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Two - Segmented Tendon Driven Continuum Manipulator

Alan Antony, Amal Francis, Arshal Agnus George, Lamiya KV
Department of Robotics and Automation
Dhanalakshmi Srinivasan Engineering College (Autonomous), Perambalur

Abstract: *Continuum Inspection Robot can perform complex 3D motions providing an innovative solution for concurrent issues faced in industries for inspecting tight spaces and pipelines. Uses Continuum Mechanism that has no joints which give an advantage over traditional arms in terms of reach and degree of freedom in movement. This mechanism has two segments, since there are zerojoints, thus it has infinite degree of freedom. The manipulator is a circular shape robot flexible with backbone. Each backbone is separated with spacer disks. Actuation of the continuum robot is done by pulling the tendons which results in bending motion. The flexible lightweight robot arm, which is composed of each segment can be controlled using three tendons as a result the robot can adopt highly non-linker shapes which allow manipulators in confined spaces. Each tendon is driven by stepper motor controlled by a microcontroller [Arduino mega]. The input signal one given to microcontroller using joystick and its signal is transmitted using the wireless communication devices. The main specialty of this robot is that it's end effector can be interchangeably used according to the circumstances. The power for the mechanism is provided by step down transformer suitable for the internal electronics. The articulation is done wirelessly through the integration of Bluetooth module in microcontroller and special user interface created in smart phone..*

Keywords: Continuum, Dof, Zero Joints, Arduino, Bluetooth Module, Tendon Driven, Spacer disks, Segments, Stepper motor

I. INTRODUCTION

Inspections need to be conducted in sensitive industries for safety purpose. It is assumed that some deterioration mechanisms are active in any pipeline, which over time can compromise the integrity of the pipe. Therefore, conducting regular inspections can help locate problem areas and rectify them before they become incidents or accidents. In-line inspection is a technique used to assess the integrity of natural gas transmission pipelines from the inside of the pipe. In-line Inspection (ILI) involves the evaluation of pipes and pipelines using "smart pigs" (both tethered and non-tethered) that utilize non-destructive examination techniques to detect and size internal damage. Robotic inspection can provide significant advantages over current methods of inspection and have the ability to operate in hazardous, harsh and dirty environments. Inspection robots are vital to ensuring product quality and for protecting the integrity and safety of a product.

A continuum robot is an acutable structure whose construct material form curves with continuous tangent vectors, or more. Specifically, this continuumversatile robot can allow continuum manipulation to adjust and modify their shape out any point along their length, granting them the possibility to work in confined speed and complex environment where standard rigid link robot cannot operate.

This project proposes a novel approach in the design, construction and analysis of a continuum robot for industrial inspections. The paper examines the drawbacks of existing designs and proposes a new mechanical design that uses a single rubber tube as the central member, providing a design that is both simple and robust and also incorporate multiple segments for improved modulation and flexibility. Next, a new, simplified method of modelling kinematics is introduced. A novel verification procedure is then applied to examine the validity of the proposed model in two different domains of applicability and could be used to verify many other models that are constructed based on similar assumptions. Finally, a microcontroller based controlling scheme enables rapid prototyping.

Multi-section, continuous-backbone ("continuum") robot design is based on an innovative concept. Its implementation is novel with respect to previous continuum robot designs in that stiffness and extension, in addition to bending, are actively controlled in each section of the robot. This requires a non-trivial extension of previously proposed kinematic models, and poses challenges for real-time control of the robot. We introduce a manual adjusting controlling mechanism for overall cable lengths and per-section cable lengths. Details of the design and its implementation are presented, along with a summary of real-time control issues and experimental results.

The robots are equipped with a range of sensors and cameras, and they use a wireless network to communicate with a human operator located in a safe control room. They are often used to ensure the regular inspection of unmanned facilities in remote locations with harsh environments. Smart phone integrated control mechanism enables faster error correction and trail of experimental motions. Smooth communication between Bluetooth module and smart phone is establish with special software and user interface installed in smart phone.

