Rapid Operator Awareness via Mobile Robotics (ROAMR), Customizable Human Safety using Mobile and Wearable Co-Robots

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Overall Project Vision

Key Challenge: How can human performance be increased with mobile and wearable co-robots.

- ❑ Construction sites, manufacturing plants, disaster areas, and conflict zones can feature humans, machines and robots working closely together.
- ❑ These environments require teams of humans and machines to work together safely but lack the controlled safety of manufacturing plants or other indoor settings.

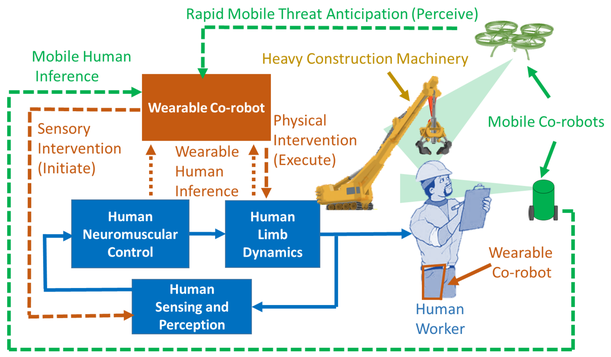
Core Solution: **Use physical robots and robotics principles to create *customizable* human-centric safety by enhancing the situational awareness and physical response of the human operator.**

- ❑ Focus on three studies:

G1) How can broad sensor coverage enable humans to respond to threats faster and more effectively.

G2) What are the best ways to predict human behaviors in order to provide physical assistance.

G3) Can wearable co-robots provide increased overall performance by providing physical assistance to the human operator.



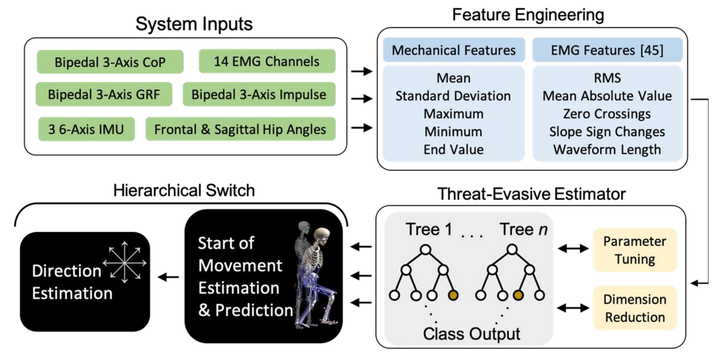
Broader Impact

- ❑ Human-centric approach means human operators in manufacturing, public safety, construction, and national security can benefit.
- ❑ Scientific studies improve understanding of human performance and human-machine teaming.
- ❑ Outreach activities include: Robotics summer camp, REU student participation, undergraduate research, partnership with Atlanta Educator, and development of relatable VR games.

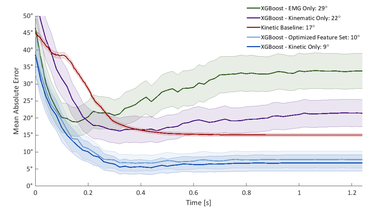
Predict Human Avoidance Response (Infer)

G2

- ❑ A human-centric approach relies on assisting human motions.
- ❑ Our team has demonstrated how machine learning can be used to infer onset of motion and desired cardinal direction.
- ❑ We use human-worn kinematic and myography (EMG) sensors.
- ❑ We currently use motion capture and force-plates for some kinematics and kinetics.
- ❑ A 2-stage machine learning algorithm predicts onset of motion and direction.
- ❑ We have identified the key sensors needed for accurate direction inference.
- ❑ We are currently examining biomechanical synergies that can simplify intention recognition and wearable co-robot control.



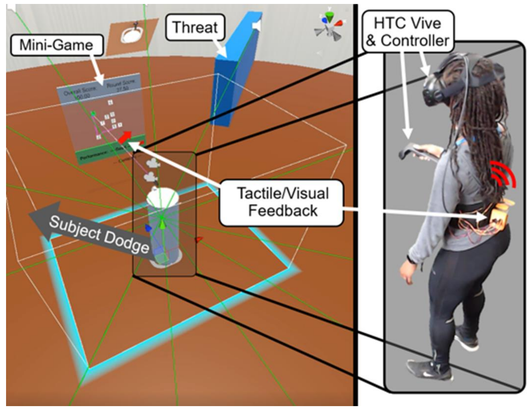
	300 ms Prior	200 ms Prior	100 ms Prior	0 ms Prior
Transition Classification Error	41.5%	25.4%	13.2%	9.7%
Total Classification Error	17.9%	10.3%	4.8%	2.7%

