THE SMART CAR PROJECT: DEVELOPMENT AND IMPLEMENTATION OF A MODULAR SCALED TEST-BED

Seung kook Jun               Venkat N. Krovi
Mechanical and Aerospace Engineering
University at Buffalo (SUNY)
Buffalo, NY 14260
Presentation Overview

• Goal
• Background
• System Overview
• Case-Studies
• Discussion
Goal

Development and implementation of an inexpensive test-bed equipped with a real-time mediated control system for studying:

1. Mediation of human user control of complex robot systems.


3. Robustness of the control in the presence of varying grades of communication.
“Smart Cars” are a central feature of the proposed Intelligent Vehicle Highway Systems (IVHS) of the future.

A “Smart Car” is a semi-autonomous intelligent automobile with computer-enhancement/computer-assist to facilitate “augmented driving”.

Key Capabilities

1. Extracting information from the users (drivers/passengers) and the surroundings (vehicles/highways) via sensors
2. Exchanging information with central servers and nearby vehicles via the internet
Augmentation

Information Assist
Night Vision & GPS

Courtesy www.gm.com

Driving Assist
Adaptive Steering System & Adaptive braking System

Courtesy, www.italiaspeed.com
Challenges
Requires considerable testing

Simulation-based

Physical Testing

Courtesy www.experts.renault.com

Courtesy www.asee.org
Our Solution

Create a scaled testbed using COTS Hardware and Software and study:

1. mediation of human user control
2. Multi-user shared teleoperation
3. varying grades of communication

Also examine

1. Hardware-in-the-Loop Testing
2. Rapid Control Prototyping
Hierarchical Implementation

Mediated Teleoperation

1. A supervisory human-in-the-loop control layer, operating at a low control bandwidth.

2. An underlying real-time control layer with high control bandwidth permits the overall system to respond to these inputs while compensating for external disturbances and ensuring system stability.

References

Hardware Overview

1. **Subsystem-based decomposition** to reduce main processor burden

2. Independent subsystems **share data and synchronize** via latched digital I/O.
1. **Tamiya TXT-1** controlled by a six channel Futaba Skyport 6 dual-joystick handheld controller.

2. The TXT-1 is **rugged enough** for use outdoors.

3. Adequate reserve drive power and chassis space **to carry a significant payload** (the PC/104 system, embedded subsystems, sensors, actuators etc.).
1. **PC/104** form-factor

2. **x86 architecture processor** using PC-based accessories and software.

3. **Communication** channels include: latched digital I/O, a radio frequency (RF) based serial-modems and a wireless internet (802.11b).
The sensing and control load on the main processor is distributed onto intelligent embedded subsystems.

(i) An obstacle ranging subsystem;

(ii) A motor-control subsystem

(iii) A receiver subsystem,
Rapid Control Prototyping

Simulink blocks with virtual joystick

Simulink blocks with USB joystick

Our approach emphasizes:

1. Development of the models and algorithms in a **graphical, high-level block diagrammatic language**

2. Rapid conversion of the refined algorithms into a real-time executable (using **xPC Target**) for deployment on the PC/104 type embedded computer.
Case Studies

Development and implementation of an inexpensive test-bed equipped with a real-time mediated control system for studying:

1. **Mediation of human** user control of complex robot systems.

2. **Multi-user shared** teleoperation.

3. Robustness of the control in the presence of **varying grades of communication**.
Mediation of Human Control

Standard configuration

Transmitter

Receiver

Platform

- Wireless Communication
- Analog Signal

Goal     Background     System Overview     Case-Studies Discussion
A wide variety of linear/nonlinear, continuous/discrete transformations can also be applied on the input data, thereby creating a wide variety of functional input/output relationships.
**Variant 1:**

Mediation of user-inputs based on distance from the obstacle.

**Variant 2:**

Speed-sensitive user-input/motor output scaling.
Case Study 2: Multi-user Mediated Operation

Operator 1
Using the handheld remote-control unit (with the inclusion of mediation).

Operator 2
Using virtual and USB joystick at console of a remote-host computer.
1. A dedicated but relatively low-bandwidth serial communication (56 Kbps) using RF modems.

2. The relatively high bandwidth but non-dedicated TCPIP communication (up to 11Mbps) using 802.11b wireless ethernet.
The open-loop controller is unable to recover from the disturbance while the **closed loop controller** is successfully able to compensate for the disturbances and attain the desired wheel velocity.
Preliminary Result 2

System response is governed primarily by the PID speed controller when the obstacle is far away.

Response of the system is governed primarily by the obstacle avoidance controller as the obstacle approaches the vehicle.

Quantitative study of interaction is now possible.
1. **Quantitatively and experimentally validate the performance** of many aspects of intelligent vehicle control systems on the scaled experimental test-bed.

2. Our framework and test-bed can be easily leveraged to deploy and validate such **distributed command and control architectures**

3. **The hardware modularity and encapsulation** promoted by the subsystem approach coupled with the ease of development of hardware-in-the-loop simulations played a significant role in speeding up the process of development and testing.
Future Work

1. Development of rough terrain vehicle

2. Embedding high performance sensors
   – GPS, Vision
Thank You
Appendix
Appendix
Appendix

Encoder, optical 200 Resolution W index