAR Labs. This team, headed by Professor Veronica Teichrieb, is composed by multi-disciplinary researchers, from professors to PhD, master and undergraduate students (nowadays numbering nineteen). They work in diverse knowledge domains like computer science and computer engineering, design and mathematics, as well as application driven areas like physiotherapy.

The VOXAR Labs mission is to develop people by augmenting experiences. The values representing the core priorities in VOXAR Labs culture are creativity, cooperation, reliability, responsibility, flexibility, and enjoyment.

III. OBJECTIVES

In order to accomplish its mission the laboratory goals are:

- Take part of the creation of a world-class center of excellence for human interface technology research, focusing augmented reality applied to traversal problem domains, in CIn UFPE.
- Provide multi-disciplinary project-based learning experiences for students.
- Develop and transfer to industry leading-edge human-computer interfaces to accelerate economic development in Brazil.

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IV. Research Lines

VOXAR Labs performs research on three major subjects, which are visualization, tracking and natural interaction focusing augmented reality. The laboratory team has been involved with augmented reality research for almost six years. Recently, the VOXAR Labs was the third finalist in the Layar Creation Challenge international competition with the innovative augmented reality application Food2You[1].

Augmented reality is a technology that superimposes virtual information – 2D or 3D, textual or pictorial – onto real world scenes in real time, registered in 3D, and allows users interaction with real and virtual elements simultaneously. In this kind of interface the real environment takes part of the application context.

In augmented reality the technical challenges lie in determining, what should be shown where, and how.

A. Visualization

The latter problem is especially important when the visual appeal of the result is crucial. Then substantial effort must go into seamlessly fitting the information into the scene, according to the objectives of the system. Ideally, augmented reality proposes that the user must not be able to distinguish between real and virtual information, demanding that the virtual elements show both geometric (correct placement, correct size, occlusions identification) and photometric (shadowing, mutual reflections, chromatic adaptation to scene illumination) consistency. Even under simplified conditions these problems cannot be trivially solved due to performance and accuracy constraints. The VOXAR Labs works on this subject in its visualization research line with great efforts in real time graphics algorithms [1], massive data visualization, physics simulation [2] and 3D reconstruction approaches.

B. Tracking

The problem related to correctly positioning virtual information relative to the real environment, called registration, is solved by tracking the environment so that the synthetic elements can be adequately registered with the real scene. There are diverse tracking technologies available, such as optical sensors, movement sensors, thermal imaging, ultrasound, infrared sensors, GPSs, among others. They capture features from the real world, and based on this information the augmented reality system determines when, where and how the virtual scene should be exhibited. Optical tracking is often used for this purpose due to cost, accuracy and robustness requirements. Two types of optical tracking can be cited: marker based and markerless. Marker based tracking is a more well established approach for registration. It makes use of known artificial patterns placed along the environment in order to perform camera pose estimation. On the other hand, markerless tracking differs from the former one by the method used to place virtual objects in the real scene. In markerless augmented reality any part of the real environment may be used as a marker, since the system exploits natural features present in the real scene to perform tracking. Markerless augmented reality has received more attention from researchers in the latest years, and presents important challenges to be overcome. Tracking [3][4] and registration represents an important research line of VOXAR Labs.

[1] http://www.cin.ufpe.br/~voxarlabs/Food2You.html

C. Natural Interaction

Natural interaction is a powerful tool to achieve intuitiveness and usability for human-computer interfaces. In fact, nowadays interfaces are constantly evolving to provide users an easier way to interact with machines. Studies show multi-touch interfaces such as the ones present in Apple's iPhones and iPads being used by 6-7 years old children, which emphasizes the easiness of use of such interfaces. Another sign of this trend is the effort of current video game console generation to provide interfaces that interpret users' movements. Nintendo's Wiimote, Sony's Playstation Move and Microsoft's Kinect are recent devices that perform, using different methods, the tracking of body movements, for example. Hand and face tracking are included in this context. It attempts to provide more intuitive tools that understand users' intentions when moving their hands and head, as well as to interpret face expressions and hands postures. However, due to its high level complexity and restrictions (like running on real time), these tasks are still not resolved. This way, the problem of interpreting users' corporal intention was partitioned and classified; there are works focused on hand gesture recognition, face detection, upper-body tracking, and so on. Natural interaction is investigated by VOXAR Labs for diverse application domains, including education [5], physiotherapy and entertainment [6], among others [7].

