Final Project Report: Mechatronics

Title: Radial Force Measurement System (RFMS) for Flow Diverters and Stents

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By
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Abstract

In the research of developing Biodegradable Flow Diverters by Dr. Hossan and his team, analyzing the mechanical properties of the developed flow diverters are one of the most crucial subsections. The flow diverters have a mesh-like structure in a tubular form and investigate the radial force related to the hoop stress of the material in one of the requirements for the analysis of mechanical properties of the Flow Diverters produced by the team of researchers at UCO. The machine required to analyze this property is available in the market at a relatively high cost and also It would not be sensible to buy equipment that could only serve one purpose especially when It can be developed by engineering students if provided enough incentive and support. This solution is to develop a mechanism that would radially compress the stent to a smaller diameter while registering the force or pressure difference. This data can be later interpreted via a proper calibration of the system. The solution will save a considerable amount of expense while allowing students to have an invaluable chance of learning many aspects of developing a mechanism and a system that would be functional and applicable to the research work.

Introduction

The current environment requires flow diverters to be non-permanent in the body to reduce the possibility of developing complications like late thrombosis and restenosis after having a metallic flow diverter being inserted in the brain arteries to cure the condition of a brain aneurysm. The Brain Aneurysm is the bulging of an area of the blood vessel mainly due to the weakening of the walls of the arteries. This formation is known as an aneurysm which could be fatal if ruptures. The use of flow diverters to cure the condition of the brain aneurysm is quite popular in the medical field due to its non-invasive method to cure the condition. Producing a biodegradable/bioresorbable flow diverter can not only cure the condition of brain aneurysm but also biodegrade over time and reduce or avoid the disadvantages that come along with the permanency of metallic flow diverters. In a manner to push forward, the research and development of such flow diverters will only help the current environment of health conditions of human beings. So, In a manner to further the process, the requirement of investigating the mechanical properties of the developed flow diverter is crucial. And If that goal can be achieved without making hefty expenses on the research budget would be considered a much better solution.

Proposed Solution

Develop a mechanism that would radially compress the flow diverters and allow an electronic system to detect and collect the force versus displacement data during the testing process. The prototype of the mechanism can be 3D printed. The loadcell can be utilized to detect force variation using an Arduino and the data can be transmitted to a computer for data acquisition through a Bluetooth module. The mechanism can be operated using a power screw and stepper motor controlled again via an Arduino

Design and Prototype

The Prototype will register and collect radial force measurements. The following fig. 1 demonstrates the schematics of the Initial Idea.

