A novel intervention method to promote workers' safety awareness and mental health during human-robot collaboration

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Background

- **Research Topic 1 – Build a conditional variational auto-encoder model for posture optimization during human-robot collaboration (HRC)**

- ❏ In a few recent studies, computer vision-aided human pose reconstruction has been applied to find the optimal position of the point of operation in HRC that can reduce workers' musculoskeletal disorder (MSD) risks due to awkward working postures. Yet, the reconstructed human pose through computer vision may be less accurate or fail due to the complexity of workplace environment. Thus, we proposed a data-driven method for optimizing the position of the point of operation during HRC.

- **Research Topic 2 – Examine the effects of communication modality during HRC on workers' mental stress**

- ❏ Working and interacting with collaborative robots in close proximity can be psychologically stressful. Therefore, it is important to understand the impacts of human-robot interaction (HRI) on mental stress to promote psychological well-being at the workplace. To this end, we investigated how task complexity and communication modality affect workers' psychological stress using galvanic skin response (GSR) as an objective measurement and NASA task load index (NASA-TLX) as a subjective assessment.

Methods - Research Topic 1

- A conditional variational auto-encoder (cVAE) model-based approach was developed using an open-access posture dataset with 7 labels constraining the simulated human postures during a lifting task.

- The MSD risk of each simulated posture was evaluated by a posture scoring protocol similar to RULA. Among all simulated postures, the one yielding the smallest posture score determines the location of point of operation.

