EMBEDDED SYSTEMS AND KINETIC ART: *DRAWING MACHINES*

CS5789: Erik Brunvand
School of Computing

Art3490/4490: Paul Stout
Department of Art and Art History

Logistics

- Class meets T-Th 3:40-5:00pm
- We'll start meeting in Art 169
  - At some point we may also meet in MEB 3133 (Merrill Engineering Building) on the north side of campus
- Web page is www.eng.utah.edu/~cs5789

Kinetic Art

- Kinetic art contains moving parts
  - Depends on motion, sound, or light for its effect
- Kinetic aspect often controlled by microcontrollers
  - Using motors, actuators, transducers, sensors
- The artwork can react to its environment
  - Distinct from "computer art"
  - The computer is usually behind the scenes

Embedded Systems

- Computer systems that are embedded into a complete device
  - Often small or special purpose computers/ microprocessors
  - Designed to perform one or a few dedicated functions
  - Often reactive to environmental sensors
  - Often designed to directly control output devices

Drawing Machines

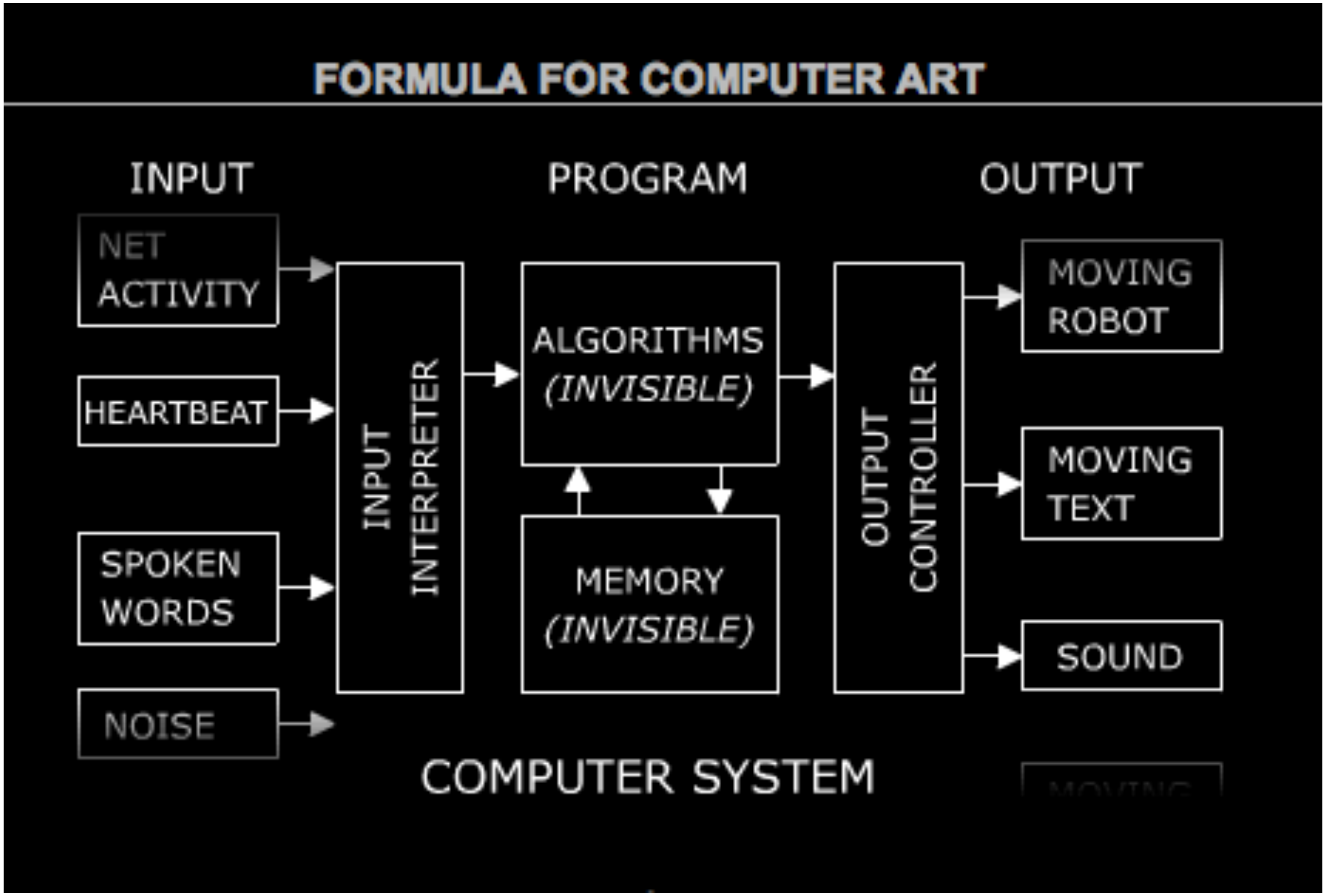
- Kinetic art that makes drawings
  - Drawing is mark-making
  - Mark-making can be interpreted in many ways…
  - We'll explore lots of options

Embedded Systems and Kinetic Art

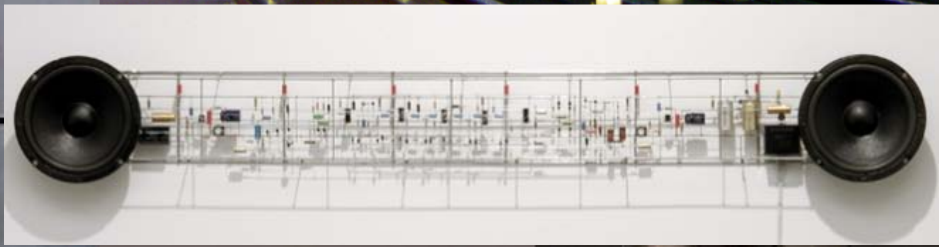
- Cross-college collaborative course
  - Brings Art students and Computer Science and Engineering (CSE) students together
  - Design and build embedded-system-controlled kinetic art
    - Drawing Machines are the focus this spring
  - Goal is that both groups of students benefit

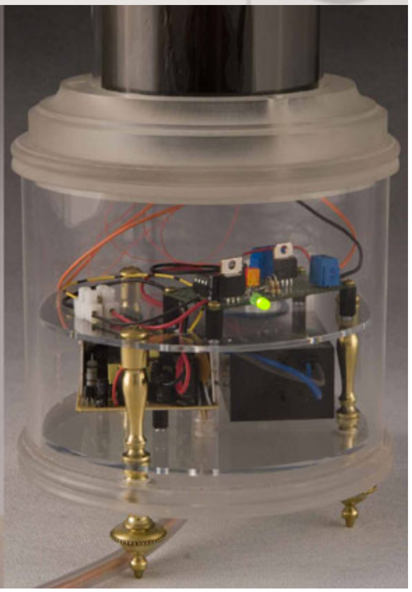
- Fundamental nature of ***Design***
  - Engineering design vs. creative design?

Jim Campbell's Algorithm

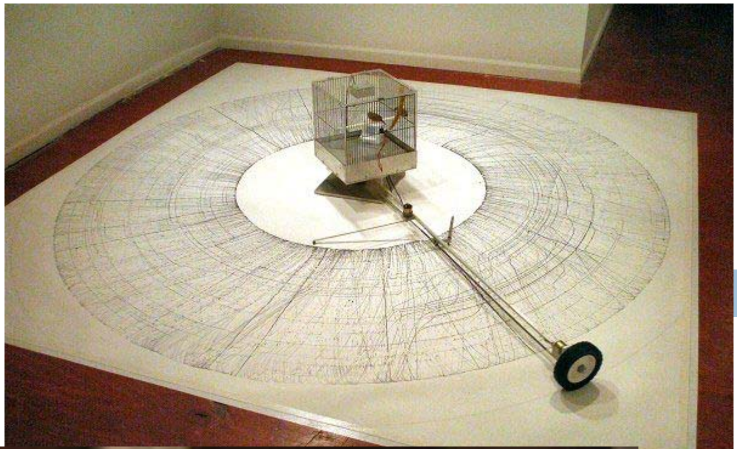


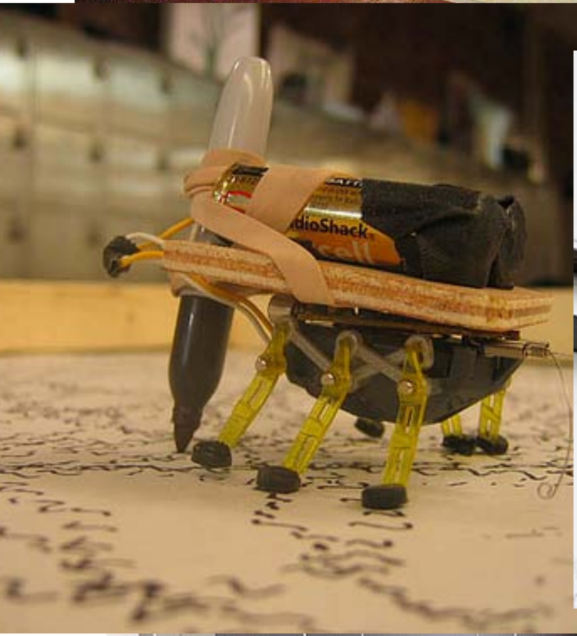
Kinetic Art

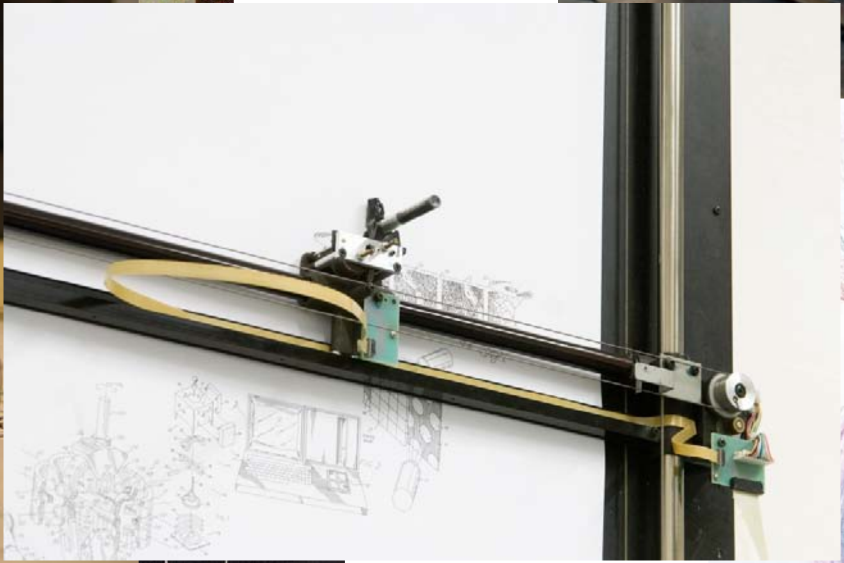




Drawing Machines





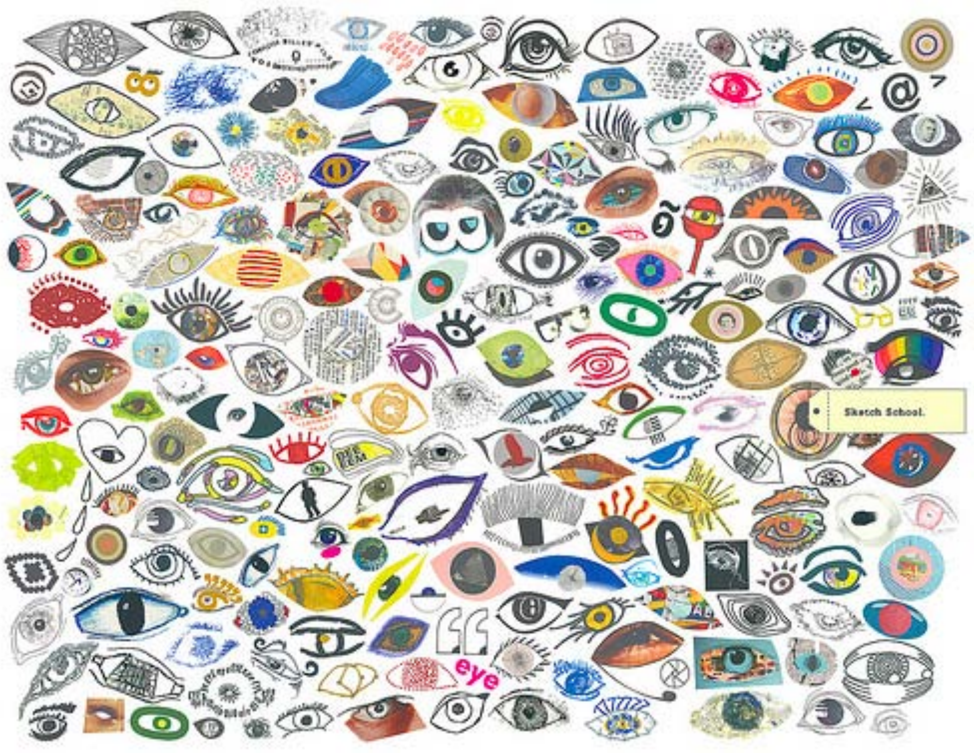


How Will the Class Work?

- Good question! It’s an ongoing experiment from both sides…
  - Start with some background study
    - Hands-on simple drawing machines to warm up
  - Some hands-on labs with the microcontroller
    - Build a toolkit of input sensors, output transducers and computer code to interface with them
  - Teams will eventually design a project (or two?) together
  - Class critiques, refinement, final build
  - Exhibit of the results in Spring

How Will the Class Work?

- Also: everybody should keep a sketchbook
  - At least a page a day
    - Not every page needs to be a masterpiece…
  - Design ideas, inspiration, thoughts, etc.
  - Look at Carol Sogard's "Sketch School" for inspiration



http://www.flickr.com/photos/carolsogard/sets/72157627069987019/

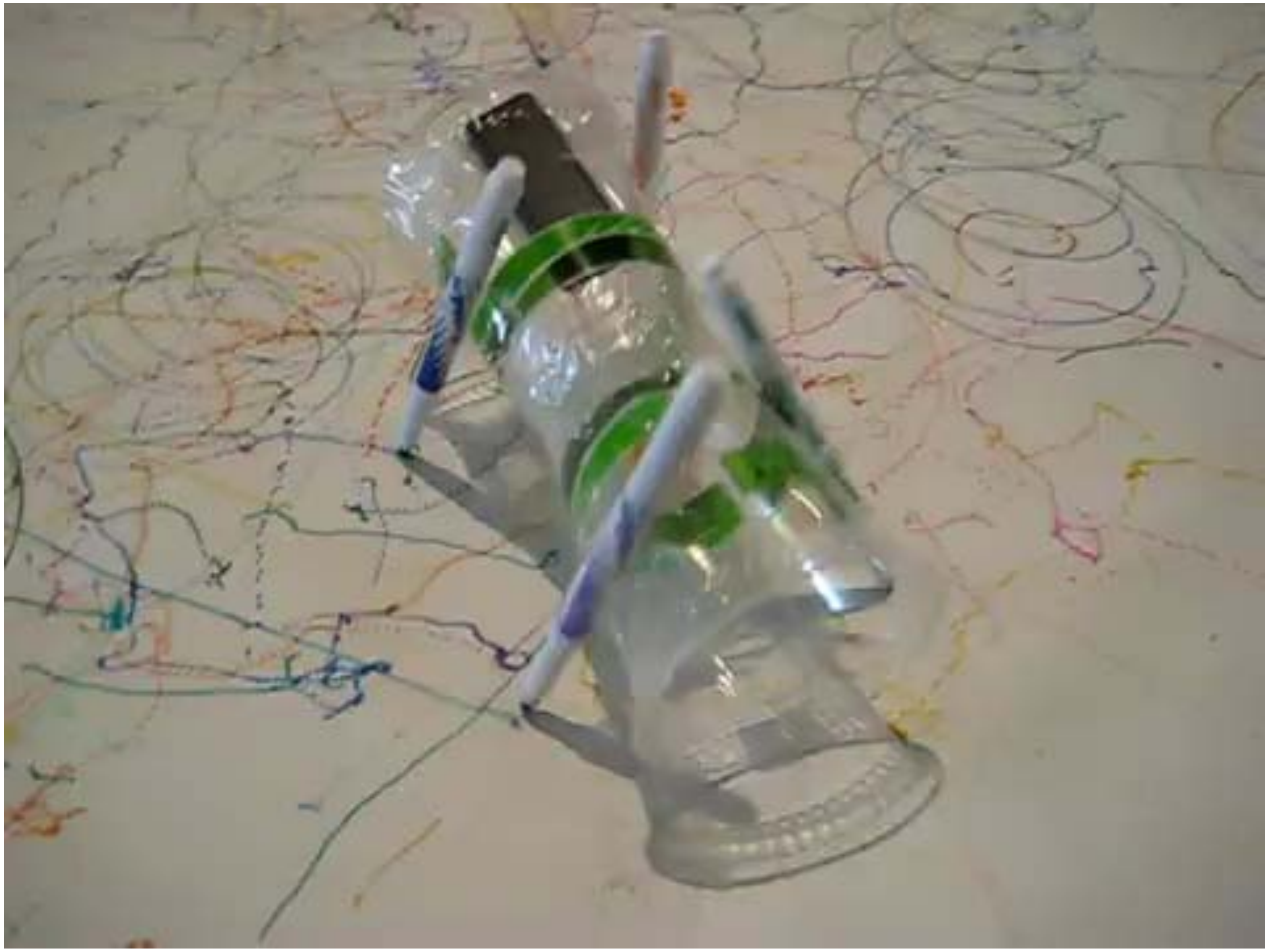
How Will the Class Work?

