

Low cost microscope automation hardware and embedded software development.

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International Centre
for Theoretical Physics



Introduction

What Is this presentation about:

- Provide a general approach for open automation of optical microscopes.
- Low cost hardware and open source software.
- Emphasizing on lowest effort of building and operation.

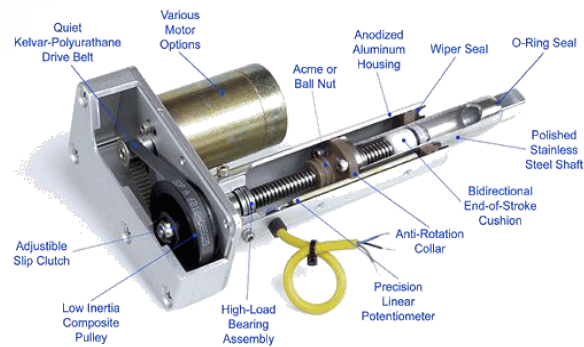
Introduction

Resources:

- Actuators

- Microcontrollers

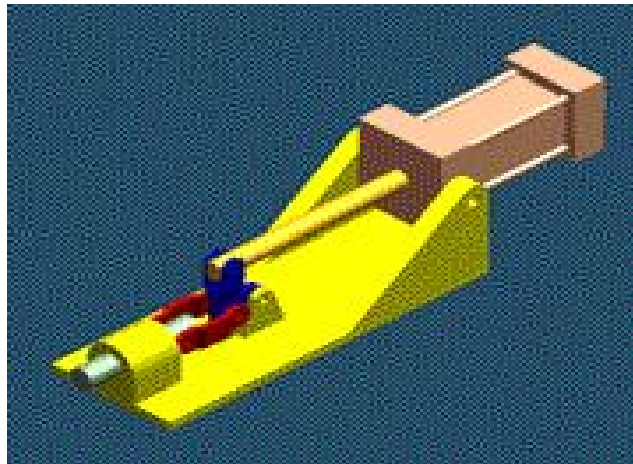
- Sensors



Introduction

What is an Actuator?

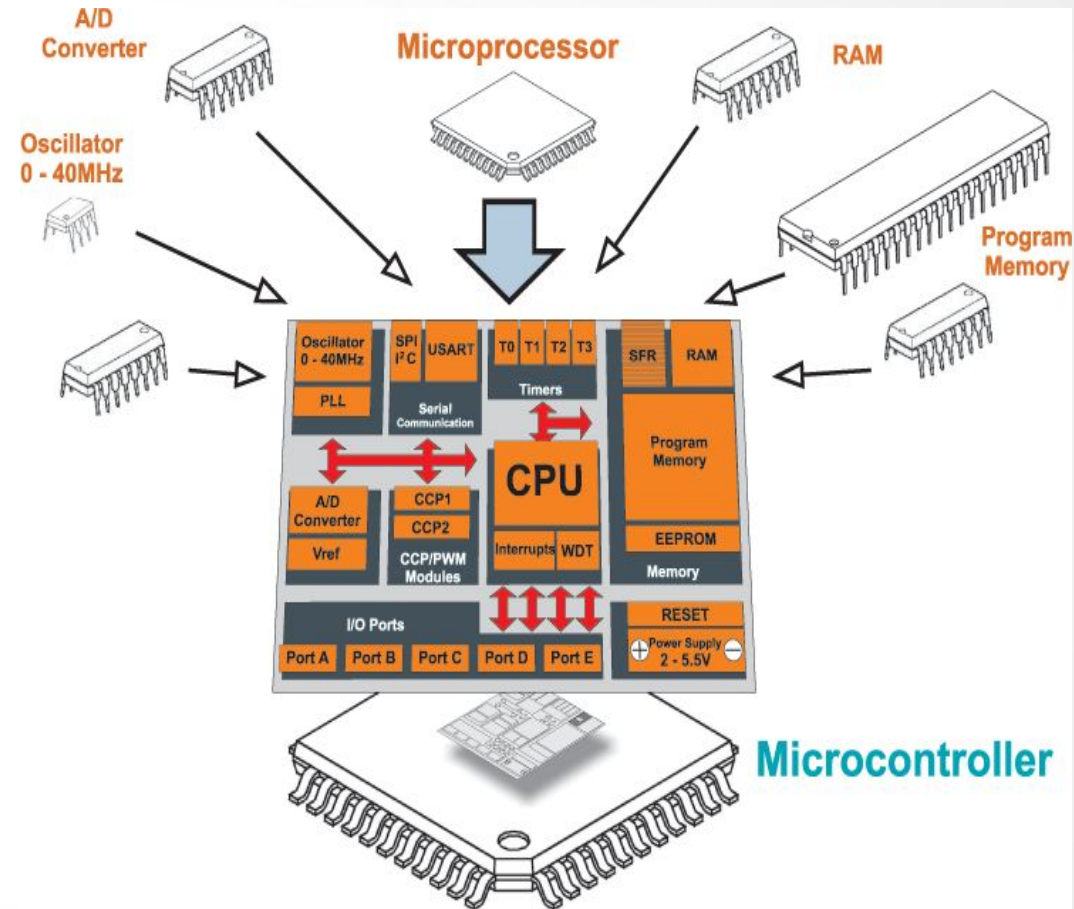
- It is a device capable of performing a movement or a mechanical action over another hardware.



Introduction

What is a
Microcontroller?

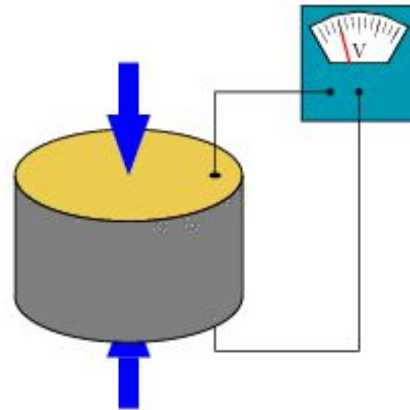
- In the most simplified form, it is a whole computer inside of a microchip.



Introduction

What is a Sensor?

- Is a device that allows us to measure real world magnitudes by converting them into an electrical signal.



The problem

My microscope is perfect without motors. Why are you doing this?

- Manufacturers and their “secrets”.
- Not easily adaptable nor modifiable.
- Software is closed source. (other functions can be added (of course, if the price is right...))

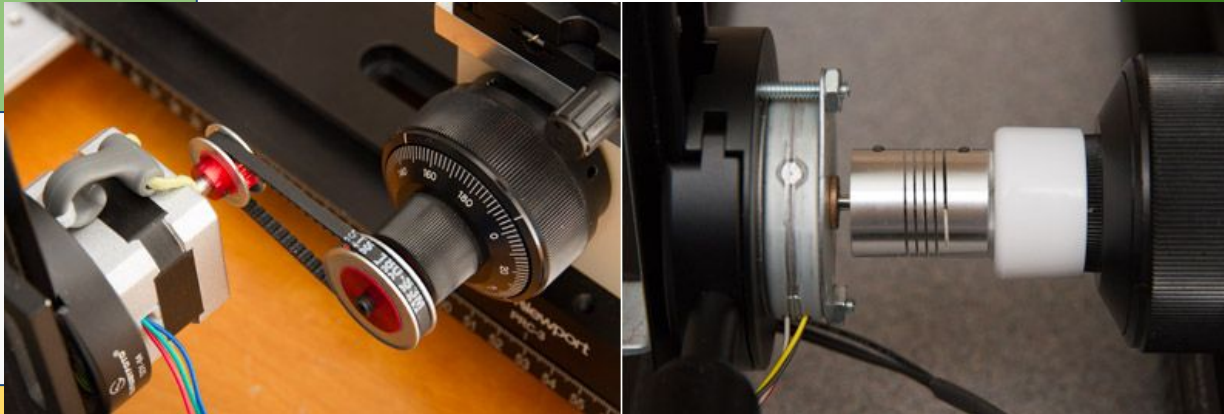


The problem

Why is a good idea to have “open” motorized microscopes?

