A Proposed Wizard of OZ Architecture for a Human-Robot Collaborative Drawing Task

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Human Robot Interaction (HRI) involves the study of how humans perceive, react and engage with robots in a variety of environments. Within HRI is the study of how humans and machines can collaborate on shared tasks, commonly referred to as Human Robot Collaboration (HRC). Both HRI and HRC research can involve very labour intensive integration between the hardware (robot) and study variables, which can be a constraint for members from different disciplinary backgrounds. This poster describes a proposed software framework that enables various researchers to run a HRC study with minimal development time. The framework in question currently centres around an interaction in which a participant and a UR10 contribute to a shared artwork. The applied experiment required the UR10 to give the appearance of an autonomous social entity while having the capability to both draw and react to external stimuli. This architecture is controlled using the Wizard of OZ (WOZ) experimental design methodology, allowing an operator to control the robot's behaviour in real time. The wizard of OZ control method is a widely accepted technique for experiments evaluating human response to robotic behaviour, especially when the robot is required to demonstrate a certain level of intelligence. Consistent behaviour is crucial to maintaining uniformity in experience across all participants. Sketches which contained basic objects and images easily recognised were essential so that participants could readily contribute to regardless of drawing ability. The location for this study was the Questacon - National Science and Technology Centre in Canberra, Australia where the public was invited to interact with the UR10 where an individual would sit at the table in a position that would enable both participants (human and robot) to physically interact. The UR10, under direction of the WOZ operator, would lead the interaction by prompting the participant to complete various actions through non-verbal cues. A key benefit of the built architecture enables researchers with little technical knowledge to add, remove and execute anthropomorphic motions with a heuristics based approach.

