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PHAGWARA, PUNJAB

TOPIC-CONTINUUM ROBOT

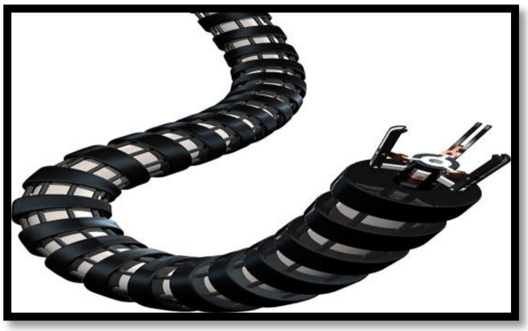

Figure 1-Continuum Robot

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ABSTRACT

Continuum robots with redundant degrees of freedom and post actuated devices are suitable for application in aerospace, nuclear facilities, and other narrow and multi-obstacle special environments. The development of a snake-inspired continuum robot is presented in this report. The continuum robot is inspired by biological trunks, tentacles, and snakes. Continuum robot designs can traverse confined spaces, manipulate objects in complex environments, and conform to curvilinear paths in space.

The morphological skeleton structure of the snake body is simulated using underactuated continuum joints, which include several rigid-body joints in series. Each rigid-body joint is driven by the traction of a wire rope. Based on the layered-drive principle, angular synchronous motion can be realized in space with multiple rigid-body joints in a single continuous joint, which can considerably reduce the complexity of the inverse kinematics solution, terminal drive box, and control system.

The static and dynamic characteristics of the snake-inspired robot are obtained through torque balance and an equivalent transformation. We discuss relevant research in design, modelling, control, and sensing for continuum manipulators, and we highlight how this work is being used to build robotic systems for specific surgical procedures. We provide perspective for the future by discussing current limitations, open questions, and challenges. Our results of research will be useful in our development of a continuum robot for future projects.

INTRODUCTION

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A **continuum robot** is a type of robot that is characterised by infinite degrees of freedom and number of joints.[1] These characteristics allow continuum manipulators to adjust and modify their shape at any point along their length, granting them the possibility to work in confined spaces and complex environments where standard rigid-link robots cannot operate.[2] In particular, we can define a continuum robot as an actuatable structure whose constitutive material forms curves with continuous tangent vectors.[3] This is a fundamental definition that allows to distinguish between continuum robots and snake-arm robots or hyper-redundant manipulators: the presence of rigid links and joints allows them to only approximately perform curves with continuous tangent vectors.

The design of continuum robots is bioinspired, as the intent is to resemble biological trunks, snakes and tentacles. Several concepts of continuum robots have been commercialised and can be found in many different domains of application, ranging from the medical field to the undersea exploration.

WHY CONTINUUM ROBOTS?

In the manufacturing industry, robots have steadily gained importance in assembly-line operations due to their compelling value proposition: reduced cycle-time and increased accuracy, along with a skillset. A typical industrial robot is floor-mounted for safety and consists of discrete rigid links that are actuated for gross movement of the end effector and of a task-appropriate end effector with fine motor control. Sophisticated control software operates individual robots or coordinates multiple robots in order to maximize their value in a specific industrial operation.

Against this backdrop, continuum robots are emerging as a novel concept, at least in research, with the potential to be used across a wide range of industrial applications. Continuum robots are hyperflexible electromechanical structures with infinite degrees of freedom which provide them with the ability to manoeuvre complex curvilinear pathways (a survey on continuum manipulators). A key advantage of continuum robots over those with rigid links is that, due to their considerably lower weight for the same maximum output force, they can be ceiling-mounted as opposed to floor-mounted. This advantage significantly increases their safety when they are used in joint operations with humans on the factory floor. On the flip side, continuum robots are inherently more nonlinear and thereby harder to control than their discrete rigid-link counterparts, thereby presenting a barrier to adoption in the industry.

