Mechanical Calculation, Implementation, and Control of Biorobotics for MiniRobotEarthworm

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Abstract

This paper describes a effective on biorobotics locomotion systems which experimentally constructed an exact modelling and micro-scale wriggle forward units based on a Internal Degrees of Freedom Biorobotics (IDFBs) for MiniRobotEarthworm research by Jiabin Science Laboratory. In particular, the paper considers previous research efforts related to modelling of IDFBs for MiniRobotEarthworm, physical theory development of these mechanisms, and accomplish control design efforts for biorobotics locomotion systems. A 3-D model of the central to the mission of the biorobotics project is the development, south (S) and north (N) magnetic poles cyclic inputs on the joints of the MiniRobotEarthworm whose internal motions provide a net displacement in a desired direction. Through an exact mechanical calculation modelling had been achieved on a random received some additional information after spontaneous and unexcepted event such as earthquake, mud-rock flow and geology explore, etc. Examples of such tasks include wriggle, gap crossing, under earth into a hole in a wall, across railroad track, and further design for camera scanning with the head of the MiniRobotEarthworm.

Keywords

Biorobotics, earthquake, force effect, locomotion systems, Worm-like Robot.

1. Introduction

In the present years, earthquake and mud-rock flow frequently occur in China. Especially, on April 15 of 2015, the 4.5 magnitude mudsildes in the devastating earthquak in Linzhao Country Dingxi City Gansu province of China.

Moreover, MiniRobotEarthworm highly articulated biorobotics devices can coordinate their internal degrees of freedom to receive some additional information after spontaneous and unexcepted event such as earthquake, mud-rock flow and geology explore, etc. The true worm-skeleton of this Mini- and Micro-devices that it is an exact modelling, achieving behaviors not limited to explore (1).

Research on snake robots has been conducted for several decades (2). Early empirical and analytical studies of snake locomotion were reported already in the 1940s by Gray (3), and Hirose developed the world's first snake robot as early as 1972 (4). Through an exact mechanical calculation and analysis modelling, MiniRobotEarthworm depend on Internal Degrees of Freedom Biorobotics (IDFBs) formation wriggle effects.

There have been many kinds of mobile micro robot using the micro actuators such as Ionic Polymer Metal Composite (IPMC), micro motors and piezo actuators (5). These actuators generally require electric cable for power supply, in particular IDFBs such only south (S) and north (N) magnetic poles cyclic prime mover.

2. Modelling System

Internal Degrees of Freedom Biorobotics (IDFBs) for MiniRobotEarthworm has also built models of worm-skeleton supply control systems that might exist in the biorobotics. The wriggle supply triggering coil engender south (S) and north (N) magnetic poles. Both of these structures allow the coil to move and wriggle utilizing its own energy. The wriggle pattern as shown in Fig. 1 and Fig. 2.

In correlative previous works and research (6) and (7), Jiabin Science Laboratory was introduced the overall idea: the structure of the manipulator is based on a Triggering coil engender south (S) and north (N) magnetic poles are serially connected (see Fig. 3), and itself presents the cap-ability to be independently actuated and stiffened push itself forward.

MiniRobotEarthworm was able to assist rescue teams or aid worker accomplish relief work, just as China soldiers and Chinese medical workers/doctors. Earthquake detection system can detect the quake victims in the moments after a big tremor strikes, which its time enough to save and search lives. A short time was allowed for the decision to be made.

The longitudinal muscles play a two-way linear actuator role and the setae play a clamping device role. This mechanism is simple but effective. Such mechanism enables the earthworm to move on any environments (8).

Internal Degrees of Freedom Biorobotics (IDFBs) for MiniRobotEarthworm incoming into subbasement have hunted for some lives signal—a precursory from underground、under-sediment, below the mud-rock flow and so on. Rescue teams or aid worker speculation and estimate whether or not to accomplish relief work.

