Low cost microscope automation hardware and embedded software development.

J. Ramirez – A. Villa – M. Toscani

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

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.

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

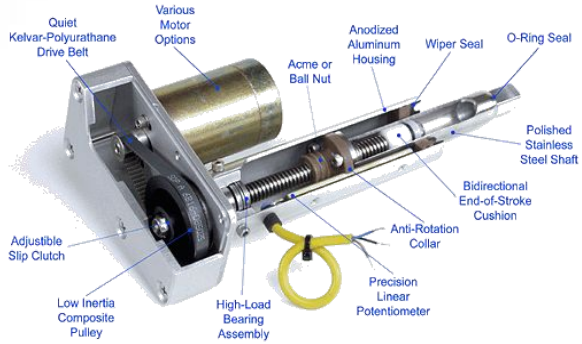
ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Introduction

Resources:

- Actuators



- Microcontrollers

- Sensors

MIPT
MOSCOW INSTITUTE
OF PHYSICS AND TECHNOLOGY

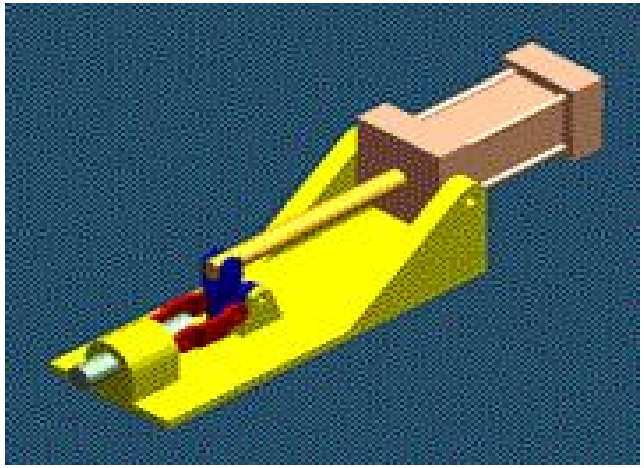
ICTP
The Abdus Salam
International Centre
for Theoretical Physics

IVIC
Venezuelan
Institute
for
Scientific
Research

Introduction

What is an Actuator?

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



MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

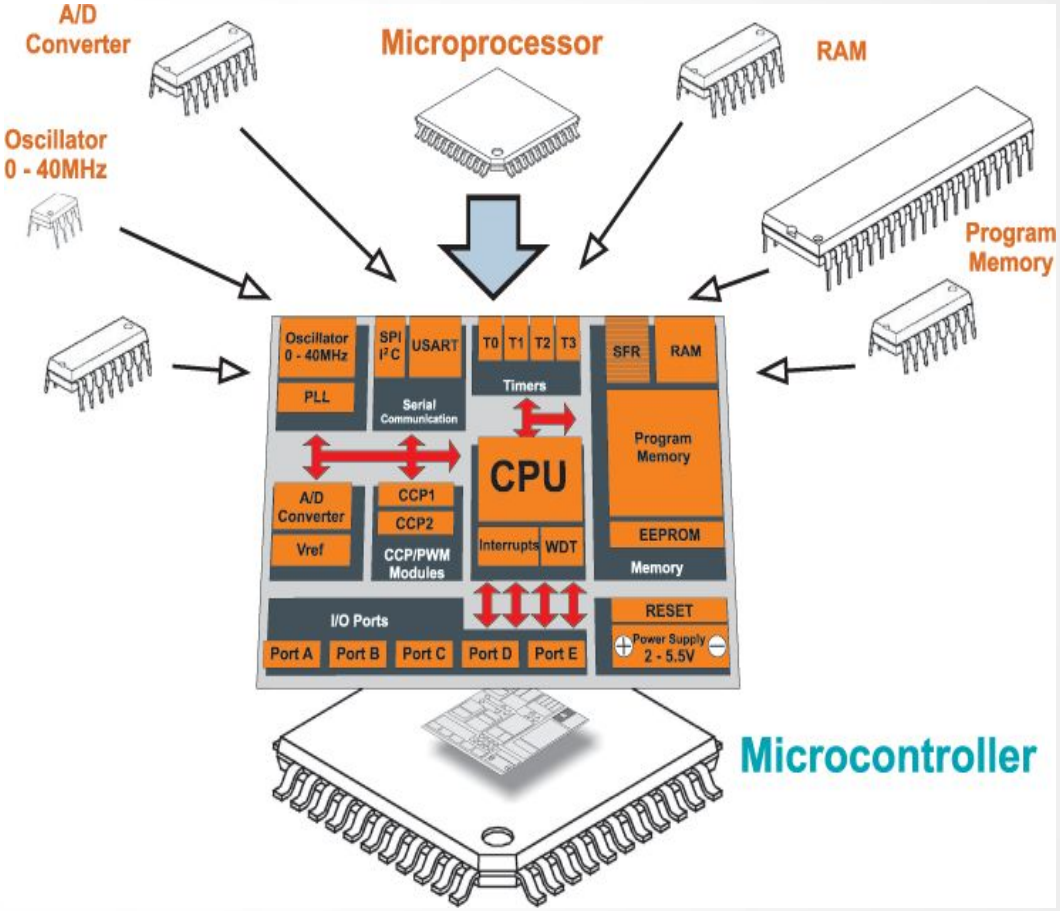
ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Introduction

What is a Microcontroller?

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



MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

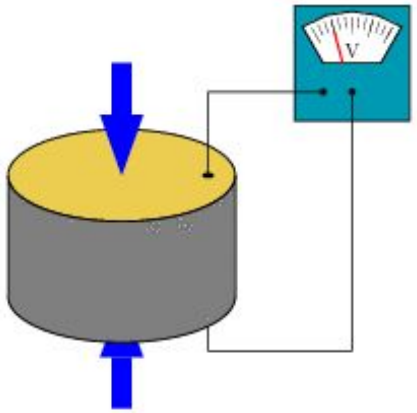
ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Introduction

What is a Sensor?

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



MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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…)

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

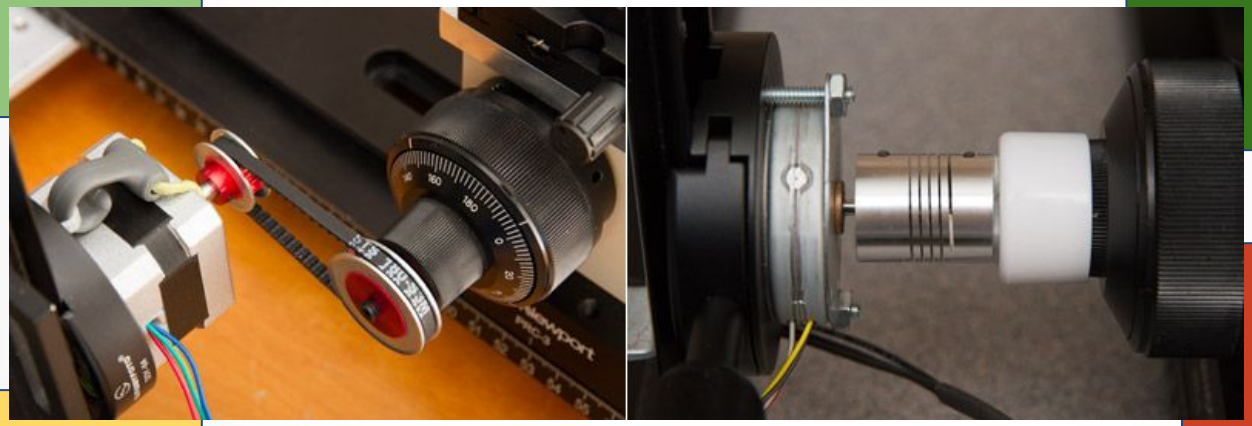
IVIC
Venezuelan Institute for Scientific Research

The problem

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

Repetitive tasks

Instrument Isolation



Remote operation

‘peculiar’ additions tend to be frowned upon.

