
2018 ASEE Mid-Atlantic Section Spring Conference: Washington, District of Columbia Apr 6

Exploring Human-Co-Robot Interactions: Real-time Feedback or not?

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Dr. Tucker holds a joint appointment as Assistant Professor in Engineering Design and Industrial Engineering at The Pennsylvania State University. He is also affiliate faculty in Computer Science and Engineering. He teaches Introduction to Engineering Design (EDSGN 100) at the undergraduate level and developed and taught a graduate-level course titled Data Mining–Driven Design (EDSGN 561). As part of the Engineering Design Program’s ”Summers by Design” (SBD) program, Dr. Tucker supervises students from Penn State during the summer semester in a two-week engineering design program at the École Centrale de Nantes in Nantes, France.

Dr. Tucker is the director of the Design Analysis Technology Advancement (D.A.T.A) Laboratory. His research interests are in formalizing system design processes under the paradigm of knowledge discovery, optimization, data mining, and informatics. His research interests include applications in complex systems design and operation, product portfolio/family design, and sustainable system design optimization in the areas of engineering education, energy generation systems, consumer electronics, environment, and national security.



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Introduction

Grand Engineering Challenges of the 21st century: Development of Personalized Learning*

In traditional learning environments, instructors are able to provide **personalized** and **real-time feedback** based on the facial or body language **cues students project**, as well as their **performance** on the task at hand.