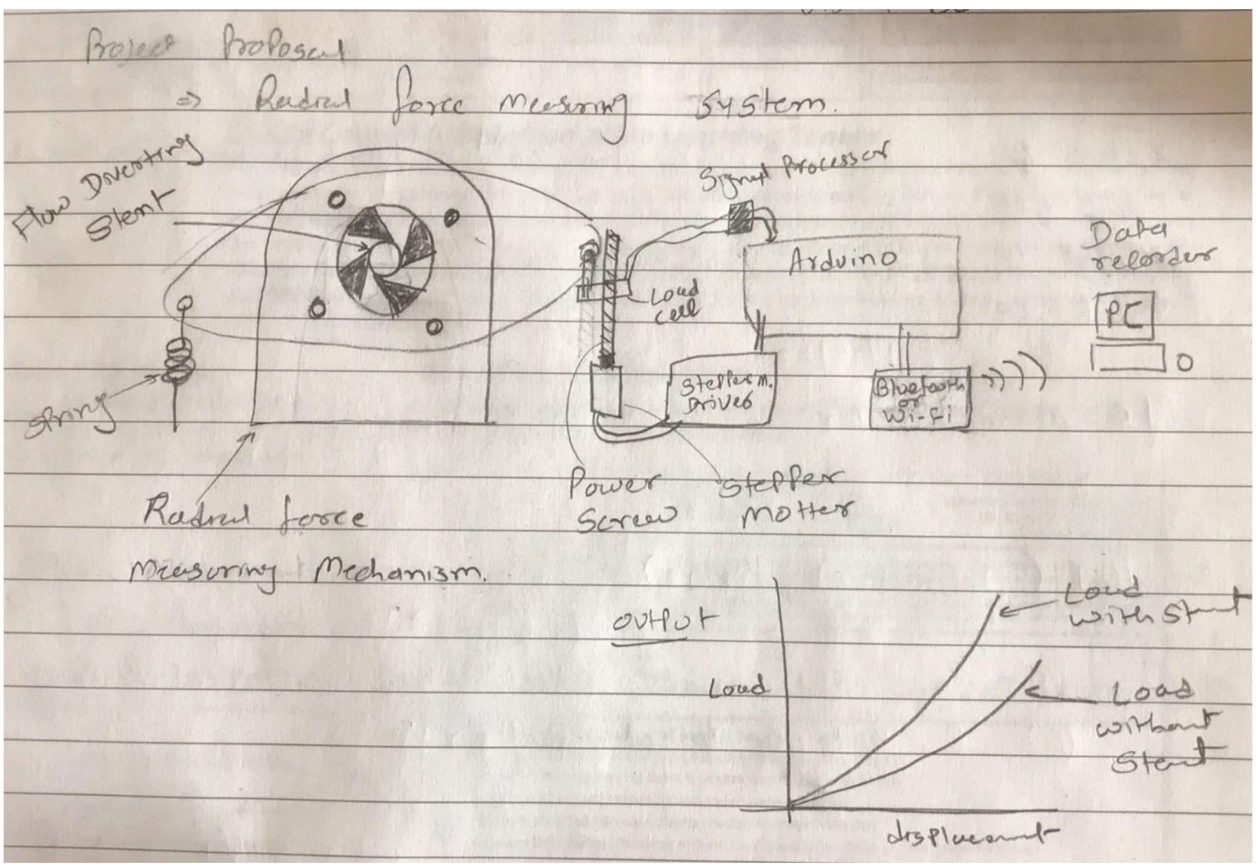


Fig. 1 Rough Schematics for the Radial Force Measurement Device

The following Fig. 2 demonstrates the flowchart of the functionality of the prototype. The flow diverter will be inserted into the mechanism which will be mechanically operated via a lead or power screw mechanism operated through a stepper motor. The mechanism will also be connected to the load cell to register and collect the force measurement data through the radial compression of the flow diverters. Both load cell and stepper motor (via stepper motor driver) will be operated and controlled using an Arduino Uno microcontroller. The logical programming would initiate the test, collect the data during the radial compression and export the data to the monitoring computer via Bluetooth connectivity.