- Also occasional readings
  - One-page responses, and class discussions
  - Readings will be posted to the class web page
  - First reading: “Art in the Age of Mechanical Reproduction”
    - 1936 essay by German cultural critic Walter Benjamin

Drawing Machine Survey

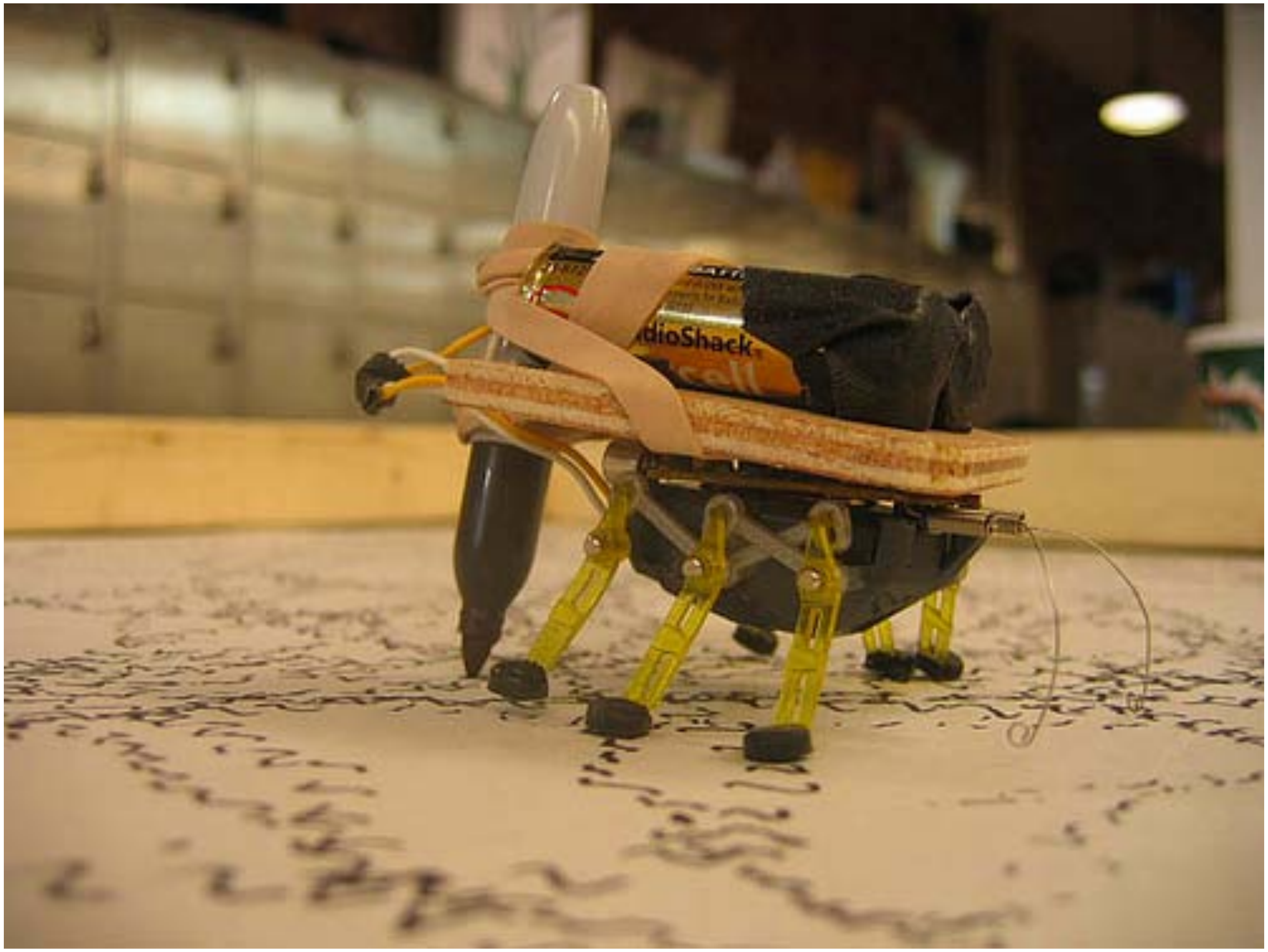
- Not comprehensive!
- Kinetic art as drawing machines
  - Ranges from very simple to very complex
  - Mark-making takes on many meanings

Very Simple Drawing Machines



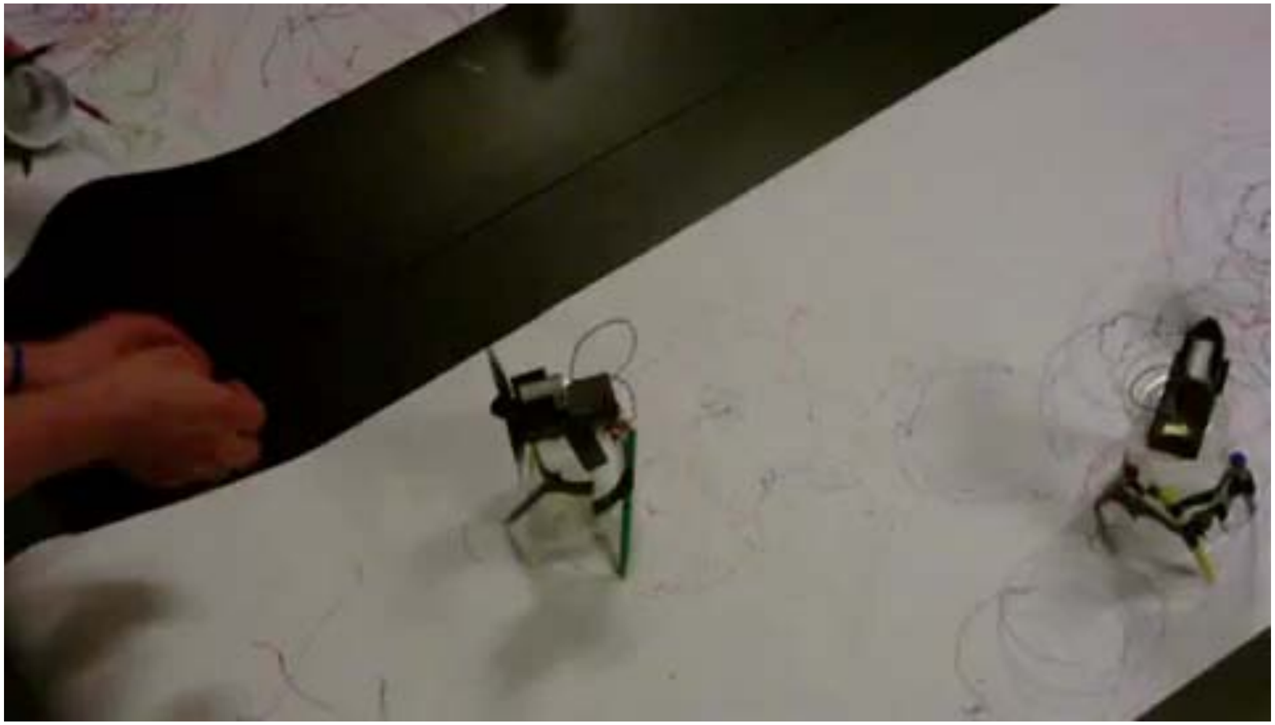
http://www.youtube.com/watch?v=oQMcRvkkoO0

