The 7th International Conference on Virtual Learning
VIRTUAL LEARNING – VIRTUAL REALITY

Phase II - Period 2010-2020: e-Skills for the 21st Century
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Special edition dedicated to "2012 Alan Turing Year"

ICVL and CNIV Coordinator: Dr. Marin Vlada

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On Virtual Learning

NOVEMBER 2-3, 2012

MODELS & METHODOLOGIES, TECHNOLOGIES, SOFTWARE SOLUTIONS
Phase II - Period 2010-2020: e-Skills for the 21st Century

Special edition dedicated to "2012 Alan Turing Year"

editura universității din bucurești, 2012
MOTTOS

„The informatics/computer science re-establishes not only the unity between the pure and the applied mathematical sciences, the concrete technique and the concrete mathematics, but also that between the natural sciences, the human being and the society. It restores the concepts of the abstract and the formal and makes peace between arts and science not only in the scientist' conscience, but in their philosophy as well.”

Gr. C. Moisil (1906-1973)
Professor at the Faculty of Mathematics, University of Bucharest,
Member of the Romanian Academy,
Computer Pioneer Award of IEEE, 1996
http://www.icvl.eu/2006/grcmoisil

"Learning is evolution of knowledge over time"

Roger E. Bohn
Professor of Management and expert on technology management,
University of California, San Diego, USA,
Graduate School of International Relations and Pacific Studies
http://irps.ucsd.edu/faculty/faculty-directory/roger-e-bohn.htm
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2010 – TOWARDS A LEARNING AND KNOWLEDGE SOCIETY – 2030
VIRTUAL ENVIRONMENTS FOR EDUCATION AND RESEARCH

C³VIP: "Consistency-Competence-Clarity-Vision-Innovation-Performance"

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Partners: Ph. D. Prof. Grigore Albeanu, Ph. D. Mircea Dorin Popovici,
Prof. Radu Jugureanu, Prof. Olimpius Istrate
Institutions: The Romanian Ministry of Education, Research, Sports and Youth of
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**Participate**

The Conference is structured such that it will:
- provide a vision of European e-Learning and e-Training policies;
- take stock of the situation existing today;
- work towards developing a forward looking approach.
The Conference will consider the perspectives and vision of the i-2010 programme and how this will stimulate the promotion, and development of e-Learning content, products and services and the contribution of these to lifelong learning.

Participation is invited from researchers, teachers, trainers, educational authorities, learners, practitioners, employers, trade unions, and private sector actors and IT industry.

**Research papers – Major Topics**

The papers describing advances in the theory and practice of Virtual Environments for Education and Training (VEL&T), Virtual Reality (VR), Information and Knowledge Processing (I&KP), as well as practical results and original applications. The education category includes both the use of Web Technologies, Computer Graphics and Virtual Reality Applications, New tools, methods, pedagogy and psychology, Case studies of Web Technologies and Streaming Multimedia Applications in Education, experience in preparation of courseware.

**Thematic Areas / Sections**

- MODELS & METHODOLOGIES (M&M)
- TECHNOLOGIES (TECH)
- SOFTWARE SOLUTIONS (SOFT)
- "Intel® Education" – Innovation in Education and Research (IntelEdu)

**Objectives**

2010 – Towards a Learning and Knowledge Society – 2030

At the Lisbon European Council in March 2000, Heads of State and Government set an ambitious target for Europe to become "the most competitive and dynamic knowledge-based economy in the world" by 2010. They also placed education firmly at the top of the political agenda, calling for education and training systems to be adapted to meet this challenge.

Relevant topics include but are not restricted to:

- National Policies and Strategies on Virtual Learning
- National Projects on Virtual Universities
- International Projects and International Collaboration on Web-based Education
- Dot-com Educational Institutions and their Impact on Traditional Universities
- Educational Portals for education and training
- Reusable Learning Objects for e-Learning and e-Training
- Testing and Assessment Issues of Web-based Education
- Academia/Industry Collaboration on Web-based Training
- Faculty Development on Web-based Education
- Funding Opportunities for Projects in Web-based Education
Learning and the use of Information and Communication Technologies (I&CT) will be examined from a number of complementary perspectives:

- **Education** – supporting the development of key life skills and competences
- **Research** – emerging technologies and new paradigms for learning
- **Social** – improving social inclusion and addressing special learning needs
- **Enterprise** – for growth, employment and meeting the needs of industry
- **Employment** – lifelong learning and improving the quality of jobs
- **Policy** – the link between e-Learning and European / National policy imperatives
- **Institutional** – the reform of Europe’s education and training systems and how I&CT can act as catalyst for change
- **Industry** – the changing nature of the market for learning services and the new forms of partnership that are emerging

**General Objectives**

The implementation of the Information Society Technologies (IST) according to the European Union Framework-Programme (FP7)

- The development of a Romanian Framework supporting the professional and management initiatives of the educational community.
- The organization of the activities concerning the cooperation between the educational system and the economical companies to find out an adequate distribution of the human resources over the job market.
- To promote and implement the modern ideas for both the initial and continuing education, to promote the team based working, to attract and integrate the young graduates in the Research and Development projects, to promote and implement IT&C for initial and adult education activities.

