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Performance Evaluation of a Blended Shared Control Method in Human-Robot Teams

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Introduction

One of the main problems that control theory attempts to solve is the optimization of a system input to result in a desired output. Control theory seeks to improve stability, controllability, and observability of a given system. In order to address this, various control frameworks have been designed by researchers to enhance the performance of control systems and ensure that an optimal goal, or output, is realized. Here, we provide a solution to optimizing the interaction between a human and autonomous (robot) operator by introducing the blended shared control scheme; a control framework that blends human and electronic agent inputs.

Abstract

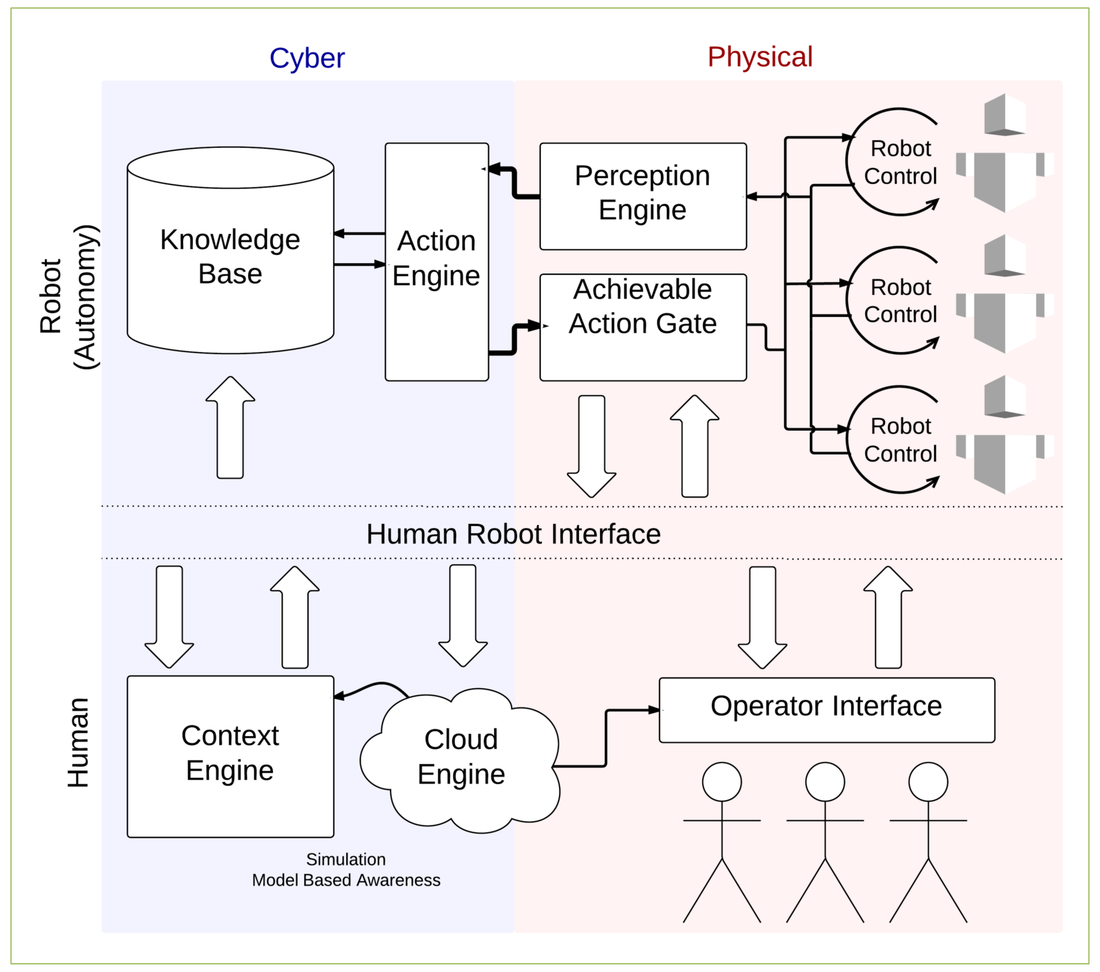
In this project, we investigate the implementation of a blended shared control (BSC) scheme for a mobile robot. We test the reliability and applicability of this approach by introducing environmental stimuli that inhibit the operator's ability to control the robot properly. We performed experiments with 12 human operators and it was concluded that BSC improved the operator's control in the presence of velocity drift. However, no increase in performance was determined with communication delay.

