Aftermarket Parking Assist

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ECE 445
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Team 77 Dynamics

February 4 - Team 77 created with two members

February 19 - Third member added to team after proposal submission

March 1 - Team reduced back to two members after design review

April 7 - Team reduced to one member with no parts

April 26 - Team 77 demo 9:20am
Introduction

- Parking can be a nightmare!
- Current drivers just guess
- Why can’t old cars have what the new cars do?

Figure 1, Car with damaged front bumper

Figure 2, Lamborghini with ultrasonic sensors
Objectives

- Create a product for already purchased cars
- Both front and rear sensing
- Powered by car battery
- Accurate system that can aid the driver
- Out of sight (no visual distractions or bulkiness)
- Different frequencies for different distances
Project Overview

- Front and rear array
- 6 sensors per array
- Powered by car battery
- Sound alerts to driver

Figure 3, Sensor that will be seen on bumper

Figure 4, Buzzer that will be installed inside the vehicle

Sensing Area

Sensor
Figure 5, Block Diagram
Power

- Input voltage = 12V DC
- Output voltage = 5V DC +/- 10%
- Maximum current of 200mA
- LM7805, 1uF & 10uF capacitors

Table 1, Measured output from regulator circuit

<table>
<thead>
<tr>
<th>Load</th>
<th>Voltage (V)</th>
<th>Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No load</td>
<td>4.98V</td>
<td>16mA</td>
</tr>
<tr>
<td>1 Sensor</td>
<td>4.98V</td>
<td>16mA</td>
</tr>
<tr>
<td>12 Sensors</td>
<td>4.96V</td>
<td>21mA</td>
</tr>
</tbody>
</table>

Figure 6, Voltage regulator circuit
Sensing

- Sensor min/max rating 2 cm/400 cm
- Rated for 15 degree sensing angle
- 30 degrees is advised by community
- Need to cover 70 inch bumper
- No interference between sensors

Figure 7, HC-SR04 ultrasonic sensor
Sensing Circuit

- 4 pins: 5V, GND, Trig (output), Echo (input)
- Controlled by Master Atmega328
- DEMUX used to select Trig for each sensor
- MUX used to select Echo
- Trig set high to tell the sensor to start sensing
- Echo sends eight 40Hz pulses
- Time Echo is high can be converted to distance
Sensor Timing Calculation

- 3 mph, 150 cm away, 700 ms reaction time
- 418.47 ms before buzzer output
- With 6 sensors in each array each sensor can only take 70 ms

\[
\text{Theoretical Time} = \frac{\text{Distance (cm)}}{\text{Speed of Sound (cm/s)}} \times 2
\]

Figure 8, Oscilloscope plot of Trig and Echo
Actual Sensor Timing

- Atmega328p execution time = 0.02 ms
- Trigger signal = 0.01 ms
- Trigger delay = 1.0 ms
- Echo signal = 1.0 ms maximum
- Sensor delay (has to be at least 30 ms for no interference) = 50 ms
- Total time for one sensor = 52.03 ms < 70 ms
Sensor Coverage

- Need each sensor to have 40 degree coverage to each side
- Each sensor needs to cover 29.63 cm for a 70 inch bumper
- Leaves (29.63 cm - 16.78 cm) = 12.85 cm gap at midpoint of two sensors