**Particular objectives**

The development of Research, projects, and software for E-Learning, Software and Educational Management fields

- To promote and develop scientific research for e-Learning, Educational Software and Virtual Reality
- To create a framework for a large scale introduction of the e-Learning approaches in teaching activity.
- To assist the teaching staff and IT&C professionals in the usage of the modern technologies for teaching both in the initial and adult education.
- To improve the cooperation among students, teachers, pedagogues, psychologists and IT professionals in specification, design, coding, and testing of the educational software.
To increase the teachers' role and responsibility to design, develop and use of the traditional technologies and IT&C approaches in a complementary fashion, both for initial and adult education.

To promote and develop information technologies for the teaching, management and training activities.

To promote and use Educational Software Packages for the initial and adult education.

**Thematic Areas/Sections**

**Models & Methodologies (M&M):**
- Innovative Teaching and Learning Technologies
- Web-based Methods and Tools in Traditional, Online Education and Training
- Collaborative E-Learning, E-Pedagogy,
- Design and Development of Online Courseware
- Information and Knowledge Processing
- Knowledge Representation and Ontologism
- Cognitive Modelling and Intelligent systems
- Algorithms and Programming for Modelling

**Technologies (TECH):**
- Innovative Web-based Teaching and Learning Technologies
- Advanced Distributed Learning (ADL) technologies
- Web, Virtual Reality/AR and mixed technologies
- Web-based Education (WBE), Web-based Training (WBT)
- New technologies for e-Learning, e-Training and e-Skills
- Educational Technology, Web-Lecturing Technology
- Mobile E-Learning, Communication Technology Applications
- Computer Graphics and Computational Geometry
- Intelligent Virtual Environment

**Software Solutions (SOFT):**
- New software environments for education & training
- Software and management for education
- Virtual Reality Applications in Web-based Education
- Computer Graphics, Web, VR/AR and mixed-based applications for education & training, business, medicine, industry and other sciences
- Multi-agent Technology Applications in WBE and WBT
- Streaming Multimedia Applications in Learning
- Scientific Web-based Laboratories and Virtual Labs
- Software Computing in Virtual Reality and Artificial Intelligence
- Avatars and Intelligent Agents

Topics of interest include but are not limited to:
Virtual Environments for Learning (VEL):
- New technologies for e-Learning, e-Training and e-Skills
- New software environments for education & training
- Web & Virtual Reality technologies
- Educational Technology and Web-Lecturing Technology
- Advanced Distributed Learning (ADL) technologies
- Innovative Web-based Teaching and Learning Technologies
- Software and Management for Education
- Intelligent Virtual Environment

Virtual Reality (VR):
- Computer Graphics and Computational Geometry
- Algorithms and Programming for Modeling
- Web & Virtual Reality-based applications
- Graphics applications for education & training, business, medicine, industry and other sciences
- Scientific Web-based Laboratories and Virtual Labs
- Software Computing in Virtual Reality

Knowledge Processing (KP):
- Information and Knowledge Processing
- Knowledge Representation and Ontologism
- Multi-agent Technology Applications in WBE and WBT
- Streaming Multimedia Applications in Learning
- Mobile E-Learning, Communication Technology Applications
- Cognitive Modelling, Intelligent systems
- New Software Technologies, Avatars and Intelligent Agents
- Software Computing in Artificial Intelligence

Education solution towards 21st Century challenges (IntelEDU):
- Digital Curriculum, collaborative rich-media applications, student software, teacher software
- Improved Learning Methods, interactive and collaborative methods to help teachers incorporate technology into their lesson plans and enable students to learn anytime, anywhere
- Professional Development, readily available training to help teachers acquire the necessary ICT skills
- Connectivity and Technology, group projects and improve communication among teachers, students, parents and administrators
Medical Simulation and Training: “Haptic” Liver

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Abstract
Tactile perception plays an important role in medical simulation and training, specifically in surgery. The surgeon must feel organic tissue hardness, evaluate anatomical structures, measure tissue properties, and apply appropriate force control actions for safe tissue manipulation. Development of novel cost effective haptic-based simulators and their introduction in the minimally invasive surgery learning cycle can absorb the learning curve for residents. Receiving pre-training in a core set of surgical skills can reduce skill acquisition time and risks. We present the development of a cost-effective visuo-haptic simulator for the liver tissue, designed to improve practice-based education in minimally invasive surgery. Such systems can positively affect the next generations of learners by enhancing their knowledge in connection with real-life situations while they train in mandatory safe conditions.

