Project Proposal

Arduino-Based Object Detection System

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Frank Ervin

Project Abstract

For some time, I have been interested in making some some sort of robot based on the Arduino platform. I am specifically looking at the Aeroquad platform (http://aeroquad.info/bin/view) as a potential longer-term hobby project. This project is a mature open-source effort, and rewriting such a system from scratch would likely be both counterproductive and very difficult. This being the case, I intend to concentrate work on my own customization, which is an object detection system which could be retrofitted to a semi-autonomous robot platform up the road.

The system will leverage infrared (IR) and ultrasonic distance sensing in order to detect obstacles located laterally to a test harness. The ultrasonic sensor will be mounted on a motor in order to have a 3D perspective. Four other digital IR sensors will also provide data on possible collisions. The apparatus will send sensor readings and distance measurements over Zigbee to a computer for output, and code running on the microcontroller will generate audible alerts as objects are detected.

Strategy

I intend to complete this project on the Arduino Duemilanove, namely because it a popular platform and because I have one already, complete with an XBee shield. Up the road, due to shortages of pins on the Duemilanove, I would likely want to substitute a Mega or other Arduino-compatible board with more power and analog and digital inputs in order to build a complete robot.

I intend to use four digital IR sensors, one small servo, and one ultrasonic sensor. Each of the digital sensors will be positioned in order to sense laterally, and the ultrasonic sensor will be mounted on a servo in order to sweep out beyond the limited range of the digital sensors. I initially intended to utilize the Analog to Digital Conversion (ADC) capabilities of the Arduino with a distance sensor, but I found an ultrasonic sensor that uses the I2C interface. This means that I can place analog pins 4 and 5 into I2C mode. This would work in conjunction with the Wire library to communicate on the I2C bus.

This project might also require the microcontroller's digital input capabilities for the other four distance sensors. I have identified an I2C IR sensor set which I would love to use for this project, but it is currently out of stock everywhere.

The project will also use the digital output capabilities for moving the servo on which the ultrasonic sensor is mounted and for generating informative tones from a piezo buzzer using Pulse Width Modulation (PWM), which is an available mode on three of the Duemilanove's digital ports. I am also investigating using a SpeakJet chip instead of a buzzer. This would also require a single digital pin for communications over a softserial port.

All of the sensors that I am looking into purchasing run at 5v and are compatible with the Arduino's power supply and internal step-up resistance. This will make assembly of the apparatus straightforward.

The Zigbee interface to the computer will simply be used a serial port replacement for data IO to and from the microcontroller. This interface can be used to update code, but a small circuit must be built to step up the output voltage of one of the XBee pins in order to register on the Arduino's reset pin. Time permitting, this may or may not be in scope for this project.

For the sensor circuitry, I intend to purchase IR sensors manufactured by Solarbotics which are based on Sharp sensors and an ultrasonic sensor manufactured by Devantech. The parts are itemized in the product list that follows in this proposal.

In my research, I've learned that some servos have non-mechanical issues with being commanded to a full 180-degree rotation, so I need to do some more research on what servos the IR sensors can be mounted which minimize weight and maximize range of motion.

For the SONAR sensor apparatus, I will need a routine that will coordinate movements of the motor with readings from the sensor. There is a library included in the Arduino IDE that supports up to two servos which will be useful for this.

Another routine will check the digital IR sensors and output if an object is detected, and on which sensor.

Yet another routine will serve as a sensor manager and call a routine to generate audible alerts, based on what sensors have been activated. The goal is to generate unique alerts for each of the digital sensors. I would like to use a VoiceBox shield (leveraging a SpeakJet chip) for this purpose, although a piezo buzzer would also be sufficient.

The sensor manager must be designed in such a way that it could easily be merged into a robot's code in order to affect actual movement. An example of how the sensor manager could be applied to a fight control system would be to replace the unique output tones with directional flight commands, and the beacon controls with speed reduction commands.