Continuum robots have increased flexibility, and thereby dexterity, compared to their rigid-link counterparts (the importance of continuum robots). Figure 1 illustrates the essential difference between a discrete, a serpentine, and a continuous-link structure. It is clear from this figure that continuum structures have more degrees of freedom to move, and thereby, they can move more precisely along the shape of an object. In addition, their ends can position themselves in many more 3D facing directions compared to rigid-link structures. Researchers are developing continuum robots for a variety of navigation and exploration, manufacturing and assembly, and medical and surgical applications.

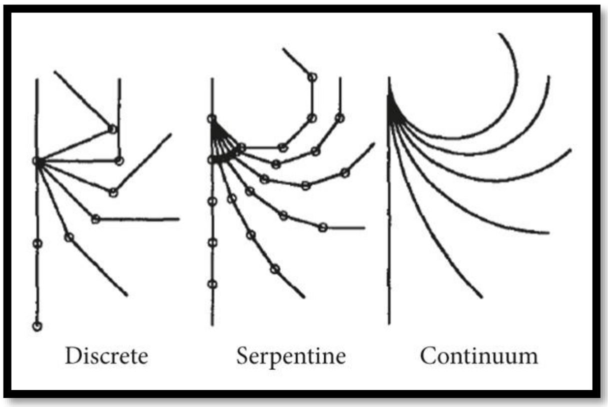

Figure 2-Discrete, Serpentine, Continuum

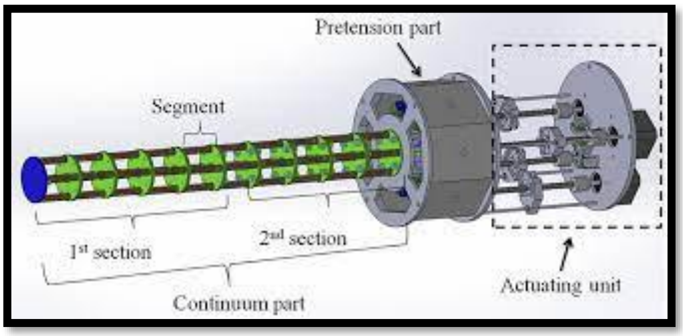

Figure 3-sections of a continuum robot

LITERATURE SURVEY

- *Michael B. Pritts and Christopher D. Rahn Department of Mechanical Engineering The Pennsylvania State University Park, PA* in 2004 proposed a novel continuum manipulator consisting of two flexible sections connected by rigid base plates. Each section uses 6 - 8 opposing contracting and extending McKibben actuators to provide two-axis bending. The contracting/extending actuator pairs are sized and positioned to provide matched rotation and torque. The experimental manipulator generates large rotation (30 - 35 degrees per section and 50 degrees for the entire manipulator) and load capacity (25 lb. vertical lift) at 60 psi. With a large strength to weight ratio, this manipulator also is highly flexible, simple to manufacture, and low cost.

- *Yingzhong Tian,1,2 Mingxuan Luan,1 Xu Gao,1 Wenbin Wang,3 and Long Li1,2 1 School of Electrical and Mechanical Engineering and Automation, Shanghai University, Shanghai 200072, China 2 Shanghai Key Laboratory of Intelligent Manufacturing and Robotics, Shanghai 200072, China 3 Mechanical and Electrical Engineering School, Shenzhen Polytechnic, Guangdong 518055, China in 2016* presented r presents the kinematic analysis of a continuum bionic robot with three flexible actuation rods. Since the motion of the end-effector is actuated by the deformation of the rods, the robot structure is with high elasticity and good compliance and the kinematic analysis of the robot requires special treatment. We propose a kinematic model based on the geometry with constant curvature. The analysis consists of two independent mappings: a general mapping for the kinematics of all robots and a specific mapping for this kind of robots. Both of those mappings are developed for the single section and for the multiexcitons.

