Human Interface Device for Mobile Robot Navigation

Project Proposal

Brian Walsh and David Buckles

Advisor: Dr. Malinowski
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PROJECT SUMMARY

The overall purpose for integrating features onto the Pioneer 3D-X chassis is to create an agent that can operate in a combat environment autonomously or be controlled by the user in real time while mapping the environment and relaying sensor information in an easily comprehensible visual format. This project seeks to use ultrasonic and infrared sensors to gather information about the mobile agent's environment. This data can be used directly by the robot in autonomous mode or relayed visually to the user via an LCD eyepiece. In manual override mode the robot is controlled using a sensor glove that detects hand motion and recognizes gestures.

GOALS

The goals for this project entail:

- Mapping the robot's current environment in 3D, in real time, and utilizing OpenGL to display the data on an LCD eyepiece to provide visual feedback
- Provide user override of the automated navigation systems via a glove with sensors and software with feature recognition
- Implement infrared sensors
- Implement a sensor (possibly ultrasonic) to detect ceiling height
- Implement a grasping device controllable by the sensing glove
- Provide means for entering data (goal position) into the navigation system
- Integrate existing IR sensors into the mapping portion of existing navigation program
- If time permits, attach a 2 degree of freedom robotic arm to the grasping device, also controllable via sensor glove with feature recognition
- If time permits, add force-feedback functionality to the glove that is used to provide feedback from the grasping mechanism or in manual override mode for obstacle avoidance.

SUBSYSTEMS

The first subsystem is the robotic glove. The sensors mounted on the glove will provide pitch, yaw, and rotational feedback, as well as finger position and tracking for overall hand movement. The force feedback sensors would be located on each of the fingers.

The second subsystem is the microcontroller for the operator. The microcontroller will obtain data from the sensors located on the glove and transmit them to the laptop, as well as controlling the force-feedback sensors used with the grasping mechanism.

The third subsystem is the laptop, which will display the openGL map on a user eyepiece and communicate with another laptop.

The forth subsystem is another laptop, which will interpret sensor data from the robot, provide the algorithms used in autonomous mode, and map the data from the environment from the sensors.

The Pioneer robot subsystem shall gather data about its surroundings using ultrasonic and infrared sensors and transmit this data to the computer, as well as receive commands from the computer for either navigational mode.

There are two additional microcontroller subsystems that are attached to the robot. The first microcontroller will take data from the ceiling sonar sensor and the infrared sensors, and transmit them to the robot. The second will be used to control the grasping device.

Figure 1.0 illustrates the overall functional system block diagram.