Standard set of hardware

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

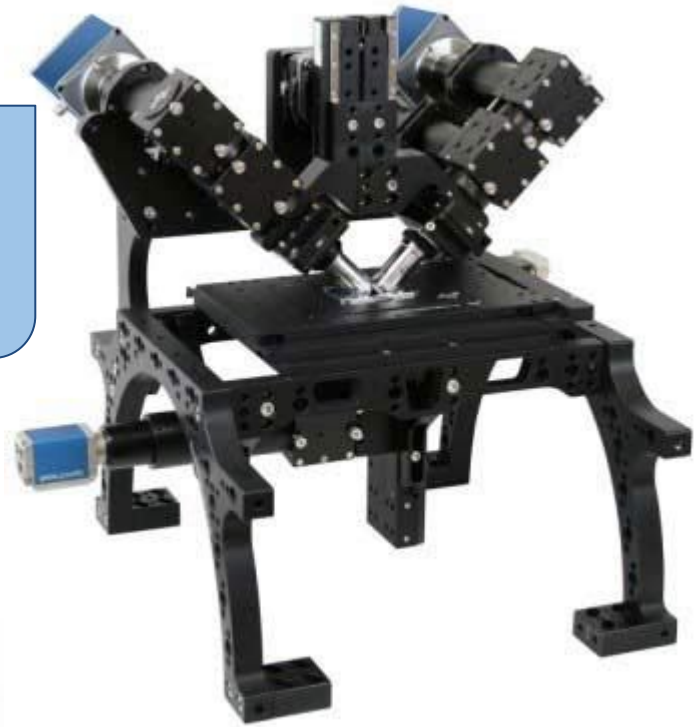
ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

The problem

Do I need a motorized microscope?

- Non functional requirements



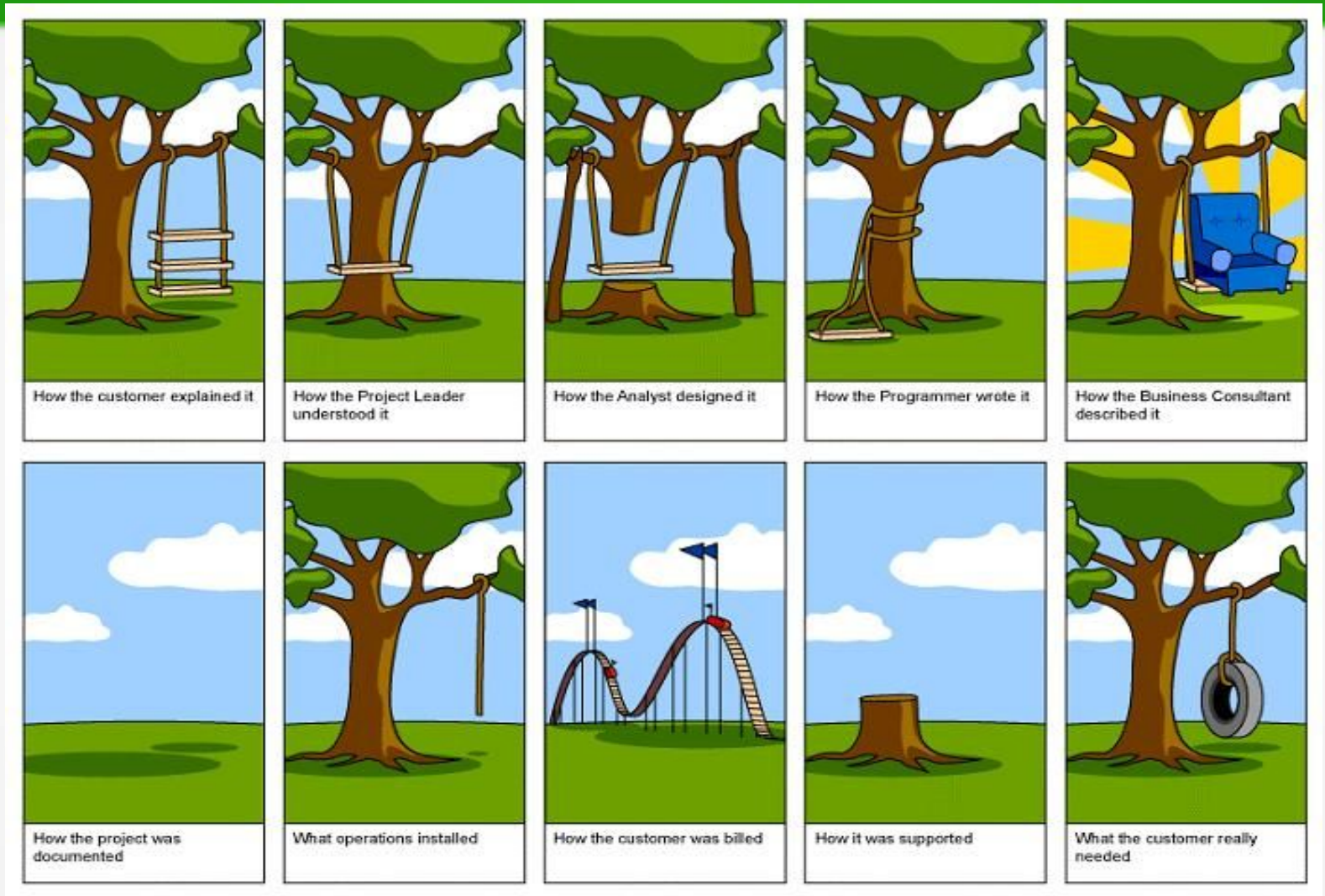
- Functional requirements

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

The problem



MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

The problem

How to face the need of solutions

- Time-of-building vs deadlines.

- Time-of-building vs scientific production increase.

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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.

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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”.

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Some examples

Official website of the Department of Homeland Security

Contact Us | Quick Links | Site Map | A-Z Index

Homeland Security

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

Science and Technology

$A = \log_{10} \frac{I_0}{I}$ $P_{r-est} = 8 \times (Z)^{-2.44}$ $x_t = x_t(1+r)^t$

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

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

Share / Email

2010 Archives

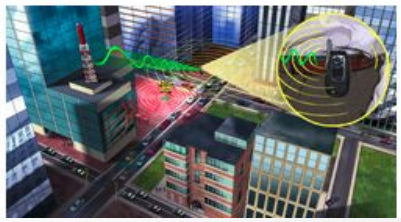
Cell-All: Super Smartphones Sniff Out Suspicious Substances

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

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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.