Impact

BSC ensures that:

1. There is a human in the control loop while the robot optimizes the human's trajectory commands.
2. The optimal path is followed by both operator and robot.
3. There is no binary switch between user or robot control.

Approach



Shared Control Equations

$$\dot{p}_p = \alpha \dot{p}_u + (1-\alpha)\dot{p}_a$$
$$= \begin{bmatrix} \alpha \dot{x}_u + (1-\alpha)\dot{x}_a \\ \alpha \dot{y}_u + (1-\alpha)\dot{y}_a \\ \alpha \dot{\theta}_{v,u} + (1-\alpha)\dot{\theta}_{v,a} \end{bmatrix}$$

α: Shared Control Parameter

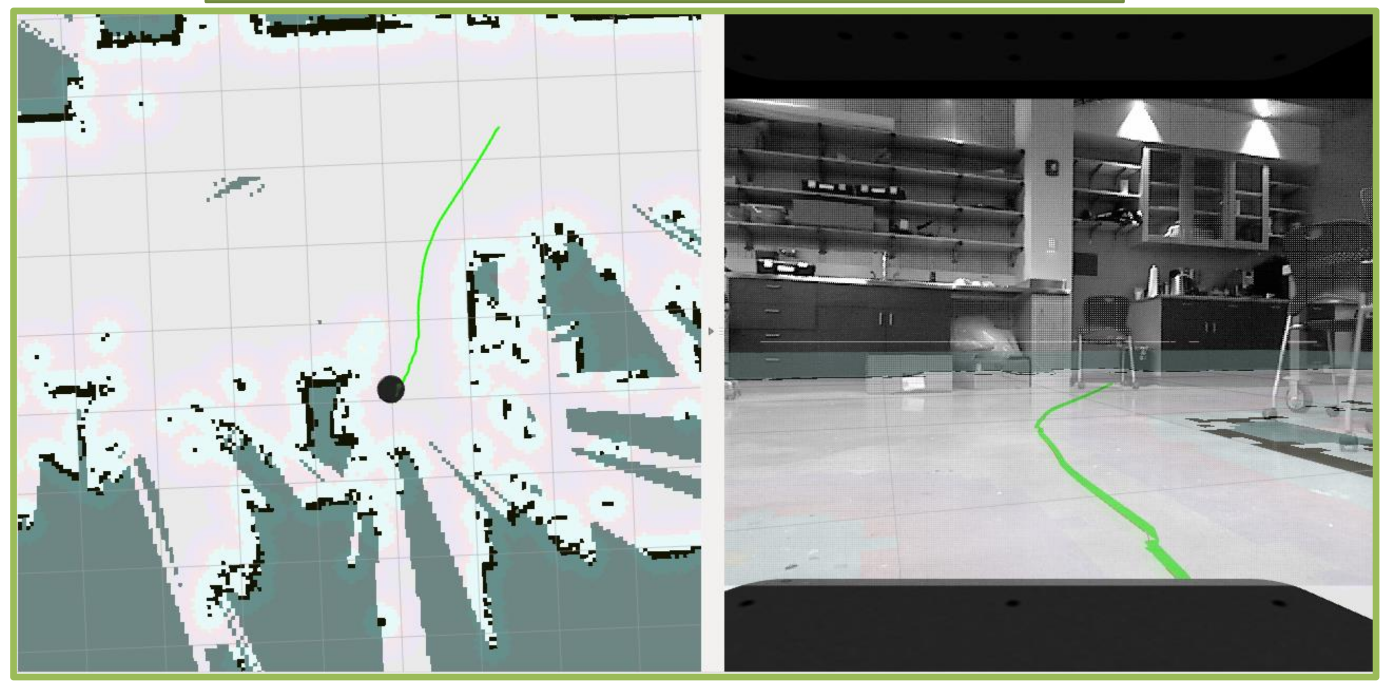
$\dot{x}, \dot{y}, \dot{\theta}$: Task Space Coordinates

