MODEL RAILROADING WITH ARDUINO

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WHAT IS AN ARDUINO?
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- Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software.
- It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.
- A little programmable computer platform designed help people “make things go.”

http://www.arduino.cc/
Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).
WHAT IS OPEN SOURCE?

• Source Code is Publicly Available
  • No Secrets Hidden from Developers
  • License Controls How Code Can Be Used
• Different Code & Projects Use Different Licenses

• “Like Playing Poker With Everyone’s Cards Face Up”
THERE IS EVEN A MOVIE…

http://vimeo.com/18539129
HARDWARE

• Based upon widely available 8-bit Micro-controllers
  • Single-chip Computers as powerful as the early PCs

• Open Hardware
  • Schematics available under various licensing terms

• Kits and Built-up Boards from $15 to $80

• Expand with “Shields” (Stackable Boards)
HARDWARE

• 13 digital I/O pins
  • 6 can be PWM-ed (digital dimmer)
• 6 Analog Inputs
  • Can also be used as extra digital I/O pins
• 6V-12V Power Supply or 5V from USB
• Easily Expandable & Customizable to add features
SOFTWARE
SOFTWARE

• Works with Windows, Mac OS X, and Linux
• Open Source
  • Free to Download & Use
  • Source Code Available
• Program Hardware via USB or Serial Port
SOFTWARE

• C-like Language

• Programs for the Arduino are called “Sketches”
  • Ideal for Hobbyists, Artists, and Explorers

• Rapid Prototyping of small projects is the goal

• Easy to use “Libraries” developed by others
  • DCC, Communications, LED etc.
SOFTWARE

• All the “gruff work” is done for you by Arduino

• Only two functions to create
  
  • `setup()` : initialize inputs & outputs
  
  • `loop()` : run over and over again until power is removed

• Sketchbook and examples to build upon, too.
“BLINKY” SKETCH
/*  Blink: Turns on an LED on for one second, then off for one second, repeatedly.
 *  LED connected from digital pin 13 to ground.
 *  Note: On most Arduino boards, there is already an LED on the board connected to
 *  pin 13, so you don't need any extra components for this example.
 *  Created 1 June 2005
 *  By David Cuartielles
 *  http://arduino.cc/en/Tutorial/Blink
 *  based on an orginal by H. Barragan for the Wiring i/o board
 */

int ledPin = 13;    // LED connected to digital pin 13

// The setup() method runs once, when the sketch starts
void setup()
{
    pinMode(ledPin, OUTPUT);     // initialize the digital pin as an output:
}

// the loop() method runs over and over again, as long as the Arduino has power
void loop()
{
    digitalWrite(ledPin, HIGH);   // turn the LED on
    delay(100);
    digitalWrite(ledPin, LOW);    // turn the LED off
    delay(100);
}
ARDUINO “SHIELDS”
MOTOR SHIELD

http://www.adafruit.com/
SOUND EFFECTS

WAV Shield
http://www.adafruit.com/

MP3 Player Shield
http://www.sparkfun.com/
RELAY SHIELD

http://shop.evilmadscientist.com/
CONNECTING WIRES

Adafruit Proto-screwshield

http://www.adafruit.com/
“PATCH SHIELD”

NEED MORE I/O?

Centipede Shield (64-GPIO)  MuxShield II

ETHERNET

Ethernet Shield

Arduino Ethernet*

http://www.arduino.cc/
WIFI

$84.95!!!

$69.95!!!
MICROCHIP RN-XV WIFI

XBee Form-Factor WiFi Module

$24.95

$34.95
“ELECTRIC IMP” WIFI

$19.95 + $29.95

(The “Imp” is actually a cloud-programmed WiFi Micro)
BLUETOOTH 4.0

http://redbearlab.com
SPECIAL EFFECTS
NOTE: This is an mbed, not an Arduino; probably should re-shoot the video.
EFFECTS YOU CANNOT BUY

Sperry Rail Service Inspection Vehicle
ARDUINO & YOUR LAYOUT
MIX AND MATCH

• An Arduino can connect to existing Model Railroad Electronics

• Chubb SMC12 for using digital output to control Tortoise

• DCCOD, TeamDigital DBD22, and NCE BD20 Detectors
LED SIGNALS
CONNECTING LEDS

• **Anode** (+, long leg) of LED to +5V (or 3.3V)

• **Cathode** (−, short leg, flat side) of LED to DIGITAL I/O Pin through a 470Ω resistor (330Ω for 3.3V)

• **Anode** (+, long leg) to DIGITAL I/O Pin through a 470Ω resistor (330Ω for 3.3V)

• **Cathode** (−, short leg, flat side) to Ground
SWITCHING 12V CIRCUITS

NPN Transistor as Low Side Switch
DIVING INTO CODE
int ledPin = 13;  // LED connected to digital pin 13

void setup() {
  pinMode(ledPin, OUTPUT);
}

void loop() {
  int dark;
  for (dark=0; dark<1000; dark++) {
    if (dark<500) {
      digitalWrite(ledPin, HIGH);  // set the LED on
      delay(random(10-10*(dark/500)));
    }
    digitalWrite(ledPin, LOW);    // set the LED off
    delay(random(10+dark,50+dark));
  }
}
int ledPin = 13; // LED connected to digital pin 13

void setup() {
    pinMode(ledPin, OUTPUT);
}

void loop() {
    int i, count;
    count = random(10, 60);
    for (i = 0; i < count; i++) {
        digitalWrite(ledPin, HIGH); // set the LED on
        delay(random(60));
        digitalWrite(ledPin, LOW); // set the LED off
        delay(random(200));
    }

    delay(random(800, 2000)); // wait a random bit of time
A GRADE CROSSING
BUILDING THE HARDWARE

