

Project Final Report  
Possessed Beaker  
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Sean Riggs



# Overview

For the final project in CSCI 4415 “Real Time Embedded Systems”, I created a “possessed Beaker head”. The idea was to create a “head” like the Muppet character Beaker which made sounds and had blinking eyes, with both changing due to how close someone got to the head. The end result is a little different than what was envisioned. A few problems were found along the way which necessitated some changes in design. These will be detailed later in this report.

For this project, the Zilog context kit from class was used as the primary controller. For the light effects, RGB LEDs were used. For sound, the speaker provided for lab 2 was used. For proximity sensing, an ultrasonic sensor from Parallax was used. Finally, a secondary “debug” interface was also added which used a laptop paired with an Arduino to drive communication to the Zilog kit board.

## Hardware Overview

### **RGB LEDs**

Three color LEDs were used for the “eyes” in this project. Two LEDs were used, with model number YSL-R596CR3G4B5C-C10. Each of these LEDs has four pins—one for voltage, and one for each of the colors red, green and blue. For each LED, on each of the three “color” pins, a 4.7k-Ohm resistor was placed. The voltage pin on each of the LEDs was spliced into one wire going to the 3.3 V voltage source on the Zilog board. The “color” pins were connected to port E on the Zilog board.

### **Speaker**

The speaker used was a 0.5 watt speaker provided as part of the Zilog kit in class. The speaker has two wires, both of which were connected to port C on the Zilog board.

### **Ultrasonic Sensor**

The “PING)))” ultrasonic distance sensor, part #28015 from Parallax was used for determining distance of an outside body to the Beaker head. This sensor has three pins—a voltage source, ground, and a signal pin. The voltage source was connected to the 5V voltage source on the Zilog board. The signal pin was connected to port D.

### **Arduino**

An Arduino Duemilanove was used to provide a debug interface for the Beaker head. Three wires were connected from the Arduino board to port B on the Zilog board. The Arduino was driven by a custom serial interface running on a laptop.

## Hardware Schematic

The schematic on the next page details the connections made between the hardware used and the Zilog board. Note that the PC driving the Arduino needs to have the Arduino IDE available (so that the serial terminal available in that IDE can be run, thus allowing for the debug interface to be used.)