Repetitive tasks

Instrument Isolation



Remote operation

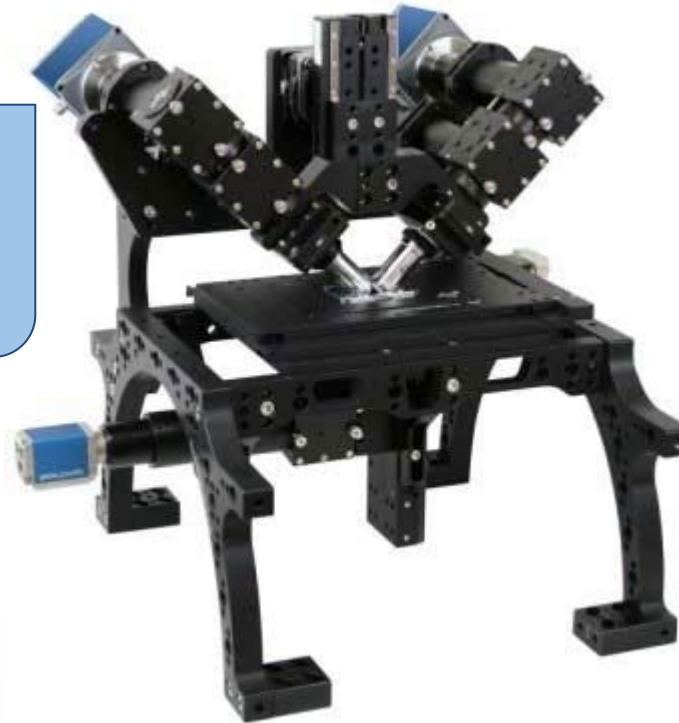
Standard set of hardware

‘peculiar’ additions tend to be frowned upon.

The problem

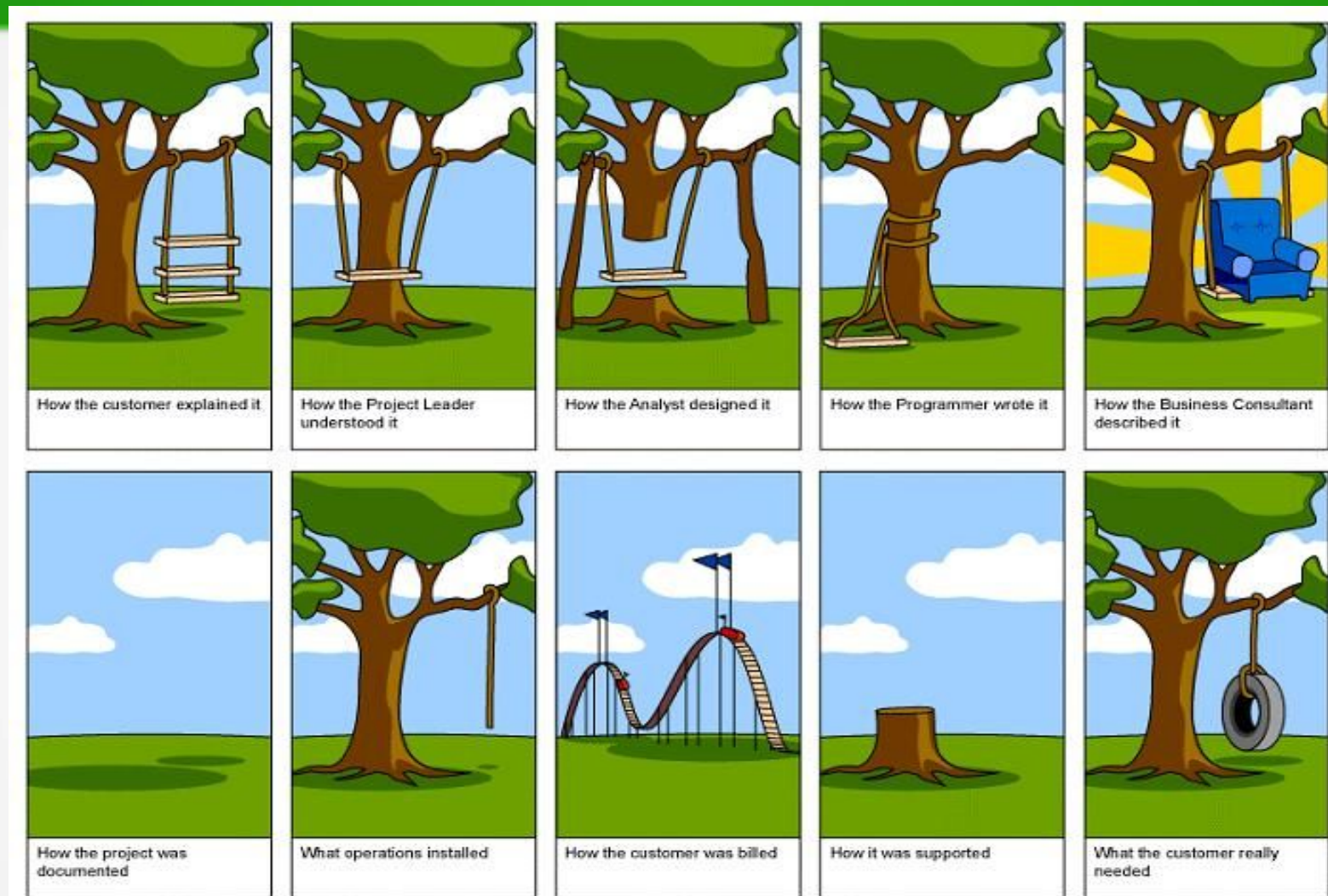
Do I need a motorized microscope?

•Non functional requirements



•Functional requirements

The problem



The problem

How to face the need of solutions

- Time-of-building vs deadlines.
- Time-of-building vs scientific production increase.

The problem

Ok now it has motors. How is it going to be a better tool for me?

.Remote operation

.Better than commercial

.Full device automation

.Optimizable for specific app.

.Complete experiment automation.

The problem


Do I need a Mechanical engineer with knowledge in optics and buy a specialized PLC?

- No. Just basic knowledge of gluing some parts together.
- The PLC would be “built”.

Some examples

Official website of the Department of Homeland Security

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Topics | How Do I? | Get Involved | News | About DHS

Science and Technology

Our Work | Strategic Directions | Business Opportunities | S&T News | About S&T | First Responders

Home > Science and Technology > S&T News > S&T News Archives > 2010 Archives > Cell-All: Super Smartphones Sniff Out Suspicious Substances

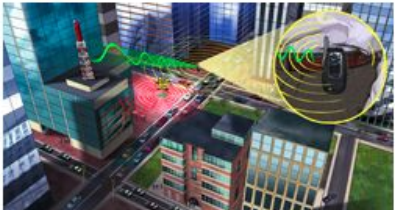
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2010 Archives

- Cell-All: Super Smartphones Sniff Out Suspicious Substances
- Honing the Art and Science of Fingerprinting
- It Takes a Water Purifier
- Mapping an Emergency

Cell-All: Super Smartphones Sniff Out Suspicious Substances

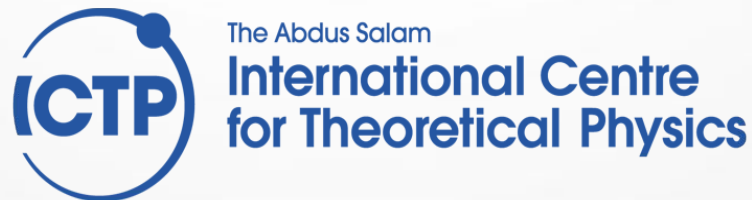
Years ago, if you wanted to take a picture, you needed a dedicated camera. You needed to buy batteries for it, keep it charged, learn its controls, and lug it around. Today, chances are your cell phone is called a “smartphone” and came with a three-to-five megapixel lens built-in—not to mention an MP3



$A = \log_{10} \frac{I_0}{I}$

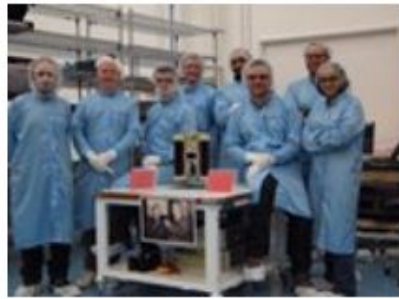
$P_{r-est} = 8 \times (Z)^{-2.44}$

$x_t = x_t(1+r)^t$



Some examples

STRaND-1



STRaND-1: Smartphone nanosatellite

Space researchers at the University of Surrey's Surrey Space Centre (SSC) and SSTL developed STRaND-1, a 3U CubeSat containing a smartphone payload that was launched into orbit in 2013.