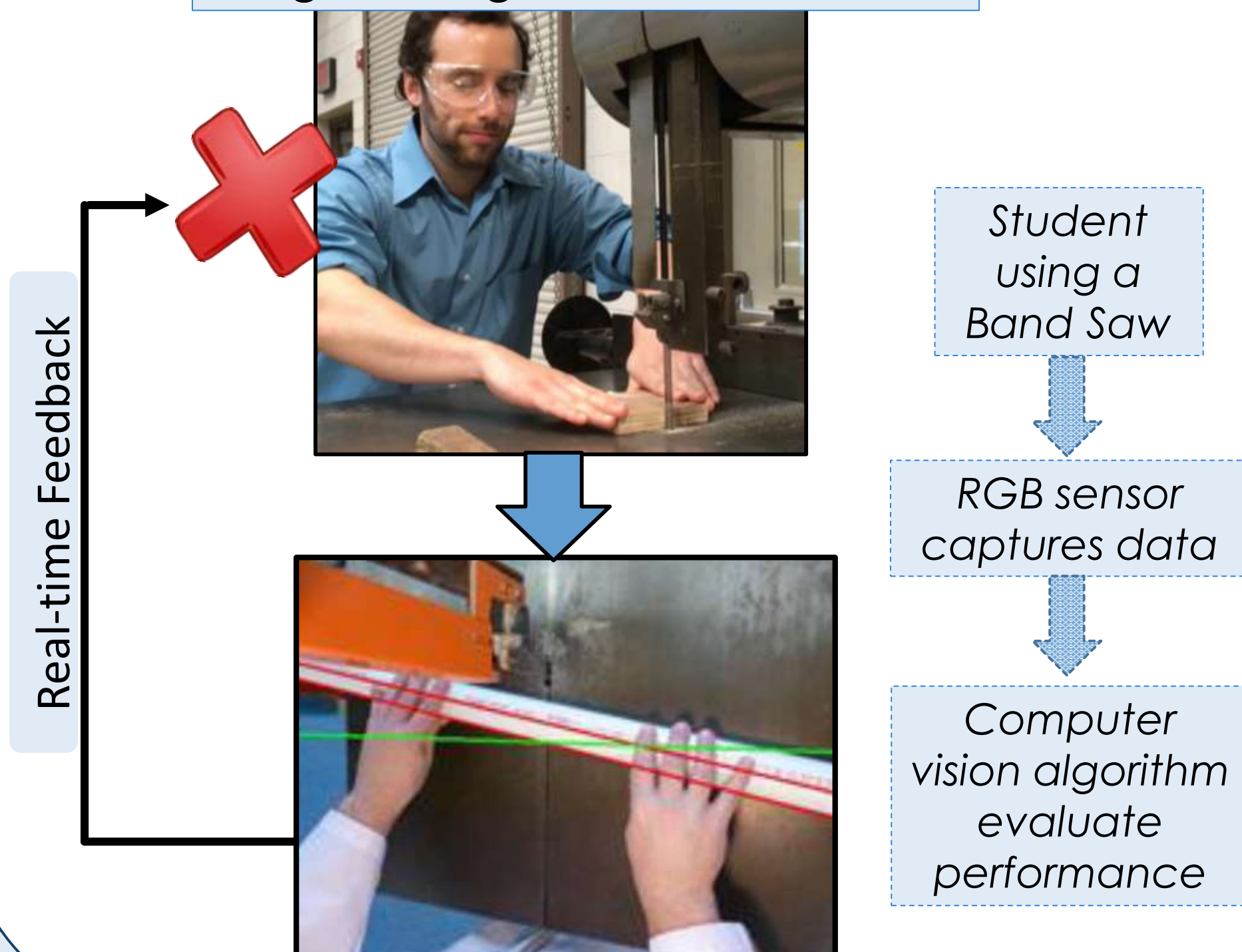


Unfortunately, this personalized assistance and real-time feedback is **DIFFICULT TO ACHIEVE** where **in-person interactions** are challenging, or the **student to instructor ratio** is high. (e.g., *E-learning, Eng. Laboratories*)

Current Research State

