

# FlowIO Platform

Making Prototyping with Soft Programmable  
Materials Seamless and Universally Accessible

Ali Shtarbanov

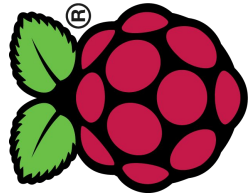
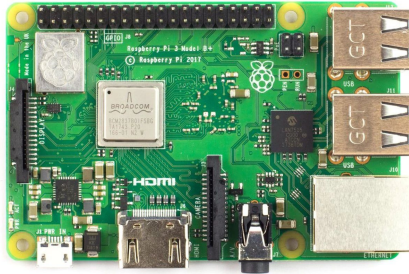


**Personal Mission:** *To make innovation and prototyping in emerging fields easily accessible for everyone...*

*...through the **development** and **deployment** of new tools and platforms that are highly versatile, general purpose, and simple to use.*

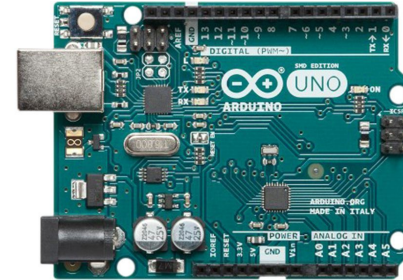


## Portable Computing

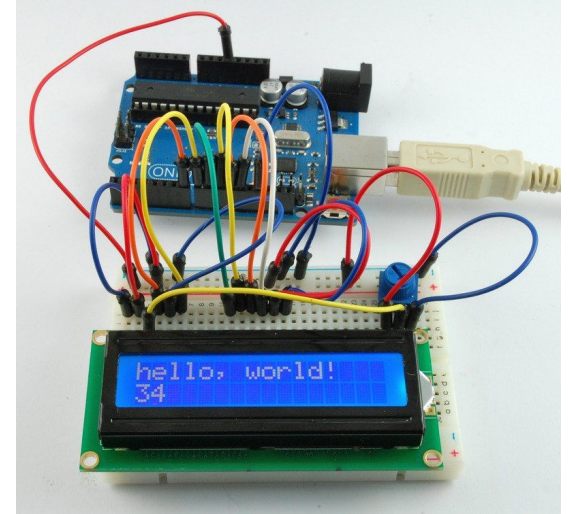
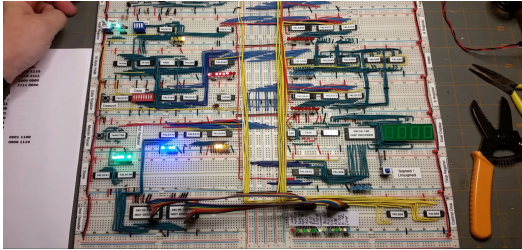


Raspberry Pi

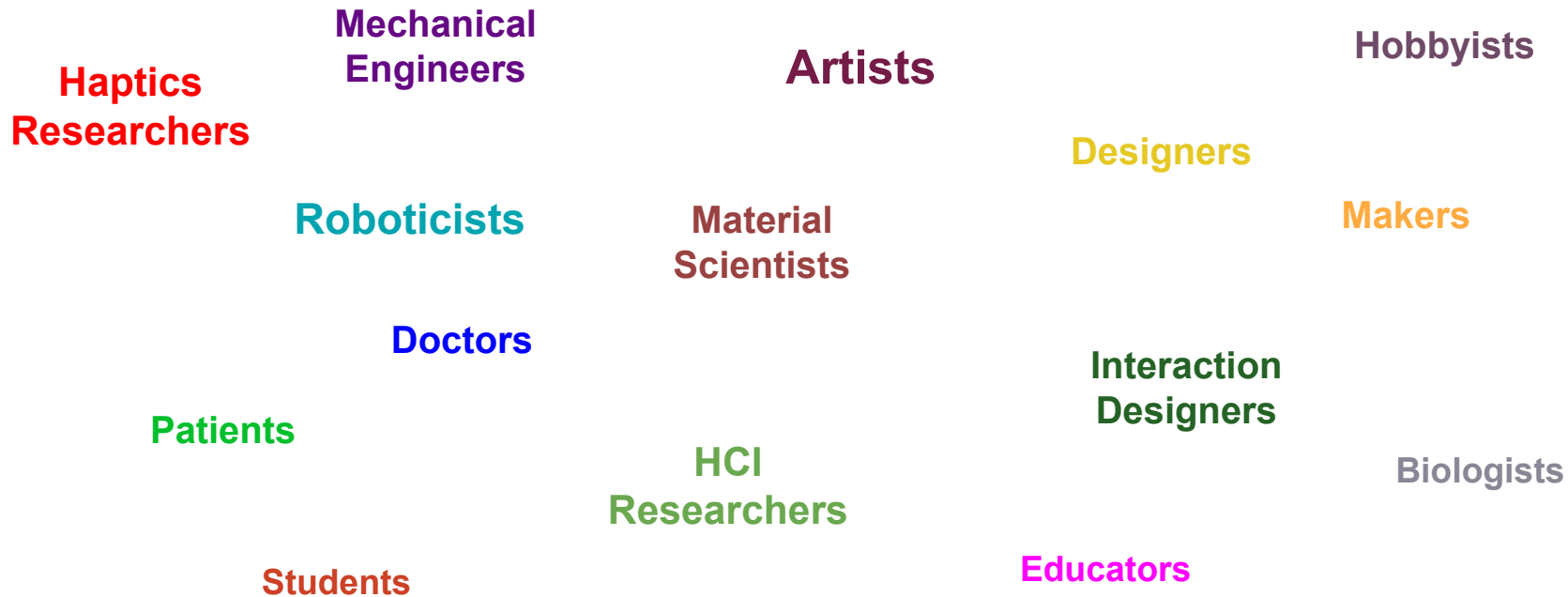
## Electronics



# Electronics Prototyping Transformation



# Soft Programmable Materials Across Disciplines



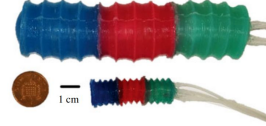
# Soft Programmable Materials Across Applications



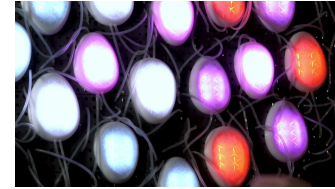
AeroMorph (UIST'16)



MorphIO (DIS'19)



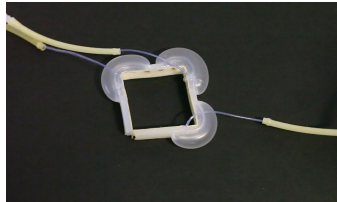
EuMoBot (2018)



AuxeticBreath (TEI'21)



Vine Robots (2018)



PneUI (UIST'13)



Bubble (CHI'19)



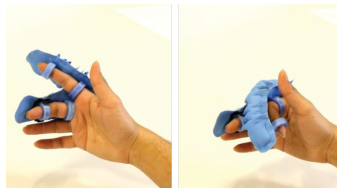
Jamming UIs (UIST'12)



Colorise (TEI'18)



VSPA (Science'17)



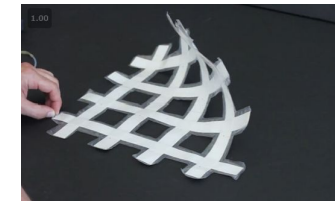
PrintFlatables (CHI'17)



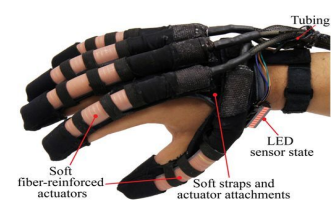
Force Jacket (CHI'18)



Exoskin (2013)

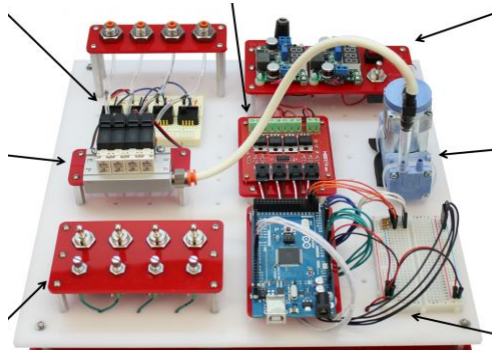


JamSheets (TEI'14)

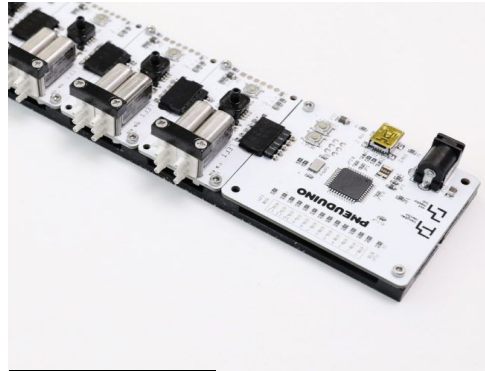


Soft Robotic Glove (2015)

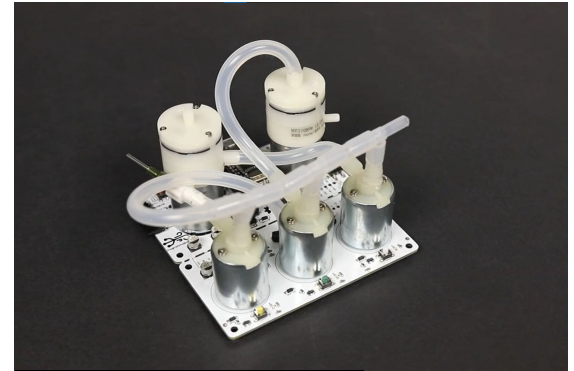
# Existing Pneumatic Toolkit Attempts



**Soft-Robotics Toolkit**

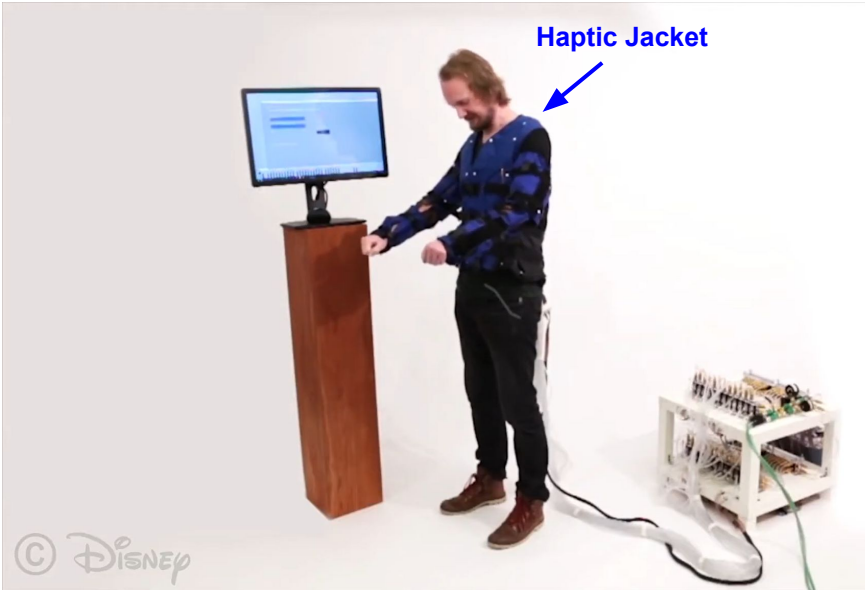


**Pneduino**

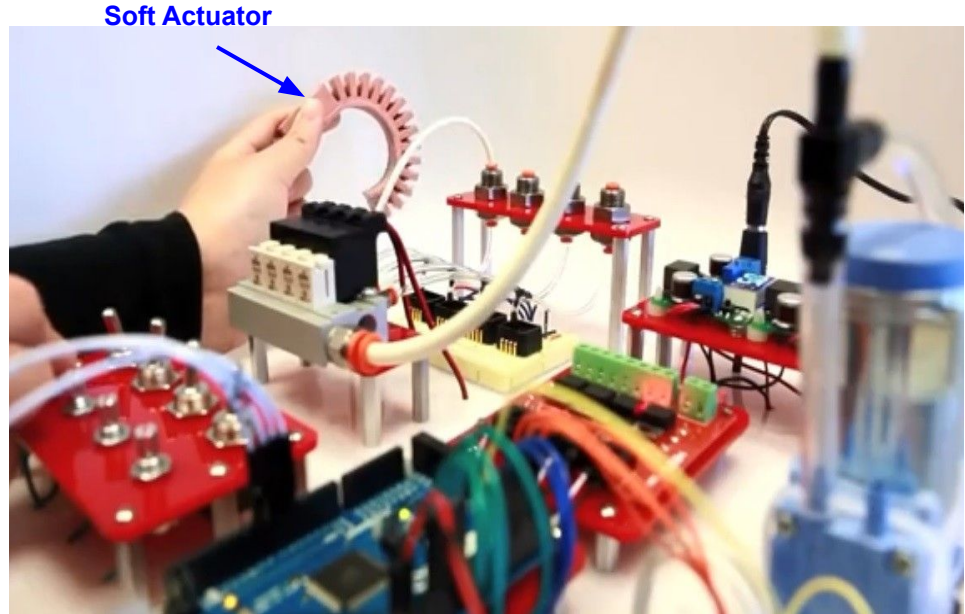


**Programmable-Air**

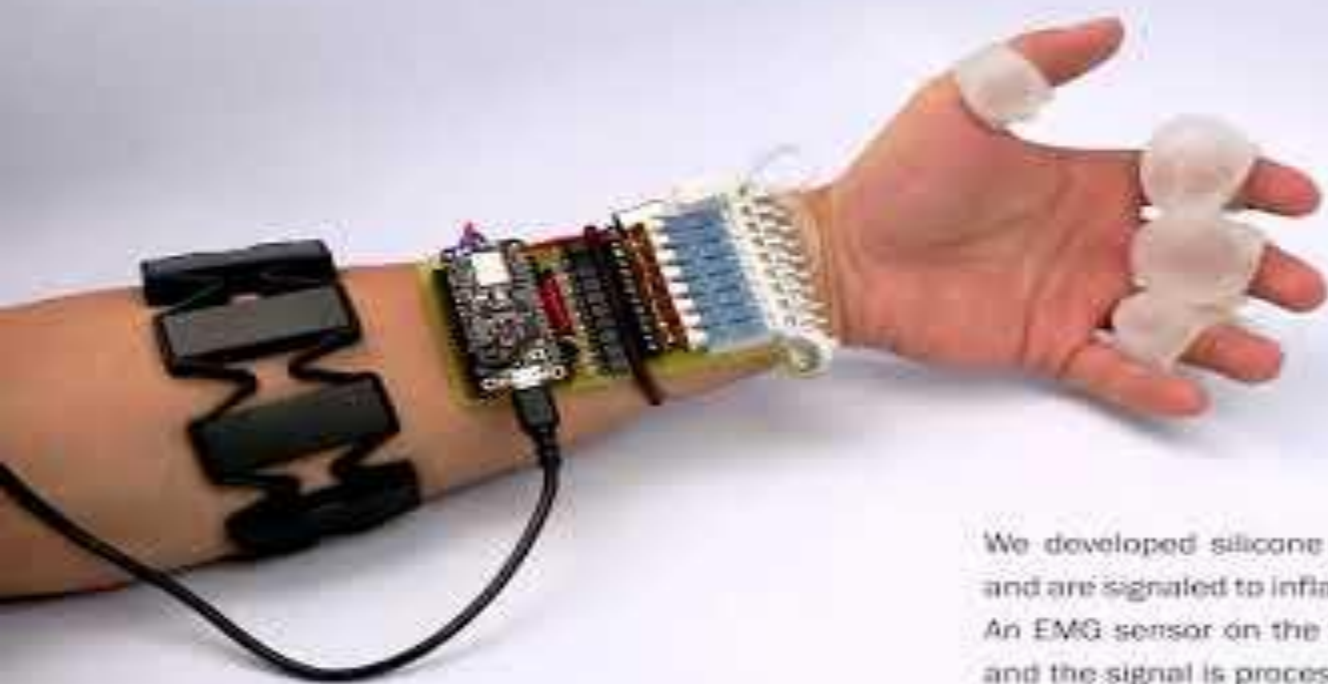
# 2 Examples of Pneumatic Controls used today



© Disney  
Force Jacket (CHI'18)



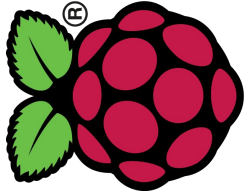
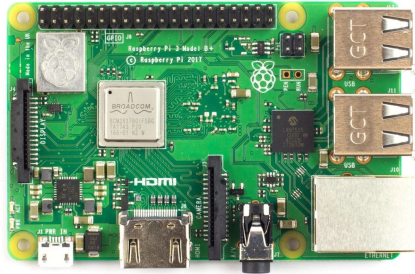
Soft Robotics Toolkit



We developed silicone chambers that attach to the hand and are signaled to inflate or deflate by certain arm motions. An EMG sensor on the forearm detects the muscle activity, and the signal is processed via a neural network.



## Portable Computing



Raspberry Pi

## Electronics



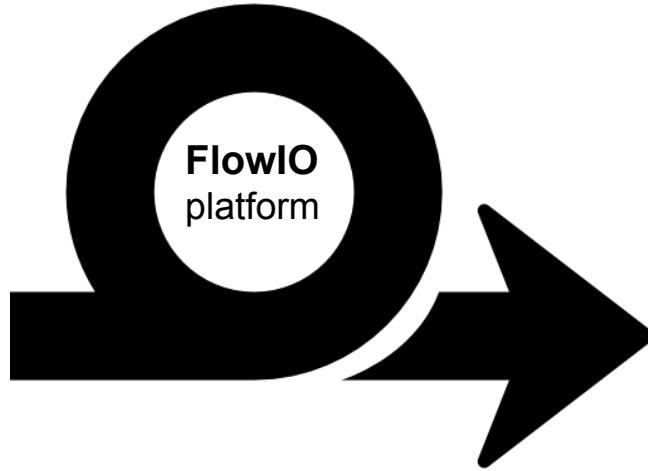
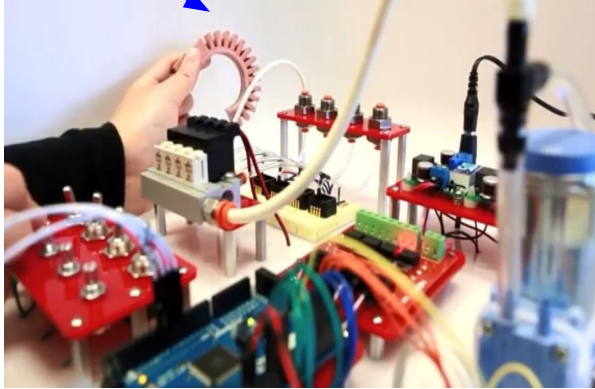
## Soft Robotics



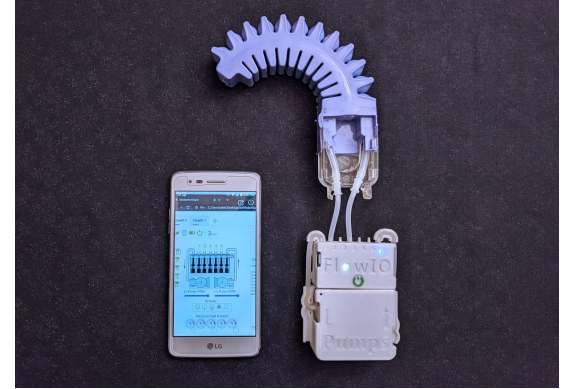
FlowIO  
Platform

# Soft Robotics Prototyping Transformation

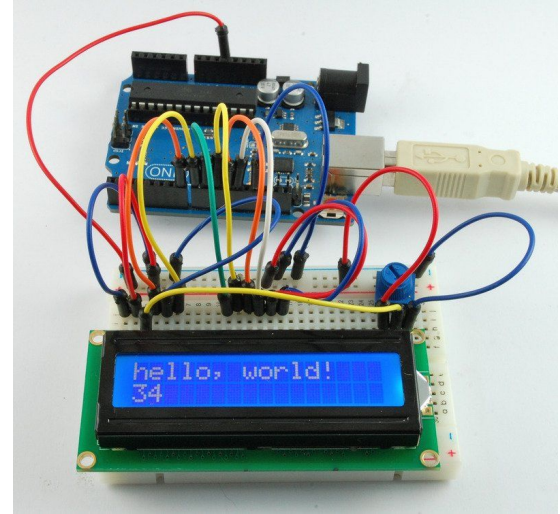
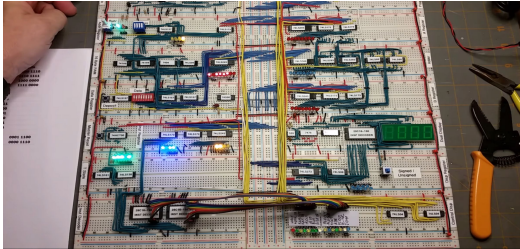
Soft Actuator