- An empirical validation was conducted to examine the effectiveness of this method in reducing MSD risks during an HRC task.
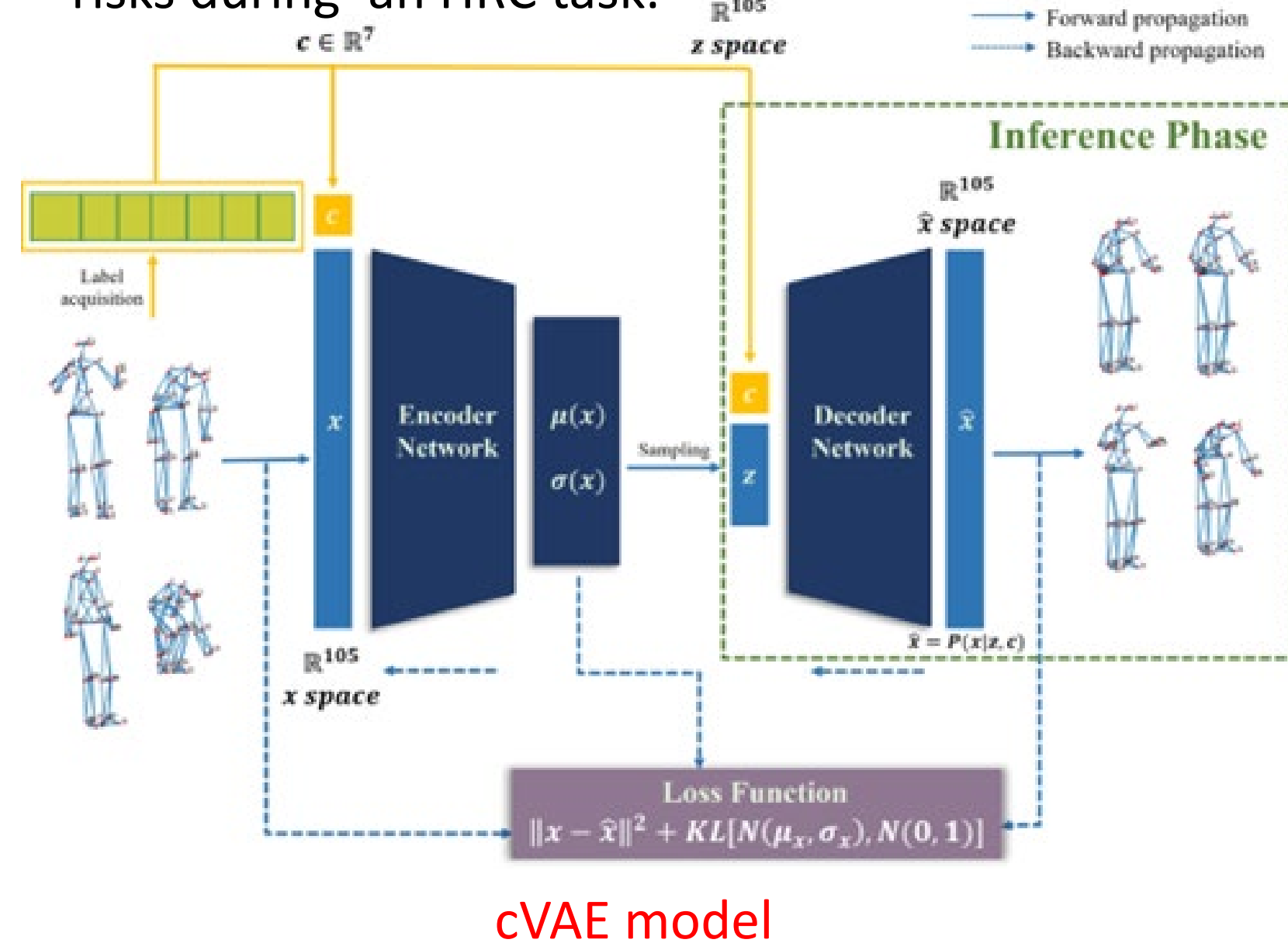
cVAE model
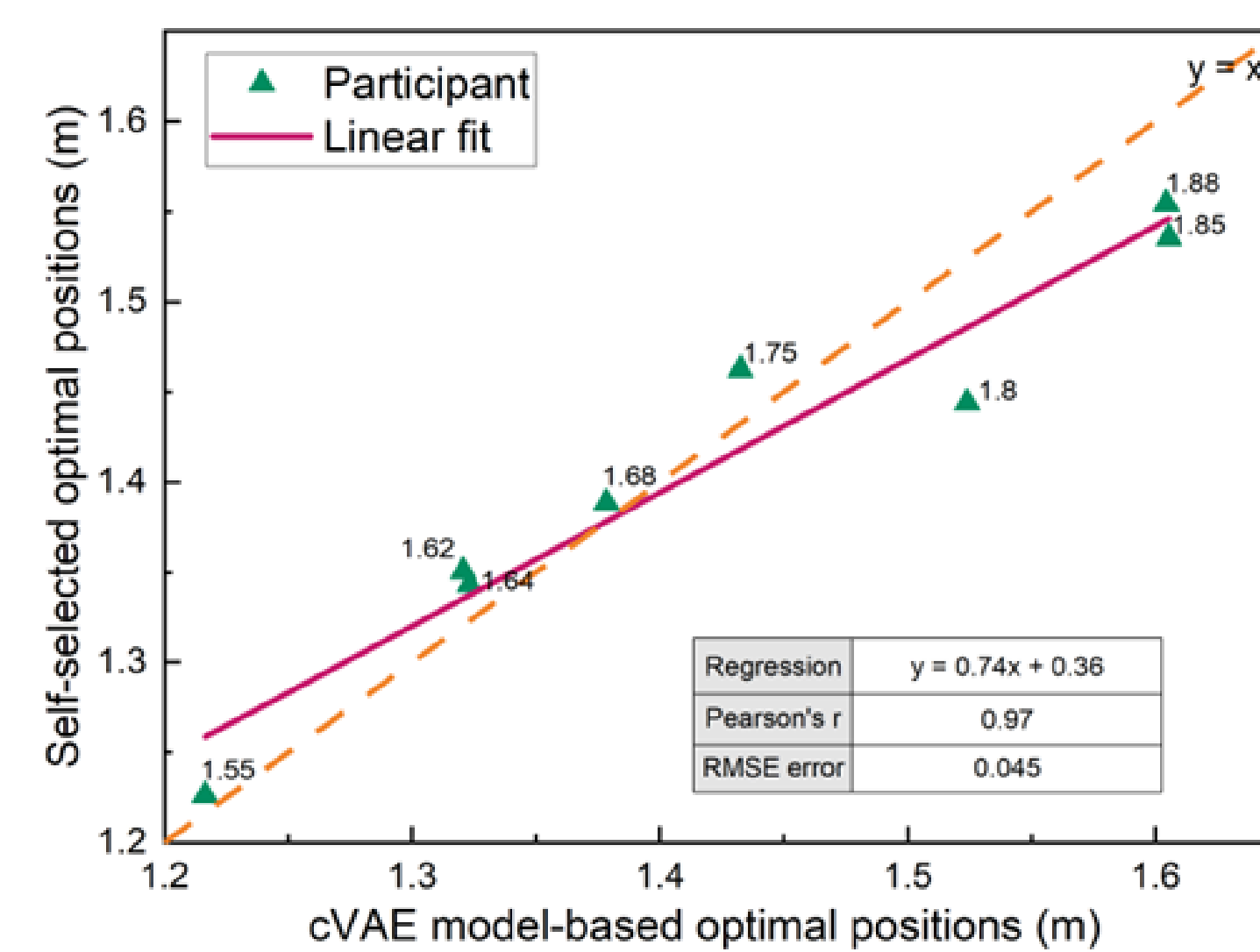
A comparison with experiments