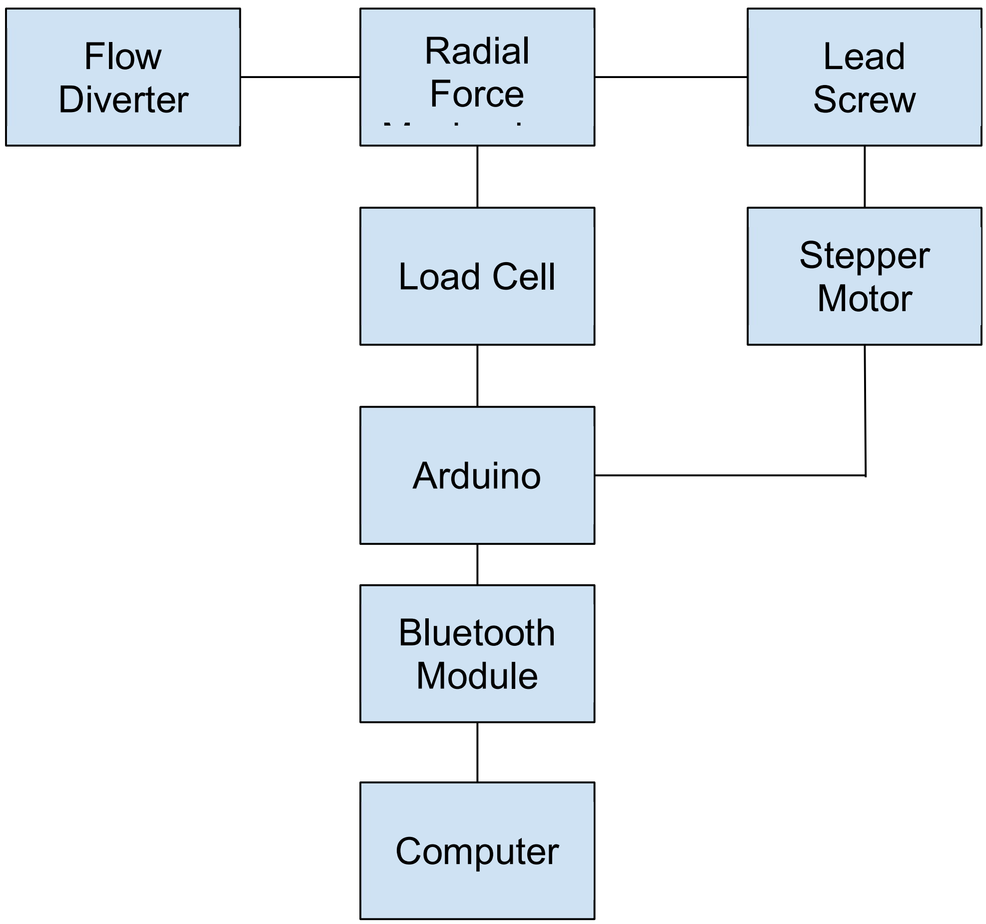


Fig. 2 Flowchart of the RFMS

Fig.3 illustrates the 3D modeling and simulation stage of the project and Fig 4 demonstrates the process of manufacturing the components of the mechanism using the additive manufacturing process.

Gantt chart for completing the project on time

Radial Force Measurement System for Flow Diverters and Stents

Mechatronics & Lab

By Angela Franco, Vishal Barot

Project start date: 2/2/2022

Milestone marker: 1

February

19	20	21	22	23
S	S	M	T	W

Milestone description	Assigned to	Progress	Start	Days
Final Project Proposal				
Order parts	Vishal	10%	2/9/2022	14
Stepper Motor	Vishal	25%	2/16/2022	14
Arduino	Vishal	45%	3/2/2022	14
Programming Aruino	Vishal	50%	3/16/2022	14
Bluetooth/Wifi	Angela	70%	3/30/2022	14
Testing data recorder on PC		75%	4/6/2022	13
IoT Integration		80%	4/13/2022	9
Completining Project		100%	4/15/2022	11

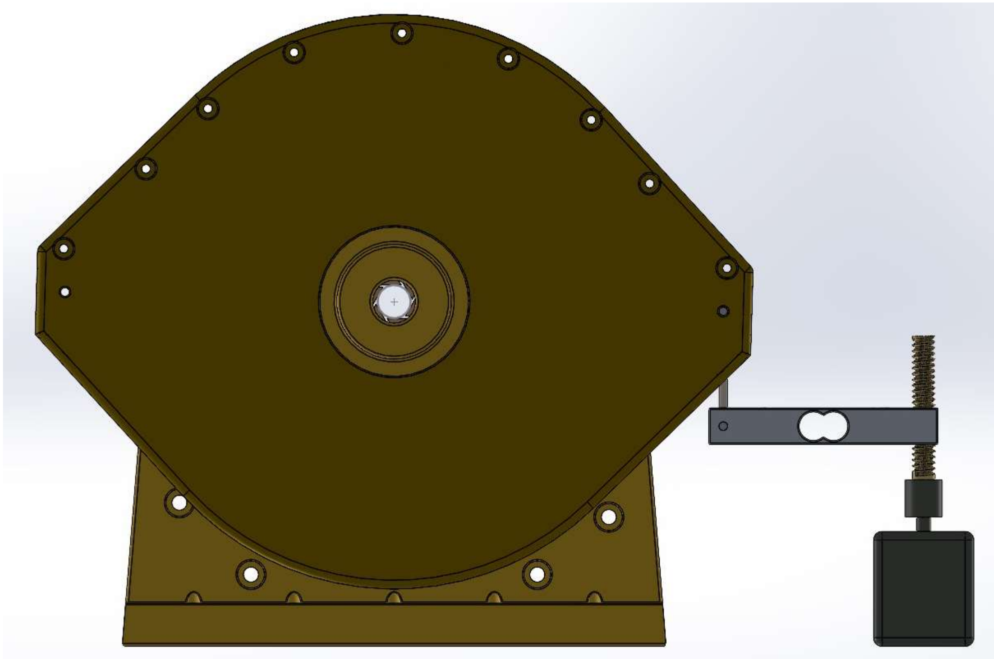
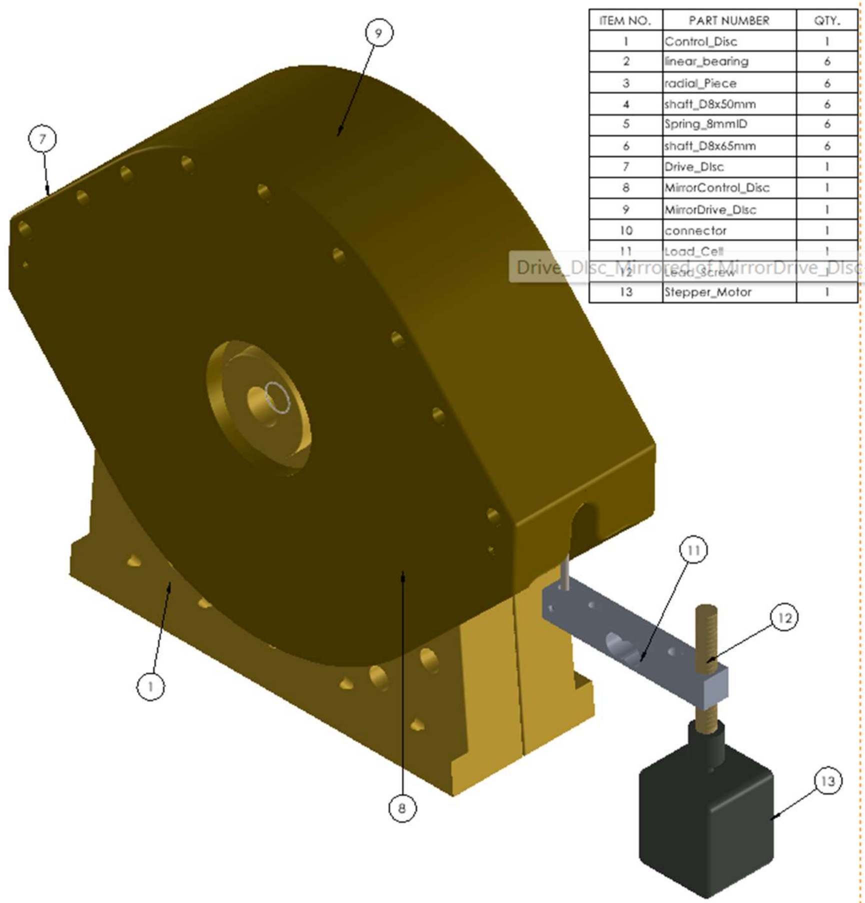