STRaND-1 was built in engineer's free time using advanced commercial off-the-shelf components, fitting perfectly with SSTL's innovation and low-cost philosophies.

Some examples

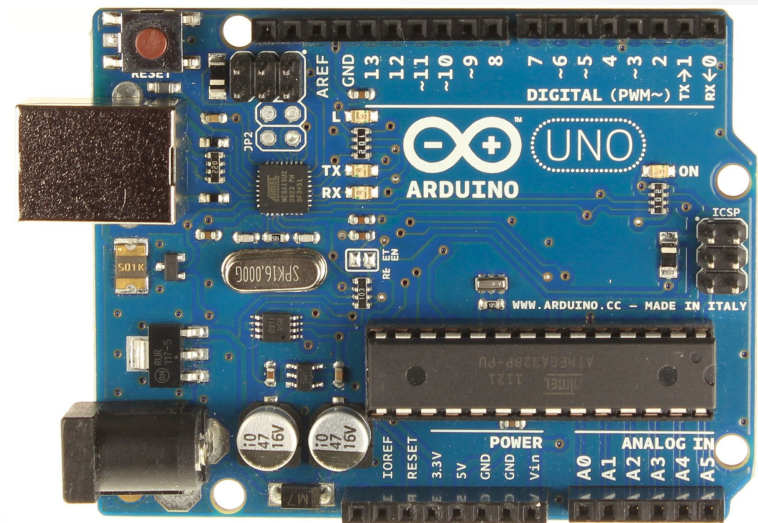
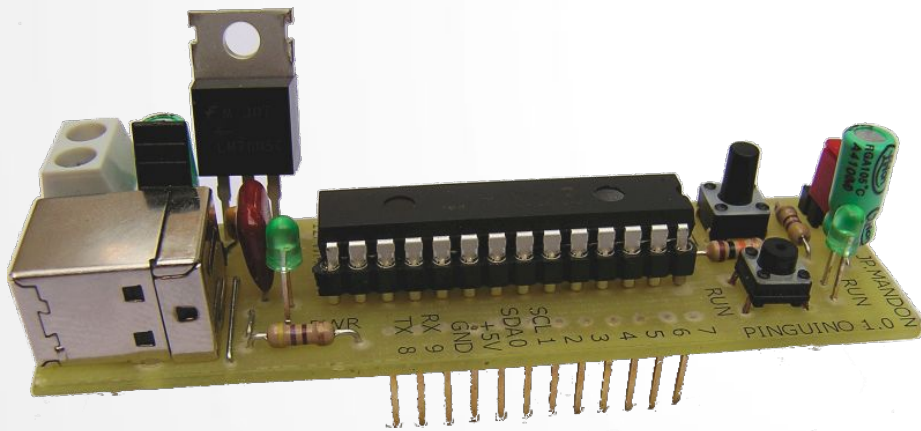
Mobile Phone Microscope Magnifier Lens



The Solution

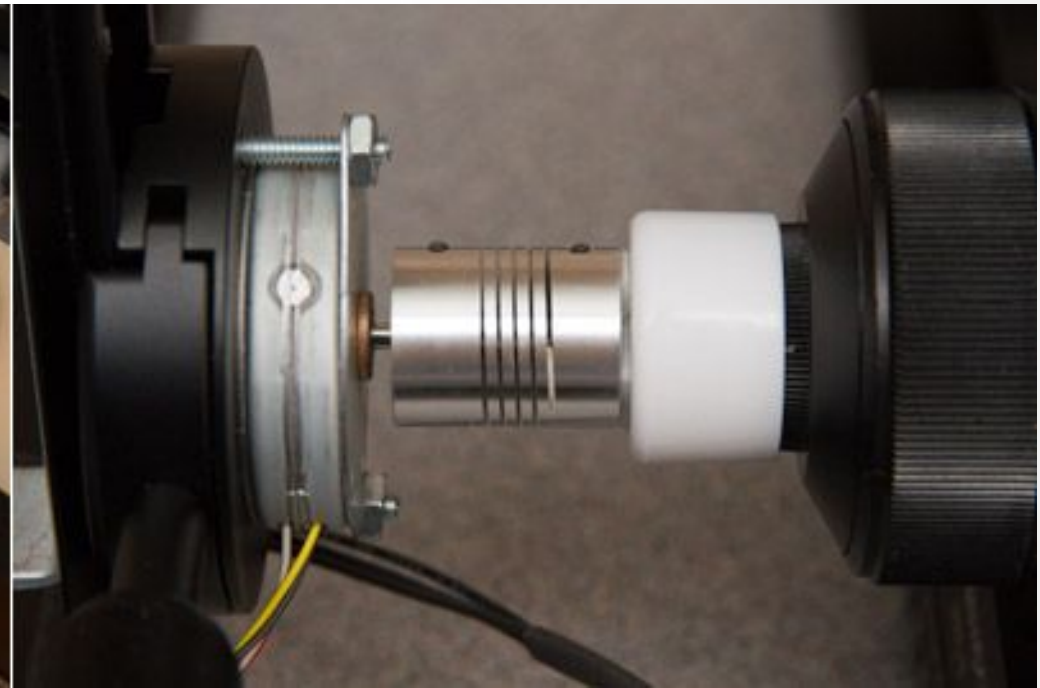
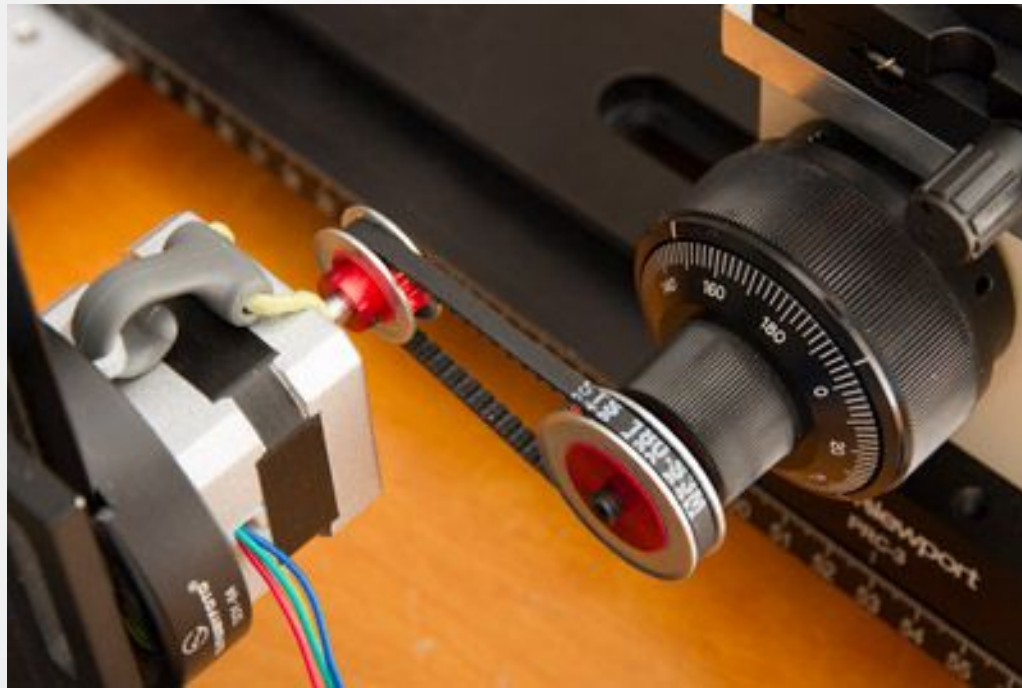
Hardware & Software

