Controllable Cancer Stiffness in Rectum Phantom Design

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Introduction

This project investigates "soft robotics controllable rectum phantom modelling" to model humans' rectum and examine tissue abnormalities to validate the force sensor being developed. It will utilise a stiffness variation mechanism to simulate the cancer tissues and healthy tissues. The varying stiffness values will simulate different stages of cancer providing a test bed for the methodology development. The phantom model serves as a testing platform before the sensor is tested in patients to minimise tissue damage. This reduces the risk of causing complications in patients especially when unpracticed trainees perform procedures[2].

Aims

- Design and fabricate a soft model of the rectum using silicone material
- Consider both the internal and external structure of the wall
- Integrate tumorous lesions into the design
- Simulate both normal and unhealthy lesions
- Control the size of the tumor
- Implement a technique to vary the tumor stiffness
- Design suitable experiment to test and validate the colon phantom

Figure1: Rectum CAD model

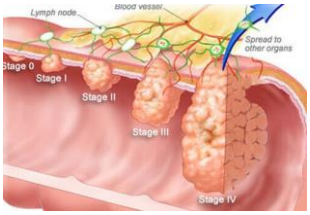


Figure2: Cancer tissue stages[3]

Method

Rectum phantom:

- 3D print the upper and lower rectum mould.
- Screw the mould parts together
- Pour silicon to the mould through the hole.

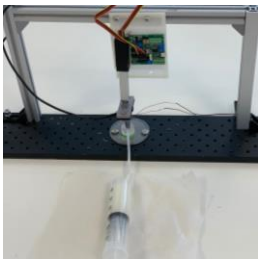
(a) (b)

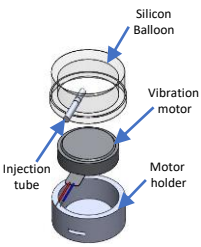
Figure3: (a) upper rectum mould. (b) lower rectum mould

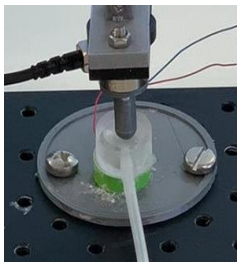
Vibrating the non-Newtonian fluid:

- Inject the Non-Newtonian fluid (corn flour and water, ratio of 1:2) inside a silicon balloon using a syringe.
- Vibrate the fluid using a vibration motor at different frequencies
- Use the force sensor to calculate the stiffness of the fluid at different frequencies

Method continue





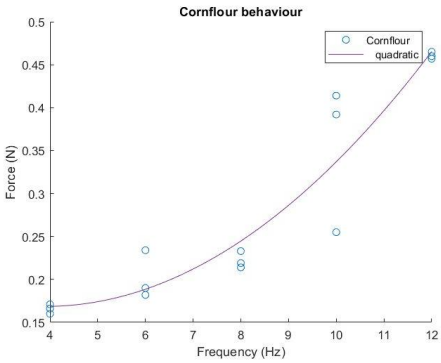


(a) (b) (c)

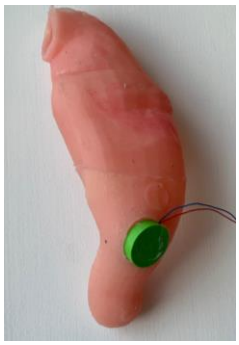
Figure4: (a)Testing setup. (b)Vibration motor assembly to vibrate the balloon (c)Force sensor collecting data while the fluid is vibrating

Preliminary Results

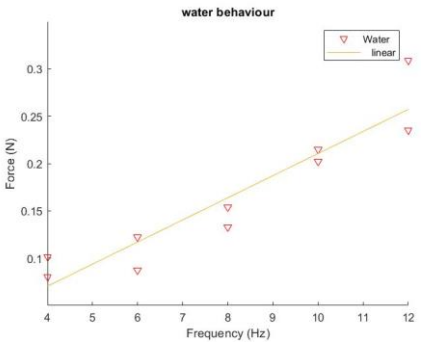
- To vary the stiffness of the cancer tissue in the model, the non-Newtonian fluid was vibrated at the following frequencies: 4Hz, 6Hz, 8Hz, 10Hz, and 12Hz.



(a)



(c)



(b)

(d)

Figure5: (a)The behavior of the Non-Newtonian fluid at each frequency, (b)The behavior of water at each frequency, (c)Silicon rectum phantom, (d)Example of how the designed cancer tissue will be implemented inside the phantom

Future work/Conclusion

- Collect more data with the force sensor and test wider range of frequencies
- Define the frequency range that will be used
- Implement the cancer tissue inside the phantom
- Get ratio of the normal tissue to cancer tissues
- Apply the same methodology to the intestine.

References

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