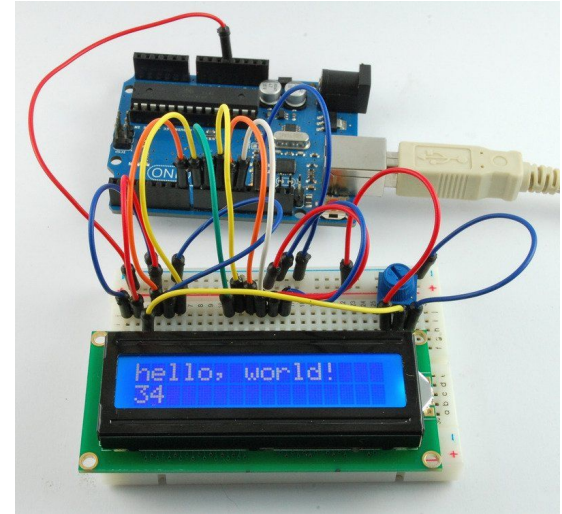
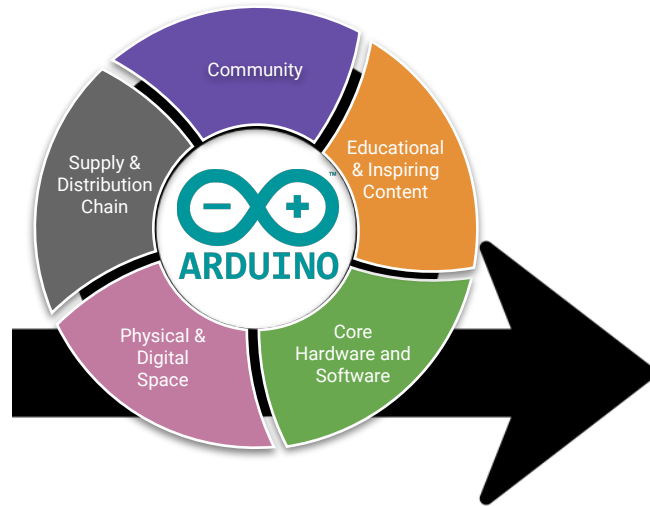
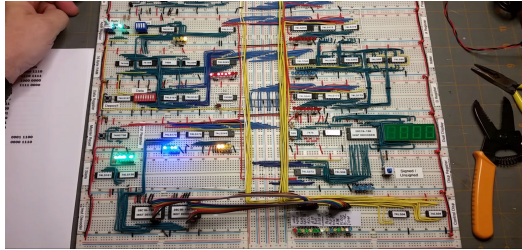
Soft Actuator

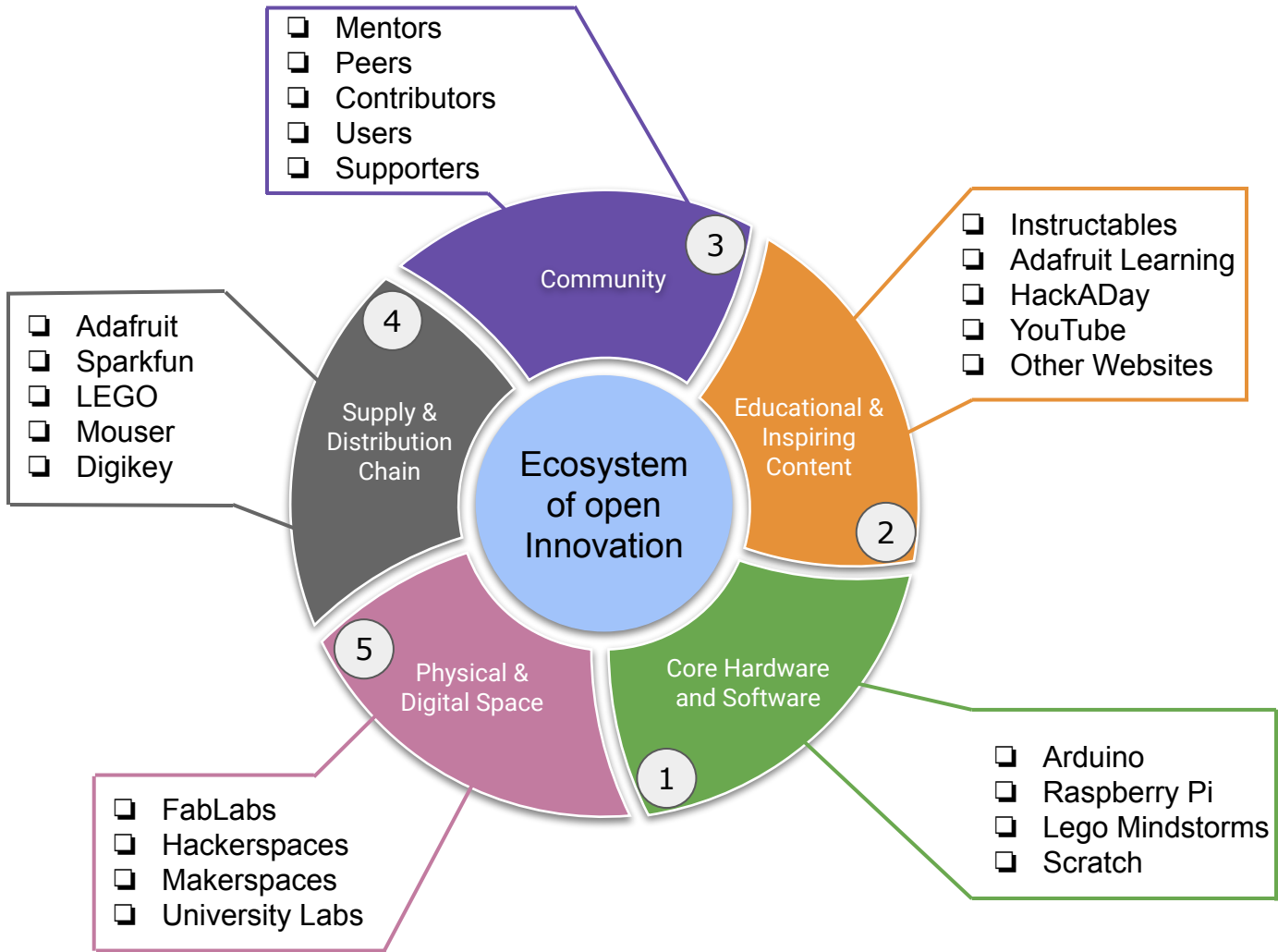


# Electronics Prototyping Transformation

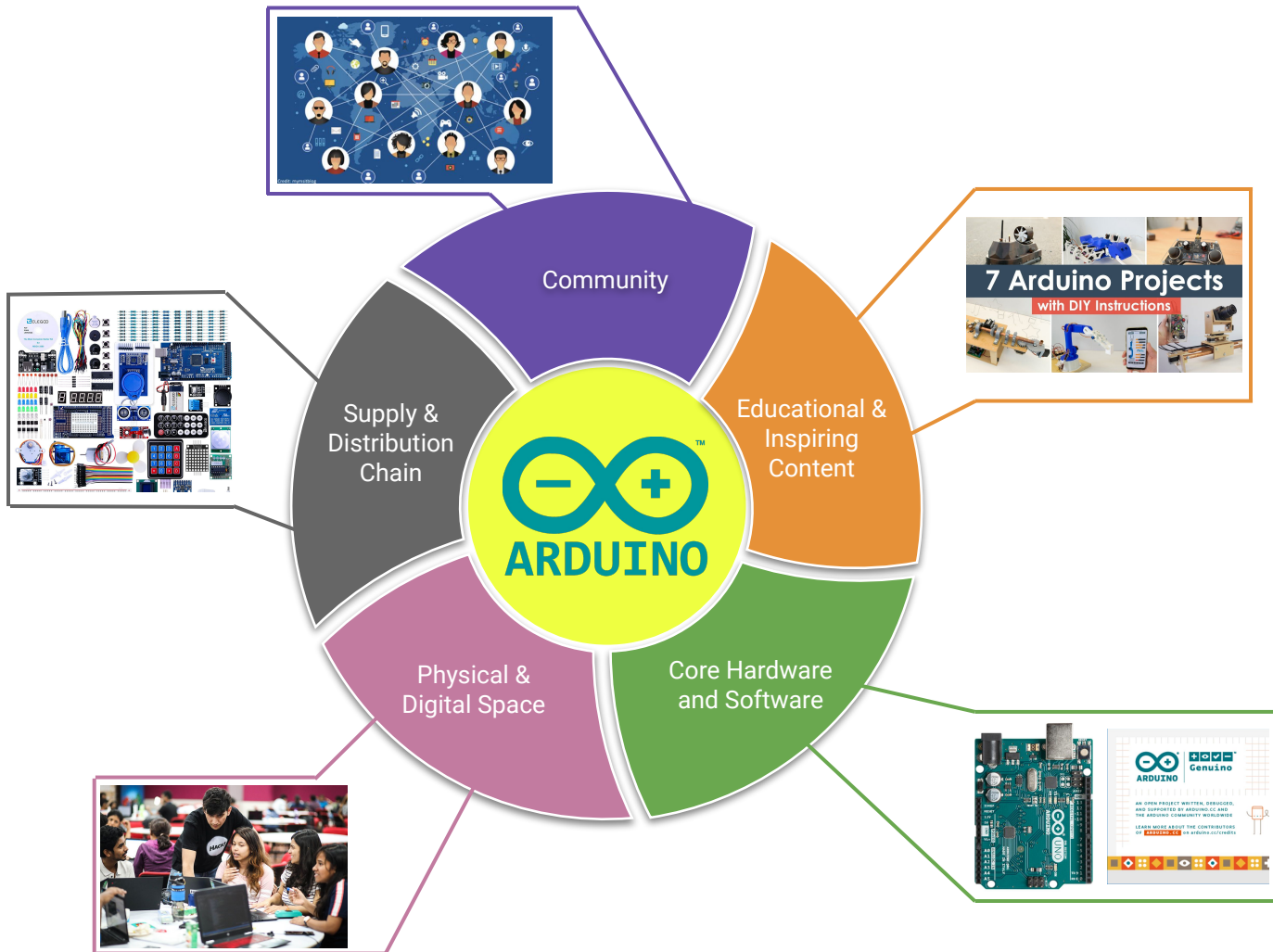


# Electronics Prototyping Transformation







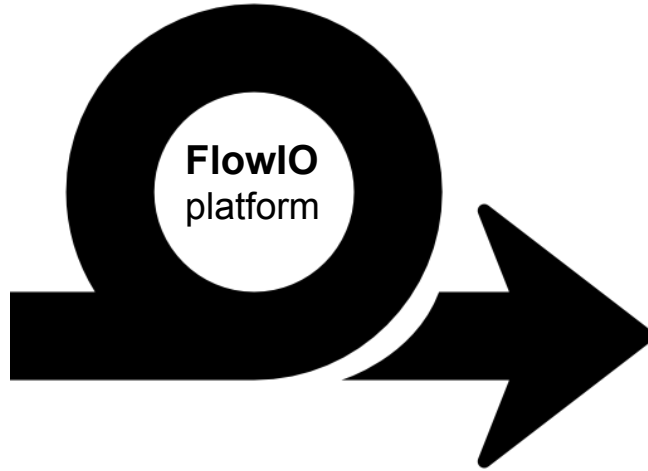
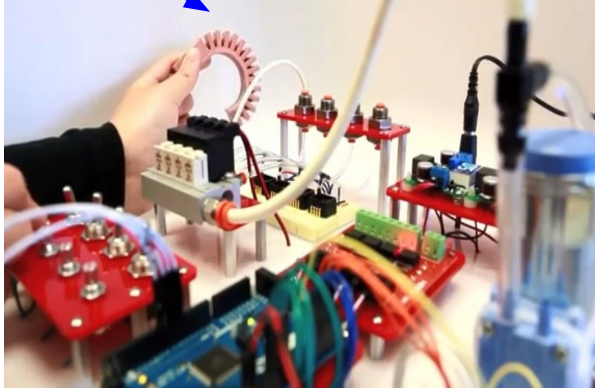




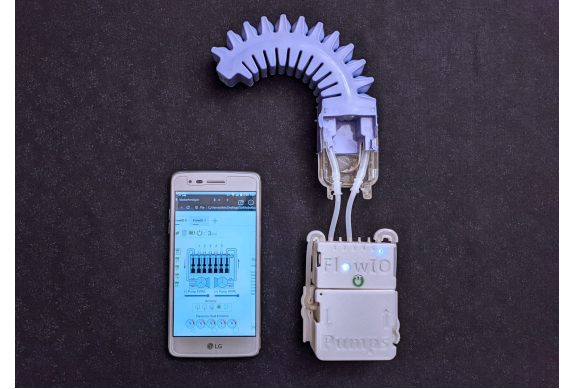


# Soft Robotics Prototyping Transformation

Soft Actuator

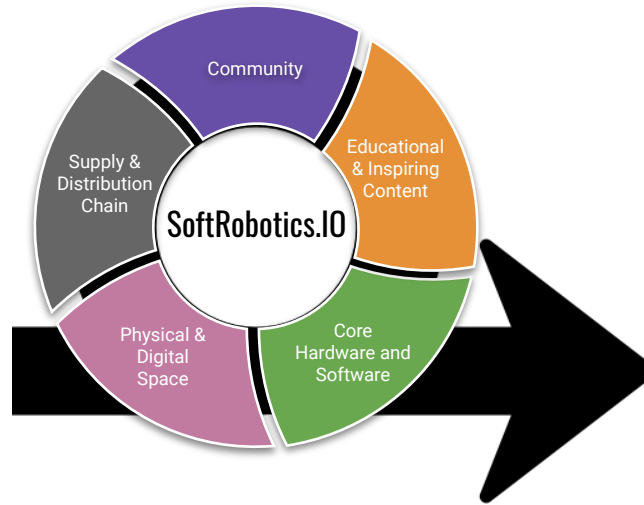
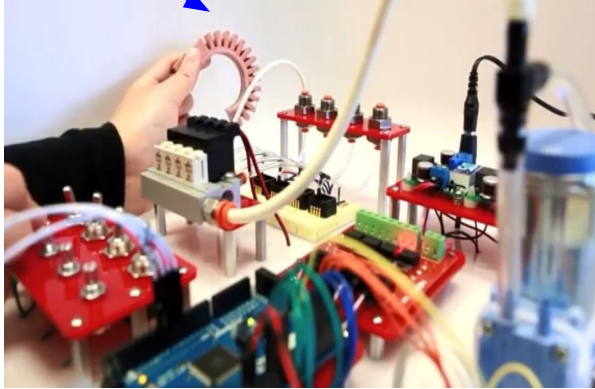


Soft Actuator

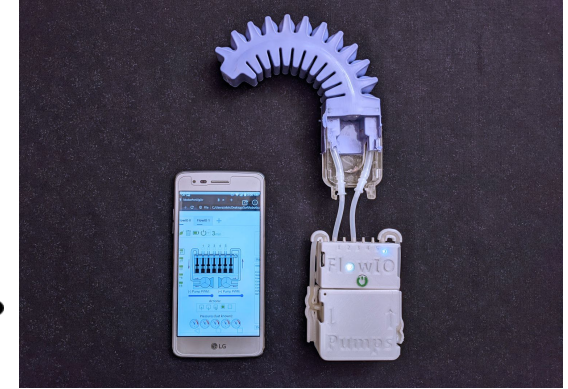


# Soft Robotics Prototyping Transformation

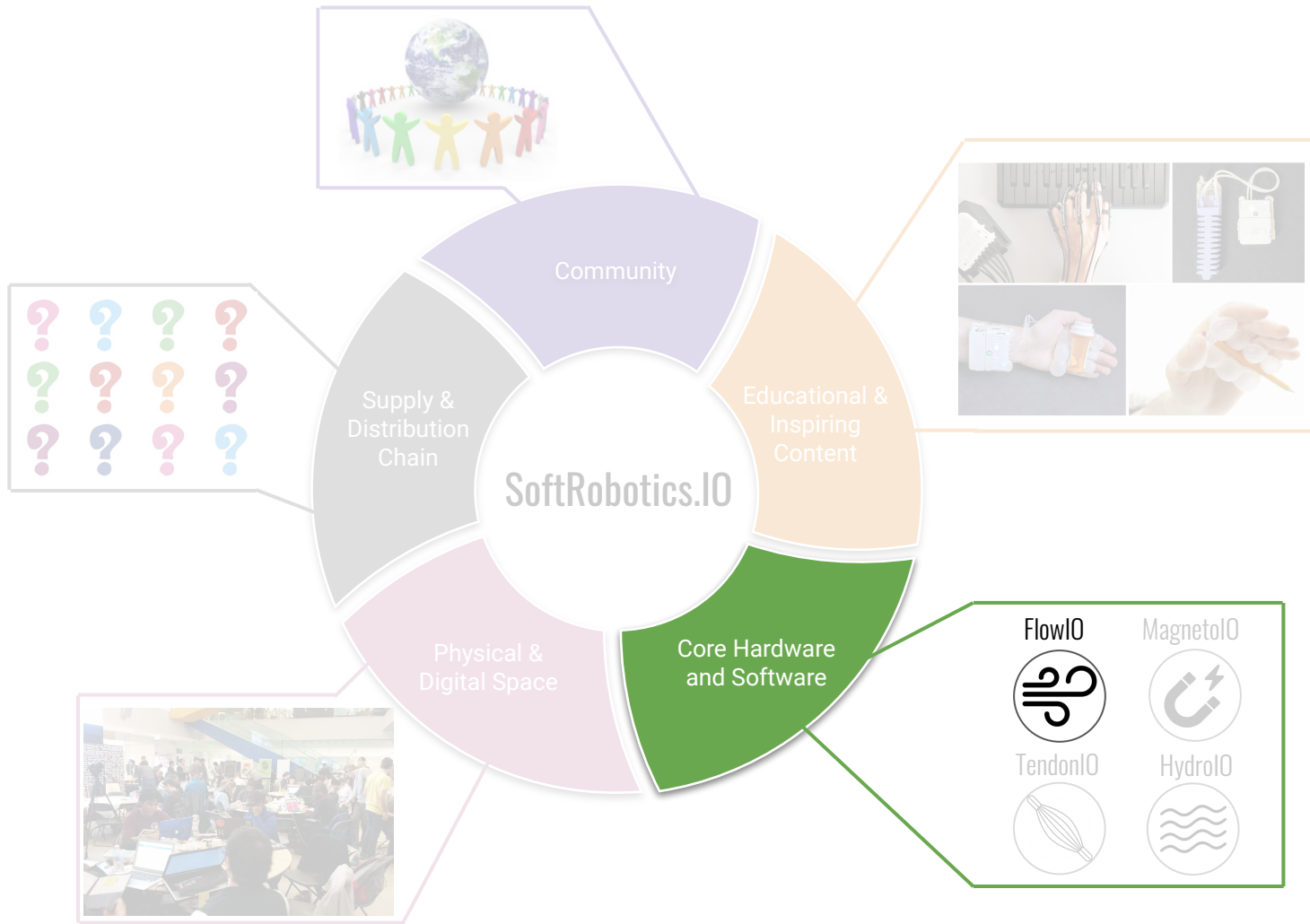
Soft Actuator

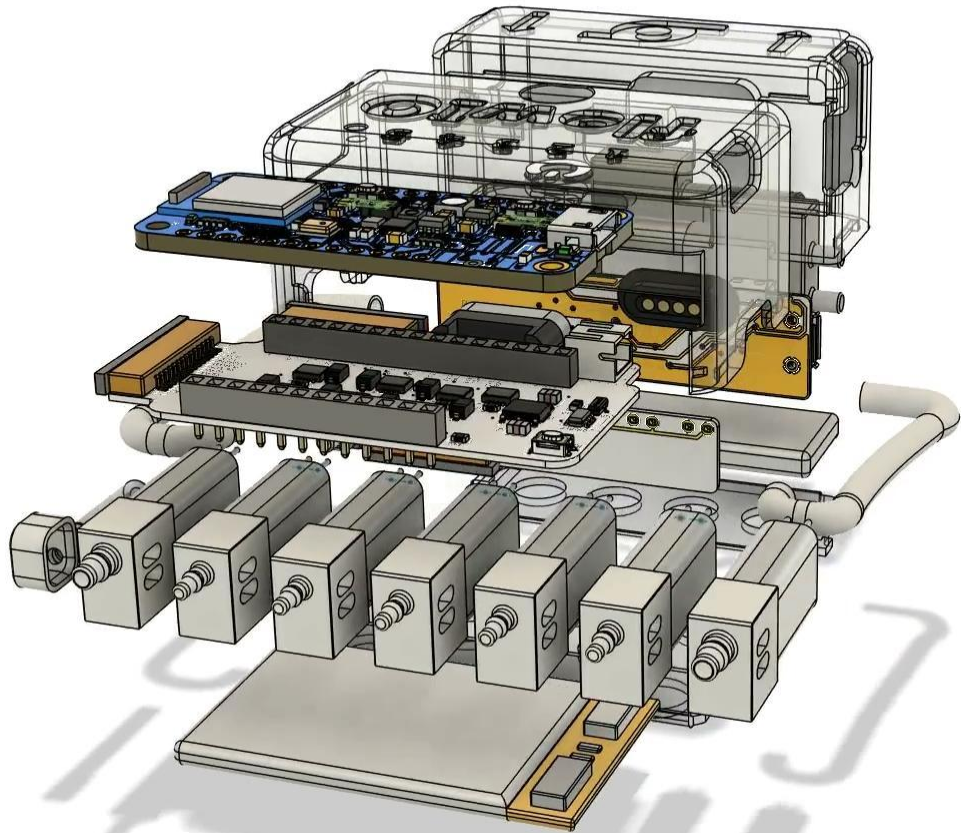


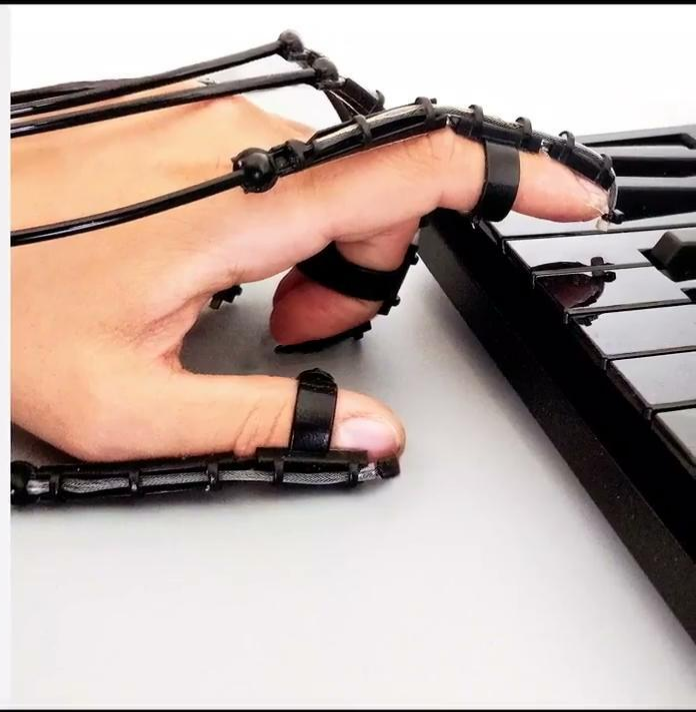
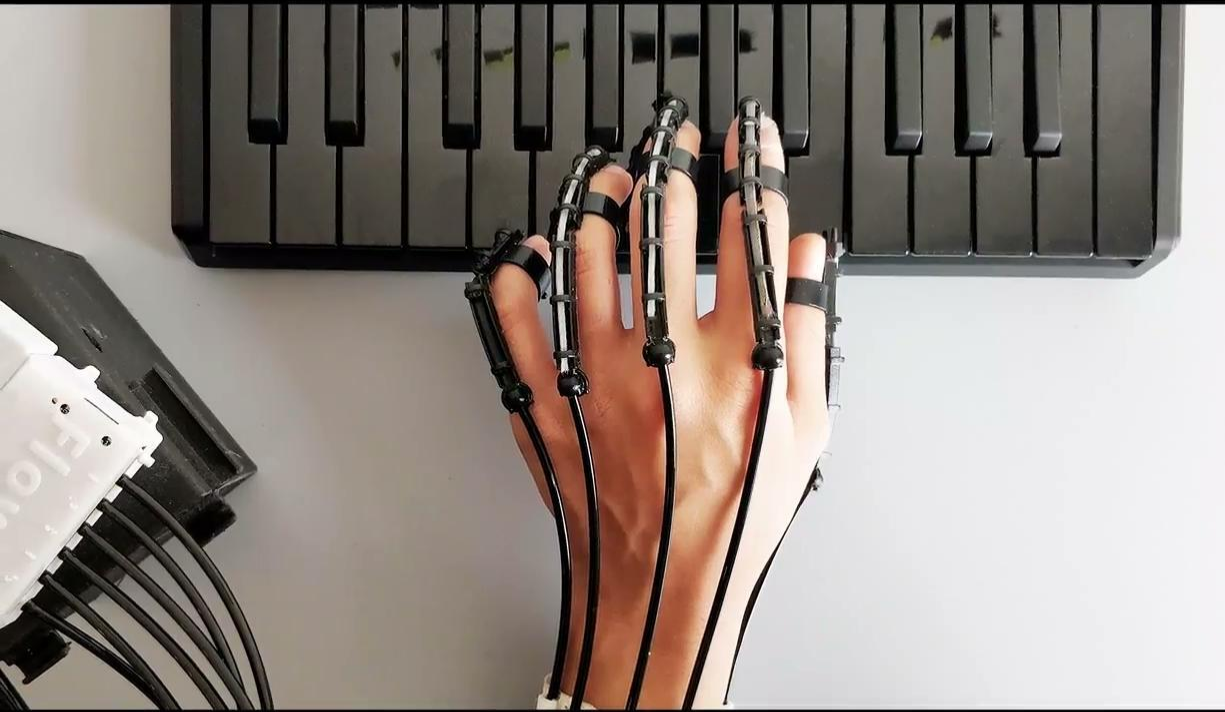
Soft Actuator