Very Simple Drawing Machines



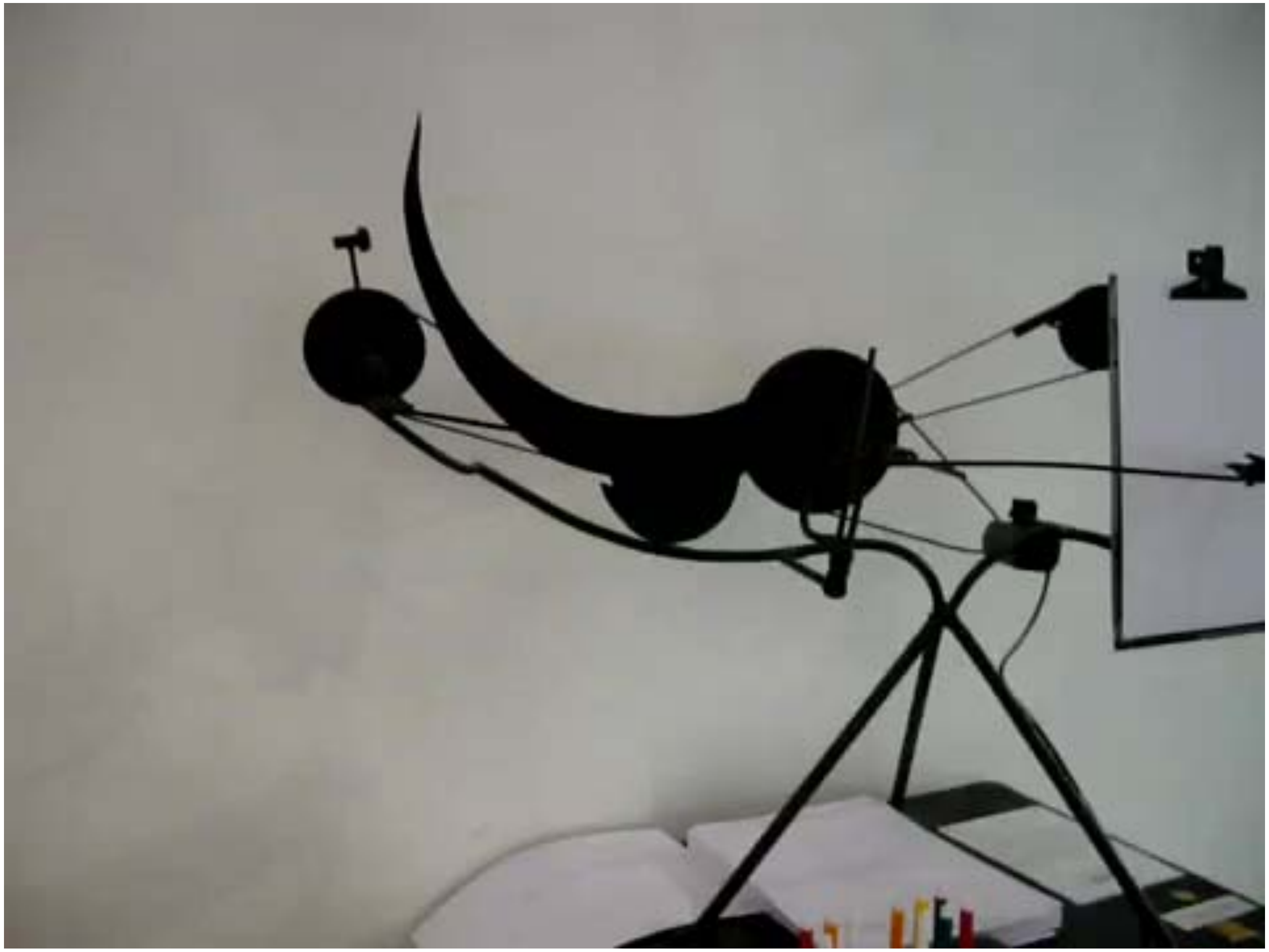
http://blubee.com/theblog/?p=53

Very Simple Drawing Machines



http://www.youtube.com/watch?v=nJuVvxLeeaU

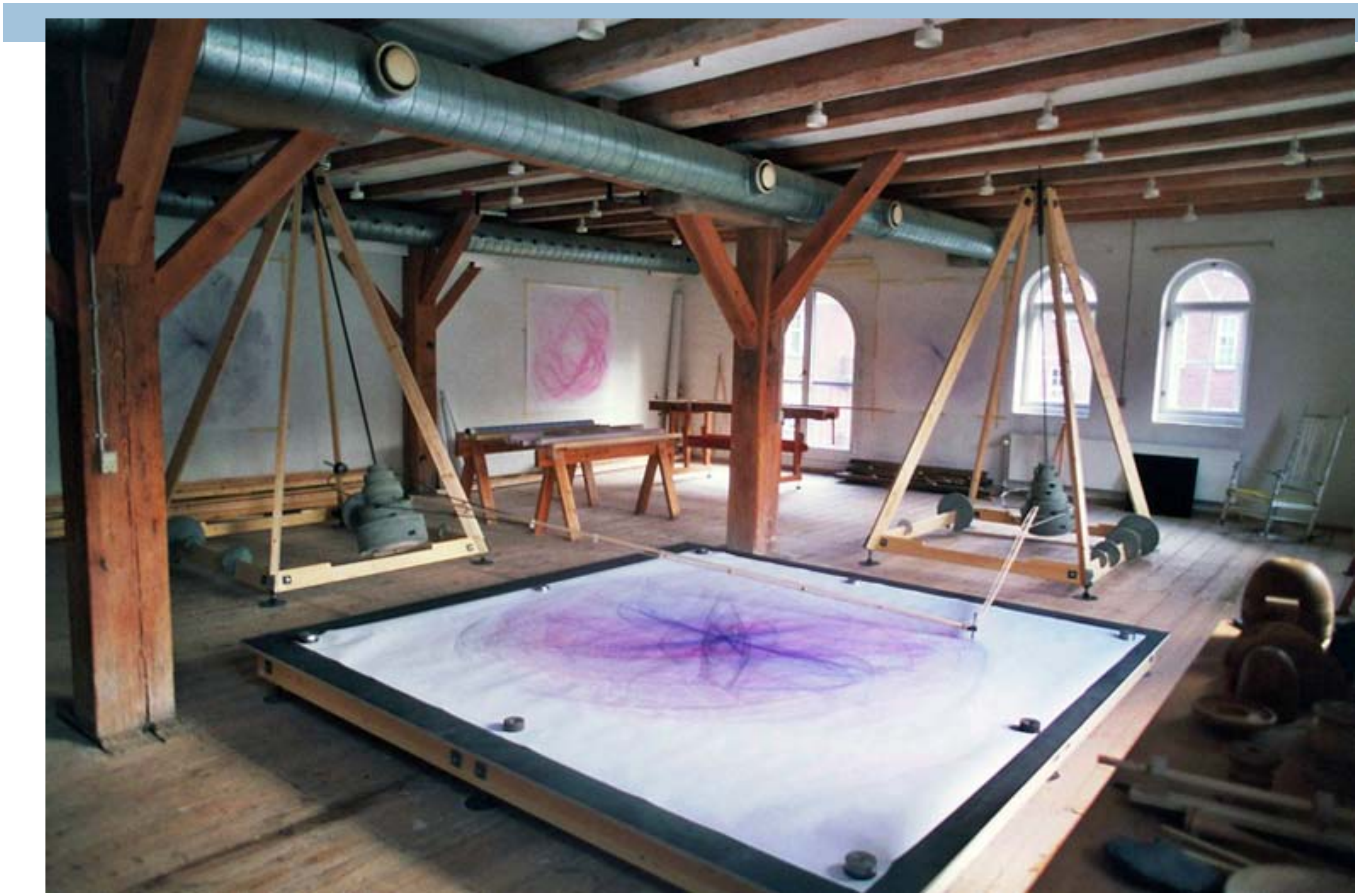
Mechanical Drawing Machines



Jean Tinguely
Metamatic
1959

http://www.youtube.com/watch?v=GOo5uq2fH6g

Mechanical Drawing Machines

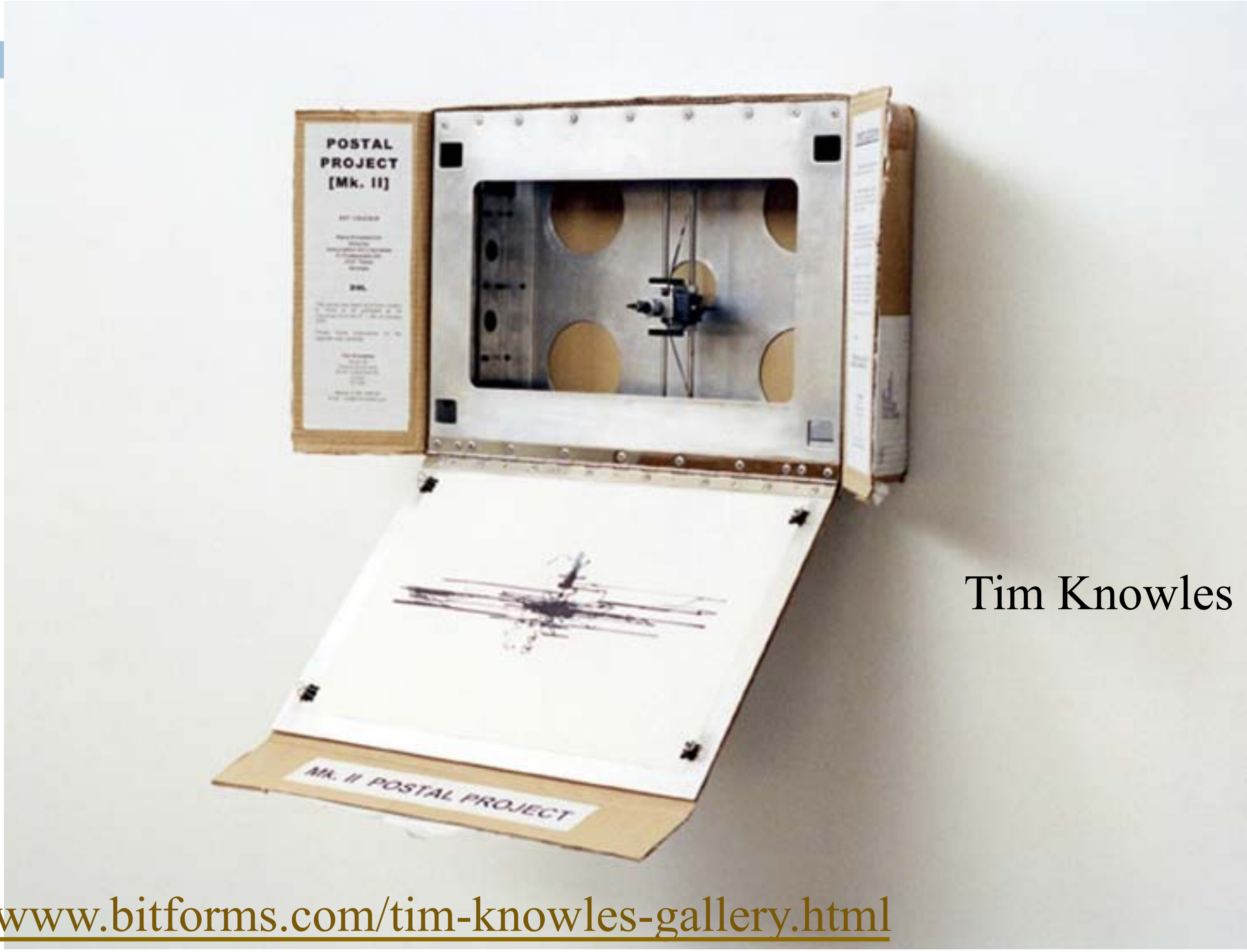


http://www.happy-pixels.com/2011/07/08/drawing-machine/

Mechanical Drawing Machines

http://www.youtube.com/watch?v=5yumD0ezoVE

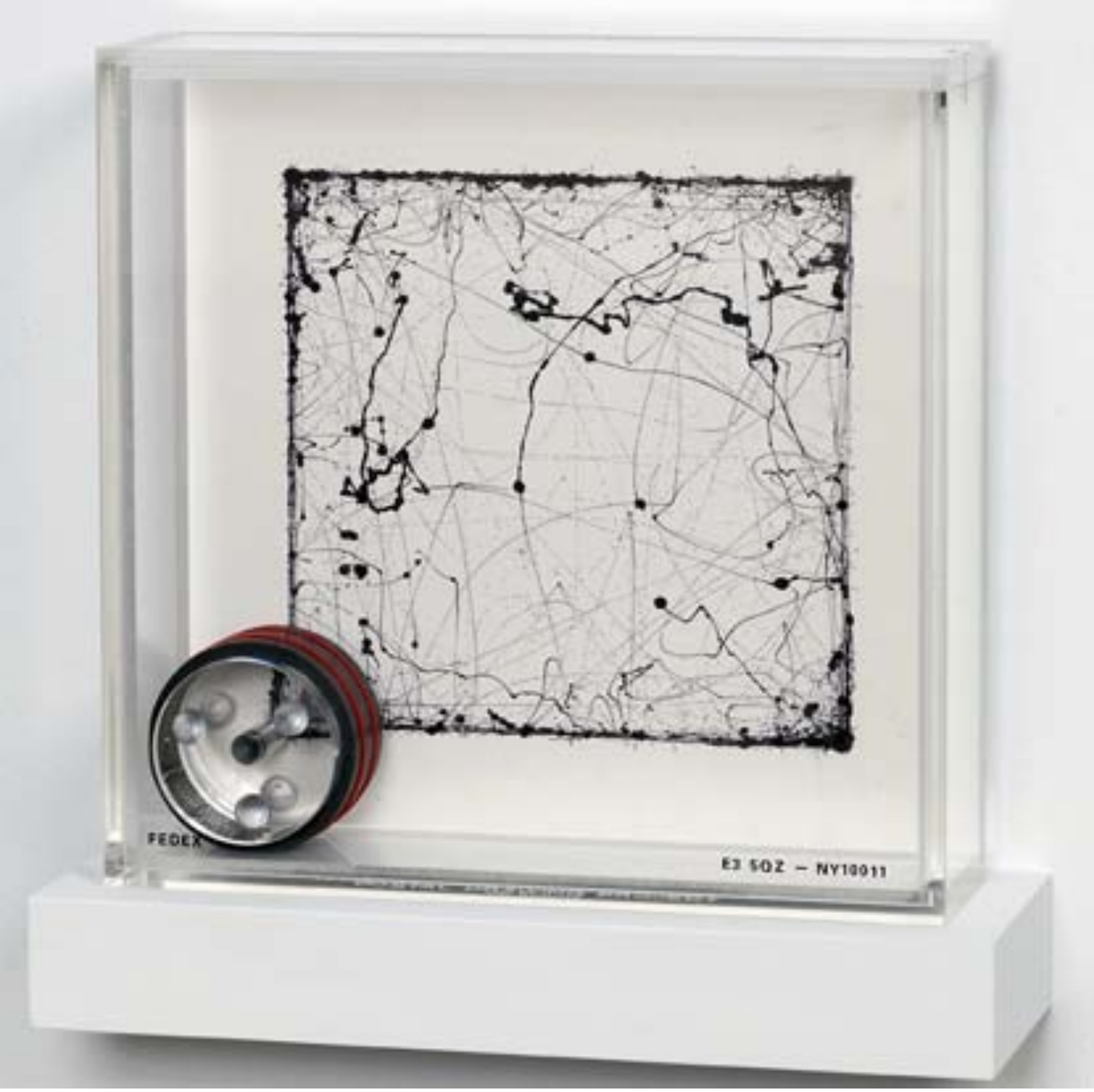
Mechanical Drawing Machines



Tim Knowles

http://www.bitforms.com/tim-knowles-gallery.html

Mechanical Drawing Machines



Tim Knowles

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Mechanical Drawing Machines

http://www.youtube.com/watch?v=dPZ-Mpbn37U

Mechanical Drawing Machines

http://www.youtube.com/watch?v=4O8tDgYh7LY

Mechanical Drawing Machines

http://www.fi.edu/learn/sci-tech/automaton/automaton.php?cts=instrumentation

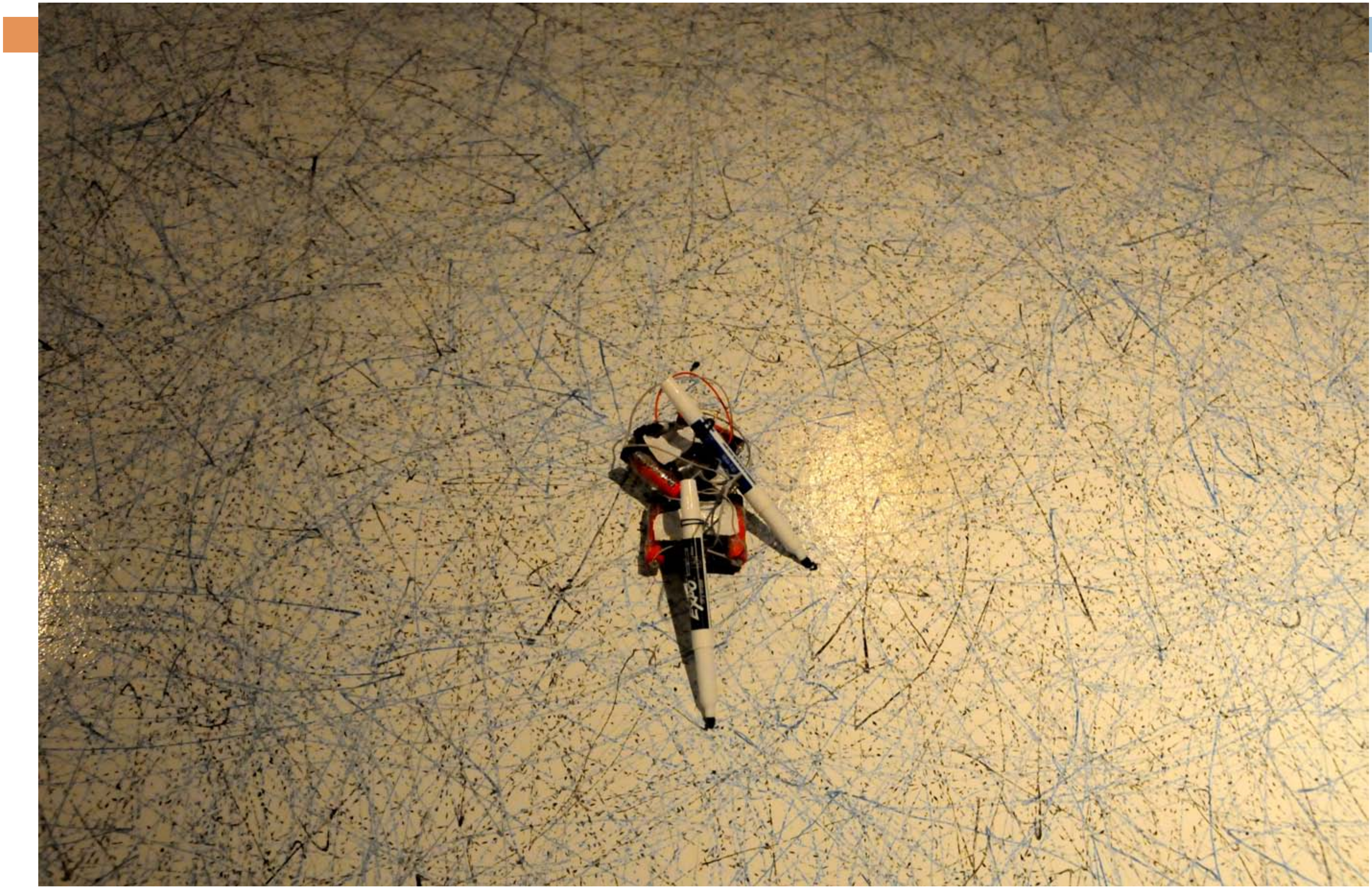
Mechanical Drawing Machines

http://www.youtube.com/watch?v=pokSViy6Eck

Mechanical Drawing Machines

http://www.youtube.com/watch?v=Qem8FVdQ5gA

Computer Controlled Machines



Computer Controlled Machines

Computer Controlled Machines

http://www.dwbowen.com/

Computer Controlled Machines

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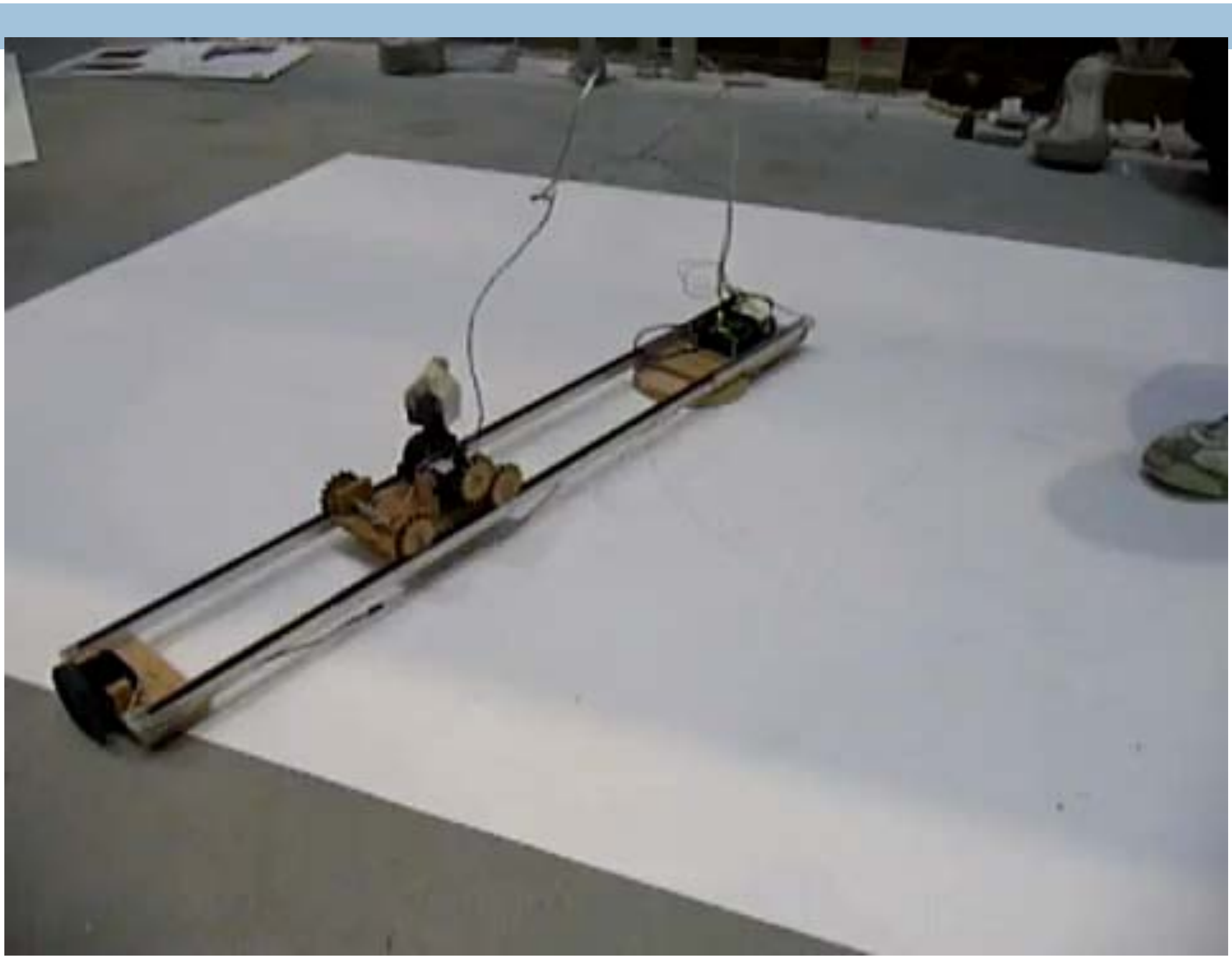
Computer Controlled Machines