- Arduino & Pinguino



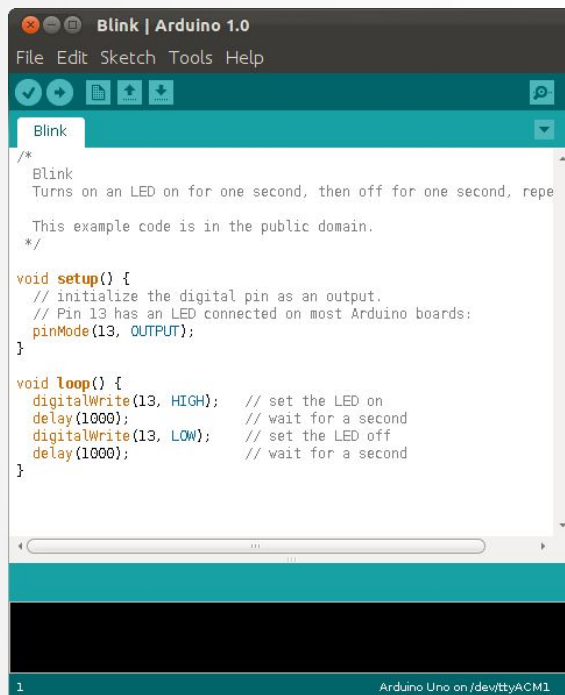
The Solution

<http://www.ryleeisitt.ca/articles/building-a-focus-stacking-g-controller/>



The Solution

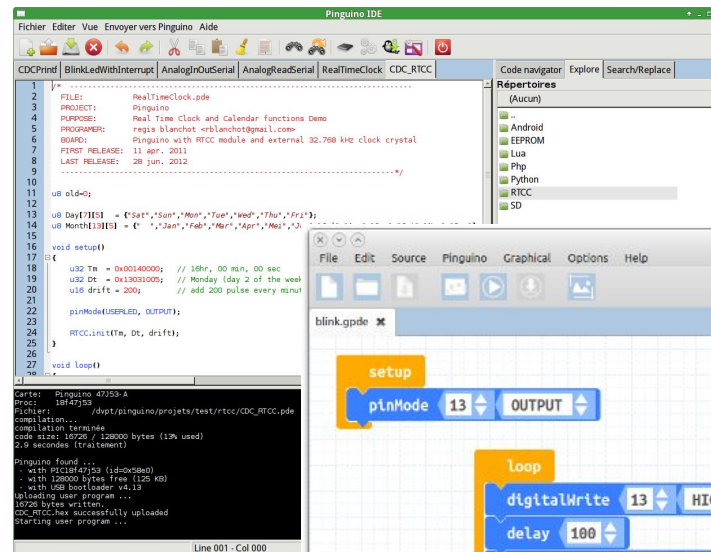
Why Arduino & Pinguino?



```
Arduino IDE - Blink | Arduino 1.0
File Edit Sketch Tools Help
Blink
/*
 * Blink
 * Turns on an LED on for one second, then off for one second, repeats.
 * This example code is in the public domain.
 */

void setup() {
  // initialize the digital pin as an output.
  // Pin 13 has an LED connected on most Arduino boards:
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH); // set the LED on
  delay(1000);           // wait for a second
  digitalWrite(13, LOW); // set the LED off
  delay(1000);           // wait for a second
}
```

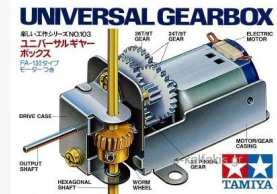
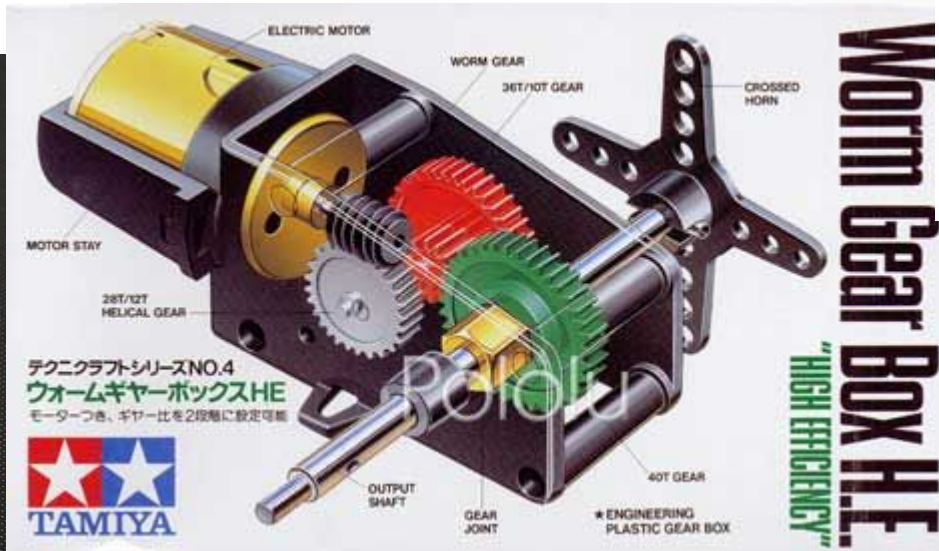
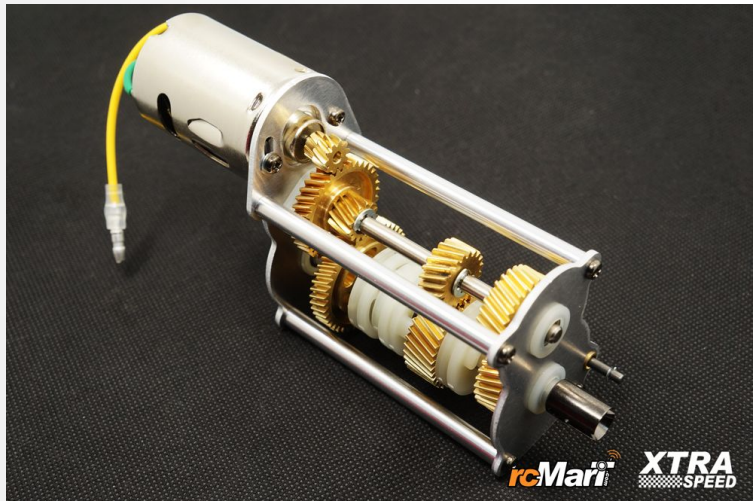


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Pinguino IDE
Fichier Editer Vue Envoyer vers Pinguino Aide
CDCPrint BlinkLedWithInterrupt AnalogInOutSerial AnalogReadSerial RealTimeClock CDC_RTCC
Code navigator: Explore Search/Replace
Répertoires (Aucun)
Android EEPROM Lua Php Python RTCC SD
1 FILE: RealTimeClock.pde
2 PROJECT: Pinguino
3 PURPOSE: Real Time clock and Calendar functions Demo
4 PROGRAMMER: regis.blanchot@blanchot@gmail.com
5 BOARD: Pinguino with RTCC module and external 32.768 kHz clock crystal
6 FIRST RELEASE: 11 apr. 2011
7 LAST RELEASE: 28 jun. 2012
8
9 -----
10 void old();
11
12
13 void DayTime() {
14   u8 DayTime = {'Sat','Sun','Mon','Tue','Wed','Thu','Fri'};
15   u8 MonthTime = {'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec'};
16 }
17
18 void setup() {
19   u8 Yr = 0x0140000; // 10hr, 00 min, 00 sec
20   u8 Dc = 0x13031000; // Monday (day 2 of the week)
21   u8 drift = 200; // add 200 pulse every minut
22   pinMode(USELED, OUTPUT);
23   RTCC.init(Yr, Dc, drift);
24 }
25
26
27 void loop() {
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The Solution

