EN.530.420 Robotic Sensors and Actuators

Design Project:
Remote-Controlled and Simple Autonomous Car

For our design project, I would like you to utilize our knowledge of sensors, actuators, and microcontrollers to adapt a toy remote-controlled car to be autonomous in a simple way.

I would like us to create a remote-controlled toy car that could be used for two purposes:

- driving by remote control, and
- patrolling an area, autonomously, kind of like a Roomba robotic vacuum cleaner.

For our design project, I will supply the robot car chassis, with an Arduino, two encoder servomotors for the drive wheels, a hobby servo for steering, an RF transceiver, and a GPS receiver. I will also supply a controller Arduino with an RF transceiver, a joystick for control, and a button to change modes. I would like you to utilize our knowledge of sensors, actuators, and microcontrollers to create an Arduino program (or programs) to accomplish those tasks.

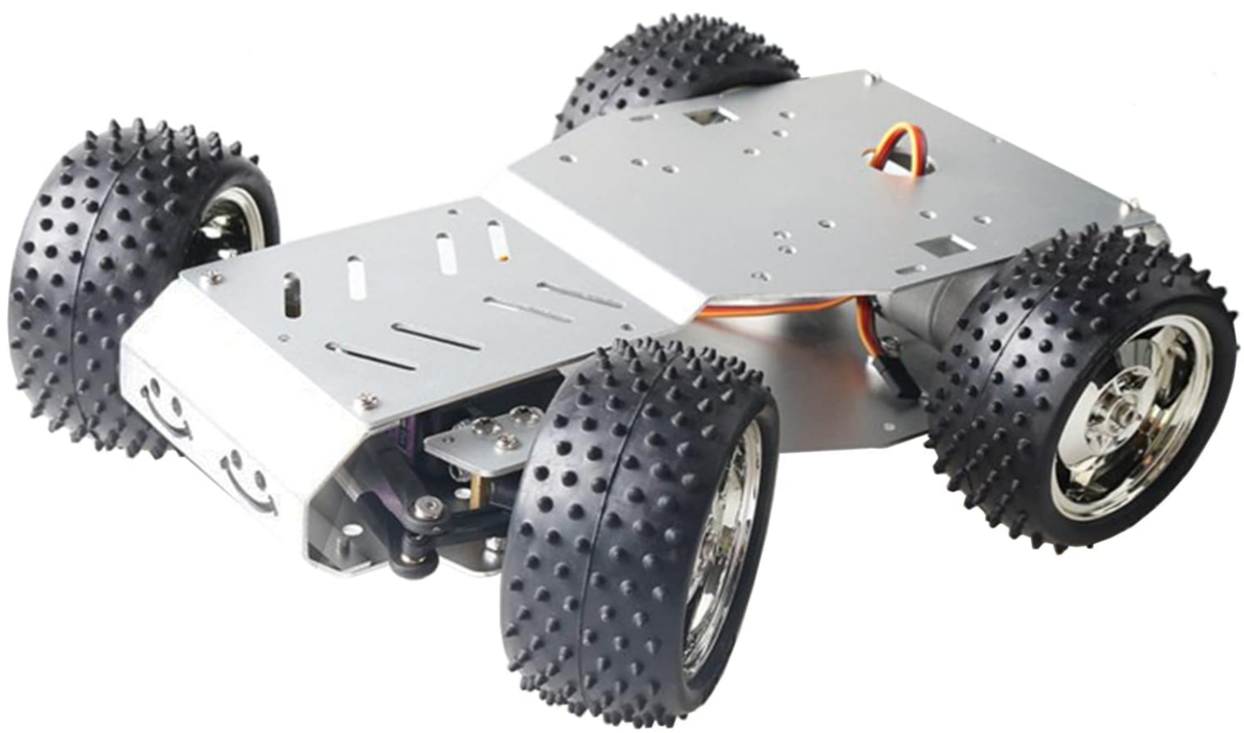

Figure 1. Remote-controlled toy car.

Suggestions:

If you choose to tackle **the car problem**, here are some suggestions:

- I will provide the car, with two drive servomotors and hobby servomotor for steering.
- The car will have an Arduino with an RF transceiver;
- There will be an Arduino to be used as the remote control with one joystick (two potentiometers, for x- and y-axes, connected to a spring-loaded joystick) as well as a momentary switch (button) that can be monitored, and an RF transceiver to send information to the car;
- Your solution should consist of two Arduino programs (or an Arduino program with two modes) to handle the remote-controlled mode and the autonomous patrol mode.
- Sensors on the car: GPS receiver, IMU (accelerometer/gyroscope/magnetometer)
- Actuators: hobby servomotor for steering and two drive servomotors
- Implement manual remote control
- Automate the car to patrol an area, Roomba-style, in its simple autonomous mode

Feel free to use your own ideas!

Requirements

Your device should:

- Use a microcontroller to coordinate the process;
- Include ***at least*** one sensor and one actuator;
- Solar power and rechargeable batteries are desirable, and should be addressed *in the report (but not necessarily in hardware)*.

Alternate Project

If you like, you are welcome to come up with your own project idea.

Your device should:

1. Use at least two sensors. A pushbutton switch is not considered a sensor under this requirement.
2. Use at least one actuator of any type.
3. Use the Arduino or similar programmable controller device; your program must use variables and conditionals (e.g. if-then).
4. Have some form of human input from the human operator/user.
5. Have some form of quantitative display to the human operator/user.