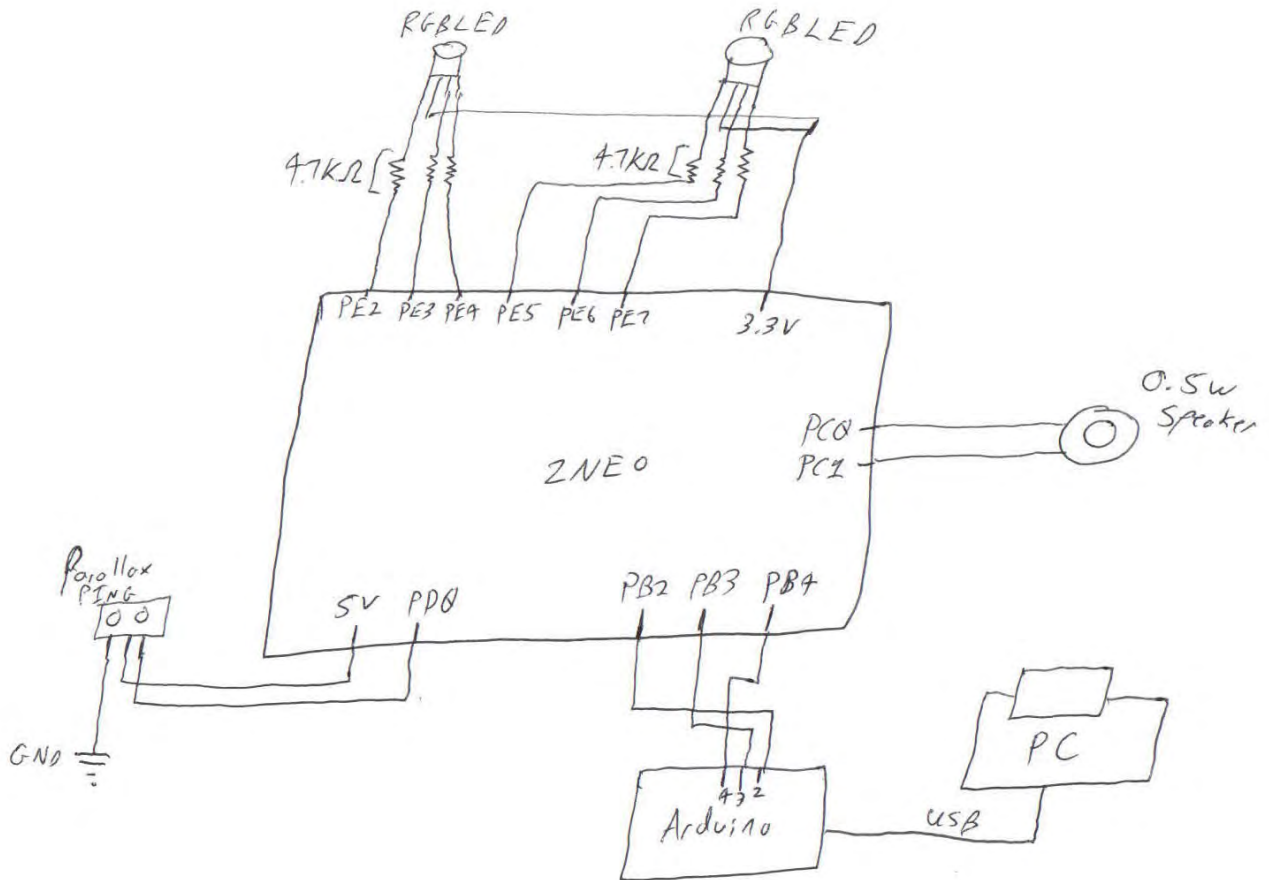


Illustration 1: Block Schematic For Possessed Beaker

## Software

The software for this project is broken into several modules. Most of the software runs on the ZNEO, but the debug/serial interface also had to be written as an Arduino sketch. A listing of the source files involved follows.

**arduinocomms.c:** this is the ZNEO half of the debug interface. It is responsible for reading the control “message” sent from the Arduino. The corresponding header file lists the legal messages.

**ping.c:** this code is responsible for taking a reading from the PING ultrasonic sensor.

**light.c:** this code is responsible for providing all the LED functionality used in the project.

**sound.c:** this code is responsible for providing all the sound functionality used in this project.

**delay.c:** this is supporting code which provides the ability to delay for a specified number of milliseconds or microseconds. This functionality is used in various places throughout the project.

**main.c:** this is the “driver” for the program. It runs a forever loop in which distance is read from the sensor and the appropriate light and sound is triggered. If the debug interface is in use, then a separate logic path is followed which simply executes the desired action as per the message received from the

debug interface.

**project\_arduinoComms.pde:** this is an Arduino “sketch”, and provides the Arduino half of the functionality required for the debug interface.

## Construction

In addition to the hardware specified, the head was constructed from wood. The back and sides were constructed from 1.5” x .75” Oak. The face was constructed from a much thinner wood product, with poster board cut to fit and a face hand drawn. Holes were drilled out for the eyes, as was an additional hole to pass through the wires for the ultrasonic sensor as well as the wires for the speaker.

The project was put together over a period of weeks. The construction of the wood was a small piece of work done in one evening. Construction of each piece of software was done in an experiment/implement cycle. Namely, “test” programs were first written to test hardware functionality, as well as my understanding of how the hardware worked. Once I felt I fully understood the hardware, construction moved on to implementing the needed functionality for the project as a module for the hardware. Eventually, all modules were complete, and they were then combined into a “main”, with all desired functionality integrated. From this point, several tests were conducted and development was mostly a matter of fine tuning the software. The main issue at this point was with regard to timing of the various components. But timing issues were resolved and construction was completed.

