Modeling Humans in the Teleoperated Robot System Loop

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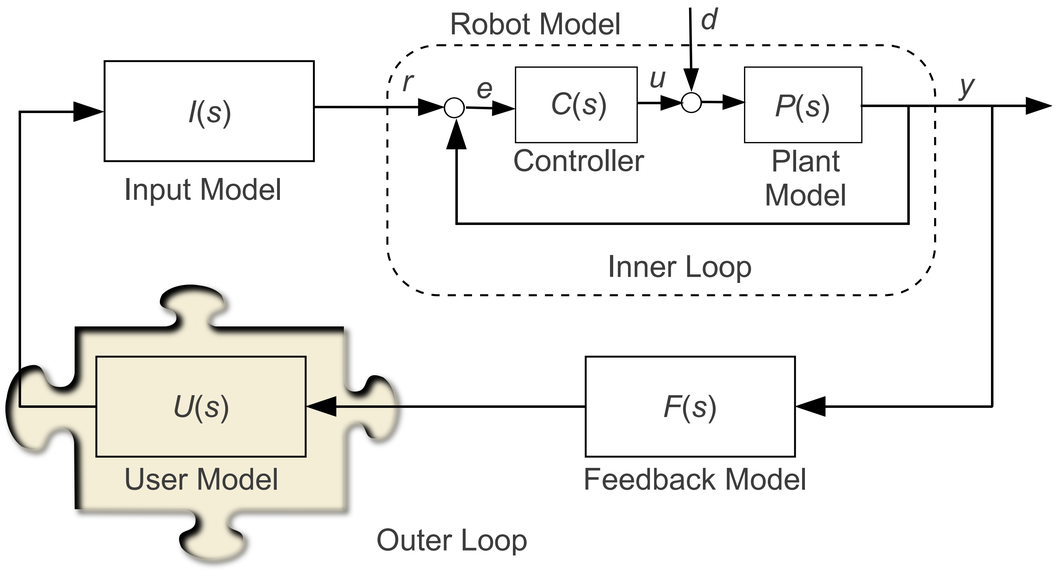
Text

Introduction

Despite advances in autonomous robotics, there are still many situations in which teleoperation is required or preferred.

- **Teleoperation remains a slow and difficult task for remote operators**, even when time is of the essence.
- **System models can be used to more efficiently design teleoperated robots**, reducing some of the time and cost of prototyping and physical testing.
- **Teleoperation can be modeled as an inner loop/outer loop feedback system**, with the human in the slower outer loop.
- While a model of the robot can be derived from physical laws and algorithmic rules, **it is difficult to reliably emulate the behavior of a human operator**.

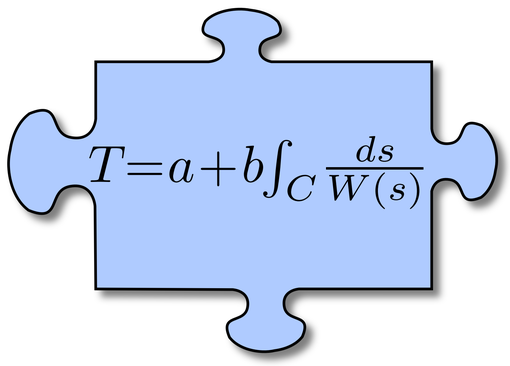


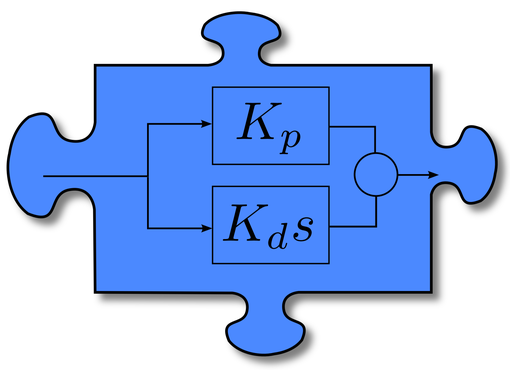
Proposed Research

- **Modeling human users has a rich history** in the automotive and human-computer interaction (HCI) domains.
- While we can draw inspiration from **previous studies in other domains**, the resulting models have been developed for tasks dissimilar enough from teleoperation that they **cannot be used directly**.
- It is therefore desirable to **develop a set of models describing how humans interact with robots** in the context of teleoperation.
- **Models will take multiple forms**, depending on the task and modeling objectives, including:

Mathematical Relations

can be used as predictive models of human performance in teleoperation tasks. Similar work has been done in the HCI community with Fitts' Pointing Law and its derivatives, including the Steering Law [1]. Such relations for teleoperation could be used to objectively evaluate different types of user interfaces.