Keywords: Haptic, Laparoscopy, Simulation, Minimally Invasive Surgery, VR

Introduction
Haptic devices generate small forces through a mechanical linkage (e.g., a stylus in the user’s hand), allowing the user to sense the shape and some material properties of virtual objects. Haptic hardware and associated technology have become increasingly more available, especially in entertainment (e.g. electronic games) and the medical field (e.g. simulation and training of surgical procedures) (Basdogan et al., 2004). In the area of medical diagnosis and minimally invasive surgery (e.g. laparoscopy) there is a strong need to determine mechanical properties of biological tissue for both histological and pathological considerations. One of the established diagnosis procedures is the palpation of body organs and tissue.

In this paper we present a visuo-haptic simulator designed to improve practice-based education in laparoscopy. We focus on liver palpation simulation and laparoscopic tools manipulation. The simulator can be used as a preliminary step for minimally invasive surgical training in liver related surgical procedures.

The paper is structured as follows. Section 2 presents a few facts about liver pathology as well as related work in laparoscopy simulation for liver based procedures. Section 3 presents the graphical and haptic user interface for the system. Section 4 presents the simulation cases of different liver pathologies followed by the assessment of the simulator in Section 5.

Simulation and Training for Liver-based Laparoscopy Procedures
The largest organ in the human body, the liver is also one of the most affected by disease. For example hepatitis C virus infection is a growing public health concern. Globally an estimated 180
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million people, or roughly 3% of the world’s population, are currently infected (Ford et al., 2012). The normal liver is smooth, with no irregularities. The smoothness is due the fact that the liver is covered in the most part by visceral peritoneum that forms its serous membrane. The liver has greater consistency than other glandular organs. It is tough and its percussion gives dullness. It is brittle and less elastic, so that it breaks and crushes easily. The liver has a high plasticity, which allows it to mould after neighbouring organs (Târcoveanu et al., 2005).

In minimally invasive surgery internal tissue palpation is an important pre-operative activity (Khaled et al., 2004). Liver palpation can reveal multiple issues: presence of emphysema with an associated depressed diaphragm, fatty infiltration (enlarged with rounded edge), active hepatitis (enlarged and tender), cirrhosis (enlarged with nodular irregularity), hepatic neoplasm (nodular consistency).

State-of-art hepatic laparoscopic simulations, like other cutting-edge surgical simulations, take advantage of increased computational power and haptic device accuracy to supplement the pre-operative planning process and surgeons training.

The EU PASSPORT project is an example of a current laparoscopic liver resection simulation. The project utilizes “advanced methods and the computational power of today GPUs to simulate multiple organs with high-resolution deformations and collisions in real-time” (Passport, 2012). A similar research effort (Acharya et al., 2008) studied the effects of surrounding organ kinematics and geometry on liver access. The group modelled respiratory diaphragm motion for integration into surgical training and planning simulators. Villard (Villard et al., 2009) went a step further, including rib cage respiratory movement, soft tissue behaviour, and a collection of virtual patients and their organs, segmented from CT scans of actual patients in their liver biopsy simulator. These forward strides have necessitated parallel advances in the area of organ modelling.

Lister (Lister et al., 2011) developed a nonlinear liver model through experimental setups designed to collect precise measurements in force-displacement, surface deformation, and organ boundary conditions. The model was augmented with an outer capsule that constrained surface tissue movement for added realism. Model accuracy was assessed through a probing simulation. Beyond organ modelling, surgical procedure modelling has also improved. Marciel (Maciel et al., 2008) developed a real time physics-based virtual electrosurgical simulation tool in which heat generation in the tissue is linked to the applied electric potential. Such electro-surgery tasks are indispensable in laparoscopic surgery simulation specifically for a virtual liver ablation.

While 3D organ models have progressed in the last decade from linear (Delingette, 2000) to nonlinear (Ayache et al., 2003), simulations have grown increasingly complex and layered—imparting invaluable physiological knowledge and experience that may be otherwise impossible to attain.

HapticMed Simulator

During our business analysis phase, through discussions with surgeons from Constanta Regional Hospital we identified four scenarios for training in the HapticMed simulator. The first case presents a 3D haptic model of a healthy liver tissue; the second case focuses on the pathologic case of cirrhosis; the third case, on a liver with tumours and case number four simulates a hepatic liver.