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Some examples

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

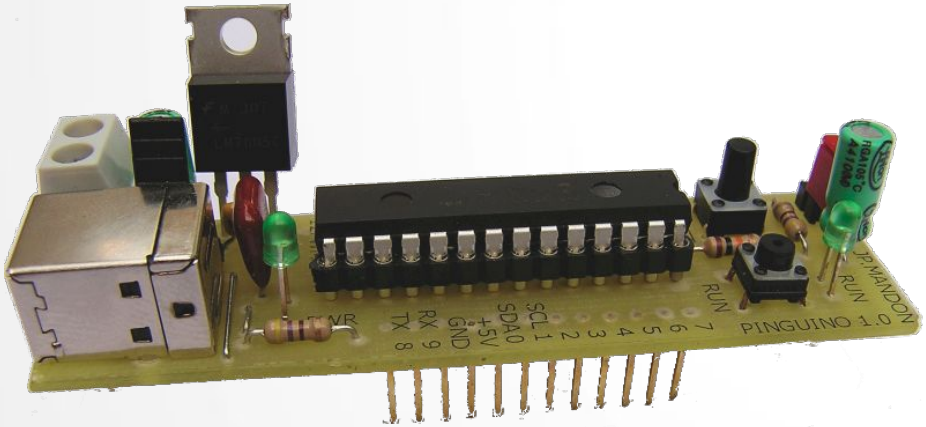
ICTP
The Abdus Salam International Centre for Theoretical Physics

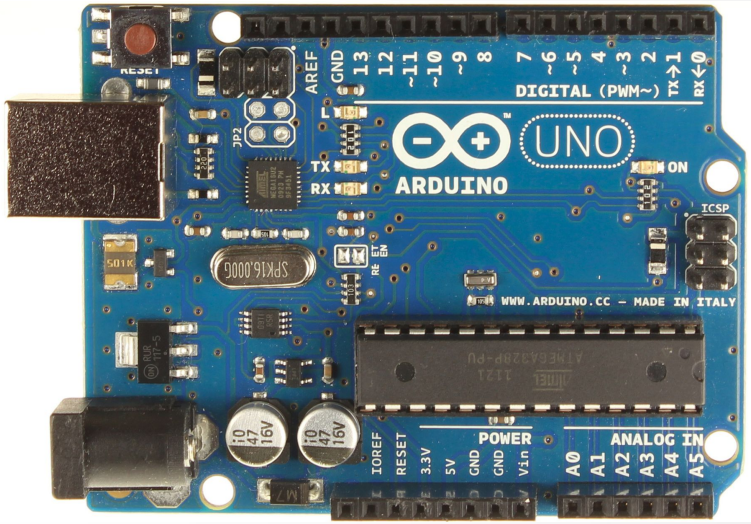
IVIC
Venezuelan Institute for Scientific Research

The Solution

Hardware & Software

- Arduino & Pinguino





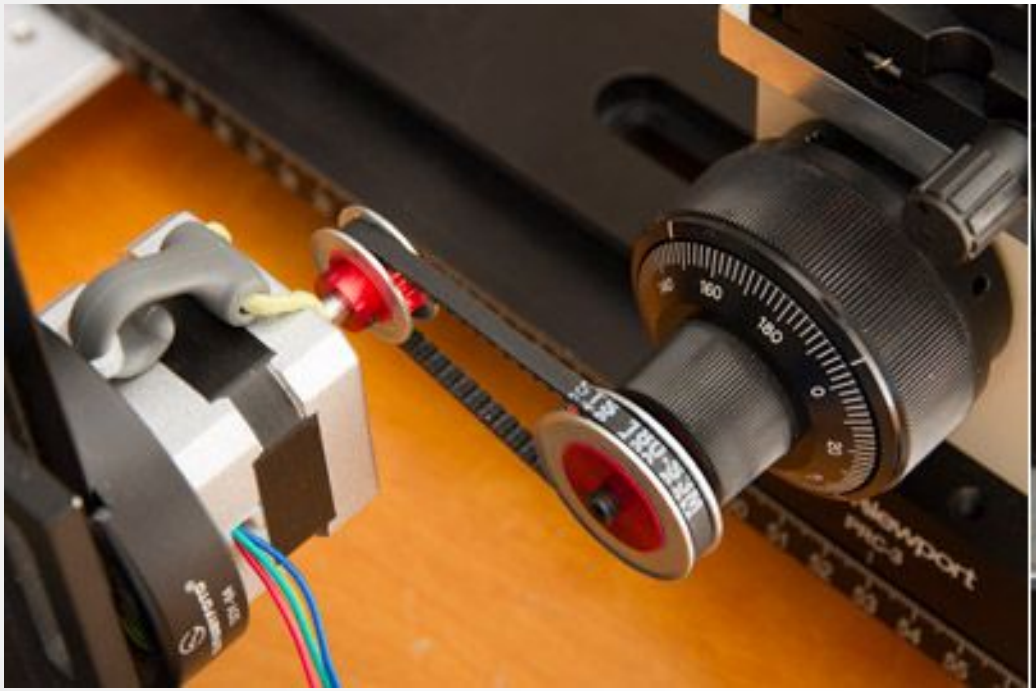
MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

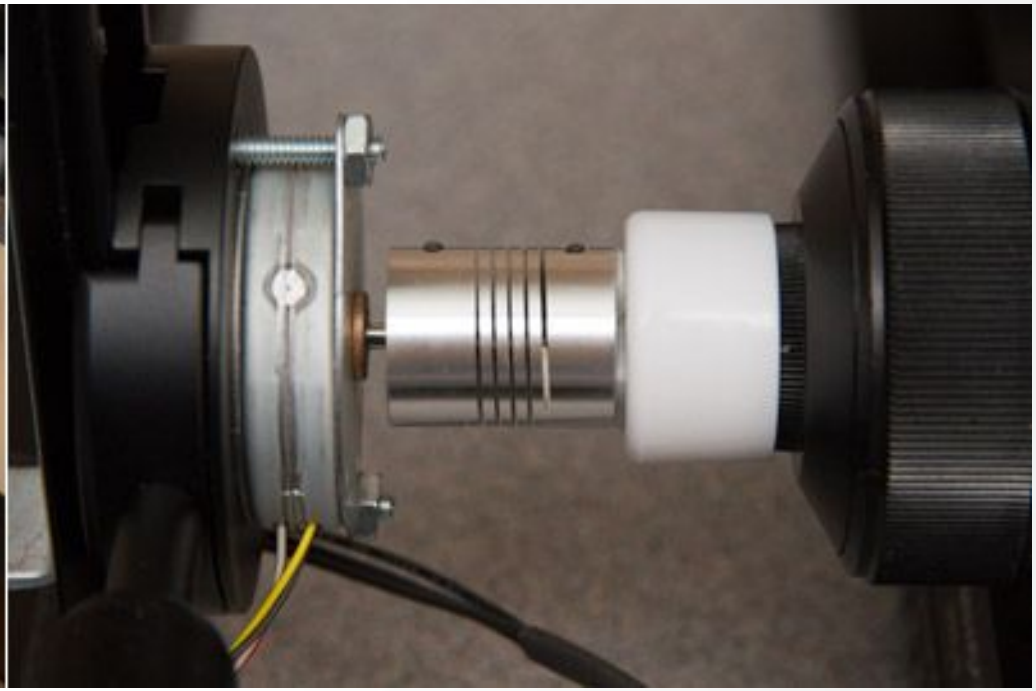
ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