II. EXISTING SYSTEM AND ITS LIMITATIONS:

2.1 Traditional Inspection Robots

Traditional inspection mechanisms used are robotic arms with joints. These jointed robots manipulate each joint to achieve the desired positions. The degree of freedom of these robots were defined by joint constraints. The common type of arm used for inspection has 3 to 4 dof. The company's that deploy inspection robot deploy them has implemented them on mobile carriers for greater mobility. A continuum robot is an acutable structure whose construct material form curves with continuous tangent vectors, or more. Specifically, this continuumversatile robot can allow continuum manipulation to adjust and modify their shape out any point along their length, granting them the possibility to work in confined speed and complex environment where standard rigid link robot cannot operate.

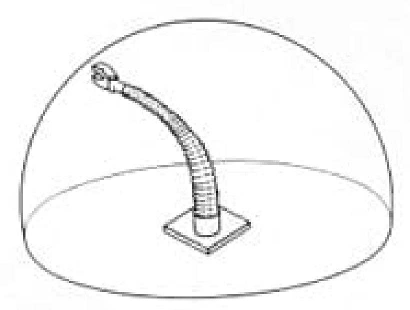

Fig 3.1 - Continuum Mechanism

The best and most popular pipe inspection techniques include pipeline radiography (RT) and ultrasonic testing (UT), including phased array ultrasonic testing (PAUT). These popular pipe inspection techniques are forms of NDT pipeline inspection and can be used to detect flaws without harming the asset. For example, advanced UT inspection methods, such as the total focus method (TFM), can accurately and cost-effectively detect manufacturing flaws, in-services flaws and parent metal flaws in pipelines.

Advanced total focus method ultrasonic testing (or TFM UT) is the best pipeline corrosion inspection technique. TFM UT can be used to detect corrosion on in-service pipelines. This method is fast, accurate and cost-effective.

Common pipeline inspection methods and pipeline inspection equipment include pipeline camera inspection, pipeline QV inspection, and pipeline sonar inspection. These three pipeline inner inspection methods can basically meet the needs of municipal official network inspection, and the needs of street, community, and enterprise inspection.

IV. PROPOSED SYSTEM

To develop an inspection robot that can be used to inspect tight spaces and pipelines in industries.To develop an existing single tendon driven continuum mechanism into two segment mechanism.To design a wireless control inspection robot using smartphone and Arduino Interfacing.

The mechanism includes Power supply, Bluetooth module, Arduino, D.C Geared motors, Continuum Mechanism and Smart Phone. This tendon driven mechanism enables flexible and continuous motion during inspection process. Various Inspection equipment's can be attached to the end effector for effective inspection of inspection sites.

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This is simple but have infinite degree of freedom to reach into unreachable positions which cannot be achieved by other inspection mechanisms used traditionally. Continuum inspection robot is robust and very much sensitive in control using UI interface on smart phone.