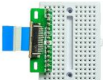










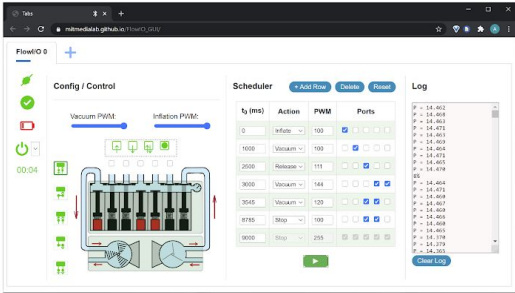


# HARDWARE




Controller	 <p><b>Main Module</b> (59 x 33 x 28) mm</p>		
Pumps	 <p><b>Small</b> (59 x 22 x 28) mm</p>	 <p><b>Medium</b> (60 x 51 x 28) mm</p>	 <p><b>Large</b> (70 x 66 x 64) mm</p>
Expansion Modules	 <p><b>Sensors++</b></p>	 <p><b>Expansion Breakout</b></p>	 <p><b>16-pin Analog Input</b></p>
Accessories	 <p><b>Wrist Strap</b></p>	 <p><b>Auxiliary Tube</b></p>	 <p><b>Lego Base</b></p>

# SOFTWARE




## Web-GUI



### APIs & Libraries

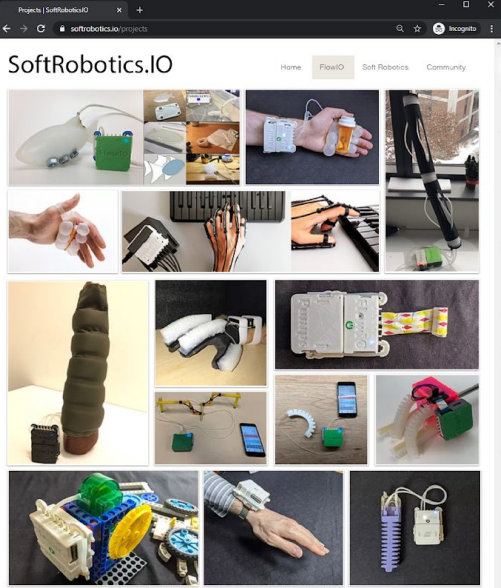




### Compatibility

# COMMUNITY

## SoftRobotics.IO



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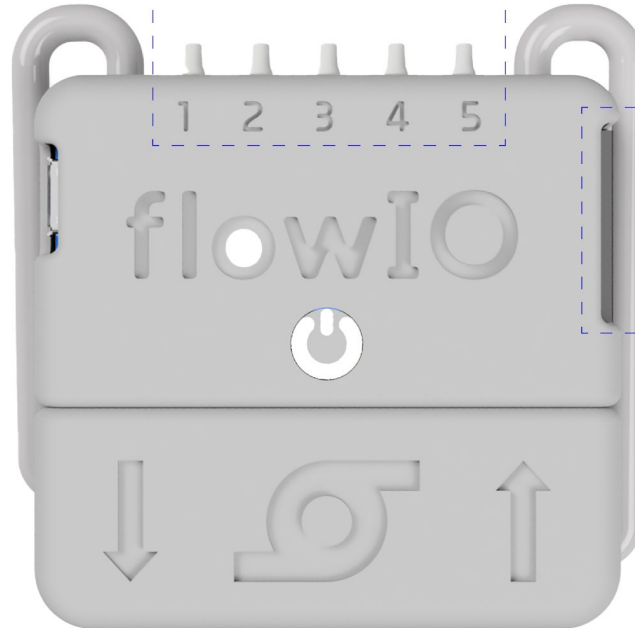
# H A R D W A R E

5 Pneumatic  
I/O Ports







14-Pin  
Expansion Port

## Pneumatic Actions

-  Inflation
-  Vacuum
-  Release
-  Hold
-  Pressure Sense
-  Flow Variability








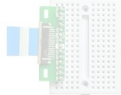
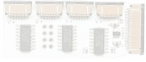



## Connectivity

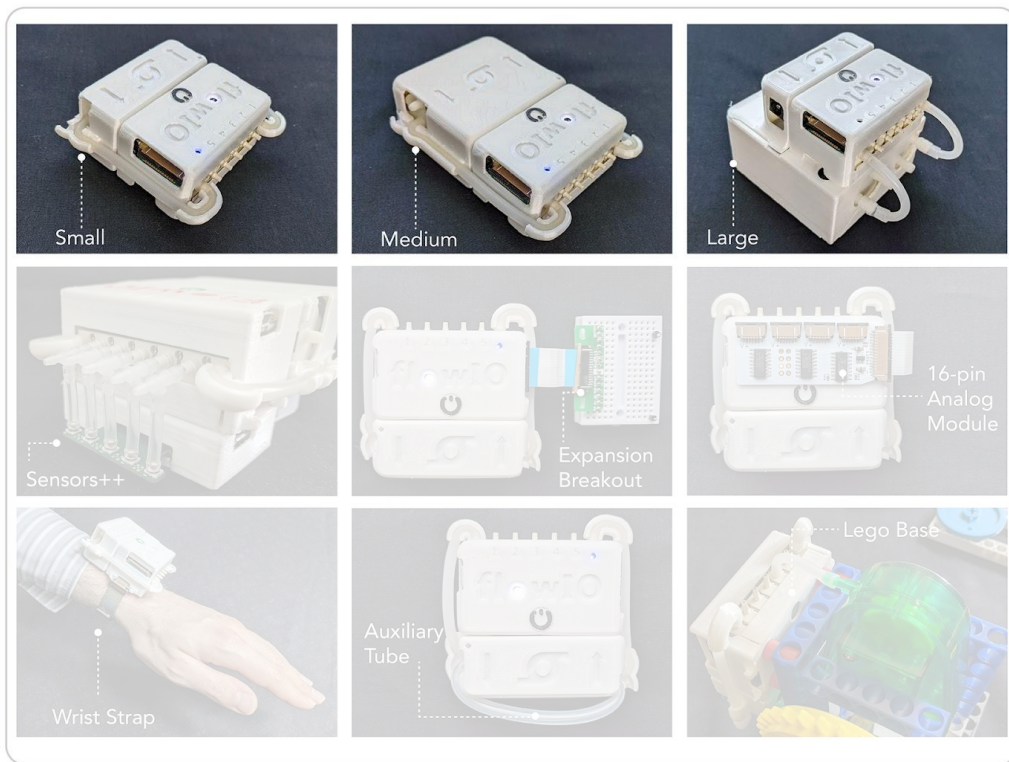
-  Bluetooth LE
-  USB
-  GPIO Pins
-  SPI
-  I2C
-  UART








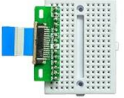






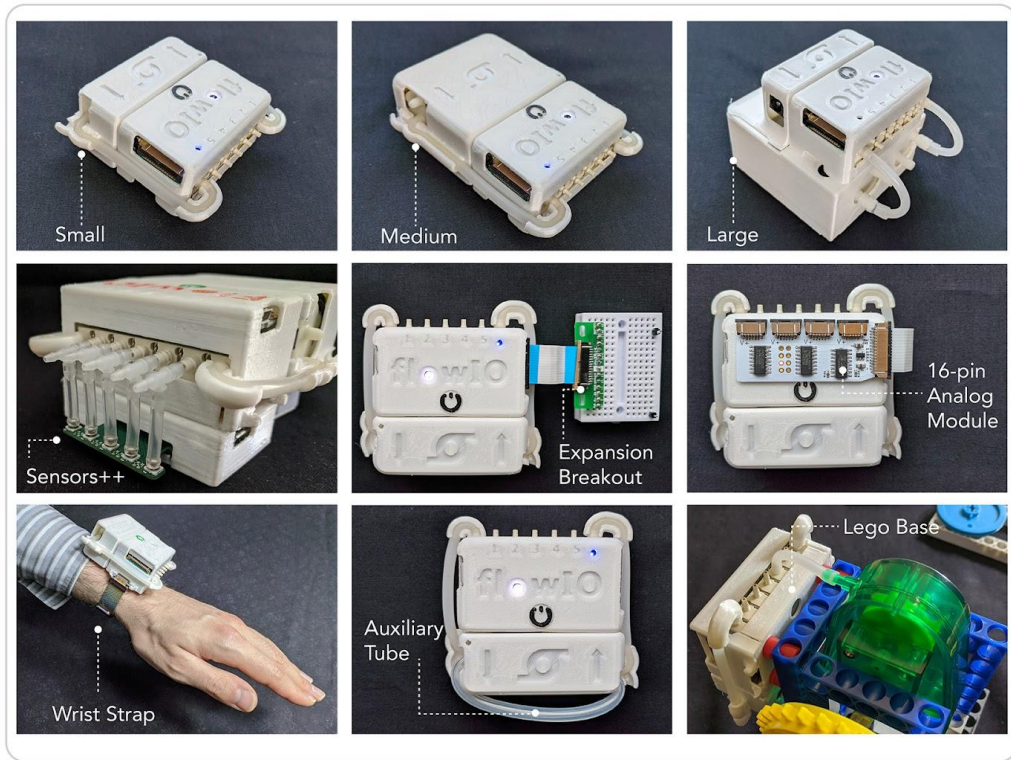
# H A R D W A R E

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Accessories	 <p>Wrist Strap</p>	 <p>Auxiliary Tube</p>	 <p>Lego Base</p>



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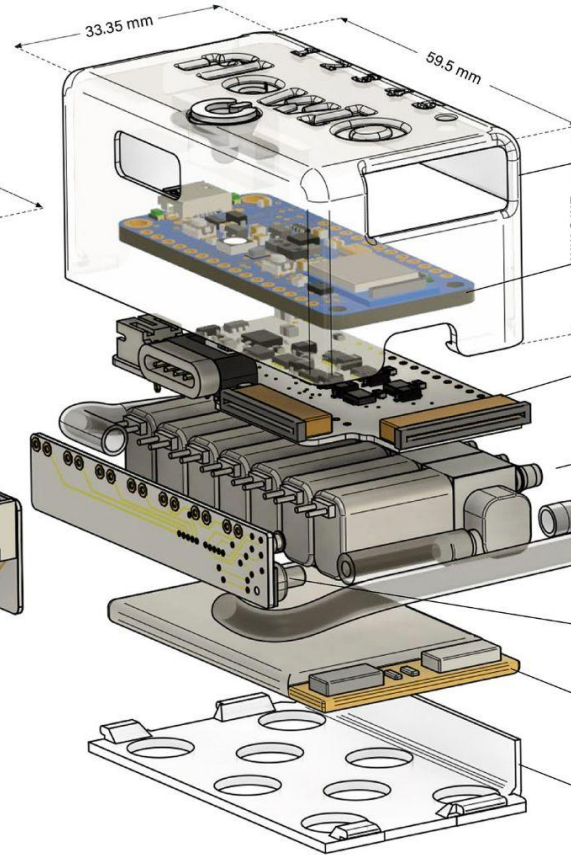
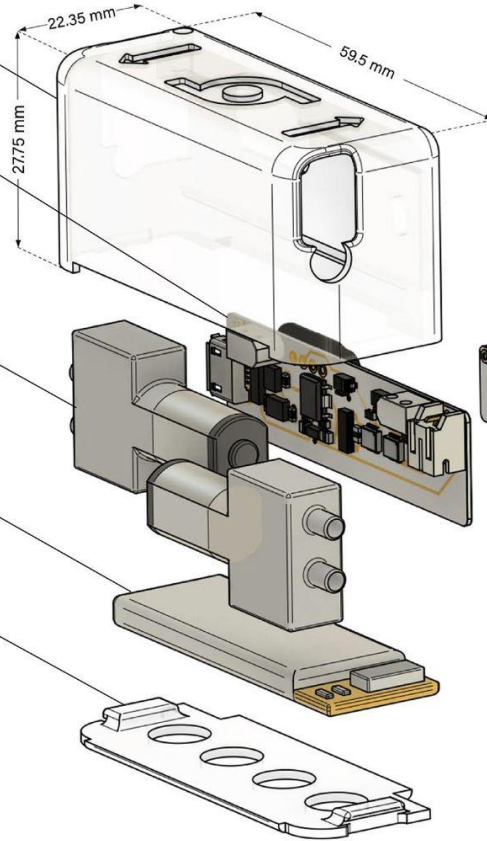
Enclosure - Pumps

Pumps Driver PCB

Micro Pumps

LiPo Battery

Base - Pumps



Enclosure - Main

Microcontroller

Main Driver PCB

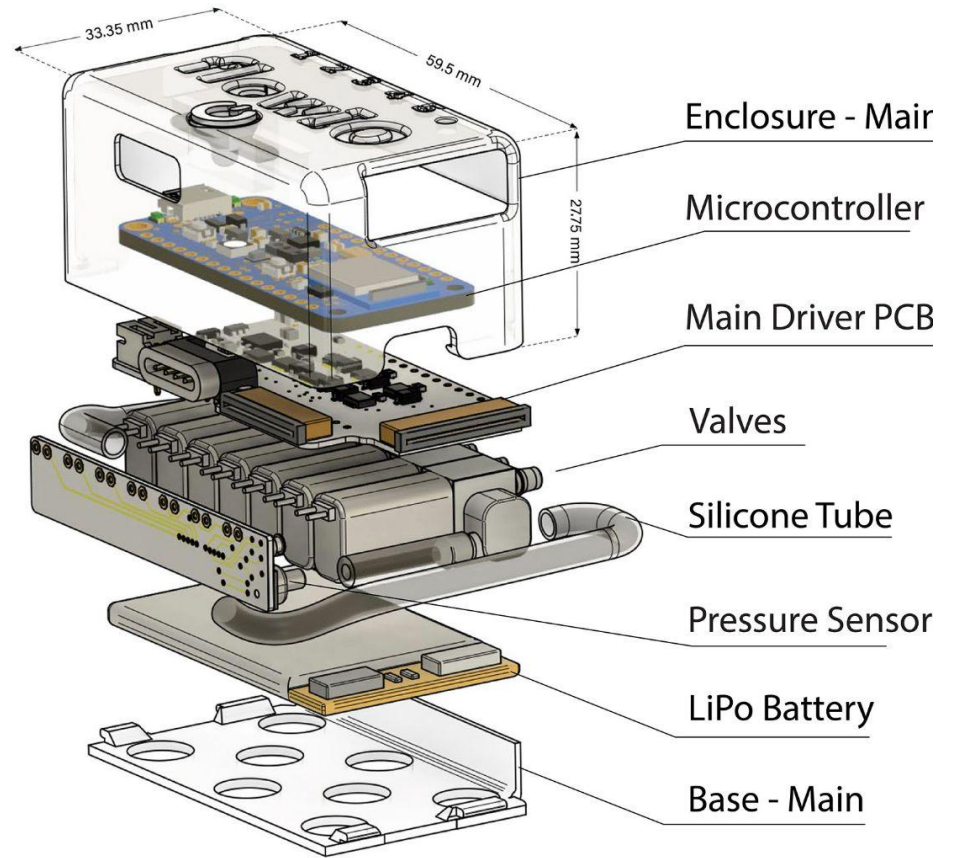
Valves

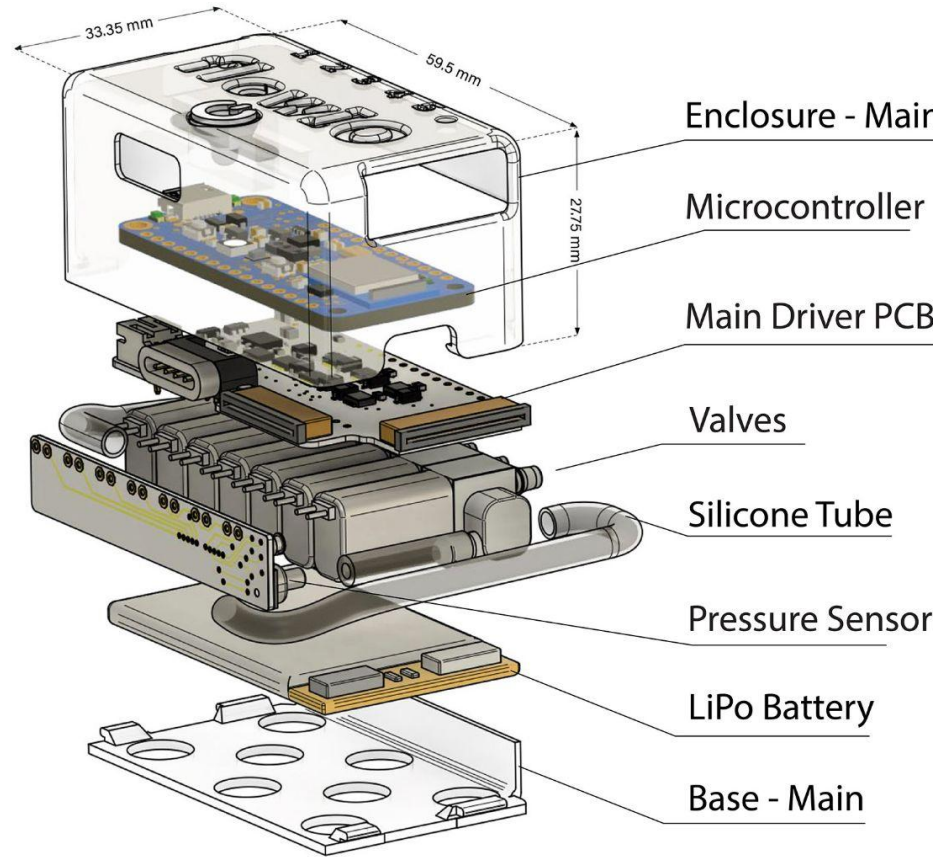
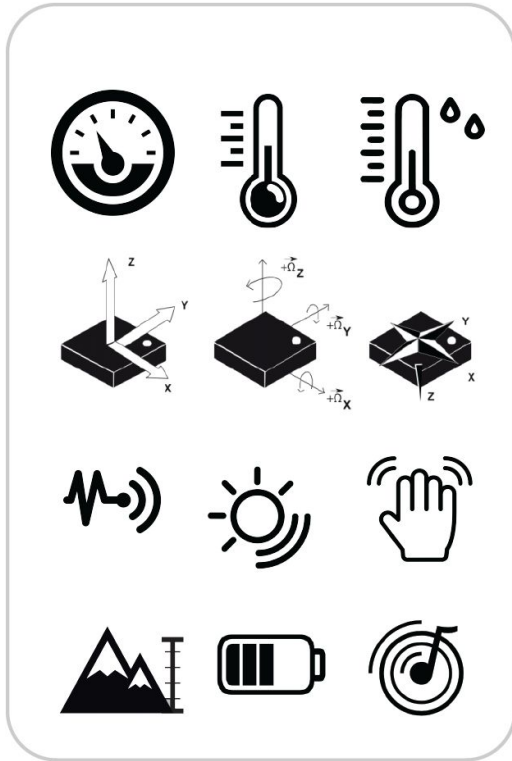
Silicone Tube