V. Ongoing Projects

The laboratory performs research, development & innovation projects that are carried out in collaboration with academic and research institutions, government agencies and industry partners, in Brazil and overseas. In sequence, major projects executed by the VOXAR Labs' team are briefly introduced, representative of the laboratory's visualization, tracking and natural interaction research lines.

1) ARVS – Hybrid model based markerless 3D tracking for augmented reality and visual servoing

The ARVS project aims to handle the problem of monocular real time 3D object tracking targeting augmented reality and visual servoing applications. Augmented reality and visual servoing may be applied to different scenarios, such as industrial assembly and maintenance support. This information is superimposed on the real world image in real time through an intuitive graphical interface, increasing efficiency and decreasing operation errors, costs, risks and time needed to perform these tasks. Visual servoing allows robotic systems to correctly position themselves relative to the target they have to manipulate in automated assembly and maintenance. These systems can be used in hostile environments and present accurate results with an overall low cost when compared to manpower. A hybrid model based markerless 3D tracking approach will be used, combining recursive tracking and tracking by detection, based on edges and textures, respectively. In order to speed up some time consuming steps of the 3D tracking pipeline, graphics hardware will be exploited for massively parallel processing. This technique will allow automatic initialization and recovery from failures along

with improved accuracy and robustness. Fig. 2 shows tracking results achieved with one of the implemented techniques (left) and the distance function from Particle Filter.

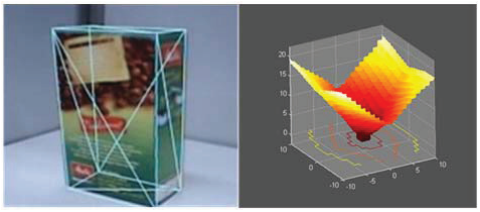

Figure 2. Interest Point Based 3D tracking technique integrated with a Particle Filter.

This project is promoted by STIC-AmSud, a scientific-technological cooperation program integrated by France, Argentine, Brazil, Chile, Paraguay, Peru and Uruguay. The aim of the program is to promote and strengthen South America regional capacities and their cooperation with France, towards the settlement of research and development webs on Science, Information Technology and Communication field.

In the ARVS case, two institutions from two different countries, besides the VOXAR Labs from Brazil, integrate the project, namely the Robotics and Automation Division from the Advanced Mining Technology Center of the University of Chile, Chile and the IRISA-INRIA Rennes Lagadic project team, France. Therefore, ARVS project is funded by CAPES, CONICYT and INRIA, representing the Brazilian, Chilean and French funding agencies, respectively.

2) "Furnas::AR" – Research and development of a virtual and augmented reality based environment for simulation of procedures in electrical substations

The so called "Furnas::AR" project aims researching and developing augmented reality techniques that allow the creation of an augmented reality based application able to hasten and simplify the design of engineer's activities in the planning of electrical substations. Fig. 3 illustrates an electrical substation rendered on top of its map.

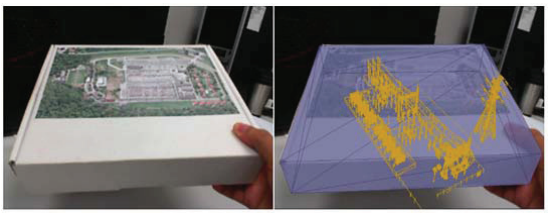

Figure 3. Augmented reality prototype.

"Furnas::AR" is executed in collaboration with Eletrobras Furnas and the Institute of Technology for Development (LACTEC), being ANEEL the funding agency.

3) RT^2 – Real Time Ray Tracer

The RT^2 project researches major concepts related to 3D visualization of massive models. Such models are defined by complex geometric shapes in quantitative terms, commonly from 10^6 to 10^9 primitive units like points/particles and triangles. Usually, massive models demand tackling three issues: 1) high level of detail not possible to be seen by the human eye without zooming; 2) data consuming hundreds of GB or TB for storage; 3) data exceeding conventional processing capacity. In this context, VOXAR Labs is investigating advanced technologies for real time visualization of 3D environments and intends to render massive models using ray tracing on massively parallel computing platforms such as GPUs, as the model shown in Fig. 4.