Hardware & Software

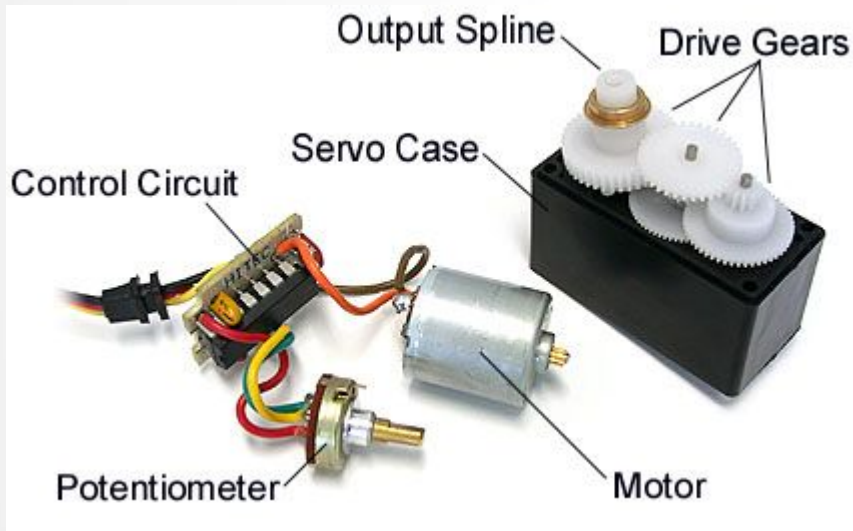
.Commercial gearboxes



The Solution

Hardware & Software

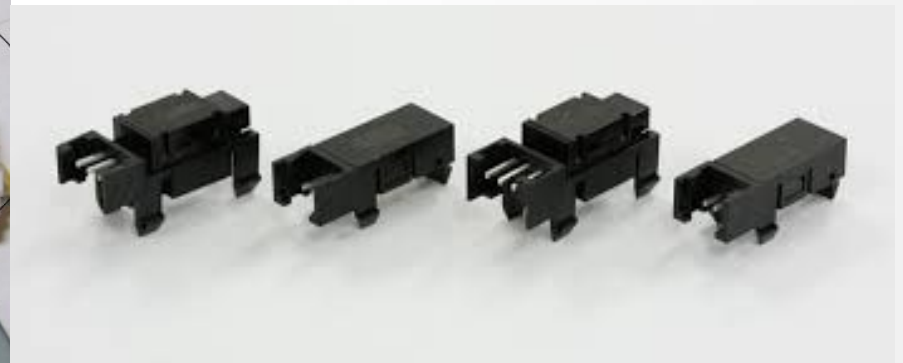
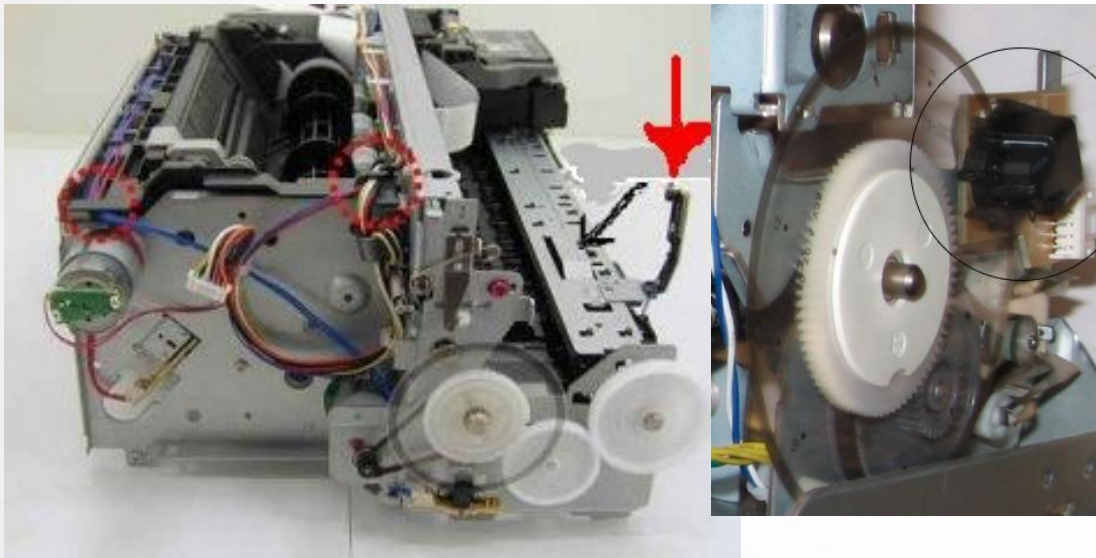
- RC and robotics servos



The Solution

Hardware & Software

- Sensors (from old equipment like printers...?)



What about integration?

μManager

THE OPEN SOURCE MICROSCOPY SOFTWARE

OVERVIEW · DOWNLOADS · DOCUMENTATION · DEVICES · PROGRAMMING · SUPPORT · EVENTS · CREDITS · LOG IN

welcome to
micro-manager!



News

Version 2.0 beta now
available!

[Use Illumina sequencer
hardware with Micro-
Manager]

micro-manager.org/Micro-Manager

Micro-Manager Open Source Microscopy Software

Announcement μManager is now developed at Open Imaging. As you may know, μManager has been developed at UCSF since the beginning of the project. Starting on October 1, 2015, μManager is developed and maintained by **Open Imaging**, a company founded by the μManager development team members. We believe that (with the community's help) this will provide a more reliable arrangement for μManager to flourish in the long term. Don't worry -- μManager will remain free and open source! Open Imaging will offer subscription-based services including technical support, which will help fund the core development of μManager.

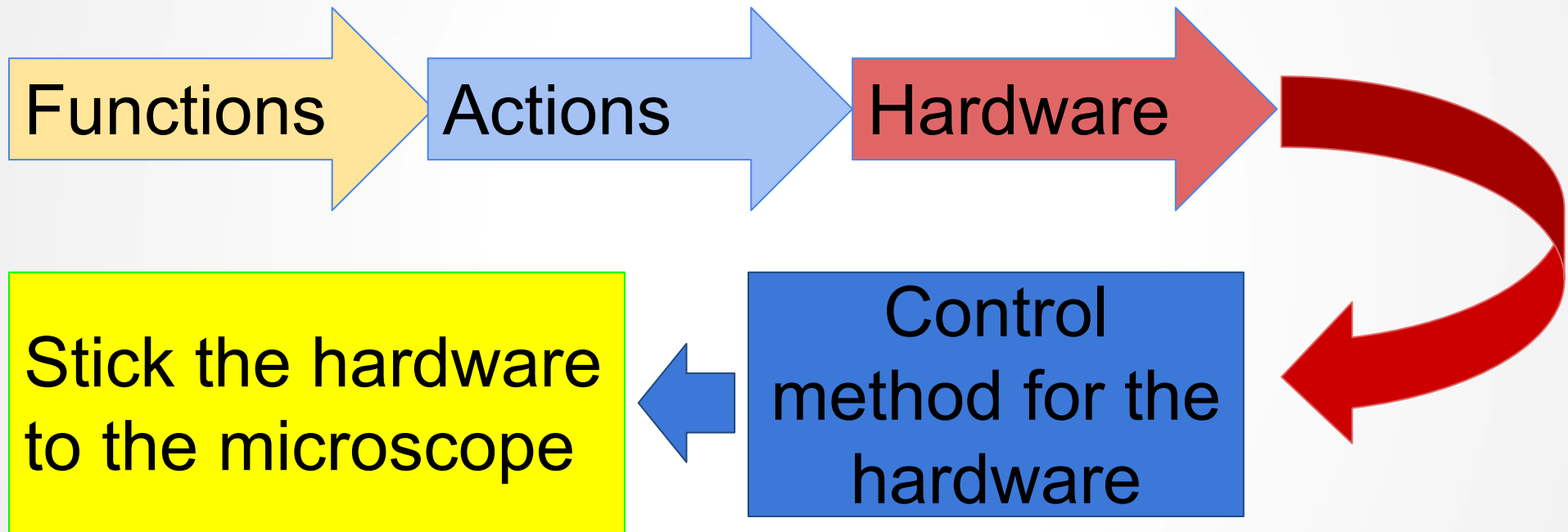


μManager is a software package for control of automated microscopes. Together with the image processing application **ImageJ**, μManager provides a comprehensive, freely available, imaging solution.