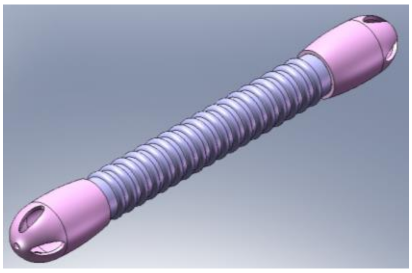
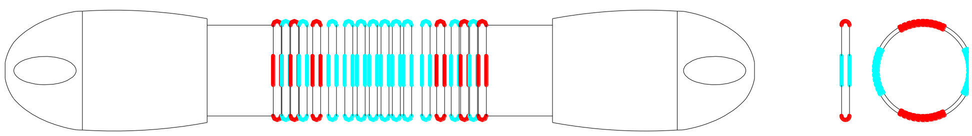


Fig. 1 A 3-D model perspective view of mechanical design of wriggling units for the MiniRobotEarthworm



(a) (b)

Fig. 2 Schematic of magnetic attaching and aligning mechanisms

(a)Wriggling units with array of magnets

(b) Triggering coil engender south (S) and north (N) magnetic poles

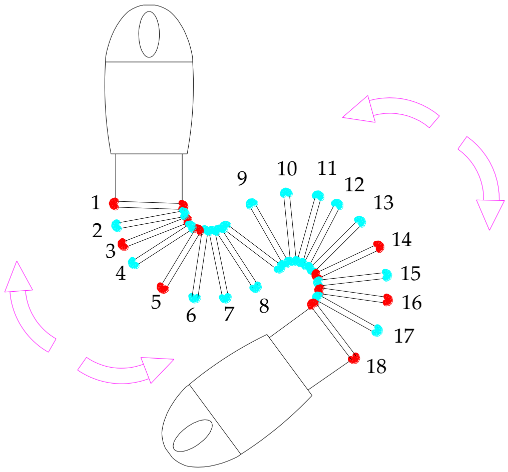
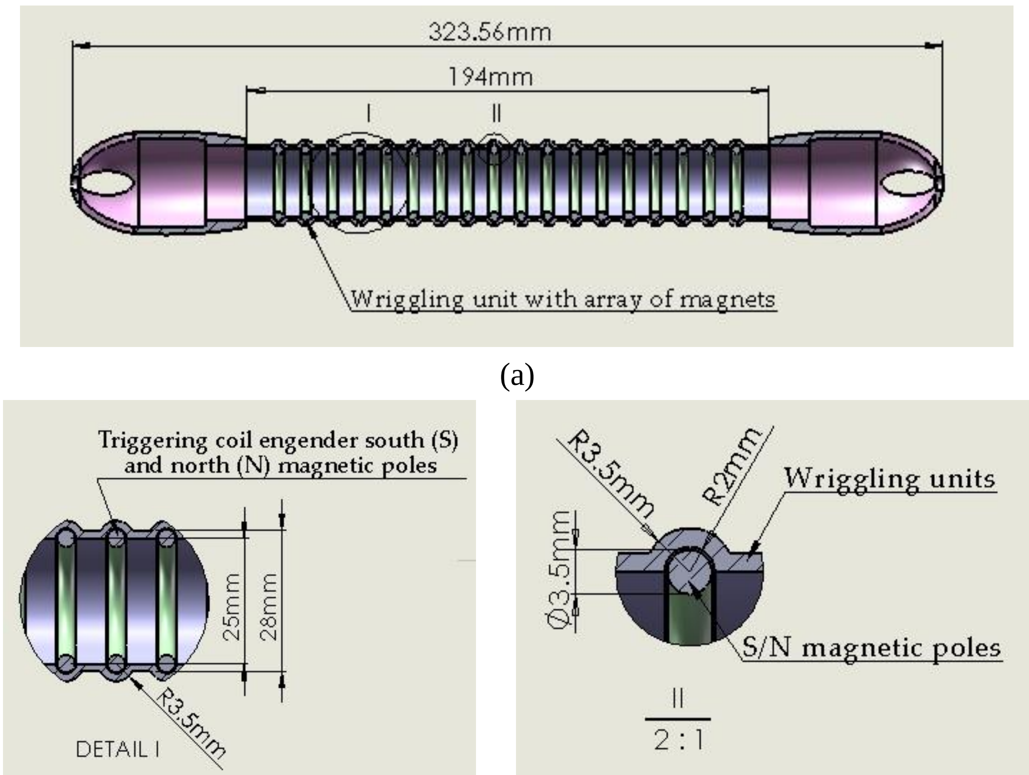