These requirements are a bit flexible; don't add things that don't make sense just to satisfy those requirements. Exceptions to the above five requirements will be granted if justified sufficiently in the proposal. The project must be presented in a proposal (see below) and approved by the instructor. The students must make the case that the project is significant, feasible, finite, and challenging.

Teams

This project will be completed in teams of 2 to 4 members from any section of the course.

Larger teams will be considered on a case-by-case basis, but the team must first justify the larger team based on the scope of the proposed project.

At the end of the semester, all students will be required to submit a brief **peer evaluation** of their team members' quality and quantity of effort.

Apparatus

If you choose to build a device in hardware:

You are welcome to borrow parts from lab, of course; please ask permission.

Each team should plan for a maximum budget of $75, including the cost of all borrowed equipment (including the Arduino).

The instructor will procure for you equipment up to a limit of $25 per team. Parts must be ordered through the instructor; reimbursements for student purchases are not allowed. Substitutions of functionally equivalent equipment will be made at the instructor's discretion. Please allow *at least* one week for the ordering and shipping process. If you would like me to purchase items for you, send me a request for a purchase via email. Include a brief description, quantity, price, supplier, and a link to the item. Please try to find the best price. Please be aware of shipping times. Amazon, Digikey, and McMaster-Carr are preferred vendors; if you find it elsewhere cheaper, please send a link to the part on one of those three, in addition to your cheaper source.

Teams are allowed to use equipment beyond the $75 budget. However, a specific plan for how the device could be made within the $75 must be included in the final report.

Here is a list of *some* of the other sensors and actuators that I have on hand in the lab:

absolute encoders
relative encoders
smaller, geared stepper motors (slower, but much finer steps and higher torque)
H-Bridge circuits
9V battery adapters for powering Arduino boards
5V voltage regulators
breadboard Arduino shields
hobby servomotors
RGB LEDs
finger pulse sensor
low-power LASER diodes
reed switches
mercury switches
shock sensors
photoresistors
accelerometer/magnetometers
SONAR sensors
Infrared transmitters and receivers
humidity sensors
IR line-tracking sensors
IR obstacle sensors
passive IR sensors ("occupancy sensors")
temperature sensors
piezoelectric buzzer speakers
small magnetic-coil-driver speakers
microphone sensors
relays
AC power relays
joystick potentiometers
Wii nunchuk controllers
solenoids

Preliminary Design Proposal

Submit a brief less-than-one-page design proposal.

- Briefly, what you plan to do;
- What sensors and actuators are needed, with a quick sketch if helpful;
- What type of user interaction is planned for the system;
- Due ***Tue 5 November*** by midnight; submit by Canvas, one per team.

Final Demonstration

Demonstrate your project with the instructor by appointment the week of Mon 2 Dec to Fri 6 Dec, or schedule another time (later is OK) for a demonstration with the instructor.

For teams who choose the car control project, the final demonstration will involve uploading software to my car and controller to be tested.

Final Design Report

Submit a final report, one per group. No specific format is required, however, the report should cover:

- An introduction briefly describing what your device does and how it does it;
- Descriptions of any sensors and actuators used in the project;
- Circuit diagrams, as appropriate;
- Photographs of the apparatus, as appropriate;
- Commented Arduino programs, as appropriate;
- The description and diagrams should be sufficient for a competent engineer to duplicate your work;
- The **target audience for your report is a competent engineer**— do not assume that the reader is in (or teaches) this course;
- A budget, outlining the inventory and cost of all parts used in your final prototype; **items that were borrowed** from the lab (e.g. an Arduino, a LCD display) **should be included in the budget**;
- A detailed plan for how the device could be made within the $75 budget, if the final cost exceeded $75;
- Your report should briefly address any modifications that you would propose for a production version of the device.

Due ***Mon 16 December*** by 5 pm (hopefully this report will be turned in long before this date!); submit **via Canvas**.

Note: Again, you are not restricted to the R/C car project. If you would like to focus your project on a different application of sensors and actuators, please feel free. Propose your project, define the scope, and show that it will be a challenging demonstration of robotic sensors and actuators.

Rubric:

Unacceptable	Needs Improvement	Meets Expectations	Exceeds Expectations
Report Writing Quality: 20%			
Hard to read; grammar and spelling mistakes threaten the credibility of the content.	Poorly organized. Noticeable grammar or spelling mistakes.	Well organized. Writing is clear.	Like poetry, but technical. Brings tears to nerds' eyes.
Circuit Diagram: 10%			
No diagram, or a circuit photo instead of a diagram.	Circuit diagram is not clear.	Clear circuit diagram.	Like modern art, but technical. Brings tears to nerds' eyes.
Project Analysis & Documentation: 40%			
No significant explanation of hardware and/or software.	Incomplete explanation.	Hardware and/or software documented, including calculations or simulations if appropriate.	Hardware and/or software innovations are documented.
Report Completeness: 10%			
Impossible to duplicate your work based on information in the report.	Incomplete information to duplicate your work.	A competent engineer could duplicate your work using this report.	Report gives insights into project troubleshooting and further development.
Quality of Execution of Prototype and/or Software: 10%			
Prototype and/or Software is non-functional.	Prototype and/or Software works intermittently, or only when held together with duct tape and/or chewing gum.	Prototype and/or Software is functional, if not production-ready.	Prototype and/or Software is ready for real-world use

If you define your own project, up to 10% bonus points for taking on a project that goes beyond expectations.

Peer Evaluation

At the end of the semester, you will evaluate the performance of each group member.