• Arduino Uno
• WAV Shield + SD Card
• Adafruit Proto-screwshield
• Optical Detectors (e.g., IRDOT or NightScope™)
• Walthers Crossing Signal
BASIC STRATEGY

• If Train Detected (IRDOTs connected to Digital Inputs):
  • Play Bell Sound Loop & Blink Crossing Lights (LEDs)
  • If Train No Longer Detected:
    • Lights Off; Stop Bell Sound Loop

• Source Code Available Here:
  https://github.com/railnerd/grade-crossing/
STATE MACHINE SIDEBAR

- Simple If… Then… Sequences are Easy
- Doing Complex, or Multiple Things at Once is Harder
  - (Blinking, Playing Sound, Reading Detectors)
- Requires Breaking Up the Work you Do
- Computer Folks Do This With “State Machines”
  - If you are a non-programmer, this can be mind blowing
#include <WaveHC.h>  // WaveShield Functions
#include <WaveUtil.h>

// Arduino Pin Assignments
#define EB_DETECT A0
#define WB_DETECT A1
#define LED_LEFT A2
#define LED_RIGHT A3

// Global State
enum {
  kIdle = 0,
  kEastboundApproach,
  kWestboundApproach,
  kApproachCommon,
  kOccupied
};

int interlockingState = kIdle;
int deactivateTimer = 10000;
```cpp
void setup()
{
  Serial.begin(9600); // for debugging

  // Set up detector inputs, and enable on-chip ~20K pullup resistors
  pinMode(EB_DETECT, INPUT);
  pinMode(WB_DETECT, INPUT);
  digitalWrite(EB_DETECT, HIGH);
  digitalWrite(WB_DETECT, HIGH);
  // Could also implement “center” detector if road is fouled

  // Set up LED outputs
  pinMode(LED_LEFT, OUTPUT);
  pinMode(LED_RIGHT, OUTPUT);

  // Get ready to play audio files from the SD Card
  setupSDCard();
  turnOffLEDs();
}
```
void loop()
{
  switch (interlockingState) {
    case kIdle:
      if ((digitalRead(EB_DETECT) == LOW) && (digitalRead(WB_DETECT) == HIGH)) {
        interlockingState = kEastboundApproach;
      }
      break;
    }
    else if ((digitalRead(WB_DETECT) == LOW) && (digitalRead(EB_DETECT) == HIGH)) {
      interlockingState = kWestboundApproach;
    }
    break;
    case kEastboundApproach:
      interlockingState = kApproachCommon;
      break;
    case kWestboundApproach:
      interlockingState = kApproachCommon;
      break;
    ....
case kApproachCommon:
    deactivateTimer = 10000;
    interlockingState = kOccupied;
    break;

case kOccupied:
    animateLEDs();
    playCrossingBell();
    // Hang out in occupied state until both detectors are showing clear
    if ((digitalRead(WB_DETECT) == HIGH) && (digitalRead(EB_DETECT) == HIGH)) {
        deactivateTimer--;
        if (!deactivateTimer) {
            turnOffLEDs();
            interlockingState = kIdle;
        }
    } else {
        deactivateTimer = 10000;
    }
    break;

default:
    break;
LED ROUTINES

void animateLEDs(void) {
  if (ledTimer)
    ledTimer--;  

  switch (ledState) {
    case kLEDsOff:  
    ledTimer = 0;  
      // fall through
    case kLEDRightOn:  
      if (!ledTimer) {
        ledState = kLEDLeftOn;  
        ledTimer = 10000;  
        digitalWrite(LED_LEFT,LOW);  
        digitalWrite(LED_RIGHT,HIGH);
        }
      break;

    case kLEDLeftOn:  
      if (!ledTimer) {
        ledState = kLEDRightOn;  
        ledTimer = 10000;  
        digitalWrite(LED_LEFT,HIGH);  
        digitalWrite(LED_RIGHT,LOW);
        }
      break;
  }
}
WHAT ELSE CAN YOU DO?

• Push Buttons
• Photocells
• Current Detectors
• Servo Motors
• Stepper Motors
• MP3 Playback Chips
• RFID Readers
• Other Computers
• WiFi
• Ethernet
COOL STUFF

- Seth Neumann’s RFID Work:

- Chuck Catania: Simple Signals With Arduino

- DCC Sniffer: http://www.mynabay.com/arduino

- DCC Throttle: http://www.oscale.net/en/arduino

- DC Control:
NEW THINGS
NEW STUFF

• More powerful boards with ARM processors now available
  • Due: http://arduino.cc/en/Main/ArduinoBoardDue
  • Teensy 3.0: http://www.pjrc.com/store/teensy3.html
OPENLCB, TOO.

http://railstars.com/hardware/io/io-duino/
RASPBERRY PI

• Another Game Changing Device

• 700MHz ARM Linux Computer for $25/$35!

• Full Linux System with GPIO, I2C, SPI, etc.

• Look for a Clinic Soon
WRAP UP
GETTING MORE HELP

• Online Resources:
  http://arduino.cc

• Arduini Yahoo Group:
  Arduini@yahoogroups.com

• TechShop Classes

• Books
USEFUL LINKS

• http://www.arduino.cc/

• http://www.sparkfun.com/

• http://www.adafruit.com/

• http://learn.adafruit.com/category/learn-arduino

• http://moderndevice.com/

• http://spikenzielabs.com/

• http://techshop.ws/

Just Google/Bing/Yahoo for “Arduino” in your favorite web browser!