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Communicating Robot Motion Intent with Augmented Reality

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Technical Aspects of Multimodal Systems

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Outline

The Future is approaching...

- Evolution of manufacturing industry, logistics, and construction
- And more...

Source: https://www.youtube.com/watch?v=1xf$_{b}waAhgw$
https://www.press.bmwgroup.com/global/photo/detail/P90242725/smart-transport-robot-carrying-roller-containers-through-the-logistics-hall-at-bmw-group-plant

https://idsc.ethz.ch/research-dandrea/research-projects/archive/flying-machine-enabled-construction.html

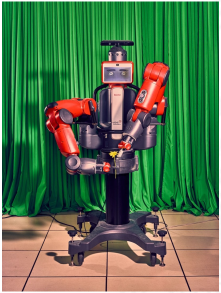
Motivation (Cont.)

The future of work is very likely transformed by collaborative robots.

- Collaborative activities fundamentally depend on ***interpredictability*** — the ability of team memebers to rapidly understand and predict the attitudes and actions of the others [1].
- This is a challenging task
- Studies report that **social cues** is a way for human better understand their movement intent and affective state [2, 3, 4].
- Research shows that motion intent cueing can improve interaction fludity and efficiency in collaboration between humans and robots [7].

Most Common Approaches

- One approach is to implement advanced warning systems.
- Another approach is to add anthropomorphic and zoomorphic features.
  - Facial expressions
  - Human-like gestures
  - Natural languages

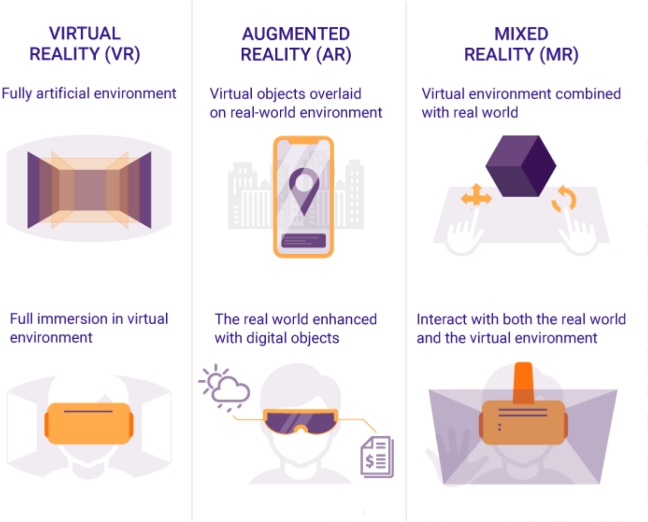


Source: https://www.newyorker.com/magazine/2017/10/23/welcoming-our-new-robot-overlords

Some downside of current methods

- Poor communication
- Hard to apply these findings to industrial robots arms or flying robots
- Longer develop perid

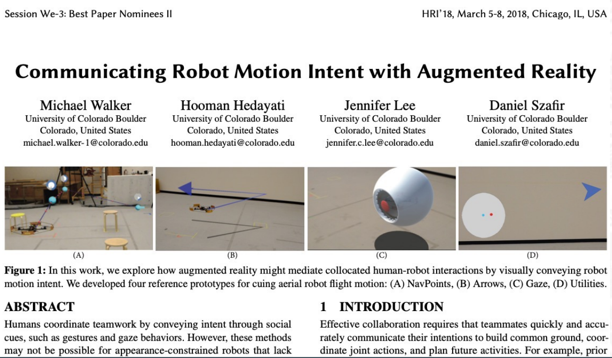
Comparison of VR, AR, and MR



Source:https://rubygarage.org/blog/difference-between-ar-vr-mr

Why Aerial Robots?

- Drone robots have been developing rapidly in recent years.
- They are ideal co-workers for logistics management in manufacturing settings.
- The ability of flying enable unique forms of assistance in a variety of collaborative tasks [6].



Session We-3: Best Paper Nominees II HRI'18, March 5-8, 2018, Chicago, IL, USA

Communicating Robot Motion Intent with Augmented Reality

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(A) (B) (C) (D)

Figure 1: In this work, we explore how augmented reality might mediate collocated human-robot interactions by visually conveying robot motion intent. We developed four reference prototypes for cuing aerial robot flight motion: (A) NavPoints, (B) Arrows, (C) Gaze, (D) Utilities.