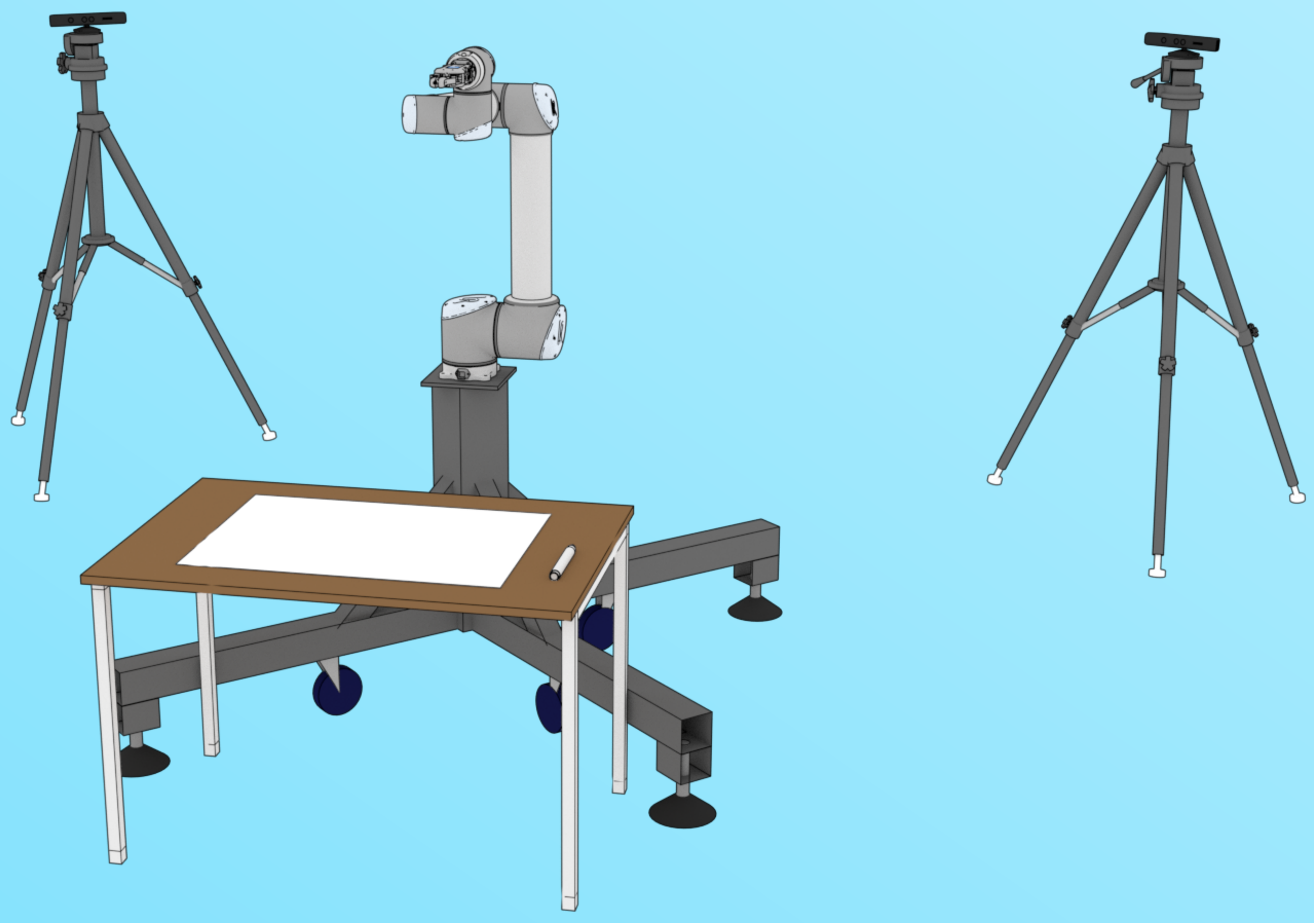

Figure 1: An experiment setup visualisation

By placing the WOZ operator away from direct view, participants more readily interacted with the robot as a social actor. To support the interaction, the operator would use a series of commands to puppeteer the robot's behaviour depending on the situation. The WOZ operator could instruct the robot how to behave in a continuous waiting manner choosing between three predetermined states with either a "nodding" motion, an "observing" animation or a "withdrawn" pose.

Upon interaction initiation, The UR10 would first greet the participant upon meeting and wait for them to take a seat. The robot would then start drawing, pause to "evaluate" its efforts (using a predetermined animation), complete the drawing and return to an idle state. Afterwards, a series of individual commands were issued to complete the desired interaction. These commands were given to complete the activities of encouraging the participant to contribute to the drawing, prompt the robot to sign the artwork, prompt the participant to sign the artwork and prompt the user to retrieve the artwork. The complete interaction is summarised in figure 2.

