Programming Arduino with Scratch (S4A)

Fotios Gioulekas, Panagiotis Katsaros

School of Informatics
Aristotle University of Thessaloniki
Greece

http://stem.lupacovka.cz
Computer programming & computer program

- Computer programming:
  - act of writing computer programs to solve a problem

- Computer program
  - structured collection of a sequence of instructions written using a Computer Programming Language to tell the computer to do a specific task

Calorie Calculator

https://www.calculator.net/calorie-calculator.html

Image taken from:
https://www.flickr.com/photos/steve_hoge/5143590110/
Microcontrollers

- A microcontroller is a computer system on a single chip that does a job (MCU, µC)
  - control electronic equipment
  - exists in electrical device, cars, washing machines, microwave ovens, telephones
  - includes central processing unit (CPU), memory (a small amount of RAM, program memory, or both), and programmable input/output peripherals, which are used to interact with various units

Images taken from:
http://d1gsvnjtkwr6dd.cloudfront.net/large/IC-ATMEGA168A-PU_LRG.jpg
http://i.stack.imgur.com/whWVa.jpg
http://slideplayer.com/slide/5881540/19/images/26/Fixed+Function+Integrated+Circuits+I+(Cont.).jpg
Arduino

- Arduino is an **open-source electronics prototyping platform** that contains both hardware and software founded by Massimo Banzi and David Cuartielles in 2005
- **open-source**: Original design files are freely distributes enabling people to study them, make changes and share those changes with others
- **Electronics**: Science sector dealing with the study of flow and control of electrons (electricity) and the study of their behavior and effects in devices using such electrons
- **Prototyping**: An original model, form or an instance that serves as a basis for other things
- **Platform**: A combination of a hardware system with software environment that can be programmed and execute other software

Arduino Uno platform – I

- One of the many flavors of Arduino platforms
- It is able to read inputs (e.g. light on a sensor, a finger on a button, or a Twitter message) - and turn it into an output (e.g. activating a motor, turning on LEDs, publishing something online)
- It can sense and react with the environment
- The μC on the Arduino board is programmed using the Arduino programming language (Wiring Language which is based on C++) and the Arduino Integrated Development Environment (IDE)
- The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller

Arduino Uno platform – II

- Input voltage: 7-12 V (USB, DC plug, or Vin)
- Max output current per pin: 40 mA

Arduino Uno Kit
Putting parts together

- How can I connect various sensors to Arduino?
- How can I connect actuators to Arduino?
- How can I tell or program an Arduino to do a job?
Programming Environment

- It is a computer software framework that includes:
  - A text editor to create computer programs
  - A compiler to compile the created programs using the text editor into binary format or
  - An interpreter to execute the programs created directly
Scratch

- Scratch is an open source visual programming language for teaching programming to children
- One can create interactive stories, games, and animations – and share the creations with others on the web
- Developed by the Lifelong Kindergarten group at the MIT Media Lab, USA
- Programming resembles to putting parts together assembling a puzzle

Source: [https://scratch.mit.edu/](https://scratch.mit.edu/)
Scratch for Arduino S4A - I

- S4A, developed in 2010 by the Citilab Smalltalk Team, is a Scratch modification that allows for simple programming of the Arduino open source hardware platform.
- It provides a high level interface to Arduino programmers so as to manage sensors and actuators.
- An Arduino sketch (S4AFirmware16.ino) has to be loaded to the board to communicate with S4A through USB.

Source: http://s4a.cat/
Scratch for Arduino S4A - II

- Comparison of a simple program that blinks a LED connected to LED BUILTIN PIN #13 on Arduino and in S4A

