Bachelorarbeit 0057
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Development of a low-cost LED vein detection sensor

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Background

- Venipuncture is one of the most common invasive procedures in medical healthcare[1]
- Improvement of success rates needed to reduce time, costs, possible complications, work for physician and to improve patient's comfort
- Need for a vein detection sensor which is low-cost (use of LEDs)

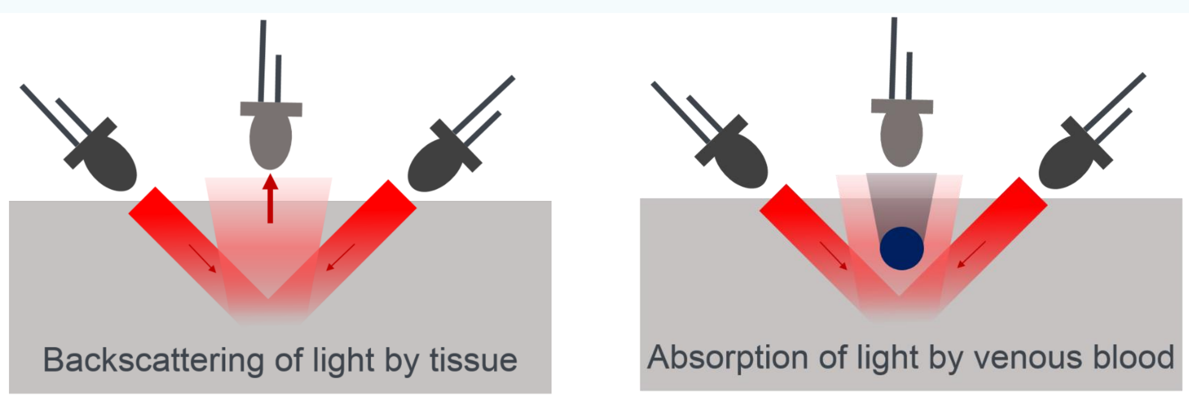

Figure 1: Working principle of the sensor

LED as sensor

- LED in reverse bias[2]
- Model of internal LED behaviour: capacitance in parallel with current source (current produced depends on light intensity as light frees electrons according to photoelectric effect)
- Charged capacitance is discharged by light dependent photocurrent
- Discharge time is measured until voltage at digital input (IN) changes from logic high to low

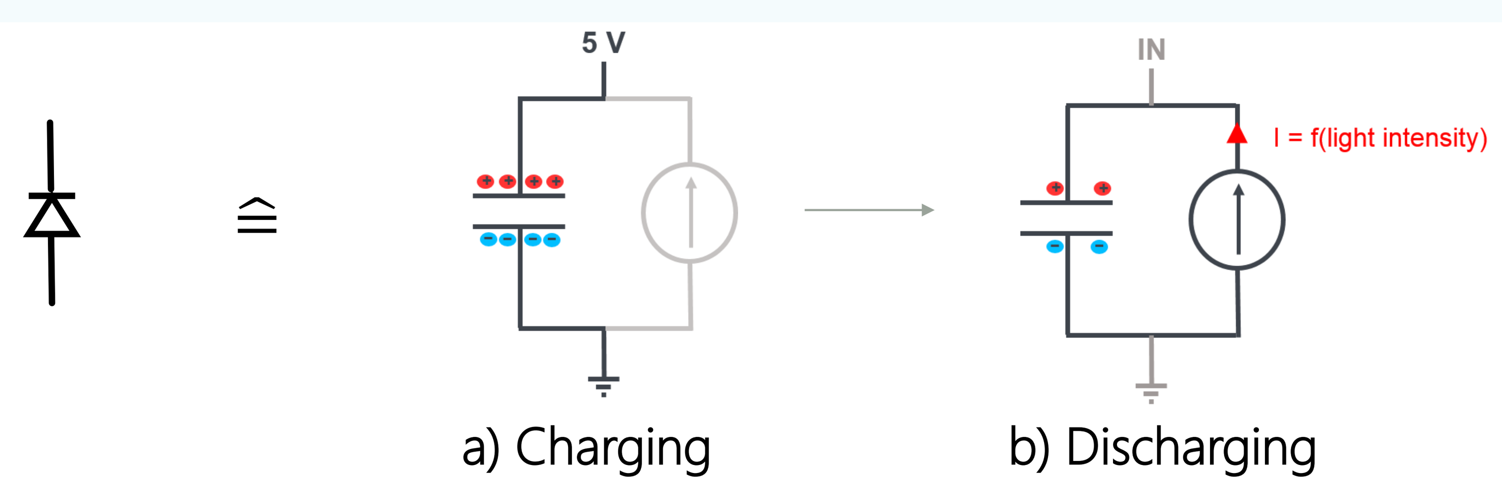

Figure 2: Model of internal LED behaviour in charging and discharging mode

Final LED vein detection sensor

- LED row constellation (two emitting and one sensing LED) integrated in casing including all electronics needed