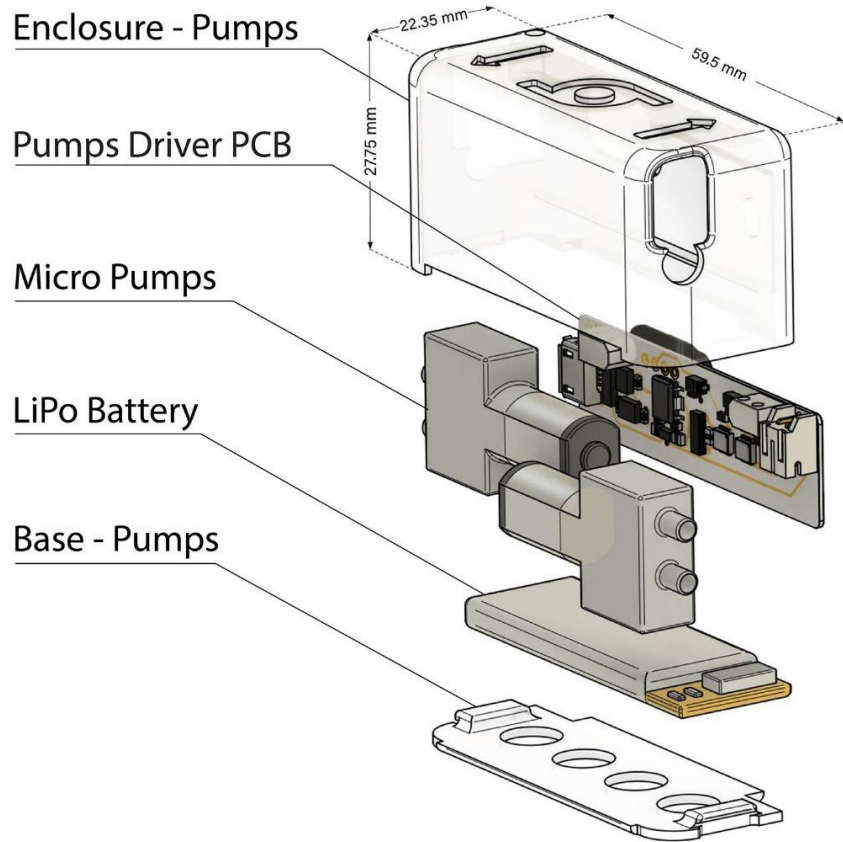
Pressure Sensor

LiPo Battery

Base - Main







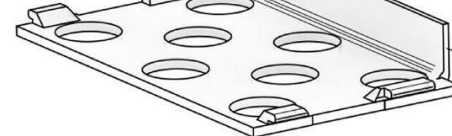
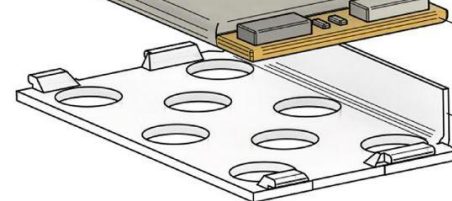
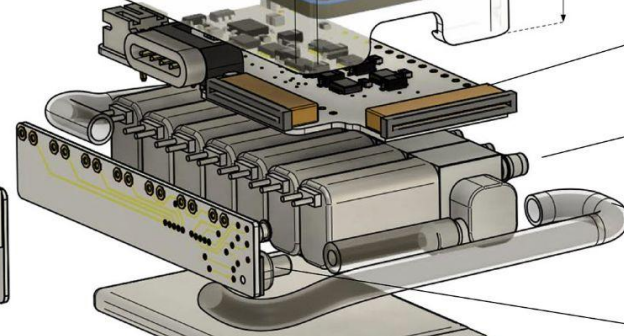
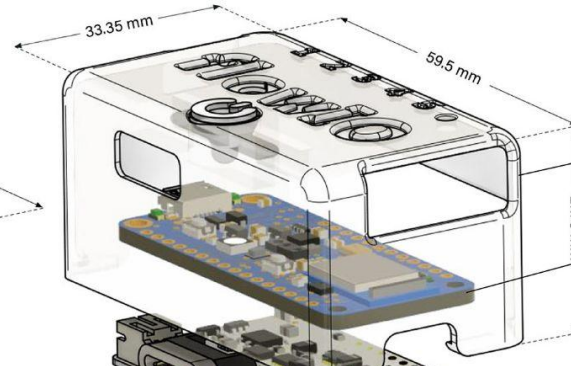
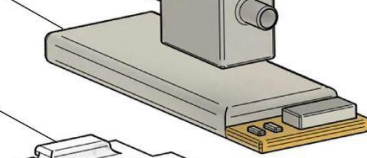
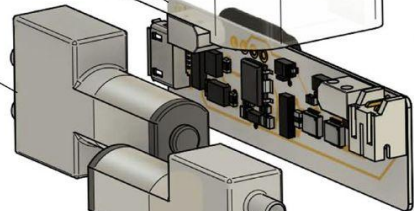
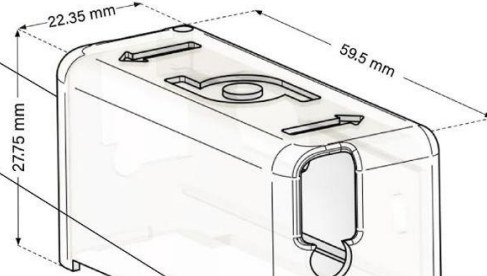
Enclosure - Pumps

Pumps Driver PCB

Micro Pumps

LiPo Battery

Base - Pumps



Enclosure - Main

Microcontroller

Main Driver PCB

Valves

Silicone Tube

Pressure Sensor

LiPo Battery

Base - Main

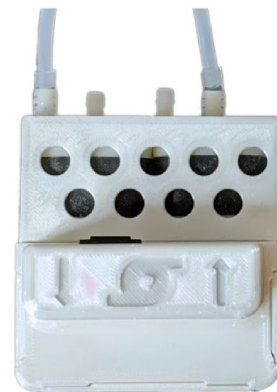




Small  
(59 x 22 x 29) mm



Medium  
(60 x 51 x 29) mm



Large  
(70 x 66 x 65) mm



Small



Medium

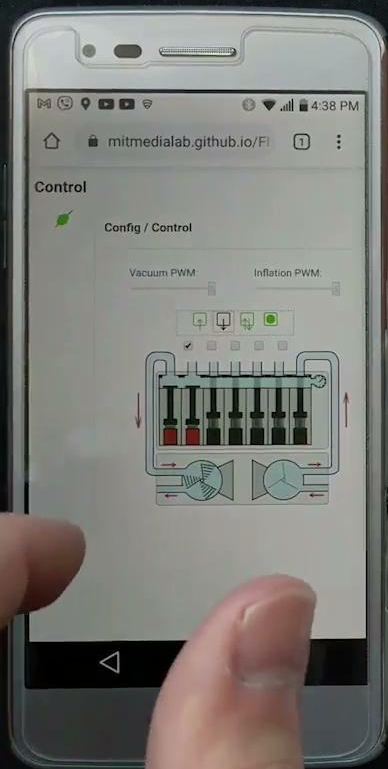


Large

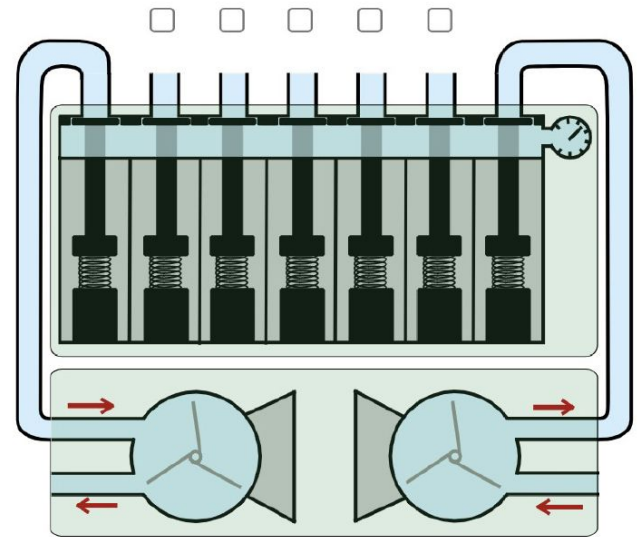
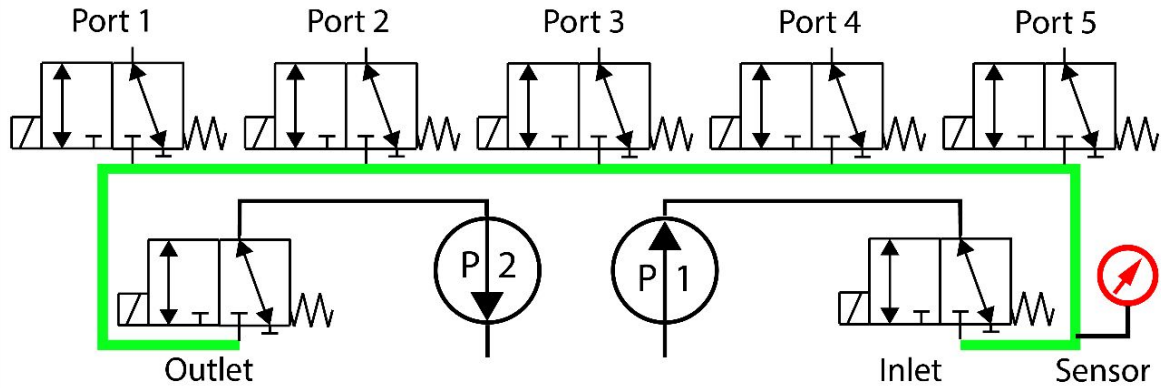
Dimensions: **6 cm** x **5.6 cm** x **2.8 cm**.



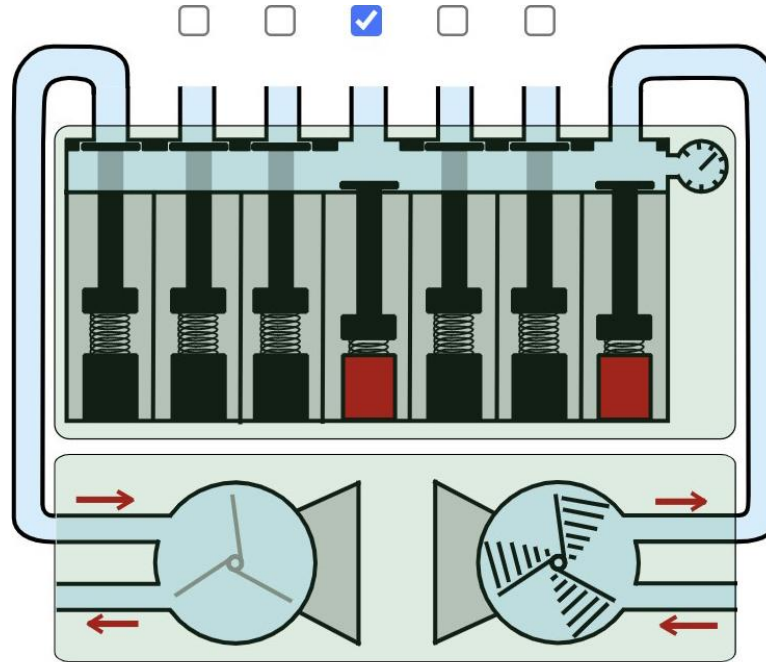
Mass: **114 g**.



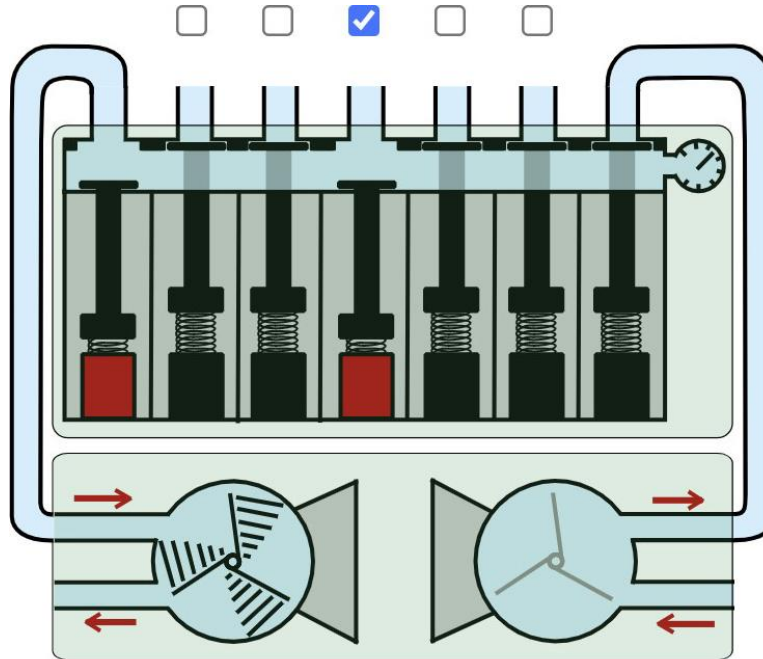
## GENERAL Configuration



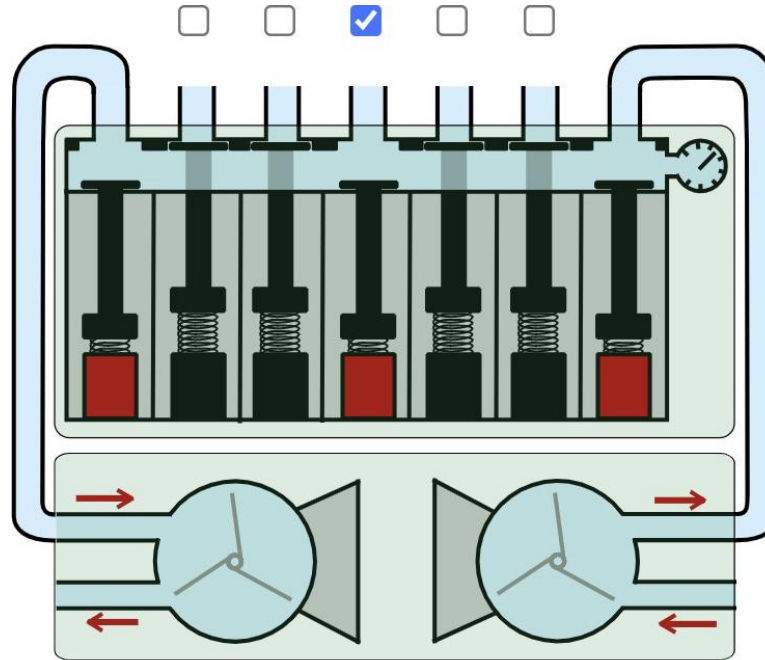
# Inflation on Port(3)

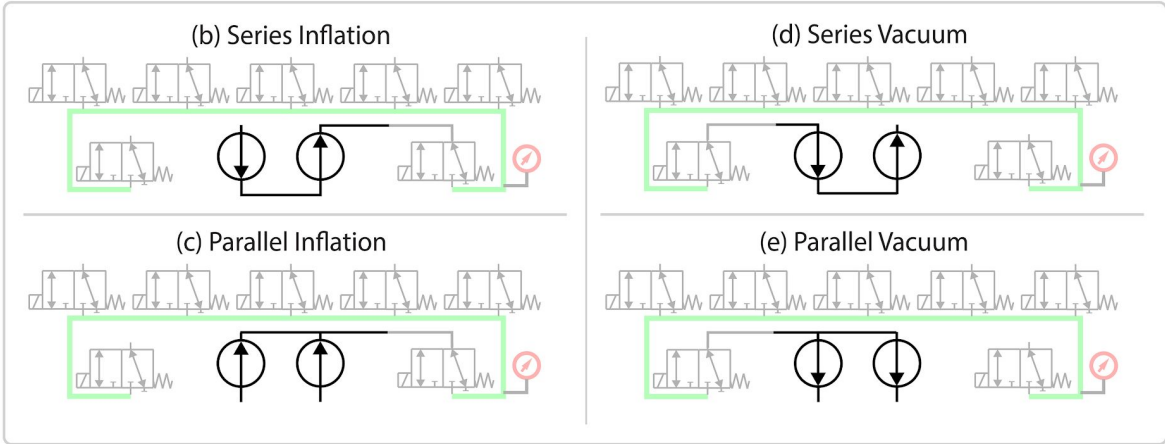
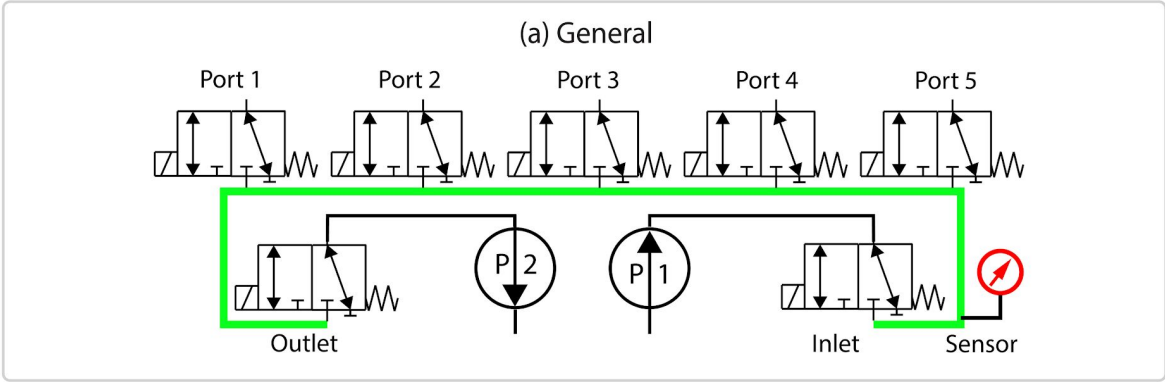


# Vacuum on Port(3)



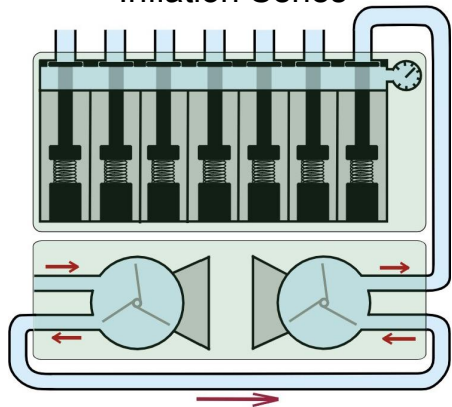
# Release on Port(3)



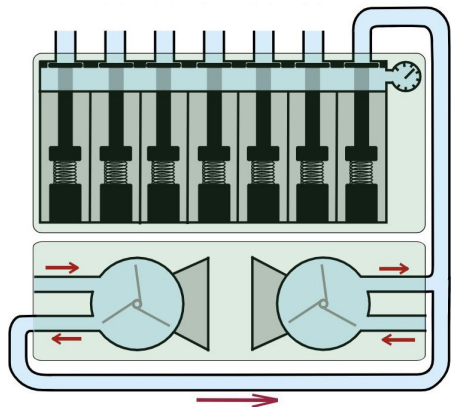




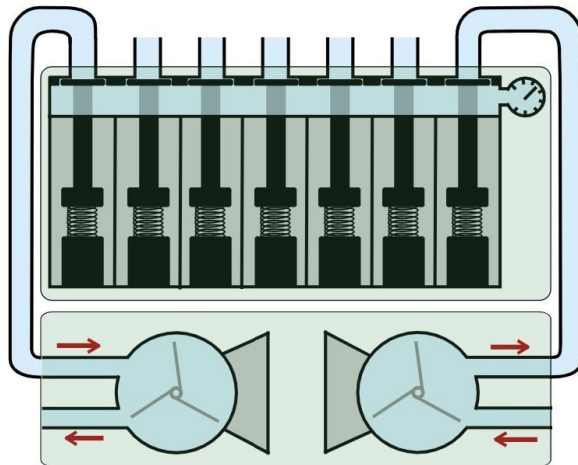
Inflation Series



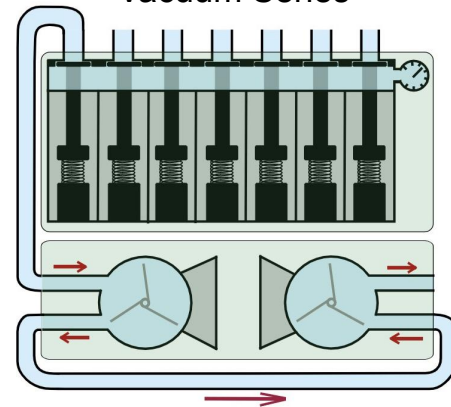
Inflation Parallel



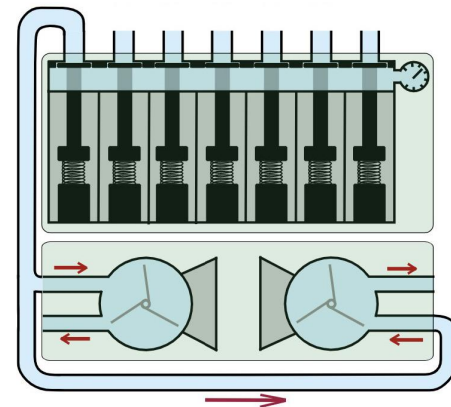
General



Vacuum Series



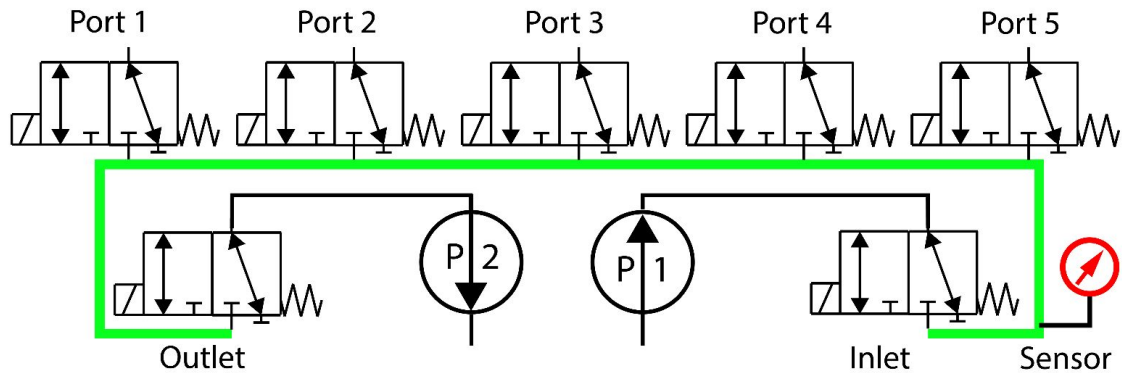
Vacuum Parallel



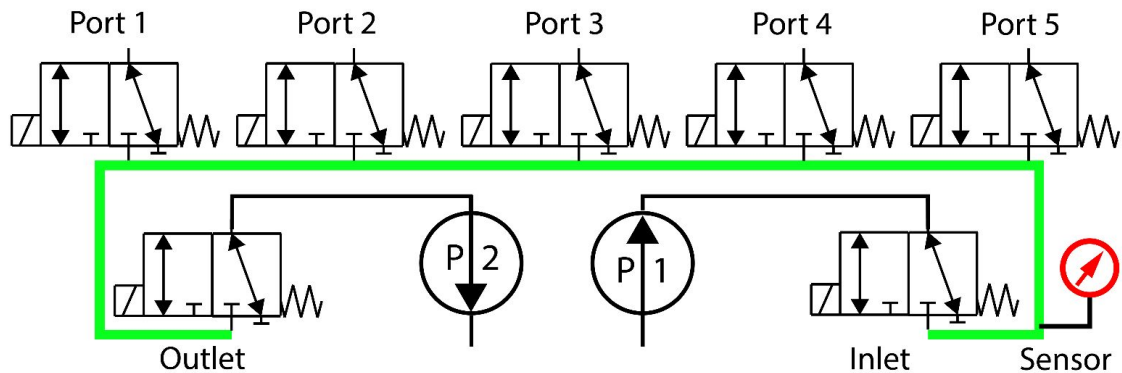
# Technical Evaluation of the Hardware

	General	Series Inf	Parallel Inf	Series Vac	Parallel Vac	
<b>Small</b>	P (min,max)	(-9, 9) psi	(0, 18) psi	(0, 9) psi	(-15, 0) psi	(-9, 0) psi
	Q (max)	0.5 L/min	0.45 L/min	0.95 L/min	-0.45 L/min	-0.95 L/min
<b>Medium</b>	P (min,max)	(-13, 22) psi	(0, 27) psi	(0, 22) psi	(-20, 0) psi	(-13, 0) psi
	Q (max)	1.6 L/min	1.5 L/min	1.8 L/min	-1.5 L/min	-1.8 L/min
<b>Large</b>	P (min,max)	(-19, 22) psi	(0, 30) psi	(0, 22) psi	(-26, 0) psi	(-18, 0) psi
	Q (max)	3.1 L/min	3.1 L/min	3.2 L/min	-3.1 L/min	-3.2 L/min

