Artificial Intelligence Driven Human-Machine Collaboration Scenarios in Virtual Reality

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Introduction

With the digitalization of industrial processes, commonly referred to as Industry 4.0, comes a paradigm shift that not only affects production processes but also the workforce. The way employees are exposed to digitalized work processes can be categorized into three major fields:
(1) **Machine-Machine Interaction**, describes "intelligent" cyber-physical systems handle autonomous production tasks, (2) **Human-Machine Interaction**, where staff is either controlling or monitoring the value chain and (3) **Human-Machine Collaboration**, where assisting systems like robots support employees, e.g. with complex assembling or maintenance tasks. Due to technological advancements, the deployment of AI in workplace environments will become more commonplace with Industry 4.0. As AI systems are still restricted, scenarios involving unique tasks and decisions based on experience will require the presence of human workers. The consequences of AI based working relationships remaining widely unexplored.

From Virtual to Reality

Virtual Reality (VR) enables the economical and safe exploration and envisioning of **Human-Machine Collaboration** scenarios in immersive and interactive simulations. The introduction of AI-based technology impacts the socio-technical system, which can lead to potential hazards and disadvantages in Human-Machine Collaboration and in the social system it is embedded in. VR allows to better understand human behavior, reactions, misconceptions, potential health risks, and to explore technological acceptance, socio-emotional consequences as well as overall pros and cons of certain workplace arrangements **before** their implementation in real-life settings. Also, the emergence of **algorithmic bias** – flawed and restricted training data that influence the behavior of the machine – and its consequences can be explored.

Step 1: People collaborate in a virtual and safe Human-Machine Collaboration task with a robot arm. A variety of data is collected about behavior and evaluation of the experience. **Step 2**: Behavioral variation of human workers is applied to a real robot and further explored regarding acceptance, safety etc..

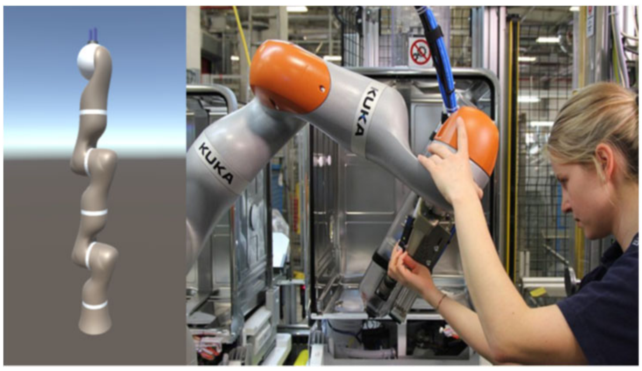

Figure 1: The digital KUKA robotics arm compared to the real one, used in a industrial assembling scenario (KUKA, 2018).

Scenario

Simulating future Human-Machine Collaboration scenarios in VR requires the creation of a digital robotics entity outfitted with behavioral characteristics that mimic its real-life counterpart of an industrial robot. This requires an adaptive AI that is able to react to user actions in order to accomplish tasks in a collaborative process. This scenario was chosen because of the relevance in digitalized production processes, as specialized and unique assembling tasks albeit automated will still require human input and experience.
The experimental setup will contain a virtual industrial environment outfitted with a digital representation of a 7-axis robotics arm based on a design manufactured by KUKA (Figure 1). The virtual robotics arm is a precise replica of the real counterpart and uses an inverse kinematic system allowing to control each joint. The Machine Learning Agents Framework (Figure 2) is first utilized to teach the arm movements and then complex assembling tasks via a set of training data. Every learning progress will be evaluated with participants that interact with the robot entity allowing for optimizations of the behavior at each step.

Machine Learning Agents

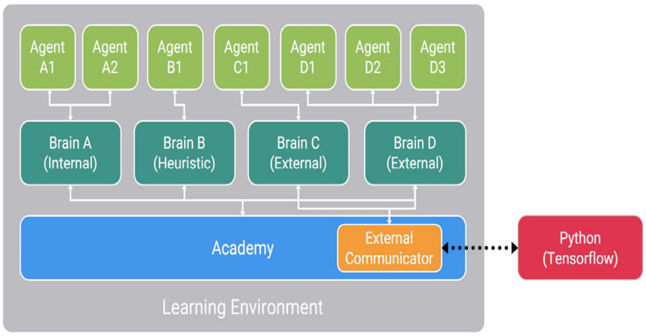

Figure 2: Structure of Unity's Machine Learning Agents Framework (Unity, 2018)

Projected Outcome and Continuation

Based on the scenario, it is anticipated that the **Cooperative Multi-Agent** setup will be suited best for the experimental setup. This way, agents can be applied to different sets of information, such as kinematics control, while others can monitor for user actions. Another possible candidate is the yet to be implemented "**Imitation Learning**", where agents record user inputs and use them as foundation to learn specific actions. Imitation Learning it anticipated to be released in spring of 2019 and will be evaluated in the next iteration of the VR-application. The next step is to create training data sets that can be applied for teaching the robotics arm a specific movements that will be necessary for an assembling procedure. Once done, the set of skills that the robotics arm will learn is incrementally expanded until it is ready to complete an industrial based Human-Machine Cooperation scenario in virtual reality.

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