Design and Development of Hexapod using Nitinol Actuator Wire

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ABSTRACT: *Hexapod robots have attracted considerable attention for several decades. Many studies have been carried out in research centers, universities and industries. This project involves the construction and working of small scale Hexapod robot. The Hexapod robot is a small, inexpensive, six-legged robot that is intended to replace huge and heavy robotic systems, containing solenoids and servo motors. The first phase of the project involves the design and construction of the structure of Hexapod. Plastic was used for the construction of body and a Nitinol actuator wire was used to drive the Hexapod's legs. Nitinol actuator wire acts as a muscle for each of the legs, providing a means of walking for the robot. With its unique ability to contract on demand, Muscle Wire (or more generically, shape memory actuator wire) presents many intriguing possibilities for robotics. The final phase involves the Hexapod interfacing with Arduino to achieve the proper locomotion of the Hexapod. In particular, the proposed design procedure takes into account the main features, such as mechanical structure and leg configuration, actuating and driving systems, payload, motion conditions, and walking gait. It was found that compact, and lightweight Hexapod robot shows promise for use in space, medical, and other macro-robotic applications.*

Keywords: Hexapod, Stiquito, search and Mobile Robot

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1. Introduction

Our aims to analyze how nitinol wire actuator can be used to make enhancement in the field of miniature robots. With the advancement of material technology, now it is possible to frame strong, compact and light weight robotic system. However, the presence of standard actuators, such as servo motors and hydraulic cylinders limits this reduction of size and complexity of robots. To replace these standard actuators and motors we have made a structure and have used nitinol wire as an actuator to loco mote that structure. We have tried to make a structure of hexapod robot and instead of using actuators we have used nitinol wire for the movement of robot to see and analyze how nitinol wires works what are its different applications in the field of robotics and its properties.

Few applications of six legged robots are it can be used as search and rescue robots and miniature robots in industries. In these fields hexapod robot present opportunities as having small size and practical mobility. When viewed from this prospective, six legged walking robot can be easily scroll by produced algorithm in all types of terrain in an advantage.