Fig. 3 Solidworks Modeling and simulation of RFMS



ITEM NO.	PART NUMBER	QTY.
1	Control_Disc	1
2	linear_bearing	6
3	radial_Piece	6
4	shaft_D8x50mm	6
5	Spring_8mmID	6
6	shaft_D8x65mm	6
7	Drive_Disc	1
8	MirrorControl_Disc	1
9	MirrorDrive_Disc	1
10	connector	1
11	Load_Cell	1
12	Lead_Screw	1
13	Stepper_Motor	1

Fig. 4 Parts list

	A	B	C	D	E
1		**Flow Diverting Stent Manufacturing Unit**			
2	**ITEM#**	**TITLE**	**QTY**	**Description**	**Cost**
3	1	Digital **Load Cell Weight Sensor kg** Electronic Scale + HX711 Weighing AD Module	1	To register the force	$8
4	2	5/8" **Roller Ball Transfer Bearing Casters**, 16PCS	1	Support the driving disc of the mechanism	$16
5	3	12 Pcs LM8UU **Linear Ball Bearings, 8mm Bore Dia, 15mm OD,** 24mm Length	1	Fits inside the Radial Piece for confined movements	$11
6	4	5Pcs **Linear Motion Shaft 8mm X 100mm** Round Hardened Lathe Bar Rod	2 Sets	Allows restricted motion to the Radial piece	$22
7	5	**Wireless Bluetooth RF Transceiver Master Slave Integrated Bluetooth Module** BT Module for Arduino	1	To connect arduino to PC wirelessly	$13
8	6	8mm 150mm **T8 Lead Screw Set Lead Screw,Copper Nut,Coupler,Pillow Bearing** Block for 3D Printer 1 Set	1	Drive the entire mechanism	$11
9	7	6808-2RS **Deep Groove Ball Bearings 40mm Inner Dia 52mm OD 7mm** Bore Double Sealed Chrome Steel Z2 4pcs	1	Holds the Driving disc and controling disc together while rotating	$8
10	8	**M3** x 6/8/10/12/16/20/25/30/35/40/45/50 mm Alloy Steel Hex Socket Button Head Cap Screws **Bolts Nuts** Washers Assortment Kit	1	For parts assembly	$25
11			Total =		$114