Figure 9, Top view of sensor coverage calculations
Actual Sensor Coverage

Figure 10, Plot of detection width vs distance from sensor

Table 2, Detection widths

<table>
<thead>
<tr>
<th>Distance from sensor (cm)</th>
<th>Actual width (cm)</th>
<th>15 degrees width (cm)</th>
<th>40 degrees width (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>3.81</td>
<td>5.36</td>
<td>16.78</td>
</tr>
<tr>
<td>20</td>
<td>3.89</td>
<td>10.72</td>
<td>33.56</td>
</tr>
<tr>
<td>30</td>
<td>4.52</td>
<td>16.08</td>
<td>50.35</td>
</tr>
<tr>
<td>40</td>
<td>7.22</td>
<td>21.44</td>
<td>67.13</td>
</tr>
<tr>
<td>50</td>
<td>8.26</td>
<td>26.79</td>
<td>83.91</td>
</tr>
<tr>
<td>60</td>
<td>9.53</td>
<td>32.15</td>
<td>100.69</td>
</tr>
<tr>
<td>70</td>
<td>9.68</td>
<td>37.51</td>
<td>117.47</td>
</tr>
<tr>
<td>80</td>
<td>9.21</td>
<td>42.87</td>
<td>134.26</td>
</tr>
<tr>
<td>90</td>
<td>10.32</td>
<td>48.23</td>
<td>151.04</td>
</tr>
<tr>
<td>100</td>
<td>12.54</td>
<td>53.59</td>
<td>167.82</td>
</tr>
<tr>
<td>110</td>
<td>14.32</td>
<td>58.95</td>
<td>184.60</td>
</tr>
<tr>
<td>120</td>
<td>16.56</td>
<td>64.31</td>
<td>201.38</td>
</tr>
<tr>
<td>130</td>
<td>18.98</td>
<td>69.67</td>
<td>218.17</td>
</tr>
<tr>
<td>140</td>
<td>20.21</td>
<td>75.03</td>
<td>234.95</td>
</tr>
<tr>
<td>150</td>
<td>22.44</td>
<td>80.38</td>
<td>251.73</td>
</tr>
</tbody>
</table>
Buzzer

- Controlled by slave Atmega328
- Five different frequency vs. distance ranges
- Programmed in Arduino IDE
- Ex. `tone(Buzzer, 600);` produces a 600 Hz tone
- Accuracy of buzzer output is dependent on sensors and master/slave communication

<table>
<thead>
<tr>
<th>Distance from sensor</th>
<th>Buzzer Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 cm or less</td>
<td>600 Hz</td>
</tr>
<tr>
<td>25 cm to 11 cm</td>
<td>500 Hz</td>
</tr>
<tr>
<td>50 cm to 26 cm</td>
<td>400 Hz</td>
</tr>
<tr>
<td>100 cm to 51 cm</td>
<td>300 Hz</td>
</tr>
<tr>
<td>150 cm to 101 cm</td>
<td>200 Hz</td>
</tr>
</tbody>
</table>
Standalone Atmega328p’s

- Bootloader loaded
- 5V input with common GND throughout system
- Requires 16Mhz timing crystal across pins 9 and 10
- Two 22pF capacitors from the crystal to GND
- One 10k Ohm resistor from reset pin to GND
- Analog 5 and Analog 4 for master/slave communication
- Programmed through rx and tx

Figure 11, Atmega328p pinout
Arduino Master/Slave

- I2C synchronous serial protocol
- Master sends 6 bytes of data to slave every half second
- Each device has a unique address
- Serial clock pin (SCL) analog 5
- Serial data pin (SDA) analog 4
- As the clock goes low to high, a single bit is sent through SDA line
Future Work and Conclusion

- Sensors are the limiting factor
- Upgrade to waterproof 115 degree by 65 degree sensors
- Work on new buzzer circuit to create beeping output
- Accuracy vs. Cost analysis
- Full working prototype installed on a car
- Gauge possible customer interest and price they would pay
- Talk to used car dealerships to see if they would install the system on their cars
Picture Citations

(1)  http://i264.photobucket.com/albums/ii189/norcalpb/66251_1648709894665_1144485927_31847818_6293082_n.jpg
(2)  http://www.avolutions.co.uk/wp-content/uploads/2015/02/Lamborghini-Gallardo-Rear-Parking-Sensors-3.jpg
(7)  http://letsmakerobots.com/files/field_primary_image/HC-SR04-lg.jpg?
Thank You!
Questions?