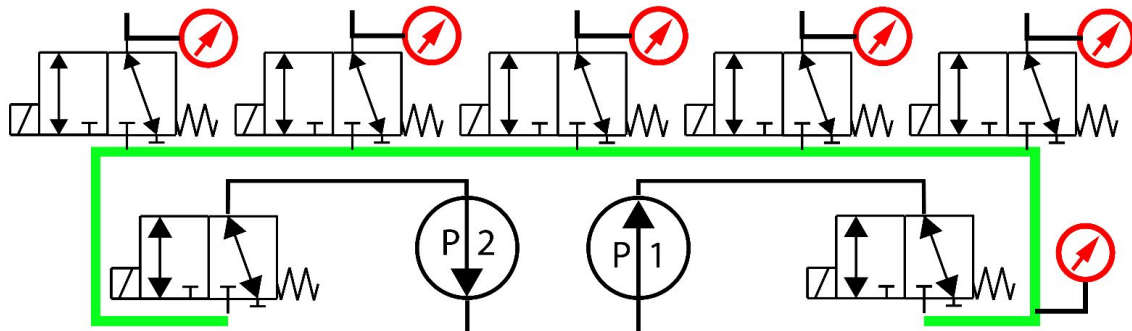
# General



### General



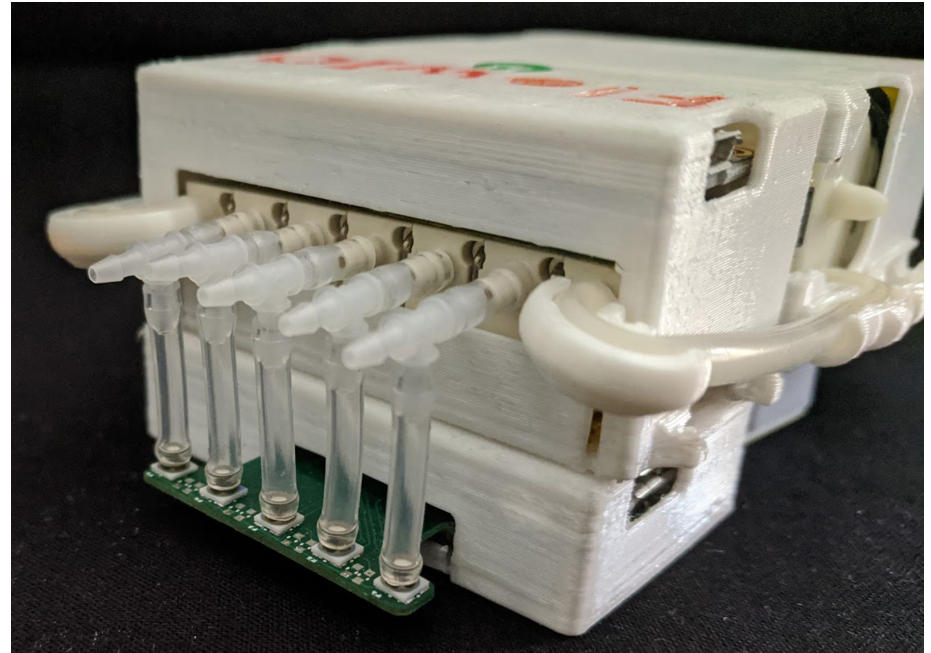
### General with Sensors++








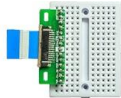




## Sensors++

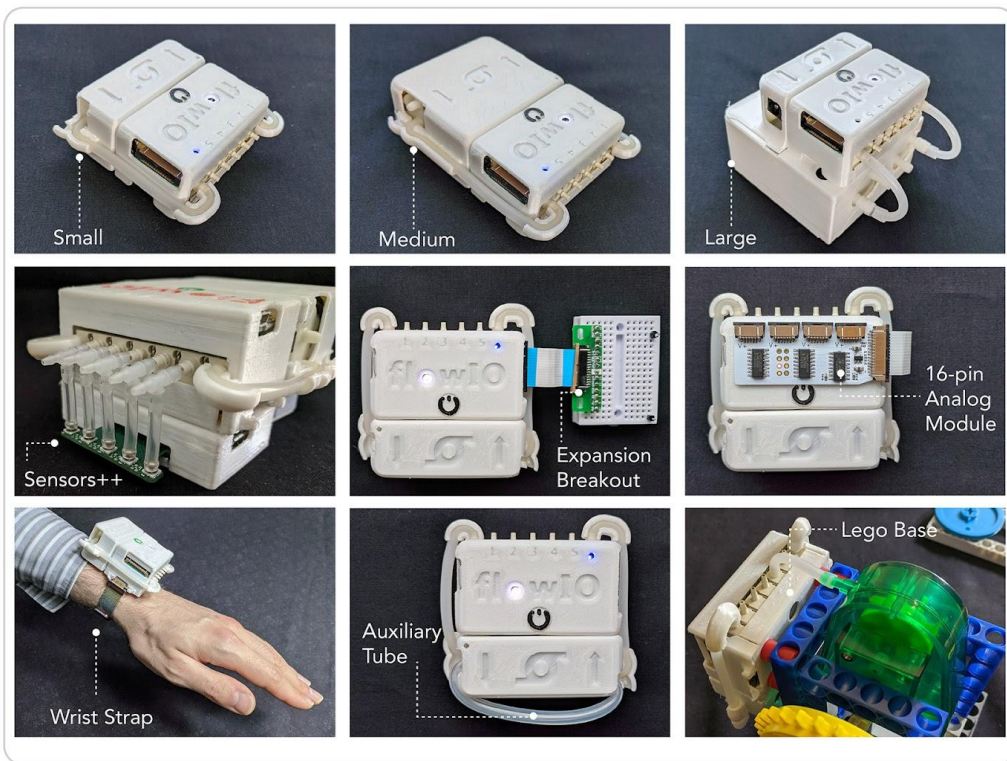


## FlowIO with Sensors++






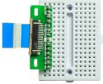






# HARDWARE

Controller	 <p>Main Module (59 x 33 x 28) mm</p>		
Pumps	 <p>Small (59 x 22 x 28) mm</p>	 <p>Medium (60 x 51 x 28) mm</p>	 <p>Large (70 x 66 x 64) mm</p>
Expansion Modules	 <p>Sensors++</p>	 <p>Expansion Breakout</p>	 <p>16-pin Analog Input</p>
Accessories	 <p>Wrist Strap</p>	 <p>Auxiliary Tube</p>	 <p>Lego Base</p>

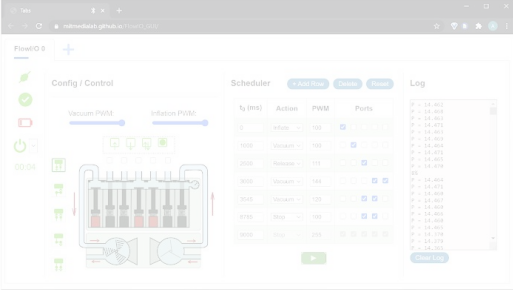


# HARDWARE


Controller	 <p><b>Main Module</b> (59 x 33 x 28) mm</p>		
Pumps	 <p><b>Small</b> (59 x 22 x 28) mm</p>	 <p><b>Medium</b> (60 x 51 x 28) mm</p>	 <p><b>Large</b> (70 x 66 x 64) mm</p>
Expansion Modules	 <p><b>Sensors++</b></p>	 <p><b>Expansion Breakout</b></p>	 <p><b>16-pin Analog Input</b></p>
Accessories	 <p><b>Wrist Strap</b></p>	 <p><b>Auxiliary Tube</b></p>	 <p><b>Lego Base</b></p>

# SOFTWARE


**Web-GUI**



**APIs & Libraries**

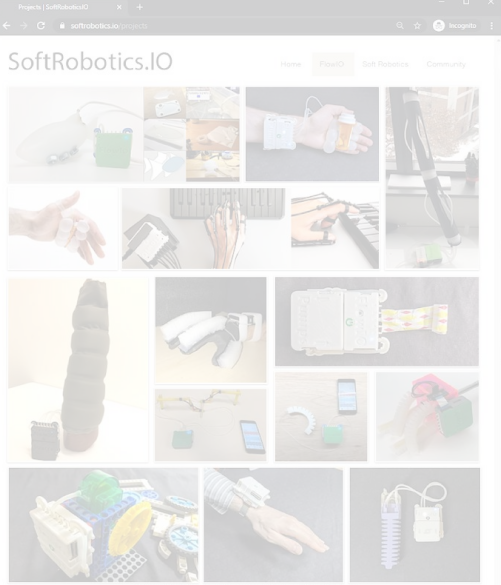


**Compatibility**



# COMMUNITY

**SoftRobotics.IO**

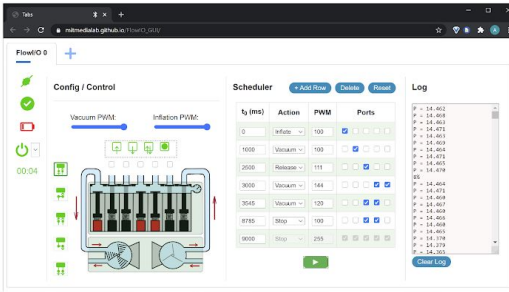


# HARDWARE

Controller	 <p>Main Module (59 x 33 x 28) mm</p>		
Pumps	 <p>Small (59 x 22 x 28) mm</p>	 <p>Medium (60 x 51 x 28) mm</p>	 <p>Large (70 x 66 x 64) mm</p>
Expansion Modules	 <p>Sensors++</p>	 <p>Expansion Breakout</p>	 <p>16-pin Analog Input</p>
Accessories	 <p>Wrist Strap</p>	 <p>Auxiliary Tube</p>	 <p>Lego Base</p>

# SOFTWARE

## Web-GUI



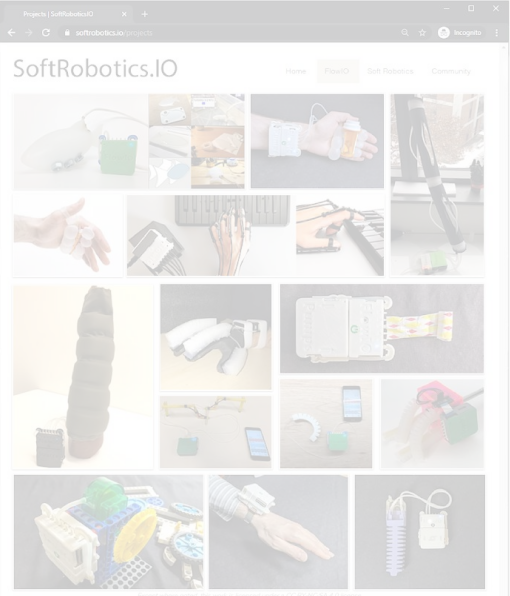
The Web-GUI interface displays a 'Config / Control' section with a visual representation of the robot's internal systems, including 'Vacuum PWM' and 'Inflation PWM'. A 'Scheduler' table is visible, listing actions and their parameters:

t <sub>0</sub> (ms)	Action	PWM	Ports
0	Inflate	100	
1000	Vacuum	100	
2000	Release	111	
3000	Vacuum	144	
3045	Vacuum	120	
8785	Stop	100	
9000	Stop	255	

Additional sections include 'APIs & Libraries' featuring Arduino and JavaScript logos, and 'Compatibility' showing support for Windows, macOS, Linux, Android, and iOS.

# COMMUNITY

## SoftRobotics.IO



The SoftRobotics.IO website features a gallery of various soft robot projects, including prosthetic hands, grippers, and other bio-inspired devices. The site includes navigation links for Home, About, Soft Robotics, and Community.



# SOFTWARE

## Web-GUI

t0 (ms)	Action	PWM	Ports
0	Inflate	100	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
1000	Vacuum	100	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2500	Release	111	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
3000	Vacuum	144	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
3545	Vacuum	120	<input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
8785	Stop	100	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
9000	Stop	255	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

## Compatibility



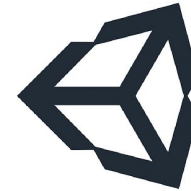
## APIs & Libraries



JavaScript



Additional future support for





You Can Control **FlowIO** from  
any Device and any OS



ANDROID



This work is licensed under [CC BY-NC-SA 4.0](#) which requires attribution, by citing either [this paper](#) or the creator's name and a link to [softrobotics.io](#).

Get Started

Introduction

Documentation

GUI Overview

Launch GUI

Software Stack

Arduino API

JavaScript API

Introduction

Documentation

GUI Overview

GUI

Software Stack

Arduino API

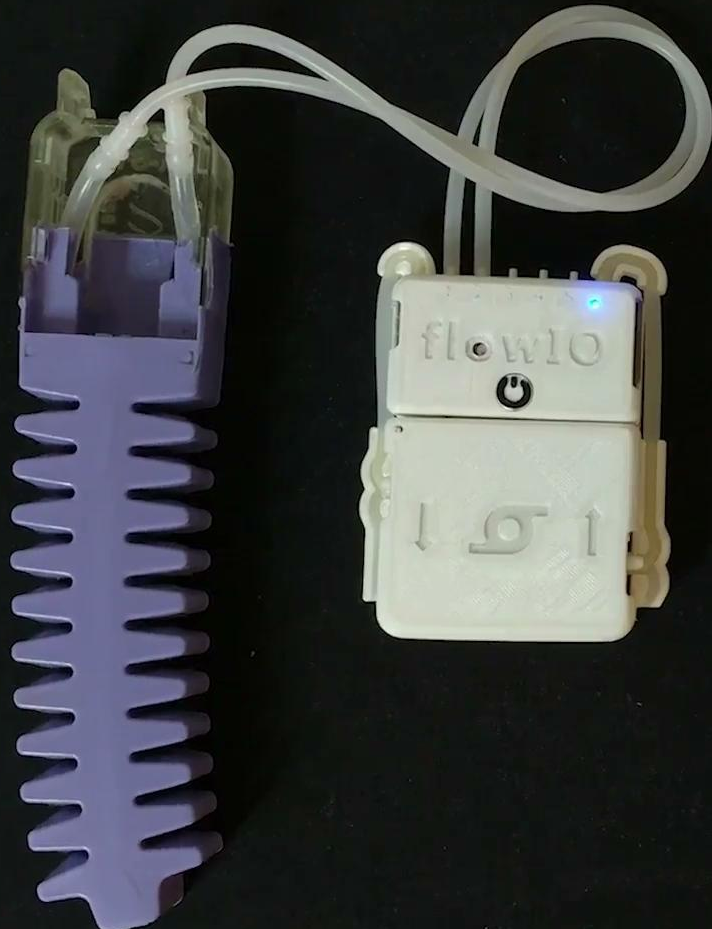
## Launch the GUI

After launching the GUI, click the Connect button in the upper left corner to connect to your FlowIO device and activate the controls.

There is much more documentation, tutorials, project videos, and other content that is slowly being added to this website. If interested in helping with any of these or other tasks, please consider volunteering.

**Get Involved**

Find out how you can help



FlowIO GUI Screenshot

mitmedialab.github.io/FlowIO\_GUI/

FlowIO 0 +

Config / Control

Vacuum PWM: [Slider] Inflation PWM: [Slider]

00:02

Scheduler

t <sub>0</sub> (ms)	Action	PWM	Ports
0	Inflate	255	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
4000	Release	255	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
4500	Inflate	255	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
6000	Release	255	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
6700	Inflate	255	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
8500	Vacuum	255	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
10000	Inflate	255	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
11700	Release	255	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
13000	Stop	255	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

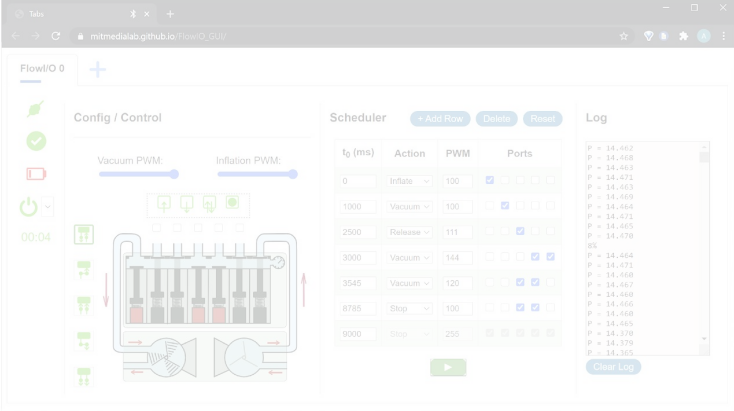
Log

P = 17.455  
P = 17.353  
P = 17.284  
P = 17.284  
P = 17.374  
P = 17.273  
P = 17.224  
P = 17.371  
P = 17.279  
P = 17.133  
P = 17.266  
P = 17.266  
P = 17.044  
P = 17.118  
P = 17.000  
P = 16.952  
P = 17.056  
P = 16.932  
P = 16.878  
P = 16.862  
P = 16.801  
P = 16.922  
P = 16.740  
P = 16.860  
P = 16.906  
P = 16.838  
P = 16.813

Clear Log

# SOFTWARE

Web-GUI



t <sub>0</sub> (ms)	Action	PWM	Ports
0	Inflate	120	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
1000	Vacuum	100	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2500	Release	111	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
3000	Vacuum	144	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
3545	Vacuum	120	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
8785	Stop	100	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
9000	Stop	250	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>

APIs & Libraries

ARDUINO


JavaScript

Additional future support for

Python

Scratch

Compatibility



**FlowIO()**

Class Definition: /FlowIO/FlowIO.h  
 Class Source: /FlowIO/FlowIO.cpp

Keywords: /FlowIO/keywords.txt

**CONSTRUCTORS:**

**FlowIO(Configuration config) ;**

*config* - the type of pneumatic configuration. Can be one of the following:

**GENERAL, INFLATION, SERIES, INFLATION\_PARALLEL, VACUUM, SERIES, VACUUM\_PARALLEL**

*NOTE: If you specify no parameters in the constructor, then the GENERAL configuration is assumed, where pump1 is for inflation and pump2 for vacuum.*

*(You must instantiate the FlowIO object outside the setup loop, and you must initialize it at the top of the setup loop, before any Bluetooth commands. If you initialize it after you have set up Bluetooth, then you may run into issues.)*

You can check the current configuration or change it at any time using the following methods:

**void setConfig(Configuration config) ;**

**Configuration getConfig() ;** returns the configuration as a single byte whose value is between 0 and 4.

**Pressure-Sensing API**

**bool activateSensor() ;**

Initializes the I2C communication with the integrated pressure sensor, and checks the status byte sent by the sensor.

RETURNS: **true** if the status byte is as expected; otherwise returns **false** and error code 222.

**void setPressureUnit(Unit pUnit) ;**

Sets the unit that will be used by the getPressure() method. Use this method only if you want to change the default - PSI.

You can change the units at any point in the code. Possible argument values are **PSI, ATM, KPA, PA, MBAR**.

**float getPressure() ;**

Gets a new absolute pressure reading from the integrated sensor in terms of the unit in **setPressureUnit()**.

**float getPressure(Unit pUnit) ;**

Gets a new absolute pressure reading from the integrated sensor in terms of the unit specified in the argument.

Possible argument values are **PSI, ATM, KPA, PA, MBAR**.

