

Fingers See Things Differently (FIST-D):

A Robotic Explosive Ordnance Disposal (EOD) based on Augmented Tactile Imaging

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https://www.nsf.gov/awardsearch/showAward?AWD_ID=1925194

Main Task

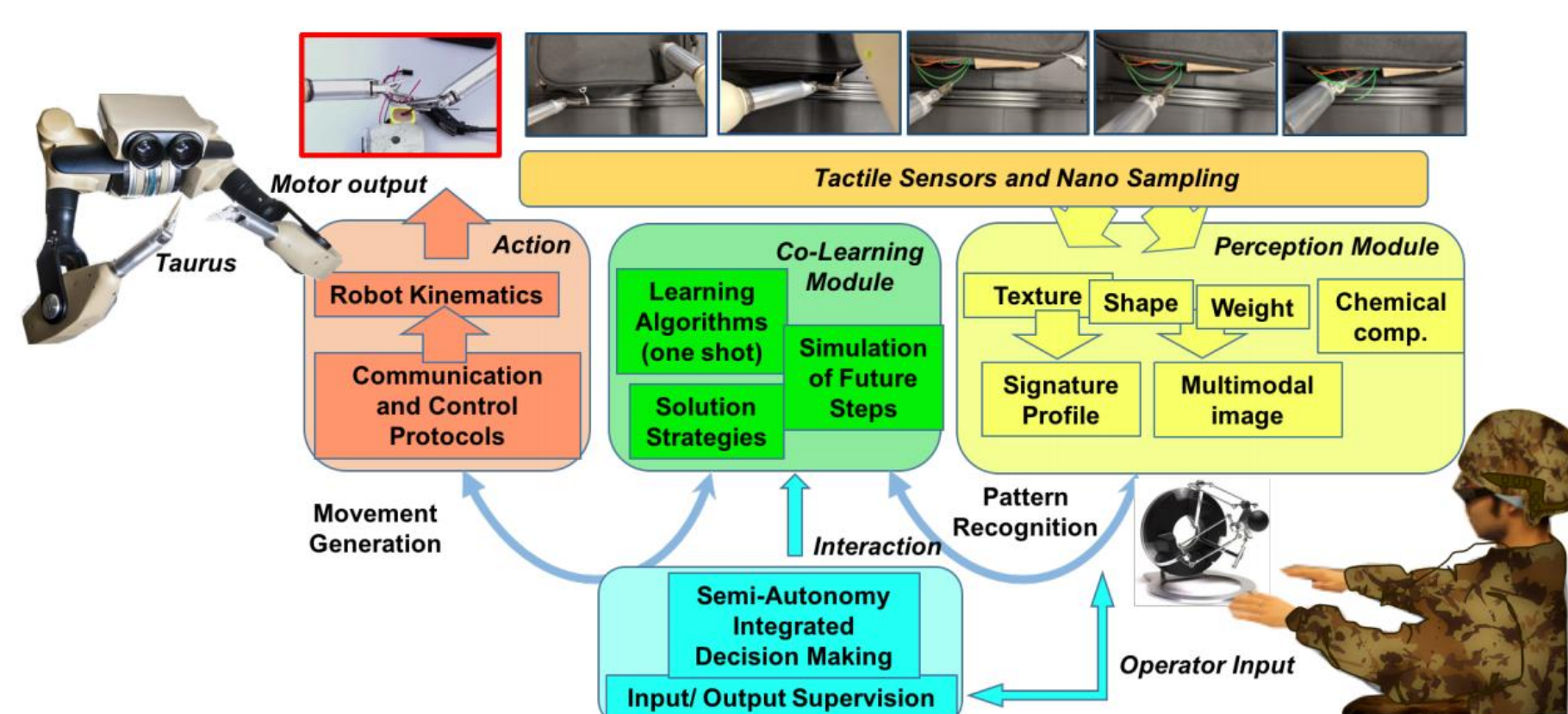
Explosive ordnance disposal is among the most hazardous occupations. We mitigate the risks by developing a EOD robot that can be teleoperated from afar. Currently available robots depend heavily on vision and video telemetry, which can be drastically impaired when IEDs are concealed. This research addresses this scientific challenge by developing a robotic system with multi-modal perceptual image comprised of tactile, optical, and force information.