http://www.youtube.com/watch?v=VnwActJx2nU

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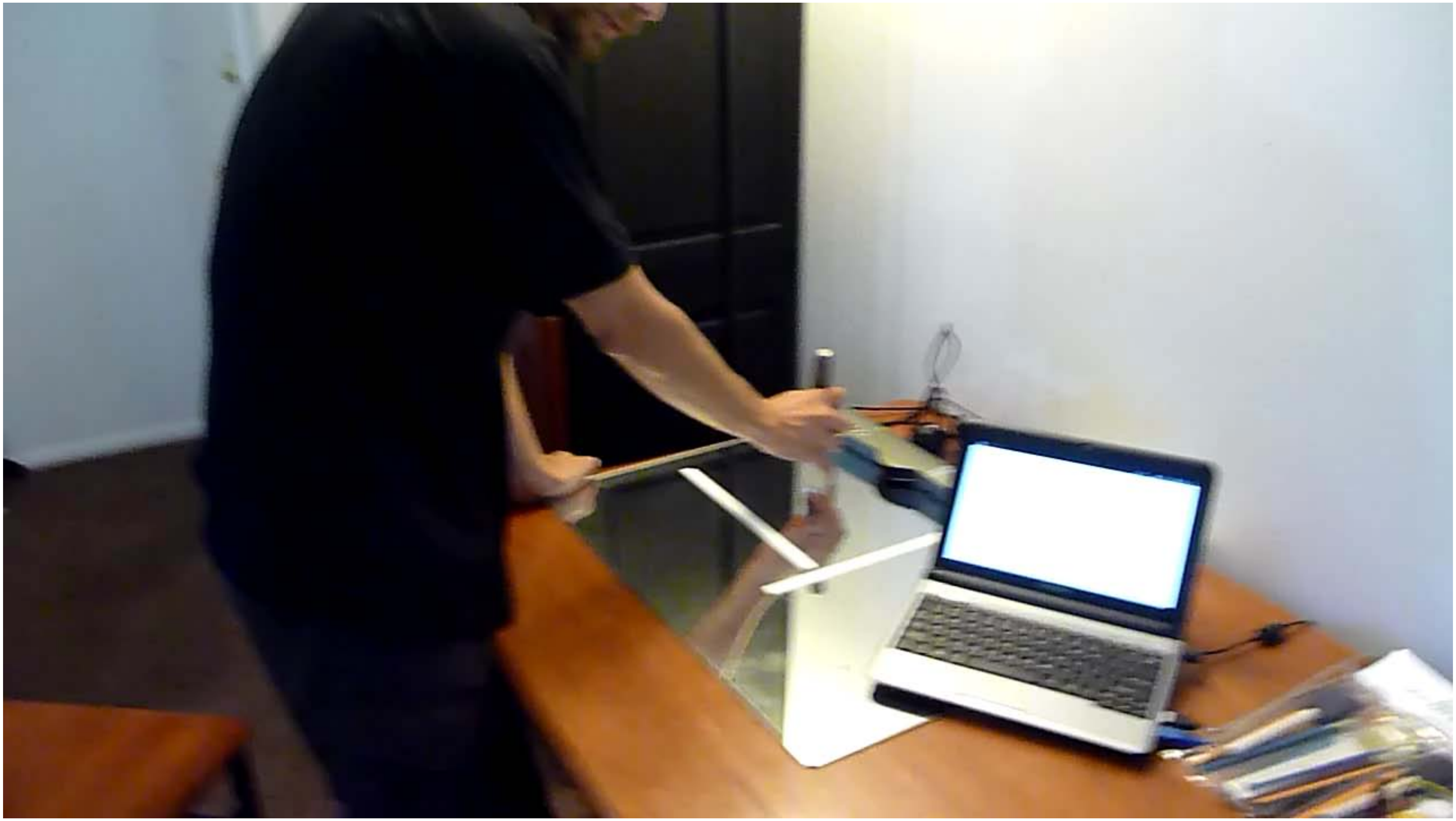

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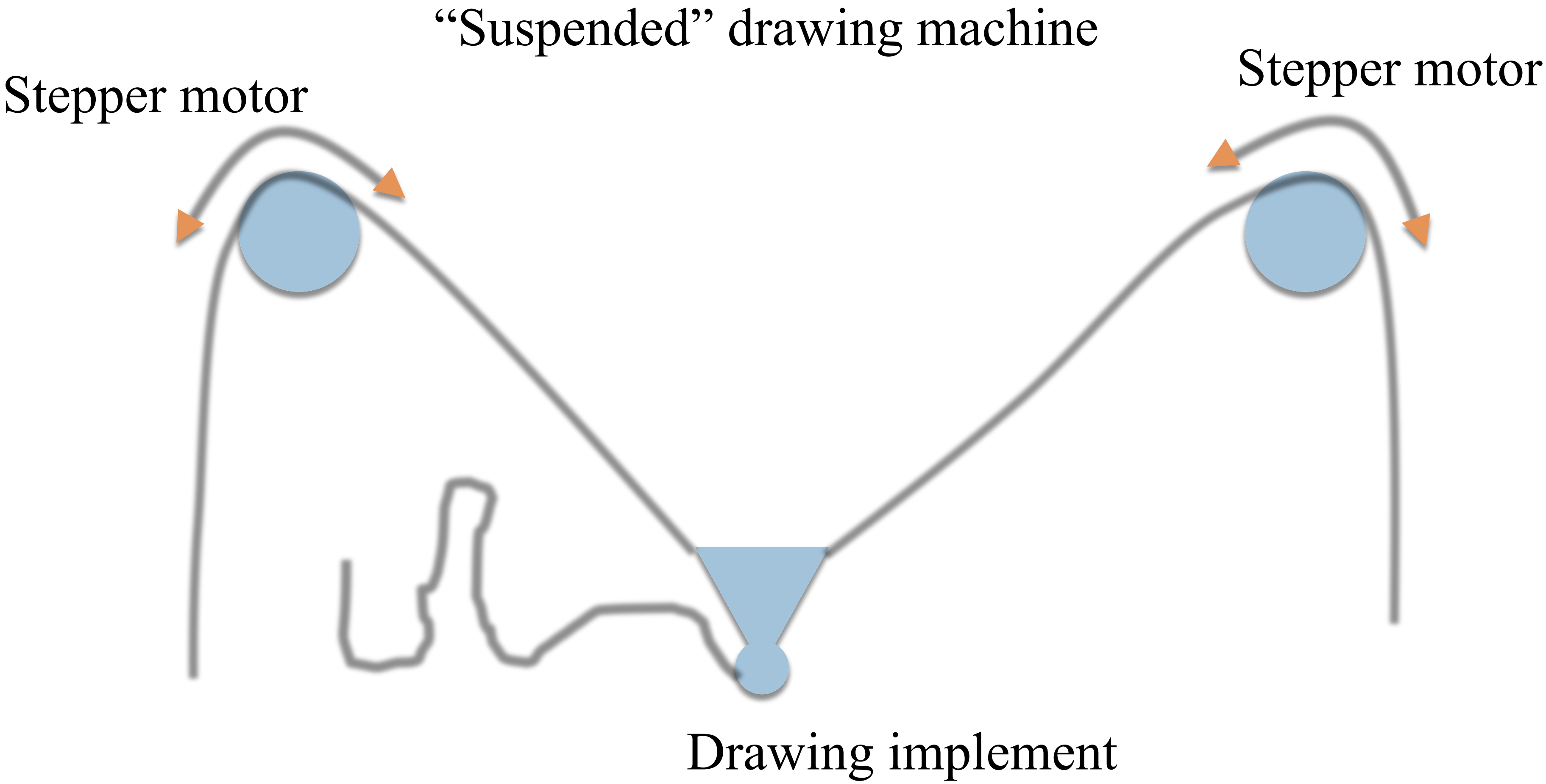

Computer Controlled Machines

Computer Controlled Machines

http://www.youtube.com/watch?v=i5rxxGuWUo8

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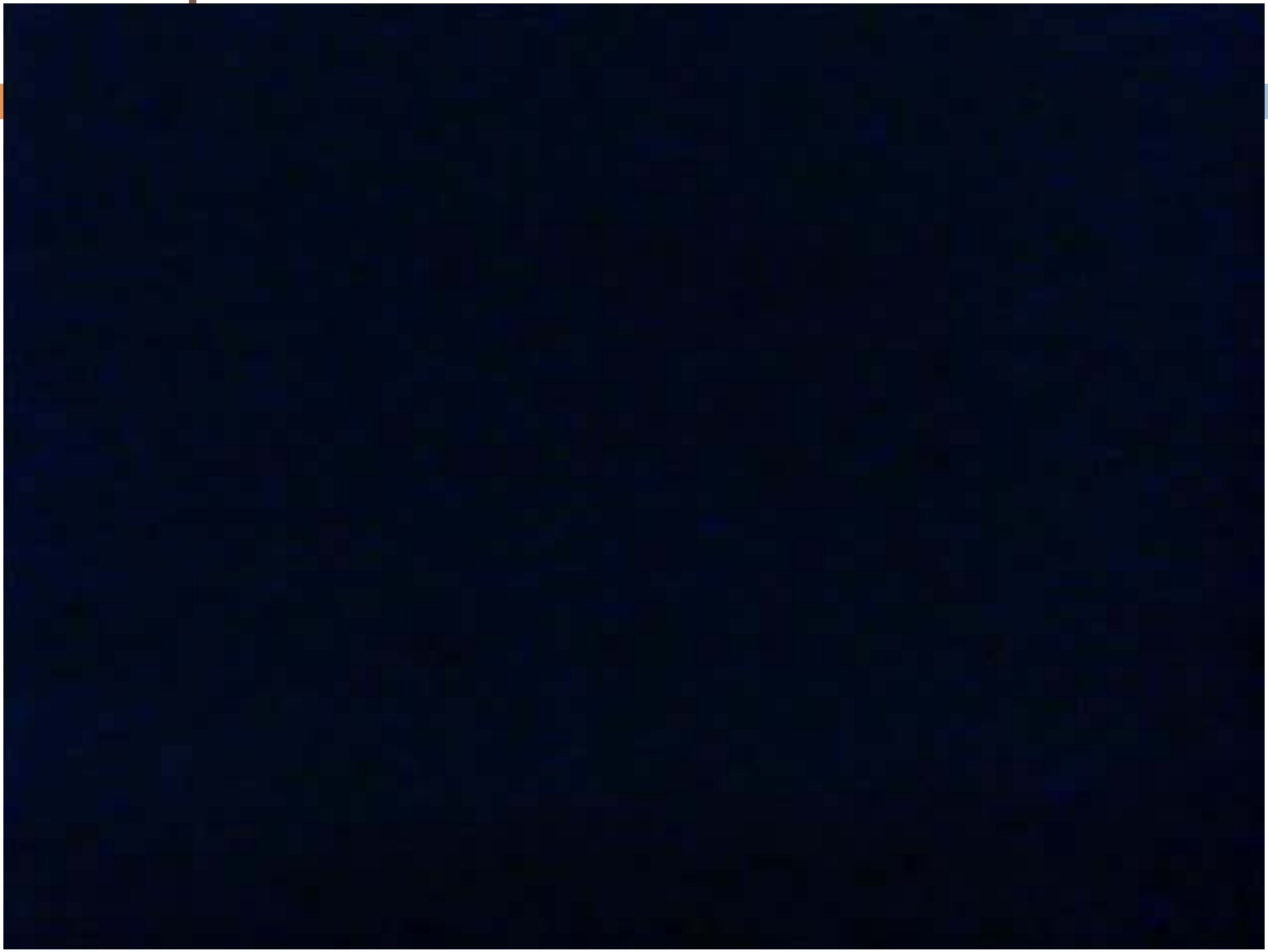
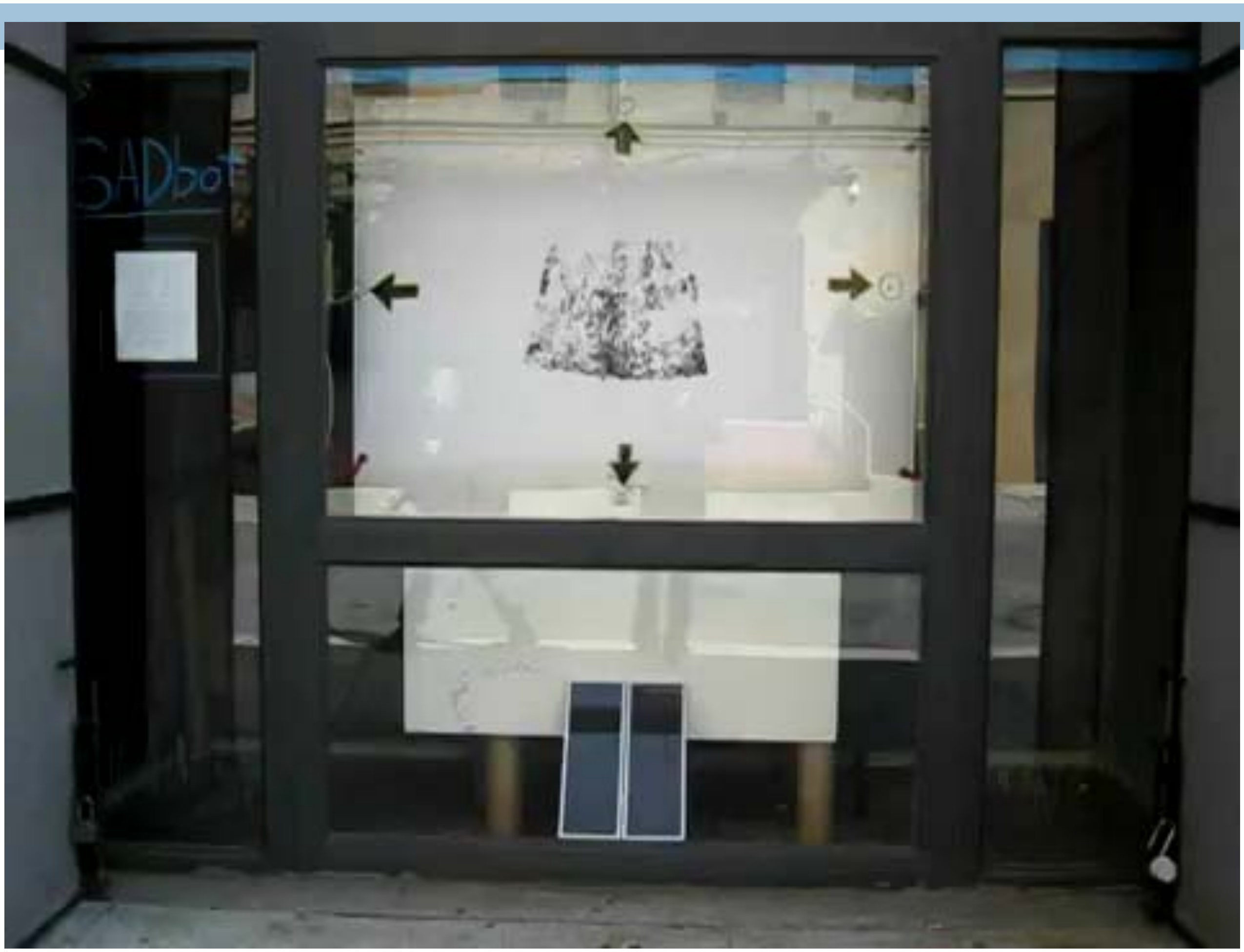


