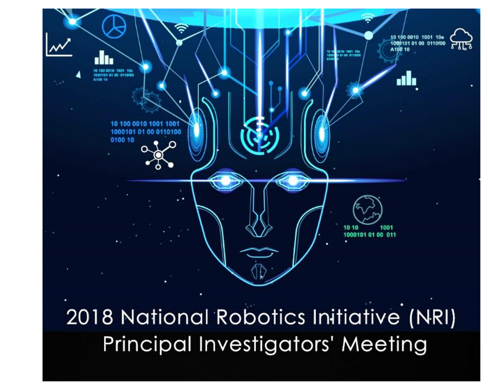
Rapid Operator Awareness via Mobile Robotics (ROAMR), *Customizable Human Safety using Mobile and Wearable Co-Robots* (NRI 1830498)



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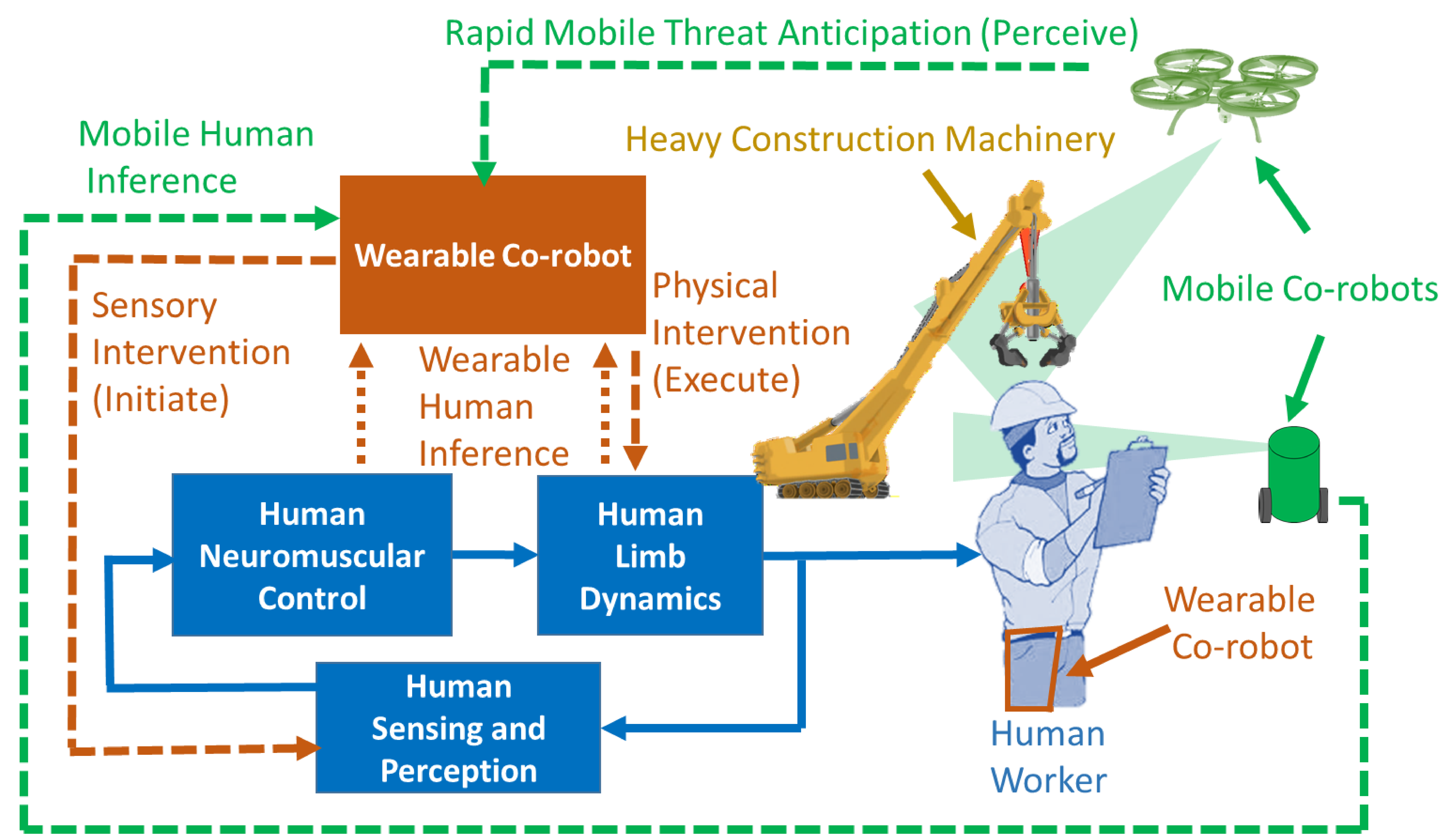
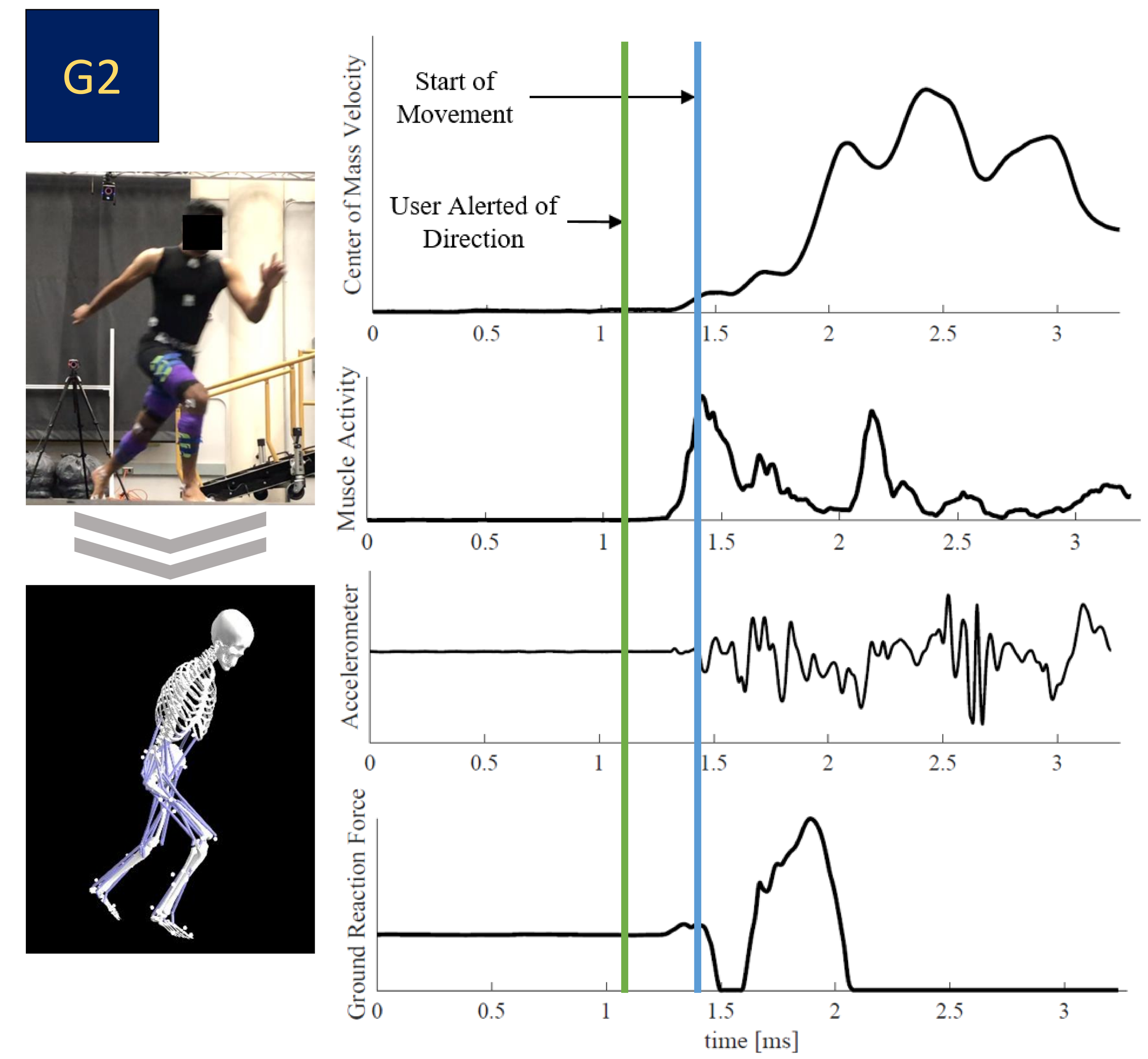
Overall Project Vision