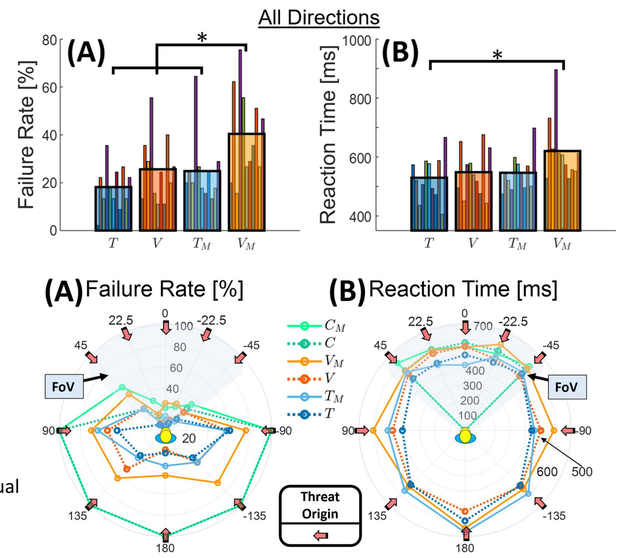


P. Moolchandani, A. Mazumdar, A. Young, "Design of an Intent Recognition System for Dynamic,Rapid Motions in Unstructured Environments," Under Review, Dec. 2020

Communicate Threats and Safe Paths to the Human Operator (Initiate)

G1



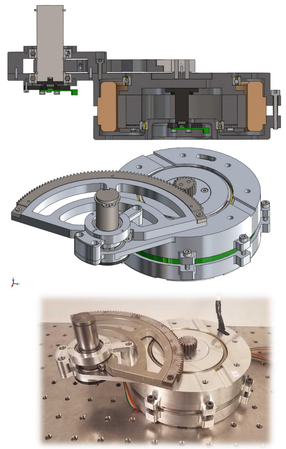


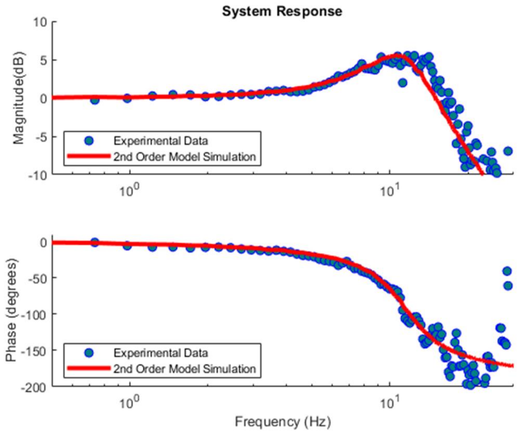
- ❑ Have examined a range of perceptual cues for dynamic threat avoidance.
- ❑ Tactile cues have shown particular promise in the presence of visual distraction.
- ❑ Currently combining vibro-tactile cues with motion planning algorithms for AI-enabled human performance.

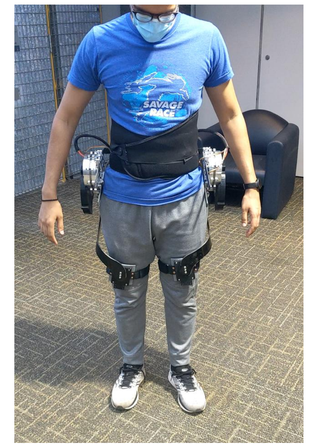
A. Bajpai, J. Powell, A. J. Young, A. Mazumdar, "Enhancing Physical Human Evasion of Moving Threats Using Tactile Cues," IEEE Transactions in Haptics, December 2019. [doi: 10.1109/TOH.2019.2962664]
A. Bajpai, K. Feigh, A. Mazumdar, A. Young, "Enhancing Physical Human Evasion of Moving Threats Using Tactile Cues,"Submitted to IEEE Transactions on Human Factors, Under review, Feb. 2021.

Physically Assist Human Response (Execute)

G3







- ❑ Dynamic motions require fast wearable co-robot response.
- ❑ We have designed an intrinsically low-impedance set of actuators for assisting hip motions in the sagittal plane. Our previous studies showed that these motions were more difficult than lateral motions.
- ❑ Physical device is capable of large (~100Nm) peak torques and high-force bandwidth.
- ❑ Device has been fabricated and integrated into a wearable system.

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