Embedded Software Development

Divide and conquer

- Split the processes in:



Example of Software Development

- Functional requirement: sample plate end stop detection.
- Is an optical switch sufficient: yes (on or off).
- Possible states: 2 (on or off).
- How many inputs do I need: 2 (up-down).
- How to present the data: LCD, or image acquisition PC.
- This action can block (by software) the corresponding motor to protect our microscope.

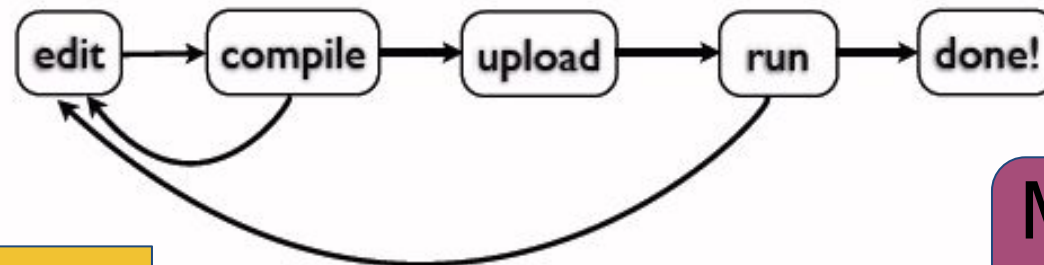
How to program

Graphical programming.

Students.

Development Cycle

- Make as many changes as you want
- Not like most web programming: edit → run
- Edit → compile → upload → run



Free control libraries.

Mature software.

An application case

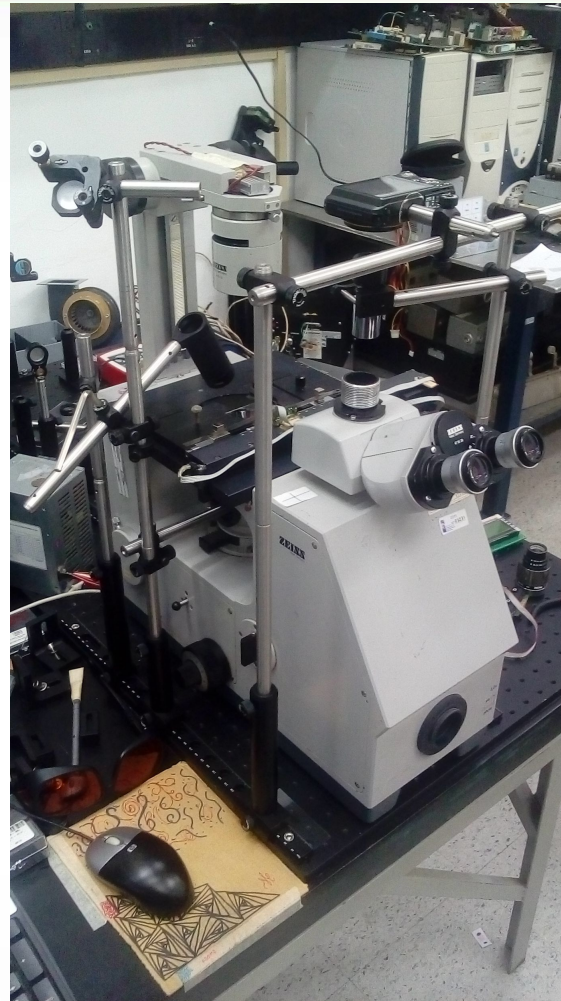
- Arduino based laser microlithography platform using low cost hardware.with G code implementation (on development).

Arduino Laser Microlithography platform

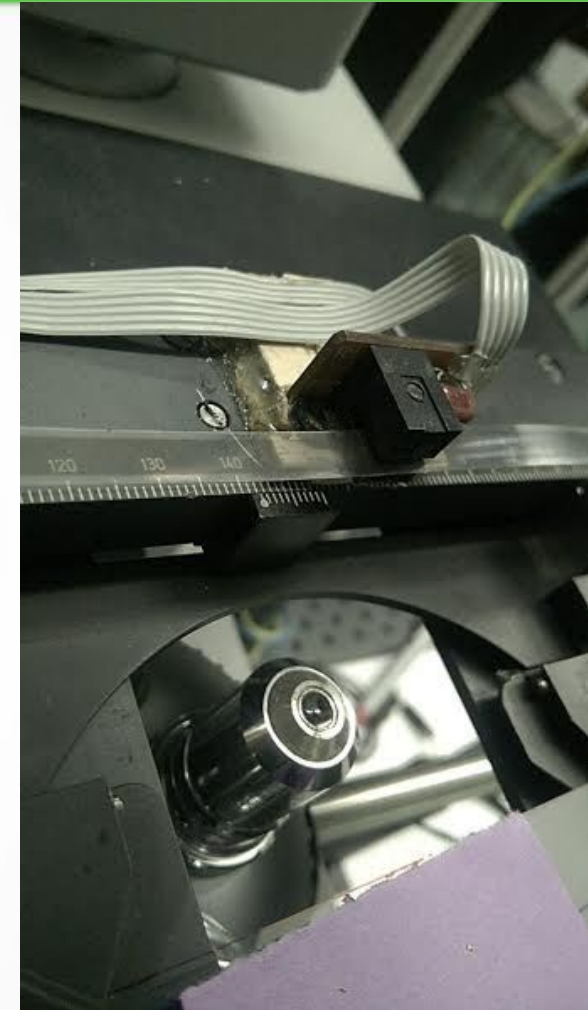
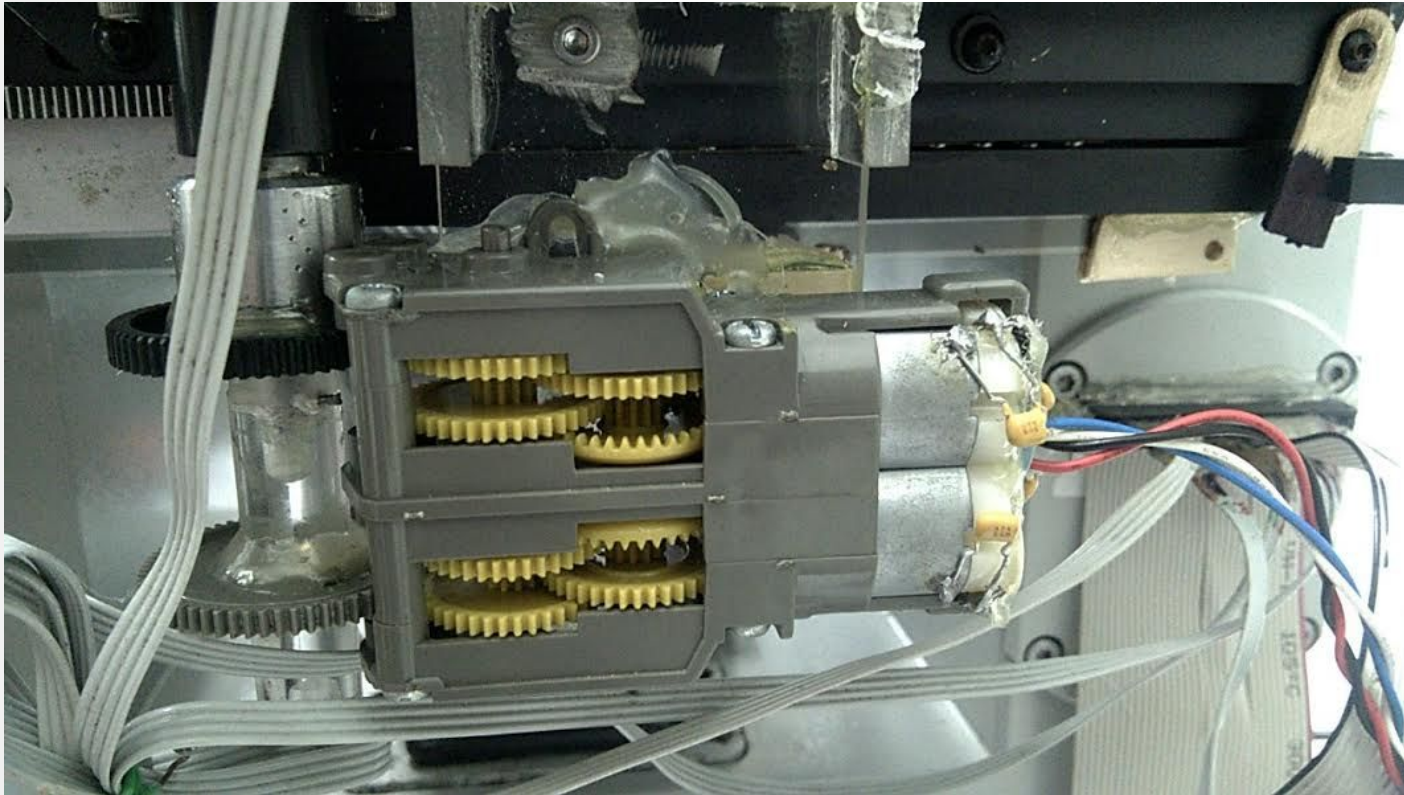
- Old microscope: Zeiss IM35 circa 1950.
- Arduino Mega.
- Two LCD screens
- Development PC
- Laser and focusing hardware.
- Two motor gearbox and sensors.