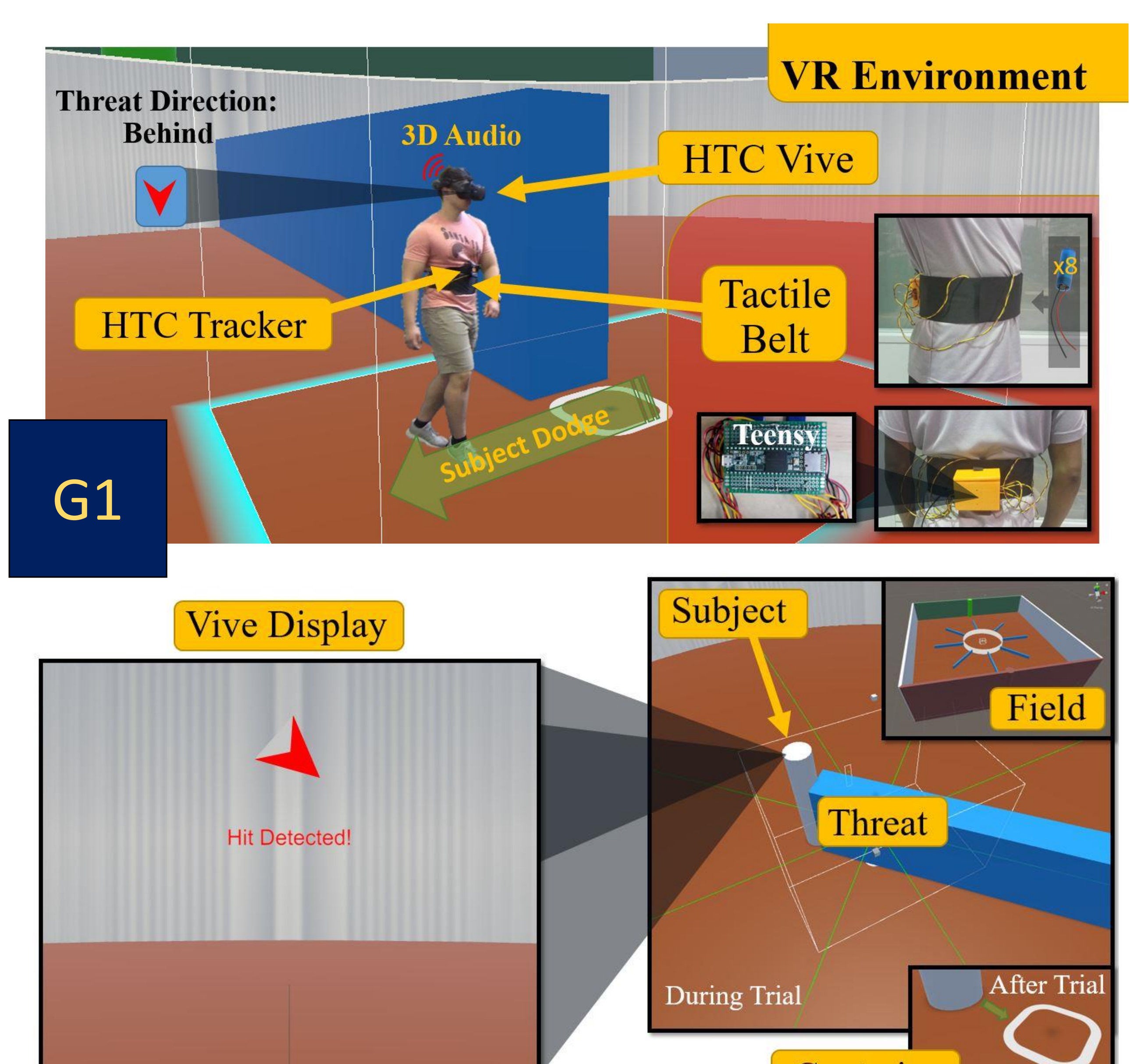
- ❑ Unstructured environments such as construction sites, disaster areas, and conflict zones rely on human intuition, dexterity, and versatility.
- ❑ These environments require teams of humans and machines to work together safely but lack the controlled safety of manufacturing plants or other indoor settings.
- ❑ Mobile and wearable co-robots can provide ***customizable*** human-centric safety by enhancing the situational awareness and physical response of the human operator.