Fig. 3 Rotate axial coupling between two wriggling units. Cycling gaits with rotate axial left and card right of 360 °

A granular jamming-based stiffening mechanism was exploited for stiffness variation on Bionic-Robot & Worm-like Robot. Some micro robot has already been demonstrated in several robotic devices (9). To our best research (10)-(15), this works in present the only control Rotate and worm strategies where contact force effect is employed in the feedback for S/N mangnetic poles (see Fig. 2 and Fig. 4).



(b) (c)

Fig. 4 Section wriggling units of the MiniRobotEarthworm

(a) 3D perspective of Front View; (b) 3D assembly drawing perspective of detail view with triggering coil engender S/N mangnetic poles; (c) 3D perspective of detail view with enlarged scale.

3. Results and Discussion

This section Jiabin Science Laboratory gives some overview of previous research and discover efforts related to modelling and calculations is of the Internal Degrees of Freedom Biorobotics (IDFBs) for MiniRobotEarthworm locomotion. The perspective is structured according to Fig. 6, which summarizes discussions all paper referred to in this section. That consider MiniRobotEarthworm locomotion from a planar (2D) perspective and works that also include three-dimensional aspects of the motion.

3.1 Biomechanical Studies of MiniRobotEarthworm

Hirose given by a planar curve whose curvature varies sinusoidally. The serpenoid curve is defined as

$$\begin{cases} x(s) = \int_0^S \cos(a\cos(b\sigma) + c\sigma)d\sigma, \\ y(s) = \int_0^S \cos(a\cos(b\sigma) + c\sigma)d\sigma \end{cases}$$

where (x(s), y(s)) are the coordinates of the point along the curve at arc lengths from the origin, and where a,b, and care positive scalars (11).

This research on MiniRobotEarthworm like muscular of a “earthworm” bionics-produces curvature and propulsion. It has a higher locomotive efficiency.

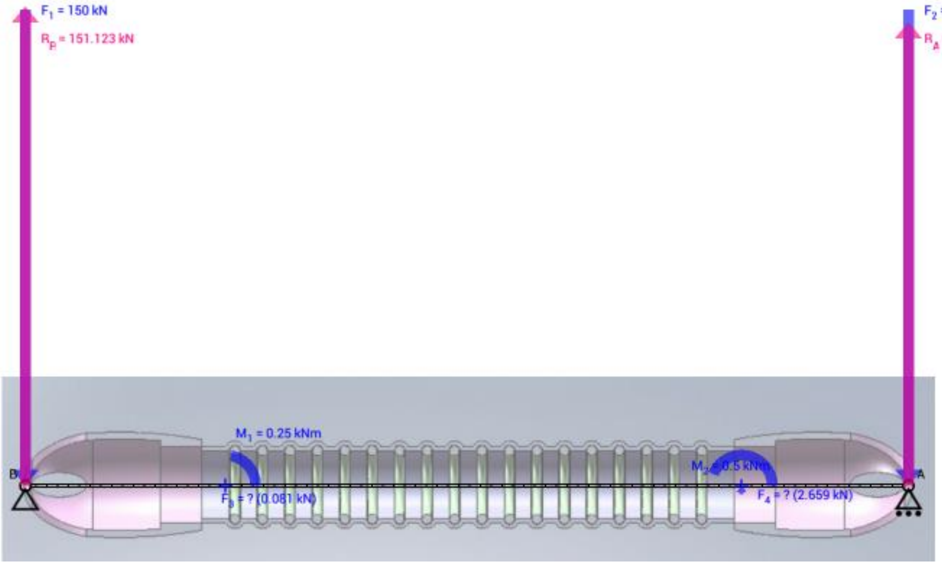


Fig. 5 Force Effect for the MiniRobotEarthworm

Fig. 5 shows force effects of the Internal Degrees of Freedom Biorobotics (IDFBs) for MiniRobotEarthworm wriggle body move curve and modelling analysis are slightly lighted from corner of the wall. It’s often referred to as sinus-lifting. In particular, the IDFBs with pegs in order to push itself forward (12).