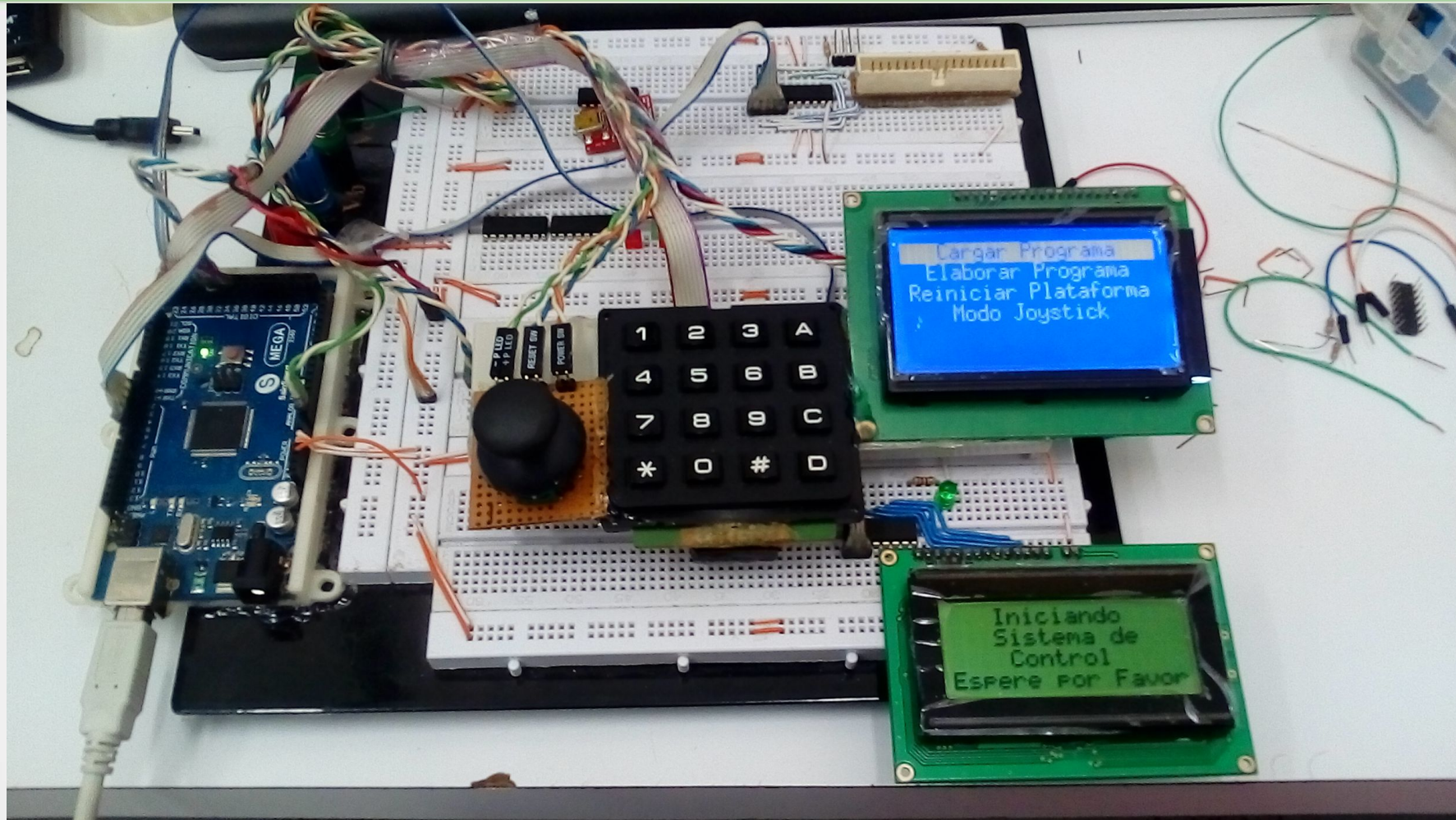
Arduino Laser Microlithography platform



Arduino Laser Microlithography platform



Controller Unit



Project Evolution

- 1. Local heating of a sample by means of a focused laser.
- 2. The team needed a motorized stage.
- 3. The system was converted for lithography.
- 4. The system is going to be used for single cell fluorescence.
- Is capable of “cutting” carbon nanotube fabric electrodes.

Results and comparison

- The system developed performed enough well to be considered a candidate to start the development of an “open source automated patch-clamp system”.
- Tolerance raw data, repetitivity and absolute displacement among coordinates proximately available on request.