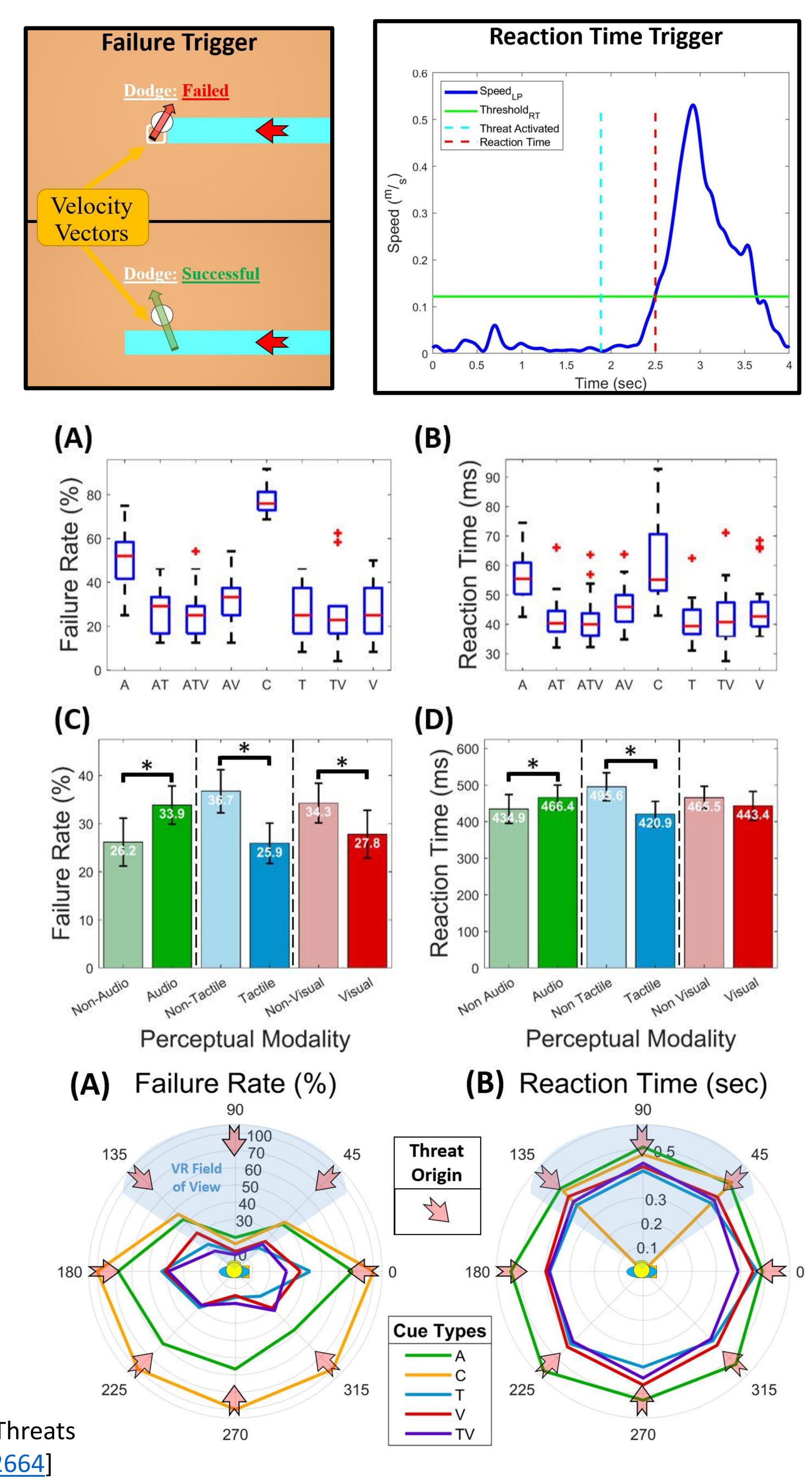
Predict Human Avoidance Response (Infer)

- ❑ A human-centric approach relies on assisting human motions.
- ❑ Our team has already demonstrated how machine learning can be used to infer desired human speed.
- ❑ We seek to infer transient avoidance behaviors in order to provide suitable physical assistance.
- ❑ Primary desired output: direction of motion.
- ❑ Secondary desired output: type of motion (jump, lunge, sidestep).
- ❑ Machine learning will be used to gauge human intention based on human kinematics, kinetics, muscle recruitment, and knowledge of the environment.
- ❑ Intention recognition algorithms will be implemented on wearable sensors for human-centric performance outside of controlled settings.



