Study on Fat as the Propagation Medium in Optical-based In-body Communications

Syifaul Fuada[1], Mariella Särestöniemi[2], Marcos Katz[3], Simone Soderi[4], Matti Hämäläinen[5]
[1,2,3,5] University of Oulu, Oulu, Finland
[4] IMT School for Advanced Studies, Lucca, Italy

Background

- For in-body communication system, Fat tissue is particularly favorable for signal propagation in terms of velocity and loss compared to other type tissues in the context of radio waves.
- Despite the fat layer has been explored by various researchers on the radio wave domain, no studies have been conducted that exploit **optical channel** characteristics.
- There are specific considerations when using porcine samples (*ex-vivo* experiment)*:* tissue temperature and tissue composition.
- Study on porcine samples containing fat and flesh composition with realistic measurement should be done for optical-based in-body communication application.
- There is a lack of research examining the influence of porcine temperature on optical channel characteristics.

Motivation

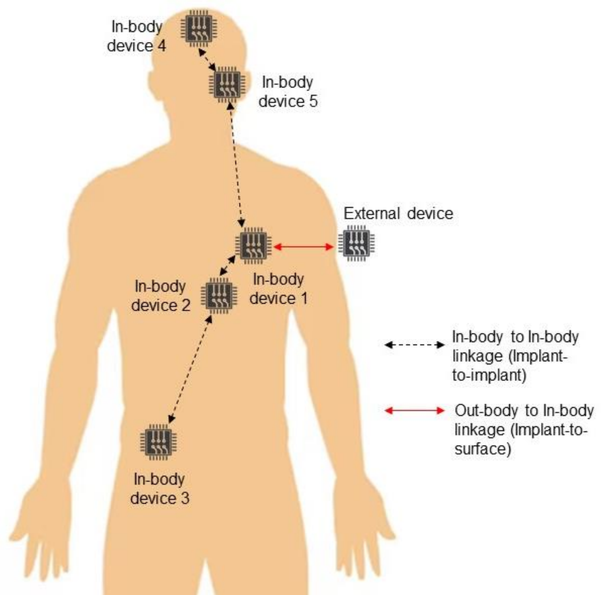
This study is to full fill the reseach gap.

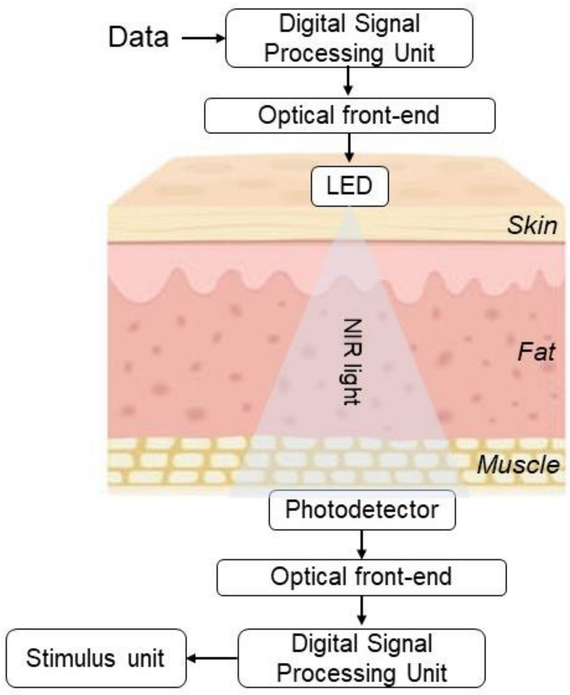
1) The optical channel characteristics are assessed using porcine: pure fat and flesh tissue samples and samples with flesh and fat layers.
2) The effect of the porcine sample's temperature on the received power.