http://vimeo.com/24647023

Computer Controlled Machines

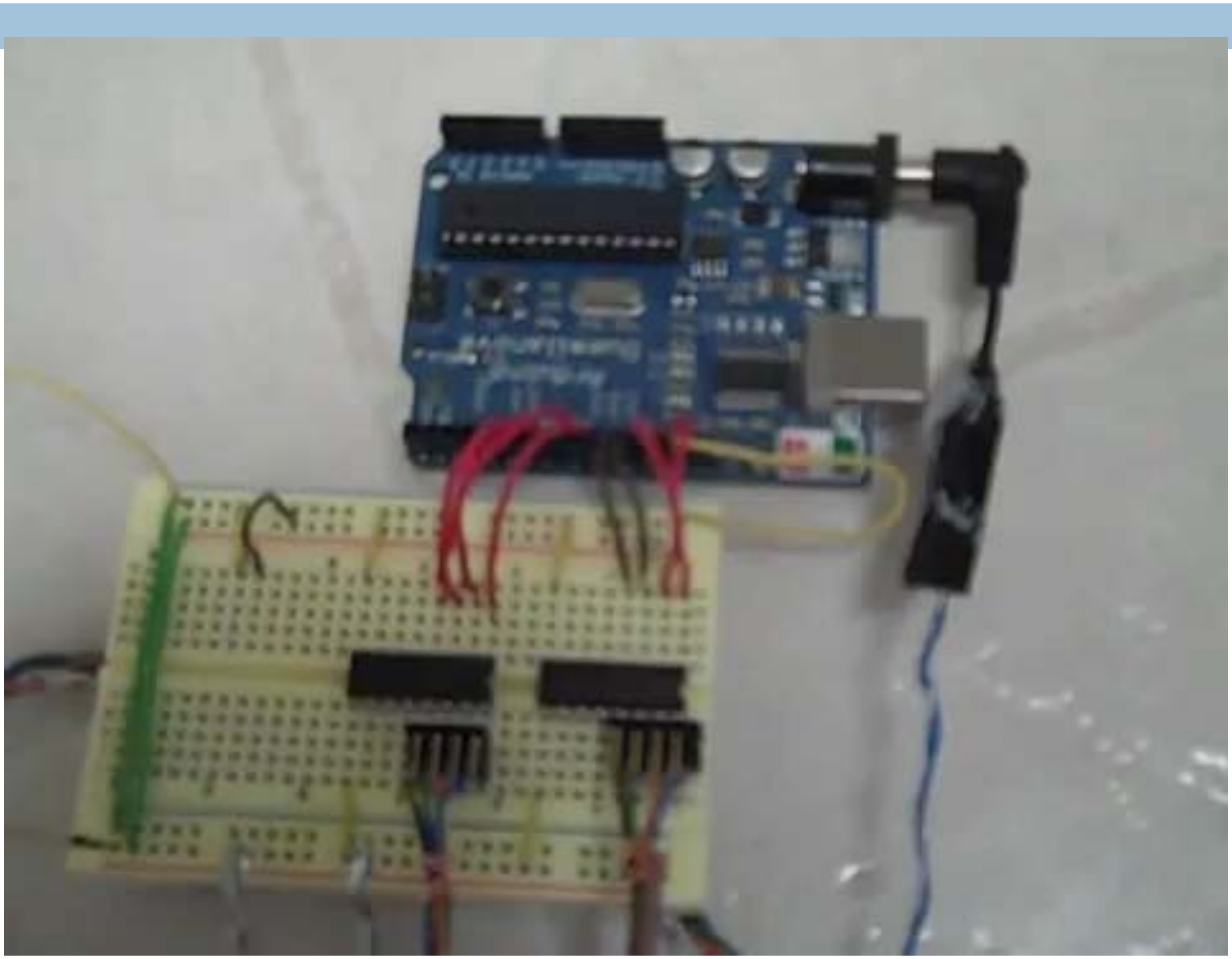
Computer Controlled Machines



“SADbot” suspended drawing machine – Dustyn Roberts

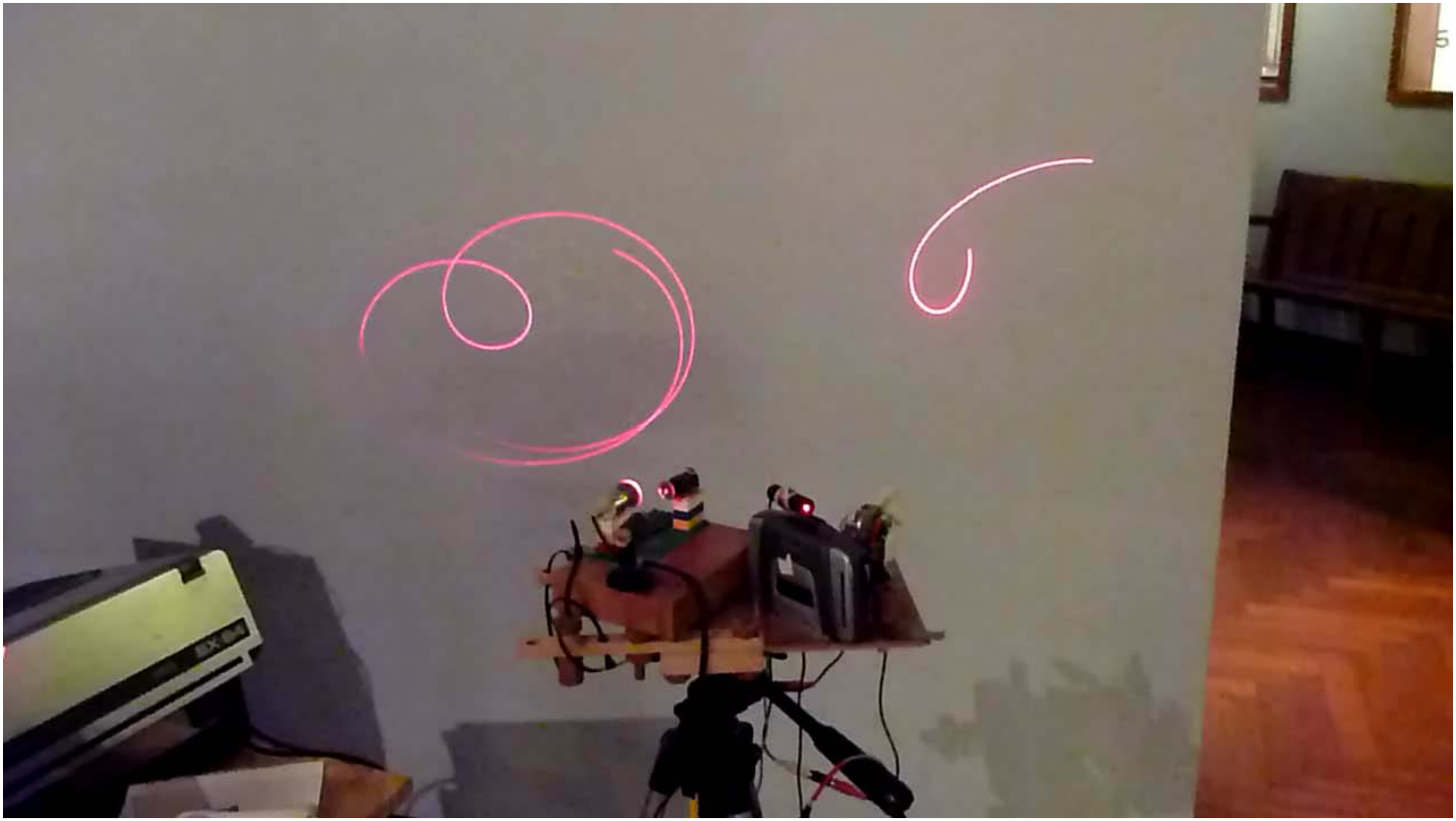
http://www.youtube.com/watch?v=mDNl4pxh_dk

Computer Controlled Machines

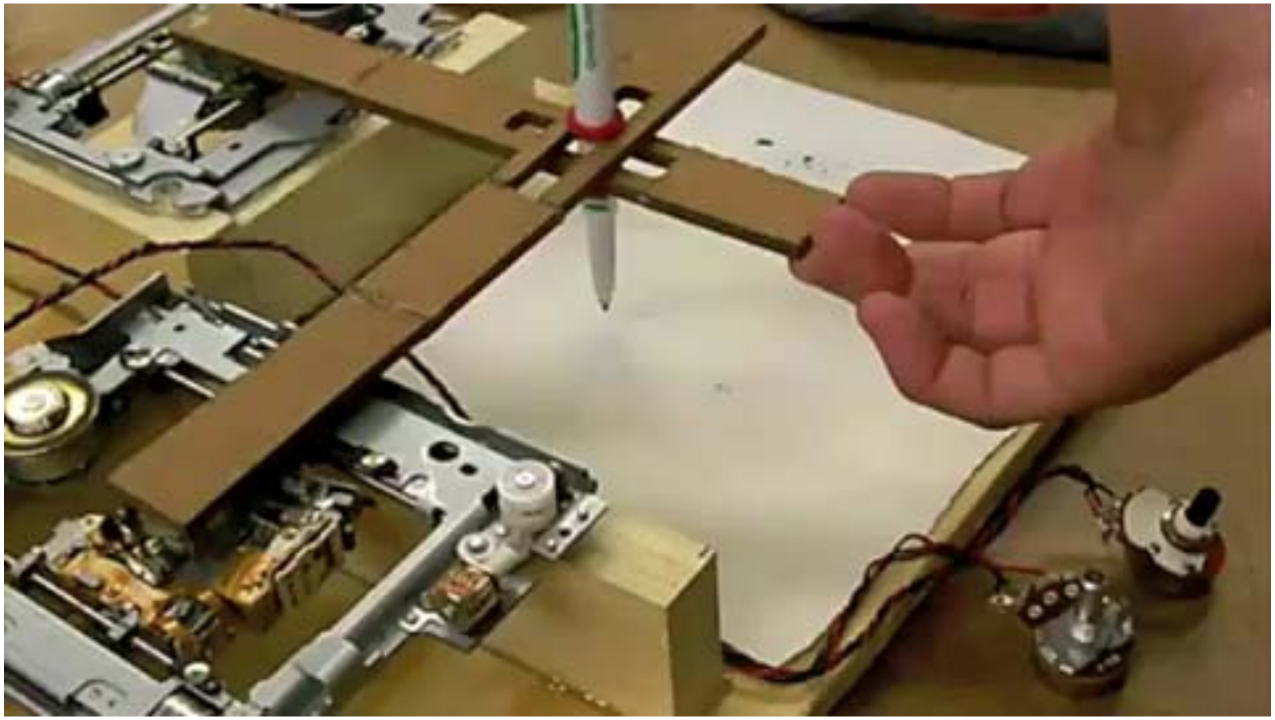


http://www.youtube.com/watch?v=z8V1eTA5R6E

Computer Controlled Machines



Computer Controlled Machines

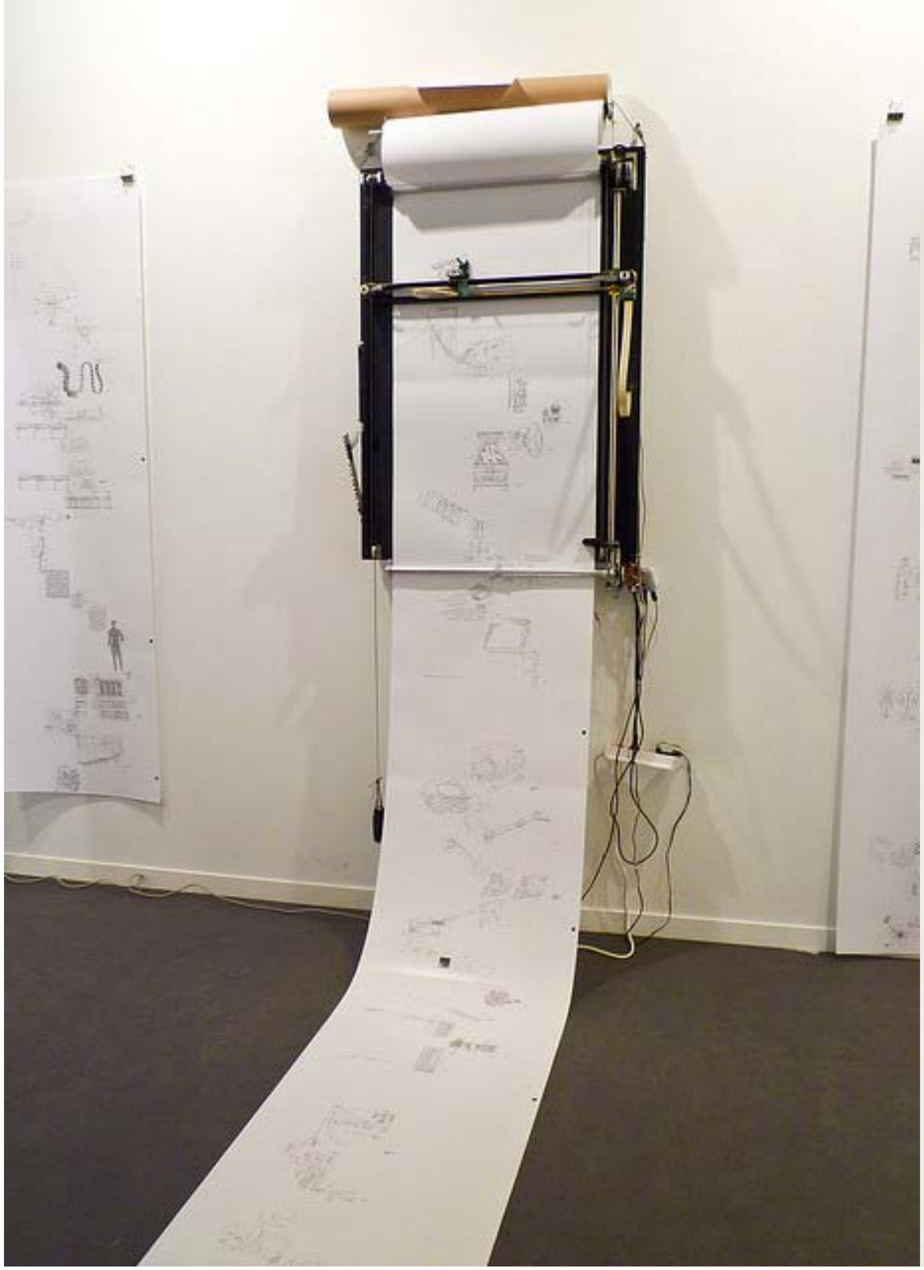


http://www.youtube.com/watch?v=qWfUAfPWoIA

Computer Controlled Machines

http://www.youtube.com/watch?v=uI5L42-ZY00

Computer Controlled Machines



http://storyteller.allesblinkt.com/

Computer Controlled Machines

http://www.youtube.com/watch?v=T0EAvqCdP2s

Whew!

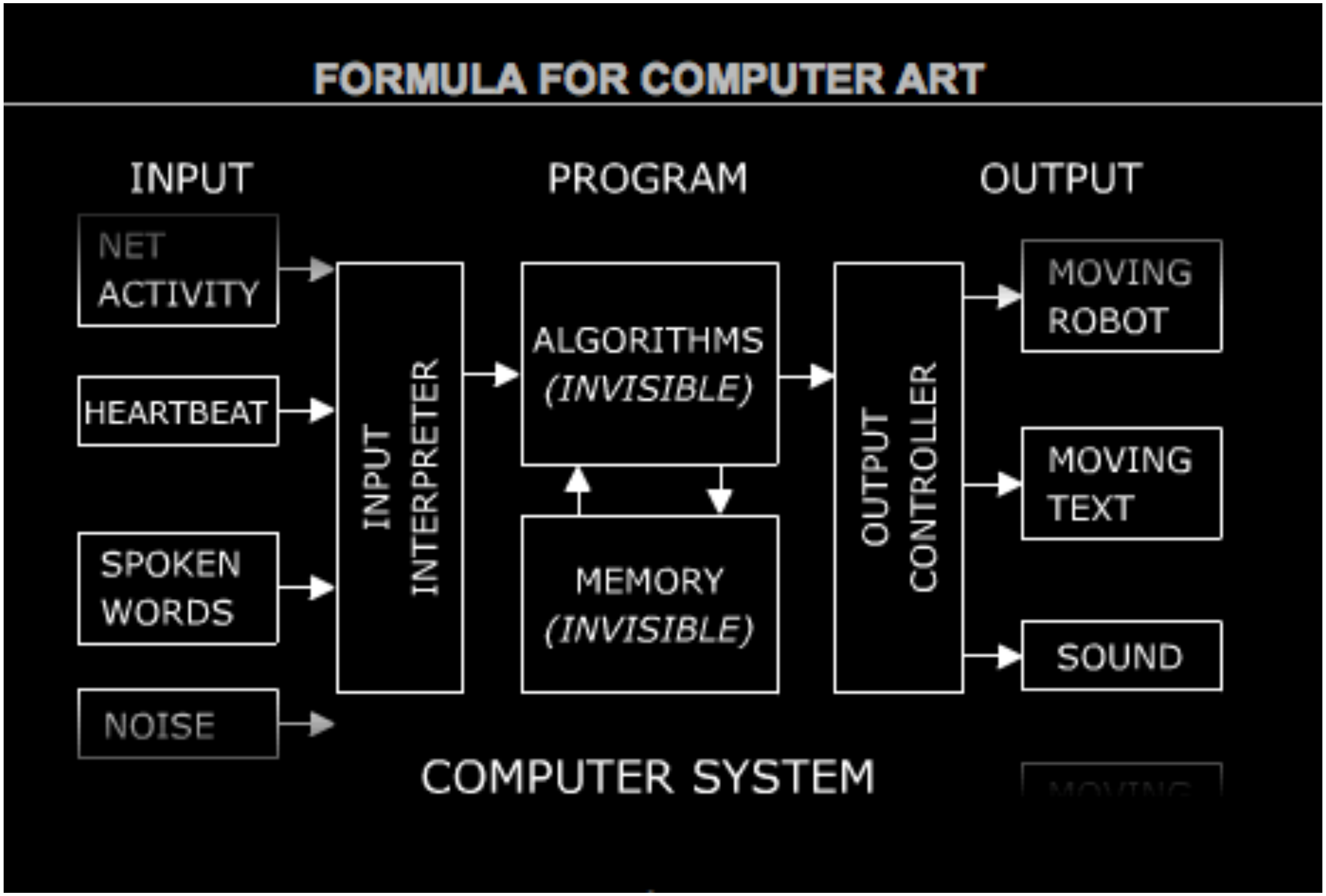
- A lot of variation in kinetic art drawing machines
- That's just a sampling…
  - Random drawing machines
    - powered by motors, wind, mail carriers, etc.
  - Mechanical drawing machines
    - hand-cranked, motor driven, wind-up, etc.
  - Reactive drawing machines
    - use environmental sensors of some sort
  - Computer controlled drawing machines
    - range from random to precise
- Pen/ink, paint, light, sand, etch-a-sketch, etc...