Hardware Components

The main hardware components of our simulation system are: a set of two Phantom Omni (Sensible, 2012) devices and a 3D visualization system based on shutter glasses. A Maryland pense (see Figure 1) is attached to the Omni device and is restricted through a metal ring that simulates the trocar entry point.
The User Interface

The simulator allows users to interact with the virtual environment through a standard keyboard and one or two haptic devices simultaneously. The graphical interface consists of a set of 3D elements such as buttons, as well as 2D labels and text.

It is essential that the user familiarizes with the haptic device manipulation in a 3D virtual space before using the simulator. Therefore, the user must touch with the haptic device a sphere randomly positioned on the screen several times in a fixed time interval (see Figure 2). If the user does not succeed, s/he can retry the task several times until s/he becomes accustomed with the visuo-haptic interface.

Simulated Scenarios

Healthy Liver and Cirrhotic Liver

The first interaction between the user and the interface is on a healthy liver model. A 3D deformable model of the liver is presented to the user and the interaction is possible though a Maryland pence as well as a Babcock pence which is broad, has flared ends with smooth tips allowing tissue palpation. All current scenarios assumes that the laparoscopic camera and the corresponding light source are fixed and do not require user attention. The visual-haptic interface is presented in Figure 3.
The goal for the Healthy Liver scenario is to complement the theoretical knowledge of the student by allowing him to palpate and obtain realistic force feedback from a healthy liver tissue. The improvement and evaluation processes for liver palpation focuses on the force range (min-max) applied during palpation, the direction of force application (based on the instrument angle to the surface) as well as the palpation methodology and palpation zones/areas.

In the Cirrhotic Liver scenario the user uses the pense to explore through touch the liver surface properties. After palpating the surface bumps, observing their consistency and frequency (Figure 3 – right side images), the user employs a menu system to present the disease condition based on attributes like tissue color and consistency.

Liver Tumours and Hepatic Liver Scenarios

These two scenarios follow the same evaluation structure like the ones for the healthy and cirrhotic liver: choosing questions, palpation execution and question answering. The tumor model presents two types of cysts: one type is visible at the liver surface and presents stiffness properties different for the rest of the liver surface, the other one is internal cysts (deep cysts) that are not visible at the surface however can be detected haptically through surface palpation. A successful liver evaluation in this case requires a full surface palpation to identify surface as well as potential deep cysts.
The hepatic liver simulation presents a visually as well as haptically modified liver model. In comparison with the healthy liver, the hepatic liver surface color is more pale and the tissue consistency is significantly increased.

**Simulator Assessment**

The force applied during palpation must be maintained in a certain range. Palpation with small forces may not reveal correctly mechanical properties of the biological tissue, while forces exceeding a certain threshold can irreversibly damage healthy liver tissue.

**Interactive Palpation Force Measurement**

We proposed and implemented a dynamic force measurement approach and visualization module to find the appropriate range of forces during the liver palpation procedure, collecting force data directly from the experienced surgeons we cooperate with. The module draws a force measurement indicator range on the left side of the screen as illustrated in Figure 5.

The range empirically agreed upon is in the interval 2.1 to 2.5 Newtons. A standard Babcock pince was connected to the haptic device and used to practice palpation.

**Force Map Visualization**

The prototype we developed represents the palpation force, position and orientation thought cones directly on the liver’s surface. The cone’s height and bottom radius are proportional with the
magnitude of the force applied on the tissue’s surface. Moreover the position and orientation of the pense is represented by the cone’s height direction. So the evaluator can see not only the force applied but also the location and the direction of the pense relative to the liver surface. The assessment method takes into consideration the palpation gesture according to the type of liver the user evaluates: the recommended palpation force used to a normal liver differs from the one used on a hepatic liver.

In Figure 6 (left) the user is an experienced surgeon: the palpation force used on each “tap” on the liver’s surface is constant. We observe that the velocity of the Babcock pense on the liver surface is constant too. In Figure 6 (right) the user is a novice: the palpation force and the haptic device’s velocity vary abruptly when it should remain at a relative constant value to avoid tissue damage.

Figure 6. Force map visualization (experienced-left, novice-right)

Conclusions

Haptic devices, allowing the simulation of touch are becoming increasingly available and affordable. Their use in medical simulation and training has been recognized worldwide for more than a decade.

We have developed the first 3D visual and haptic simulator for liver diagnostic through palpation in Romania. This custom built simulator has enabled development of new expertise in haptic system development and integration for Romanian computer science and engineering students. As opposed to commercial simulators for laparoscopic procedures, our simulator is a fraction of the cost and has been developed mainly with open source software. The results obtained so far point to direct applications in the medical industry and practice. The simulator can improve medical training thus helping save human lives.

We are in the process of assessing the simulator by the surgeon residents from the Regional Hospital of Constanta, Romania as well as developing new research collaborations with universities and research groups from Europe and US.

Acknowledgments

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