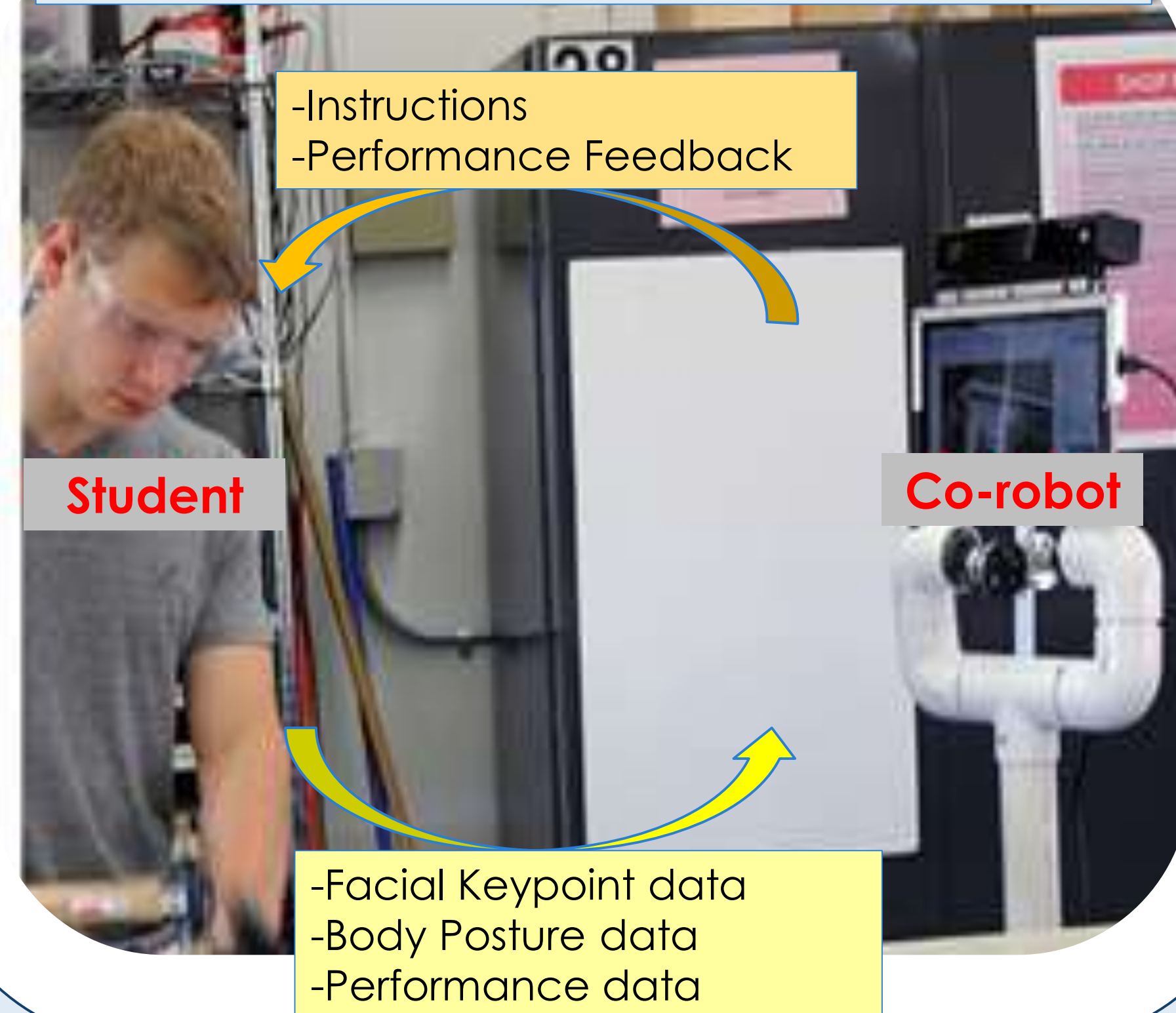
Current online learning environments can provide real-time performance feedback (e.g., online quiz). Moreover, due to the advancements in **sensor** and **computer vision** technology, current intelligent systems can provide real-time performance feedback to students during Engineering tasks.