The Solution

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





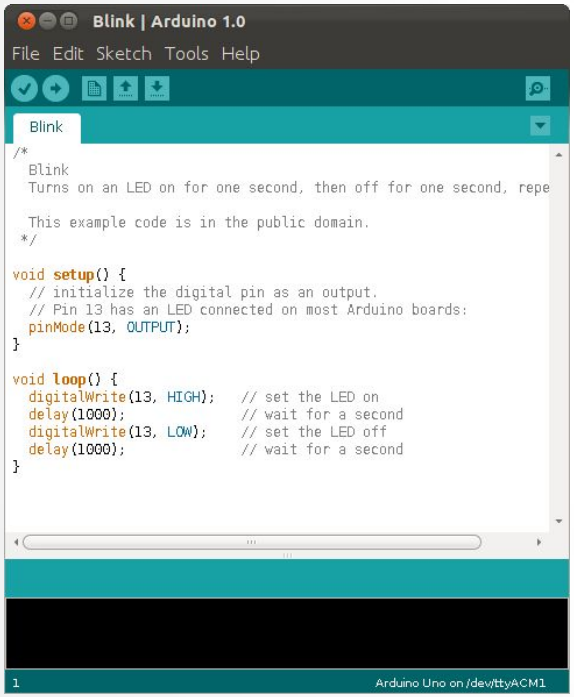
MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

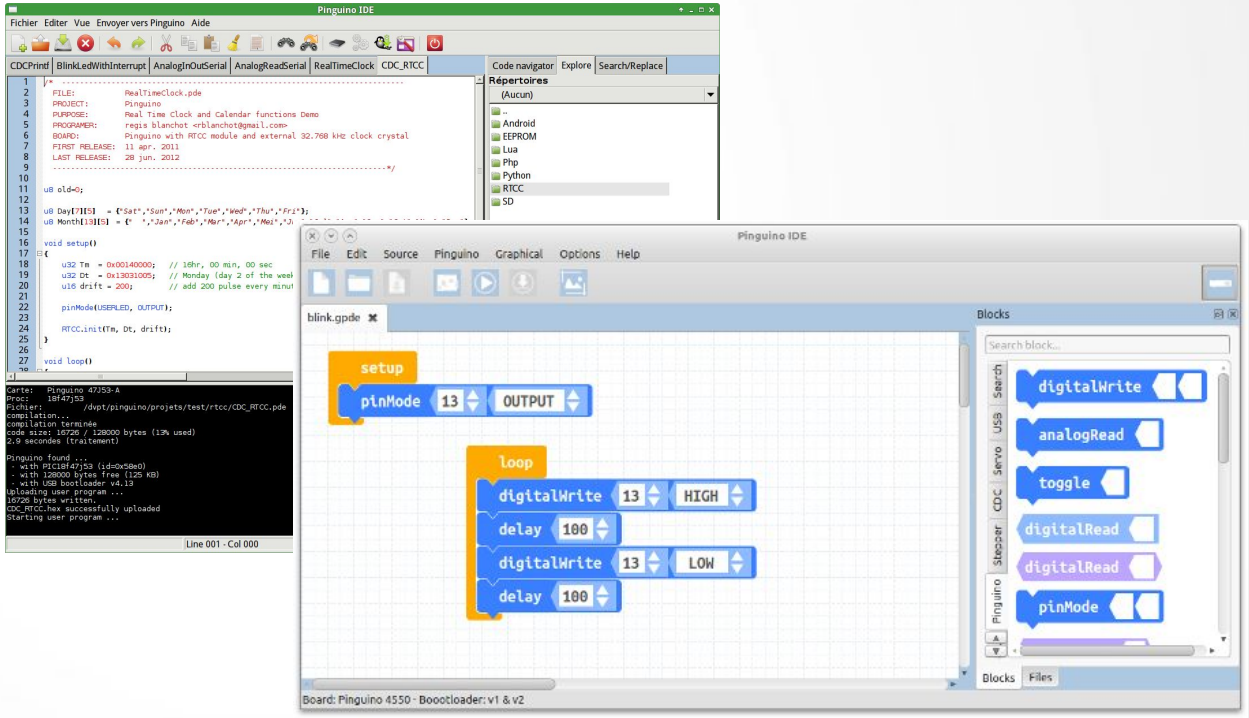
ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

The Solution

Why Arduino & Pinguino?





MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

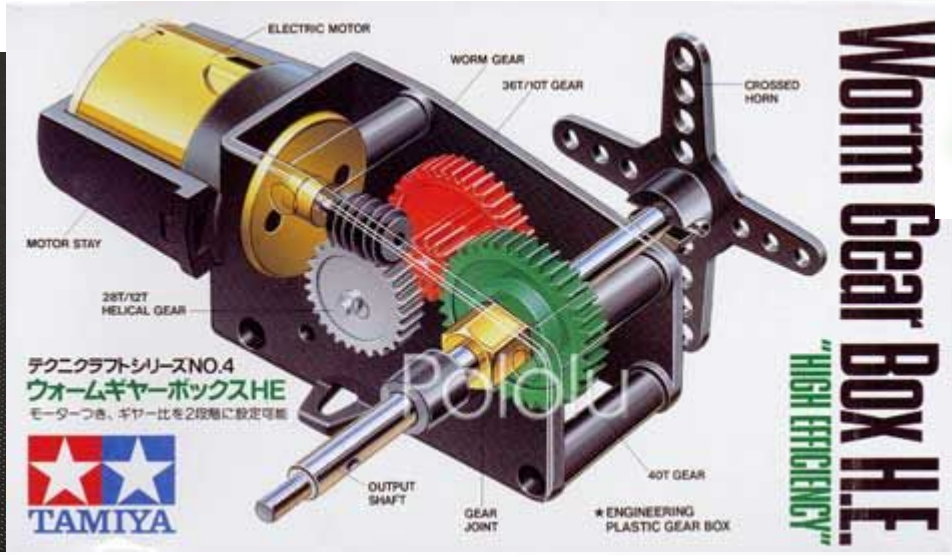
ICTP
The Abdus Salam International Centre for Theoretical Physics

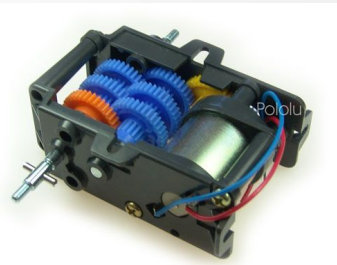
IVIC
Venezuelan Institute for Scientific Research

The Solution

Hardware & Software

- Commercial gearboxes





MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

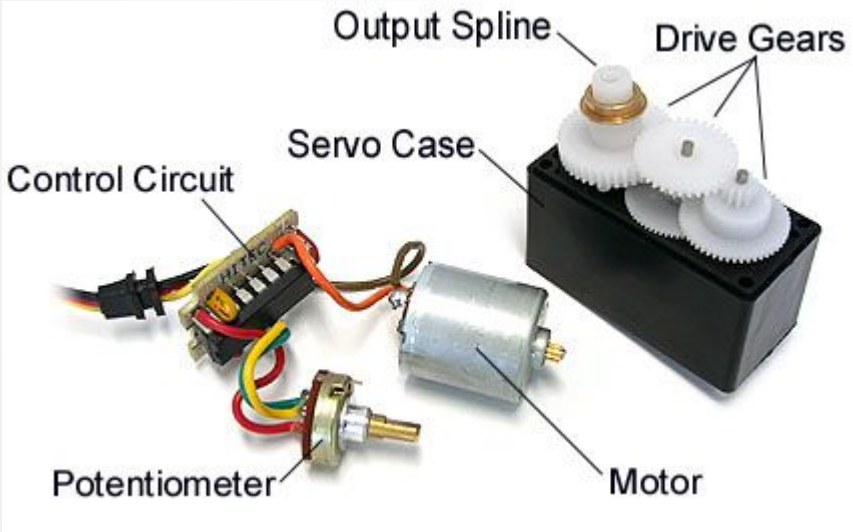
ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