Challenges

- Theorize, model and implement sensors to collect and report IEDs fingerprints.
- Recognize objects from point and texture using limited observations from tactile sampling.
- Develop an integrated haptic display system to convey sensor information being captured.
- Recommend best strategies to approach and explore the objects.

System Architecture



Scientific Impact

- Dexterity and tactile feedback is the key for successful task completion in telesurgery, which would lead to reduced casualties, treatment efficacy, and reduction of mortality.
- The ability to precisely detect trace energetics in surface residues could be also applied to other situations in which hazardous chemicals would put at risk to onsite personnel.
- The theoretical outcome will help improve currently widely used technologies such as object recognition and HCI systems.

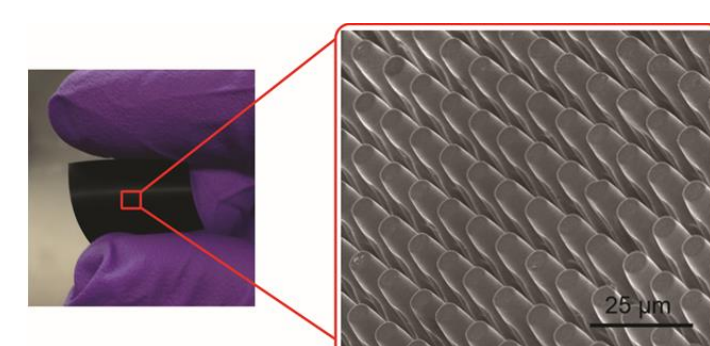
Broader Impact

- Decrease the risk of EOD teleoperators using enriched perception.
- Incorporating the research outcomes into coursework of Purdue University such as IE 474, IE 590, ECE511/PSY511, ChE205, etc.
- As an educational and creative activity, the project will exhibit at a children museum at West Lafayette, Indiana.
- Exposure students to research activities, and give them first-hand experience in using the knowledge learned in the classroom.
- The research activities will broaden the participation of minorities and female students.

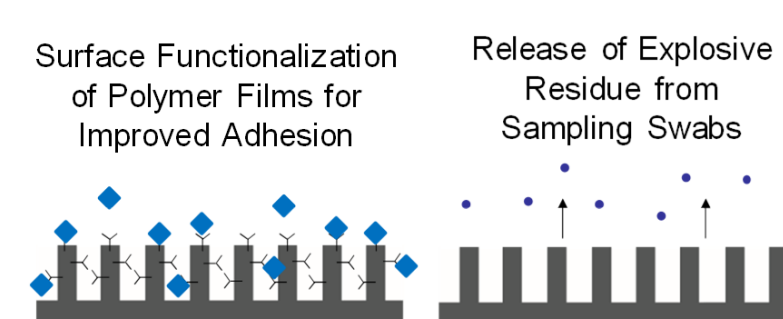
Technical Approach

(1) Design of Microstructured Conducting Polymer Films for Enhanced Trace Explosives Detection

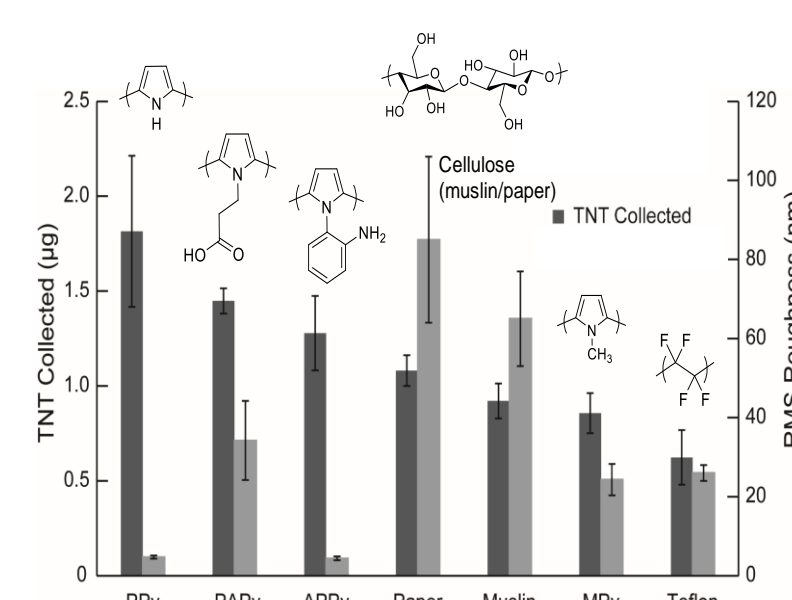
A Chemically-sensitive And Selective Surface For Adsorbing Trace Energetic Materials Is Created For Improving Residue Collection From The Substrate:



