IMMERSIVE TELEPRESENCE: A NEXT GENERATION EOD ROBOTICS INTERFACE

THE HAPTICS-BASED IMMERSIVE TELEPRESENCE SYSTEM (HITS)

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Abstract- The paper presents the current state of the art immersive telepresence system developed by Defence Research & Development Canada (DRDC) and Quanser Ltd. as a counter technique for IED. The HITS system demonstrates an advanced human-robot interface to decrease the times when complex investigations, threat articulations, and neutralization procedures require direct human interaction. Keywords: EOD / CIED / IEDD, haptics, multi-lateral teleoperation, 3D remote vision, immersive telepresence

In 2008, DRDC answered the call for alternative methods to deal with IED scenarios. The Haptic Immersive Telepresence System (HITS) explored advancing EOD robotics incorporating autonomous robotics research. I conceived the idea of making a dual-armed EOD robotics interface for HITS without realizing the true value of immersive telepresence as a capability that could be exploited anywhere.

1. What is immersive telepresence?

The term immersive telepresence is an ill-defined term that could be interpreted ambiguously. Are you really there if you are virtually there? In the sense of this paper, we consider immersive telepresence as transmission of sensory data / control feedback bilaterally between a human operator and commanded robot so that the human gains more information, elicits more brain stimulus-response from extra data so that he or she “feels” more sensory-capable at the remote workspace. Greater sensor fusion, and 3D sensation provide an almost “immersed in the situation” sensation so that the operator can understand more and conduct complicated articulations. If a person can remotely understand and react to the environment surrounding

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that IED threat completely then they don't need to don body armour and approach. Immersive telepresence holds the promise of improving EOD operator safety.

2. Key Scientific Concepts

What is anthropomorphic? It means having the form of a human, or human-like. If humans have two arms, then why do EOD robots have one? The HITS system demonstrates a triple arm master / slave haptic feedback to emulate a human-like work capability. If a human uses his/her head and eyes to rotate around an object then why do current EOD robots force the human to adjust their head pose (position and orientation)? The head camera on HITS moves under operator command to improve sensing.

In sum, the HITS system explored conforming the robot system to a human operator vice traditional designs. This is the approach taken by Rossman & Schlette[1] that use a human kinematic model to craft the space station workspace. And Kumra et. al[2] that made an anthropomorphic robot arm interface. Fig 1. is the HITS with three arms; one representing the head camera movements and two-armed manipulation, complete with fingered hands or replaceable tools (left image) and the 2D and 3D vision / haptic operator control station (right image).

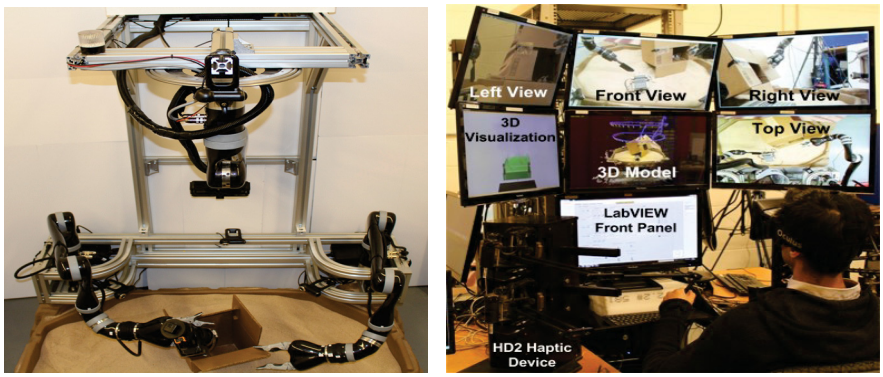

Fig 1. Quanser's HITS EOD Robot Interface (HITS images courtesy Quanser)

It may seem trivial, but watching video in 3D instead of 2D flat images has a profound impact on how much information a human can process. Why? There are many "pseudo-isolated" vision processes (Marr[4]) inside the human visual system and each contributes to resolving ambiguous data. Stereopsis (3D vision) was first described by Necker[5], where the ambiguity of intersecting 2D points in 3D space can lead to different interpretations. In Fig. 2, the left cube can be either in or out of the page and if I was to provide you extra information, your visual system automatically snaps to the most likely (probabilistic) representation. Close your eyes, open them then watch the left cube. Stare long enough and your interpretation will

oscillate between both representations. The right Necker cube is a paradox we can't solve intuitively; similar to what operators face from 2D displays.