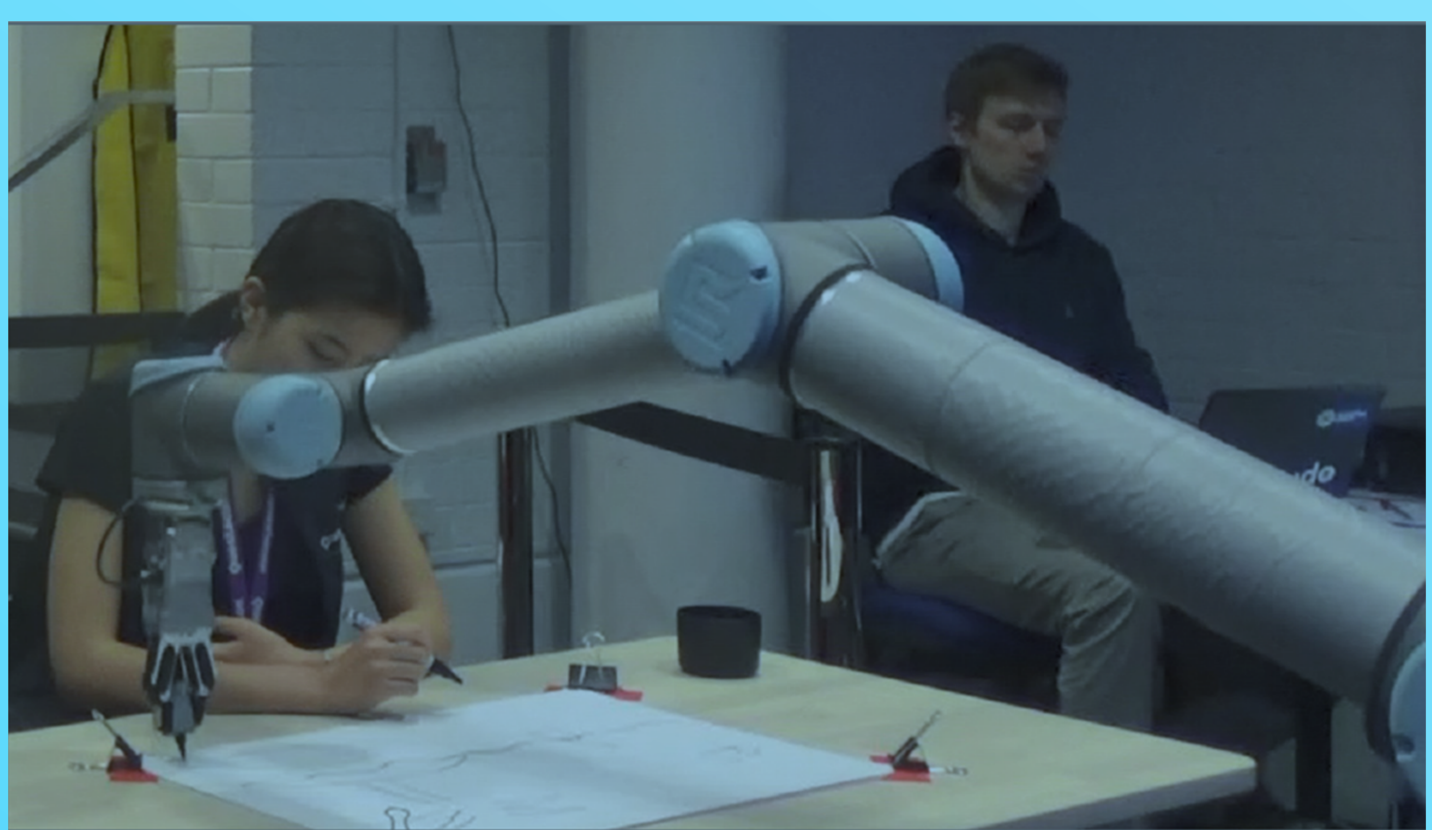

Image 1: An experiment in progress

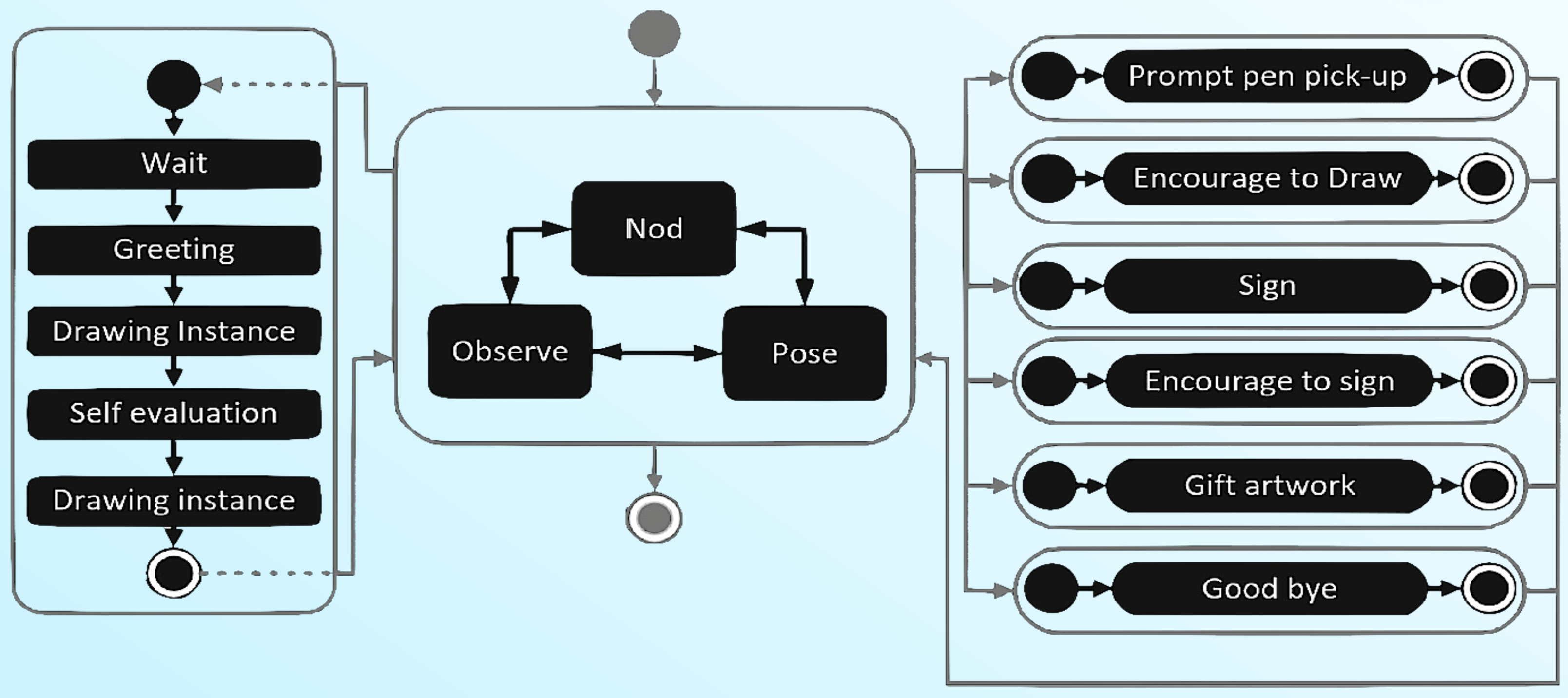

Figure 2: The WOZ command structure

The motivation for using a collaborative drawing task was to initiate collaboration between robot and participant in an open-ended task that was mutual, involved turn-taking, and was enjoyable for the participants. It was also important that the interaction fit within a limited time frame. The focus was on the interaction, rather than aesthetic criteria. Basic digital images were created and contours were extracted from this data. The contours would be passed along to be translated, scaled and physically rendered. Participants were seated opposite, facing the robot, thus the image coordinates where mapped to be drawn from their perspective. We presumed that participants would be better able to collaborate on a drawing when the image was easily recognised and drawn from their perspective.

The animations were made to exhibit anthropomorphic behaviour in order to establish non-verbal communication with a participant. To streamline the animation process, the robot was set to free drive mode in which the researcher could freely and securely manipulate the UR10 into a desired position. Once in position, the researcher would record the end-effectors coordinates. Animations are recorded by the WOZ operator from the command line terminal. While performing an animated movement, the robot did not account for accidental collision between its two aluminium tubes and the steel base. The priority was to ensure that all combinations of animated motions did not result in a collision.