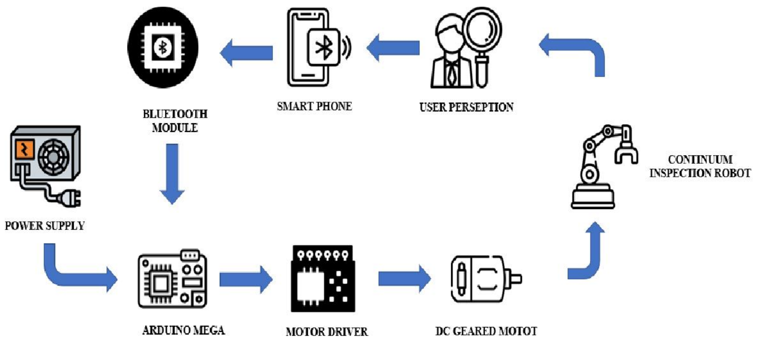

Fig 4.1

IV. SOLIDWORKS MODELING

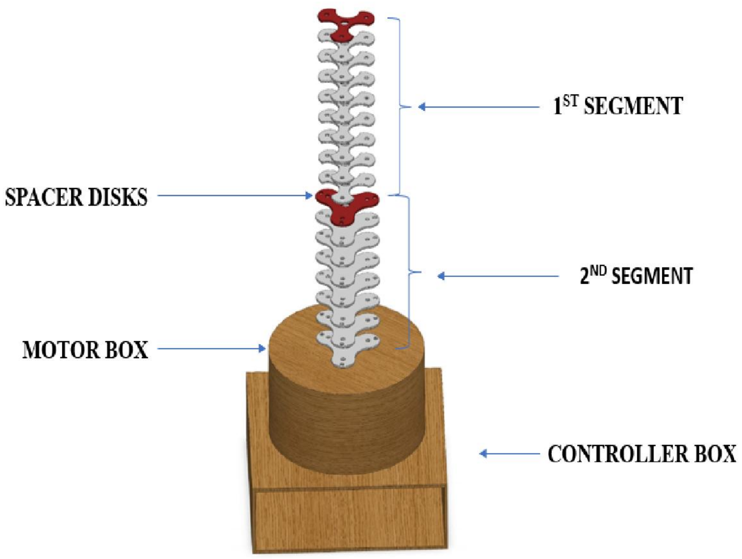

Fig 5.1 Assembly

This is the complete assembley of the our continuum inspection robot. This assembly include mainly four major parts. Which are bottom model spacer disk, top model spacer disk, spine and the base of the robot. The assembly of robot is made using many types of mating conditions and properties.

The spacer disk has harderned plastic property to provide rigidity and structural integrity to the robot arm while the spine is made of flexible latex material to contribute flexibility. The base is made of wooden material and this base includes the controller of our model so is is known as controller box.

4.1.1 SPACER DISK 1

The bottom spacer disk is a three lobed structure, this design is considered since it provides maximum structural rigidity while having minimum number of motors used for tendon driven mechanism. Each spacer disk has six holes for the tendon wires to be inserted. The bottom spacer disk is only used for the first segment of the continuum mechanism. The inner hole diameter for the spine is fixed according to the diameter of the spine.

This spacer disk is attached with spines and this spacer disk is fixed in spines with equal distances. This bottom spacer disk is present at the bottom of our spine and this will control the whole bottom movements and orientations.