First Assignment

- Look around on the web and find something interesting related to kinetic art and drawing machines
  - Think about other definitions of "draw"
  - Think about pure drawing ideas that might inspire mechanical drawing
  - Think about non-mark-making kinetic art pieces that might inspire something that makes marks
  - Think about some engineering artifact that might inspire an art piece
  - Think about other interaction modes
  - Think about other presentations and contexts

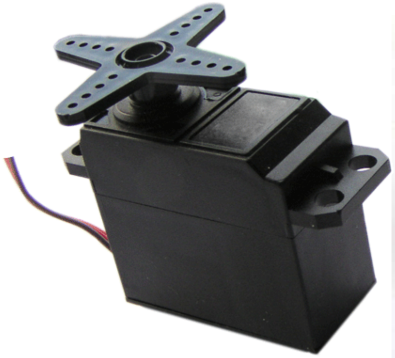
- Come on Thursday ready to (quickly) share it

Jim Campbell's Algorithm

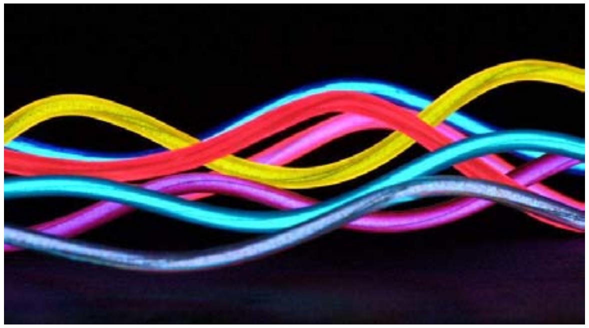


Output Transducers

- Motion
  - Motors - DC, Stepper
  - Servos

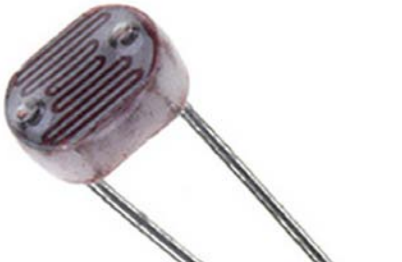


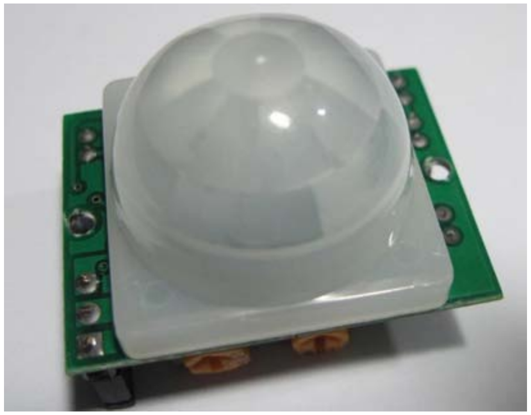
- Light
  - LED, bulbs, etc.
- Sound
  - Generated, recorded, physical, etc.



Input Sensors

- Switches
- Resistive sensors
  - Get analog values based on sensing input
  - light, temperature, knobs, flex, etc
- Proximity/motion sensing
  - PIR, distance, etc.



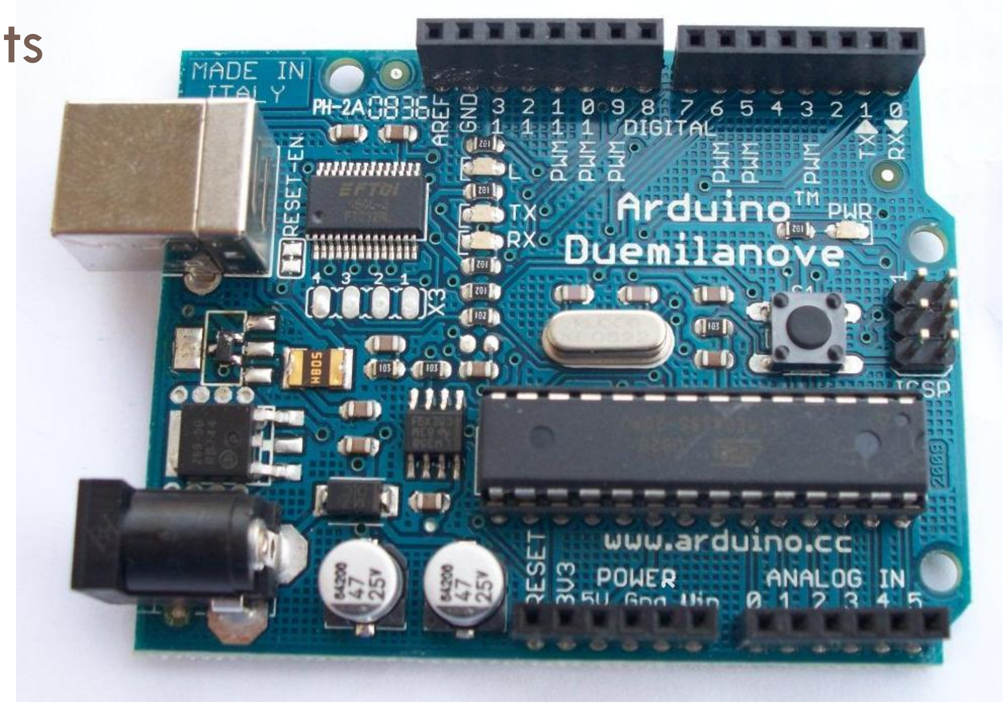


Electronic Glue

- Power supplies
- Transistors
  - used as electronic switches for medium power devices
- Relays
  - used as electronic switches for high power devices
- resistors, capacitors, wires, etc.

Computer Control

- Microprocessor
  - receive inputs
  - do some computation
    - You’ll have to write some programs…
  - send signals to the outputs

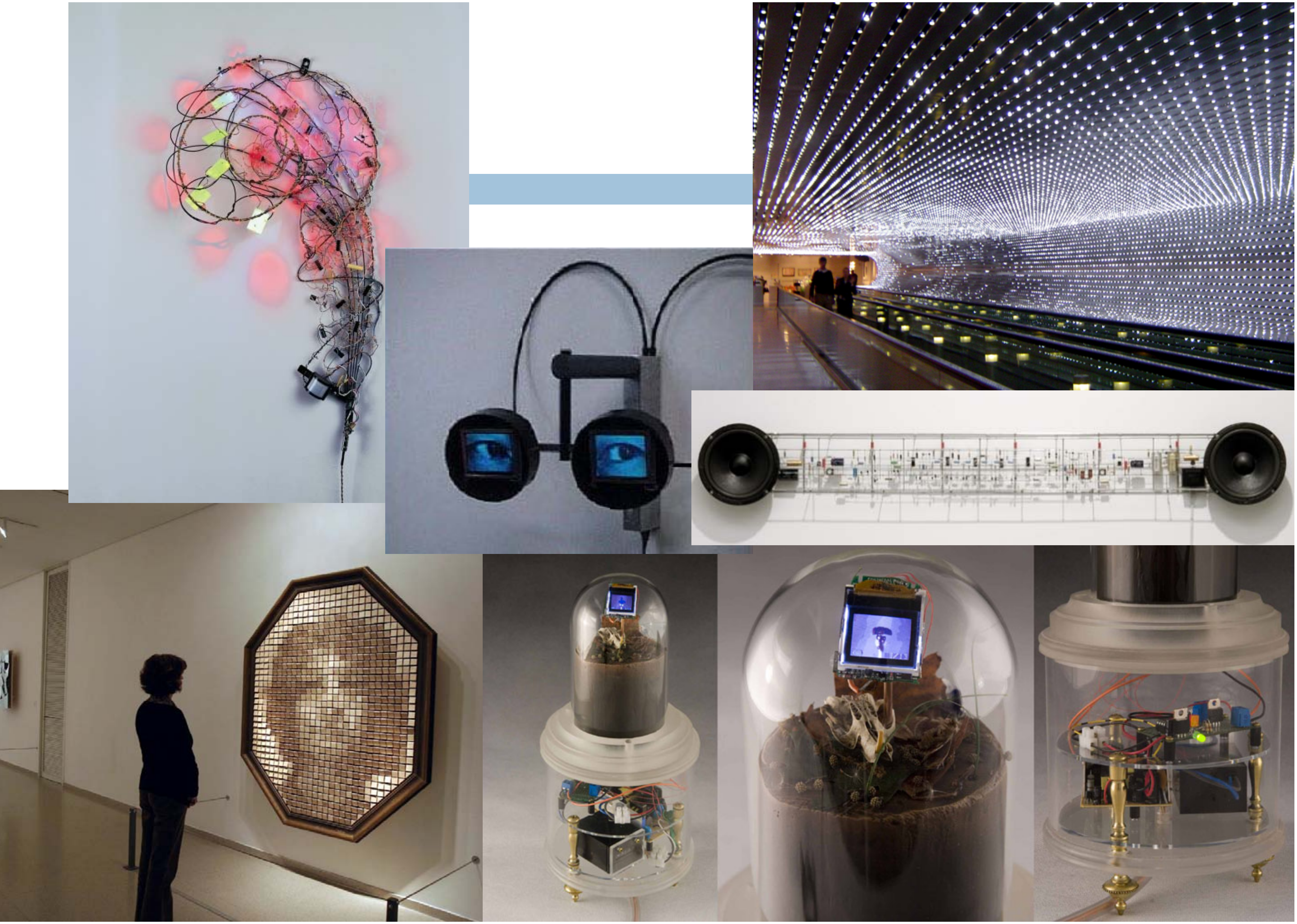


Other Resources

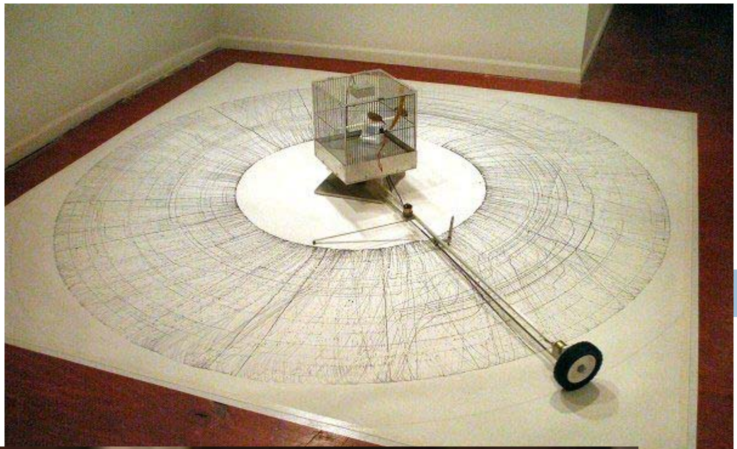
- Wood and metal shop in Art department
- Metal shop in the Engineering building
  - We'll schedule orientations…
- Laser cutter in the Art department
  - VERY cool machine – can cut many things like plastic, paper, and plywood
- Water jet cutter in Engineering
  - VERY cool machine that can cut almost anything
  - Requires training – costs $10 for training class
  - Costs $47/hour (but most jobs take only minutes)

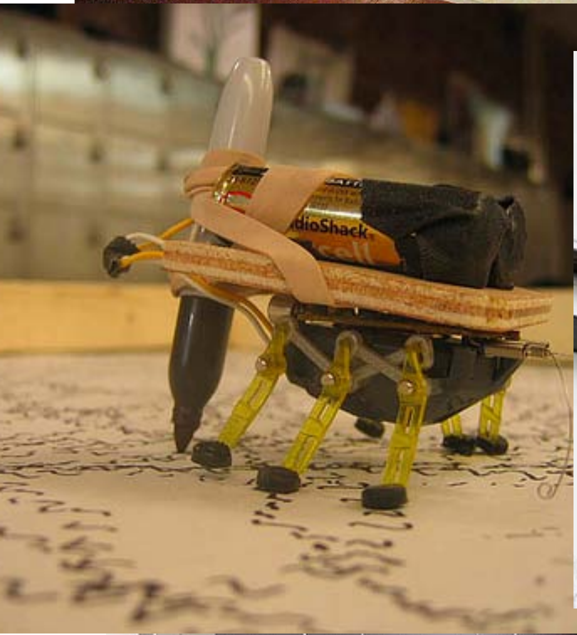
Complete Art Piece

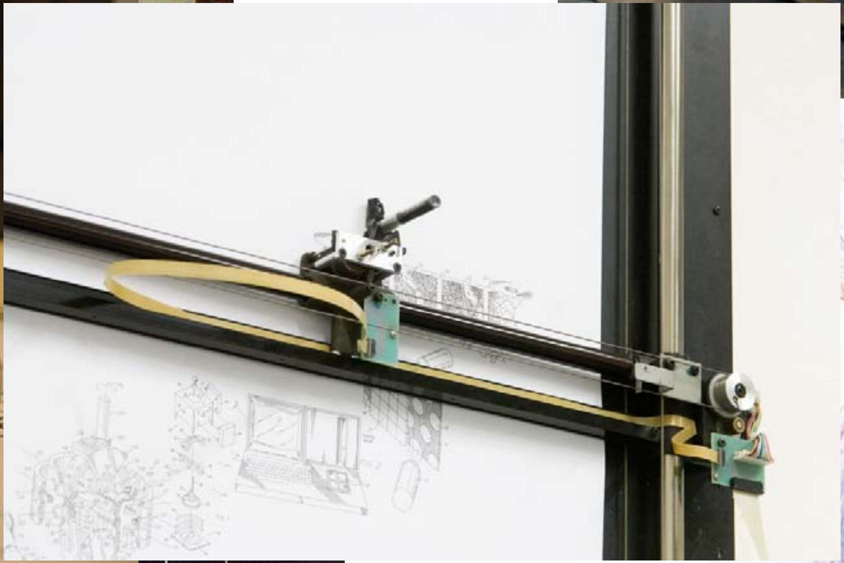
- Kinetic concept in a well-conceived and constructed artifact
- For this semester, think about making marks
  - Traditional 3d materials
  - Wood, metal, plastic, wiring, and other structural materials
  - Unattended functioning (i.e. in gallery)
  - Consider maintenance and support issues too…