Fig. 6 Bill of Materials

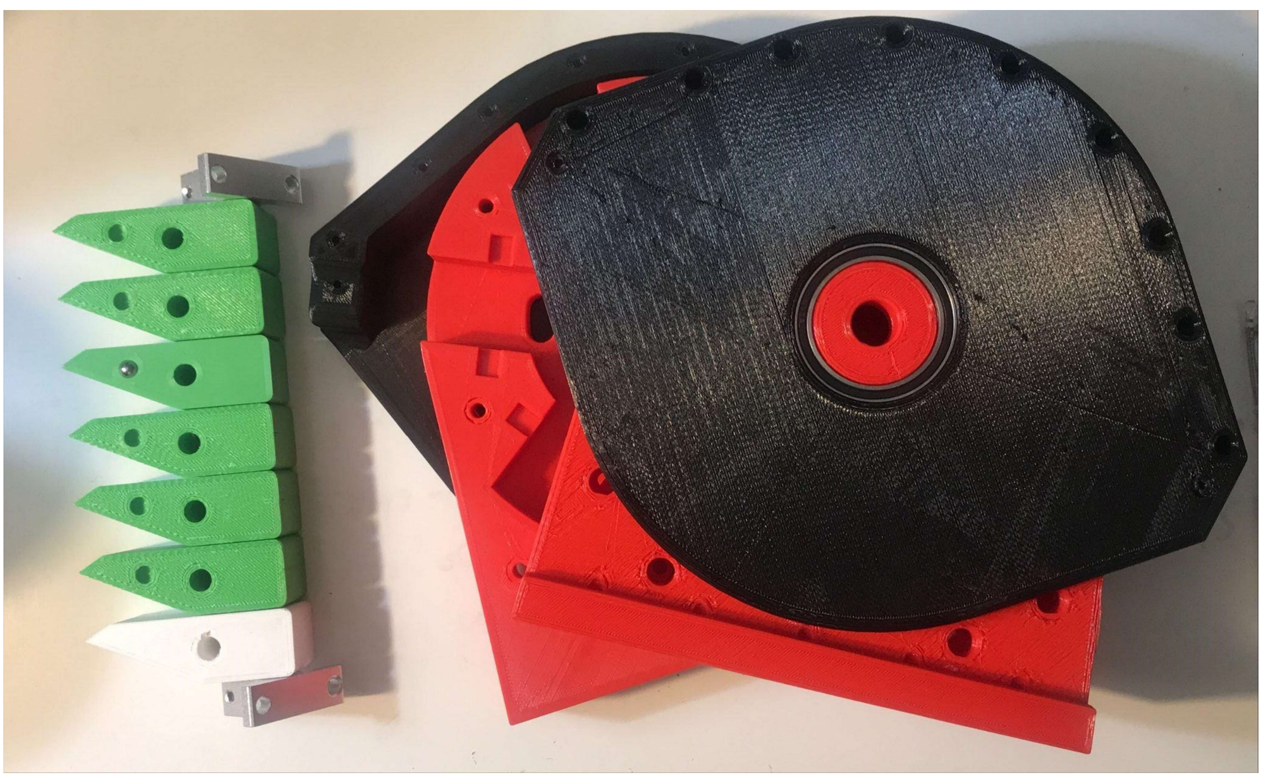


Fig. 5 Manufacturing and Assembly process of RFMS

Detailed circuit diagrams for each electronic component required for this project are displayed in the following Figures 5,6 and 7. They were demonstrated individually for the sole purpose of clarity as most of the pinouts of the Arduino Uno will be utilized after connecting them all and thus it would become a very dense and complex diagram.