Future studies

- Weather the current generative model can be adopted to simulated other high MSD risk tasks (e.g., lifting) need to be examined.
- Other direct measurements of mental stress need to be further investigated to ensure the current findings are unbiased.
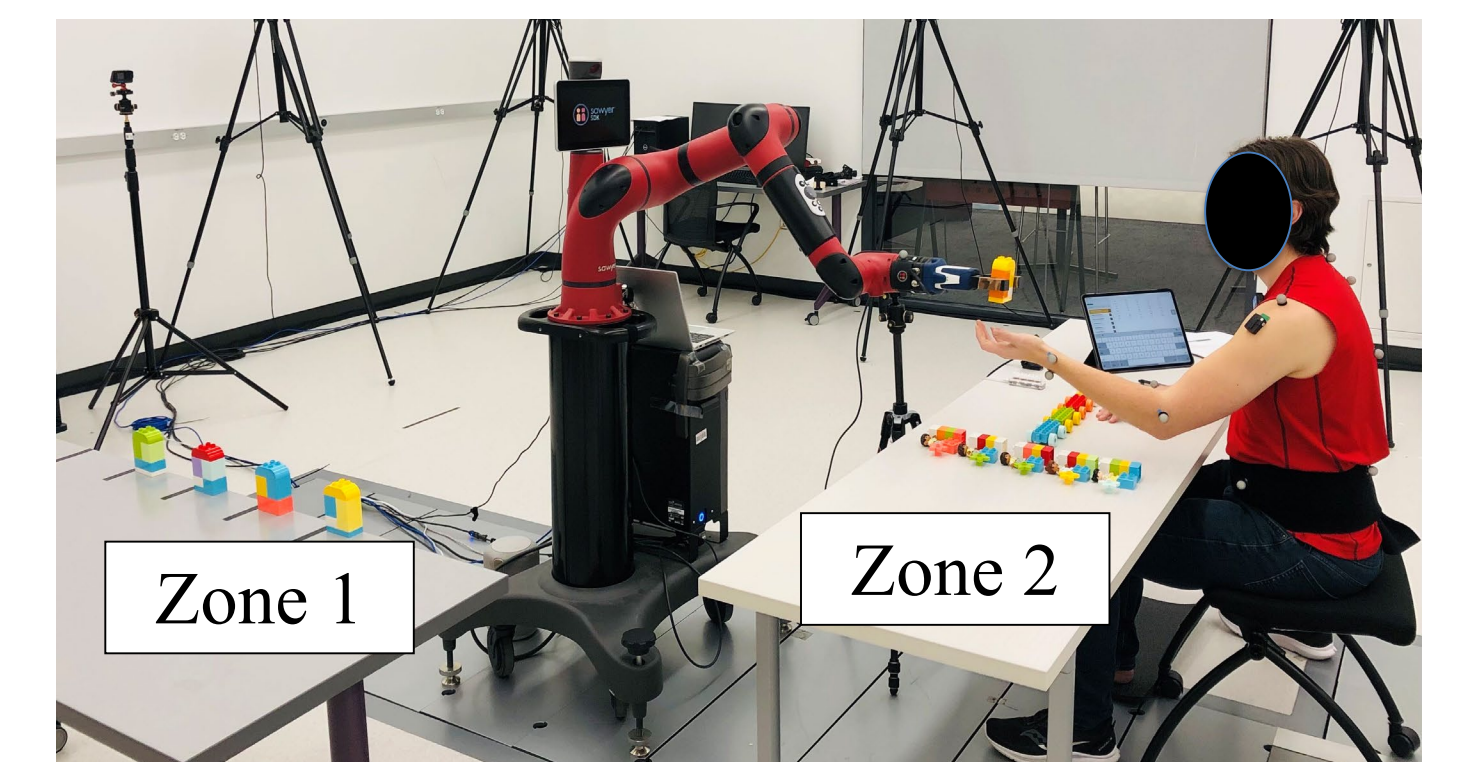
Methods - Research Topic 2

In a conducted experiment, human operators worked together with a collaborative robot on a Lego assembly task using different interaction paradigms. The co-robot picked up a large Lego block from Zone 1 and delivered it to the participant sitting in Zone 2. The participant then took the large Lego block from the co-robot and secures small irregular-shaped Lego pieces on the large Lego block.