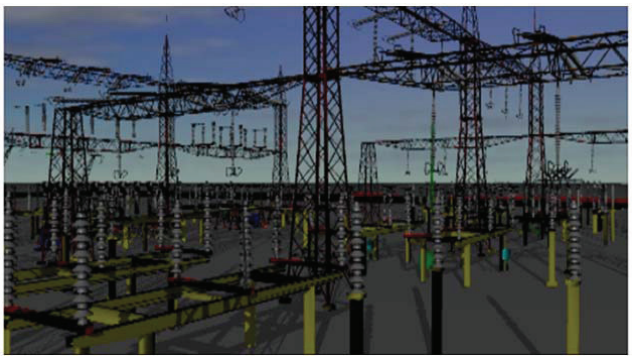

Figure 4. 18 million polygons model visualized in real time.

RT^2 is partially funded by CNPq.

4) NAVEGANTE – Collaborative technological development of a design tool for evaluating the hydrodynamic performance of submerged ships

The NAVEGANTE project aims to build a tool for aiding the hydrodynamics design of submerged ships advancing and maneuvering. Therefore, it is supported by analytical-numerical and experimental methods configured and validated in the context of case studies to be defined in collaboration with the Brazilian Navy. The RANS method will be applied regarding the analytical-numerical research topic, and as experimental method it will be used meshless particle methods.

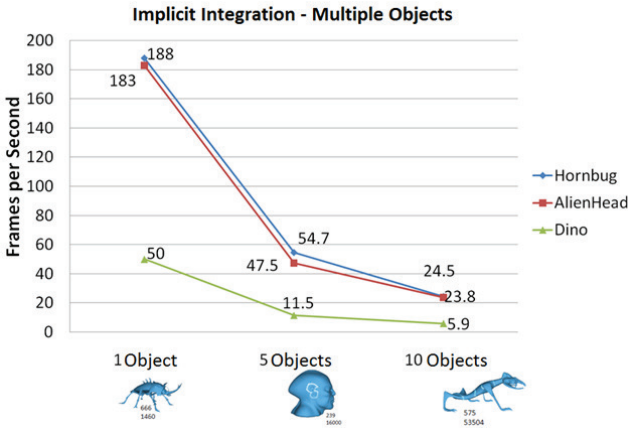

Figure 5. Point Based Animation meshless particle technique: a sequentially executed scene (Intel Core i7) containing one object (577 physical and 53,504 surface elements) simulating a Verlet explicit integration obtained rates of 4.1 fps, while in the parallel implementation (GTX 295) ten instances of the same object simulating an Eulerian implicit integration obtained rates of 6 fps.

It has been developed a simulation of point-based

deformable objects in real time, through a meshless technique called Point Based Animation. Such technique has been gaining attention mainly because it uses only points as simulation units, without connectivity information among them, therefore allowing an increase of performance and turning the simulations even more accurate. This feature enabled the development of a parallel version using the NVIDIA CUDA technology to turn some barely interactive results achieved with sequential implementations into real time results. Fig. 5 presents these performance results for three different complex objects.

NAVEGANTE is executed in collaboration with the Technological Center of the Brazilian Navy in São Paulo (Centro Tecnológico da Marinha em São Paulo – CTMSP), University of São Paulo and the Mechanical Engineering Department of the Federal University of Pernambuco. Funding is done by FINEP.

5) Guitars on Air

The Guitars on Air is a musical game following consolidated games such as Rock Band and Guitar Hero. Its playability is given through natural interaction, since users gestures are recognized. Using augmented reality, a virtual guitar is played according to a sequence of commands, nearing user experience to the reality of a musician. Therefore, control is achieved using the body of the user, in the same way as innovative devices as Kinect work. Fig. 6 illustrates the system.

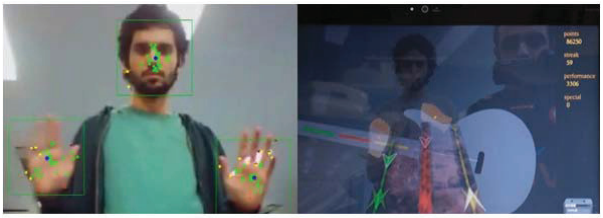

Figure 6. By tracking user hands the reality is augmented showing a virtual guitar to be played. The hand movements of the player are interpreted and then used as input to a musical game prototype.