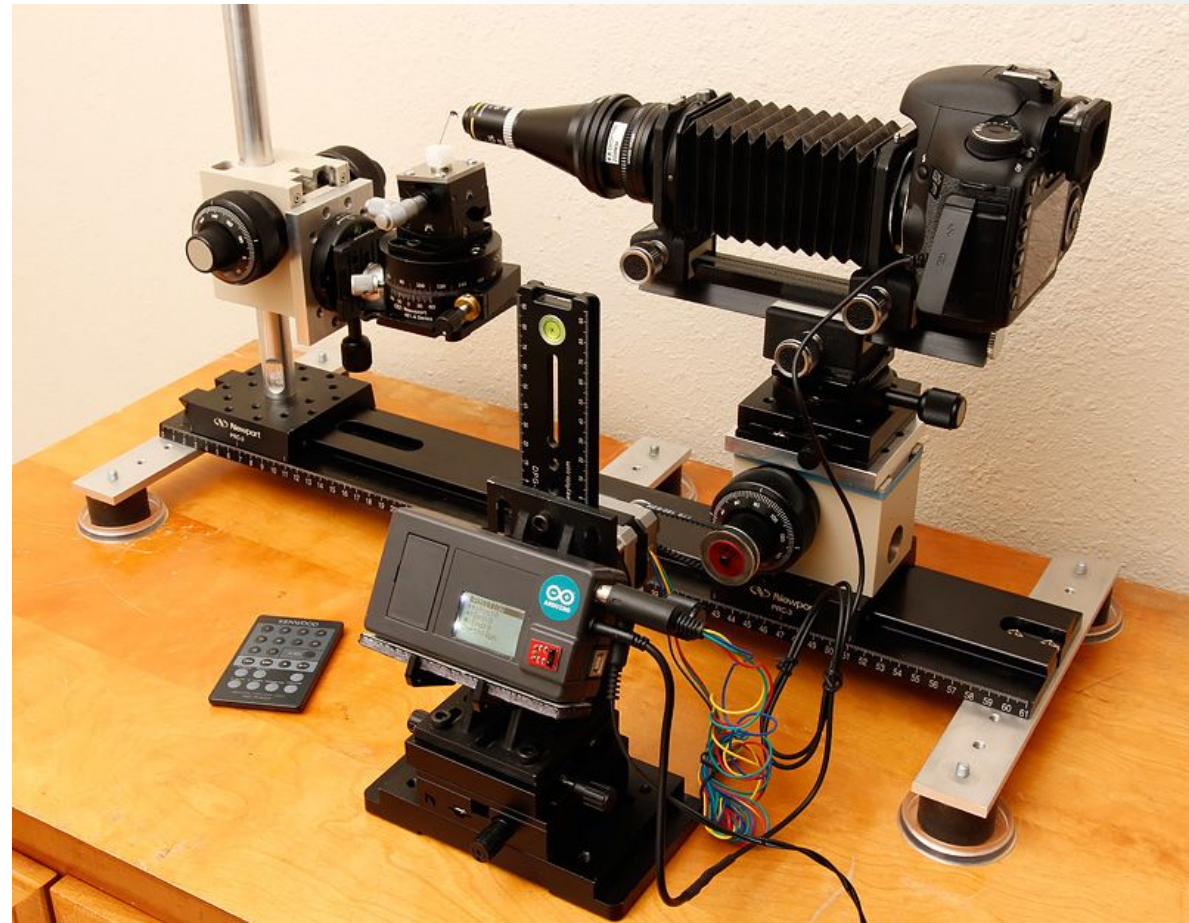
Some examples

- Rylee Isitt stacking with arduino
- <http://www.ryleeisitt.ca/articles/building-a-focus-stacking-controller/>



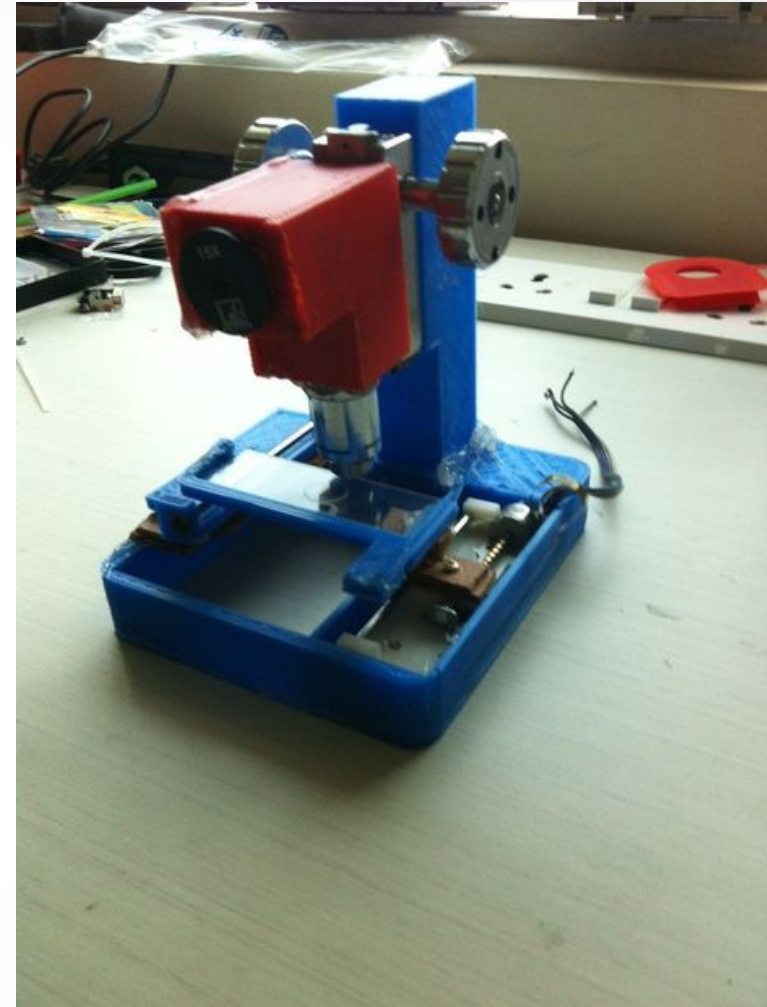
Some examples

- Rylee Isitt stacking with arduino
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Some examples

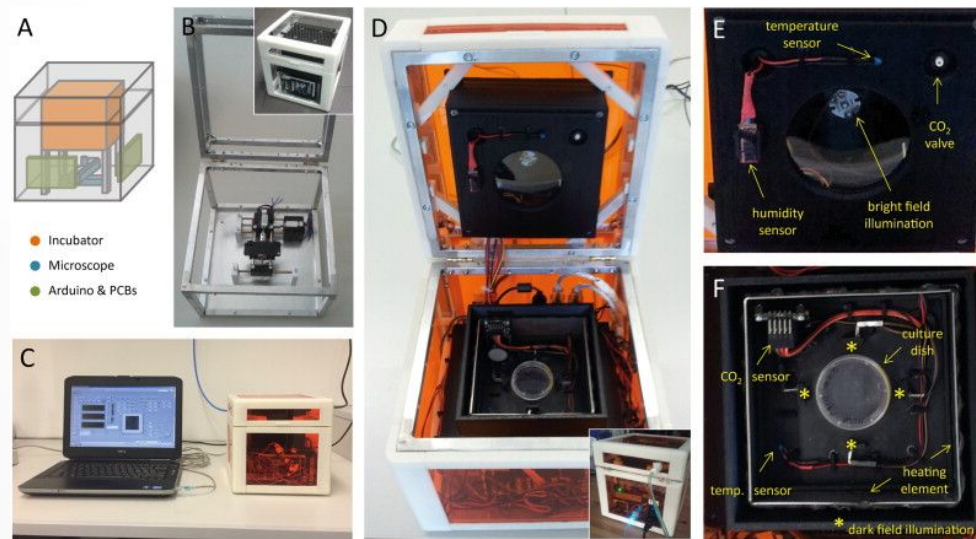
- 3D Printed microscope, semi automatic.
<http://www.instructables.com/id/Low-cost-digital-microscope-with-automated-slide-m/>



Some examples

A portable low-cost long-term live-cell imaging platform for biomedical research and education

<http://www.sciencedirect.com/science/article/pii/S0956566314007489>



Disadvantages

- Slow evolution.
- One-of-a-kind parts.
- Software integration difficult (to commercial).
- Multi language programming environments.
- Time of development.
- Device duplication.

Conclusions

Learning opportunities.

Better, faster research by less money.



Support and collaboration from communities

Useful Resources

- Low cost Microscope Automation components:
<http://www.tofrainc.net/>
- Make your own automated microscopy system:
<http://users.ox.ac.uk/~atdgroup/technicalnotes/Make%20your%20own%20automated%20microscope.pdf>
- A portable low-cost long-term live-cell imaging platform for biomedical research and education
<http://www.sciencedirect.com/science/article/pii/S0956566314007489>



The Abdus Salam
International Centre
for Theoretical Physics



Thank you for your attention.

Questions

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jaramirez@ivic.gob.ve

“Computer is not a device anymore, is an extension of your mind, and a gateway to other people” - Mark Shuttleworth.



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