The Solution

Hardware & Software

- RC and robotics servos



MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

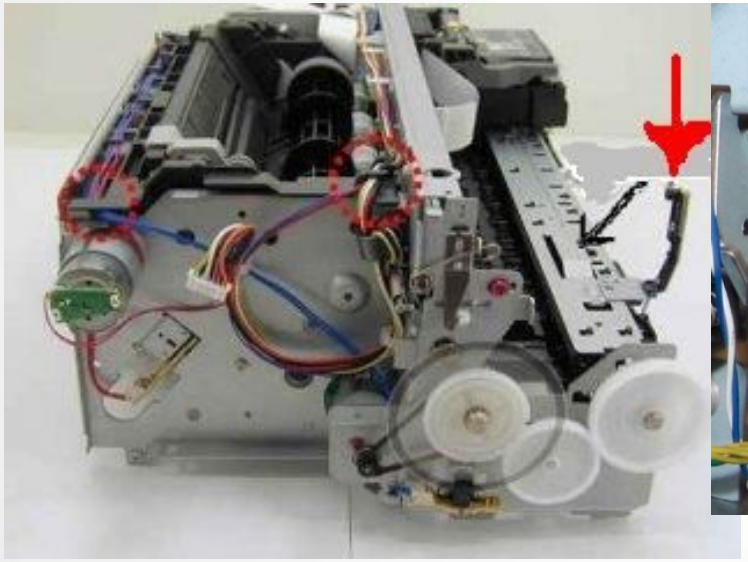
ICTP
The Abdus Salam International Centre for Theoretical Physics

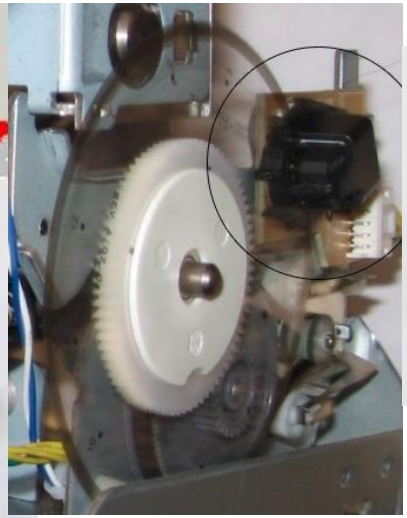
IVIC
Venezuelan Institute for Scientific Research

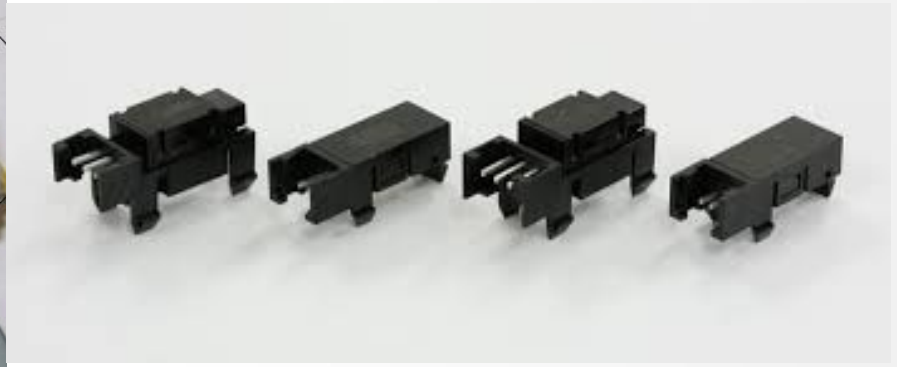
The Solution

Hardware & Software

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







MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

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 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.

µ-Manager

The Open Source Microscopy Software

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.

micro-manager.org/Micro-Manager

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

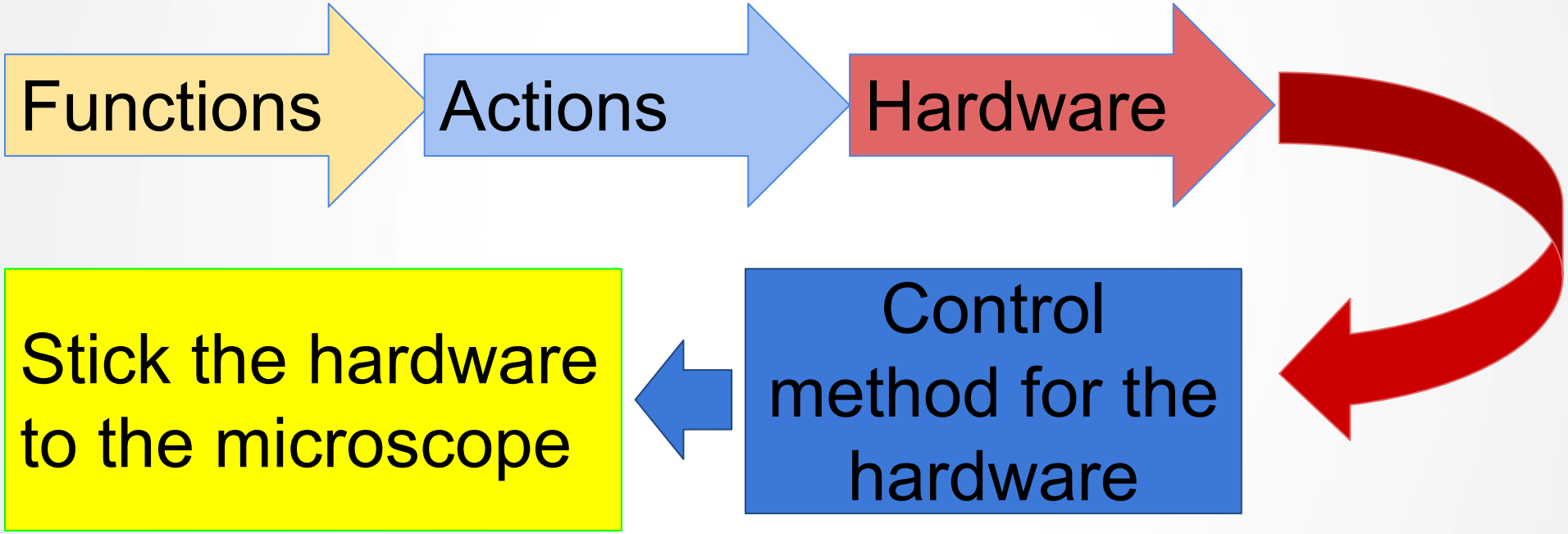
ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Embedded Software Development

Divide and conquer

- Split the processes in:



MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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.

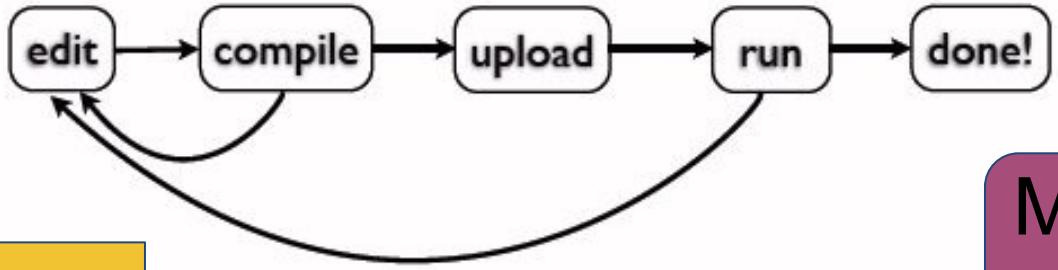
How to program

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.

