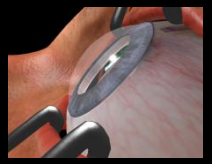
COMPUTER-BASED TRAINING SYSTEM FOR CATARACT SURGERY

Elodie Dumortier (1), Jeremie Dequidt (2), Stephane Cotin (3), Christian Duriez (4), Jeremy Allard (5), Jean-Francois Rouland (6).

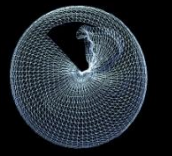
PURPOSE

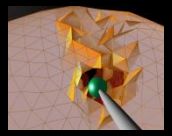
Cataract surgery is the most frequently performed procedure in ophthalmology. Current methods of training are based on companionship. Training periods of this apprenticeship model depend on the availability of the instructor and potentially expose patients to complications due to the inexperience of the operator. In this context, recent reports have demonstrated the advantages and added value of computer-based simulation over conventional training. These motivations led us to develop a cataract surgery simulator that could offer a new way of learning for young ophthalmologists and help assess their level of proficiency.

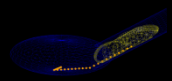


METHODS

A complete prototype of simulation system for cataract surgery has been designed and integrated in a realistic mock up surgical unit. It consists of a computer system for simulating the biomechanics of the eye and rendering the virtual anatomy. The main components of the human eye, that provide the visual background of our simulation have been designed. In addition, the dynamic behavior of the structures manipulated during the procedure has been modeled to account for their actual physical characteristics. For the physical simulation, we used the open source library SOFA, developed by INRIA and primarily targeted at medical simulation. Specific algorithms have been developed to enable real time computation without sacrificing realism. Among the available interface is an optical tracking system, integrated within a surgical microscope, which transmits the position of mock surgical instruments to the simulator. Visual feedback is provided through stereoscopic glasses, also integrated in the microscope which permits to visualize the virtual anatomy. The overall training system also includes a whole body mannequin for added realism and a higher level of immersion of the simulation.







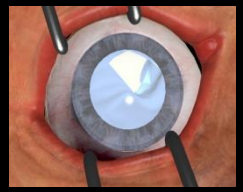
RESULTS

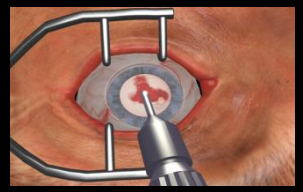
The main stages of cataract surgery, namely capsulorhexis, phacoemulsification and injection of the intra ocular lens, have been simulated.

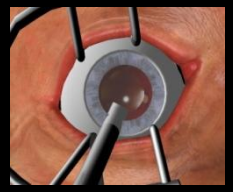
The capsulorhexis procedure is the key part of cataract surgery. This circular opening created into the lens capsule is simulated by using a computer model that takes into account the existence of fibers within the soft anisotropic tissue. This influences the deformation and impacts the direction of propagation for the fracture during tearing.

The fragmentation and aspiration of the lens is performed in 3D and in real-time by using the phacoemulsificator's pedal which activates a local change in the geometry and behavior of the lens volumetric model.

At last the injection of the lens and its deployment in the capsule in real time is performed by simulating the intra ocular lens deformation and interaction within the capsule. By combining these key steps of a cataract procedure, it is possible to recreate a realistic virtual environment for resident training.







CONCLUSION

The outcome of this work, resulting from a collaboration between clinicians of the department of Ophthalmology and researchers in the field of computer science, is the creation of a computer-based simulation system for cataract surgery. In addition the IOL deployment has never been addressed before in a system like this. It will offer an useful additional tool and an alternative surgery training for resident without risk for patients and reduced requirements for the instructor. The first results are promising. We plan to include the simulation of complications, the preoperative simulation in the complex cases and define validation metrics.