*NOTE: Sensor must be activated before requesting pressure. Otherwise **getPressure()** will return the value 888.8.*

**Indicators API**

**void blueLED(bool power) ;** Controls the onboard led. The argument can be either **LOW / 0** or **HIGH / 1**.

**void pixel(uint8\_t red, uint8\_t green, uint8\_t blue) ;** Controls the onboard neoPixel color and intensity..

For highly-dynamic actions involving the neoPixel LED, avoid using this method, and instead use the methods from the Adafruit\_NeoPixel library directly, because the efficiency and speed are much better.

**void raiseError(uint8\_t error) ;** Sets the value of the internal error flag.

**uint8\_t readError() ;** Reads the value of the internal error flag. See the error code table on the last page.

**uint16\_t getHardwareState() ;** Returns a 16-bit value, where each bit maps to the state of a hardware component.

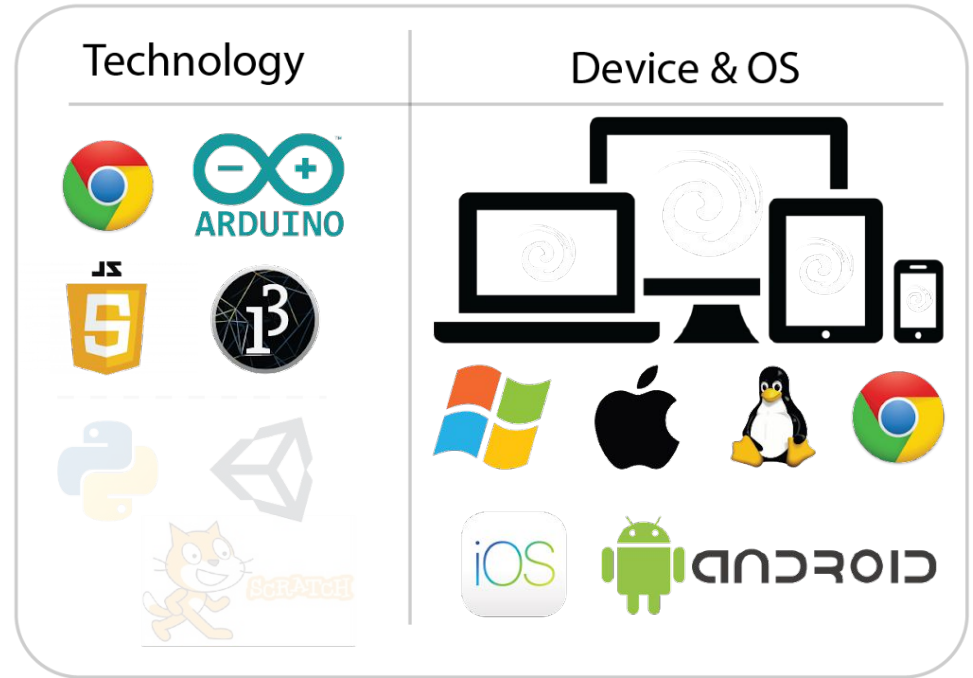
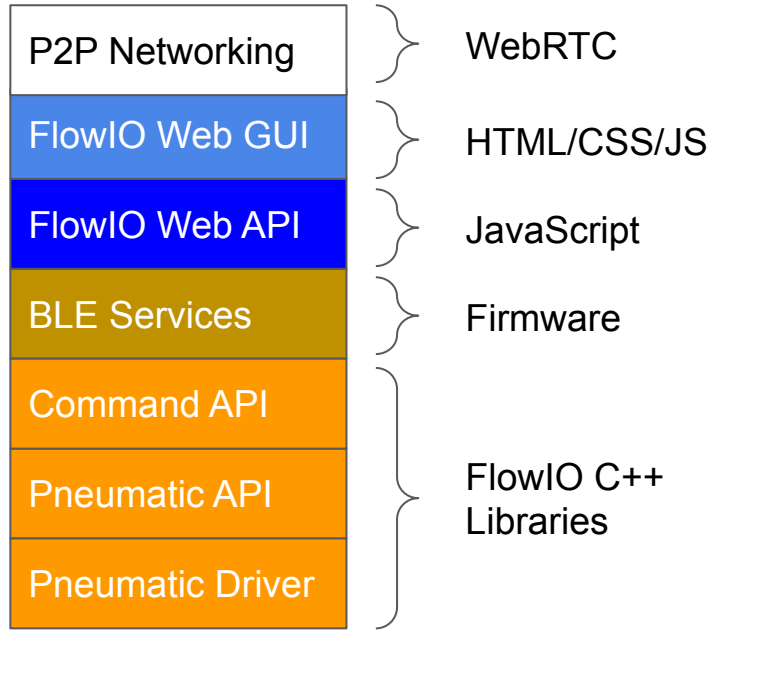
**bool getHardwareStateOf(Component componentName) ;** Takes the enum-defined component name,

**bool getHardwareStateOf(uint8\_t bitNumber) ;** Takes the bit number corresponding to a particular component,

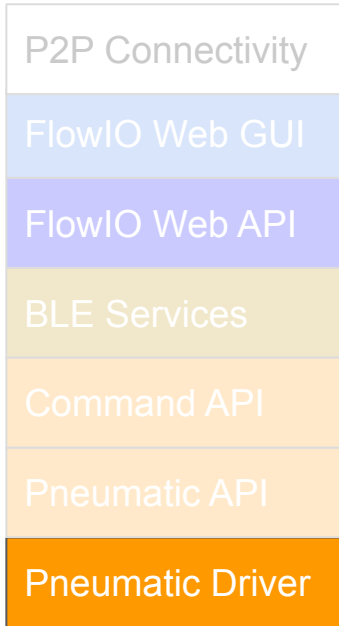
Returns **true** if that component is active / on, otherwise it returns **false**.

Bit #	11	10	9	8	7	6	5	4	3	2	1	0
Component	SENSOR	LEDBLUE	LEDRD	PUMP2	PUMP1	OUTLET	INLET	PORT5	PORT4	PORT3	PORT2	PORT1

# Software Stack

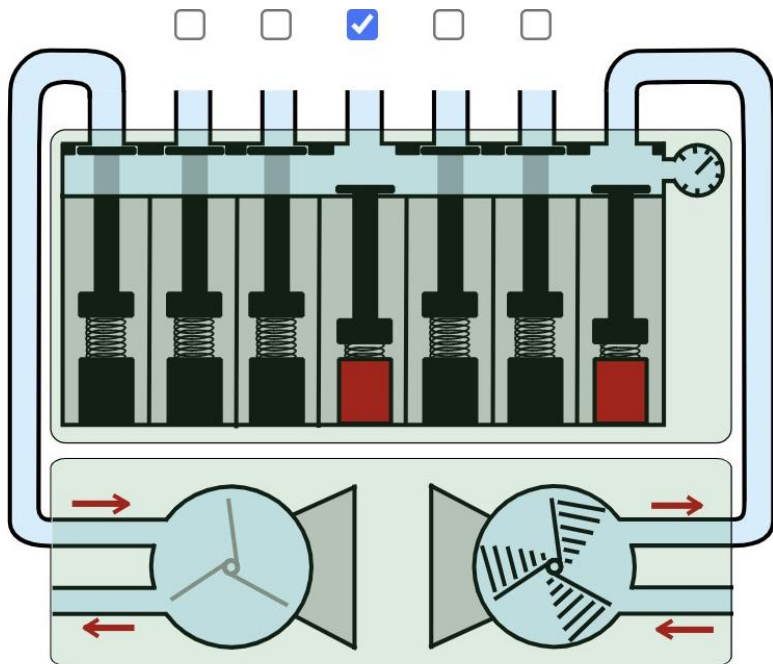


# Pneumatic Driver



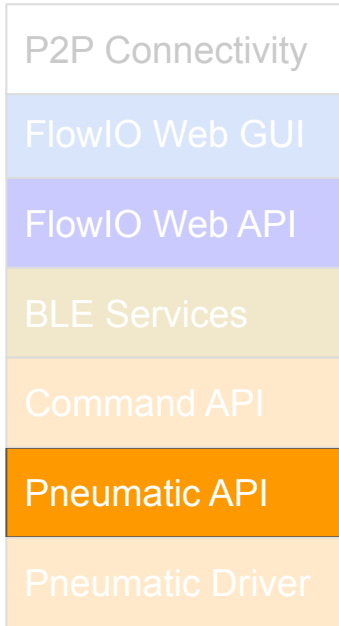
- Controls primitive tasks involving single pneumatic components
- C++ Library that is Arduino compatible.
- Representative functions include (not full list):
  - `void startPump(uint8_t pumpNumber, uint8_t pwmValue=255);`
  - `void stopPump(uint8_t pumpNumber);`
  - `void openInletValve();` (*right side*)
  - `void closeInletValve();`
  - `void openOutletValve();` (*left side*)
  - `void closeOutletValve();`
  - `void setPorts(uint8_t ports);`
  - `void openPorts(uint8_t ports);`
  - `void closePorts(uint8_t ports);`
  - `void powerOFF();`



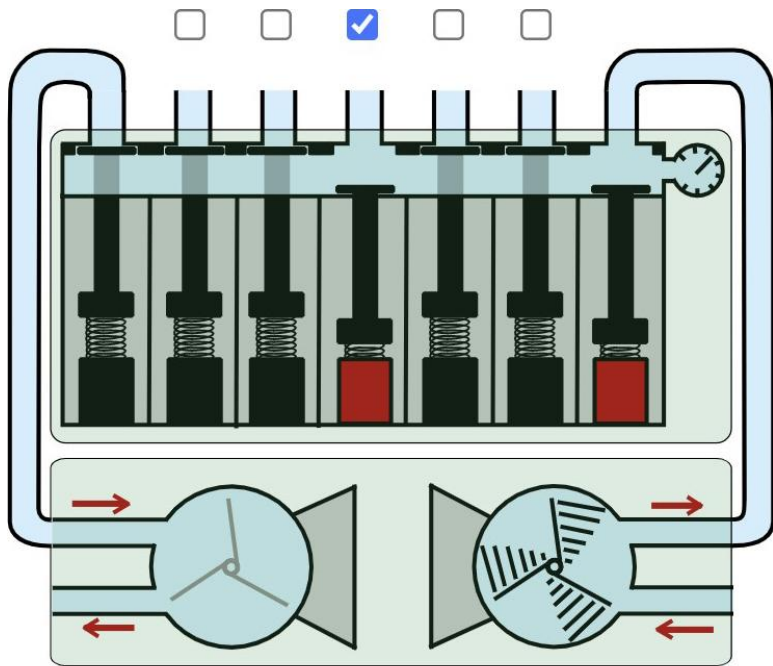


```
flowio.startPump(1,255);  
flowio.openInletValve();  
flowio.openPorts(0b00000100);  
float p = flowio.getPressure()  
    *  
    *  
    *  
flowio.closePorts(0x04);  
flowio.stopPump(1);  
flowio.closeInletValve();
```

# Pneumatic API

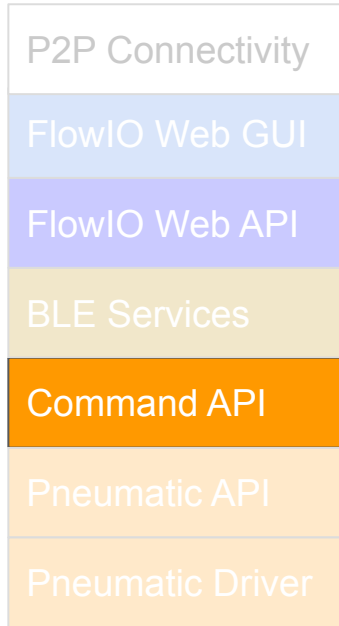


- Controls entire activities involving combinations of components and multiple tasks done in the appropriate sequences.
- C++ Library that is Arduino compatible.
- Representative functions include (partial list):
  - `void startInflation(uint8_t ports, uint8_t pwmValue=255)`
  - `void startVacuum(uint8_t ports, uint8_t pwmValue=255)`
  - `void startRelease(uint8_t ports)`
  - `void stopAction(uint8_t ports)`
  - `uint16_t getHardwareState()`
  - `float getPressure(Unit pUnit)`



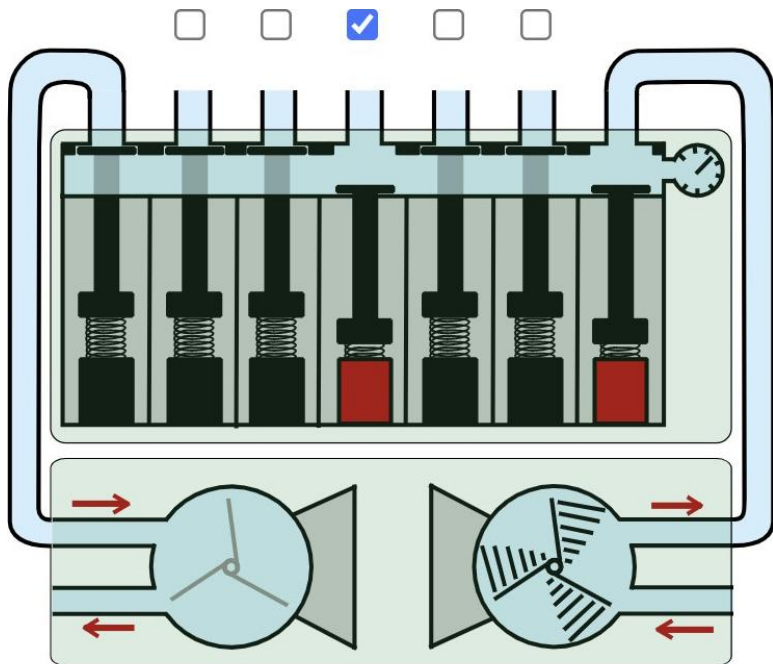
```
flowio.startInflation(0x04, 255);  
float p = flowio.getPressure()  
*  
*  
*  
flowio.stopAction(0x04);
```

# Command API



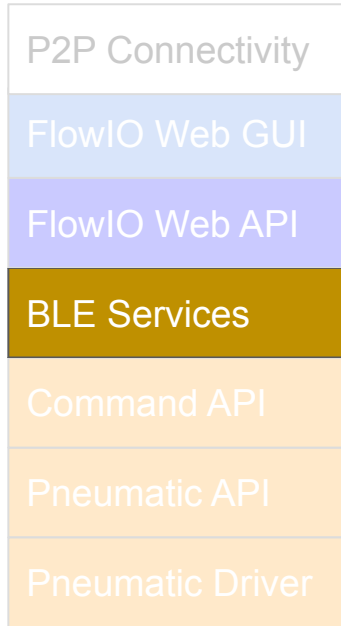
- A command-control interface for FlowIO.
- C++ Library that is Arduino compatible.
- 3-bytes that encode for **What**, **Where**, and **How**
- Returns the pressure value.
- Example: Start Vacuum on ports 3 and 4 with pwm of 50% duty cycle would be sent as the command : ('-', **0b00001100**, **127**)

```
float command(uint8_t action, uint8_t ports, uint8_t pwmValue=255)
```

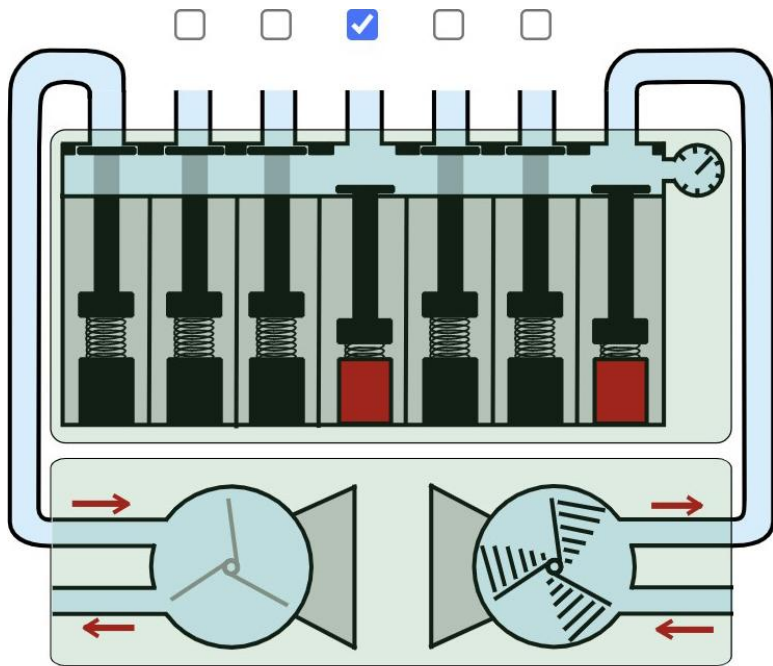


```
p = flowio.command('+', 0x04, 255)
*
*
*
flowio.stopAction(0b00000100);
```

# Bluetooth LE Services



- Firmware running on the FlowIO device
- 7 custom Bluetooth services with multiple characteristics:
  - **indicator Service**
  - **config Service**
  - **control Service**
  - **pressure Service**
  - **gpio Service**
  - **power Off Service**
  - **battery Service**
- This is the layer that enables you to control everything on FlowIO via Bluetooth Low Energy!



## Control Service

Command Characteristic

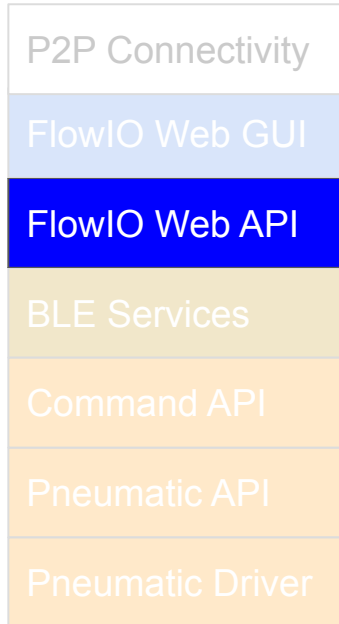
+

0x04

255

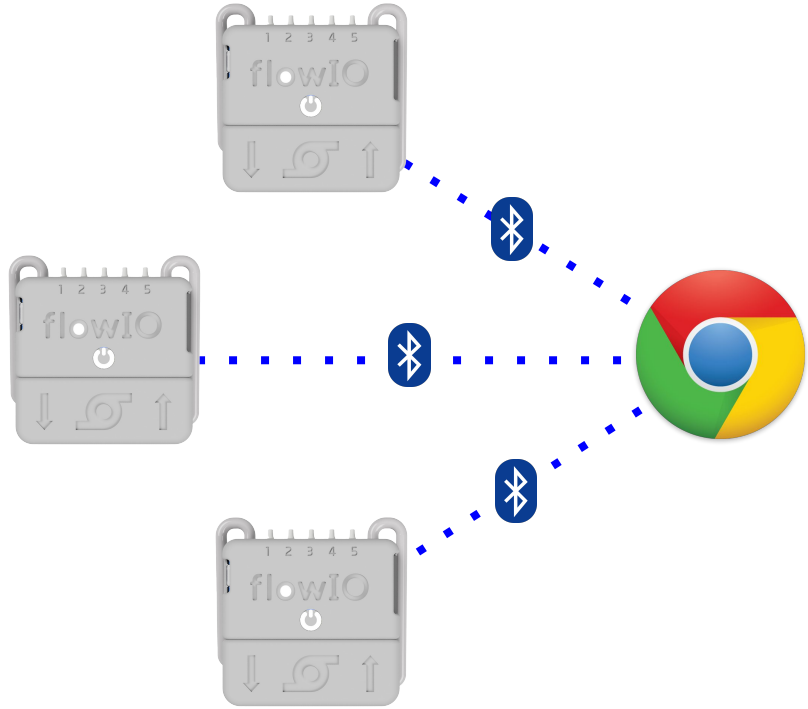
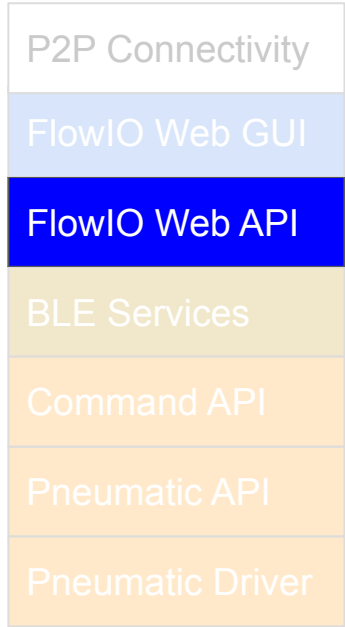
Hardware Status  
Characteristic

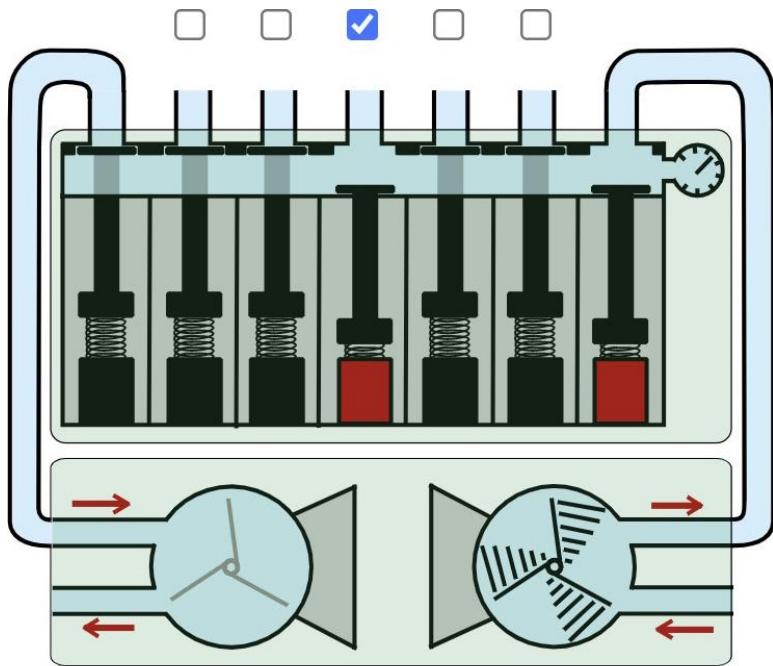
# Web API



- An object-oriented JavaScript API
- Compatible with Google Chrome
- Based on Web-Bluetooth protocol
- Based entirely on the custom BLE services from the layer below.
- Runs in the web-browser, and is capable of executing computationally-heavy tasks.
- No software or drivers downloads needed to be installed.
- Requires only Google Chrome, making it compatible with just about any device and operating system.







```
p = flowios[0].command('+', 0x04, 255)
*
*
flowios[0].stopAction(0x04)
```

