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Improved Human Control of Robots

Controlling robots is a difficult task for humans. Robots can contain many different arms, wheels, cameras, sensors and other components. The operator needs to be aware of all these components simultaneously so they can control the robot with ease. Traditionally, remotely operated vehicles (robots) are controlled manually using keypads or joysticks. The operator is able to see what is being done via an array of screens, which are connected to cameras on the robot. There are additional controls to adjust the view of the cameras, so the operator can change their view depending on the current task. The operator's ability to focus and perform effectively are decreased as the tasks required by the robot become more complicated. In order to make controlling the robots feel more natural, researchers have developed new human-machine interfaces. These human-machine interfaces add a layer of abstraction to the robot controls. These interfaces allow the operator to focus on the task at hand, and forget about the mechanics of controlling the robot. These interfaces use virtual reality and specialized graphics to "trick" the user into feeling like they physically are the robot they are controlling [1,2].

There are many kinds of remotely operated vehicles that can benefit from an improved human interface. This paper will focus on autonomous underwater vehicles (AUV) and traditional land-based mobile robots. Both of these robots perform challenging tasks that can benefit from an easier operation interface.

The first paper I read, titled "Be the robot: Human embodiment in tele-operation driving tasks" discusses how researchers developed a new method for tele-operating mobile land-based robots. In many ways, robot controls have a lot in common with video games. The player of a video game player is able to control a character that is in a different world. Most of the time, the player sees the character on a map. The player is able to use controls to rotate their view, move or use their hands. For most people, this feels very unnatural. It also requires a great amount of hand-eye coordination, which makes playing challenging. These same principles are true for robot operation. However, the steaks are much higher when operating an expensive robot that has to perform a mission-critical task.

This paper references the movie *Avatar* in order to demonstrate the ideal way robots should be operated. In the movie, the characters move themselves, and their Avatar bodies move as they would. There is no thinking required, and no additional controls are needed to turn their heads or move their legs. This is known as physical embodiment. It is the goal for human-machine interfaces.

One of the methods used to accomplish the physical embodiment is the use of a head mount display (HMD). A HMD work in conjunction with a camera mounted on the robot that can pivot. Through the use of a HMD, the operator sees what the robot "sees". When the operator rotates their head, the camera on the robot rotates in the appropriate direction. This gives the user a natural feeling of control. In conjunction with the HMD, gesture-based control of the robot is used as well. Gesture-based control allows the user's body movements to control the movement of the robot, removing the need for joystick or keypad controls. In this study, the gesture-based controls were implemented using a Microsoft Kinect sensor. Through the use of the HMD and gesture-based controls, robot

operators reported increased precision and ease of use when utilizing the system to operate a demo robot [1].

The second paper, “A Natural Interface for Remote Operation of Underwater Robots”, is very similar to the first paper. Both papers discuss the improvement of robot human-machine interfaces. This paper focuses on the application of this technology to autonomous underwater vehicles (AUV). AUV’s operate in hazardous underwater conditions, so accurate performance by the operator is critical. Since these robots operate underwater an increased number of sensors must be used, which creates a more complex user interface.

There are many areas in which human error can negatively impact the operation of a robot. They include operators not understanding how to control the equipment, operators not issuing the correct command in time, and operators forgetting to issue a command. All these can be improved by implementing controls that are easier to use. This decreases the mental fatigue of the operator, allowing them to focus on the necessary tasks. Additionally, by adding a layer of abstraction to the robot controls the computer can interpret the action that the intended to give, even if that was not the command they actually gave. For example, if the robot is going too deep into the ocean, and the user gives the “move down” command, the computer and interpret that command as a mistake and ignore it [2].

After reading both papers, “A Natural Interface for Remote Operation of Underwater Robots” and “Be the robot: Human embodiment in tele-operation driving tasks”, it is clear that both were very similar in topic. They each evaluated methods that can be used to develop improved human-machine interfaces, most of which are the same. It is clear from

reading them that the paper published earlier was an important resource for the authors of the recent paper. The major difference between the two was the results of their studies of usability of the systems. The first paper reported that users equipped with a HMD VR device and gesture-based controls reported the highest ease of use and precision [1]. The second paper reported that users with a HMD and physical joystick controls reported them to be the easiest to use. It explicitly states that users found the gesture-based controls to be unnatural [2]. One possible explanation for this discrepancy is that the first paper evaluated land-based robots, and the second paper evaluated underwater robots.

References

[1] L. Almeida, B. Patrão, P. Menezes, and J. Dias. Be the robot: Human embodiment in tele-operation driving tasks. In *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, pages 477–482, Aug 2014.

[2] J. C. García, B. Patrão, L. Almeida, J. Pérez, P. Menezes, J. Dias, and P. J. Sanz. A natural interface for remote operation of underwater robots. *IEEE Computer Graphics and Applications*, 37(1):34–43, Jan 2017.