Picture and SEM Image of Microstructured Unfunctionalized Polypyrrole

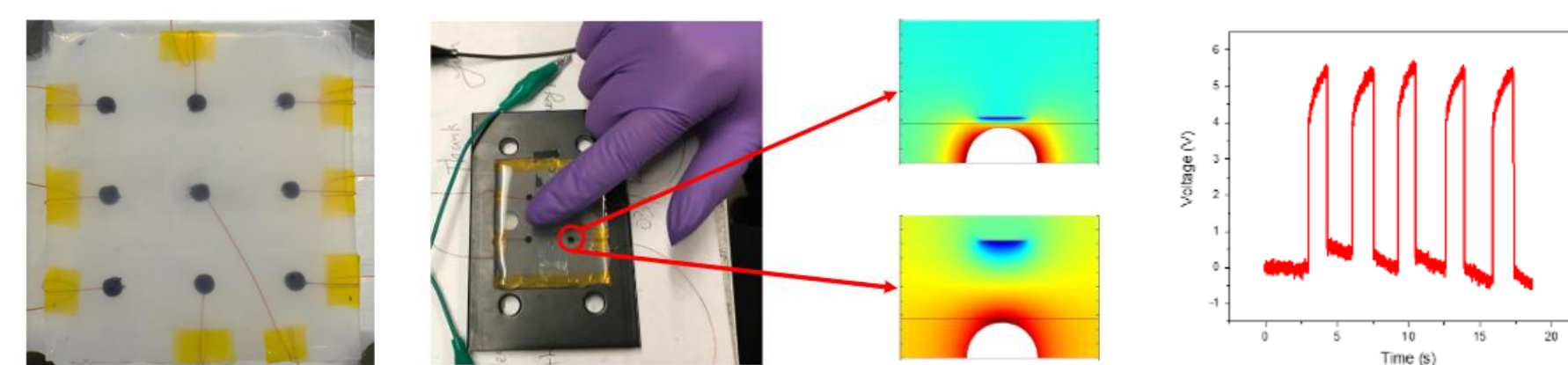


Schematic of Particle Adhesion to Functionalized Microstructure, and Release of Explosive Residue



Mass of TNT Collected Using Derivatives of Polypyrrole Along With Their Surface Root Mean Square Roughness Compared To Common Alternative Materials

