Teleoperation Robot as a Tool in Datacenters

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Abstract:

Robots are being applied to a broad range of human activities and will be ever more ubiquitous in the future. Example domains with at least some current deployment include datacenters, industry, education, hospitals, and urban search and rescue. While the ultimate goal of robotics is fully autonomous processing, much current work involves human tele-operation. This paper compares two different interface methods, set-and-leave using a touch screen versus on-off using a keyboard, both allowing an operator to control a humanoid robot with twenty-two degrees of freedom. Participants were tasked with controlling the robot using the given interface mechanism while simultaneously performing another task (a mathematical quiz) to examine the event of multi-tasking using the interface method. According to both performance results and a NASA-Task Load Index (NASA-TLX) assessment, set-and-leave was the most useful method.

Introduction:

Navigation is an essential element in all applications of mobile robotics [1-5]. While fully autonomous navigation and control is the ultimate goal of most robotics applications, to date much work still relies on control by humans either in a semi-autonomous or fully teleoperated mode. In teleoperation, a human stands in the place of the robot, receiving its perceptions and acting as if the operator were the robot [6]. The robot must provide inputs to the operator through devices (e.g. maps, video), and over the long term the operator must build a mental picture of the robot and the world around it. Approaches to providing input to the robot are also crucial - based on an estimation of the robot's current state, a human operator must conceptualize the operation desired (e.g. go left, go right) and then communicate that using some interface (e.g. speech, text, signal) and associated device. Using teleoperated robots in datacenters can be very beneficial. Real-time reporting, performance management, and monitoring for system failure are some of the current needs in any datacenters. All these needs can be satisfied with employing a semi or fully autonomous robots. To save costs, a human operator can handle many robots in different datacenters, using teleoperated robots.

It is challenging to teleoperate a robot over a long period of time. Humans fatigue quickly from integrating the inputs provided by the robot and maintaining models of the world around the robot, while at the same time doing the same information processing on the human's own environment. This problem of maintaining remote situational awareness is well known [6-10]. This is complicated further when a human is controlling more than one robot, dividing attention between them, since each robot's situation must be reconstructed individually with every context switch.

Related Work

Guo and Sharlin [10] suggested the use of a Tangible User Interface (TUI) for robot control. They used an AIBO robot dog for their experiment and controlled the robot using two Nintendo Wii game controllers and a keyboard. Sakamoto et al. [13] proposed an interface that uses a touchscreen device to control a Roomba vacuum cleaner. The robot was controlled by drawing sketches on the touchscreen and having the robot move by following the sketched path. Our two interface methods are based on these approaches, but with some differences. For example, in our scenario there is no specified start and finish point for the sketch. In Fig. 1., a human operator is controlling our robot from the laptop screen (no direct look was allowed) and should avoid the obstacles (boxes, chairs).

