Development of a Virtual Reality Environment for Human–Robot Task Allocation

Context

In collaborative work settings, effective task allocation between humans and robots is crucial for maintaining productivity while preventing operator fatigue or overexertion.

This project aims to design and implement a virtual reality (VR) simulation that allows the testing and evaluation of task allocation strategies aimed at reducing human workload during shared tasks.

VR provides a safe and immersive testbed for exploring these strategies before deploying them on real collaborative robots, supporting future developments within the AugmentX infrastructure.

Objective

The goal is to develop a Unity3D-based VR environment where a human (via VR headset and controllers) collaborates with a simulated robot (e.g., Franka Emika Panda) on a simple assembly or manipulation task.

The student will design, implement, and test different task allocation strategies that balance task load between the two agents, with the aim of minimizing human workload while maintaining task efficiency.

Methods

1. Literature Review

- Study previous research on human–robot task allocation, adaptive collaboration, and workload modeling.
- Review how VR environments are used for evaluating human–robot interaction.
- Identify relevant metrics and models for quantifying physical and/or cognitive workload.

2. VR Environment Development

- Create a collaborative Unity3D scene representing a simplified assembly or sorting task.
- Simulate a robot arm (e.g., Franka Emika Panda) using Unity physics or the Unity Robotics Hub.
- Integrate real-time Xsens IMU data to capture the human operator’s body posture.
- Derive a workload or fatigue indicator from the posture data (e.g., time in non-neutral positions).

3. Task Allocation Strategies

- Implement and compare two strategies:
- Fixed allocation : human and robot perform predefined subtasks.
- Adaptive allocation : the robot assists or takes over tasks when the human workload indicator exceeds a threshold.
- Visualize task assignments and transitions in VR.

4. Evaluation

- Conduct experiments in which participants perform the collaborative task under both allocation modes.
- Collect data on:
    - Objective metrics: task completion time, errors, posture-based workload indicators.
    - Subjective metrics: perceived workload (e.g., NASA TLX), collaboration quality, and satisfaction.
    - Analyze differences between the allocation strategies to determine the effect on human workload.

Prerequisite

- C#, C++
- Unity3D
- ROS

Contact person

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