3D-printed peristaltic pump kit

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Abstract

This document serves as a comprehensive guide for assembling, operating, and maintaining a DIY peristaltic pump. Adapted from the original work by Terry Ching (2021)[1] with modifications tailored for enhanced reproducibility, this documentation aims to provide clear and accessible instructions for individuals interested in constructing their own peristaltic pump. By leveraging readily available materials and components, particularly those accessible in Switzerland, this guide facilitates the replication of the pump design with ease. The documentation covers detailed assembly instructions, operating procedures, maintenance guidelines, troubleshooting tips, and safety precautions, ensuring users can effectively utilize and maintain the peristaltic pump for various applications.

1 Introduction

A peristaltic pump operates by compressing and relaxing flexible tubing using rotating elements, typically rollers, which create a series of occlusions and releases to propel fluids through the tube. The peristaltic pump presented here is based on the original design outlined in the previously mentioned paper, with modifications aimed at enhancing reproducibility and accessibility. Utilizing 3D printing technology, specifically resin prints from the Formlabs Form 3+ printer, we've adapted the manufacturing process to ensure ease of replication while maintaining precision and reliability. Our pump retains the cost-effectiveness of the original design while striving for easier reproducibility. To drive the pump, we've integrated a stepper motor controlled by an Arduino microcontroller providing control over flow rates. Please note that we only reproduced the **Variant A** (bottom-loaded configuration) of the pump from the original paper since it gave us more reliable results than the other variant (top-loaded configuration).

[1] Terry Ching, Jyothsna Vasudevan, Hsih Yin Tan, Chwee Teck Lim, Javier Fernandez, Yi-Chin Toh, Michinao Hashimoto, Highly-customizable 3D-printed peristaltic pump kit, 2021, `https://www.sciencedirect.com/science/article/pii/S2468067221000316`

2 Materials

2.1 Bill of materials

Component	Number	Cost/unit [CHF]	Total cost [CHF]	Source (hyperlink)
Tubing Tygon				
Micro Gear Motor, 2-Phase 4-Wire – 5 rpm	1	5.17	5.17	Digikey
stepper motor driver L293D	2	7.14	14.28	Digikey
Acrylic breadboard				
Solid ø2mm metal rod, 50cm	1	2.15	2.15	Conrad
Silicone tubing (ID 0.5 x OD 1mm), 1m	1	8.95	8.95	ultimus
0.96 Inch I2C Graphic 1 3.50 OLED Display Module	1	5.95	5.95	Fruugo
Arduino Micro (or Nano)	2	15	30	Berry base
Tactile Push Button switch	3	0.95	2.85	Berry base
On-Off-On switch	1	1	1	Digikey
USB power Adaptor, 1A, 5V	1	3.95	3.95	Berry base
MicroUSB Cable, 1m	1	1.45	1.45	Berry base
Heat Shrink Tubing				
Wire (minimum size AWG30)				
Fa 830 Points Solderless 1 Breadboard	1	1.95	1.95	Berry base
Pin header	1	0.50	0.50	Berry base
Arduino Jumper Wire (M-M)	1	1.65	1.65	Berry base
Arduino Jumper Wire (F-F)	1	1.65	1.65	Berry base
M2x4mm Stainless Steel 17 Hexagon Socket Head Cap Screw				
M2 Tap	1	9.90	9.90	Galaxus
Adafruit Perma-Proto Bread-board	1	5.45	5.45	Berry base
Stacking bars arduino	2	2.10	4.20	Distrelec

Table 1: Parts and where to buy them

2.2 CAD files

To construct the peristaltic pump, various components are needed, some of which are manufactured using a resin printer or 3D printer (Prusa i3 MK3S), while others are created using a laser cutter and acrylic sheets. The table below outlines the different parts required for the pump and indicates whether they are printed using a resin printer or cut using a laser cutter and acrylic sheet. The parts reported here are available on the lab Github repository and are the ones used in our prototype, some of them are modified from the original article.