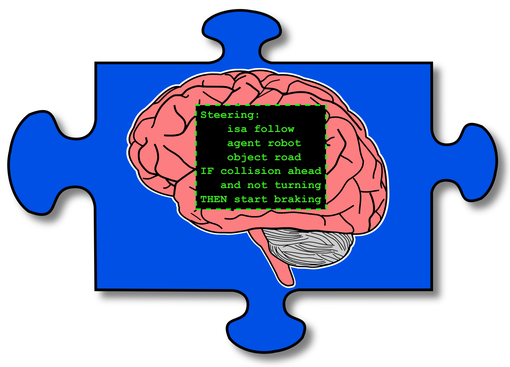


Systems Theory Models

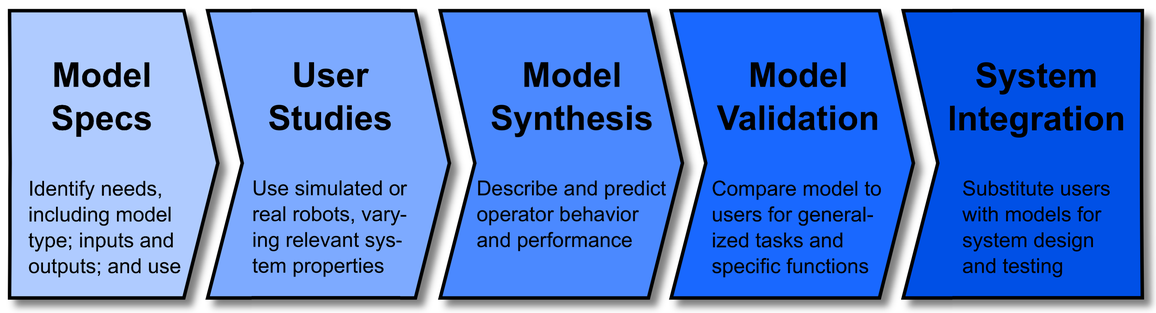
such as transfer functions, nonlinear controllers, and fuzzy logic are often used in the automotive domain to model human drivers for use in simulation [2]. My previous research [3] showed that a human teleoperator's steering behavior for a simulated robot under different types of latency could be modeled as a PD controller based on a projected lateral displacement signal.

Cognitive Models

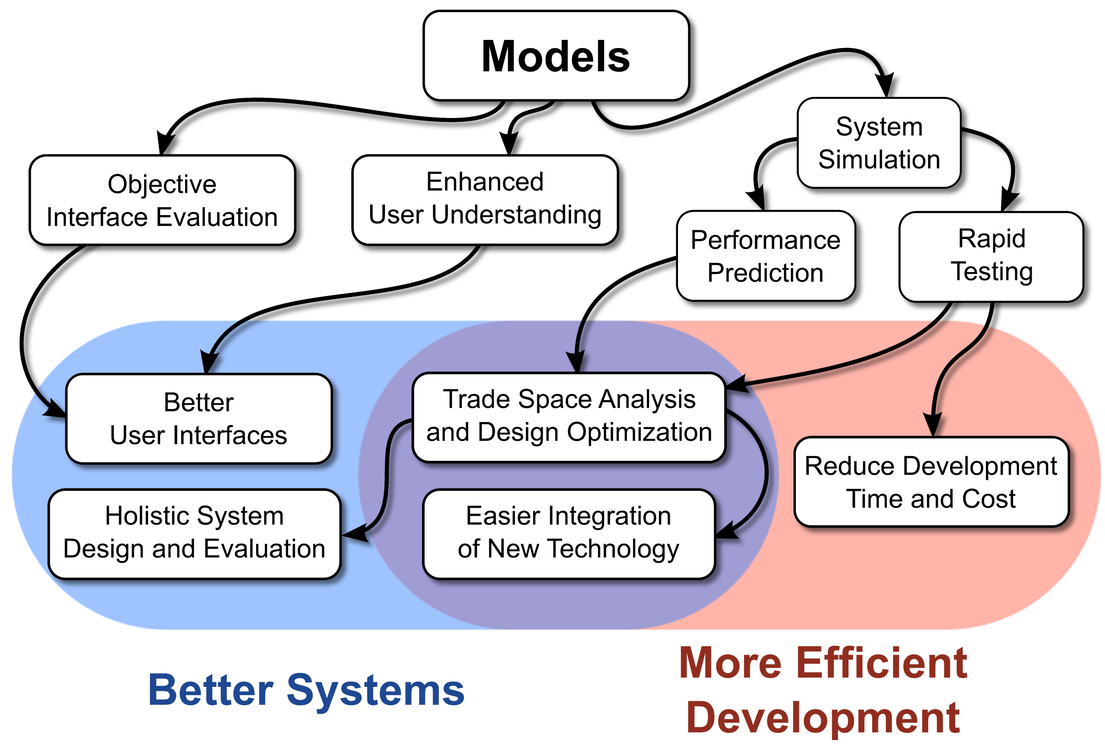
of human operators can be developed with the help of cognitive architectures such as ACT-R [4] and can be used to simulate the mental processes of a human operator to predict and/or simulate such complex behavior in the teleoperation loop.



Model Development



Projected Impact



References

[1] J. Accot and S. Zhai, "Beyond Fitts' law: models for trajectory-based HCI tasks," in *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*. ACM, 1997, pp. 295–302.

[2] C. C. MacAdam, "Understanding and modeling the human driver," *Vehicle System Dynamics*, vol. 40, no. 1-3, pp. 101–134, 2003.

[3] S. Vozar, "A framework for improving the speed and performance of teleoperated mobile manipulators," PhD, University of Michigan, Ann Arbor, Aug. 2013.

[4] Carnegie Mellon University, "ACT-R." [Online]. Available: http://act-r.psy.cmu.edu/