Disposable Soft 3 Axis Force Sensor for Biomedical Applications

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Abstract

We propose a disposable soft 3D force sensor capable of measuring force or vibration. It uses three Hall effect sensors orthogonally placed around a cylindrical beam made of silicon rubber. A niobium permanent magnet is inside the silicon. When a force is applied to the end of the cylinder, the beam is compressed and bent to the opposite side of the force displacing the magnet. This displacement causes change in the magnetic flux around the Hall sensors. By analyzing these changes, we calculate force components along the three directions using a lookup table. This sensor can be used in minimal invasive surgery and haptic feedback applications. The cheap construction, bio-compatibility and ease of miniaturization are advantages of this sensor. The sensor design, and its characterization are presented in this work.

Force Sensor and Characterization

Palpation of the liver.

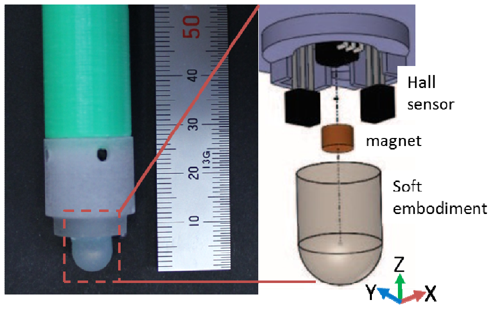
http://clinicalmethods.blogspot.jp/

Laparoscopic surgery

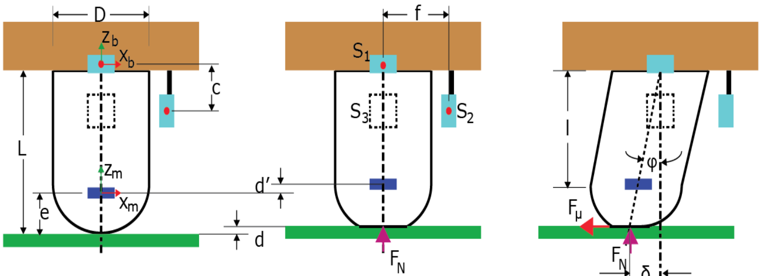
https://en.wikipedia.org/wiki/Laparoscopic_surgery/

Pneumatic Haptic Feedback System, UCAL

http://casit.ucla.edu/body.cfm?id=24



Soft tactile sensor consists of a soft element, three RLS sensors and a cylindrical permanent magnet. The magnet is embodied by the soft element.



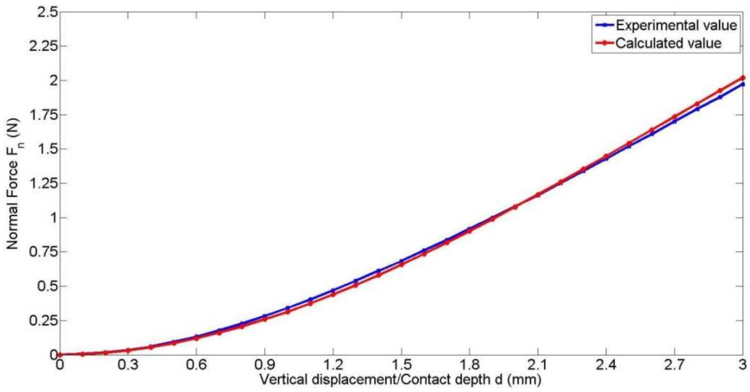
Sensor is characterized as a .cylindrical beam compressed and bent under a vertical and horizontal forces F_n and F_μ.

$$F_N = \frac{EA}{L} d$$

$$F_\mu = 3EI \frac{\delta}{(l + e - d)^3}$$

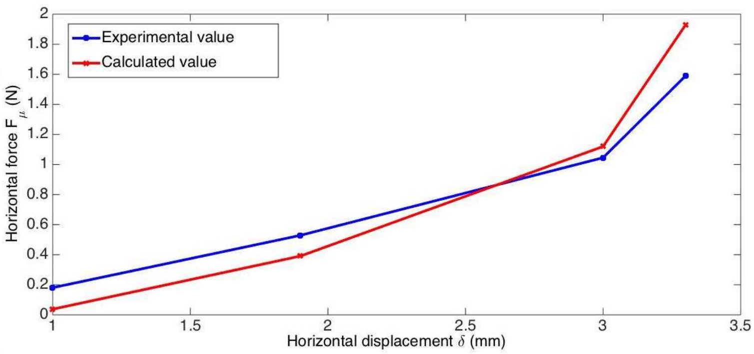
E – Young's Modulus
I – Moment of inertia
d – contact depth

Normal force F_N



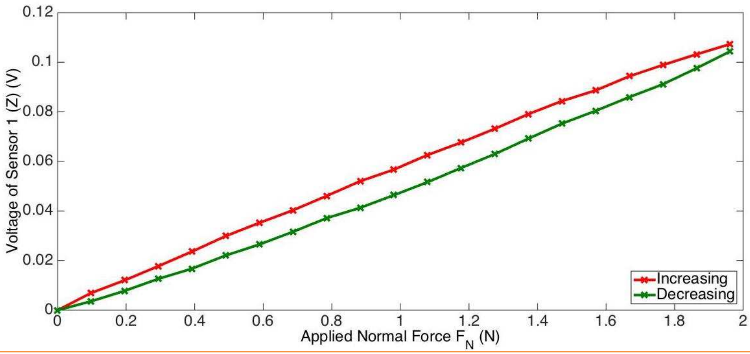
Error under 5% of full scale value

Tangential force F_μ



Error under 10% of full scale value

Hysteresis of sensor Z



Conclusions

- The construction of the sensor provides price advantage over many existing force sensors
- Measurement errors of the sensor:
  less than 5% for normal force (F_N) and
  less that 10% for tangential force (F_μ).
- Changing the stiffness of the soft embodiment change the sensitivity and maximum rating of the sensor.