- *Yeongjin Kim, Shing Shin Cheng, Mahamadou Diakite, Rao P. Gullapalli, J. Marc Simard, and Jaydev P. Desai* proposed improvised brain tumor resection with the help of continuum robots. Brain tumor, be it primary or metastatic, is usually life threatening for a person of any age. Primary surgical resection is one of the most effective ways of treating brain tumors and can have a tremendously increased success rate if the appropriate imaging modality is used for complete tumor resection. Magnetic resonance imaging (MRI) is the imaging modality of choice for brain tumor imaging because of its excellent soft-tissue contrast. MRI combined with continuum soft robotics has immense potential to be the next major technological breakthrough in the field of brain cancer diagnosis and therapy. In this paper, we present the design, kinematic, and force analysis of a flexible spring-based minimally invasive neurosurgical intracranial robot. It is comprised of an interconnected inner spring and an outer spring and is connected to actively cooled shape memory alloy (SMA) spring actuators via tendon driven mechanism. Our robot has three serially connected 2-DoF segments, which can be independently controlled due to the central tendon routing configuration. The kinematic and force analysis of the robot and the independent segment control were verified by experiments. Robot motion under forced cooling of SMA springs was evaluated as well as the MRI compatibility of the robot and its motion capability in brain-like gelatin environment.

- *Rongjie Kang*, Yong Guo, Lisha Chen, David T. Branson, Jian S. Dai* in their paper stated that-Continuum robots have attracted increasing focus in recent years due to their intrinsic compliance that allows for dexterous and safe movements. However, the inherent compliance in such systems reduces the structural stiffness, and therefore leads to the issue of reduced positioning accuracy. This paper presents the design of a continuum robot employing tendon embedded pneumatic muscles (TEPMs). The pneumatic muscles are used to achieve large scale movements for preliminary positioning while the tendons are used for fine adjustment of position. Such hybrid actuation offers the potential to improve the accuracy of the robotic system, while maintaining large displacement capabilities. A 3-dimensional (3-D) dynamic model of the robot is presented using a mass-damper-spring based network, in which elastic deformation, actuating forces and external forces are taken into account. The design and dynamic model of the robot are then validated experimentally with the help of an electromagnetic tracking system.

- *Joseph D. Greer, Tania K. Morimoto, Allison M. Okamura, and Elliot W. Hawkes* in their 2018 paper discussed about soft continuum robots. They stipulated that soft econtinuum robots exhibit access and manipulation capabilities in constrained and cluttered environments not achievable by traditional robots. However, navigation of these robots can be difficult due to the kinematics of these devices. Here we describe the design, modeling, and control of a soft continuum robot with a tip extension degree of freedom. This design enables extremely simple navigation of the robot through decoupled steering and forward movement. To navigate to a destination, the robot is steered to point at the destination and the extension degree of freedom is used to reach it. Movement of the tip is always in the direction tangent to the end of the robot’s backbone, independent of the shape of the rest of the backbone. Steering occurs by inflating multiple series pneumatic artificial muscles arranged radially around the backbone and extending along the robot’s whole length, while extension is implemented using pneumatically driven tip eversion. We present models and experimentally verify the growing robot kinematics. Control of the growing robot is demonstrated using an eye-in-hand visual servo control law that enables growth and steering of the robot to designated locations.

- *Xin Dong, Mark Raffles, Salvador Cobos-Guzman, Dragos Axinte and James Kell* in their paper discussed about continuum robots using twin-pivot compliant joints. A twisting problem is identified from the centrally located flexible backbone continuum robot. Regarding this problem, a design solution is required to mechanically minimize this twisting angle along the backbone. Further, the error caused by the kinematic assumption of previous works is identified as well, which requires a kinematic solution to minimize. The scope of this paper is to introduce, describe and teste a novel design of continuum robot which has a twin-pivot compliant joint construction that minimizes the twisting around its axis. A kinematics model is introduced which can be applied to a wide range of twin-pivot construction with two pairs of cables per section design. And according to this model, the approach for minimising the kinematic error is developed. Furthermore, based on the geometry and material property of compliant joint. A continuum robot which has a twin-pivot compliant joint construction that minimizes the twisting around its axis is introduced, described, and tested. A kinematics model is introduced which can be applied to a wide range of twin-pivot construction with two pairs of cables per section design.

METHODOLOGY FOLLOWED

Nowadays, people have already found the incredible ability of adaptation, excellent locomotion, and capability of being dexterous to move in complex environment presented by snakes, elephant's trunk, and octopus tentacles from nature. These outstanding performances have inspired researchers to explore further in the fields of flexible bionic robots.