2. Structure

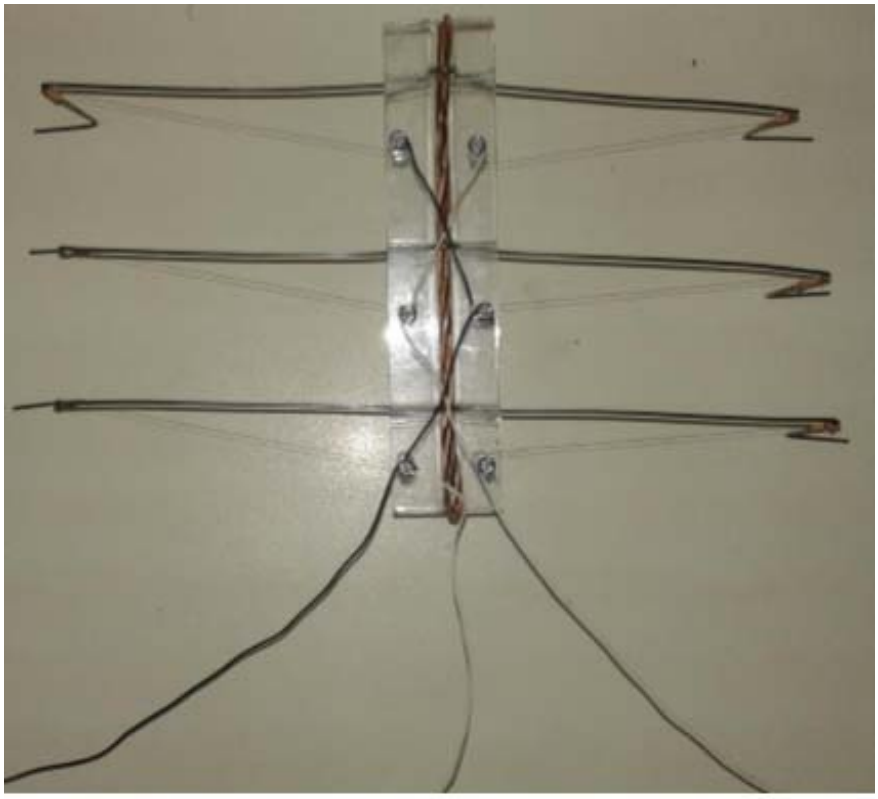
The structure of hexapod is usually thin and light in weight as the hexapod as is the small robot which is similar to spider as it is small and its weight is light so we consider hexapod as a spiderbot and usually the actuators use in robot are servo motors but here we have replace servomotors another actuating material known as Nitinol wire(Flexinol wire) it comes in SMA(Shape Memory Alloy) category it is an actuator which changes its original shape when it is energize and when it is DE energize it comes to its original shape so it memorizes its original shape that is why is known as SMA, it is used in research and development. The servomotors are they are that much costly, heavy in size, and when we are dealing with biometric robots servomotors are kept aside but on other hand Nitinol wire is thin in size, flexible and having different diameters, but in this structure we are using two diameters 0.006"and 0.004" and key to note is different has different characteristic as diameter decreases robot speed increases but weight caring will decrease and vice versa, in every structure main part is body for which you have to decide that which shape and material you want to used ,here we have used rectangular shaped robot body, commonly bodies are made of either metallic material or other but to prevent from electric shock, current fluctuation which are harmful for human life as they are major subject in safety hazard so to secure oneself from these harmful condition the engineers and designers prefer the plastic or wood as body material, robotic body use here is made of hard plastic, as the flexinol can carry light weight that's why we are using plastic material for our body, Hexapod defines a six leg robot so here we have used an stainless material for the legs that is thin in shape easily turned to make the legs shape, the stainless steel is same material as the piano wire or musical wire so we have use three musical wire and the legs are assembled in pairs from three 180 mm lengths of stainless steel. The body provides structural strength and locates the attachment points for the legs and the nitinol actuator wires. To construct the body cut the hard plastic of thickness 1 cm, to the length of 6inch and width of 2 inch. The attachment points for the legs and actuators are a series of holes and grooves that are drilled. The Plastic is then Sawed, and cut into the body. Begin constructing the attachment points by marking three horizontal lines on one wide side of the body. Let's start with the bottom side. The lines locate the leg holes and the leg clip grooves. Mark two lines 19mm from each end. Mark a third line in the middle 74mm from each end. This spaces the three lines 50 mm apart. Drill two 1mm diameter legs holes on each line. Drill completely through the body, keeping the leg holes vertical. If drilled perfectly, the leg holes will emerge on the top side 1mm apart, with the seam centered between them. The leg holes locate and align the leg pairs and locate the bend in the stain less steel wire that will clamp the power bus securely to the top side of the body, the power bus is use as aground to the nitinol wire, the legs are insert in the holes equally as making V shaped over power bus that V shape will lock the power bus at one place, Drill two 1mm diameter body crimp holes 5mm behind each clip-groove, centered in each half of the body. Drill completely through the body, keeping the body crimp holes vertical. These large hole are used for putting the screw of 39mm which will used for connecting the nitinol wire with the legs, use two or three washer with it which will help in maintaining the nitinol wire angle and balancing it. The Arduino is connected as to drive the nitinol wire and move the legs in the tripod gait fashion, wave gait fashion depends on the code which is uploaded we have use tripod as the primary code, the is use and with Arduino as to provide the exact voltage and current that which is actuating is needing and to perform the gait system automatically, so in hexapod we can change structure according to the condition and platform.

3. Working

As we have connected the body, all legs, power bus and the nitinol wires together after that time to check it, here we have used 0.006" diameter nitinol wire.

To begin with check single leg possibly it is working legitimately or the nitinol is not wear out so we have utilize one 22ohm 5watt Power as there warmth sink capacity is great and don't burns early, now give the ground to the power transport as it is giving ground to the legs and give the positive supply of 12V to the resistor one terminal and other terminal yield to the screw on which the nitinol wire is associated , so simply give the supply about half second as to check wire and the leg movement is appropriately working or not, on the nitinol wire is wear out or it is not misshaping to its unique shape. We have used an Arduino and are utilizing just the advanced pins of it as to make the project basic simple to utilize so in an Arduino board there are 54 input/output pins in which 14 are PWM but we are utilizing just six pins. 22 to 27 simply giving the legs power to on and off with time delay i.e.(on time 1sec and off time 2sec) the off time is bigger on the grounds that the nitinol need to misshape to its unique shape and as we as of now talk about that why the on time is less. The Dual H-Bridge Driver Module known as power scaffold from which

we can drive the reasonable power so it has the pin for Vin in which we will supply 12 V we will offer ground to the ground pin, 5 V which we will drive from Arduino and the jumper pins which we which we will utilize we drive 12 V from it as we have six legs so we will drive three outputs from one extension and three from another along these lines our robot will running ceaselessly. The project through which our robot will run consistently.



4. Materials And Methods

The material we have used which is our main component the actuating wire known as Nitinol commercially called as Flexinol wire.