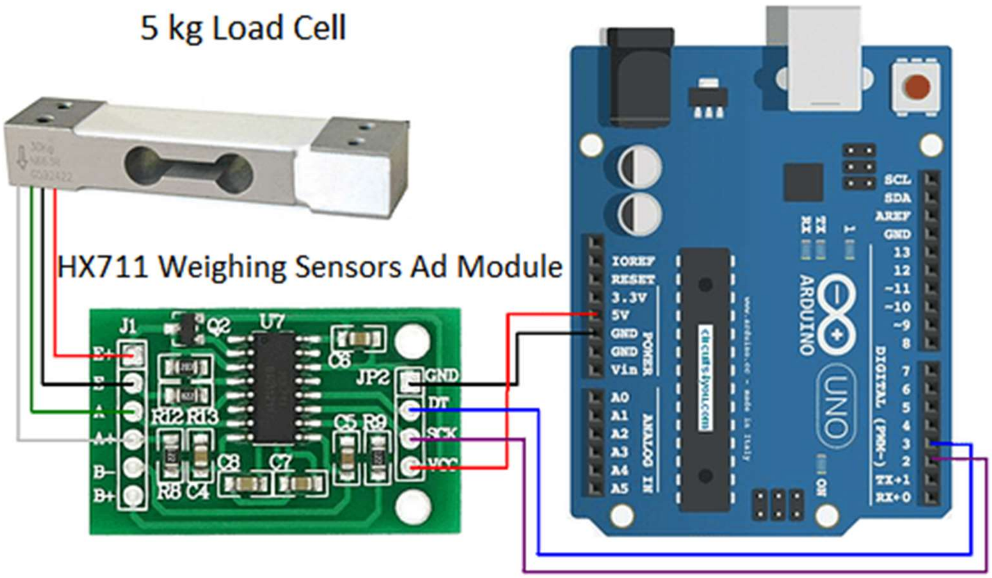


Fig. 6 Circuit Diagram to connect Load Cell to Arduino Uno via HX711 module

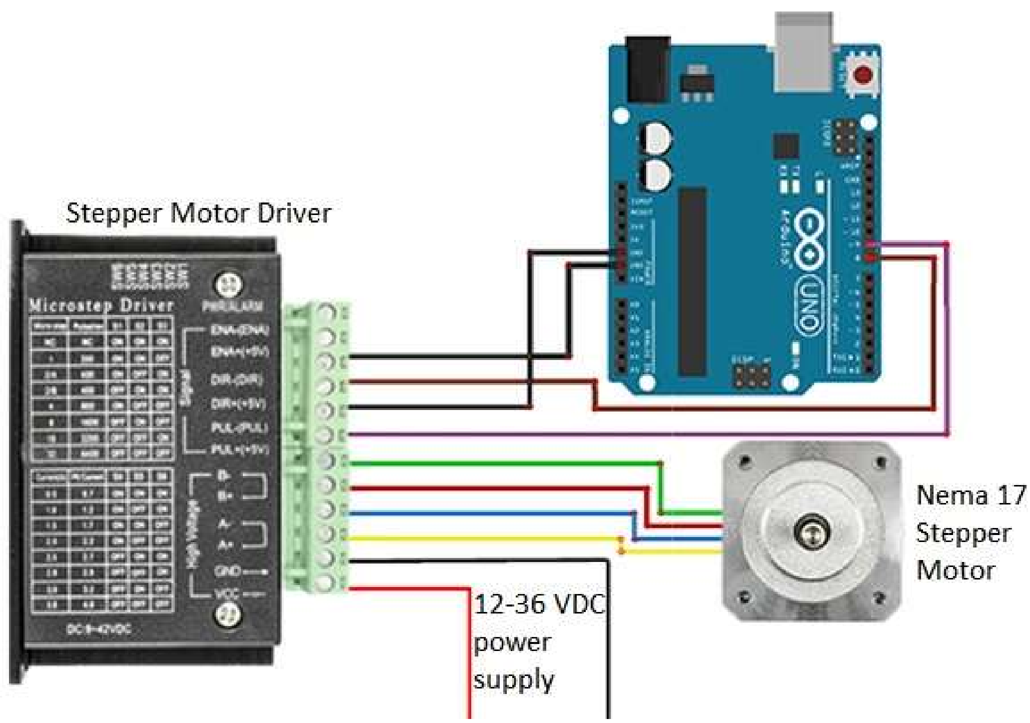


Fig. 7 Circuit Diagram to connect Nema 17 stepper motor to Arduino Uno along with A4988 stepper motor driver chip

