Proposed Project Topic

Error Detection and Autonomous Intervention in the Teleoperation of Physical Systems - *Partie Deux*

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Introduction

In many applications, mechanical systems are often teleoperated by a human user in order to efficiently complete a complex task. Examples include machinery in factories as well as unmanned aerial vehicles. Even if a human user is highly trained and experienced in the teleoperation procedure, errors cannot always be avoided, either due to problems in interpreting the sensory feedback or due to human mistakes. Such errors can endanger the mechanical unit itself, the success of a critical mission or they can even put human lives in danger.

On one hand, fully automating such procedures could provide a solution but is not always a valid option. This can be either because we have not reached the level of algorithmic and technological sophistication required for the problem or due to the characteristics of specific applications that require teleoperation. On the other hand, incorporating a certain level of machine intelligence and autonomous operation in the teleoperation procedure has the potential of addressing the issue while still allowing a human user to control the system.

This integration can be in the form of a procedure that detects human commands that might lead the system to dangerous situations, such as a collision with obstacles. Then the system can inform the human operator about this possibility. An alternative is for the system to intervene and temporarily override the human command. In this case, the system must end up in a safe state and return the command to the human user as soon as possible. The intervention motion must contradict the motion specified by the human operator as little as possible.

Roadmap for Implementation

This proposal invites you to design and build a wireless teleoperation system for a Segway Robotic Mobility Platform 200 (RMP), install a camera unit on the platform, improve upon and potentially implement new alternatives for an error detection and autonomous intervention procedure using the sensing input and motion planning algorithms.

The students implementing this project will have direct access to a Segway RMP unit, a laser sensor for computing distances to obstacles, a secondary battery unit, a joystick, a new portable computer, a communication board for wireless operation and wireless nodes that can be used to establish a wireless mesh network. Additional equipment that can be purchased includes a camera, as well as a GPS device. Depending on the specific objectives of the project, additional equipment may be purchased. The students will also be provided access to a room in the underground floor of the Jones Visitor Center where they will be able to contact their experiments. The RMP unit provides a CAN bus or USB interface so as to receive commands and transmit RMP sensor data. It also utilizes dynamic stabilization to balance and overcome obstacles while being able to carry heavy loads. Due to the self-balancing, however, the teleoperation of the unit is not straightforward and a human operator often leads the systems to collisions with obstacles.

The following sequence of steps are proposed for completing the overall project:

1. The team should familiarize itself with the platform, as well as with the software, interface and equipment produced by the team that worked on the Segway robot last year. This step includes mounting the laser sensor permanently on the robot. It should be possible pretty quickly to repeat the results that the team from last year achieved (i.e., wired and wireless control of the platform, with and without the autonomous obstacle avoidance).

2. Install the wireless nodes in the south part of the UNR campus and setup a wireless mesh network. This will allow larger-scale, outdoor experiments with wireless control. The students should be able to remotely control the platform by communicating through the wireless network.

3. Mount a camera on the unit and connect it to the battery and the communication board. It should be possible after the completion of this step to control the Segway through visual feedback and without direct line of sight between the operator and the robot. The existing interface should be augmented so as to support the incoming images from the camera. [Note: In every experiment that the operator does not have a direct line of sight with the robot, an additional member of the team should be in close proximity to the robot, ready to remove the safety cable whenever necessary.]

4. Experiment with the existing solution for error detection and autonomous intervention. Identify the situations where the current system fails and the reasons why. In coordination with the adviser investigate alternative solutions that will improve robustness.

5. The team is also free to pursue specific objectives that are more interesting to its members. For example:

    - Complete autonomous control of the platform. This will require building or providing to the robot a map of the environment and using path planning techniques to guide it to its destination. An integration with the obstacle avoidance algorithm will also be useful.
    - Person following algorithms. Using the input from the camera, design an algorithm that will follow a human that precedes the platform through color tracking.
    - Control the operation of the robot through the sensor network. Provide a high-level map of the campus to the sensor network and localize the unit as it moves. The wireless nodes are responsible in this scenario to provide the appropriate directions to the robot's destination while the robot itself only employs the obstacle avoidance technique.
    - Exploration algorithms. Control the robot so as to build an accurate map of the environment as soon as possible.