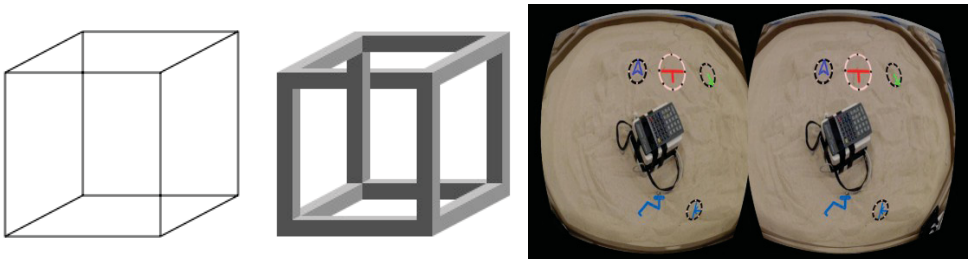

Fig 2. Necker cube[1] (left), 3D operator's viewpoint from Oculus Rift head mounted display complete with augmented reality (right).

3D vision algorithms (Fig. 2 right panel) improve our proprioceptive 3D model / representations through disparity mapping thereby resolve ambiguities faster and allow operators to achieve more remotely. This finding was demonstrated for EOD tasks first by Edmondson, et. al.[3] where EOD operators overwhelmingly preferred 3D vision on a modified one arm Talon robot to the original 2D camera system. Of incredible value to any operator is an EOD robot that could survey the scene in 3D, construct a model that can be zoomed, rotated, explored, measured, stored, databased, presented as evidence, emailed, teleconferenced and so on. HITS can survey the area around a threat and construct a 3D model *a priori* neutralization as shown in Fig. 3.

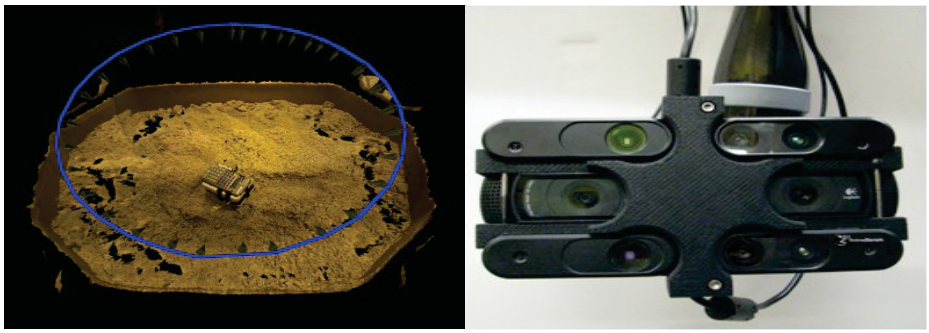

Fig. 3. Using MDA's mobile scene modeller (left), the HITS cameras (right) captures 3D data from cameras on head and creates a 3D model for inspection.

Haptics[6] provide additional sensory feedback to a human operator. Imagine the difference between lifting a cloth bag with a heavy weight at the bottom and lifting a solid box. Without haptics, the operator cannot distinguish heavy from soft resistance (and so on) with the high-gear ratio robot arm joints. The dual-armed HITS systems provides accelerations and velocities back to the operator from the commanded robot motions and

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environment's reactions to it as haptic force feedback. Figure 4 shows various complex articulations possible with single arm actions like prying, twisting, lifting, or reaching, and dual-armed articulations like carrying with both hands, and hold and prod amongst others. Human-like 1:1 kinematic arms (KINOVA Jaco) were selected to conduct experiments using human and remote neutralization tasks.