ABSTRACT

Humans coordinate teamwork by conveying intent through social cues, such as gestures and gaze behaviors. However, these methods may not be possible for appearance-constrained robots that lack

1 INTRODUCTION

Effective collaboration requires that teammates quickly and accurately communicate their intentions to build common ground, coordinate joint actions, and plan future activities. For example, prior

Experiment (Cont.)

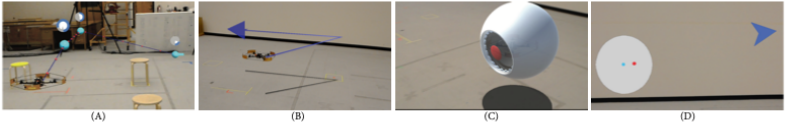

Figure 1: In this work, we explore how augmented reality might mediate collocated human-robot interactions by visually conveying robot motion intent. We developed four reference prototypes for cuing aerial robot flight motion: (A) NavPoints, (B) Arrows, (C) Gaze, (D) Utilities.

- **NavPoints**: series of lines point to the target location with information about arrival times, wait times, and velocities of each line fragment
- **Arrow**: a big arrow represents the exact path that the robot plans to do
- **Gaze**: a flying eye as a representation of the aerial robot, with the front information
- **Utilities**: a radar-like interface, indicating the location of the robot relative to the user

Experiment (Cont.)

Techologies

- Robotic Platform: AscTec Hummingbird robot
- ARHMD Platform: Microsoft HoloLens
- Develop Platform: Unity

The Task

- Participants were tasked with assembling beaded strings at workstations shared with an aerial robot.
- The goal is to make as many beaded strings as possible in exactly 8 minutes.
- If the robot traveled to the same station as the participant, they had to leave the workstation at least 2m away and wait for the robot to leave
- post-questionnaire
- Overall 30 mins long

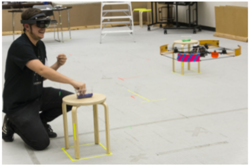

Figure 3: Participant making a bead string at one of the six assembly stations mid-task. The AscTec Hummingbird robot flies nearby (colored corner marks robot "front" for baseline participants).

Design AR Interface for Flying Robot (Cont.)

Experiment Design

5 x 1 between-subjects

- Five conditions: 4 models and one baseline condition
- Independent variable: type of AR feedback
- Dependent variables: task performance, work efficiency, intent clarity, and robot usability

Baseline condition:

- no AR feedback
- Participants need to wear HoloLens and perform the same task as in other conditions.

Experiment (Cont.)

Participants

- 60 participants
- 40 males, 20 females, evenly distribute into 5 conditions

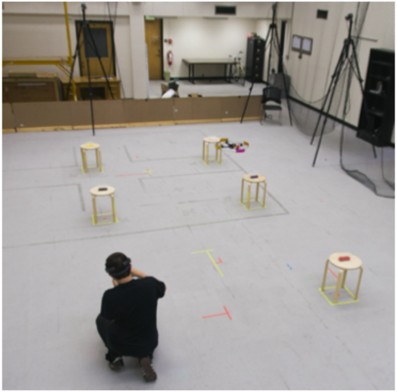

Figure 2: The experimental environment required that participants share a workspace with a collocated arial robot.

Results

Compared to the Baseline condition:

- NavPoints, Arrow, and Gaze models show significant efficiencies improvement.
- NavPoints model is the best model for movement intent clarity.

Limitations and Future Work

Limitations

- The design of information transmission is not straightforward (Robot location $\rightarrow$ motion tracking system $\rightarrow$ AR feedback)
- Participants report HoloLens is uncomfortable
- The generalizability of the results may be limited due to the experimental design, task, and measures

Limitations and Future Work (Cont.)

Future Work

- Large sample size
- Within-subjects design
- Better information transmission
- Better measures for dependent variables
- Consider more aspects, e.g. gender effects

Thank You for listening
Any question?

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