ARDUINO + MUSIC

Matt Gray
dev@graybloomfield.com

- Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects. This session will take you through using Arduino as the basis for various music projects.

- We will cover MIDI interfaces and how to code an Arduino to be the bridge between your instrument and the real world. You'll learn how to either take input from the physical world and turn that into music, or how to play music and have that affect real world objects.

- Hardware requirements will be covered, so you will learn what you might need to purchase to get started.

- We will also go through some of the cool music related projects that the Arduino community has put together.

- What is Arduino

- What is MIDI

- Arduino + MIDI: hardware and software

- Coding stuff and physical stuff

- Alternative setups

- Example projects

WHAT IS THIS ARDUINO THING ANYWAY?

- Arduino is a tool for making computers that can sense and control more of the physical world

- Open-source hardware and software

- It's intended for artists, designers, hobbyists

- Inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators.

Raspberry Pi is another popular similar device. The Pi is based on Linux, and connects to a monitor and USB keyboard/mouse. The Arduino is more for embedded projects, and it is only running your code, not a whole operating system.

ARDUINO BOARDS

- Arduino boards come in a variety of sizes

- Most have similar chips, memory

- Some add ethernet, wireless, linux co-processors, USB device support

- There are official boards, and 3rd party boards

ARDUINO UNO

- ATmega328 8-bit chip

- 5-20V power supply

- 32kB flash memory

- 2kB SRAM

- 20 I/O pins

- ~$40

6.8cm
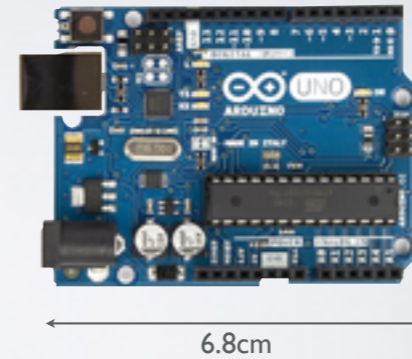
The basic starter board for Arduino. It doesn't sound like much compared to computers today - even your Apple Watch has more gigathings than this. But it is surprising how much you can do with this small amount of memory and power, when you don't have to support a fancy graphical user interface.

3RD PARTY BOARDS

- DFRobot

- Freetronics

- Sparkfun

- Funduino

- Cheaper (sometimes)

- Additional features - SD card, ethernet
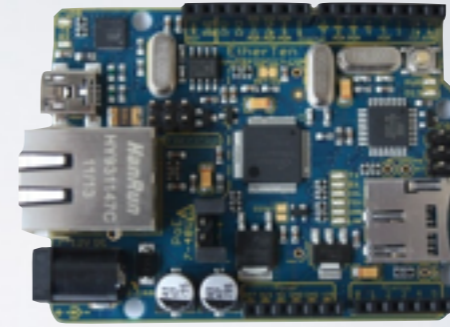
3rd party boards should be fully compatible with the official board that they are replicating. If they have extra features, that may mean that it uses up some of the resources on the board, so keep that in mind.
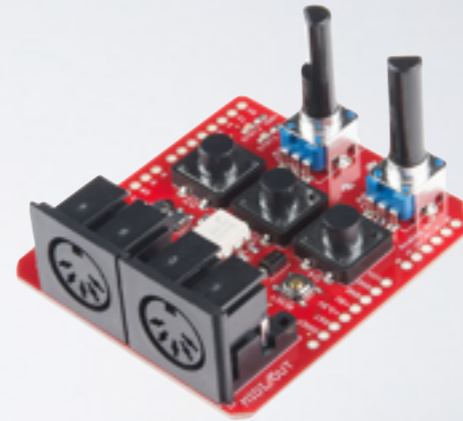
SHIELDS