A serial controller will output serialized reader data over Zigbee for possible further analysis. I will investigate the best way to encode and send this data for adequate

throughput and maximum usability. This will be more or less an exercise in serial data transfer.

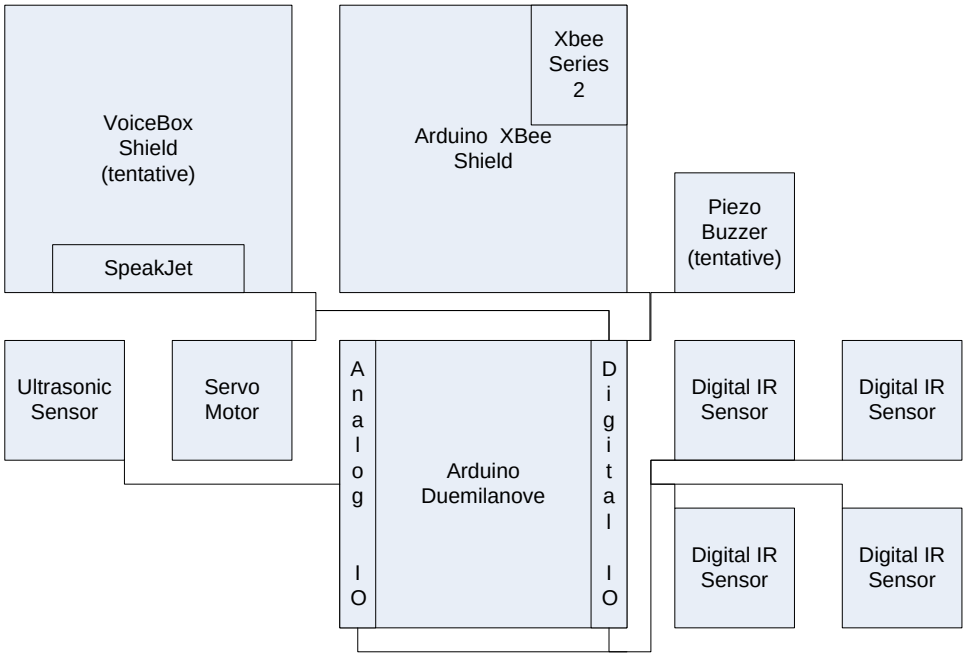

Figure 1: Preliminary Hardware Block Diagram

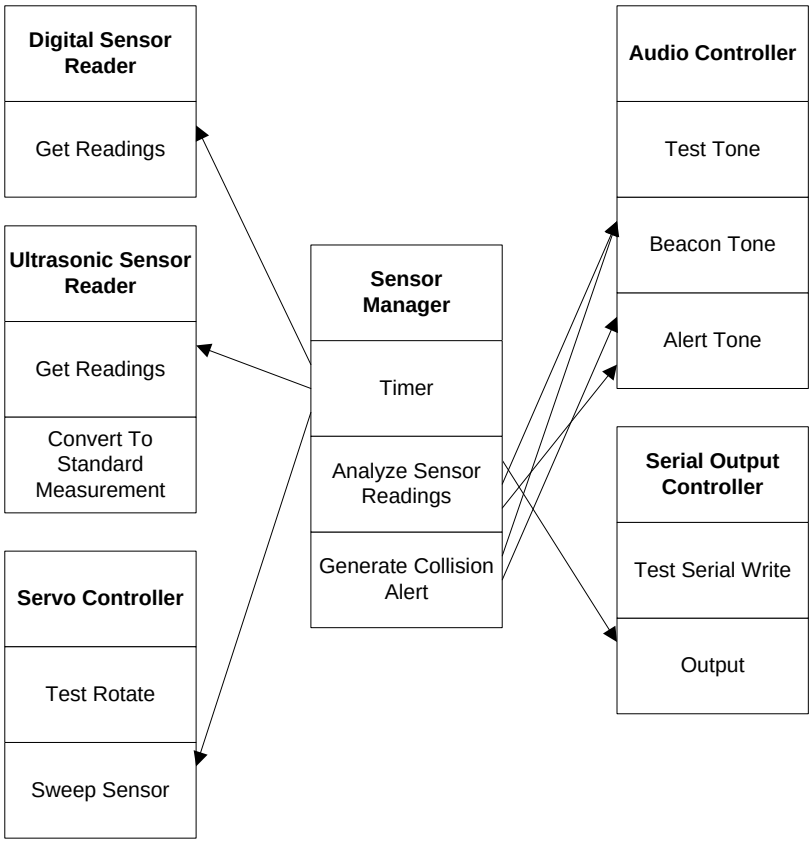

Figure 2: Preliminary Software Block Diagram

Unknowns

I have only ever written application for the Arduino that slaves the microcontroller to a PC using the Firmata firmware, so really my experience with writing code for these devices has been only light experimentation.

I have no experience with reading or addressing sensors on an I2C bus.

I am not sure how difficult it will be to convert the analog values returned from the sensors into real-world measurements. I imagine this will require sampling and measurement.

I am not sure which servos I should order, and whether or not would make sense to look for servos that are built for continuous rotation rather than 180-degree travel.

I am unsure what the best way to encode the data from the reader is, and will have to research basic serial communication protocols.

I am not entirely familiar with the code used in the Aeroquad project. I do not want to design my software in such a way that integration up the road proves to be overly

difficult or impossible. One main limiting factor that comes to mind is limitations with timers and interrupts.

Implementation Plan

I have identified a plan of the steps which must be completed with success for this project to be completed. They are articulated in the chart that follows, with time estimates.