# Web GUI

P2P Connectivity

FlowIO Web GUI

FlowIO Web API

BLE Services

Command API

Pneumatic API

Pneumatic Driver

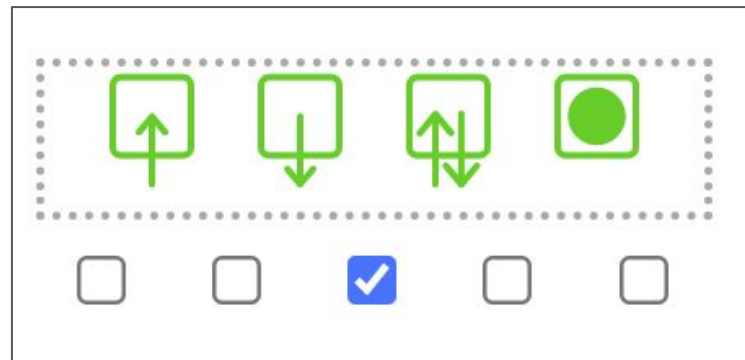
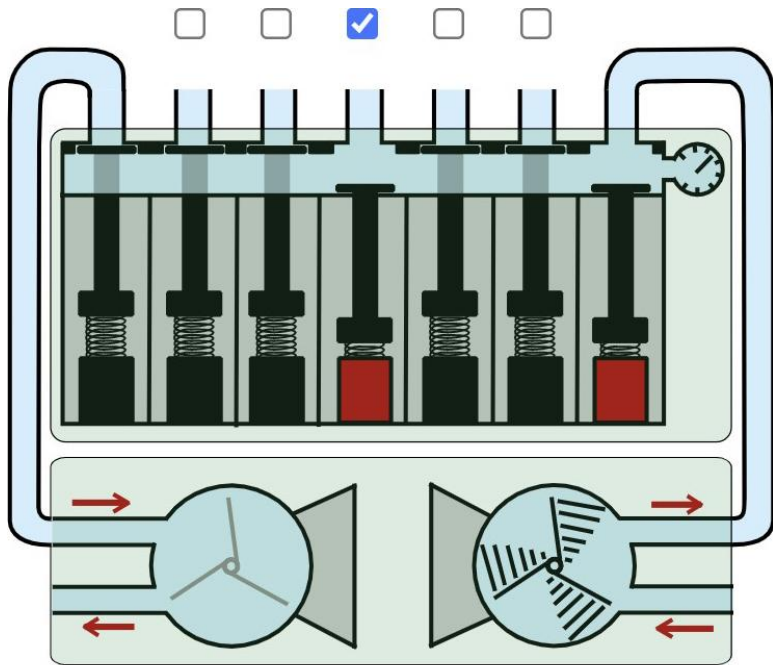
The screenshot displays the FlowIO Web GUI interface. On the left, there is a sidebar with a power button and a timer showing 00:04. The main area is divided into three sections:

- Config / Control:** Features two sliders for "Vacuum PWM" and "Inflation PWM", a central diagram of a multi-chambered pneumatic device with various valves and ports, and several status icons.
- Scheduler:** Contains a table with columns for  $t_0$  (ms), Action, PWM, and Ports. Below the table is a green play button.
- Log:** Displays a list of pressure (P) readings over time, with a "Clear Log" button at the bottom.

$t_0$ (ms)	Action	PWM	Ports
0	Inflate	100	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
1000	Vacuum	100	<input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2500	Release	111	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
3000	Vacuum	144	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
3545	Vacuum	120	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
8785	Stop	100	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
9000	Stop	255	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

Log entries (P = pressure):

```
P = 14.462
P = 14.468
P = 14.463
P = 14.471
P = 14.463
P = 14.469
P = 14.464
P = 14.471
P = 14.465
P = 14.470
8%
P = 14.464
P = 14.471
P = 14.460
P = 14.467
P = 14.460
P = 14.466
P = 14.460
P = 14.465
P = 14.456
P = 14.467
P = 14.452
P = 14.440
P = 14.370
P = 14.379
P = 14.365
```



### Scheduler

+ Add Row

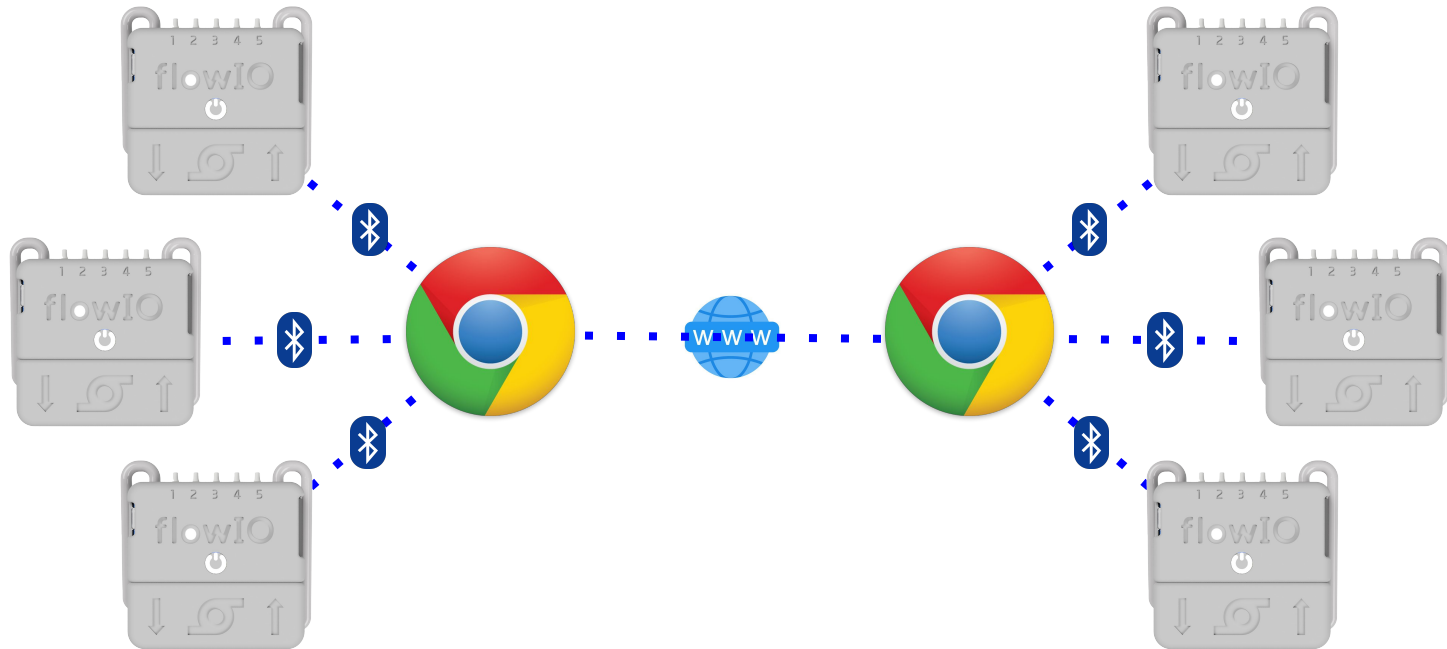
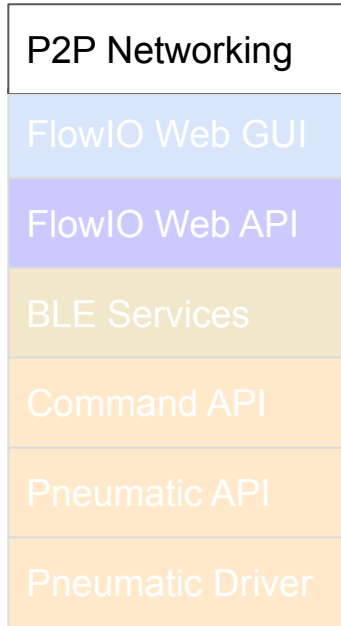
Delete

Reset

$t_0$ (ms)	Action	PWM	Ports
0	Inflate	255	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2000	Stop	255	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>



# Peer-to-Peer Networking



# Other Notable Features

Auto-Off  
Timer



00:04

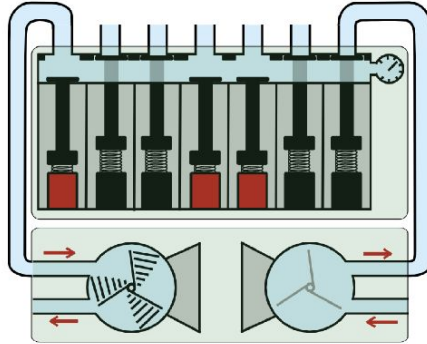
Battery Level  
Indicator



Configuration  
Selector



Real-Time  
Hardware Feedback



Pressure Indicators



PWM Flow  
Control

Vacuum PWM:



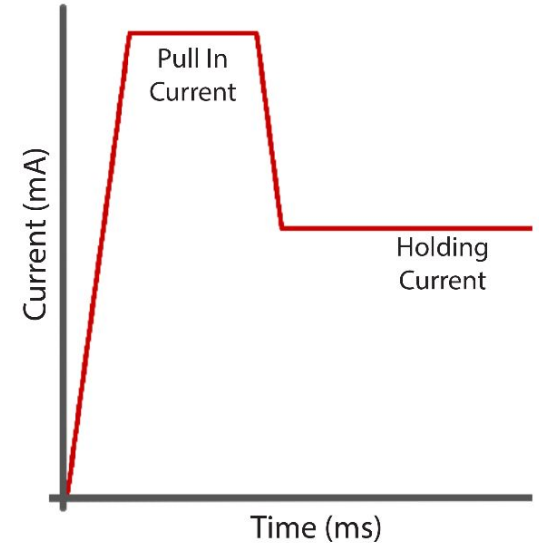
Inflation PWM:



Hardware Status &  
Error Detection



Power Saving  
Algorithms

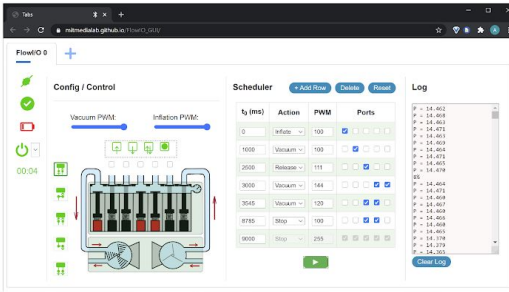


# HARDWARE

Controller	 <p>Main Module (59 x 33 x 28) mm</p>		
Pumps	 <p>Small (59 x 22 x 28) mm</p>	 <p>Medium (60 x 51 x 28) mm</p>	 <p>Large (70 x 66 x 64) mm</p>
Expansion Modules	 <p>Sensors++</p>	 <p>Expansion Breakout</p>	 <p>16-pin Analog Input</p>
Accessories	 <p>Wrist Strap</p>	 <p>Auxiliary Tube</p>	 <p>Lego Base</p>

# SOFTWARE

## Web-GUI



The Web-GUI interface displays a 'Scheduler' table with the following data:

ts (ms)	Action	PWM	Ports
0	Inflate	100	
1000	Vacuum	100	
2000	Release	111	
3000	Vacuum	144	
3045	Vacuum	120	
8785	Stop	100	
9000	Stop	255	

Below the scheduler, there are sections for 'APIs & Libraries' and 'Compatibility'.

### APIs & Libraries

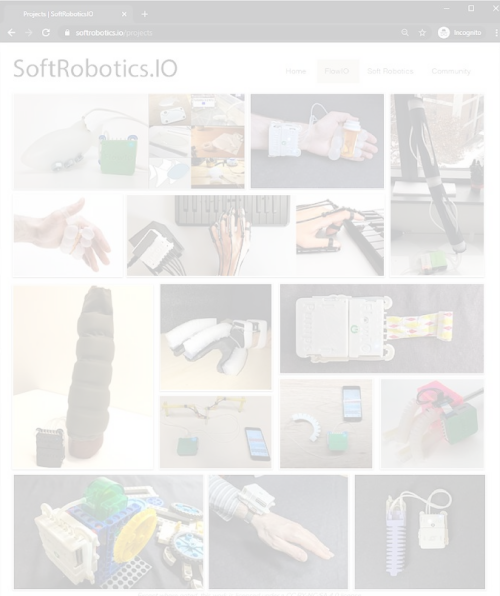
- ARDUINO
- JS
- 5

### Compatibility

- Windows
- Apple
- Penguin
- Chrome
- Android
- iOS


# COMMUNITY

## SoftRobotics.IO



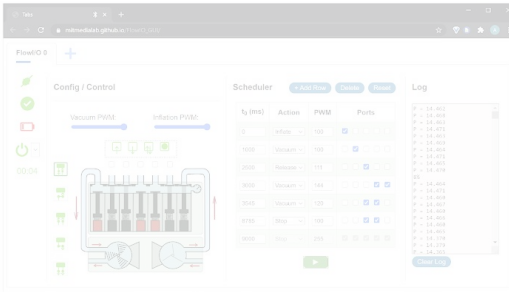
The website features a gallery of various soft robotics projects, including prosthetic hands, grippers, and other bio-inspired devices. The navigation bar includes 'Home', 'FlairIO', 'Soft Robotics', and 'Community'.

# HARDWARE


Controller	 <p>Main Module (59 x 33 x 28) mm</p>		
Pumps	 <p>Small (59 x 22 x 28) mm</p>	 <p>Medium (60 x 51 x 28) mm</p>	 <p>Large (70 x 66 x 64) mm</p>
Expansion Modules	 <p>Sensors++</p>	 <p>Expansion Breakout</p>	 <p>16-pin Analog Input</p>
Accessories	 <p>Wrist Strap</p>	 <p>Auxiliary Tube</p>	 <p>Lego Base</p>

# SOFTWARE


Web-GUI



APIs & Libraries

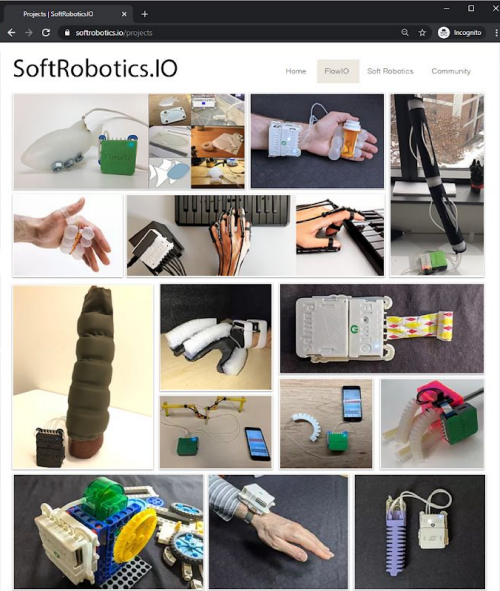


Compatibility



# COMMUNITY

SoftRobotics.IO



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# COMMUNITY

## Projects

Projects | SoftRobotics.IO

Home FlowIO Soft Robotics Community

SoftRobotics.IO

Project images showing various prosthetic devices and components.

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## Documentation

SoftRobotics.IO

Home FlowIO GUI Soft Robotics Community

Parts List

Battery Preparation

FFC Cable Preparation

Arduino Setup

Circuit Boards Soldering

Driver Assembly

Valves Preparation

Valves Assembly

Insertion into Enclosure

Expansion Boards

**Main Module Driver Board**

Label	Part
R1-R8	500k
R9	5k or 10k
Q1-Q7	BURBROT5-40KH
Q8	2N7002N/AKR or TSM240N3CX
DF1-DF7	CUS10530,H3F
FFC1	SFW12R.1STE1LF
FFC2	SFW14R.1STE1LF

**Soldering Sequence**

1. On/Off controller\* and transistor Q8
2. Voltage regulator\* and transistors\* Q1 to Q7
3. Resistors, capacitors, and diodes
4. FFC connectors\*
5. Buttons
6. LiPo battery connector\* + trim & sand feet
7. Short Female headers\* + trim & sand feet
8. Magnetic Connector\* + trim & sand feet
9. Apply Kapton tape to the PCB bottom

\* see additional details below

**1. On/Off Controller**  
These 11 marks on the chip must go on the upper left corner, where the white dot on the PCB is.

**2. Transistors Q1 to Q7**  
The 3 pads on the upper right are connected; the 4 pads on the bottom are also connected.

**2. Voltage Regulator**  
The line mark on the component must face to the left.

**4. FFC Connectors**  
Must not protrude at all beyond the edge of the PCB, and ideally should be flush with the edge.

**6. LiPo Battery Connector**  
Must be soldered from top and bottom to withstand the forces when battery is connected / disconnected. Trim the plastic flags at the back of the connector; sand its feet close to the surface.

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## Forums

SoftRobotics.IO

Home FlowIO GUI Soft Robotics Community

Forum

Search

Login / Sign up

Create New Post

**FlowIO Features & Capabilities**  
Discussion about the features and affordances of FlowIO

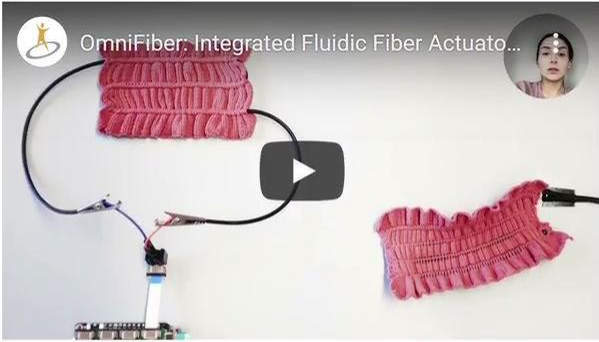
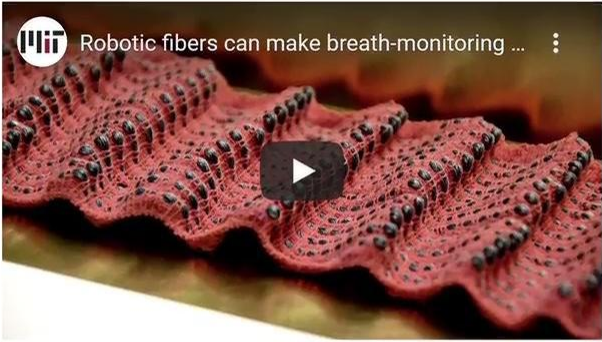
**Projects & Applications**  
Share project ideas or questions to find out if FlowIO is suitable for yo...

**Soft Robotics Resources**  
What do you want to learn about soft robotics? What resources should...

**General Discussion**  
General Discussion

**Make your own FlowIO**  
Discussion about replicating the FlowIO device

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Application: **Piano Skill Glove**



Application: **Tangible Message**



Application: **Larynx Actuation**



Application: **Robotic Toy**



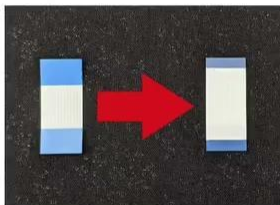
This website just launched on May 8 and is pending approval from MIT. Some parts are restricted until approval is received. Thanks for your patience.

This work is licensed under [CC BY-NC-SA 4.0](#) which requires attribution, by citing either [this paper](#) or the creator's name and a link to [softrobotics.io](#).

Make FlowIO: Overview

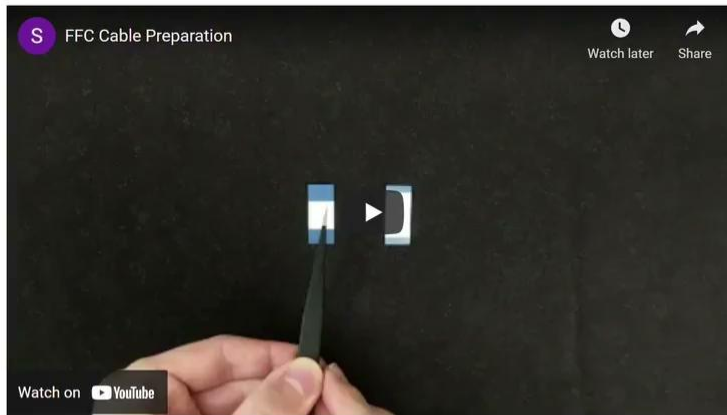
1. Parts and Materials
2. 3D Printing of Parts
3. Battery Preparation
4. FFC Cable Preparation
5. Circuit Boards Soldering
6. Microcontroller Prep
7. Valves Preparation
8. Driver + MCU Assembly
9. Valves Assembly
10. Main Module Assembly
11. Pump Module Assembly
12. FlowIO Self Tests
13. AnalogIn16
14. Sensors++ PCB Prep
15. Expansion Breakout

## FFC Cable Preparation



We will prepare the 12-pin FFC cable now in the form needed for the final assembly. We will simply need to trim some of the blue plastic on both sides, so that we can bend the cable where we need. We will need the following items:

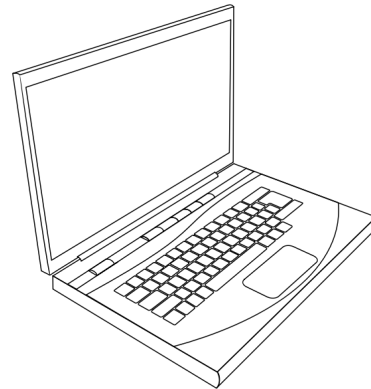
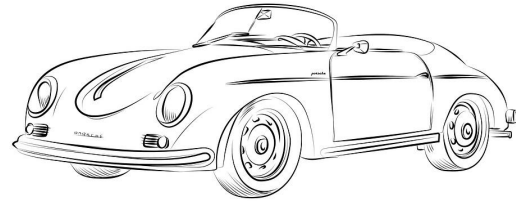
- 12-pin FFC cable
- Hot-air gun
- 12-pin FFC connector
- Knife

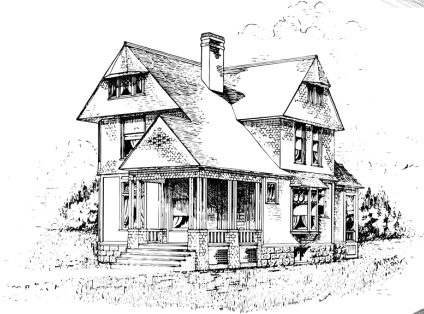
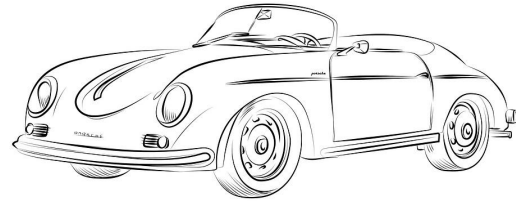


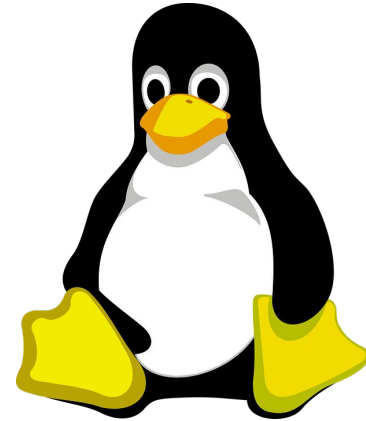
There is much more documentation, tutorials, project videos, and other content that is slowly being added to this website. If interested in helping with any of these or other tasks, please consider volunteering.