Optical Communication for In-body Communication system

Communication modalities on in-body communication can be categorized into two distinct types:

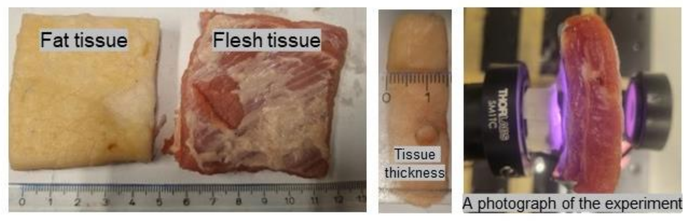
1) In-body to out-body linkage
2) In-body to in-body linkage communication

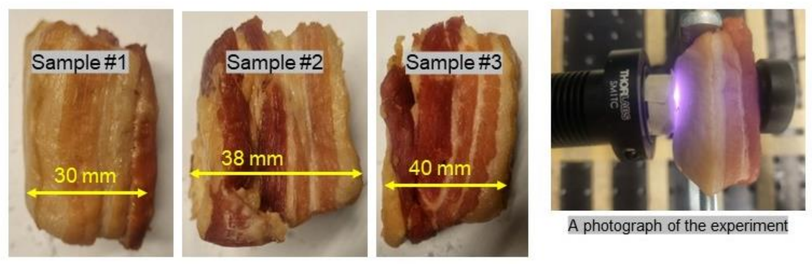




Materials and Methods

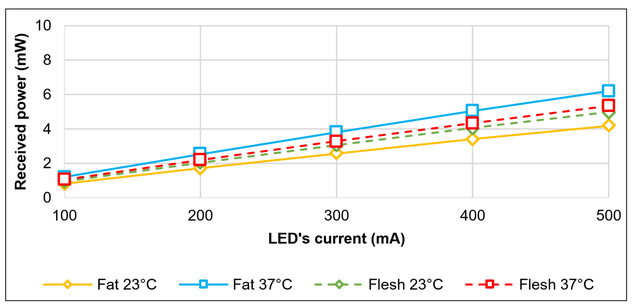
- An experimental test-bed comprised an optical transmitter (LED driver and LED) and an optical receiver (sensor and optical power meter).
- The biological tissue was used as the optical medium, which is
  (1) Pure fat tissue (15 mm),
  (2) pure flesh (15 mm),
  (3) Sample #1 (30 mm),
  (4) sample #2 (38 mm), and
  (5) sample #3 (40 mm).
- NIR light 810 nm was chosen to illuminate the biological tissue as it has better propagation properties across tis-sues than other wavelengths.
- All samples were warmed in a heat chamber to temperatures of 23° C and 37° C for measurement purposes.
- LED driver variation: 100 mA, 200 mA, 300 mA, 400 mA, and 500 mA.



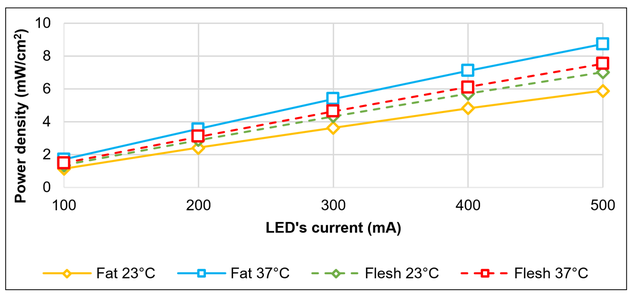


Results

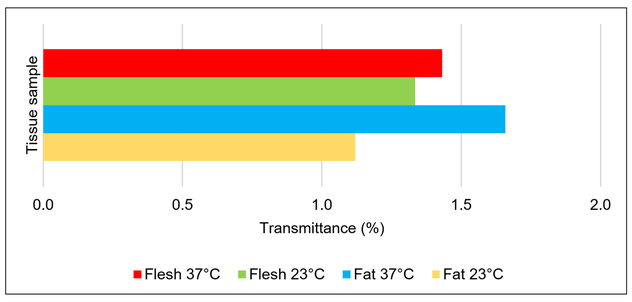
The transmittance of fat at temperatures of 23°C and 37°C was 1.1% and 1.7% respectively. The transmittance of flesh tissue at temperatures of 23°C and 37°C was 1.3% and 1.4% respectively. The findings suggest that tissue thickness influences the received power and power density level. Fatty tissue is observed to be a better medium for the propagation of NIR light than musculus tissue.



