



Biomimetic soft crawling robot for GI tract inspection



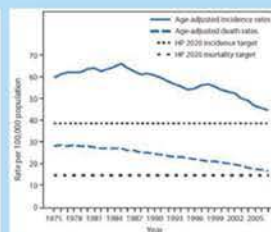
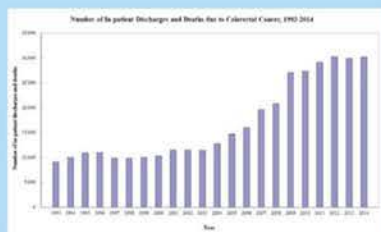
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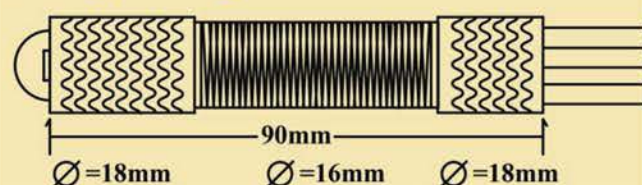
Introduction

Colorectal cancer (CRC) is the most common cancer in Hong Kong. Incidence rate has been increasing in past two decades in HK [1]. By contrast, after promoting early screen for CRC, incidence and mortality rates of CRC patient in the US are decreasing significantly since 2003 [2]. It shows that recommended CRC screening recommendations will prevent more CRC cases.

The goal of this project is to 1) Provide a complete soft and small size platform for GI tract inspection, therefore enabling intrinsic safety and improving patient's tolerance; 2) achieve active locomotion, i.e. crawling and bending.



Prototype Design



(A) Sections

(1) Head Section
-Double layer chamber for carrying an end-effector.



(2) Middle Section
-Three chambers for bending motion and one channel to head section.
-Surface pit for wrapping.



(3) Rear Section
-Five channels to connect the control system and prototype.
-Array of grooves on the surface for increasing friction.

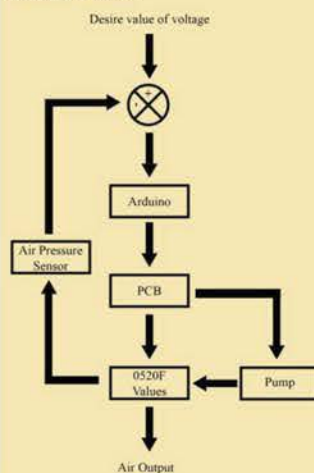


(B) Locomotion

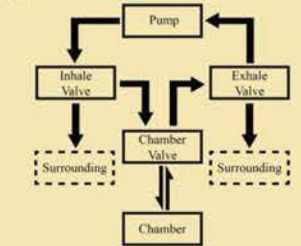
- (1) Rear section expands to anchor itself.
- (2) Middle section expands to create displacement.
- (3) Front section expands to anchor itself.
- (4) 5) Rear and middle sections relax, whereas rear section remains expanded to prevent slipping back.
- (5) Rear section expands to allow front section to relax.
- (6) Front section relaxes and back to step one.
- (7) Front section relaxes and back to step one.

Inhale/Exhale Control System

(A) Close-loop Control



(B) Inhale/Exhale Control



Inhale Valve	Exhale Valve	Chamber Valve	Chamber Performance
On	On	On	No Change
On	Off	On	Swell
Off	On	Off	No Change
Off	Off	Off	Shrink

Results

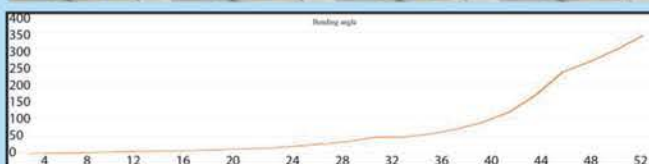
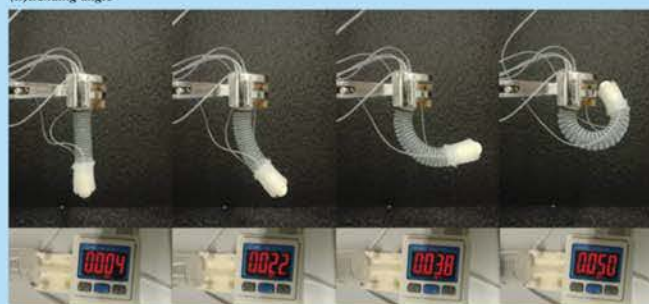
(A) Crawling speed



Fig.A shows the robot crawling in a PVC tube, it finish a 20cm crawling in 40 sec. The speed of crawling is 0.5cm/sec.

Fig.B shows the robot can bend from 0 degree to 340 degree by applying pressure from 4kpa to 52kpa.

(B) Bending angle



Conclusion

A complete soft and small size earthworm robot, which is able to perform crawling and bending, have been successfully developed. The crawling speed is about 0.5cm/sec. The maximum bending angle can reach 340 degrees which can cover most of the turning in colon. In the future, more tests, such as crawling speed and payload test, should be done in pig colon so that the performance of the soft robot can be more accurately evaluated in a clinical-likely environment.

References

- [1] Colorectal cancer, Department of Health, HKSAR, <http://www.chp.gov.hk/en/content/9/25/51.html>
- [2] Vital Signs: Colorectal Cancer Screening, Incidence, and Mortality --- United States, 2002-2010, <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6026a4.html>

Acknowledgements

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