Engineering Lab Environment



Future State

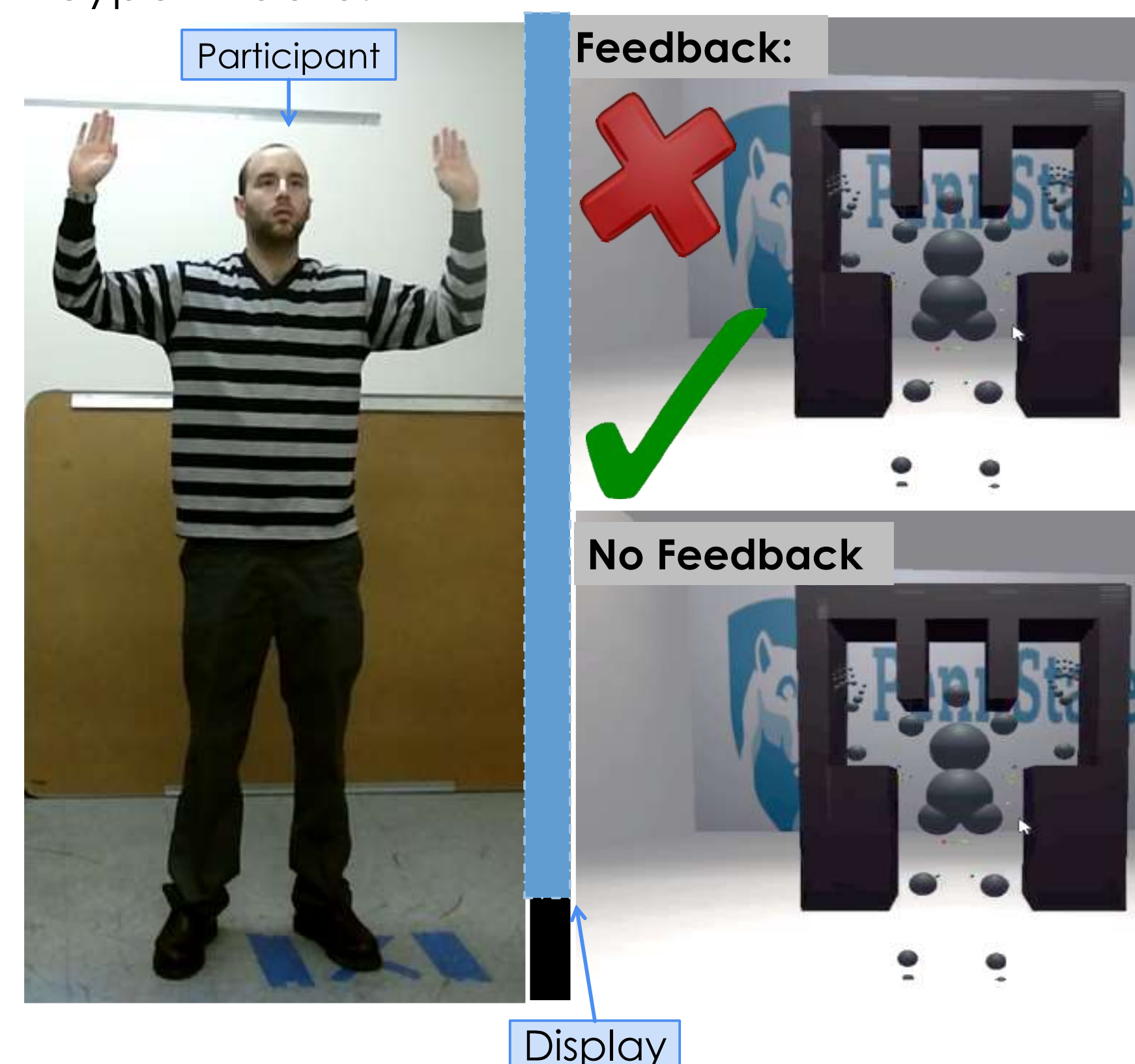
Use of Co-Robot in Eng. Environments



Case Study

(i) Physically Interactive application: 12 Tasks

- ✓ Help control for the starting and completion time of the tasks.
- ✓ Systematically capture performance and facial keypoint data.



(ii) Facial keypoints & joints location data

(iii) Stimulus (Feedback or not)

Results and Discussions

i. How does previous task performance feedback correlate to students' current task performance?

Performance Comparison Test (Intensity of Mistakes, IM)

Feedback App: No Feedback App

IM: -33586 --- IM: -32491

P-value: 0.665

ANOVA TEST | Application

$IM \sim \text{Previous Performance} + \text{Obstacle} + \text{Participant}$

Variable	Feedback App	No Feedback App
Pre-per (Pass/Fail)	0.0725*	0.153
Obstacle (1-12)	<0.001***	<0.001***
Participant (ID)	0.0198**	0.174