Setup microcontroller and IDE	Complete
Configure Zigbee interface	Complete
Finalize IR sensor decision	2 days
Research servo options	1 week
Order servos and sensors	2 weeks
Build basic test apparatus	1 week
Write **Test Tone**	2 days
Write **Test Serial Write**	2 days
Write **Test Rotate**	2 days
Interface with I2C sensor bus	4 days
Research serial output standards	1 week
Write **Serial Output Controller**	2 weeks
Write **Audio Controller**	1 week
Write **Digital Sensor Reader**	3 days
Write **Ultrasonic Sensor Reader**	3 days
Calibrate Sensor output	3 days
Write **Servo Controller**	2 days
Write **Sensor Manager**	1 week
Test sensor code	2 days
Refine **Audio Controller**	3 days
Refine **Serial Output Controller**	1 week
Test completed code	1 week
Assemble travel-friendly prototype	1 week

Resources

Supply List	**Quantity**	**Price**	**Comments**
Ardino IDE	1	N/A	http://www.arduino.cc/en/Main/Software
Arduino Duemilanove	1	N/A	On hand
Arduino Xbee Shield	1	N/A	On hand
Xbee Series 2	2	N/A	On hand
Xbee Exporer (for PC	1	N/A	On hand

interface)			
Battery Case	1	N/A	On hand
Piezo Buzzer	1	N/A	On hand
VoiceBox Shield	1	$39.95	http://www.sparkfun.com/commerce/product_info.php?products_id=9624
I2C-It IR Rangefinder 4-Pack	1	$59.20	http://www.hvwtech.com/products_view.asp?ProductID=666
Digital Infra-Red Rangefinding (DIRRS+) 4-Pak	1	$59.20	http://www.hvwtech.com/products_view.asp?ProductID=92
Devantech SRF10 Tiny Ultrasonic Ranger	1	$59.95	http://www.hvwtech.com/products_view.asp?ProductID=945
Devantech SRF10 Mounting Kit	1	$8.95	http://www.hvwtech.com/products_view.asp?ProductID=946
Small Servo	1	$15.00	http://www.hvwtech.com/