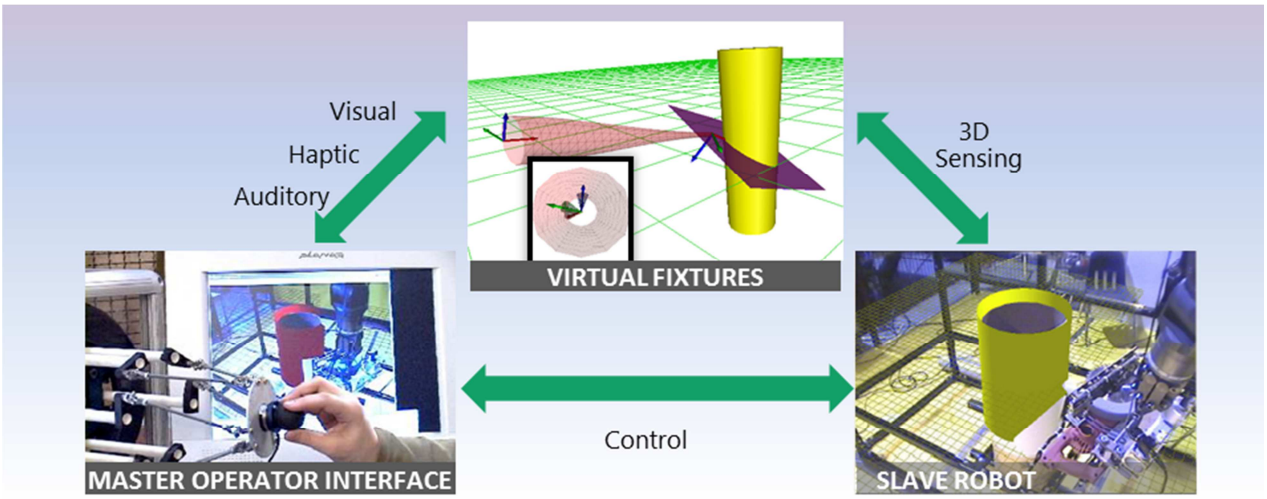
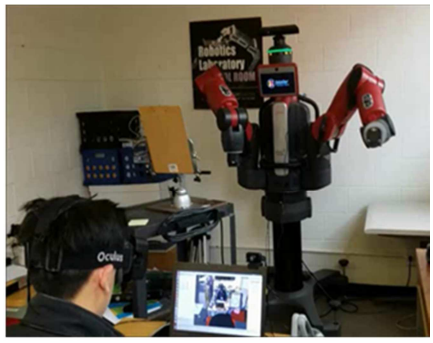
3D SENSING / MIXED-REALITY / ROBOTICS FOR NUCLEAR APPLICATIONS

Augmented-Reality Telerobotics Enables Dexterous and Precise Manipulation of Heavy Objects with Simple and Rugged Robots



OVERVIEW

This technology demonstrates an augmented reality-based immersive operator interface for intuitive and efficient teleoperation of robotic systems. Within the highly hazardous environments of nuclear applications, remotely operated robot systems are often required to perform complex and heavy operations. It is difficult to meet such performance and reliability requirements at the same time. To resolve such technology challenge, ANL has developed a new remote operation system which enables dexterous, yet heavy manipulation using simple and robust robotic equipment. Rather than pursuing complex implementations on the slave robot, the focus of innovation is directed to enhancement in the human-robot interface by incorporating MR technology.



AUGMETED TELEROBOTIC OPERATION SYSTEM

CONCEPT

The main innovation in the proposed method is the concept of 'virtual fixtures' for multi-modal perceptual augmentation of artificial geometric surfaces. These fixtures serve to guide the human operator during commanding teleoperation. Such a perceptual overlay, when placed precisely, can relieve operator's mental burden during manual teleoperation to realize more precise and efficient operation.

Also, compared to fully autonomous operation, this approach preserves human-in-the-loop control ensuring safer and more reliable operation. This is accomplished by incorporating a number of new emerging technologies: 3D sensing and modeling, virtual reality (VR) and augmented reality (AR), telerobotics, motion planning, and new sensor robot structure.