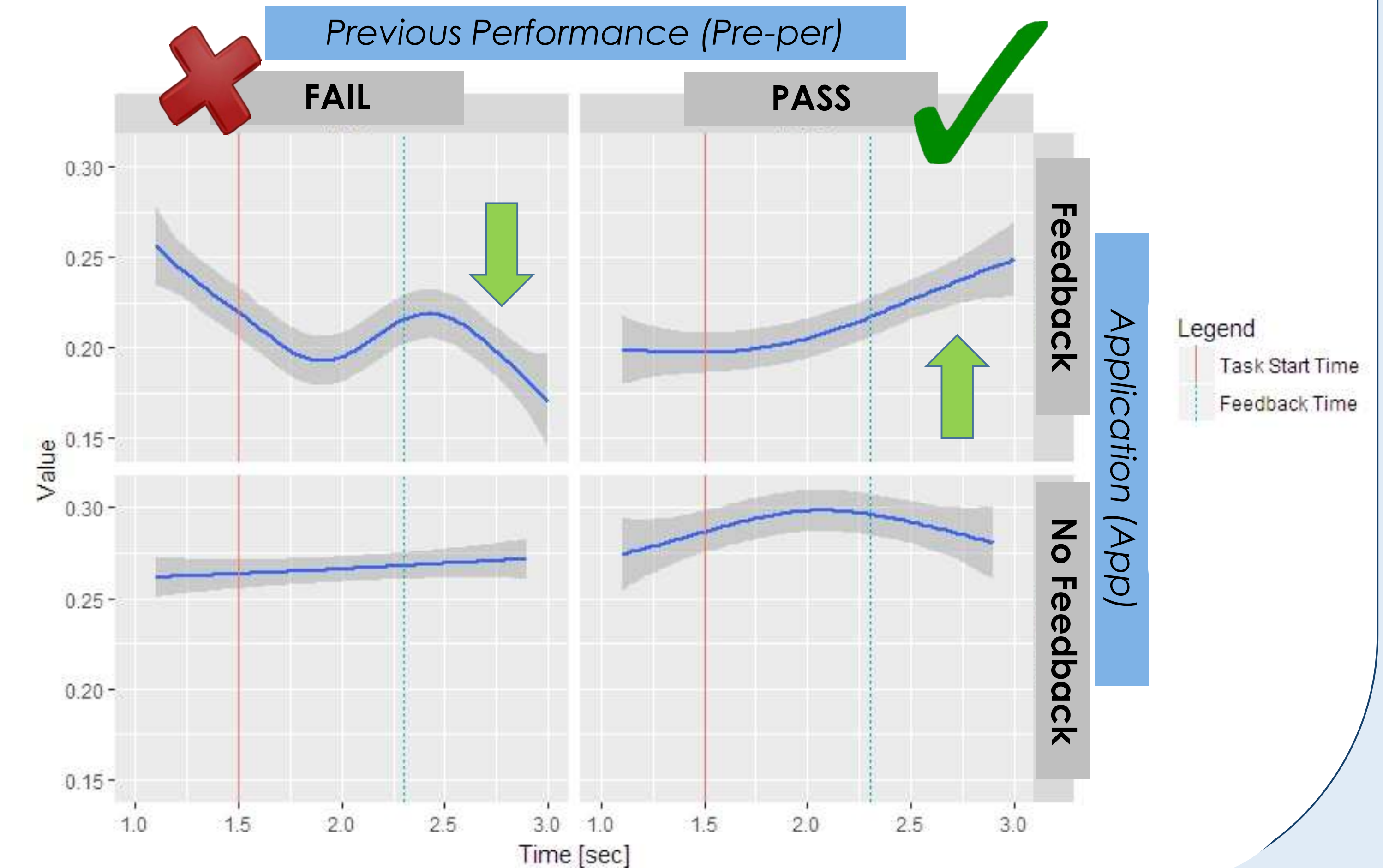
Linear Regression Analysis

$$\text{Scale}(IM) = (-1.4^{***}) + (0.03)\text{Pass} + (-0.07)\text{No Feedback App} + \text{Obstacles}$$

ii. How does students' facial expression correlate to the performance feedback?



Upper Lip Raiser Action Unit



Conclusions

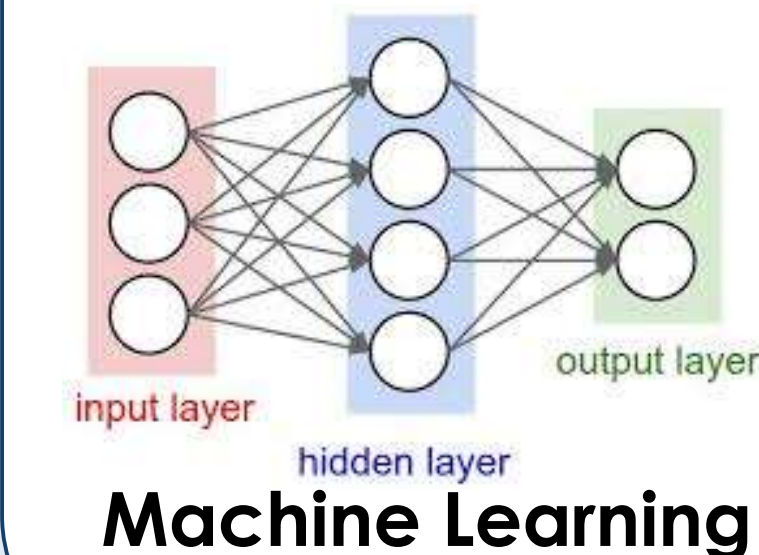
The results indicate that real-time performance feedback might not be the optimal design for every student and/or task. They reveal that students' performance on a task and their facial expression is correlated to the type of feedback provided in a previous task.

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Future Works



Eng. Tasks



Acknowledgement

This research is funded by **National Science Foundation NRI 1527148**



* Grand Challenges for Engineering, by the National Academy of Engineering Vest, C., 2008, "Context and challenge for twenty-first century engineering education.," J. Eng. Educ., 97(3), p. 235-236.