- GSM (mobile)
- Ethernet
- Wifi
- GPS
- LCD and TFT screens
- SD card readers
- Motor controllers
- Vary from $$ to $$$
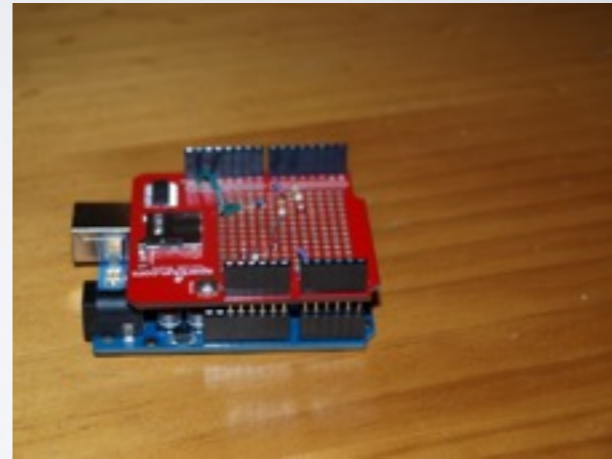
You can get a shield for pretty much any physical input or output that will plug into Arduino.

SHIELDS

- For MIDI, we can use the **Sparkfun MIDI shield**

- https://www.sparkfun.com/products/12898

- https://littlebirdelectronics.com.au/products/sparkfun-midi-shield-1

- **NOTE**: some assembly required!

This shield has MIDI in and out connectors, 3 buttons to do stuff, and two variable resistors (the turny knob things) so you can vary things and use that to affect the MIDI signals, like volume, pitch, etc.   There are other MIDI shields that just have the MIDI connectors, and don't have all the extra buttons and knobs, which you don't *really* need.

WHAT IS MIDI?

- **M**usical **I**nstrument **D**igital **I**nterface

- Introduced in 1983 as a way for different synthesiser manufacturers to interconnect hardware

- Now also available via USB, which defines a MIDI device class

If your MIDI device has only the old MIDI plugs, you can buy a MIDI to USB converter pretty cheap. Check on eBay for example.

WHAT IS MIDI?

- MIDI devices can be:

  - a **synthesiser** (it makes noises)

  - a **controller** (it has things to mash)

  - both of the above

WHAT IS MIDI?

- MIDI communicates by sending coded messages

- **"90 60 127"**
  - 90 = Turn a note on
  - 60 = Middle C
  - 127 = Note velocity (0 to 127)
- **"80 60 0"**
  - 80 = Turn a note off
  - 60 = Middle C
  - 0 = Note velocity (basically ignored when turning a note off)

The basic two commands are 90 and 80 for turning notes on and off. But there are also commands to control volume, pitch bends, modulation, timing synchronisation, and lots of other things.

MIDI CODING ON ARDUINO

- Library - **MIDI Library** by Forty Seven Effects

- Shield - e.g. **Sparkfun MIDI shield**

- MIDI to USB converter may be needed - $6 to $40 on eBay. Little Bird Electronics also stocks them.

The Arduino IDE has a library manager built in, and you can find the MIDI Library in there by searching for 'MIDI'.

MIDI CODING ON ARDUINO

- **Receiving notes**

```
//Setup
MIDI.setHandleNoteOn(handleNoteOn);

MIDI.setHandleNoteOff(handleNoteOff);

MIDI.begin(MIDI_CHANNEL_OMNI);

//Loop
MIDI.read();
```

To receive notes, we set up some functions to handle the messages (next slide), then we sit in a loop reading any incoming MIDI messages.

MIDI CODING ON ARDUINO

- **Receiving notes**

```
void handleNoteOn(byte channel, byte pitch, byte velocity) {
    if (pitch == 60) {
        digitalWrite(PIN_LED, HIGH);
    }
}

void handleNoteOff(byte channel, byte pitch, byte velocity) {
    if (pitch == 60) {
        digitalWrite(PIN_LED, LOW);
    }
}
```