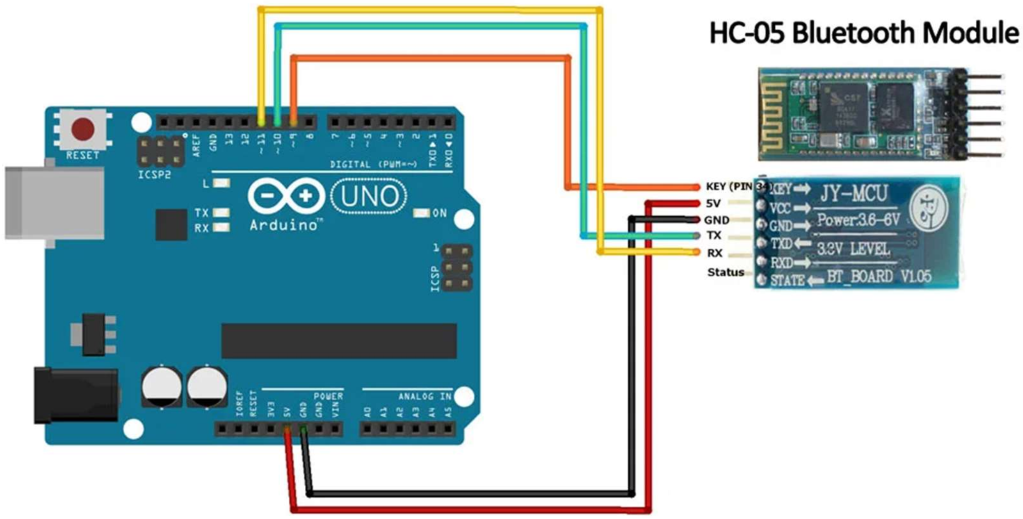


Fig. 8 Circuit Diagram to connect HC-05 Bluetooth Module to Arduino Uno for IOT application