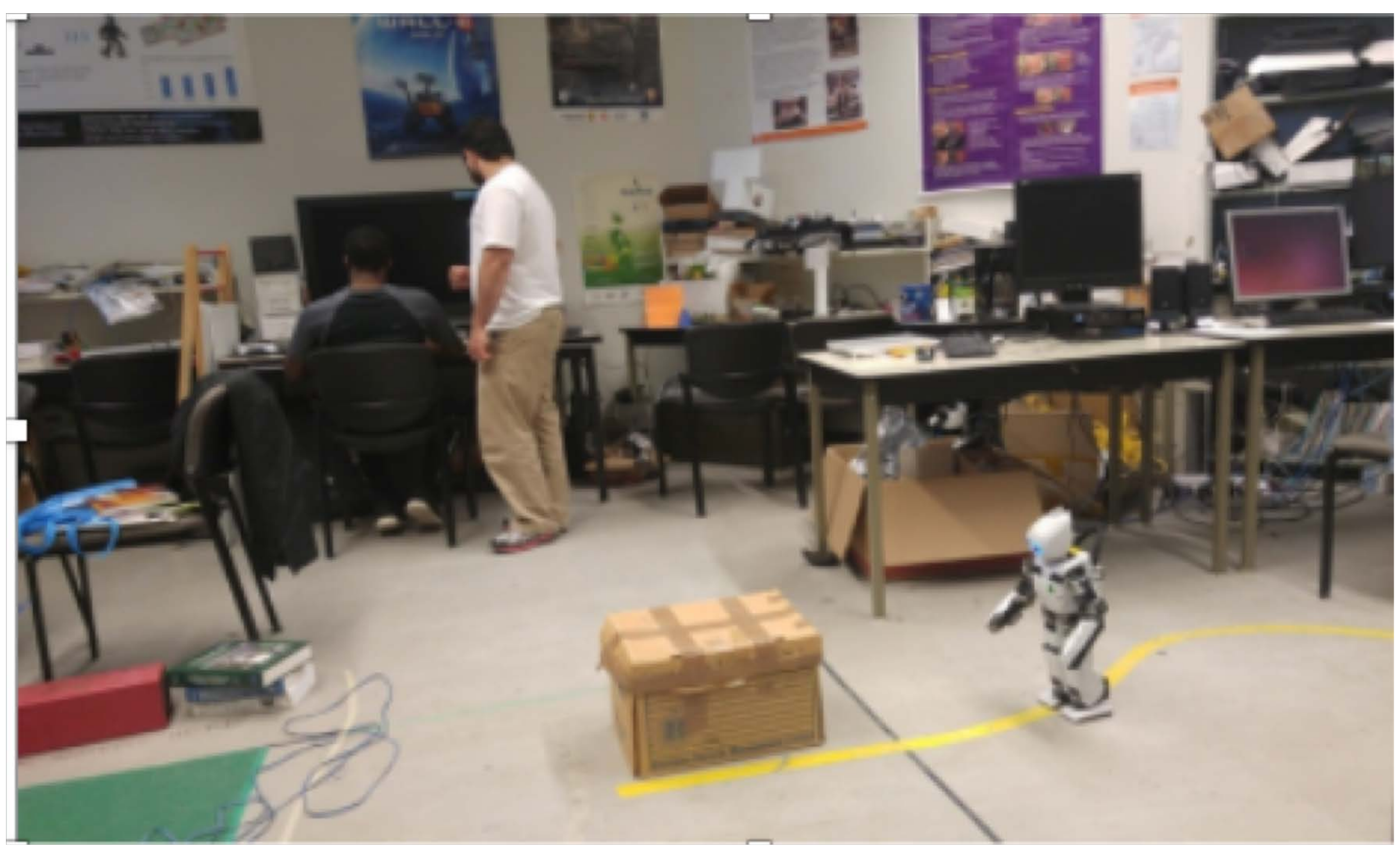

Fig. 1. Teleoperating the robot and avoiding obstacles

Interfaces

Two different interfaces were implemented and tested for this work.

On-off control method: The walking speed in this method is set to the maximum, and the operator does not have the opportunity to adjust this speed. The robot stops walking when no commands are received, hence the control is on-off and it is not possible for the operator to leave the keyboard and have the robot continue its motions. This situation is synchronous, and an operator must send continuous orders to the robot. For this method, eight keys (Fig. 2) are allocated on the keyboard to control the robot. Pressing W moves the robot forward, A and D are used for left and right turns respectively, and S is used to go backward. We also use the four arrow (direction) keys to give the controller the ability to tilt (move up and down) and pan (move left and right) the robots head, allowing a change in the environment view shown on the operator's screen, since the camera is attached to the head.

Fig. 2. Teleoperating the robot and avoiding obstacles

Set-and-Leave control method: The second (touchscreen) interface provides the ability to set a number of steps for the robot to take as well as the four main directions (front, back, right and left). Here the robot continues to take the specified number of steps unless the control is changed (hence Set-and-Leave) and the human operator is not required to continually provide input. The potential downside to this is the larger number of steps entered (the more complicated the plan) the more likely something may go wrong during this, compared to entering steps individually and monitoring each (i.e. having the operator act in a similar way to the on-off method). It is hoped that operators can balance looking ahead a given number of robot steps while allowing themselves an opportunity to multi-task. Humans must still think in terms of the number of robot steps when entering commands, i.e. if it is desired to move the robot ahead 2m, this must be estimated as 20 10cm steps. This interface uses eight touchscreen buttons to send commands to the robot to move in the four main directions (forward, backward, left and right) and to pan and tilt the head (up, down, left and right). The design of the buttons is the same as Fig. 2. A slider indicates the number of steps (Fig. 3). Multiple step commands can also be queued. For example, the operator can use a sequence of the above operations to tell the robot to go 10 steps forward and after that turn right 90 degrees. Such commands are simply entered in sequence and commands are followed one after the other