In this discussion, we research Bionic-Robot & Worm-like Robot starting from the design of the single mouule, we extend to a two-module manipulator.

Table 1 Force Effect and Results

Inputs Elements			
Element	Length	Weight	
A-B	0.450 m	Around 1.5kg	
Forces			
Force	Direction	Size	Angle
F1	↓	150.000 kN	270.0 °
F2	↓	150.000 kN	270.0 °
Moments			
Moment	Direction	Size	
M1		0.250 kNm	
M2		0.500 kNm	
Results			
Reaction Forces			
Force	Direction	Size	Angle
RA	↑	146.166 kN	90.0 °
RB	↑	151.123 kN	90.0 °

3.2 Theoretical Force Effect Calculations Analysis of MiniRobotEarthworm

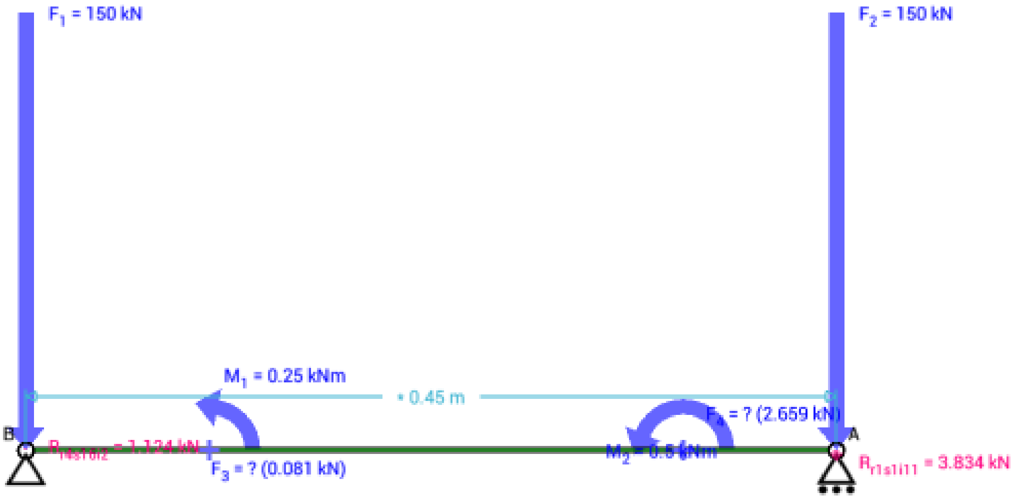


Fig. 6 Element A-B

Table 2 Element A-B Forces

Forces		
Size	Force (-)	Force (+)
Mr3s1i11 = 0.000 kNm	Rr1s1i11 = 0.000 kN	Rr4s16i2 = −0.062 kN
Mr6s16i2 = 0.000 kNm	Rr2s1i11 = −3.834 kN	Rr5s16i2 = 1.123 kN

Fig. 7 Shear Force and Moment Diagram

Fig. 8 Shear Force Effect and Moment Diagram

4. Conclusion

In this paper, Jiabin Science Laboratory designed and fabricated a wireless Internal Degrees of Freedom Biorobotics (IDFBs) for MiniRobotEarthworm-like micro robot. Based on analysis of itself force effects and motion, IDFBs like micro biorobotics was realized using a locomotion systems (see Fig. 6, Fig. 7 and Fig. 8).

We exploited different technologies and forces calculate and analysis with respect to the wriggling unit in order to tune it for specific applications as a biorobotics devices. Extensive characterization demonstrated that the proposed system is able to provide bending of almost 270 ° (Fig. 5) and elongations up to 72% (Fig. 3).

The proposed MiniRobotEarthworm mechanism is simple, but effective to detect save and search lives in narrow and earthquake environment. Of course, cycling gaits construction is dealt with in the literature had already been illustrated in Fig.2 and 3.

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