E11 - Autonomous Vehicles
The Mudduino
Autonomous Vehicles - Components

- Sensing
- Sensor Mounts
- On board Processing
- Steering Actuator
- Fuel
- Chassis
- Locomotion
- Drive Motor
Outline

- Arduino
- Mudduino
- Board Assembly
Arduino

- Open-source microcontroller platform
  - Makes hardware/software solutions inexpensive & simple
  - Popular with universities and hobbyists
Official Arduino Boards

Uno

Mega

Nano

Mini

Source: www.Arduino.cc
The Arduino system includes:

1. Power supply
2. Microcontroller
3. Analog and digital inputs and outputs
4. Host interface: a way to interface with a host computer
1. Power Supply

- Two options:
  1. Powered by USB port (5 V)
  2. Powered by external power (DC Jack) that’s connected to, either:
     - Battery (7-12 V) or
     - Wall transformer (transforms 120 VAC to 7-12 V DC)
     - On-board voltage regulator drops this to 5 V
2. Microcontroller

- Arduino system uses Atmel Microcontrollers

- Mudduino uses Atmega328 Microcontroller
  - Costs $2.32 (quantities >2000)
  - Some competing microcontrollers cost ~ $0.50
2. Microcontroller

- Your Atmega328 preprogrammed with Arduino bootloader
  - Occupies part of flash memory
  - Initializes chip at powerup or reset
  - Monitors serial port (USB port), waiting for program to be uploaded
3. Inputs and Outputs

- The processor wants everything in 1’s and 0’s
  - E.g. 01100011
  - These can be expressed as DIGITAL signals

http://www.hifipage.com/
Often, our input and output signals must take on values that are not expressed as 1’s and 0’s.
- E.g. 4.3 Volts
- These are called ANALOG signals
3. Inputs and Outputs

- Inputs and Outputs can be Analog and Digital

- How do we support Analog and Digital Inputs and Outputs?

Doris Jeanne Wagnerm 2002
3. Inputs and Outputs

- At least 14 digital PINs
  - Configured as inputs or outputs
  - HIGH, 5 V
  - LOW, 0 V
## 3. Inputs and Outputs

<table>
<thead>
<tr>
<th>Level</th>
<th>Value</th>
<th>Notes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{IL})</td>
<td>1.5</td>
<td>Maximum input voltage recognized as a 0</td>
<td></td>
</tr>
<tr>
<td>(V_{IH})</td>
<td>3.5</td>
<td>Minimum input voltage recognized as a 1</td>
<td></td>
</tr>
<tr>
<td>(V_{OL})</td>
<td>0.9</td>
<td>Maximum output voltage produced for a 0</td>
<td></td>
</tr>
<tr>
<td>(V_{OH})</td>
<td>4.2</td>
<td>Minimum output voltage produced for a 1</td>
<td></td>
</tr>
</tbody>
</table>
3. Inputs and Outputs

- Analog Outputs
  - Pulse Width Modulation (PWM)
3. Inputs and Outputs

- Analog inputs
  - Connected to 10-bit A/D (analog-to-digital) converter
  - A/D converts voltage to value between 0-1023
  - Value is proportional to voltage (0 = 0 V, 1023 = 5 V)

Kohei OHTSU, 2006
4. Host Interface

- Converter chip converts data back and forth from USB to RS232 serial communication standards
  - Sends 8 bits of data at a time
  - Requires start and stop bit for each 8 bits of data
  - 9600 baud = 9600 bits/second = 960 bytes/second

- Host and computer must agree on data rate
  - 9600 – 115,200 baud
Outline

- Arduino
- Mudduino
  - Features
  - Schematic
  - I/O Pins
- Board Assembly
Mudduino
Mudduino – Overall Description

- Designed by E11 students

- Similar to Uno, except:
  - Uses through-hole components
  - Has connectors customized to robotics applications
  - Has form factor designed for your vehicle
  - Includes a blank portion - can add your own circuitry
Mudduino – Features