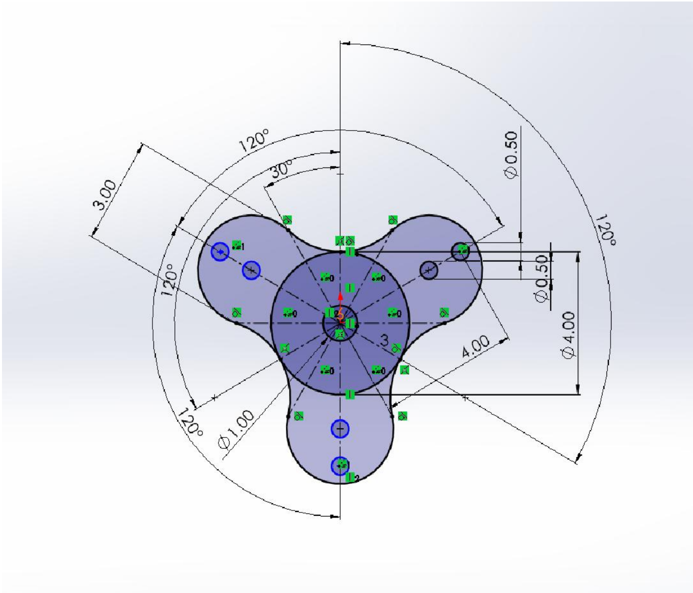

Fig 5.1.1 – Spacer Disk 1

4.1.2 SPACER DISK 2

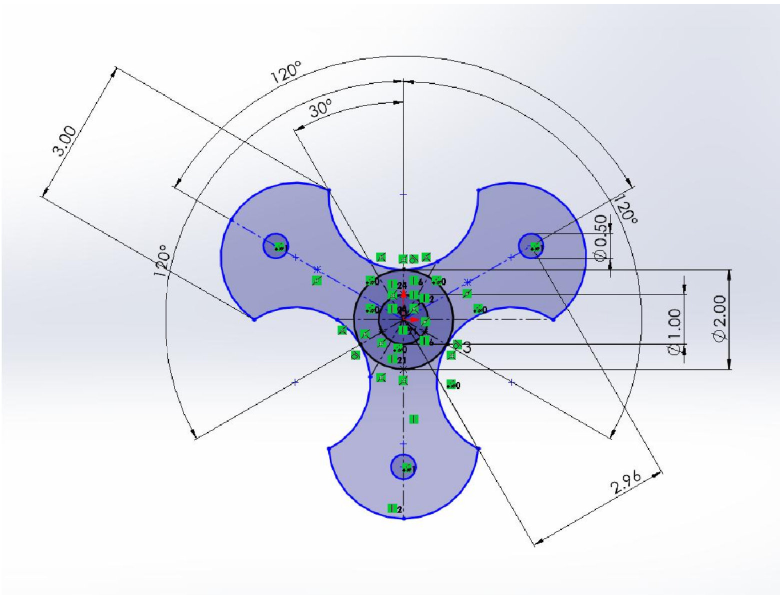

Fig 5.1.2 – Spacer Disk 2

The top spacer disk is a three lobed structure, this design is considered since it provides maximum structural rigidity while having minimum number of motors used for tendon driven mechanism. Each spacer disk has three holes for the tendon wires to be inserted. The top spacer disk is only used for the second segment of the continuum mechanism. The inner hole diameter for the spine is fixed according to the diameter of the spine.

This spacer disk is attached with spines and this spacer disk is fixed in spines with equal distances. This top spacer disk is present at the top of our spine and this will control the whole top movements and orientations.

4.1.3 SPINE

Thespine is the core part of our model where it is made up of a flexible latex material for its flexibility. Depend upon the tendons push and pull the spin will move to different orientations. This can perform any complex actions for its locomotion's and this will find the path.

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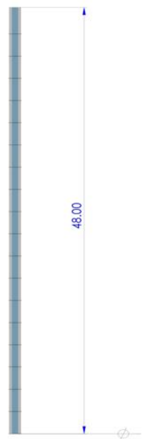
All the spacer disks in different segments were attached with this spine for the controlling purposes.



SPINE

Fig 5.1.3 – Spine

V. WORKING& CALCULATION:

5.1 WORKING

The manipulator has three lobed shaped spacer disks, these disks are to provide structural rigidity to the robot. Each disks add space between flexible backbone. The spaces are calculated to be maximum flexibility without compromising any structural integrity. It has two segments giving an advantage, these provide extra possible movement. These possible motions allow to achieve smooth curvepaths. Actuation of the Continuum robot is done by pulling the tendons which results in bending motion. These tendons are connected to the end of the continuum module and are carried inside the mechanism. The other end of the tendon which is string is attached to DC geared motors. The lightweight manipulator can be controlled using (3 + 3 = 6) six tendons as a result the robot can adopt highly non –linear shapes which allow manipulators move in confined spaces. Each tendon driven by DC motors and controlled by Arduino mega microcontroller. Totally there are six motors used. The rotation of motor pulls the tendons and in turn pulls the continuum module.

The precise control of continuum robot is achieved by manual control of each motor. This is achieved through motor shield used and interfaced with the Arduino microcontroller. The input for the microcontroller is given through special app used in mobile which transmit the input to the Bluetooth module then to Arduino. The signals received in Arduino is transmitted to motors for operation and movement of the robot structure

6.2 CALCULATIONS

Maximum length up to which the internal coiled spring steel rod can stand upright on its on (x) = 60 cm
To support manipulator weight, length of spring submerged under spines support (y) = 12 cm
Length of inspection manipulator (z) = x-y = 60 -12 = 48 cm
Diameter of spacer disks = 20% of length of Spine (48) = 9.6 ~ 9 cm
Minimum space required between two consecutive disks (s) = 2.5cm
Number of spacer disks required = z / 2.5 = 48/2.5 = 19 disks

VII. FUTURE IMPROVEMENTS:

In our future model we plan to include additional segments for its better orientation in any direction, through the adding of segments we can achieve more flexibility and complicated movements. Based on our view we can direct the movements. Also, we plan to add a soft robotics technique with our model for better applications. The locomotion of our continuum robot is much easier through by adding soft robotics. It can penetrate it into any complex small space areas for the wider inspections, by adding of soft robotics we can remove the tendons used in our continuum robots so our continuum robot gets more reliable.

By adding the mobile power supply to our robot, it will get more flexible throughout the works also we can use it in and areas that lack of power sources. Our continuum robot is also have much ability to work with any type of grippers or end effectors, we can easily change the end effectors depend upon the situations. Also, the hybrid type grippers are possible in our models.

We can run our continuum robot as autonomous in future it will very helpful for the operators for its monitoring and reduces the complexity of work. By adding of these extra features to our continuum robot it can perform in wide range of applications.

IX. CONCLUSION

Successfully completed the Design and Fabrication of Continuum Inspection Robot. Many design challenges faced while designing has overcome. The fabrication errors were removed by trial-and-error method. Tested and verified the manipulability of two segment Continuum mechanism. The two segments provide additional motions and flexibility. Remote operation of Inspection robot also assured. The remote connectivity was smooth and reliable. In overall, the project goal was achieved and design and fabricated of continuum inspection robot is completed.