**Get Involved**

Find out how you can help







FlowIO is Creative Commons Hardware...



...and is provided FREE of charge to approved users



This website just launched on May 8 and is pending approval from MIT. Some parts are restricted until approval is received. Thanks for your patience.

# Soft Robotics Workshop

## How To Make (Almost) Anything, Fall 2019

Ali Shtarbanov  
MIT Media Lab  
alims at mit.edu

- Forums
- Workshop Intro
- Workshop MSRs
- Projects
- Institutions
- Review Articles

### Soft Robots

Systems built from highly-compliant materials with mechanical properties similar to those found in living tissues. Many kinds of soft robots exist, but in this workshop we will focus primarily on pneumatically actuated soft robots.



# SoftRobotics.IO Analytics



Monthly Visitors: 1000+

Site Members: 260+

FlowIO Request Proposals: 65

FlowIO Devices Given: 18

Volunteers: 15

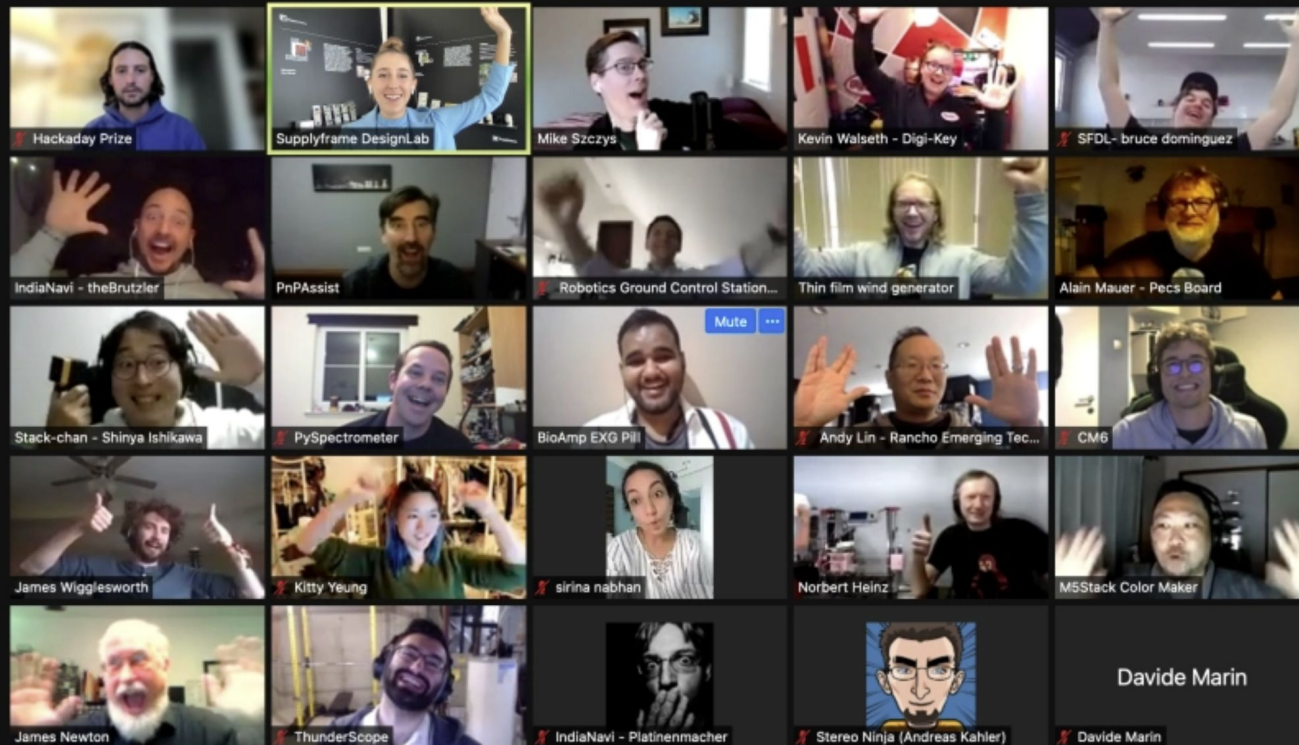
Donors: 14

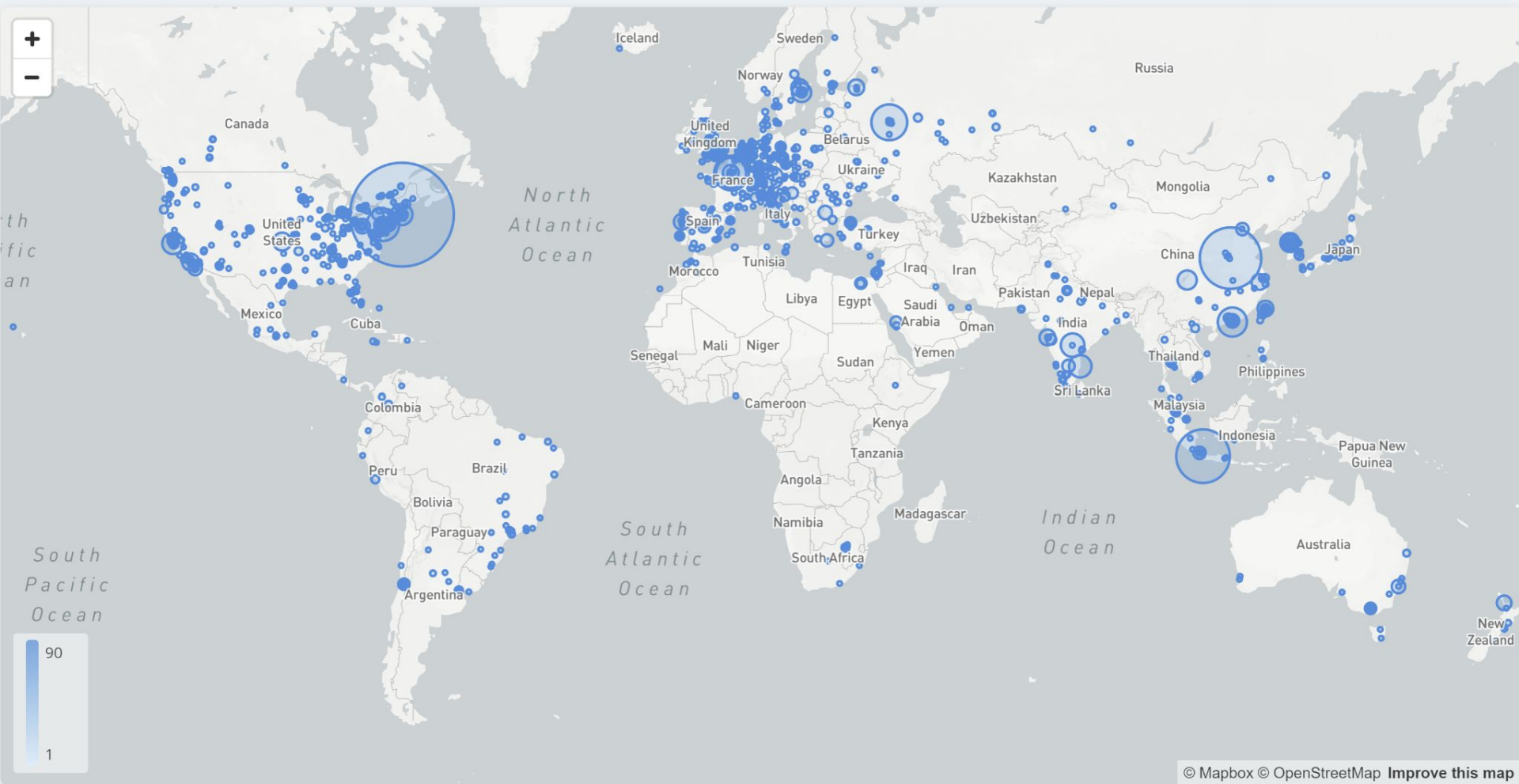
# FLOWIO TAKES TOP HONORS IN THE 2021 HACKADAY PRIZE

by: [Dan Maloney](#)

 [7 Comments](#)

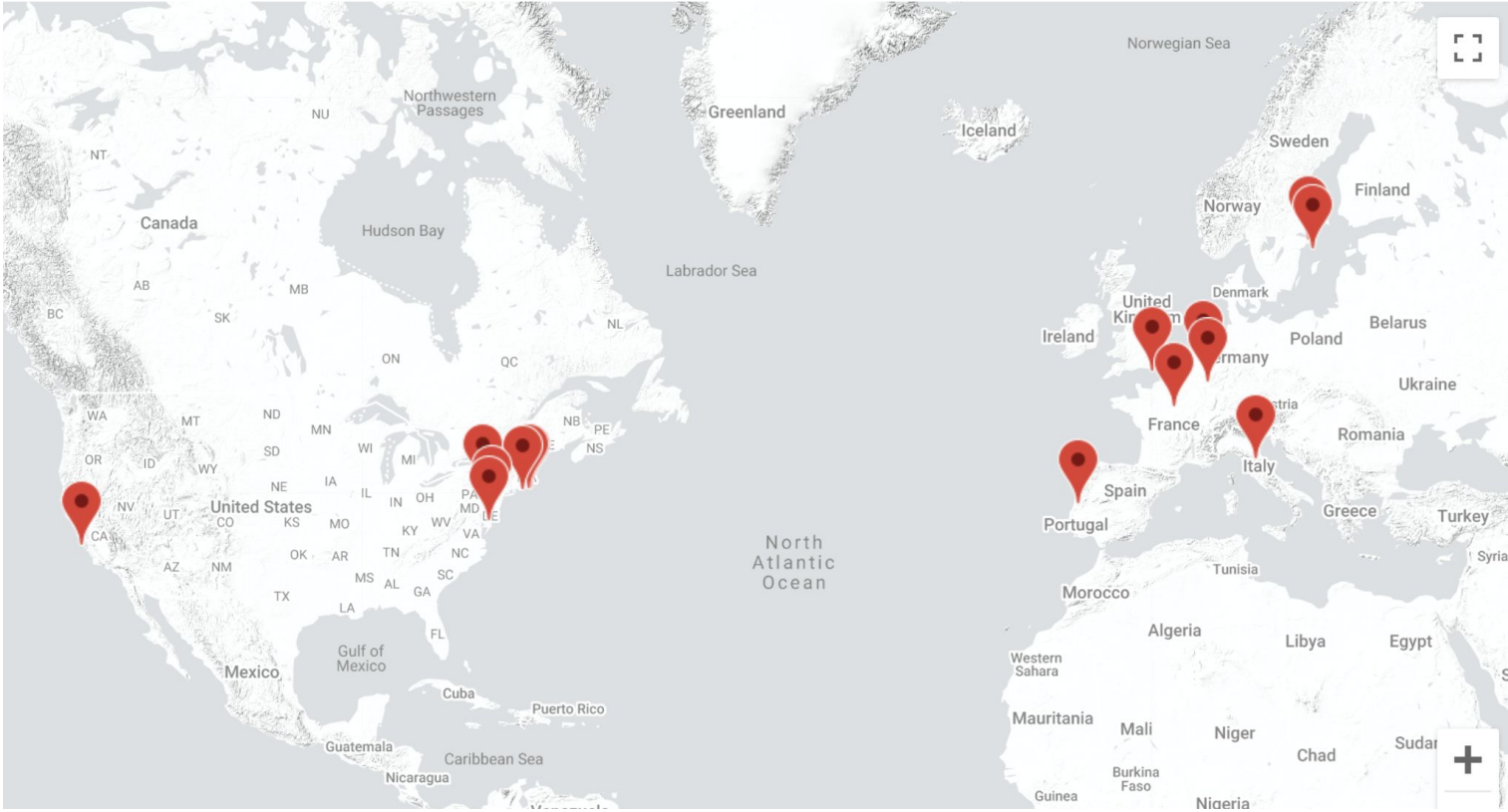
November 20, 2021





© Mapbox © OpenStreetMap Improve this map

# 18 FlowIO Devices Given to Date



# Awards for FlowIO



## Donations

Alive Leyang Xiao  
Brad Holschuh  
David Saldana  
Ed Moriarty  
Francesco Bondesani  
Hyejun Youn  
Irmandy Wicaksono  
Karthik Chandrasekaran  
Markus Nemitz  
Muhammed Oguz Yildiz  
Neil Gershenfeld  
Ozgun Afsar  
Thrishantha Nanayakkara  
Wanhui Li

## Applications

Ali Shtarbanov  
Bai Li  
Francesco Bondesani  
Hyejun Youn  
Irmandy Wicaksono  
Michael Bell  
Ozgun Afsar  
Xinlei Zhang

## Graphics

Ali Shtarbanov  
Hyejun Youn  
Ozgun Afsar

## Content

Ali Shtarbanov  
Hyejun Youn  
Loyal Barakat

## Advice

Joseph Paradiso  
Jie Qi  
Ed Moriarty  
Michael Bell

## GUI

Ali Shtarbanov  
Alisha Fong  
Yoav Luft

## Electronics

Ali Shtarbanov

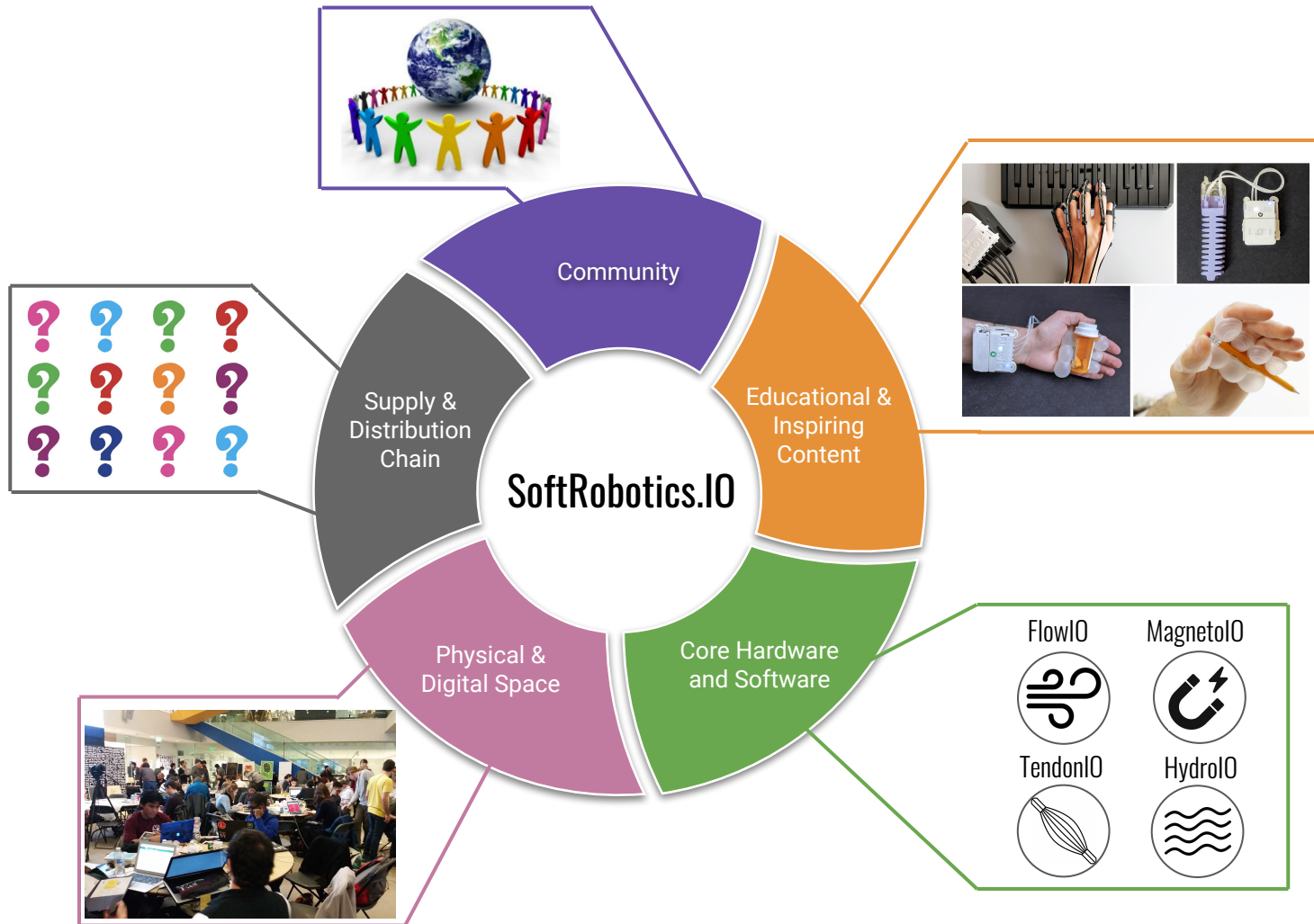
## Mechanical Design

Ali Shtarbanov

## Software Stack

Ali Shtarbanov







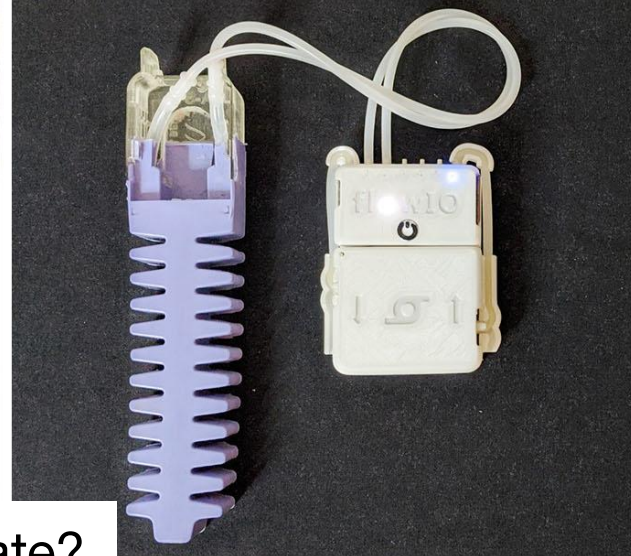
## I want to create a world...

- ...where creative opportunities are not restricted to only those who can afford them.
- ...where the objects around us are programmable and reconfigurable.
- ...where disabled individuals can create by themselves the unique solutions they need.
- ...where building a prototype takes just days or weeks instead of months or years.
- ...where the tools for prototyping and innovation are very powerful yet very simple to use.
- ...where people don't have to give up on an amazing idea just because it's too complex to build.
- ...where people are motivated, inspired, and have the means to make the world better themselves.

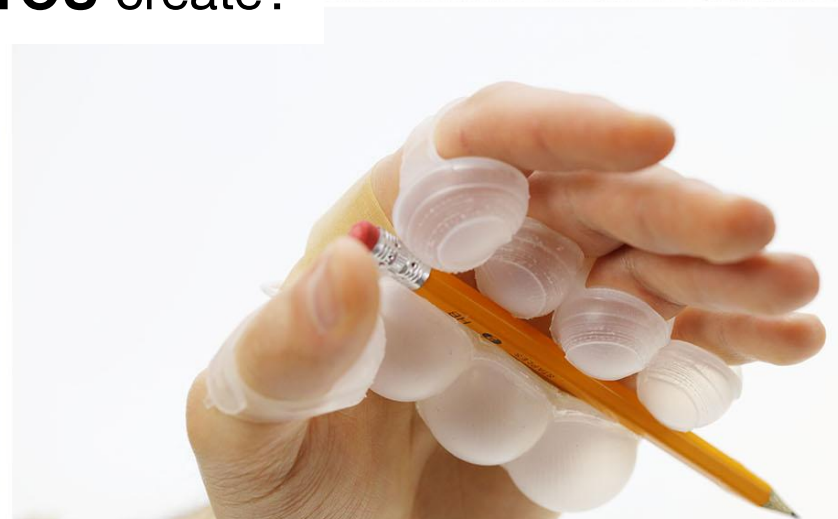


To democratize and enable rapid prototyping and innovation opportunities in emerging fields for researchers, designers, artists, and makers from all technical and socioeconomic backgrounds

through development and **deployment** of enabling platforms that are highly versatile, general purpose, and simple to use by anyone.



What will **YOU** create?







# Software Stack Details

Make a slide about the web-connectivity layer and discuss the webrtc p2p protocol.

# Pros and Cons

Cost to make is high but is free to obtain

Making FlowIO is very challenging and requires lots of modifications to parts.

Project is still far from complete - both hardware and software-wise.

More Documentation is still needed

More examples are needed

Graphical User Interface needs more work.

# Notable Projects Made with FlowIO

Peristaltic Suit

Omnifiber



# The Power of Modularity

Extendable and ability to make new modules in the future.

Others can design their own modules for FlowIO

List all other benefits or modularity from my general exam talk.

Sensors in Flowio

Alternative microcontrollers possible

People from all around the world have contacted me and got many invites to give talks and visit places

A great way to form new collaborations

Wearable first design approach

Include some slides about the evaluation with users.