Basically, we are designing a flexible robot having two bending joints, and each joint has two degrees of freedom. The end-effector can move in all directions of the workspace due to the actuated cables. We used a method of geometry analysis to develop the kinematic model of the cable-driven robot. The prototype of the bot will of having a height of 30-40cm having a end factor attached with a camera module the robot will be containing some bunch of cables(ropes) for the movement and the body will be of plastic switch boards material having a fixed base.

HARDWARE DESCRIPTION

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- We are using one circular wooden board to mount our continuum robot on it. This board serves as a base to operate on which we have mounted other important components such as the controller, motor drivers, the Johnson motors etc.
- We are using Arduino uno as a microcontroller to control the motors.
- We are using Bluetooth module HC-05 to give commands to our continuum robot to move in a particular direction.
- We are using L298 motor drivers to control the supply to our motors which are controlling the stings of our continuum robot.
- We will be using AC supply to run our continuum robot and we are using one AC to DC converter for the same.
- We are using Johnson motors with 250 RPM for our continuum robot.

RESULT

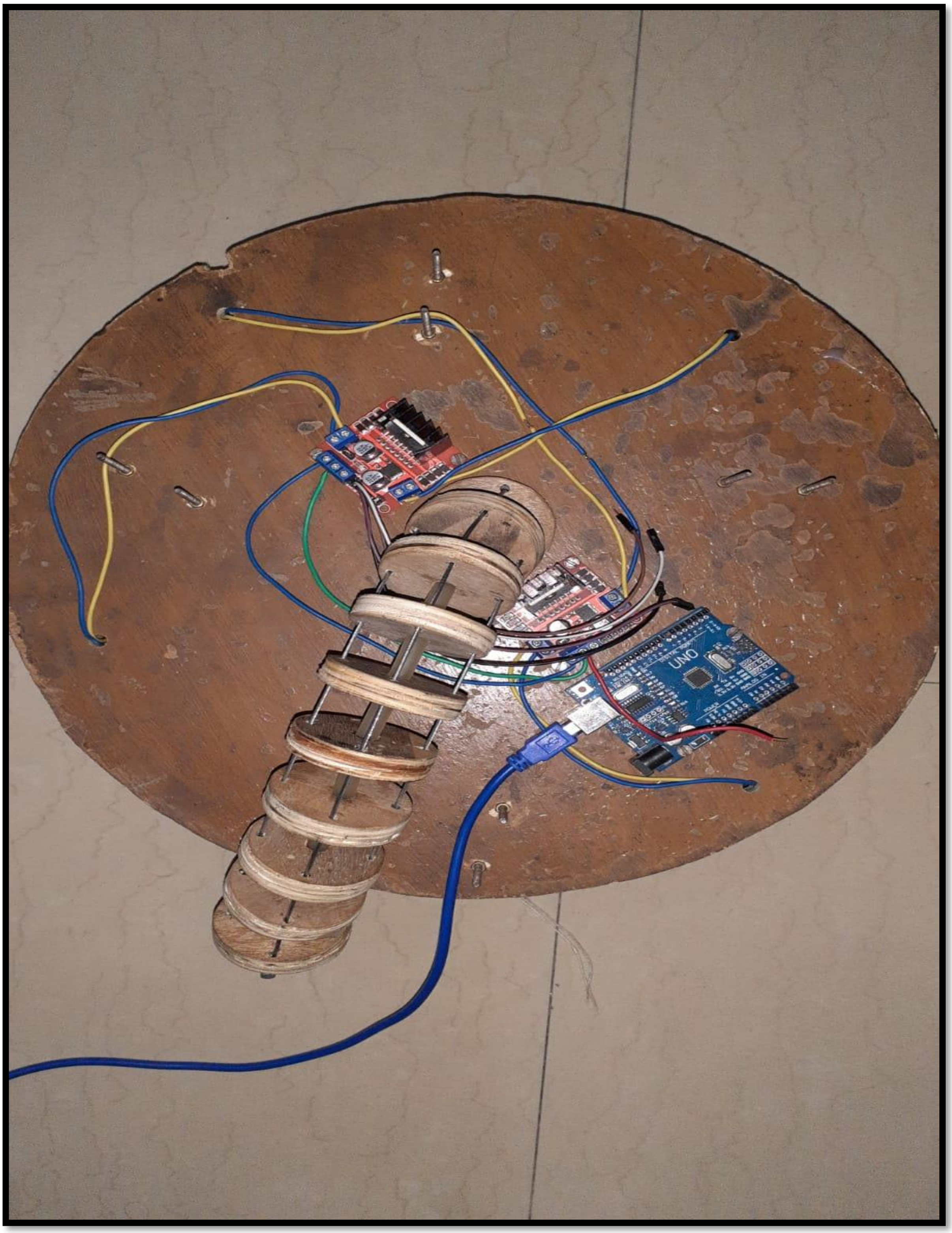

Figure 4-Continuum Robot

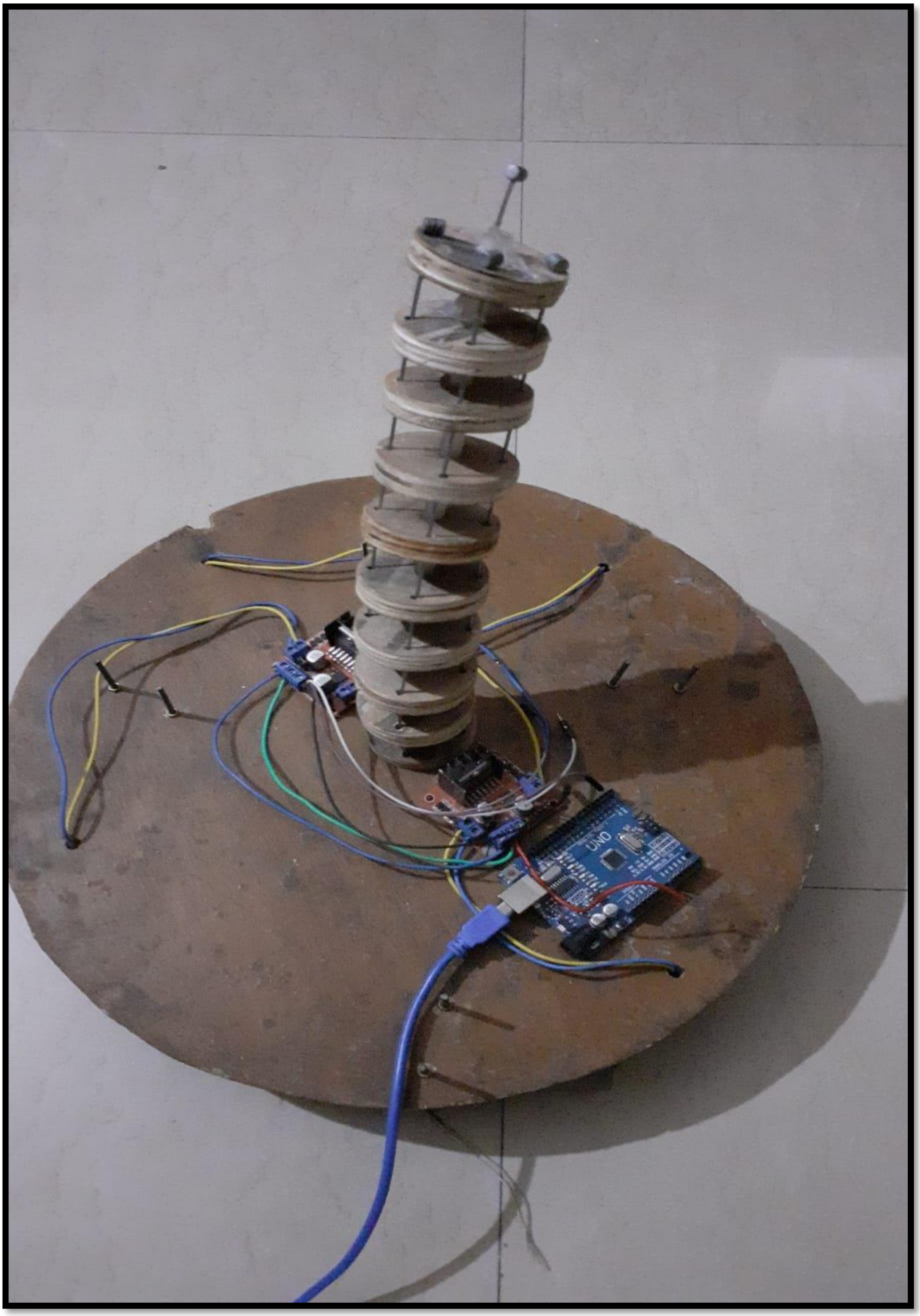

Figure 5-Bottom view of Continuum Robot

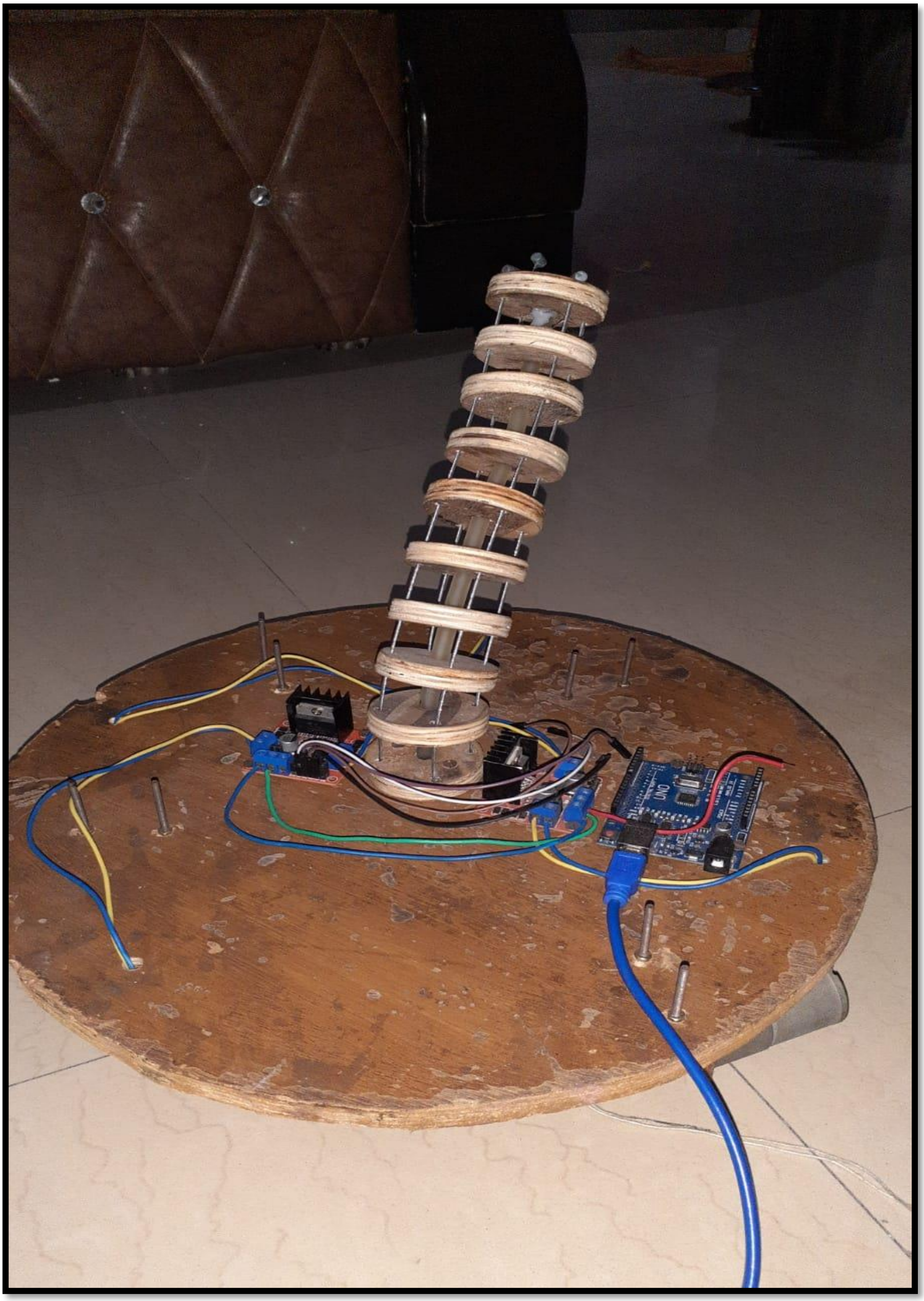

Figure 6-Final robot prototype