A very simple example of handling MIDI notes. If we get a 'note on' message for pitch = 60 (middle C), we will turn on an LED. If we get a 'note off' message for pitch = 60, turn the LED back off again.
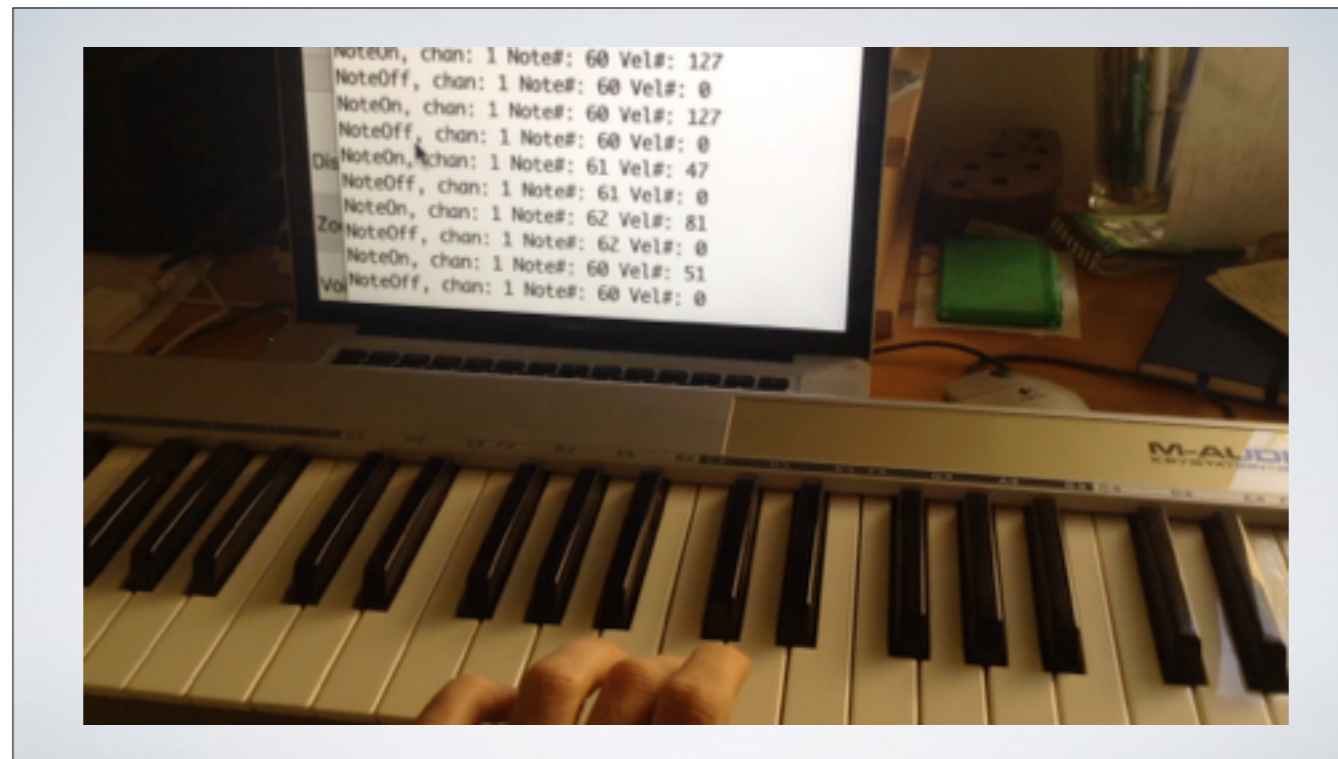
Example of Arduino receiving MIDI notes from a MIDI keyboard, and then printing the notes to a computer via USB. Pressing softly on the keys has low velocity, and pressing hard has high velocity. You can see the note on and note off messages. When I play two notes together, two 'note on' messages arrive in quick succession.

MIDI CODING ON ARDUINO

OK, so this is just flashing a few LEDs, and there aren't as many output pins on the Arduino as there are notes on the keyboard. What to do? We can use a chip called a shift register - it uses 3 pins from the Arduino to control 8 output pins. You can chain them together to get more output pins. Cost is about $1 for 74HC595. There is an Arduino tutorial called ShiftOut that covers all of this.

MIDI CODING ON ARDUINO

MIDI wasn't the only thing that was popular in the 80s. I present… leg warmers.

GETTING PHYSICAL - INPUT

- Temperature, humidity, pressure, altitude, non contact temperature
- Light, infrared signals, passive infrared movement detection, colour
- Magnetic fields, compass heading
- Sound, ultrasonic range finding
- Force, flexing, acceleration, vibration, distance, weight
- Motion capture
- Geophone (for earthquakes)
- RFID

- Electrical current
- Camera
- GPS
- Touch, Fingerprints
- Carbon Monoxide, Methane, Propane, Hydrogen
- Dust, smoke
- Alcohol!
- Heart rate, muscle movement
- FM radio

MIDI CODING ON ARDUINO

- **Playing a note**

  ```
  MIDI.sendNoteOn(60, 127, 1);

  delay(1000);

  MIDI.sendNoteOff(60, 0, 1);
  ```

Turn on middle C, high velocity, channel 1. Wait 1 second, then turn off the same note.