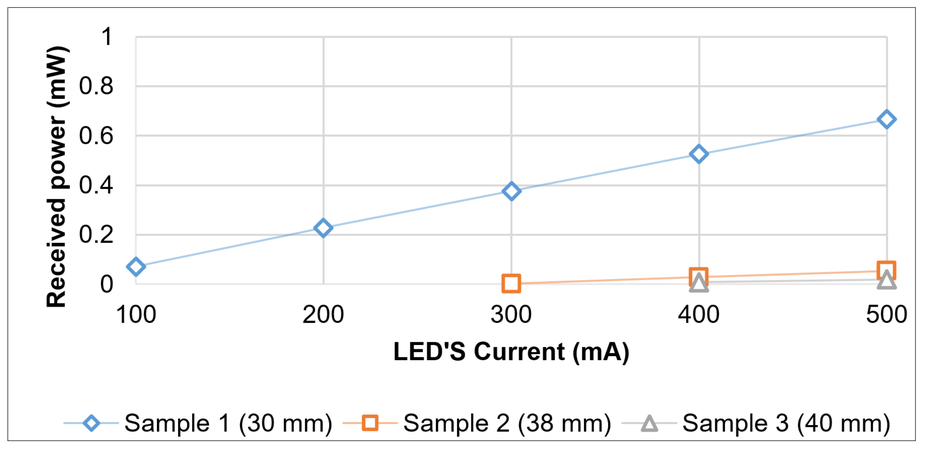
Received power in pure fat and flesh tissues



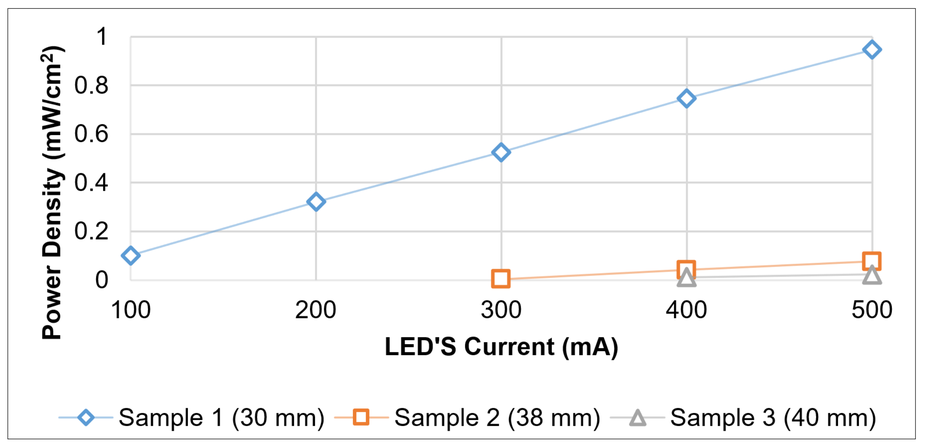
Power density in pure fat and flesh tissues



Transmittance (%) of flesh and fat tissues at 23° C and 37° C



Received power in samples #1, #2, and #3



Power density in samples #1, #2, and #3

Conclusion

- It was clear to conclude that the muscular tissue received lower optical power than fatty tissue. It means, fat layers in porcine sample results are better than flesh layers
- The temperature of porcine sample significantly impacted the optical power received by fat tissue but have minimal effect on flesh tissue. The optical power that went through fat tissue at 23° C and 37° C was higher than flesh tissue.
- The optical power received by fat tissue experiences a substantial decrease of 60% compared to its power at a temperature of 37° C, while the reduction in optical power for flesh tissue is approximately 90%. At a temperature of 37° C, flesh tissue receives 80% of the optical power that fat tissue receives.

Science with Arctic Attitude

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