**Arduino Code**

```c
void setup() {
  pinMode(LED_BUILTIN, OUTPUT);
}

void loop() {
  digitalWrite(LED_BUILTIN, HIGH);  // turn the LED on (HIGH is the voltage level)
  delay(1000);  // wait for a second
  digitalWrite(LED_BUILTIN, LOW);   // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```

**S4A Program**

- `when` clicked
- `forever`
  - `if` sensor `Digital1` pressed?
    - `digital 13` on
    - `else`
      - `digital 13` off
Breadboards

- A breadboard is used to create circuits and connect different sensors and actuators to the Arduino board through jumper wires, and electronic components.
- Horizontal hole groups are linked power and ground columns are connected vertically.
Ohm's Law (Basic Electronics Law)

- A physics law which states that current passing through a conductor is proportional to the input voltage
- Voltage (V): is the measure of electrical potential
  - unit of measurement = Volts (V)
- Current (I): is the amount of flow through a conductive material
  - unit of measurement = Amperes or Amps (A)
- Resistance (R): is the material's opposition to the flow of electric current
  - unit of measurement = Ohms (Ω)

How a LED works

- It is a light-emitting diode that emits light when activated based on the Electroluminescence (EL)
- An optical phenomenon and electrical phenomenon in which a material emits light in response to the passage of an electric current
- Electricity flows from a higher voltage to a lower voltage

Source: [https://en.wikipedia.org/wiki/Light-emitting_diode](https://en.wikipedia.org/wiki/Light-emitting_diode)
### S4A installation

- **Install S4A into your PC**
  - Download the program from [http://vps34736.ovh.net/S4A/S4A16.zip](http://vps34736.ovh.net/S4A/S4A16.zip)
  - Unzip it to a folder named S4A

- **Installing the Firmware into your Arduino**
  - Download Arduino IDE from [https://www.arduino.cc/download_handler.php](https://www.arduino.cc/download_handler.php) and run the file arduino-1.8.5-windows.exe to setup it
  - Download S4A firmware from [http://vps34736.ovh.net/S4A/S4AFirmware16.ino](http://vps34736.ovh.net/S4A/S4AFirmware16.ino)
  - Connect your Arduino board to a USB port in your computer
  - Open the firmware file (S4AFirmware16.ino) from the Arduino environment
  - In the Tools menu, select the board version and the serial port where the board is connected
  - Load the firmware into your board through File > Upload
Physical computing

- Design interactive physical systems by the use of software and hardware that can sense and respond to the real world
  - smart automotive
  - traffic control systems
  - factory automation processes
  - Smart buildings
  - Robots

Source: [https://en.wikipedia.org/wiki/Physical_computing](https://en.wikipedia.org/wiki/Physical_computing)
Lab 1 – Control a LED from S4A (I)

- Connect a LED and a 220Ω Resistor on the breadboard and with Arduino according to the schematic below.
Lab 1 – Control a LED from S4A (II)

- In S4A select Digital off and on I/O
- Drag and drop them to scripts area
- Change them to #10

Press here to switch on or off the LED
Lab 1 – Control a LED from S4A (III)

- From control place wait 1 sec block in between the on of motion blocks
- LED switches on and off every 1 sec if you click on the block of commands
Lab 1 – Control a LED from S4A (IV)

- How to make Loops in the program?
Lab 1 – Control a LED from S4A (V)

- When button is pushed, turn ON the LED for 10 seconds and then switch it OFF
- 10KΩ pull down resistor is required to avoid inducing a dead short circuit when the button is pushed down

Lab 1 – Control a LED from S4A (VI)

- Connect a LED and a 220Ω Resistor on the breadboard and with Arduino according to the schematic below.
Lab 1 – Control a LED from S4A (VI)

- S4A program
Lab 2 – Turn on a LED when LDR sensor is covered Automatic Night Light (I)

- CdS - LDR (Cadmium Sulfide - Light Dependent Resistor) or photocell sensor
- Its resistance is inversely dependent on the amount of light falling on it

![Diagram of LED circuit with LDR sensor and resistors](image-url)
Lab 2 – Turn on a LED when LDR sensor is covered Automatic Night Light (II)

- Write down the Voltage values at Analog pin A0

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>A0 VOLTAGE (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab’s light are switched ON</td>
<td></td>
</tr>
<tr>
<td>Lab’s light are switched ON &amp; Hand on the LDR</td>
<td></td>
</tr>
<tr>
<td>Lab’s light are switched OFF</td>
<td></td>
</tr>
<tr>
<td>Lab’s light are switched OFF &amp; Hand on the LDR</td>
<td></td>
</tr>
</tbody>
</table>

- What is the threshold value that differentiates darkness from lightness?
Lab 2 – Turn on a LED when LDR sensor is covered Automatic Night Light (II)

- Program S4A
- Sense the threshold voltage value of the sensor in an if loop
- Depending on the value of the sensor
  - Switch on and off the LED
Lab 3 - Temperature Alarm – (I)

- Program Arduino to buzz when temperature goes higher than a value

**LM35 analog temperature sensor**

**Output Voltage**
10mv per Degree Celsius

**Voltage Supply:** 4V – 20V

**Ground**

**Pin A3**

**Temperature**

**Vdd (5V)**

**ON**

**OFF**

**+5V**
Lab 3 - Temperature Alarm – (II)

- Schematic Topology
Lab 3 - Temperature Alarm – (III)

- Read the voltage value in pin A1
- Does it correspond to real room temperature?
- How to calculate the temperature value in °C since voltage values are read in A1 from the LM35 sensor?
  - Formula according to LM35 datasheet
  - Find what percentage of the range (1024 = 10bits representation of ADC) value in A1 is, multiplying that by the range itself (5000 mV), and divide it by 10 mV per °C
    - Temperature in °C = (A1 value * 500)/1023

Lab 3 - Temperature Alarm – (IV)

- S4A program
  - Loop forever
  - Enter the formula in S4A
    - If temperature is above 25°C
      - Buzzer is activated
    - Else
      - Buzzer is deactivated

- Make 1 variable
  - temperature
Lab 3 - Temperature Alarm – (I)

- Final S4A program
Thank you