File name	Number needed	File type	Material
part 1	1	STL file	Resin
part 2	2	STL file	Resin
part 3	2	STL file	Resin
part 4	3	STL file	Resin
part 5	2	STL file	Resin
part 6	1	STL file	Resin
part 9	as desired	STL file	Resin or PLA
part 9 5ml	as desired	STL file	Resin or PLA
shaft coupler	1	STL file	Resin
pump case bottom	1	STL file	PLA
pump case top	1	STL file	PLA
breadboard	1	SVG file	Acrylic

Table 2: all the parts required

3 Building

3.1 Mechanical part

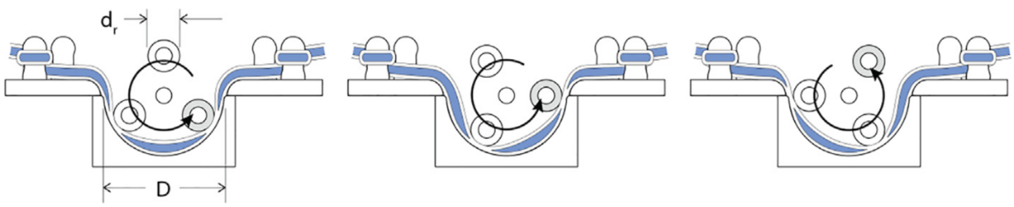

Figure 1: Working principle of a peristaltic pump. As the rollers undergo rotation, they alternately compress and release the flexible tubing, generating both positive and negative pressures within the tube. This cyclical action effectively draws fluid through the tubing, facilitating the pumping process.

The assembly of the pump is quite straight forward. However, after printing the resin parts, it is essential to tap the holes in parts 1, 5, the shaft coupler and the acrylic breadboard in order to create threads inside the holes allowing us to use screws to maintain everything fixed. Furthermore, you might also need to use a 2mm drill bit on parts 3, 4 if necessary to ensures that the 2mm metal rod moves smoothly through the components.