- Atmega328 microcontroller
  - 32 KB of Flash program memory,
  - 2 KB of RAM data memory,
  - 16 MHz
Mudduino – Features

- Atmega328 microcontroller
  - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
- H Bridge for driving two high-current motors
H bridge

![H Bridge Diagram]

A1 + A2 = Clockwise
B1 + B2 = Counter Clockwise

www.hvlabs.com
Mudduino – Features

- Atmega328 microcontroller
  - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
- H Bridge for driving two high-current motors
- Two indicator LEDs (red, green)
Mudduino – Features

- Atmega328 microcontroller
  - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
- H Bridge for driving two high-current motors
- Two indicator LEDs (red, green)
- Two team LEDs (white, green)
  - glows white (looks yellow)
  - glows green (looks white)
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
FTDI connector to communicate with a host
Power supply circuitry
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches
- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
  - power (USB / BAT - battery)
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
  - power (USB / BAT - battery)
  - motors (on/off)
FTDI connector to communicate with a host
Power supply circuitry
Battery connector for untethered operation
Switches:
  - power (USB / BAT - battery)
  - motors (on/off)
  - team (white, green)
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
  - power (USB / BAT - battery)
  - motors (on/off)
  - team (white, green)
  - Center position: no selection (careful!)
FTDI connector to communicate with a host

Power supply circuitry

Battery connector for untethered operation

Switches

Expansion area for soldering on custom hardware
Mudduino – more parts!

- Reset button
  - When push button, uploaded program restarts
Mudduino – more parts!

- **Reset button**
  - When push button, uploaded program restarts
- **Clock Oscillator (16 MHz)**
Mudduino – more parts!

- Reset button
  - When push button, uploaded program restarts
- Clock Oscillator (16 MHz)
- Speaker (Buzzer)
Mudduino – more parts!

- Reset button
  - When push button, uploaded program restarts
- Clock Oscillator (16 MHz)
- Speaker (Buzzer)
- Capacitors and resistors
Important: Make sure black wire on FTDI cable is connected to pin labeled “GND” on board header.
Header pins for connecting:

- 5 digital ports
- 5 analog ports
- 2 motor ports
- Sensors:
  - Distance
  - Phototransistor
  - Reflectance
- 5 V and GND
- 20 expansion pins
Mudduino – Pins

- Header pins for connecting:
  - 5 digital ports
  - 5 analog ports
  - 2 motor ports
  - Sensors:
    - Distance
    - Phototransistor
    - Reflectance
  - 5 V and GND
  - 20 expansion pins
Mudduino – Pins
<table>
<thead>
<tr>
<th>Digital Pin #</th>
<th>Analog Pin #</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Serial TXD – don’t use</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Serial RXI – don’t use</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Header D2</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Team (0 = green / 1 = white) read only</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Header D4, Buzzer</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Header D5 / green LED / programming indicator</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Left Motor Enable</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Right Motor +</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Left Motor -</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Left Motor +</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Header D10 / Servo (use servo.write)</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Right Motor Enable</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Right Motor -</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Header D13 / red LED</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>Distance Sensor</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>Header A1</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>Header A2</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>Header A3</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>Header A4, Reflectance Sensor</td>
</tr>
<tr>
<td>19</td>
<td>5</td>
<td>Header A5, Phototransistor</td>
</tr>
</tbody>
</table>
Mudduino Schematic
Mudduino Schematic

Reset switch

Header pins

Oscillator
PCB Drawing - Traces
Mudduino Assembly

Holes through which parts are placed
Through-hole Assembly

- Place pins of part through the hole
- Solder on opposite side of board
Place parts

- Oscillator
- Reset Pushbutton
- Speaker
- Voltage regulator
- Sockets
- Resistors
- Capacitors
- Header pins
- LEDs
- Voltage regulator
Voila! – your very own Mudduino
Voila! – your very own Mudduino

Test & Debug!