Whatever shield or inputs you end up using will have some example code for Arduino, and you can then stick your MIDI code in to send notes when something physical happens.

ALTERNATIVE SETUPS

- **Teensy**

- Arduino compatible, but higher spec

- USB controller - you don't need special MIDI connectors, cables or convertors

- Just plug and play

- https://littlebirdelectronics.com.au/products/teensy-3-8

This is quite a good little piece of hardware, and might be a good spot to start if you don't already have an Arduino to build on. However, community support seems to be nowhere near the Arduino levels, so finding examples and projects to look may be harder.

ALTERNATIVE SETUPS

- **MIDI Instrument Shield / MP3 and MIDI Breakout**

- A synthesiser for playing MIDI input

- https://littlebirdelectronics.com.au/products/sparkfun-music-instrument-shield

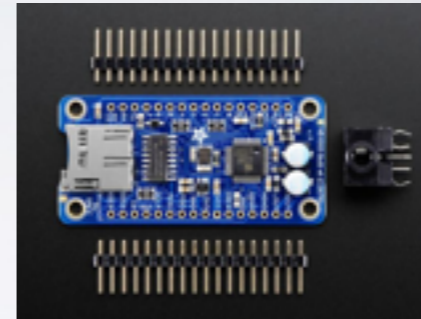- https://littlebirdelectronics.com.au/products/sparkfun-mp3-and-midi-breakout-vs1053

These boards use the vs1053 chip to play sound files or MIDI commands. If you want to build your own synth this might be the way to go for a basic setup.

ALTERNATIVE SETUPS

- **MIDI / MP3 Player Shield**

- https://learn.adafruit.com/adafruit-vs1053-mp3-aac-ogg-midi-wav-play-and-record-codec-tutorial

- https://littlebirdelectronics.com.au/products/vs1053-codec-microsd-breakout-mp3-wav-midi-ogg-play-record-v4

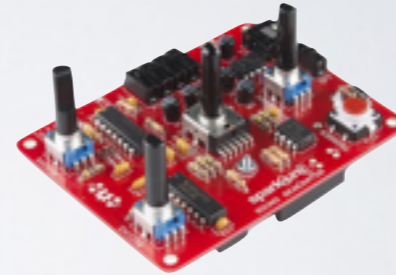Another one using the vs1053 chip… different manufacturer, and a smaller form factor.

A more capable MIDI synthesiser chip on this one? Seems to be higher spec.

ALTERNATIVE SETUPS

- **Atari Punk Console**

- Lots of knobs and switches for making noise

- https://littlebirdelectronics.com.au/products/sparkfun-sparkpunk-sequencer-kit

- https://littlebirdelectronics.com.au/products/sparkfun-sparkpunk-sound-kit

The Atari Punk Console is a basic schematic with a small number of chips that can recreate a sound similar to Atari computer music from the 80s. These kits build on that. Good fun, not really MIDI related but hey.

MAKEY MAKEY

Makey Makey has been around for a number of years now, but it's still fun to play with. You can use it for a quick start with music (or other) projects that need to use physical input.

EXAMPLE PROJECTS

https://blog.arduino.cc/2014/09/09/real-life-lego-rock-band-powered-by-arduino/

EXAMPLE PROJECTS

- 3D print your own MIDI 'guitar'

- https://learn.adafruit.com/ez-key-wireless-midi-controller-guitar/

- **Bluefruit EZ-Key** bluetooth keyboard hardware

- **VMPK** virtual MIDI keyboard software

This is a different way to get MIDI from your build to your computer. The device has a bluetooth keyboard that sends ascii keys when you interact with the instrument. The computer is then running software to map those keyboard presses into MIDI messages, to send to Garage Band, etc.

EXAMPLE PROJECTS

- Pringles tins as drums

- https://blog.arduino.cc/2016/11/03/turn-mini-pringles-cans-into-electronic-drums

Vibration sensors in the Pringles tins go to an Arduino, which converts that to MIDI signals on the drum channel.