Pictures on the following pages show three distinct views of the project:

1. Assembly/connection of the various hardware.
2. Fitting of the hardware into the head.
3. The final product, with the face on

## Changes In Design/Issues

There were two changes made from the original proposed design. The first change was with regard to the audio portion of the project. I had originally envisioned using sound samples of Beaker available online. I had planned to sample these and play them back using a hardware component. I had intended to use the SOMO-14D Embedded Audio Sound Module from 4D Systems for this purpose. This module comes with an on board micro SD memory card reader. To use the module, one must convert original audio into a format called “AD4” which the module can read. For this purpose, a conversion tool available from the manufacturer can be used. This is problematic, because the AD4 format is not a format that is easy to play on anything else. Therefore, it’s not possible to prove that the conversion worked. It was also evident from research online that the card reader won’t work for all cards from all manufacturers. Therefore it’s possible that the reader didn’t like the SD card that I used. There was some speculation online as well about the card reader being picky about the file system format of the card so I tried formatting it a couple of different ways to no avail. The last thing I attempted was to use a .25W speaker (instead of the .50W speaker made available for class.) All of this was to no avail, and I finally chose to use an approach similar to the one used for the ring tone lab so that I could be sure to get sound incorporated into my project.

The second change was that I had originally envisioned using the buttons on the ZNEO board as a debug interface for the project. However, as design progressed, it became clear I wouldn’t have direct access to the buttons. At about the same time, I was experimenting with an Arduino for the class

presentation. It seemed like a reasonable choice to use the Arduino for the debug interface instead. I wrote a simple interpreter for the Arduino and made the necessary connections to the ZNEO as well as the changes in the ZNEO program to allow for this. It is true that this could have been incorporated in the ZNEO program directly, but it was more interesting to have the Arduino communicate with the ZNEO. The interface is one way (the ZNEO doesn't ever send anything back to the Arduino) but that is all I needed for this project.

## Retrospective and Summary

The decision was made early on to use a software loop construct of:

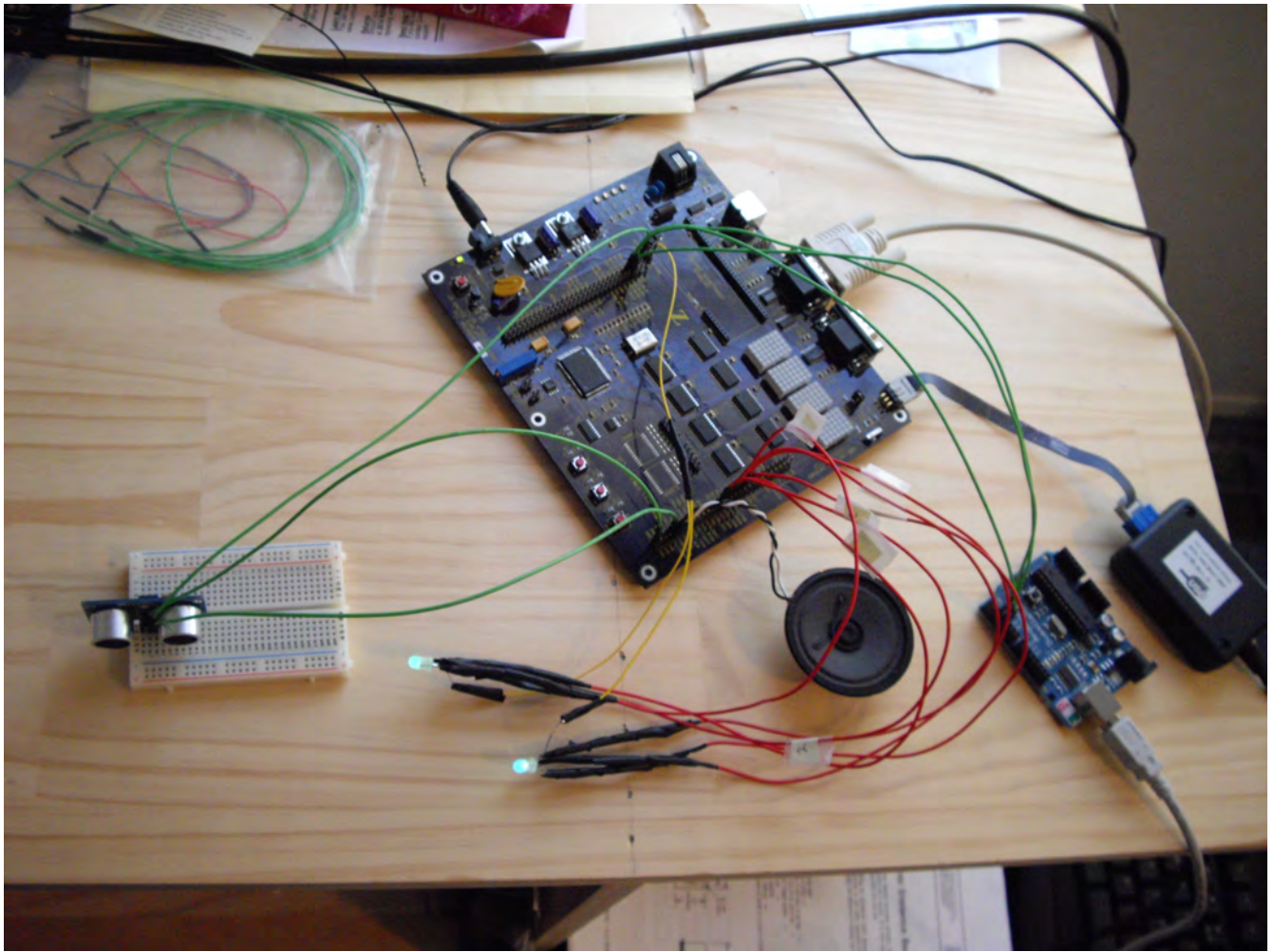
```
while(forever)
  if debug off
    determine distance
    play sound
    flash light
  else if debug on
    execute debug command
end while
```

This construct is what dictated how the individual software components were designed and implemented. Implicit in this design is an assumption that one can move quickly through this loop. Although I am happy with how this eventually turned out, in hindsight it might have been better to combine the light and sound into one module, as they really should be atomic in the sense that the “mood” conveyed by either the light or the sound should be the same. If this had been done instead, the overall effect could have been perhaps a little more cogent.