Guitars on Air is partially funded by CNPq.

6) ARBlocks

ARBlocks aims creating a platform (see Fig. 7) for educational games and activities. It uses blocks, as the ones commonly found in classrooms, exhibiting dynamically content for students that changes according to the game and the educator's needs. Using augmented reality and projections, the platform supports as well videos, animations and audio.

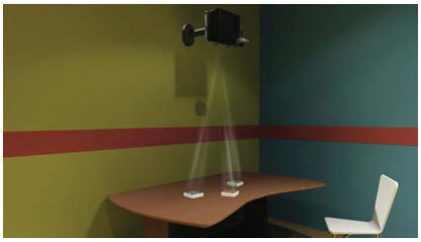

Figure 7. Conceptual image of ARBlocks platform.

ARBlocks is partially funded by FACEPE.

7) iKapp

The iKapp project aims research and development of an environment based on virtual and augmented reality techniques for rehabilitation and accessibility purposes. iKapp aims to make rehabilitation process more reliable and agreeable using natural interaction, movement orientation and physiotherapy support. Fig. 8 illustrates the game played by the patient during the rehabilitation process.

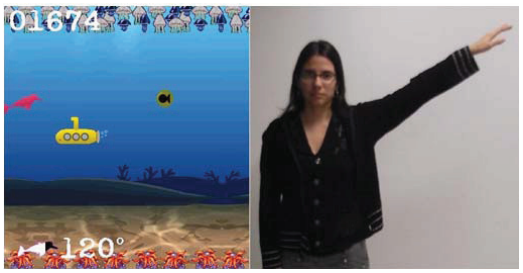

Figure 8. User's body is tracked and the patient is required to practice a specific movement of interest in his/her treatment. Then the movement is evaluated by the system and a correction suggested when needed.

iKapp is executed in collaboration with the Physiotherapy Department of the Federal University of Pernambuco, and partially funded by FACEPE. Due to its high innovative character, a patent has been submitted for registration of the intellectual property of the idea.

VI. Final Considerations

VOXAR Labs research directions focus augmented reality applied to grand challenges in diverse problem domains. Students, post-graduates, post-docs and visiting researchers interested in having such experience, from Brazil and abroad, are very welcome to our lab. We are also fostering collaborations with academic and industrial partners interested in long term problem-driven research, development & innovation projects.

References

[1] A. Santos, J. M. Teixeira, T. Farias, V. Teichrieb, and J. Kelner, "Understanding the efficiency of kD-tree ray-traversal techniques over a GPGPU architecture," IJPP, in press.

[2] M. Almeida, V. Teichrieb, and J. M. Barbosa, "Point-based deformable body simulation through GPGPU," CIMENICS, in press.

[3] J. P. Lima, V. Teichrieb, J. Kelner, and R. Lindeman, "Standalone edge-based markerless tracking of fully 3-dimensional objects for handheld augmented reality," ACM Symposium on Virtual Reality Software and Technology, pp. 139–142, 2009.

[4] J. P. Lima, P. Pinheiro, V. Teichrieb, and J. Kelner, "Markerless tracking solutions for augmented reality on the web," Symposium on Virtual and Augmented Reality, pp. 1–8, 2010.

[5] R. Roberto, D. Freitas, J. Lima, V. Teichrieb, and J. Kelner, "ARBlocks: a concept for a dynamic blocks platform for educational activities," Symposium on Virtual and Augmented Reality, pp. 28–37, 2011.

[6] L. Figueiredo, J. M. Teixeira, A. Cavalcanti, V. Teichrieb, and J. Kelner, "An open-source framework for air guitar games," Brazilian Symposium on Games and Digital Entertainment, pp. 74–82, 2009.

[7] J. Barbosa, F. Calegario, F. Simões, G. Cabral, V. Teichrieb, and G. Ramalho, "Towards an evaluation methodology for digital musical instruments considering performer's view: a case study," Brazilian Symposium on Computer Music, 2011.