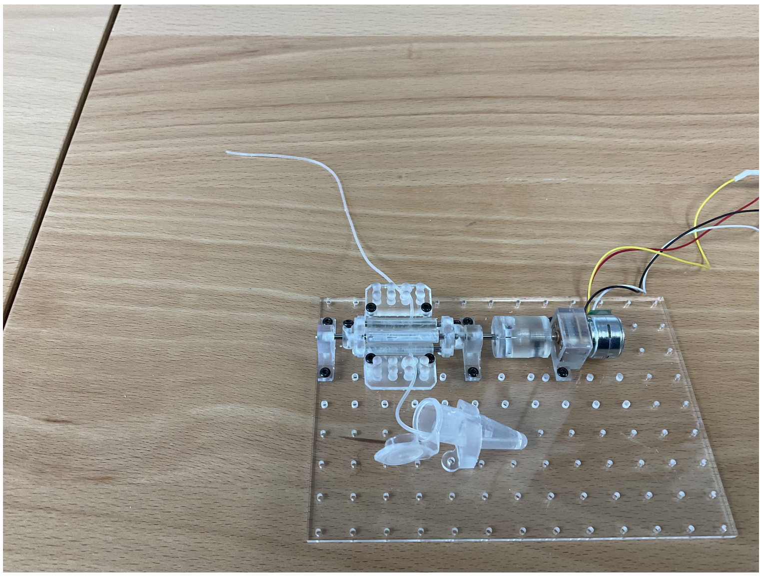

Figure 2: pump mounted

3.2 Electronical part

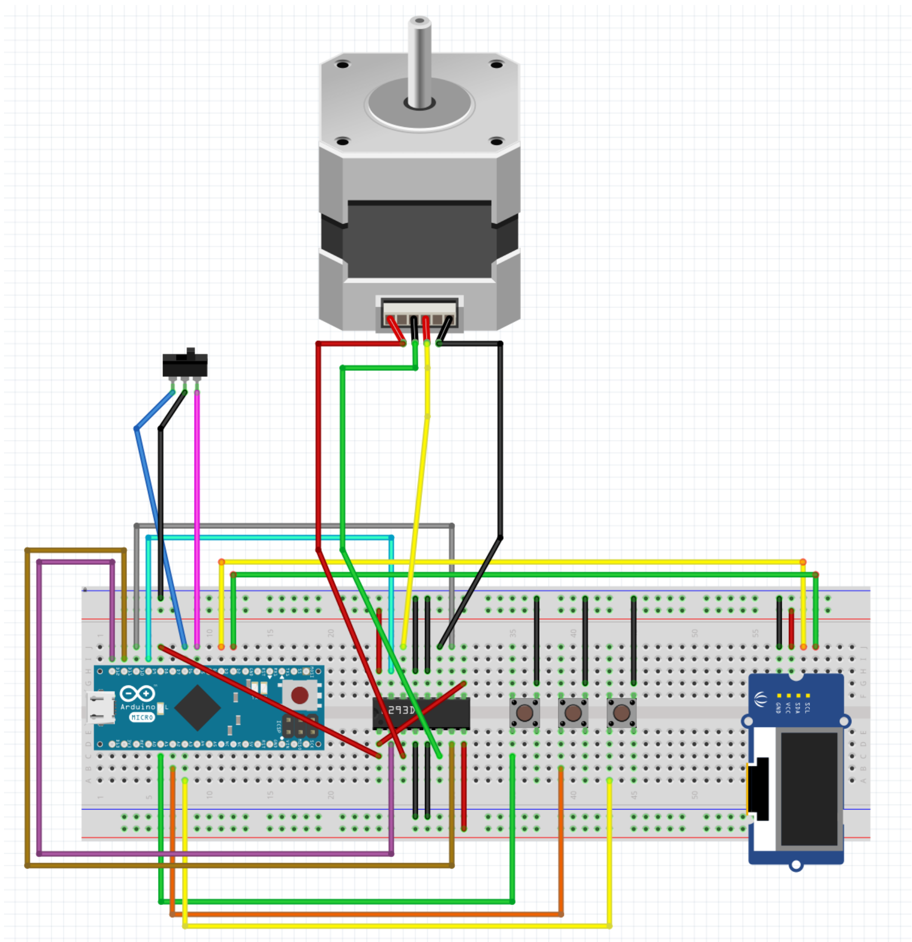

Figure 3: Connection scheme

From the original design we also had to change the electrical circuit and design by adding the L293C chip which is a motor driver. By adding it to our circuit, we gain the ability to control the motor efficiently. Ensure proper pin connections and power supply for the L293C. This chip will act as our bridge between the microcontroller and the motor.

We recommend assembling the system in two stages. First, focus of building the structure of the electrical circuit on the breadboard as shown in Figure 3 to be able to do basic check if the assembly of all parts and the code works properly.

Once the core system is operational, we decided to create a more robust construction of the pump and all the electronics by creating a case (see Figure 4) and directly soldering the components on the prema proto board making the assembly less fragile and thus more conducive to use.