- **Independent variables:**
- ❏ **Interaction presence:** with / without
- ❏ **Interaction complexity:** simple / complex
- ❏ **Interaction modality:** button / hand gesture / verbal voice
- **Dependent variables:**
- ❏ **GSR:** varying electrical properties of the skin in response to sweat secretion by sweat glands.
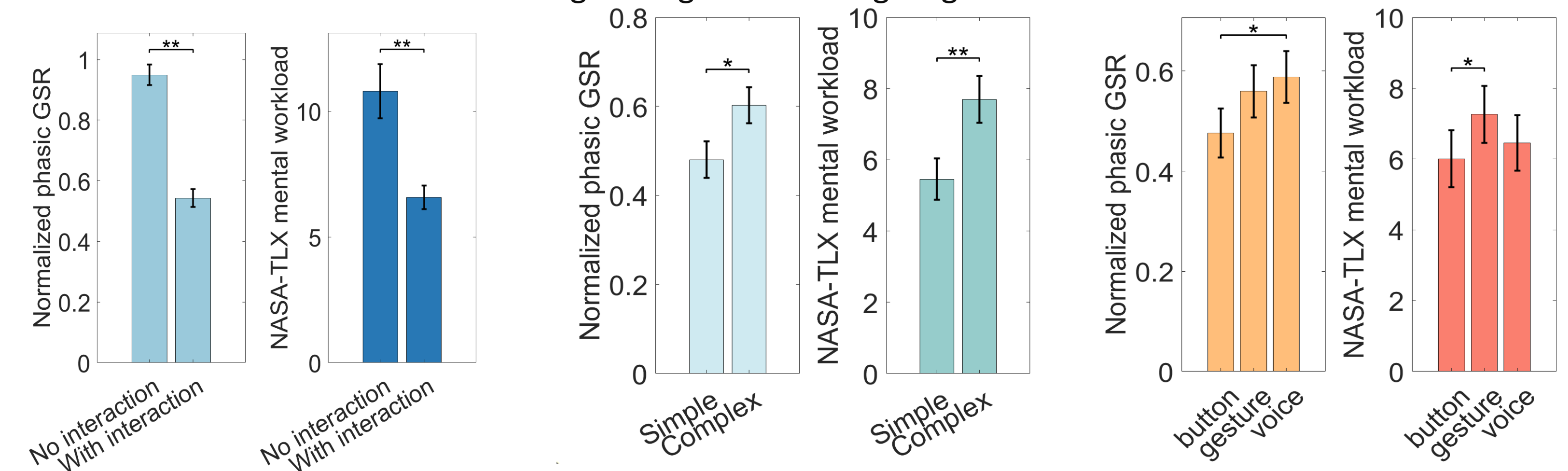- ❏ **NASA-TLX:** mental demand, physical demand, temporal demand, performance, effort, and frustration.

Zone 1   Zone 2

Results

- **Research Topic 1**
- ❏ The experiment outcome indicates that the proposed method can produced a position of point of operation similar to those chosen by individual participants through subjective selection. Therefore, this data-driven method can improve workers' musculoskeletal health by providing personalized work configurations during HRC while avoiding direct measurement of human pose at work for pose reconstructon.
- **Research Topic 2**
- ❏ The results revealed that the introduction of interactions during HRC helped reduce mental stress and that complex interactions resulted in higher mental stress than simple interactions. Meanwhile, the use of verbal commands or hand gestures led to significantly higher mental stress than pressing buttons, while no significant difference was found between showing hand gestures and giving verbal commands.

Impact - Society

- Highlight the importance of preventing MSDs during HRC tasks and provide a solution to improve occupational safety by using generative models .
- Provide insights for designing HRI paradigms with the consideration of human mental stress.

Impact - Education

- Help students understand the concepts in data-driven methods and human physiological responses under mental stress
- Result in a summer day camp activity targeting underrepresented minority high school students.