Drawing Machines

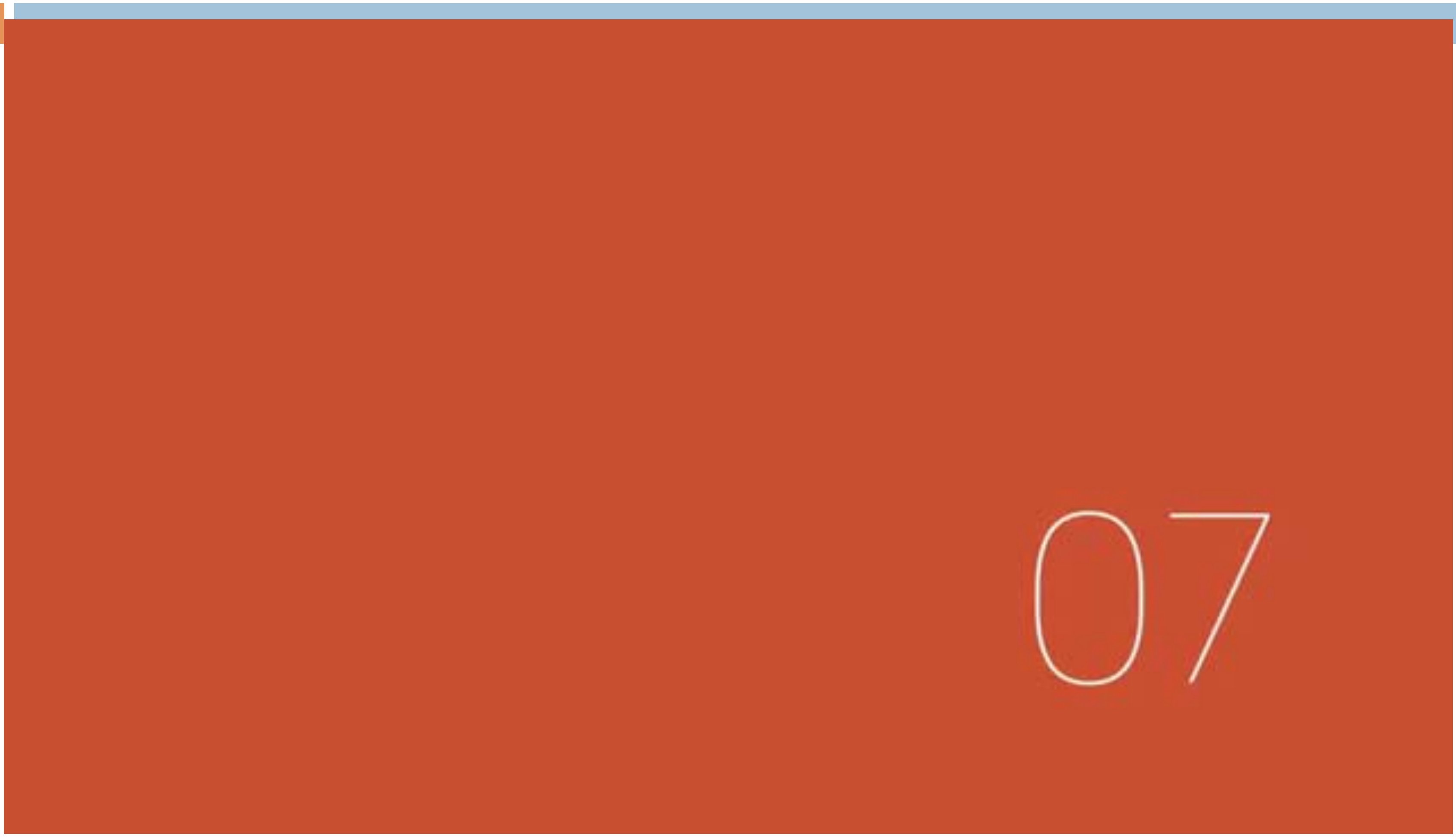






Hylozoic Veil at The Leonardo

Hylozoic Veil at The Leonardo



http://www.youtube.com/watch?v=0cdOFIkoZso

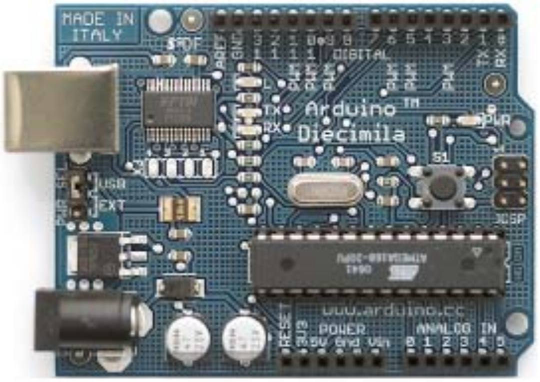
Microcontroller

- The “brains” that coordinates the kinetics
  - Small computers
  - Typically with special support for sensors and actuators
    - Analog-digital converters on inputs
    - pulse-width modulation on outputs
- We’ll use one called Arduino

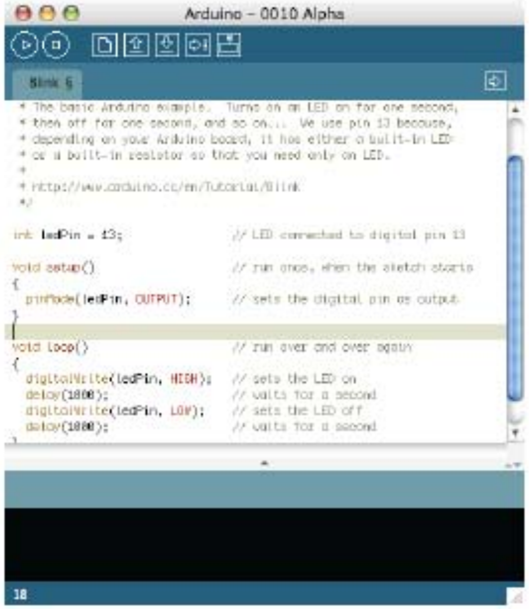
What is Arduino?

The word "Arduino" can mean 3 things

A physical piece of hardware



A programming environment



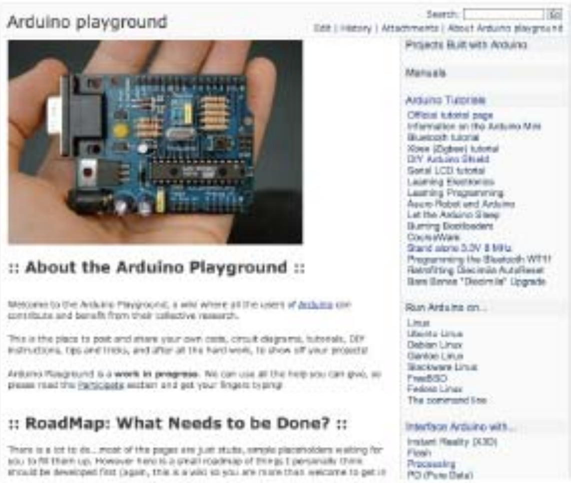
```
 * The basic Arduino example.  Turns on an LED on for one second,
 * then off for one second, and so on...  We use pin 13 because,
 * depending on your Arduino board, it has either a built-in LED
 * or a built-in resistor so that you need only an LED.
 *
 * http://www.arduino.cc/en/Tutorial/Blink
 */

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

void setup()                    // run once, when the sketch starts
{
  pinMode(ledPin, OUTPUT);      // sets the digital pin as output
}

void loop()                     // run over and over again
{
  digitalWrite(ledPin, HIGH);   // sets the LED on
  delay(1000);                  // waits for a second
  digitalWrite(ledPin, LOW);    // sets the LED off
  delay(1000);                  // waits for a second
```

A community & philosophy



:: About the Arduino Playground ::

Welcome to the Arduino Playground, a wiki where all the users of Arduino can contribute and benefit from their collective research.

This is the place to post and share your own code, circuit diagrams, tutorials, DIY instructions, tips and tricks, and after all the hard work, to show off your projects!

Arduino Playground is a **work in progress**. We can use all the help you can give, so please read the Participate section and get your fingers typing!

:: RoadMap: What Needs to be Done? ::

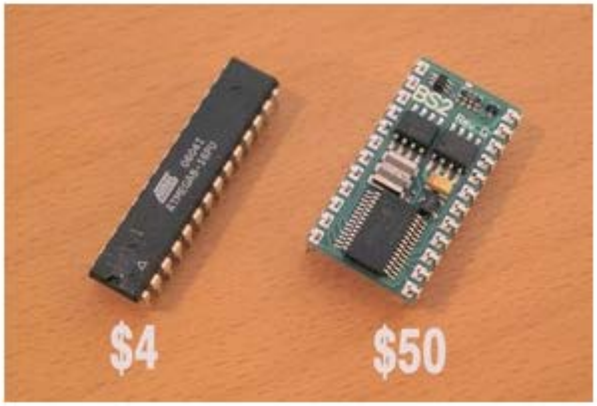
There is a lot to do...most of the pages are just stubs, simple placeholders waiting for you to fill them up. However here is a small roadmap of things I personally think should be developed first (again, this is a wiki so you are more than welcome to get in

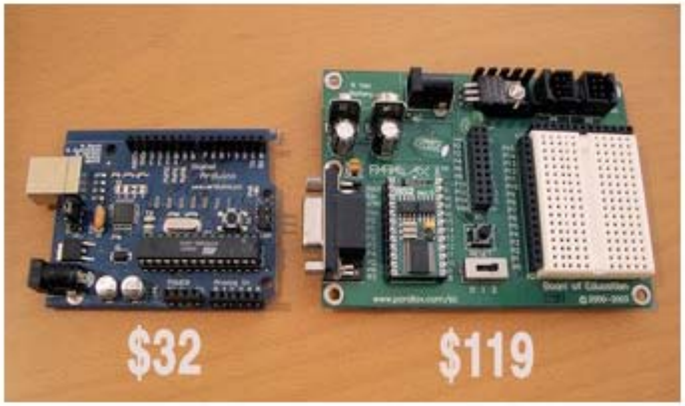
Arduino Community

- Open source physical computing platform
  - “open source” hardware
  - open source software environment
  - physical computing means sensing and controlling the physical world
- Community
  - Examples wiki (the “playground”)
  - Forums with helpful people

Arduino Hardware

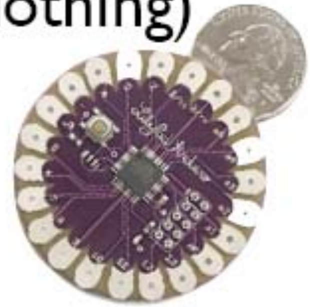
- Similar to Basic Stamp (if you know of it)
  - but cheaper, faster, & open
- Uses AVR ATmega 328p microcontroller chip
  - chip was designed to be used with C language



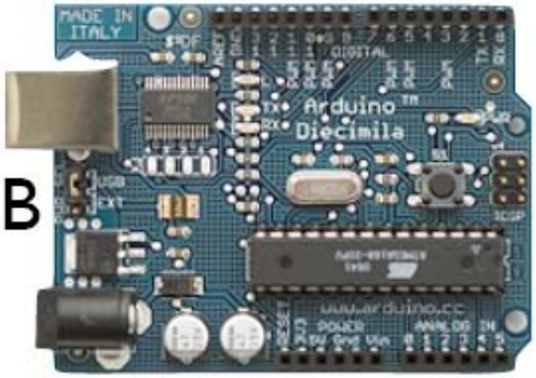


Arduino Hardware Variety

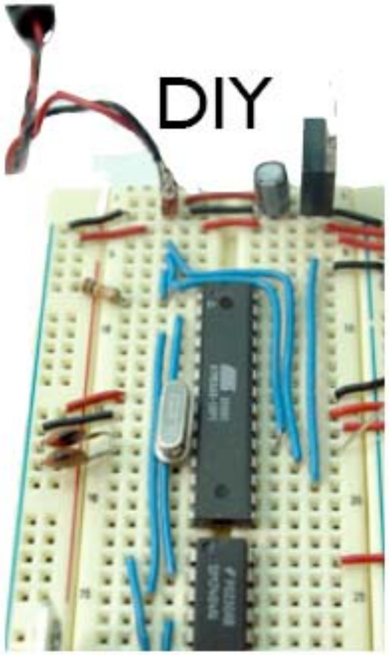
LilyPad
(for clothing)

