Final Project – Distributed Sensing and Control Framework for Mobile Robots

Demonstration: April 30th 2003, Report Due: May 8th 2003

In keeping with the procedure discussed in class, this final project will be less structured than the previous labs. In particular, students will have enormous freedom in selection of phenomena to study, implementation mechanisms as long as they stay within the broad guidelines noted below. Groups with questions are encouraged to discuss their potential projects with Dr. Krovi and Chin-Pei at the earliest to avoid many of the pitfalls.

In this final project, we wish to examine the development and implementation of a distributed sensing and control framework for a system comprised of: **the mobile robot** (with its onboard processor), the **base station,** which are coupled together by **wired and wireless communication channels**. Such a distribution of sensing and control offers many benefits including reducing the computation loads on individual processors and extending the capabilities of sensors/actuators but comes at the price of need for communication protocols, increased overhead of coordination and ultimately increased complexity. Thus, in this final project we wish to examine some of these issues using the relatively simple example of remote-control/operation of the mobile robot by a base station.

When operated in the **distributed sensing (data acquisition) mode**, the overall framework/system forms the basis of an ***intelligent remote sensor.*** The mobile robot functions to serve as the source of the information/data from outside world to the overall system. The data is acquired from one (or more) analog/digital sources such as switches, potentiometers, phototransistors, etc. on the mobile robot and this information is relayed to the base station using one of the communication channels for further processing. The processing may take the form of simply logging the data or may include other post-processing steps including but not limited to sub-sampling, averaging and plotting of the results. The overall system can also be extended into the realm of **distributed control mode**, wherein the processed information can now be sent back to the mobile base over the communication channel. The mobile base now serves as the **action agent** performing a set of actions commanded by the base station. It is noteworthy that the channels of communication have limited bandwidth and that the overall system can only demonstrate limited capability. However, this paradigm of ***multiple processors***, ***communication channels***, ***and coordinated action*** to implement an intelligent distributed sensing and control framework for mobile robot will provide us with an opportunity to investigate and use: (i) alternative communication protocols (synchronous vs. asynchronous) and wired (SPI, serial, parallel) vs. wireless (IR and RF based) communication; and (ii) Setup of programs with the capability of communicating/handshaking and distributing tasks.

Processors:

The Stamp Works Kit that you used for some of the preliminary labs will serve as your **base-station**. Also investigate the use of StampPlot Lite as a potential mechanism for logging and plotting the processed data (Refer to the previous Lab).

The BOE-BOT Kit (and the complementary series of exercises discussed in the Robotics Student Workbook) provides an expedient method for creating simple **wheeled mobile robots** (which will serve as our **remote sensor/actuator**). In our work, we will build upon the hardware and software framework to further extend the capabilities of this BOE-BOT in this final project.

> Explore http://www.parallax.com/html_pages/robotics/index.asp and some of the affiliated links for more details about the BOE-BOT and other useful information. The Robotics Student Workbook v1.5 is available for download from: http://www.parallax.com/Downloads/Documentation/edu/Robotics.pdf. (Local copy: click here). Also, you can refer to the Lab 3 reports from previous semester from: http://www.eng.buffalo.edu/Courses/mae576/Spring2002/LAB_REPORTS.

Communication:

IR Communication

Asynchronous Serial IR Communication between the base-station and remote-robot can be implemented in a variety of ways and one of the easiest methods would be using the FireStick II.

- Interfacing Firestick II to the Basic Stamp: http://www.rentron.com/FS-2.htm.
- Full color operating instructions (MS Word format) http://www.rentron.com/Files/fs-ii.doc

RF Communication

Asynchronous serial RF-based communication between the two processors may be implemented easily using the "***8-Bit Remote Control Combo Package***"

- Wireless Communications With BSII: http://www.rentron.com/Stamp_RF.htm
- ***8-Bit RC Combo Package***: http://www.rentron.com/remote_control/TWS-8-bit-combo.htm.
- TWS-434 transmitter and RWS-434 receiver module: http://www.rentron.com/Files/rf.pdf
- 433MHz whipstyle antenna: http://www.rentron.com/remote_control/434-RF-Antenna.htm
- 8-Bit transmitter schematics using the TWS-434 433MHz RF transmitter with Holtek 8-Bit encoder HT-640. http://www.rentron.com/PicBasic/8-BIT-RF2.GIF
- 8-Bit receiver schematics using the RWS-434 433MHz RF receiver with Holtek 8-Bit decoder HT-648L. http://www.rentron.com/PicBasic/8-bit-rf.gif
- HT-640 Datasheet http://www.rentron.com/Files/ht-640.pdf
- HT-648L Datasheet http://www.rentron.com/Files/ht-648l.pdf

The advantage of the above two methods is that they permit ***wireless operation*** but the disadvantages include the relatively low transmission bandwidth, dangers of insecure data transmission and the principally unidirectional nature of the communications

Wired Interfaces

It is also possible to setup asynchronous/synchronous serial communication between the two processors using a ***wired interface*** between processors, facilitating a **dedicated, secure, bidirectional** channel of communication between the two systems. See the descriptions of SERIN/SEROUT and SHIFTIN/SHIFTOUT in your BS2 manual and some of the examples for further details.

Devices that may potentially be interfaced:

- Displays/Sensors/Actuators available on Stamp Works NX-1000 Board
  7-Segment Displays,LEDs, LCD, Photoresistor, 555 timer; 8-bit serial to parallel and 8-bit parallel chips, DS1620 Digital Thermometer, DS1302 Real Time Clock, ADC0831, MAX7219, LM358, 12 volt unipolar stepper motor; Parallax standard servo;
- Displays/Sensors/Actuators available with BOE-BOT Kit
  Photoresistors (EG&G Vactec VT935G group B), Infrared receivers (Panasonic PNA4602M or etc.), Infrared LED covered with heat shrink tubing (QT QEC113)

Ideas:

http://V.webring.com/webring?ring=stamp;list **Basic Stamp Web Ring**
www.al-williams.com/awce/index.htm **Al Williams web site**
www.seetron.com **Scott Edwards Electronics web site**
www.hth.com/losa **List of Stamp Applications**
www.emesystems.com/BS2index.htm **Tracy Allen's Stamp resources**

In all cases:

Test each subsystem separately before attempting to integrate into a single large overall system. Please make sure that you read through the documentation carefully before attempting to connect up the various subsystems

Reporting:

Provide a self-standing document, which could be used as an **"Application Note"** which describes and explains your system and would enable someone else to replicate your work. Document your system with a circuit diagram, list of components, and parts cost estimate. Include a listing of your program with ***thorough*** comments:

- Please follow the guidelines provided at http://www.eng.buffalo.edu/Courses/mae576/ReportFormat.htm.
- For sample reports see http://www.eng.buffalo.edu/Courses/mae576/SampleReport.pdf and http://www.eng.buffalo.edu/Courses/mae576/Spring2002/LAB_REPORTS/.