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(G*) Estimating applied force on tissue with light

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When force is applied to tissue in a healthcare setting, tissue perfusion is reduced in response to the applied force; it is perfusion that is important in assessing tissue health and potential injury from the force 1,2. Traditional means of measuring force involve quantifying the mechanical strain or electrical responses of a sensor; these techniques do not necessarily correspond to the physiological responses to the applied force.
It is also known that contact force is a confounding issue in reflectance type optical measurements of tissue, such as Near Infrared Spectroscopy (NIRS) and Photoplethysmography (PPG) 3-6. We propose that the signal from reflectance type optical measurements can be used to predict sensor contact force, due to the physiological response of the underlying perfused tissue.
There is a complex relationship between the reflected optical signals and the underlying physiological response; there is no simple biophysical model to apply. Because of this, we used machine learning to explore this relationship. We used a PPG sensor to collect reflected optical data from the index finger from a participant (n=1). The applied force was also measured simultaneously with a load cell. We collected 240,000 data points with a range of 0 to 10 N of applied force.
While many models worked well to estimate the applied force, we decided on using the random forest model. We were able to achieve an accuracy between the machine learning predictions and the measured ground truth with a median absolute error of 0.05 N and an R2 score of 0.97. From this, we have determined that it is possible to predict the amount of applied force on a vascularized tissue from reflected optical signals. This has potential applications in neurosurgery or robotic surgeries, where careful sensing of the amount of applied force on delicate tissues may reduce injuries.

[1] Roca, E., and Ramorino, G., "Brain retraction injury: systematic literature review,"Neurosurg Rev, 46(1), 257 (2023).
[2] Zagzoog, N., and Reddy, K. K., "Modern Brain Retractors and Surgical Brain Injury: A Review,"World Neurosurg, 142, 93-103 (2020).
[3] Chen, W., Liu, R., Xu, K. et al., "Influence of contact state on NIR diffuse reflectance spectroscopy in vivo," Journal of Physics D: Applied Physics, 38(15), 2691 (2005).
[4] May, J. M., Mejia-Mejia, E., Nomoni, M. et al., "Effects of Contact Pressure in Reflectance Photoplethysmography in an In Vitro Tissue-Vessel Phantom,"Sensors (Basel), 21(24), (2021).
[5] Reif, R., Amorosino, M. S., Calabro, K. W. et al., "Analysis of changes in reflectance measurements on biological tissues subjected to different probe pressures,"J Biomed Opt, 13(1), 010502 (2008).
[6] Teng, X. F., and Zhang, Y. T., "The effect of contacting force on photoplethysmographic signals,"Physiol Meas, 25(5), 1323-35 (2004).

Keyword-1

force

Keyword-2

photoplethysmography

Keyword-3

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