Fingers See Things Differently (FIST-D): A Robotic Explosive Ordnance Disposal (EOD) based on Augmented Tactile Imaging

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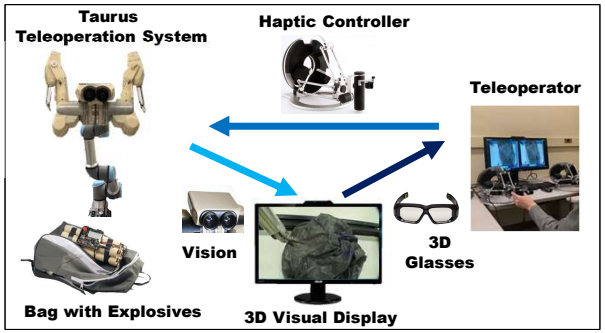
Main Task

Explosive ordnance disposal is among the most hazardous occupations. While various EOD robots have been developed, the task performance is reported to be lower than EOD technicians working on site. One major reason is that the tactile sensing of the EOD robot is not comparable to the human one. We address this problem by developing a robot that can detect and display concealed IEDs based on augmented tactile data using both human perception and tactile sensing.

Challenges

- ❖Visualize concealed objects and plan manipulation policies.
- ❖Develop tactile device with high resolution and contact sensitivity.
- ❖Develop selective polymers to detect explosive residues with high sensitivity.
- ❖Develop a haptic display system to convey the multi-modal information.

System Architecture



Scientific Impact

- ❖Technology for detecting trace energetics in surface residues can be applied to the detection of hazardous chemicals.
- ❖Intelligence based tactile exploration can be extended to scenarios where optical information is not available.
- ❖The enhanced tactile feedback in teleoperation can improve the task performance of telesurgery.
- ❖The developed haptic display system can help users with hearing/visual impairments in exploring physical objects.

Broader Impact

- ❖Reduce the risk of EOD teleoperators using enriched perception.
- ❖Incorporate the research outcomes into the coursework.
- ❖Increase the participation of minorities.

Acknowledgement

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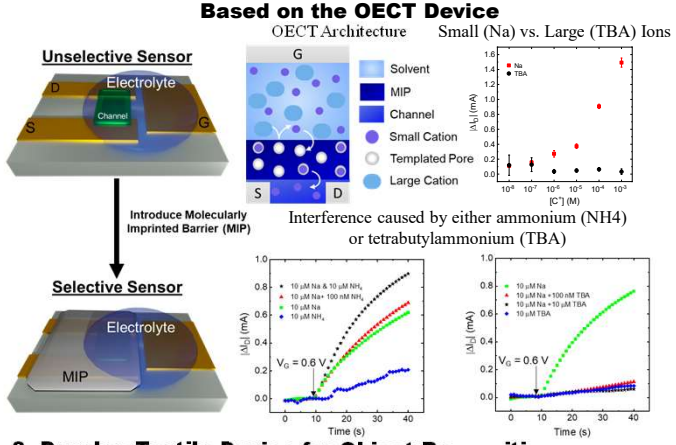
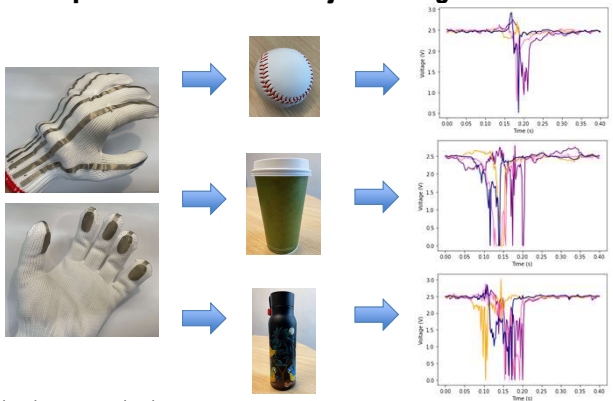
Technical Approach

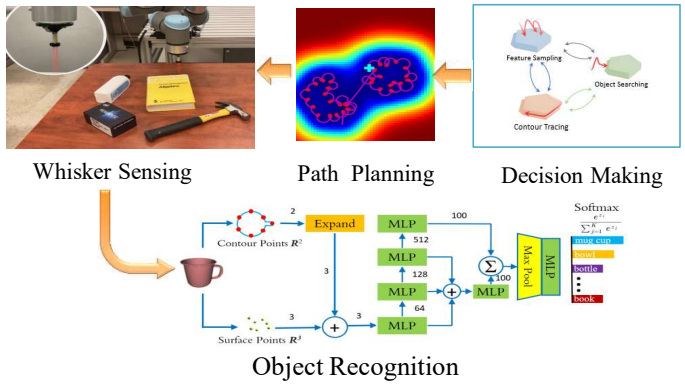
1. Sensing Solution: Explosive Recognition Based on the OECT Device



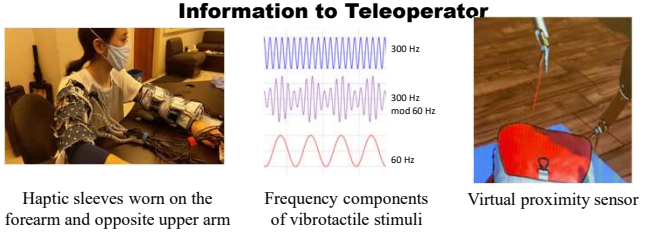
2. Develop Tactile Device for Object Recognition



3. Intelligent Assistive System Based on Tactile Data



4. Haptics Display for Conveying Multi-modal Information to Teleoperator



Haptic sleeves worn on the forearm and opposite upper arm

Frequency components of vibrotactile stimuli

Virtual proximity sensor

- ❖ Tactile Display for continuous sensor data such as proximity or contact force
- ❖ Operators can selectively attend to stimuli on one arm while ignoring the other with high accuracy.
- ❖ Two frequencies and three locations encoding categorical information can be reliably identified per arm.

Conclusions

The following technologies have been developed and verified:

- ❖ The ability to recognize explosive residues by a quantity achieved by swabbing.
- ❖ Triboelectric tactile sensor that is capable of conveying pressure and material type.
- ❖ The ability of autonomous scene exploration by tactile modality only.
- ❖ Haptics display for conveying contact signal from teleoperation applications.