Argonne National Laboratory, Advancing the nuclear application through Applied Science, Technology and Innovation

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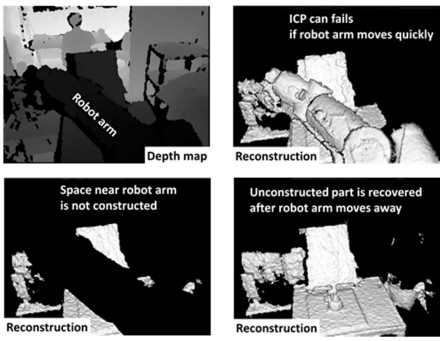
DESCRIPTION

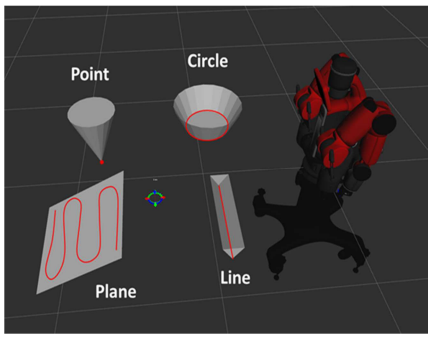
The R&D scope addresses the integrated development of an enhanced teleoperation system incorporating:



REAL-TIME SENSING, 3D RECONSTRUCTION

3D Sensing and Reconstruction:

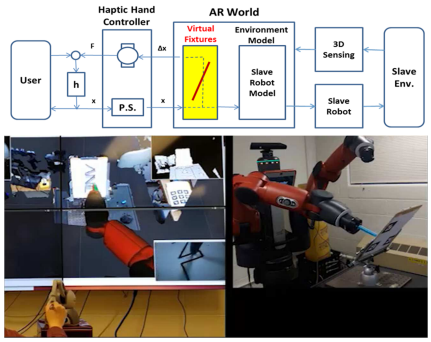
Utilizes 3D cameras to construct a 3D geometric model of the environment. Compared to the current technology, the enhanced 3D reconstruction has greater spatial precision and dynamic object tracking capability, which enhances the precision and reliability of tasks in dynamic environments.



MIXED-REALITY (VR/AR) DISPLAY

AR-based Operator Interface:

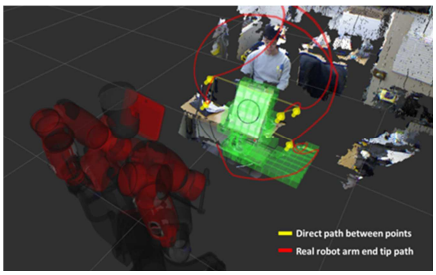
Composes mixed-reality environment including the virtual robot model, augmented display of environment and artificial geometries. Virtual surfaces of various geometries and dynamic characteristics can be consistently overlaid in camera, robot and operator hand control spaces.



AR-BASED TELEOPERAION SYSTEM

Enahnced Teleoperation:

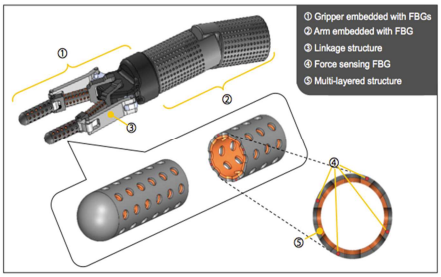
By integrating 3D sensing and AR operator interface, enhanced telerobotic system is developed. Based on use of 'virtual fixtures', it allows precise and dexterous manipulation of heavy manipulation with simple and rugged robotic and remote systems.



AUTONOMOUS MOTION PLANNIG

Sensor-based Autonomy:

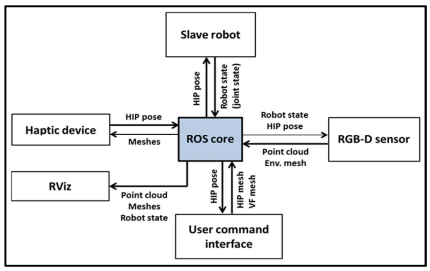
While manual teleoperation may be required for reliability, introducing partial autonomy may enhance task performance in some structured environments. ANL has directed R&D in this regard, including capabilities for construction of collision model of the task environment, and generating the desired motion primitives.



FBG EMBEDDED ROBOTIC MANIPULATOR

Optically Sensorized Robust Slave Robot:

Is a new bilateral manipulator being developed exploiting the low-cost, reliable, and robust fiber-optic technology. Using shape deposition manufacturing and 3D printing process, fiber sensors will be embedded directly into the robotic structure. This bilateral robotic skeleton further enhances the dexterous manipulation capability.



Distributed System Integration based on ROS

Robot Operating System (ROS):

Is a network-based distributed robot operating system which provides a unique opportunity to streamline integrated development of robotic systems. ANL has early adopted and is pioneering its use in telerobotic system for mission critical nuclear applications.

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