Flexinol

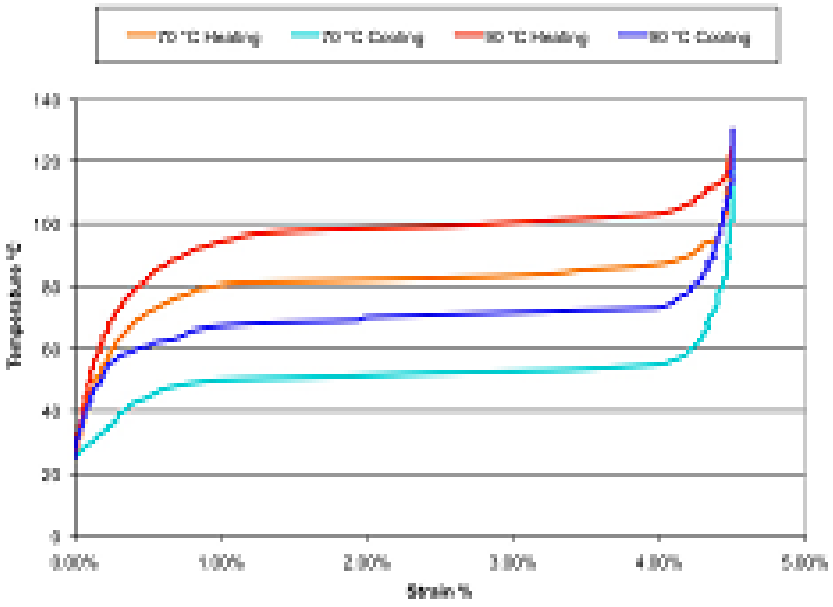
The material made up of nickel –titanium having different forms or "phases" at distinct temperatures, is called Flexinol (Shaped Memory Alloy) (also known as Muscle Wire). It is thin, highly processed strand of a nickel-titanium alloy that is why it is also called as Nitinol wire. This small diameter wire contracts like muscle when electrically driven. It comes in eleven sizes and two transition temperatures as mentioned earlier. Both the contraction and relaxation are virtually instantaneous with the relaxation of wire.

Working Principle And Properties of Flexinol

Flexinol is easily stretched by a small force at room temperature. However , when conducting an electric current , the wire heats and changes its shape by stretching out , and changes to a much harder form that returns to the "unscratched shape at low temperature by using some stressing force . Wires shorten in length with a usable amount of force. It can be shorten by up to 3 to 5 percent range and can run for millions of cycles with very reliable performance.

NIickel - Titaniium Alloy Physical Properties

Characteristic Curve:



Typical Temperature vs. Strain Characteristics for Dynalloy's standard 158°F (70°C) "LT" and 194°F (90°C) "HT" Austenite start temperature alloys, at 172 MPa

Density	0.235lb/in3 (6.45 g/cm3).
Specific Heat	0.20 BTU/lb * °F (0.2 cal/g * °C)).
Melting Point	2 370 °F (1300 °C).
Latent Heat of Transformation	10.4 BTU/lb(5.78cal/g).
Thermal Conductivity	10.4 BTU/hr * ft * °F (0.18 W/cm * °C)
Thermal Expansion Coefficienti. i. Marten siteii. ii. Austenite	 3.67x10-6/°F (6.6x10-6/°C) 6.11x10-6/°F (11.0x 10-6/°C)
Poisson Ratio	0.33
Electrical Resistivity i. Marten siteii. ii. Austenite	 32micro-ohms*in(80micro ohms*cm)39 micro-ohms * in (100 micro-ohms * cm)

Nickel Titanium Alloy Physical Properties

Advantages of Flexinol

The advantages of flexinol actuator are significant. Its solutions can be physically small as compared to a servo motor or solenoid .flexinol is light in weight. These solutions do not introduce any magnetic noise in a circuit because the activation mechanism is heat rather than magnetism.

Electrical characteristics

Important electrical characteristic of flexinol wire are summarized in following table.

Wire Diameter inches (mm)	Resistance ohms/inch (ohms/meter) Pull Force pounds (grams)	Pull Force pounds (grams)	Approx. Current to Contract in 1 Second (mA)	Cooling Time "LT" Wire (seconds)	Cooling Time "HT" Wire (seconds)
0.004 (0.10)	3 .2 (126)	0.31 (143)	200	1.1	0.9
0.006 (0.15)	1.4 (55)	0.71 (321)	410	2	1.7

Disadvantages of Flexinol

Working with flexinol brings its own challenges. Flexinol is thin, tough wire and also can be physically difficult, and to achieve transition we can be required a substantial current.

Figures and Tables

a) Tripod Gait Response

Gait Following	Time	Distance	Speed
Tripod	1min6sec	3cm	0.45e-3

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