- As you can see, we have successfully built one small prototype of the continuum robot which was our intention at the first place.
- We have used Johnson motors, if we would have used servo motors then we would have been able to achieve more accuracy.

FUTURE SCOPE

Robots will increase economic growth and productivity and create new career opportunities for many people worldwide.

Artificial Intelligence (AI) increases human-robot interaction, collaboration opportunities, and quality. The industrial sector already has co-bots, which are robots that work alongside humans to perform testing and assembly.

Advances in AI help robots mimic human behavior more closely, which is why they were created in the first place. Robots that act and think more like people can integrate better into the workforce and bring a level of efficiency unmatched by human employees.

Robot designers use Artificial Intelligence to give their creations enhanced capabilities like:

- Computer Vision: Robots can identify and recognize objects they meet, discern details, and learn how to navigate or avoid specific items.
- Manipulation: AI helps robots gain the fine motor skills needed to grasp objects without destroying the item.
- Motion Control and Navigation: Robots no longer need humans to guide them along paths and process flows. AI enables robots to analyze their environment and self-navigate. This capability even applies to the virtual world of software. AI helps robot software processes avoid flow bottlenecks or process exceptions.
- Natural Language Processing (NLP) and Real-World Perception: Artificial Intelligence and Machine Learning (ML) help robots better understand their surroundings, recognize and identify patterns, and comprehend data. These improvements increase the robot's autonomy and decrease reliance on human agents.

APPLICATIONS

Continuum robots have been applied in many different fields.

Medical

Continuum robots have been widely applied in the medical field, in particular for minimally invasive surgery. For example, Ion by Intuitive is a robotic-assisted endoluminal platform for minimally invasive peripheral lung biopsy, that allows to reach nodules located in peripheral areas of the lungs that cannot be reached by standard instrumentations; this allows to perform early-stage diagnoses of cancer.

Hazardous places

Continuum robots offer the possibility of completing tasks in hazardous and hostile environments. For example, a quadruped robot with continuum limbs has been developed: it can walk, crawl, trot and propel to whole arm grasping to negotiate difficult obstacles.

Space

NASA has devloped a continuum manipulator, named Tendril, that can extend into crevasses and under thermal blankets to access areas that would be otherwise inaccessible with conventional means.

Subsea

The AMADEUS project developed a dextrous underwater robot for grasping and manipulation tasks, while the FLAPS project created propulsion systems that replicate the mechanisms of fish swimming.

Apart from these there are numerous application areas where the continuum robot has huge advantage like any place where a human can’t reach a continuum robot may and as we know that miniturisation is possible then the applications increase many fathom. Like using AI the continuum robot can be taught to do works which will reduce human work and help finding problems in a big machines or factory settings easily.

CONCLUSION

Practical knowledge means the visualization of the knowledge, which we read in our books. For this, we perform experiments and get observations. Practical knowledge is very important in every field. One must be familiar with the problems related to that field so that he may solve them and become a successful person.

After achieving the proper goal in life, an engineer must enter professional life. According to this life, he must serve an industry, may be public or private sector or self-own. For efficient work in the field, he must be aware of practical knowledge as well as theoretical knowledge.

Due to all the above reasons we decided to make a continuum robot as our artificial intelligence project for this term. We think that Continuum robot will help to us understand how the kinematics of infinite degree motion work and what all applications can be developed from it.

We have tried our level best to achieve our goal. In this process we have been through some research papers on what studies have been going on Continuum Robots, and how people are developing applications in this field. We have stated what our expected outcome will be at the end of our project completion. We have discussed our approach in making a continuum robot and has done sufficient literature survey for your perusal.

We will inform you about the conclusions of practical implementation at a later point of time.

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