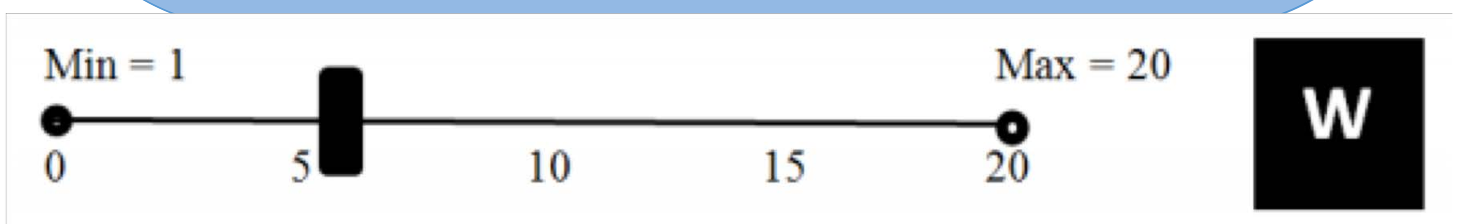

Fig. 3. The slide bar is pointing at number 6 which means the robot has to go 6 steps that is equal to 6*10 = 60 cm. and after this by pressing the W button on the touchscreen device it starts moving forward for 6 steps.

Results and Finding

In all cases with both interface mechanisms, all participants were able to move the robot as required within the 10 minute time interval. Overall results and finding are based on the NASA-TLX and the results from the mathematic quiz and accomplishment of the given task in the 10-minute time frame. In overall the set and leave control had a better results . Figure 5 demonstrates and compare the mathematic quiz results for both of the control methods.

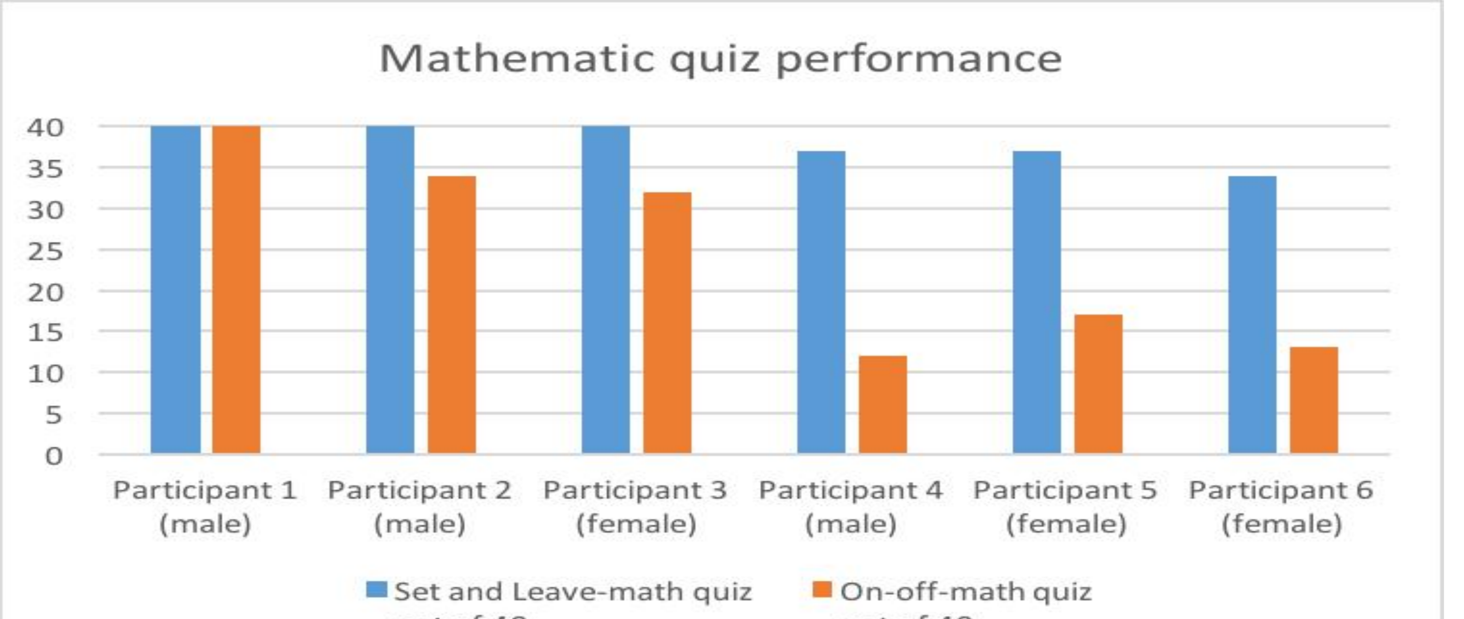

Fig. 4. Mathematic quiz comparing set and leave control and on-off control

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