(2) Wearable Devices For Tactile Sensing

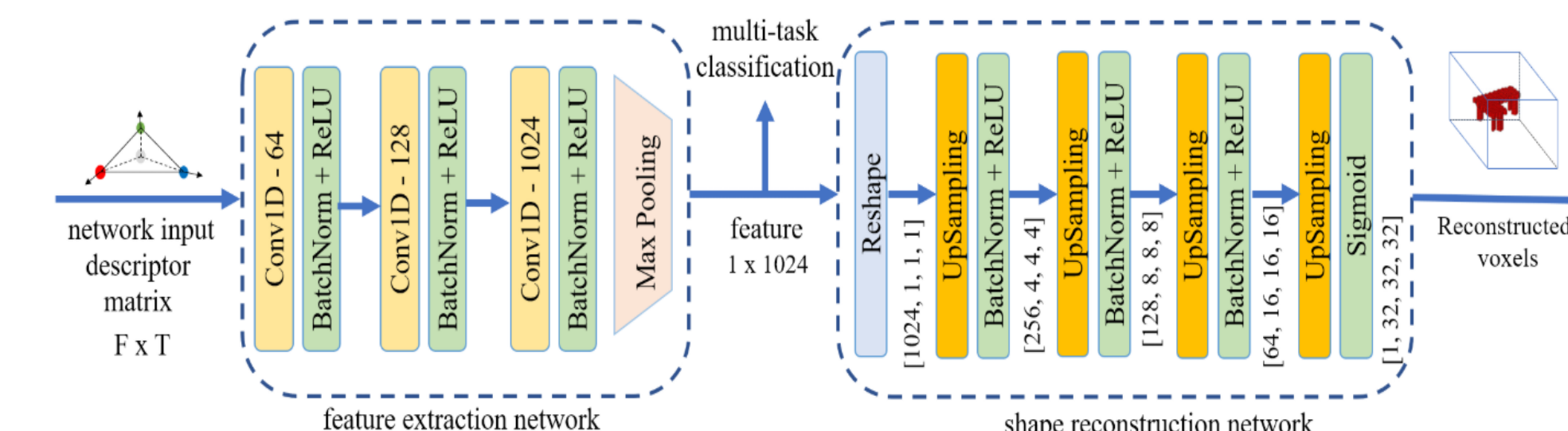


Development of Tactile Sensor with Multiple Contact Pixels

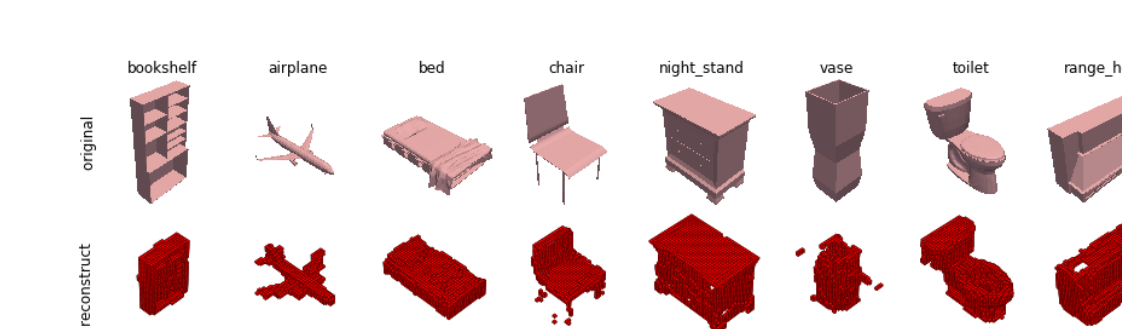
Response Signal of Repetitive Contacts. The Signal Magnitude Contains Texture Information

Tactile Sensing and Explosive Detection

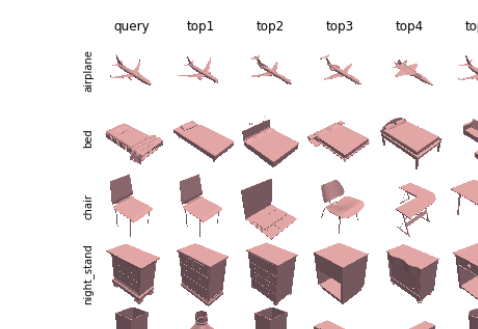
(3) Our Proposed Machine Learning Approach for Object Recognition Based on Limited Observations from Tactile Sensing



We Designed a Descriptor for Feature Extraction From Sparse Point Clouds. The Extracted Feature Can Be Learned by the Above Neural Network That Can Accomplish Object Classification and Reconstruction



The Object Reconstruction Result Using Only 16 Points Randomly Sampled From Each Object



Object Retrieval Result Using Only 16 Points Based on Our Learned Similarity Metric

(4) Tactile Display System for Conveying Multi-modal Information to EOD Teleoperator



Mimo Vue Monitor With Tanvas Touch Friction Display. The Surface Haptics Enable Friction Modulation To Convey Texture Information.

Stretch-pro Wearable Skin-stretch Device Two Rollers Can Be Used To Pinch Or Stretch The Skin.

TAPs Tactile Speech Communication System Developed By Prof. Tan's Lab.

Multi-modality Display Using Tactile / Force Feedback / Vision