EXAMPLE PROJECTS

- Glove controlled MIDI sliders for guitar

- Uses a metal detector to control the MIDI messages

- https://blog.arduino.cc/2016/10/17/a-touchless-midi-controller-for-your-electric-guitar/

The Touchless MIDI Controller

A metal detector built into the guitar, and a metal glove lets him control the effects by moving his hand closer and further away from the guitar.

EXAMPLE PROJECTS

- Life size Roland TR-808

- http://sonicrobots.com/Project/mr-808-interactive/

A software controller on a tablet talks to an Arduino, which then controls motors playing the physical drums.
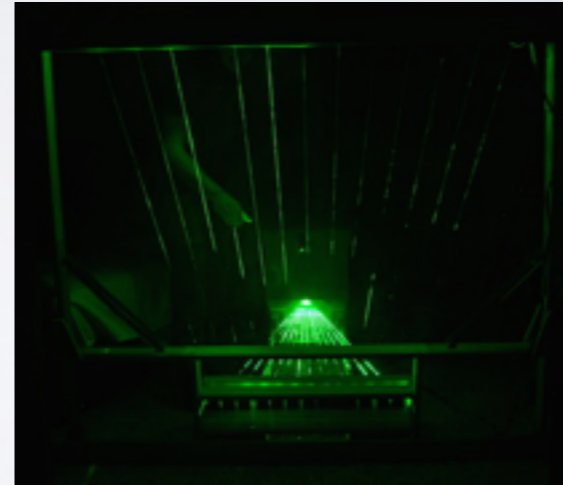
EXAMPLE PROJECTS

- Interactive musical sidewalk

- https://blog.arduino.cc/2016/07/13/
  interactive-sidewalks-plays-music-to-
  your-shadows/

A large installation in Arizona - shadows trigger light sensors embedded in the ground, which goes to one of 6 Arduino controllers, which then interface with music software.

EXAMPLE PROJECTS

- MIDI laser harp

- https://blog.arduino.cc/2016/05/04/play-some-tunes-on-a-13-note-midi-laser-harp/

USEFUL STUFF

- **http://arduino.cc**

- **Arduino and compatible boards:**

  - https://littlebirdelectronics.com.au/collections/arduino-boards

  - www.sparkfun.com

  - www.dfrobot.com

  - www.freetronics.com

- **MIDI / Music stuff:**

  - https://www.amazon.com/Arduino-Music-Audio-Projects-Mike/dp/1484217209

- https://learn.sparkfun.com/tutorials/midi-tutorial/all

- http://makezine.com/projects/make-35/advanced-arduino-sound-synthesis/

- **MIDI Shield:**

  - https://www.sparkfun.com/products/12898

  - https://learn.sparkfun.com/tutorials/midi-shield-hookup-guide

  - https://littlebirdelectronics.com.au/products/sparkfun-midi-shield-1

USEFUL STUFF

- **Teensy:**

  - https://ask.audio/articles/how-to-build-a-simple-diy-usb-midi-controller-using-teensy

  - https://www.pjrc.com/teensy/td_midi.html

  - https://littlebirdelectronics.com.au/products/teensy-3-3

  - https://littlebirdelectronics.com.au/products/teensy-3-8

- **Other hardware:**

  - http://makeymakey.com

- https://littlebirdelectronics.com.au/products/sparkfun-sparkpunk-sequencer-kit

- https://littlebirdelectronics.com.au/products/sparkfun-sparkpunk-sound-kit

- https://littlebirdelectronics.com.au/products/bleep-drum-kit-with-midi

- https://littlebirdelectronics.com.au/products/sparkfun-music-instrument-shield

- https://littlebirdelectronics.com.au/products/sparkfun-mp3-and-midi-breakout-vs1053

- https://www.arduino.cc/en/Tutorial/ShiftOut

USEFUL STUFF

- **Example projects:**

  - **https://blog.arduino.cc/category/music/**

  - https://blog.arduino.cc/2016/11/03/turn-mini-pringles-cans-into-electronic-drums

  - https://blog.arduino.cc/2016/10/17/a-touchless-midi-controller-for-your-electric-guitar/

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THANKS!

dev@graybloomfield.com

http://graybloomfield.com/cw16/