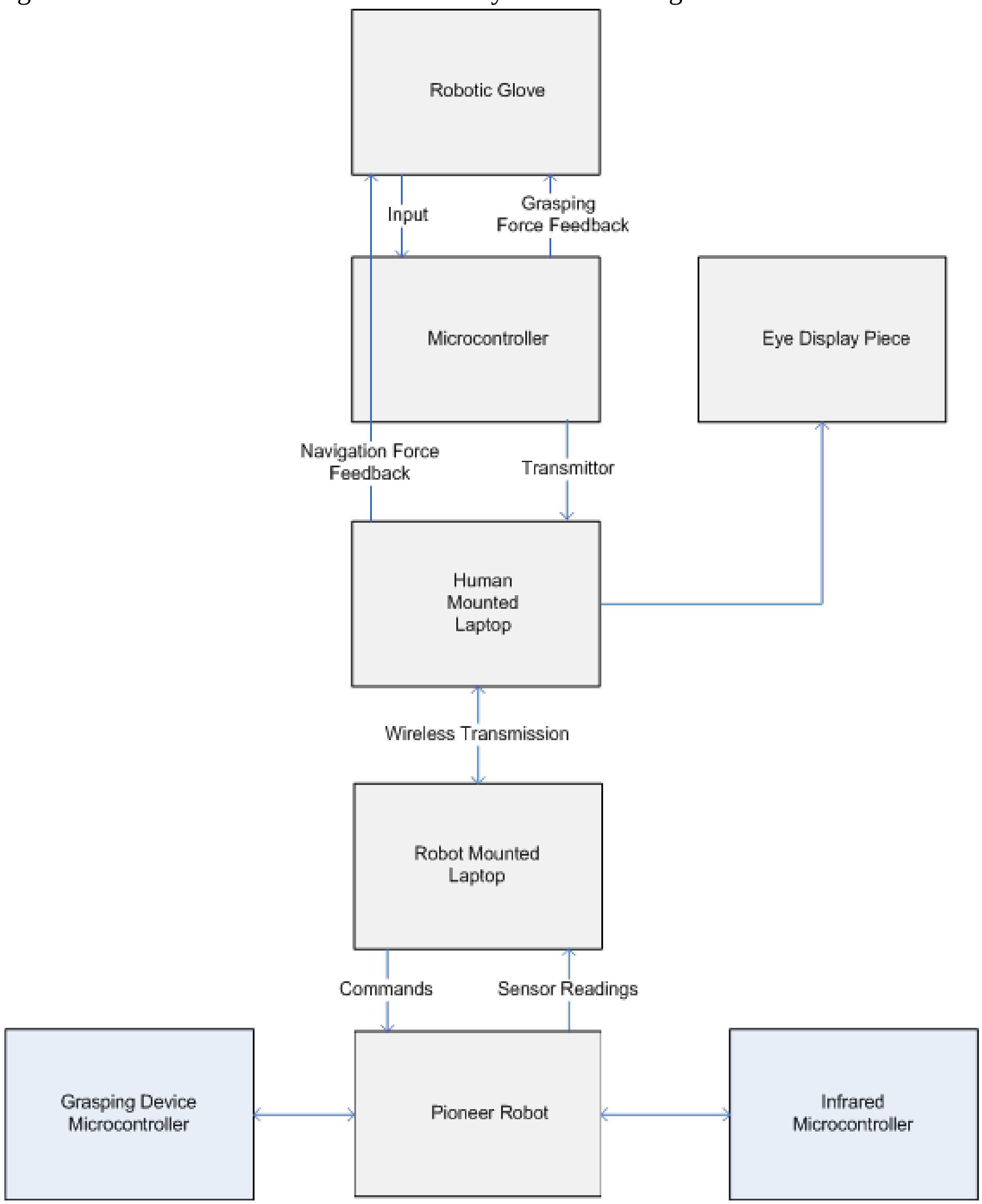

Figure 1: Functional System Block Diagram

FUNCTIONAL REQUIREMENTS

- This system shall be able to operate in autonomous or manual override mode
- Mode shall be selected using feature recognition from the glove
- A hand sensor shall be able to detect the flex of fingers
- A hand sensor shall be able to detect the orientation of the hand
- A sensor shall be able to pick up a shift in position of the user's hand utilizing gyroscopes, accelerometers, digital compass, and whatever else may be necessary to attain less than 3 degrees of drift per second.
- Motion of the feedback LCD eyepiece shall be detected utilizing gyroscopes, accelerometers, digital compass, and whatever else may be necessary to attain a usable amount of precision
- This motion shall be used to control the perspective of the visual feedback
- The robot shall be able to autonomously navigate by potential field planning
- The robot shall be able to take manual directional controls from a sensor glove
- The LCD eyepiece shall display the environment found by sensors on the robot using openGL
- The LCD eyepiece shall have a resolution of 600x800 pixels
- The LCD eyepiece shall have a refresh rate of 12 Hz
- The LCD eyepiece shall have a 180 degree range of vision with 5 degrees of accuracy
- The robot shall be able to measure walls within the range of 20 to 150 cm with 2 cm accuracy
- The robot shall be able to determine ceiling height within 3 m with 5 cm accuracy
- The environment will be mapped using infrared sensors for wall, and a single sonar sensor for the ceiling

PRELIMINARY RESULTS

The robot has a wall following algorithm using the ultrasonic sensors with manual joystick override. This software uses the aria package provided by mobilerobots.com.

The openGL simulation can display a map in two ways. One takes the measured boundaries and uses a height map to produce a 3D model of the map. The model is not very smooth, is takes noticeable time to update the display for larger maps, and does not allow for distinct color differences in walls. In its current iteration, manual navigation is not possible.

The other map display, in its current stage, can only build walls based off an existing map. It is easy to differentiate the walls, as they can be colored, and currently manual keyboard navigation is supported.

These results came from working with a variety of openGL tutorials. The first tutorial that was used was an American Flag display program that just simply allowed for some minor study of openGL in a 2D environment. The next tutorial program that was studied was the previously mentioned height mapping program, which had terrain proportional to the darkness of an existing bitmap file. Then a crab pong tutorial game was analyzed, as it allowed for manual control of a system inside openGL, as well as providing some modifiable 3D objects.

The human interface portion involved acquiring specifications for sensors that would pick up head and hand movement, as well as selecting sensors that would meet the specifications determined. Then, some ideas for testing sensor parameters and compensating for inherent inaccuracies needed to be generated.

Research began on how joints in the human body move. A physical therapist assistant was consulted to gain some common knowledge for degrees of flexure of the wrist and hand. Next, a previous senior project that had dealt with sensing hand movement provided some specifications for the accelerometer and gyroscope to be mounted on the hand. However, due to glove selection, this work may be unnecessary; however, if the accelerometer mounted on the purchased glove is not sufficient for our purposes, then this research will be very valuable. Since a gyroscope, accelerometer, and digital compass are all required for the lcd eyepiece, components were that could meet those specifications as well. The gyroscope and accelerometer need only to be 2-axis, however the digital compass must be 3-axis. This is because a 2-axis digital compass must be perpendicular to the ground in order to work properly. Tilt-compensated models are available but much more expensive, so by purchasing a 3-axis model and tilt-compensating it in software about a hundred dollars can be saved.

The ideas for testing the sensors to determine experimental parameters and compensating for inherent imperfections came last. It was determined that a servo motor, combined with some geometric calculations, would be used to test the sensors and determine how much inherent drift is present. Then, either a Kalman or adaptive filter will be implemented to compensate for the drift. However, if the parameters obtained are better compensated by some other method, then of course our compensation method will evolve accordingly.

Week	David	Brian
1	Test Accuracy of Accelerometer, Digital Compass, and Gyroscope	Set-up Wall objects
2	Test and interface Dataglove	Set-up Wall objects
3	Begin to construct filter for MEMS Devices	Make Wall creation algorithm
4	Filter Construction	Simulate 3D Map
5	Filter Construction	Modify navigation code for infrared
6	Filter Construction	Add in ceiling detection
7	Filter Construction	Add in ceiling detection
8	Begin to integrate LCD headpiece	Preliminary wireless transmission
9	Continue to integrate LCD headpiece	openGL to headpiece
10	Begin to integrate Hand	Debug headpiece interface

11	Continue to integrate Hand	Replace joystick control with hand
12	System Integration	Debug hand interface
13	Compile Final Report	Compile Final Report
14	Compile Final Report	Compile Final Report
15	Compile Final Report	Compile Final Report

CONCLUSION

This project includes many challenges on both the hardware and software levels. Currently, we are expecting favorable results when we have the hardware fully implemented with software compensation, but also expect some small, inherent errors. The virtual environment is progressing well: already able to display a 3D environment, and we expect that integrating sensor readings from the agent will not be an insurmountable obstacle, although doing this in real time will prove to be a challenge.

References

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