X. APPENDIX

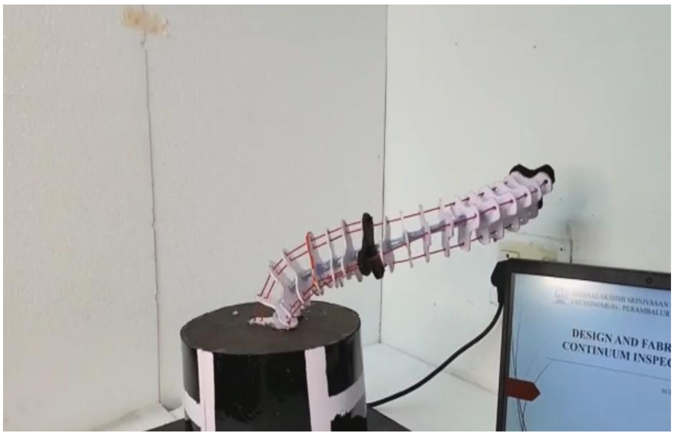


Fig 11.1

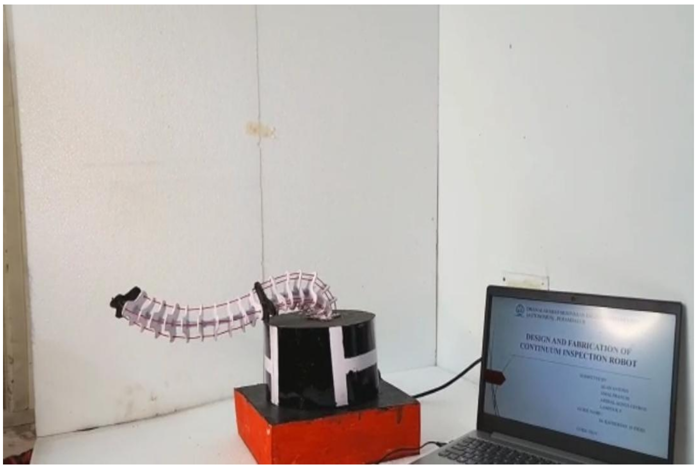


Fig 11.2

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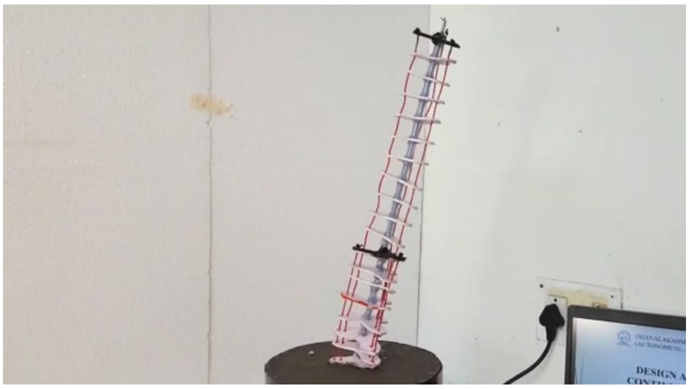

Fig 11.3

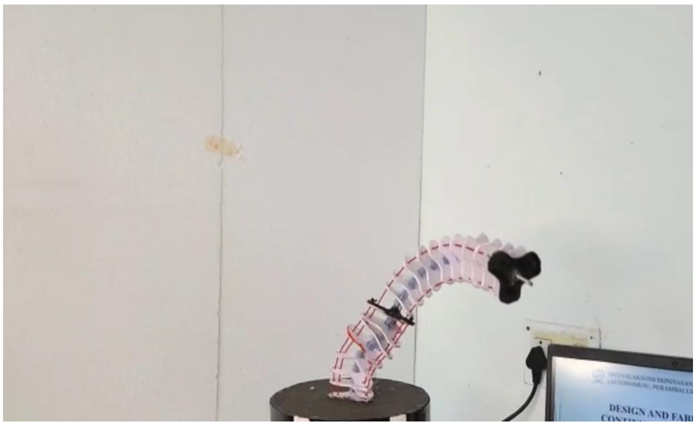

Fig 11.4

Fig 11.5

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