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

An application case

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

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Arduino Laser Microlithography platform

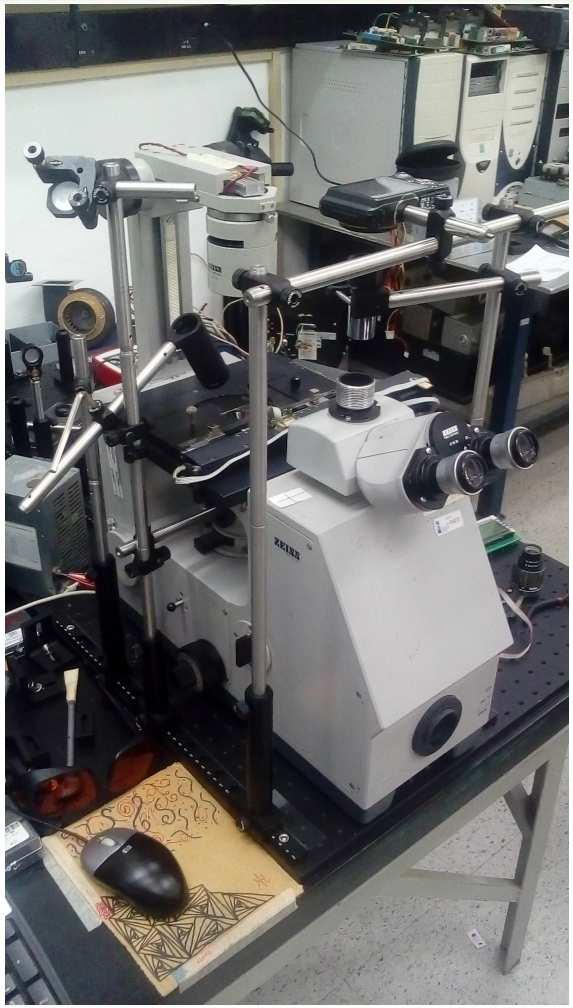
- Old microscope: Zeiss IM35 circa 1950.
- Arduino Mega.
- Two LCD screens
- Development PC
- Laser and focusing hardware.
- Two motor gearbox and sensors.

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Arduino Laser Microlithography platform

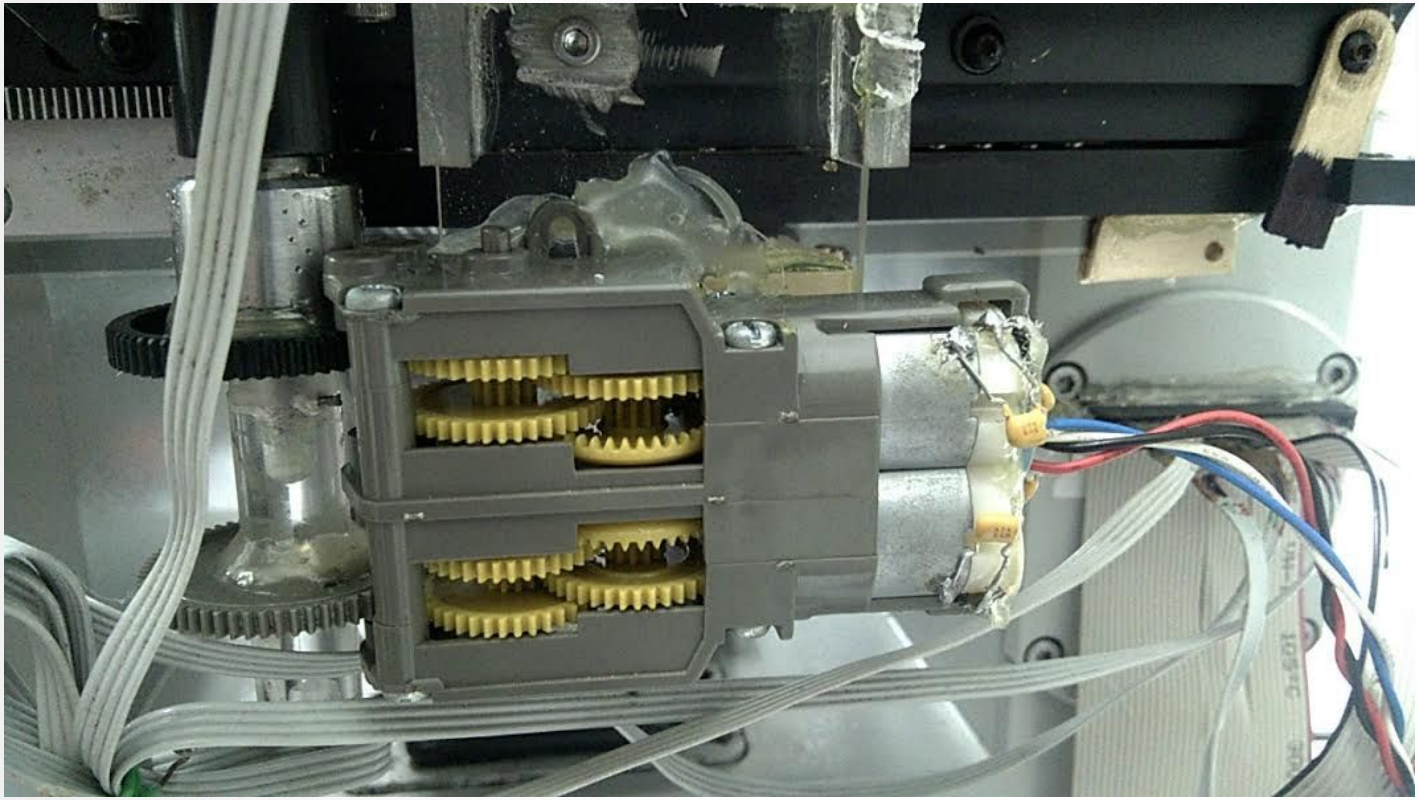


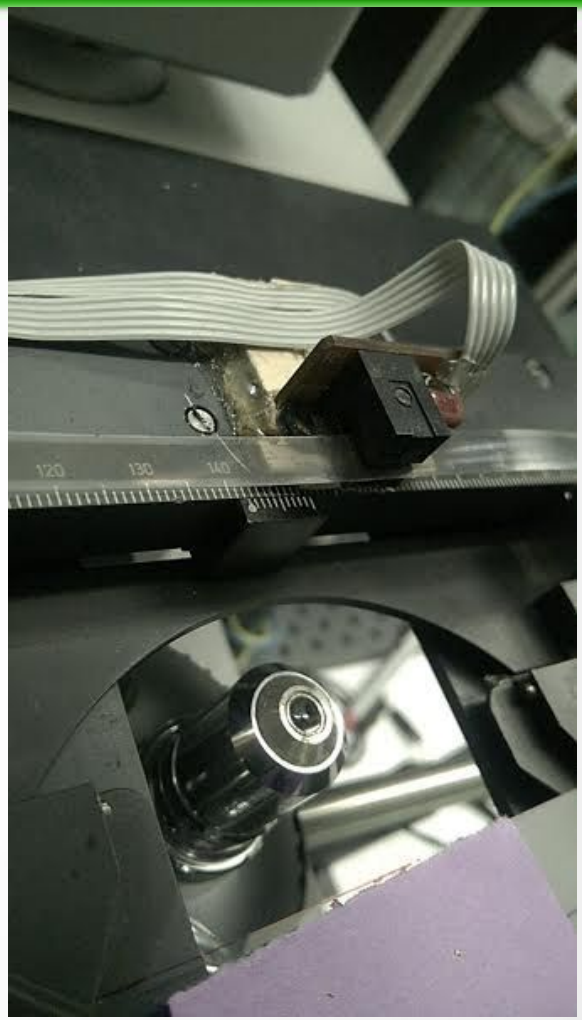
MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Arduino Laser Microlithography platform