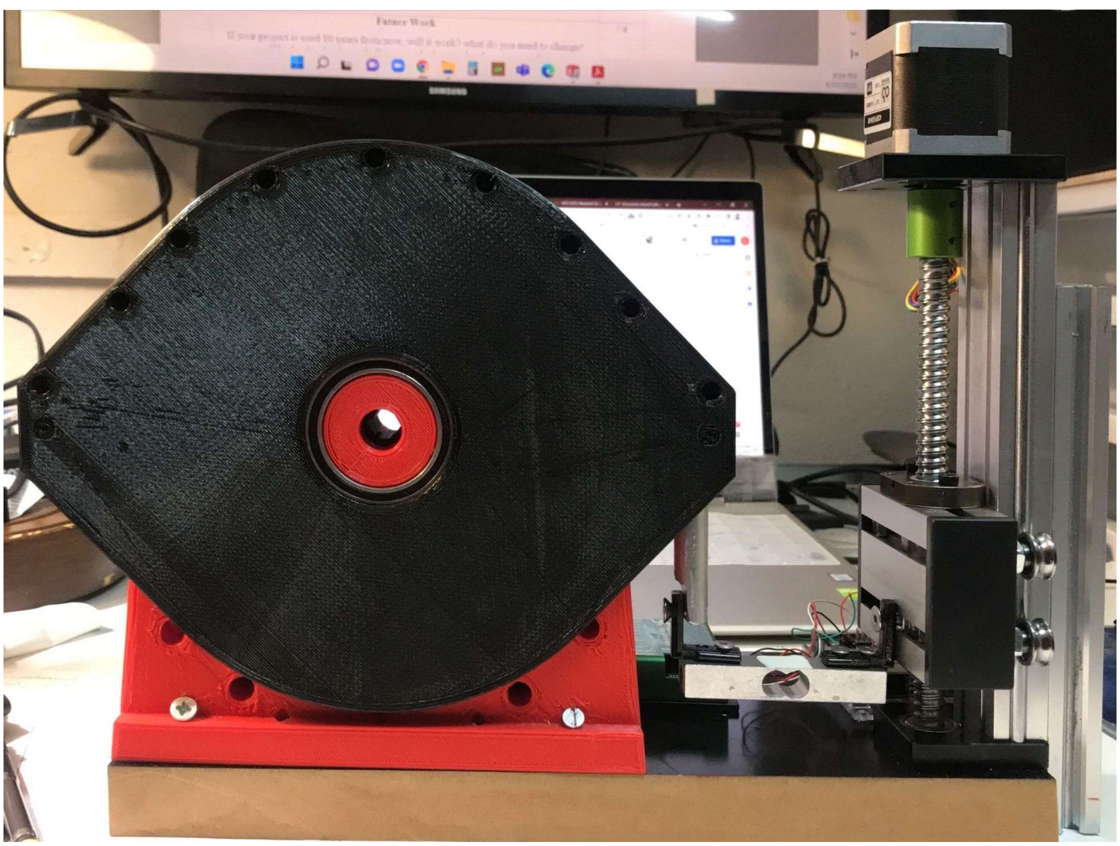


Fig. 9 Initial position of the radial device

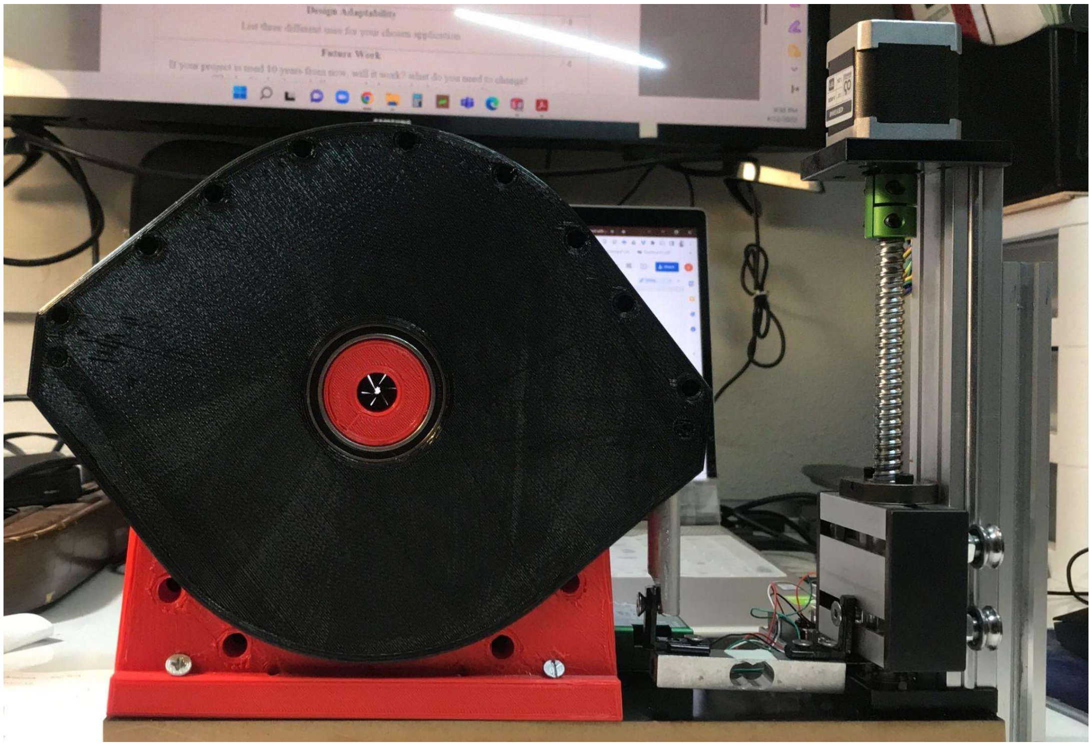


Fig. 10 Final position of the radial device

Figures 8 and 9 demonstrate the completed project with its ideal position when the radial mechanism is fully open to about 13 mm in diameter in Fig. 8 and closed down to about 1 mm diameter in Fig 9. The process of reducing the diameter through the mechanism will compress the flow diverter which will result in detecting a larger force value to estimate the radial force produced by the flow diverter.

Click the link to watch the design and demonstration with some background review of the project. https://youtu.be/eQT90Z1PZ-U

Design Adaptability

Since the project is heavily concentrated on performing one task of measuring radial force, It can be used to measure radial compressive strength related to hoop stress of any flexible material with a cylindrical shape. It can be used to test pressurized flexible tubing to estimate the pressure of the tube without intruding into the fluid pipeline which is what most instruments do to measure the pressure of a pipeline. With certain modifications in mechanism, It can perform several types of mechanical testings that require force within the range of the load cell. There are several load cells available in the market with a higher capacity which can be an applicable variety of mechanical testing.

Future Work

My project will work longer than 10 years if handled properly and performed regular maintenance and parts replacements in case of failure. But to make it highly accurate and precise, the parts of the mechanism should be manufactured out of metal and not from 3D printed materials via the CNC machining process and other industrial-grade manufacturing processes. Also, the load cell and microcontroller should be replaced with more reliable, high-quality replacements to ensure long-term consistent performance.

Design Considerations and Engineering Standards

ISO 25539-1:2017: Cardiovascular implants — Endovascular devices — Part 1: Endovascular prostheses

ISO 25539-2:2012: Cardiovascular implants — Endovascular devices — Part 2: Vascular stents

ASTM F3067: Guide for Radial Loading of Balloon Expandable and Self Expanding Vascular Stents

References

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