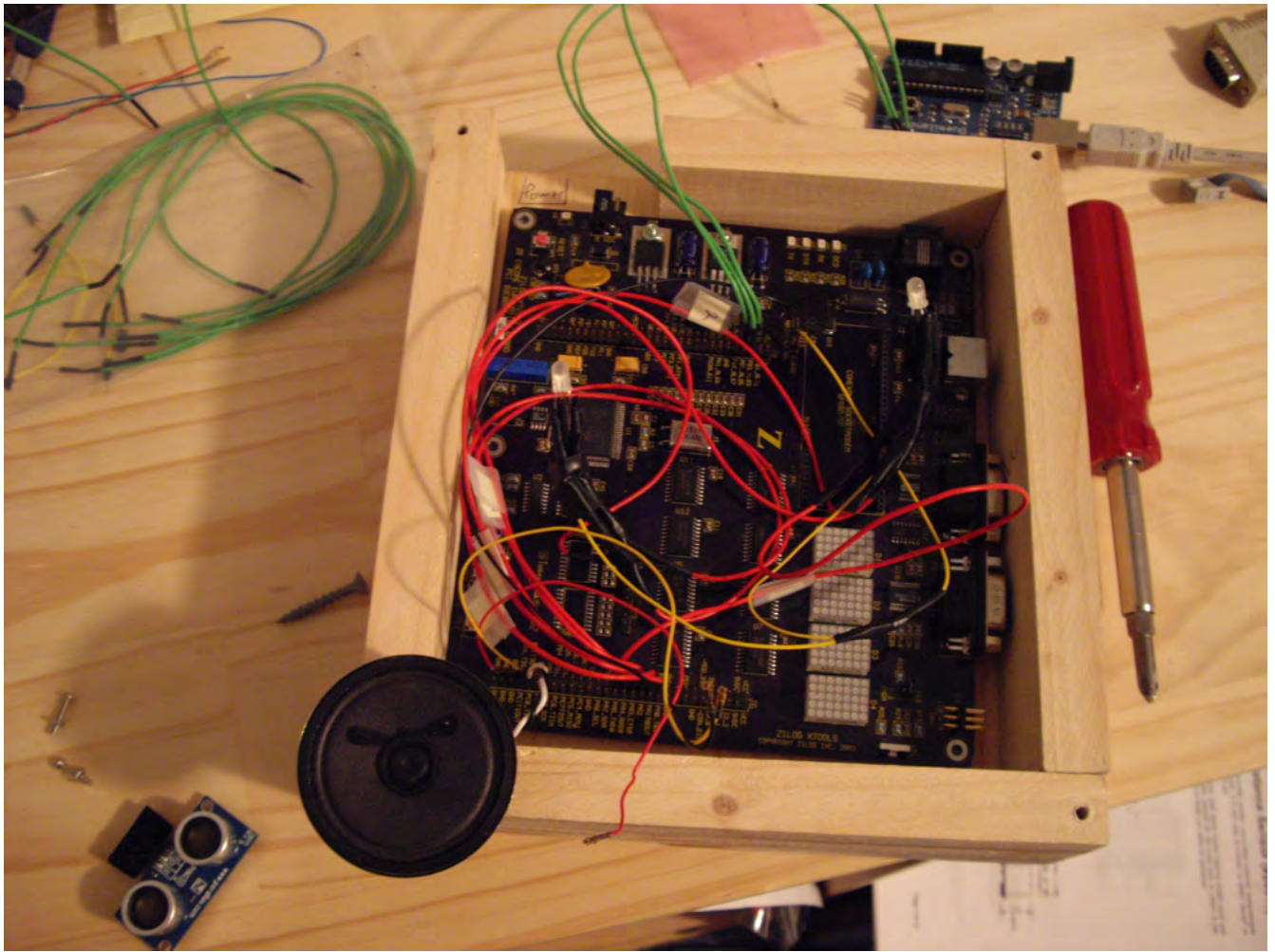
Although the loop construct worked well, another thing that might have been done differently is to try an interrupt based approach for the distance. As is, the ultrasonic sensor does not lend itself directly to an interrupt based approach, but there might be a hardware based way to wrap the sensor up to allow for this... perhaps a hardware accumulator that can fire an on signal at a particular threshold (i.e. distance). Unfortunately, this is beyond my level of electronics expertise. But if it had been possible, it would have allowed for a more interesting illusion of response (due to a quicker response.)

For the most part, I am happy with the way the project turned out. I would have preferred to use real Beaker sounds, but given that I couldn't make the original sound module work, I am happy that I ended up being able to still have ANY sound. The sound module was of course a low point and not something that I would ever attempt to use again—my current opinion of it is that it is junk.