$\dot{p}$: Primary tasks (user & agent input)

Experiment

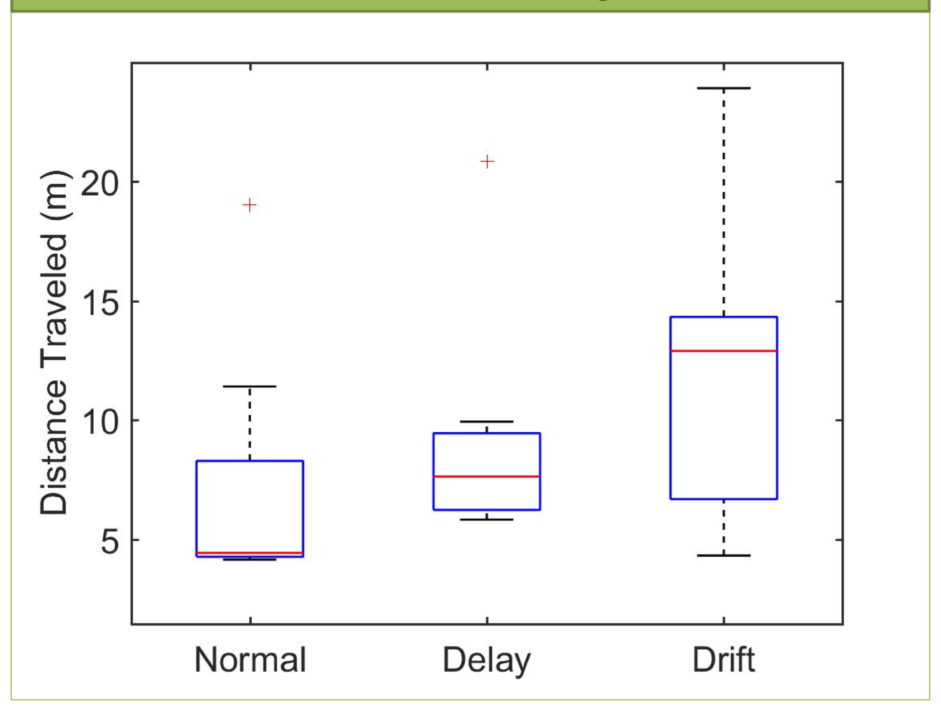
- 12 human operators were used to test BSC on a Turtlebot.
- Each user was drove the Turtlebot to a predetermined goal.
- 3 trials were conduced with different environmental stimuli: Base trial, input delay, & drift.