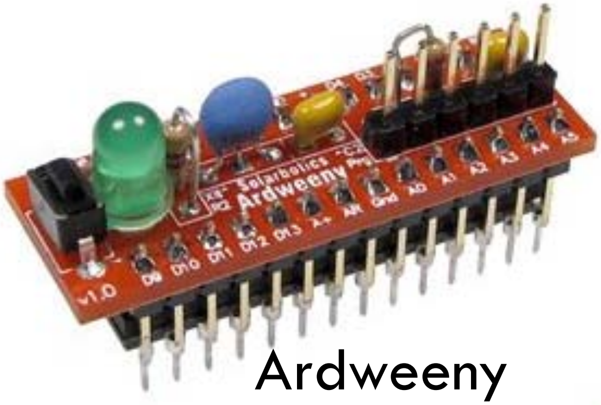


USB



DIY





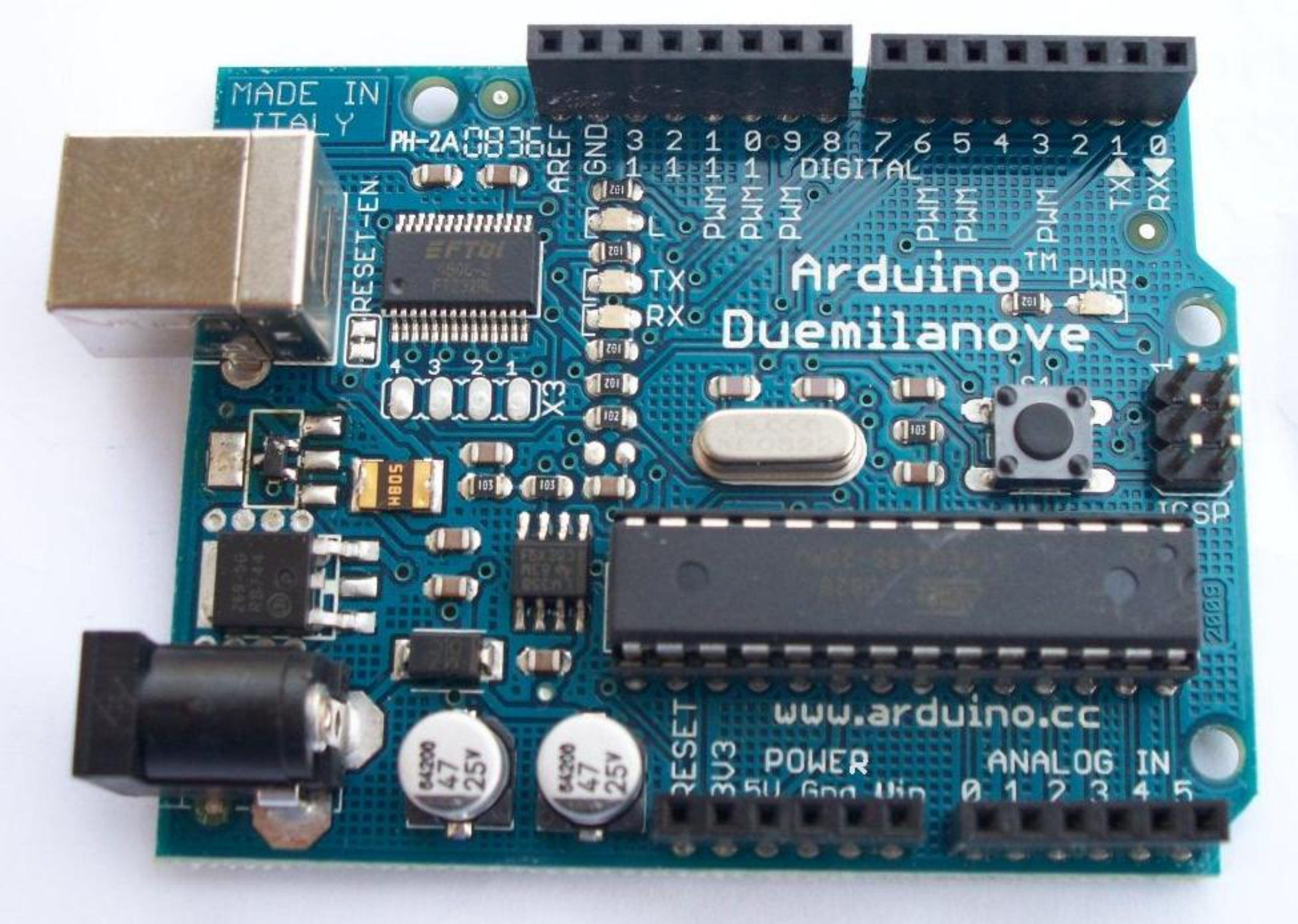
Ardweeny

Boarduino Kit

“Stamp”-sized

many different variations to suite your needs

Arduino


MADE IN ITALY
AREF
GND
13
12
11
10
9
8
DIGITAL
7
6
5
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3
2
1
0
PWM
TX
RX
RESET-EN
L
Arduino™
Duemilanove
PWR
ICSP
www.arduino.cc
RESET
3V3
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ANALOG IN
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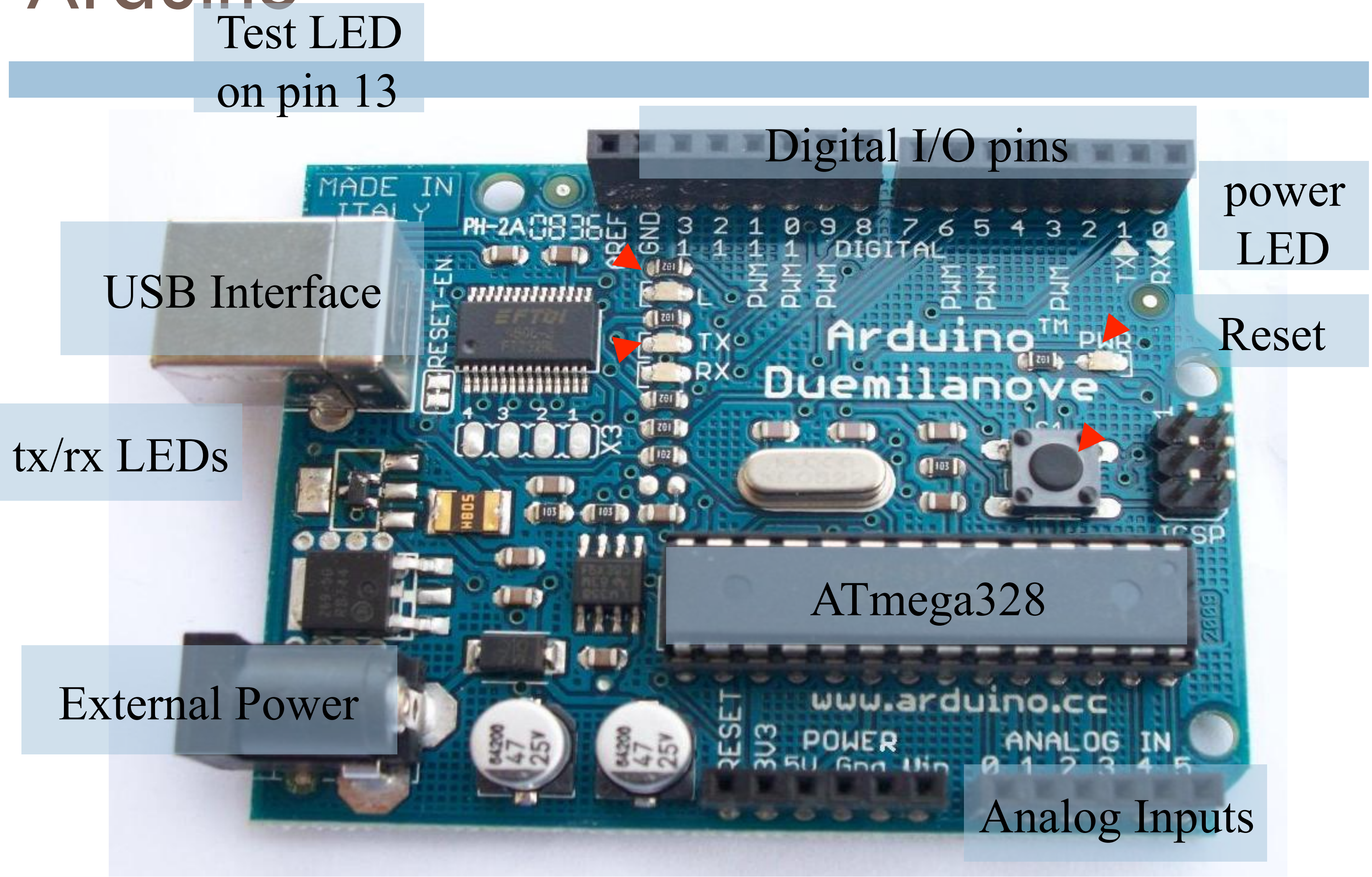
Arduino



Test LED on pin 13

Digital I/O pins

power LED

USB Interface

Reset

tx/rx LEDs

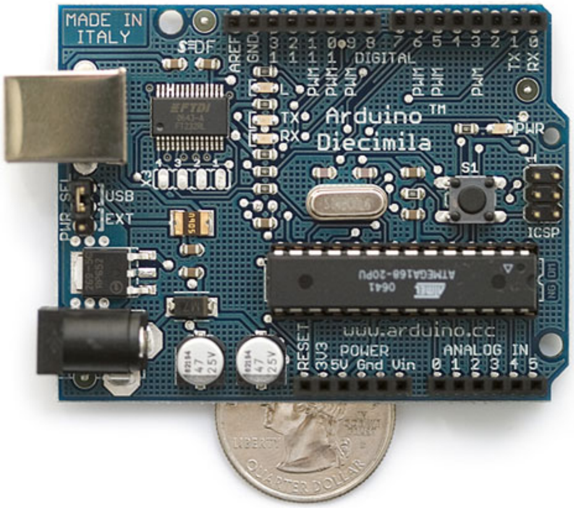
ATmega328

External Power

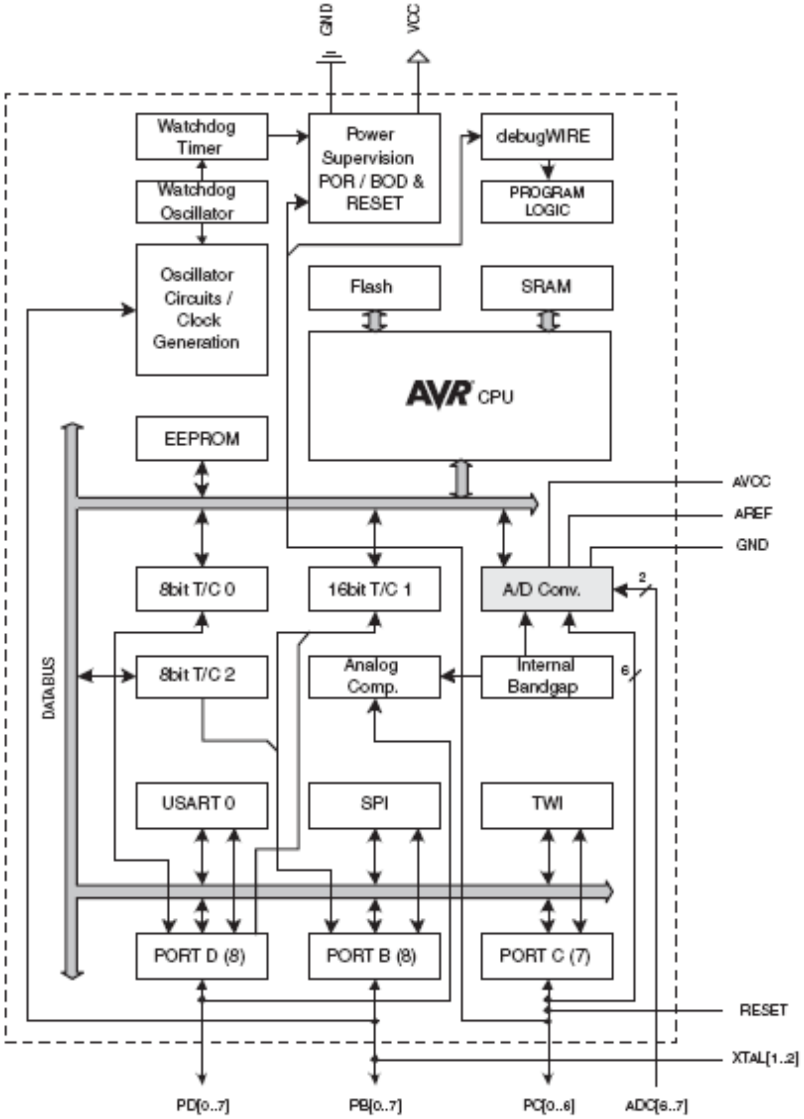
Analog Inputs

Arduino

- Based on the AVR ATmega328p chip
  - 8 bit microcontroller (RISC architecture)
  - 32k flash for programs
  - 2k RAM, 2k EEPROM, 32 registers
  - 14 digital outputs (PWM on 6)
  - 6 analog inputs
  - Built-in boot loader
  - Powered by USB
    or by external power



ATmega328P



8-bit RISC CPU – 16MHz

32 registers

32k Flash, 2k SRAM, 1k EEPROM

3 8-bit I/O ports

6 ADC inputs

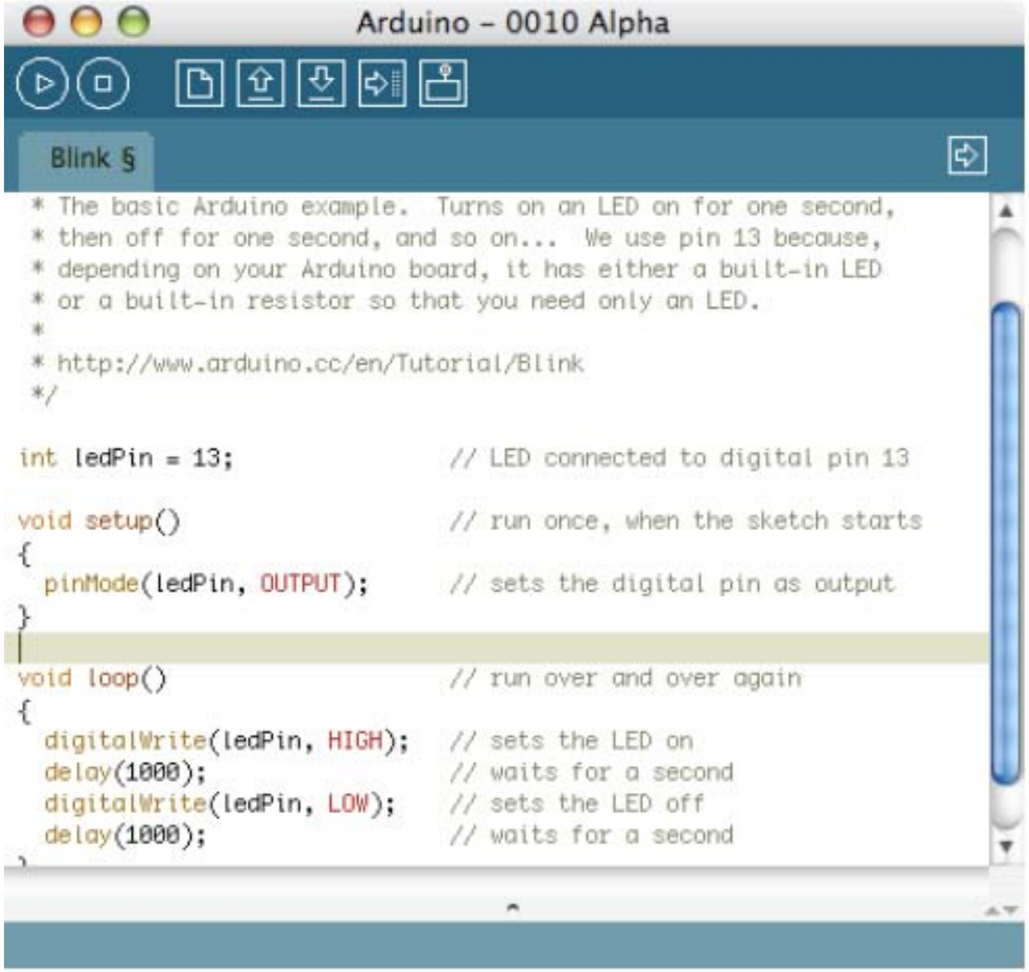
2 8-bit timers

1 16-bit timer

USART

SPI/TWI serial interfaces

Arduino Software

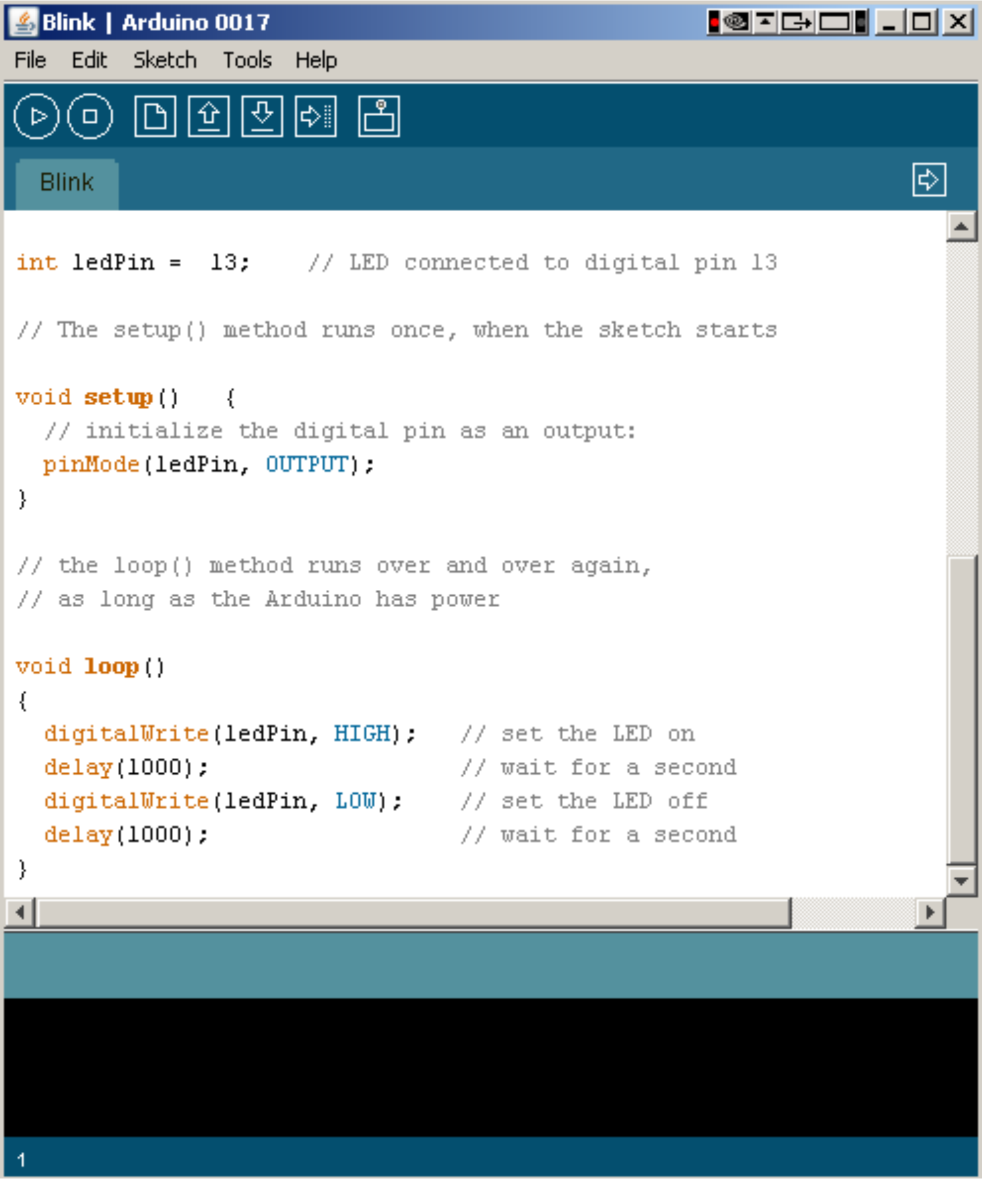


```
 * The basic Arduino example.  Turns on an LED on for one second,
 * then off for one second, and so on...  We use pin 13 because,
 * depending on your Arduino board, it has either a built-in LED
 * or a built-in resistor so that you need only an LED.
 *
 * http://www.arduino.cc/en/Tutorial/Blink
 */

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

void setup()                    // run once, when the sketch starts
{
  pinMode(ledPin, OUTPUT);      // sets the digital pin as output
}

void loop()                     // run over and over again
{
  digitalWrite(ledPin, HIGH);   // sets the LED on
  delay(1000);                  // waits for a second
  digitalWrite(ledPin, LOW);    // sets the LED off
  delay(1000);                  // waits for a second
}
```

- Like a text editor
- View/write/edit sketches
- But then you program them into hardware

Programming Arduino

- Open-source programming environment
- Arduino language is based on C
  - Actually, it *is* C/C++
  - Hiding under the hood is gcc-avr
  - But, the Ardiuino environment has lots of nice features to make programming less scary…



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

// The setup() method runs once, when the sketch starts

void setup()   {
  // initialize the digital pin as an output:
  pinMode(ledPin, OUTPUT);
}

// the loop() method runs over and over again,
// as long as the Arduino has power

void loop()
{
  digitalWrite(ledPin, HIGH);   // set the LED on
  delay(1000);                  // wait for a second
  digitalWrite(ledPin, LOW);    // set the LED off
  delay(1000);                  // wait for a second
}
```

More Arduino Info?

- www.arduino.cc/
  - Main Arduino project web site
- www.arduino.cc/playground/Main/HomePage
  - “playground” wiki with lots of users and examples
- www.freeduino.org/
  - “The world famous index of Arduino and Freeduino knowledge”
- www.eng.utah.edu/~cs5789
  - our class web site

Resources for this class

- We have some supplies for the class
  - Arduino boards
  - sensors of various different types
  - motors and servos
  - LEDs and LED controllers
- You should expect to have to buy a few more parts on your own to complete your project though…

Questions?