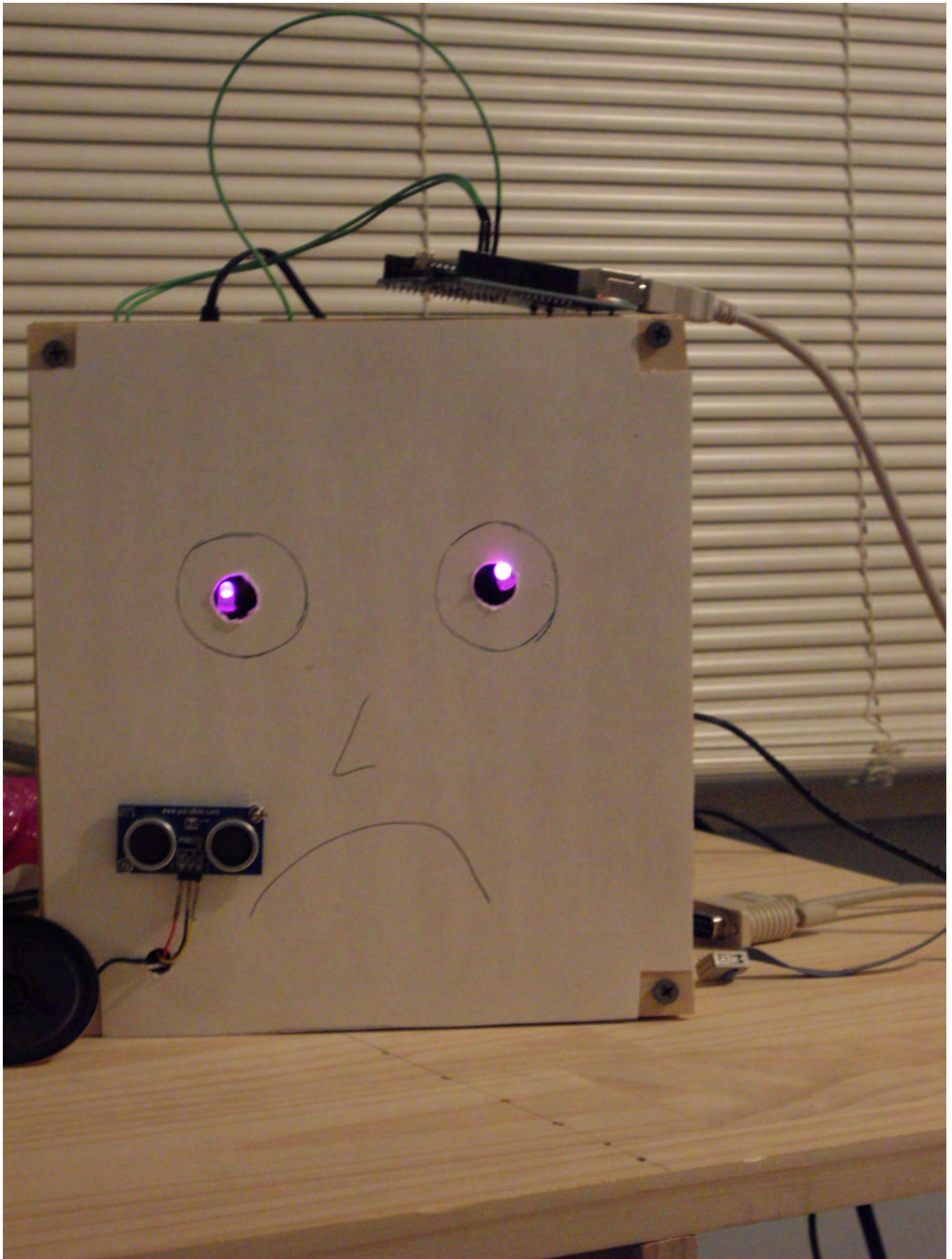
On the other hand, the ultrasonic sensor was a real surprise. I assumed that it would probably be hard to use. It was in fact very easy to use. Being a central component of the project, I very much appreciated its simplistic design and I look forward to using it again in the future.



*Illustration 2: Hardware Assembly*



*Illustration 3: Hardware Fitting*



*Illustration 4: Final Product*

## Attachments

In addition to both ZNEO and Arduino source code, included in the submission of this project are the data sheets for the ultrasonic sensor and the RGB LEDs. I could not find a data sheet for the speaker.