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Proposal

Discussion Concept 1

As a developer of medical simulation and haptic interface devices, Immersion Corporation has identified some key needs in this market that could be enabled through next generation robotic interfaces. Existing medical simulation platforms are constrained by the physical interface that they provide to the user. Each new procedure typically requires development of a completely new robotic-haptic interface. Some procedures, such as laparoscopy, have dynamic physical approaches that are often difficult support with a single haptic interface. A next generation surgical simulation and training platform should mimic human physiology as much as possible, yet enable dynamic pathology and complication introduction to facilitate training and evaluation needs.

Robotics has the potential to transform currently lifeless manikins into appropriate medical training platforms that support these needs. There are several technical innovations needed to facilitate a robotic manikin trainer:

1. An encounter style haptic interface [1] would provide enormous flexibility in manikin response and enable both open and MIS style procedure training. One or more haptic capture mechanisms could be embedded in the peritoneum. These interfaces would dynamically readjust their mechanical configuration to receive laparoscopic insertion devices and provide appropriate impedance functions for the user. Following trocar insertion, various laparoscopic tools could be introduced into the trocar and automatically captured by the encounter-style haptic interface.
    a. Enabling technologies
        i. High bandwidth, multi-DOF robotic graspers with small work envelope
        ii. Advanced robotic control for dynamic reconfiguration and impedance display
2. Advanced augmented reality display technologies would further enhance the realism of this robotic testbed. Visual overlay display of the operative surrounding, other participants and the patient physiology/anatomy would make the learning/analysis experience nearly identical to a real scenario. Direct haptic display on the user's hands could enable simulation of a wide variety of surgical tools, eliminating the need for a large physical collection of surgical instruments and medical tools. Auditory and olfactory displays would round out the simulation experience.
    a. Enabling technologies
        i. External environment registration and overlay for visual augmentation
        ii. High DOF, high bandwidth hand based haptic display
        iii. Massively scalable simulation infrastructure

The proposed robotic-augmented reality simulation infrastructure would have enormous value in the training of residents and surgeons through controlled case presentation. The system could also enable the development of novel surgical techniques and tools without risk to patients.

[1] Yokohohji, Y., Muramori, N., Sato, Y., Yoshikawa, T., 'Designing an Encountered-Type Haptic Display for Multiple Fingertip Contacts based on the Observation of Human Grasping Behavior,' Robotics Research, Vol. 15, 2005, pp. 182-191, Springer Berlin/Heidelberg.

Discussion Concept 2

Current commercial healthcare robotics platforms such as the daVinici and the InTouch systems provide a key value to overburdened service networks: telepresence. Medical and healthcare robotics is an enabling technology that allows clinical expertise to travel virtually and fluidly to where it is needed the most. With a dramatically aging population it is essential that general and specialist physicians are able to leverage the information age infrastructure to provide assistance, guidance and telepresence throughout the world and without the need for costly and time consuming physical travel.

The daVinci master/slave system enables telesurgical interventions by reflecting the operative field into the master console giving the surgeon the perception that they are physically located at the end of an endoscope that could be across the room or across the world. Although the sense of virtual presence is great for the daVinci system, there is still significant room for innovation to fully immerse any surgeon in a remote operative procedure.

In a complementary fashion, the InTouch robot aims to enable remote presence through a physical avatar and a standard desktop computer interface. Current generation technology is limited to a sort of mobile video conference. Future slave systems should target full remote presence as might be embodied by a robotic double with full human dexterity and affective display capabilities.

These two commercial examples demonstrate two extremes of the needs in the medical and healthcare marketplace. There are many intermediate scenarios that require more advanced master interfaces than the InTouch system but less complex than the DaVinici (e.g. remote endoscopy) and likewise there are intermediate scenarios that require more *human* slave systems than the daVinici.

The US medical and healthcare initiative should embrace significant research initiatives in development of technologies and interfaces the smoothly mediate and enable telepresence across. It is unlikely that a single solution exists for either side of remote interface but the value of a broad research initiative will be immeasurable when it is possible to:

- Have a world renowned surgical expert specialist available to treat cases in remote villages of Africa during their spare time
- Enable family doctors to have patients from all over the country/world
- Have on-call physicians be instantly available at multiple remote locations
- Have a class of residents learn surgical technique hands-on regardless of the location of the professor
- Enable 24x7 non-emergency physician appointments with a family practice that has physicians in all major time-zones