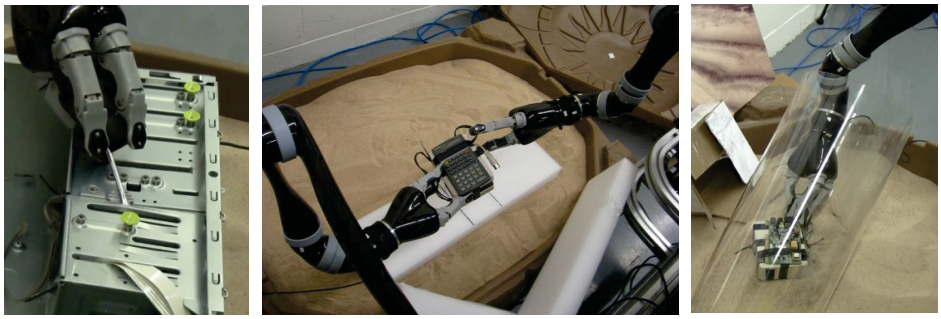

Fig. 4 Haptics-augmented single and dual-armed complex articulations possible with HITS interface.

The most critical technological element of HITS is the reason why dual-armed EOD robots aren't available now. A high torque multi-manipulator system needs a real-time active collision avoidance system to ensure operators cannot crush remote arms by accident; HITS avoids collisions in real time for all joint space (Fig 5) and is the only one of its kind so far.

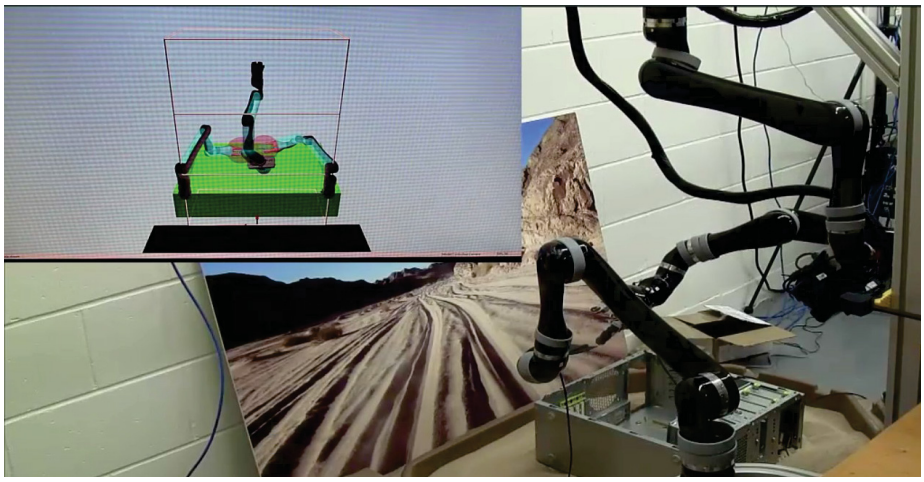

Fig. 5 (left) shows Quanser's patent-pending real-time collision detection and avoidance system (right).

This system also demonstrated haptic UGV driving, reconfigurable toolsets, robotic operation of human tools, and reconfigurable control system for any robotic arms.

Testing results are preliminary. Tests completed for static prototype against a small range of targets did demonstrate immersive telepresence

feasability. The interface in it's basic form is usable after about five minutes of personal introduction. Every EOD technician, police bomb technician, and soldier that has used the static system would prefer his next EOD robot have a HITS-like interface to a one-armed EOD robot. Although we have proven early success, the ambitious project scope caught up with the reality of making so many complicated systems perform reliably together. More development, evaluation, and testing is required but immersive telepresence is a promising area for EOD/IEDD.

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