Robot Operating System (ROS) is a popular open source middle-ware for the development of robotic applications. ROS provides integrated communication between independent software modules (referred in ROS as 'nodes'). The nodes communicate via pairs of publishers and subscribers sharing a specific topic. There are three ROS nodes running simultaneously that make up the framework's core. They are the *interrupt*, *social command* and *robot interface* nodes. The *social command* node contains two publishers with subscribers in the *robot interface* node. The *WOZ command* publisher sent the majority of commands across including all social actions, drawing routines and parameter calibrations, while the *override command* was used to disable any running actions if needed. The *robot interface* node returned values to the *social command* node indicating what state the robot was operating in via the *robot feedback* publisher. Any message received from the *robot feedback* publisher was displayed back to the user. The *interrupt* node was created as a safety feature that allowed the WOZ operator to send a signal that caused the robot to withdraw to a safe distance in the event of a potential collision with a participant which was triggered by the WOZ operator. Following a withdraw motion; the UR10 would attempt to execute the last task, be it drawing or gesturing to the participant. The ROS framework is summarised in Image 2.

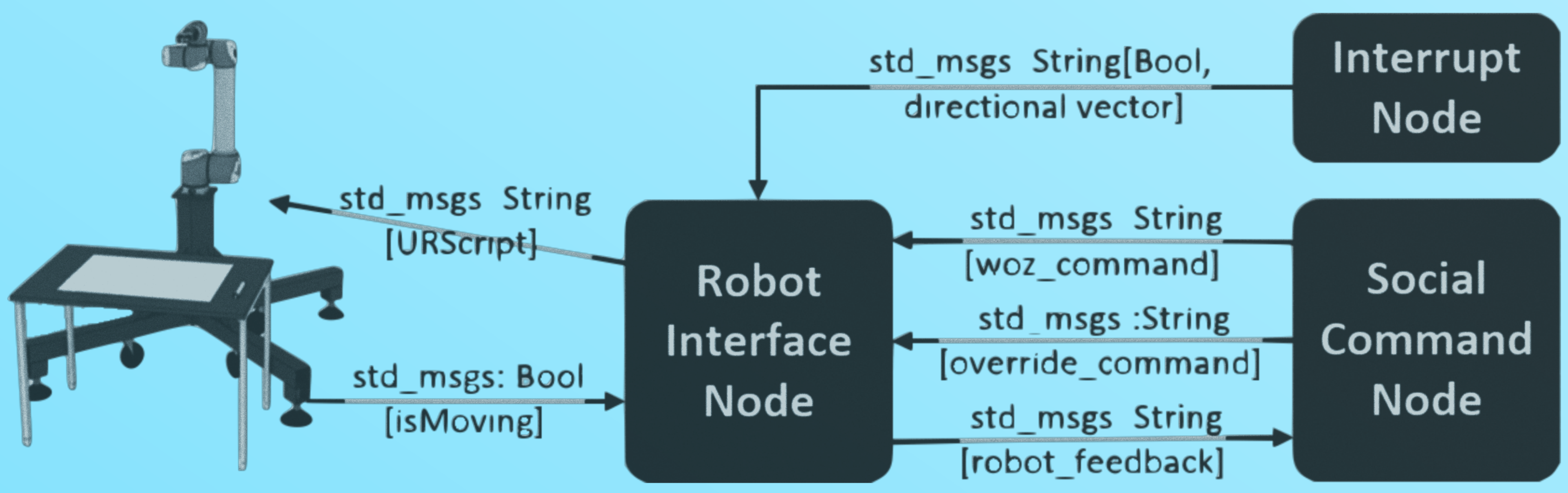

Figure 3 2: Visualisation of ROS Structure

Currently this architecture is hard coded to work in this experimental context. However this can be adapted to test a multitude of social and physical variables. Additionally this framework is hard coded to a fixed set of commands and one collaborative task. Future development will investigate how to make this architecture more flexible and allow for different collaborative tasks to be integrated. At the present, the WOZ commands are terminal-based therefore certain tasks become more convoluted. For this reason, a graphical user interface (GUI) will be added to give the WOZ application a more intuitive user interface and streamlined functionality. Other features could include forms of data logging and recording to make the experiment evaluations easier to monitor. A complete analysis of the experimental data is forthcoming at NordiCHI 2018.

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