Experimental Setup

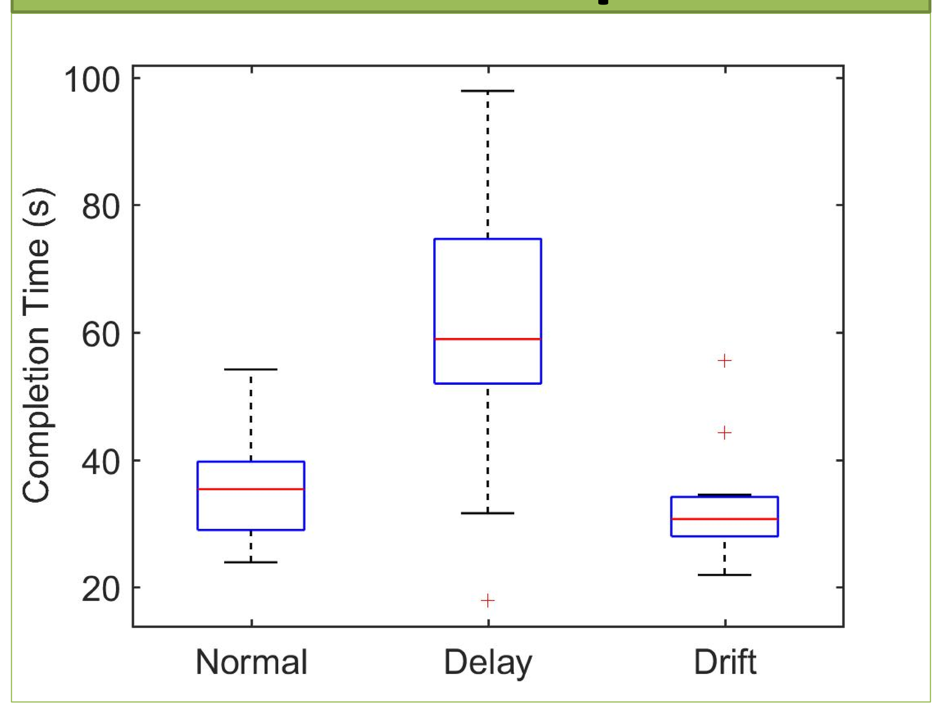


Results

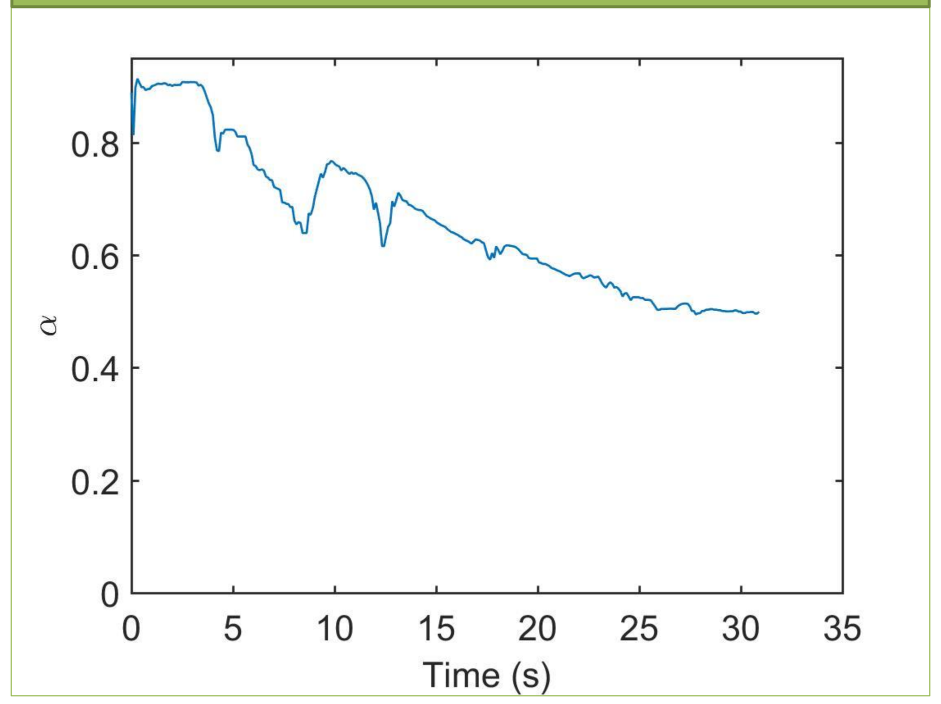
Dist. To Complete



Time to complete



Change in Control Parameter



Results & Conclusion

- BSC improves operator control in the presence of velocity drift.
- No increase in performance occurs with communication delay.
- **BSC can be an effective control scheme for human-robot teams, when a robot operates in a known environment.**