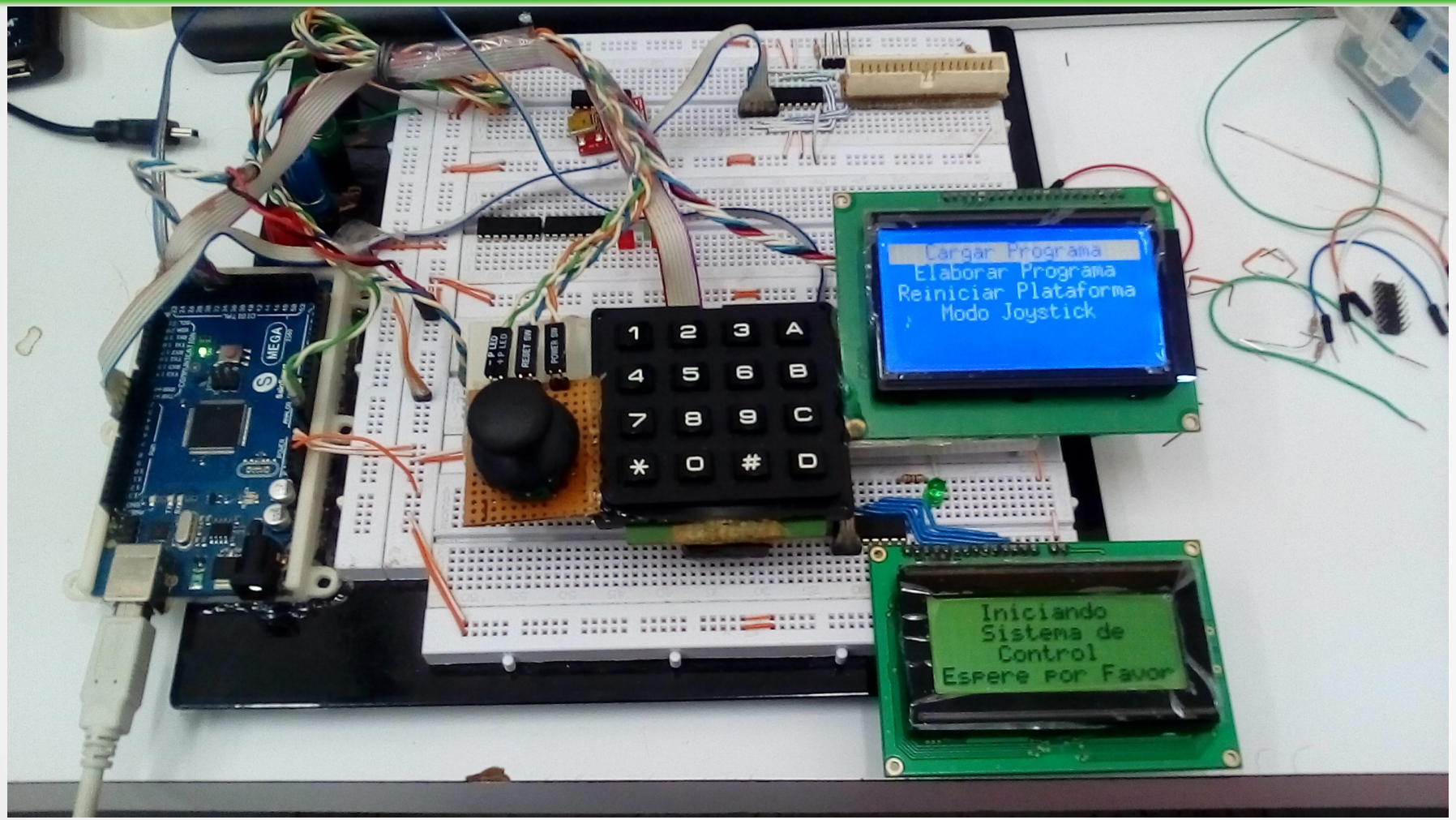


MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Controller Unit



MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam
International Centre
for Theoretical Physics

IVIC
Venezuelan
Institute
for
Scientific
Research

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.

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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.

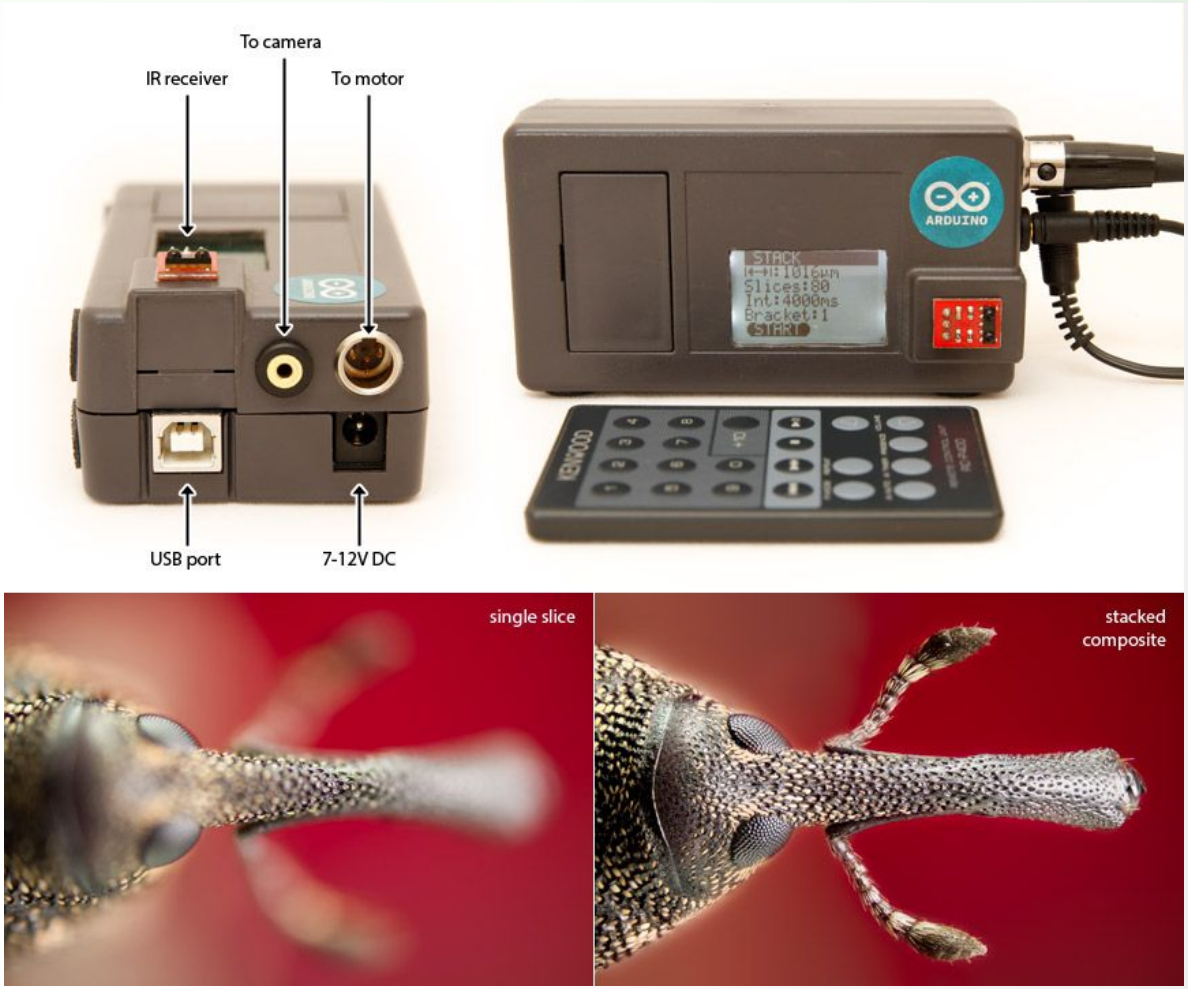
MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