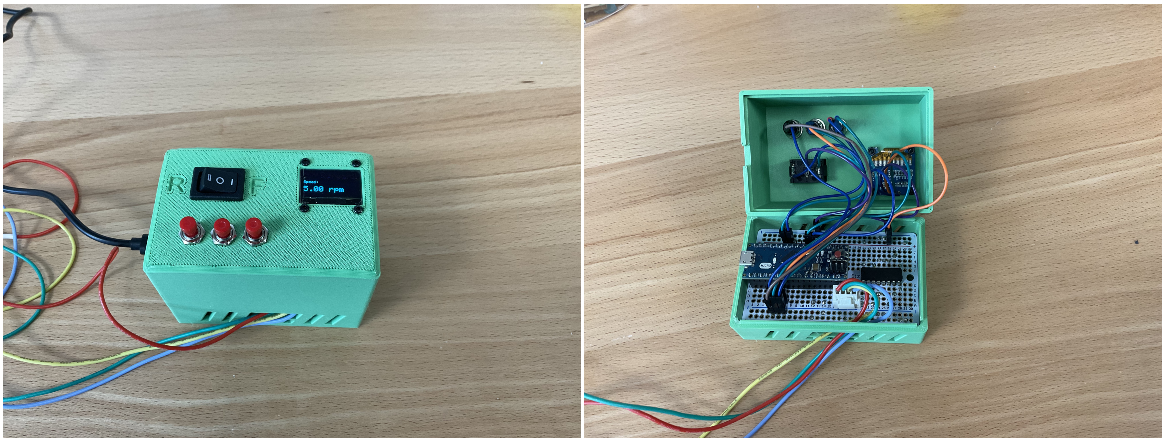

Figure 4: Enclosure of the electronics

3.3 Code

The Arduino code provided in this repository serves to control the operation of the peristaltic pump, ensuring precise manipulation of fluid flow rates. Based closely on the original code, slight modifications have been implemented to enhance the setup's usability and flexibility, particularly in manipulating the pump structure. These adjustments account for minor changes in the code, aimed at improving the overall functionality and user experience.

The code is readily available on our lab's GitHub repository. Users may find it necessary to customize certain parameters, such as lines 104-108, depending on their specific requirements. For instance, in our setup, the maximum rotation per minute (rpm) of the motor is 20 rpm, with increments of 5 rpm when adjusting the speed using the designated button. However, these values can be easily adjusted to suit individual needs.

4 Performances

Finally, it's worth emphasizing that the calibration process for the pump, as outlined in the original paper, lacked reproducibility. To address this limitation, we conducted our own calibration and have included the results in the graph below. This calibration graph serves as a reliable reference point for users, aiding in the comprehension and adjustment of the pump's performance to suit specific applications and needs.

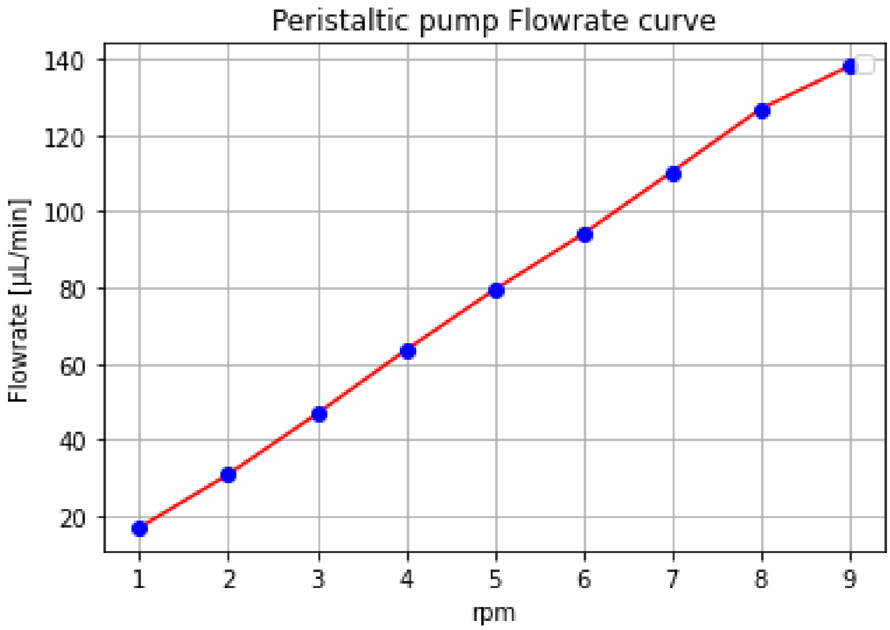

Figure 5: Flowrate measure with rpm