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

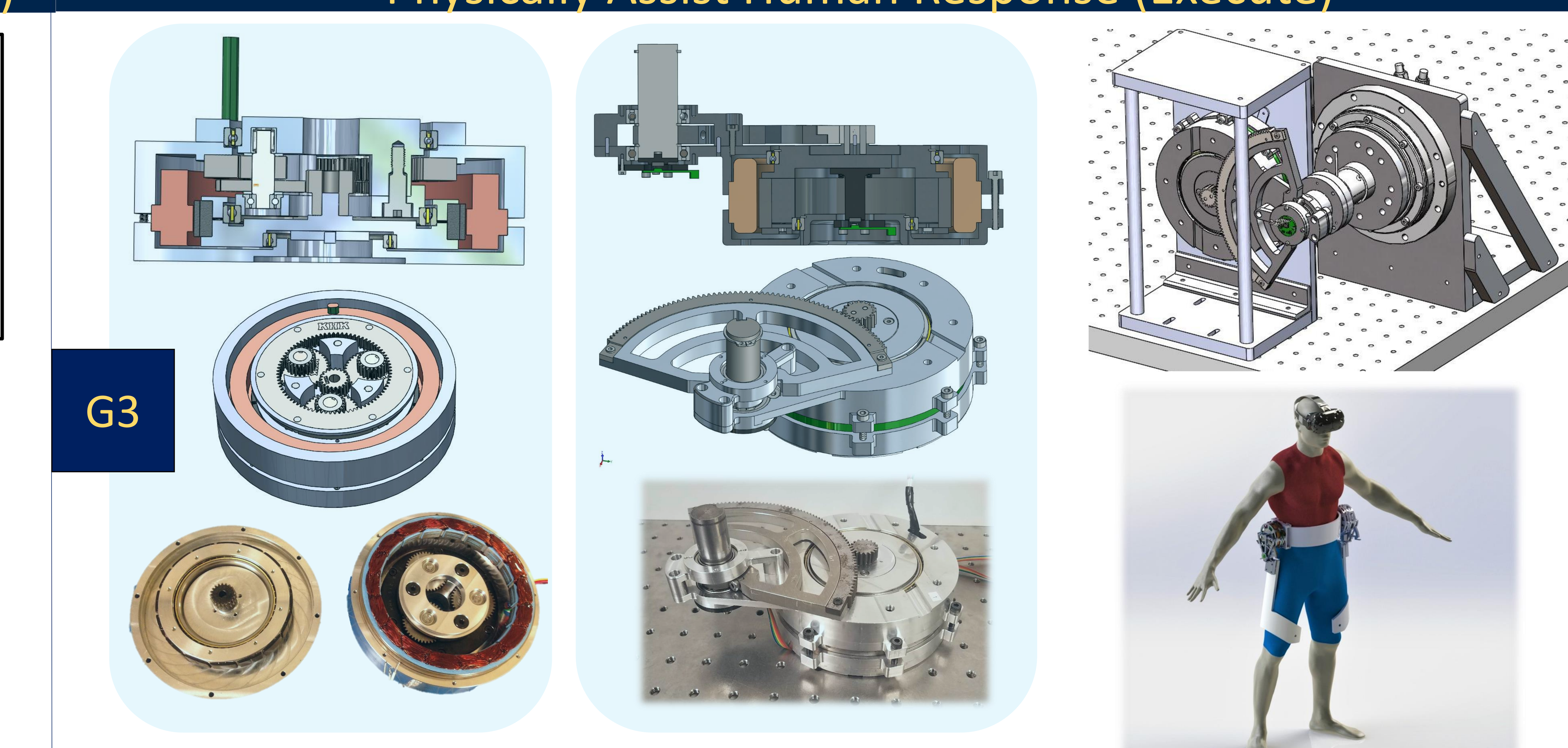




- ❑ A range of multi-sensory communication methods have been explored. Physical communication that helps induce a avoidance response will be of particular interest.
- ❑ Potential threats as well as a safe "escape path" will be communicated to the human operator.
- ❑ We will explore how natural human intuition interacts with an automated motion plan.

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]

Physically Assist Human Response (Execute)



- ❑ We seek to physically accelerate the human response using a human-worn co-robot.
- ❑ Physically assisting rapid human behaviors remains relatively unexplored.
- ❑ Obstacle avoidance experiments will be performed with flying objects and/or padded ground robots. Physical obstacles enable humans to utilize their range of senses and physical intuition.
- ❑ Metrics of performance include time to reach safe zone, ability to avoid moving obstacles.
- ❑ Results can help inform a different class of assistive robots intended for enhancing transient behaviors rather than steady-state ones.
- ❑ A range of physical assistance strategies will be explored using a novel hip exoskeleton device.
- ❑ EMG based control can enhance customizability.