Some examples

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



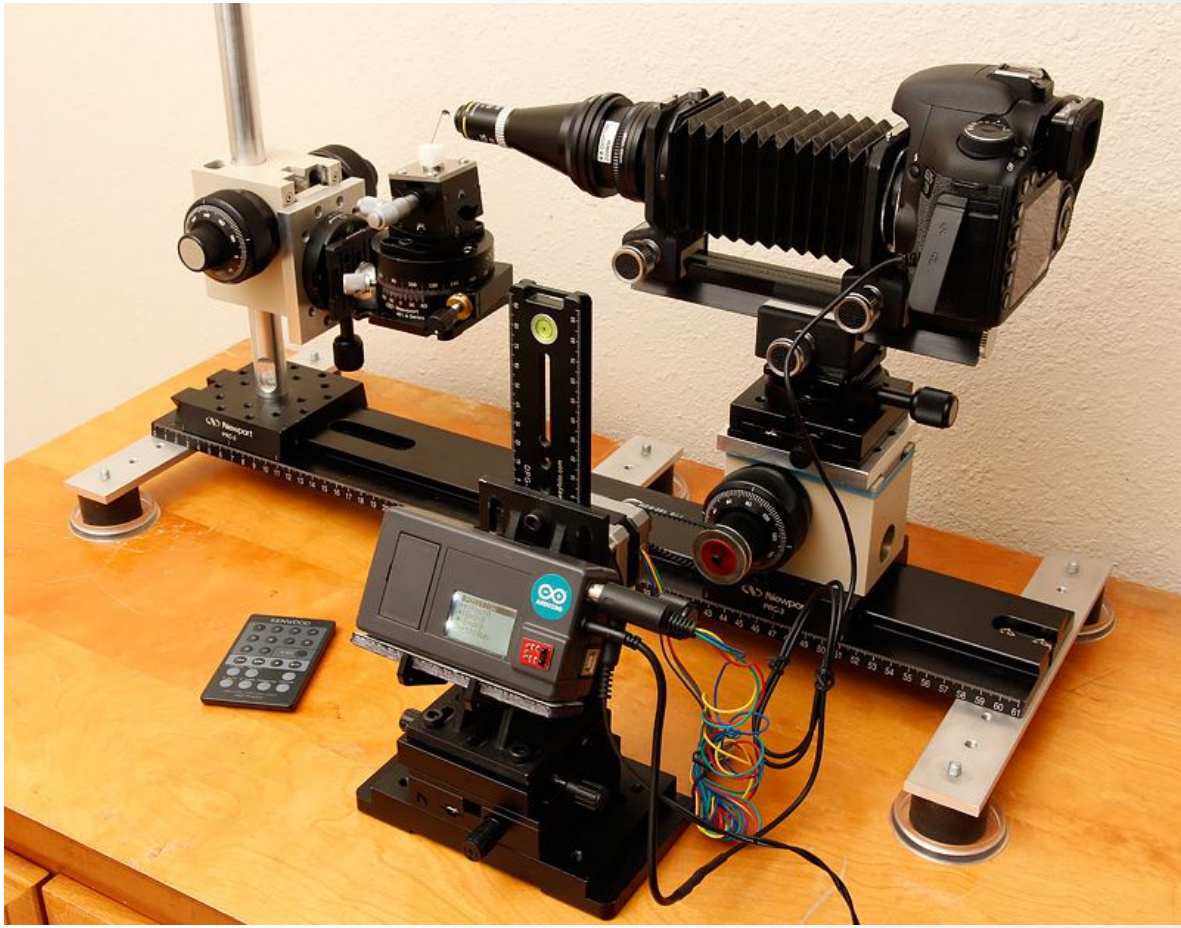
MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Some examples

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



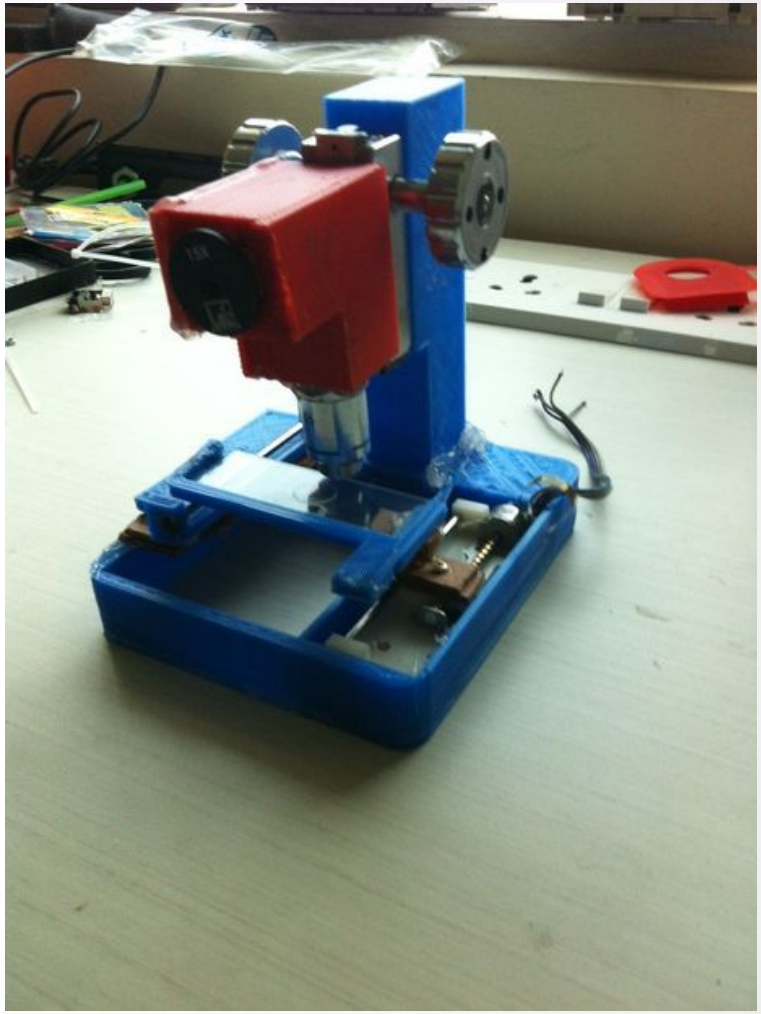
MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Some examples

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



MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

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.

Support and collaboration from communities

Better, faster research by less money.

MIPT
MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP
The Abdus Salam International Centre for Theoretical Physics

IVIC
Venezuelan Institute for Scientific Research

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

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research

Thank you for your attention.

Questions

javierramirezbenavides@gmail.com
jaramirez@ivic.gob.ve

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

MIPT MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

ICTP The Abdus Salam International Centre for Theoretical Physics

IVIC Venezuelan Institute for Scientific Research