**Proposal for Natural Human-Robot Interaction through the Use of Robotic Arms**

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*Abstract*—The study of the ways in which humans interact with robots is a multidisciplinary field with multiple contributions from electronics, robotics, human-computer interaction, ergonomics and even social sciences. The robotics industry is mainly focused on the development of conventional technologies that improve efficiency and reduce the amount of repetitive work. To achieve this, enterprises must train their technical staff to accompany the robot when performing tasks, during configuration and technical programming for proper operation. Taking the latter into account, the development and creation of unconventional interfaces for interaction between humans and robots is critical, because they allow for a natural control over a robot to generate wide acceptance and massive use in the performance of a wide range of possible tasks. This paper presents the challenges in the design, implementation and testing of a hand-based interface to control two robotic arms and the benefits of this technology that is between robotics and human interaction.

*Summary*

The paper begins with an analysis of current robotics applications within smaller businesses and domestic situations, highlighting the factors preventing the uptake of such systems within these spheres, namely the poor cost/efficiency ratio; robots (for industrial use in particular) are not easily implemented, usually requiring a high degree of technical skill, making set up of such systems prohibitively expensive for the aforementioned roles. It is therefore considered that a simpler, more streamlined approach could be taken, in which no programming or extensive technical ability is required.

A particularly interesting point on the commercial viability of HRI devices lies with the mention of the MakerBot 3D printer; the device was built with very narrow capabilities in mind, yet was adopted universally due to its low cost and approachability, and is now used extensively by small businesses and hobbyists. Development of a HRI system of similar ilk could generate a great deal of innovation in the area, albeit indirectly.

This research explores the use of the LeapMotion device to translate the users hand movements to control a robot arm (both locally and remotely) to complete various tasks, in the process studying the ability of untrained users to quickly learn to operate the system. Also analysed were the difficulties associated with user perception, such as depth perception.

Due to the research aims (to develop affordable HRI systems), the off-the-shelf robot arm used was somewhat limited in its capabilities; use of DC motors in place of servos keeps the cost down, but did not provide the precision movement often associated with industrial robots. However, the system did provide a suitable model for testing the efficacy of HRI using an interactive 3D workspace. Commands were sent to the arm based on hand position and gesture. Movement of the arm was controlled through opening and closing of the user’s hand (for opening and closing the end effector) and through displacement of the user’s hand from a centre position within the workspace.

Three situations were tested, with completely untrained users. The first task explored the precision of the system, asking the user to pick up a pill and place it in a container. The second aimed expanded the system to use two arms, allowing the user to manipulate various pieces of lab equipment. Finally, the tele-operation method was explored.

It was found that the system allowed the user to rapidly adjust to using the manipulators, highlighting a short learning period that is in line with the original intentions of the research. The orientation of the arm with respect to the user greatly affected the ability to carry out the given task. Having the arm opposite the user mirroring their movements caused great difficulties. For the tele-operation phase, it was found that a minimum of two cameras was required to allow completion times to approach those from the local operation phase, highlighting the necessity of some form of depth perception to efficiently operate the arms.

*Review*

The paper provides an interesting study into the possibilities of using spatial sensors such as the LeapMotion for HRI. I feel the most important aspect to take away is the user feedback – such systems will never be adopted unless they are easy to pick up as a first time user, and exploring the effects of sensory deprivation (direct line of sight, touch) on the user experience is invaluable. Some novel methods

I would say that this research needs further work before the efficacy of such systems for HRI can be proved, in particular with regards to the original research aims; though the cost of this system has been kept low, the capabilities have greatly suffered. It is worth noting also that the LeapMotion device seems underused; it is capable of full spatial/rotational mapping of the hand and digits, yet here is only used for basic directional control. It is an extremely capable sensor, which is seemingly paired with a rather poor robotic arm device. The system would need to be far more precise/capable before it would be considered an invaluable, affordable tool. I feel the author’s also failed to really clarify how a system such as this may be used by the consumer; the situations explored did not have any obvious real-world applications, as was even pointed out by the