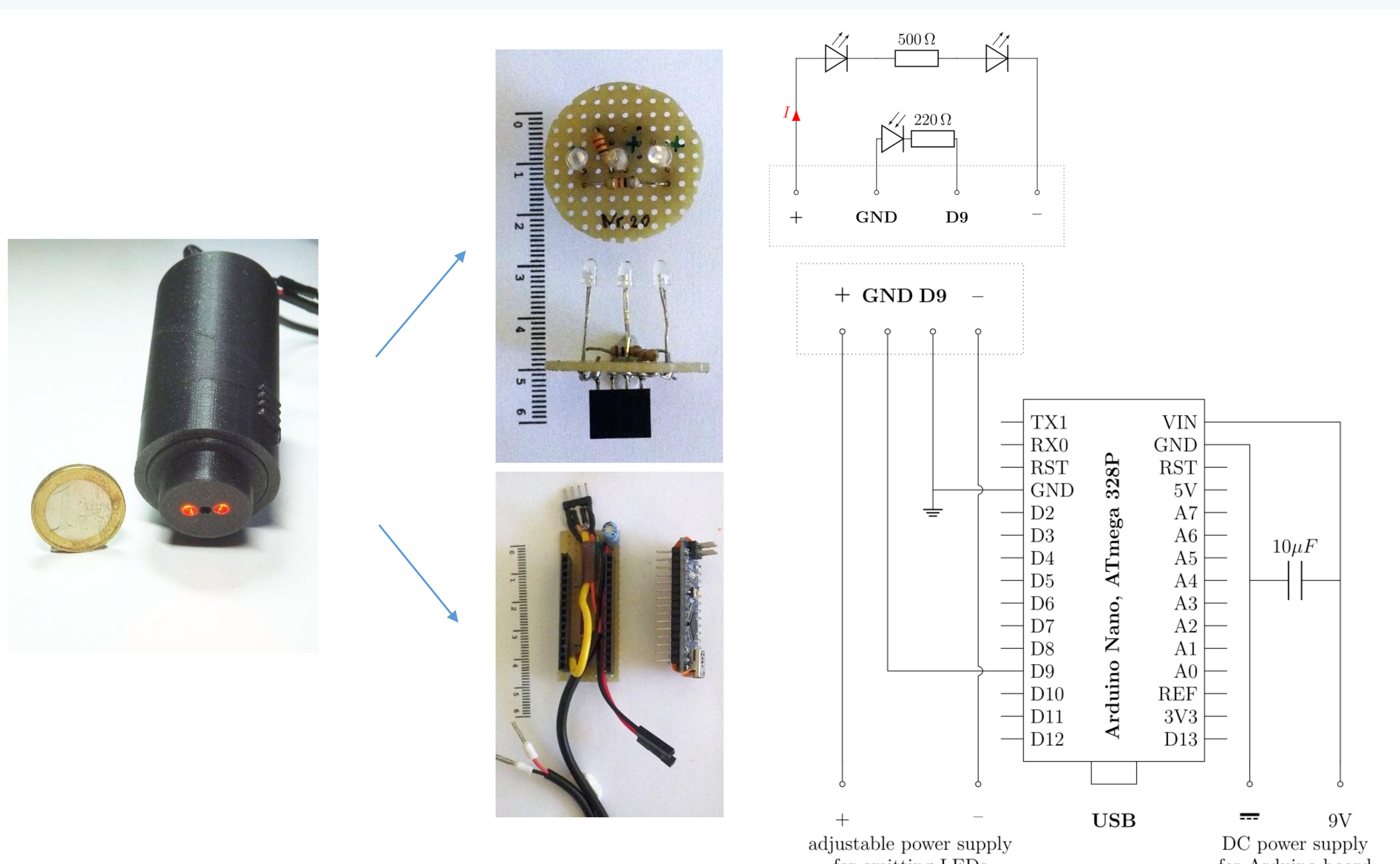

Figure 3: Vein detection sensor, soldered parts and according electric circuits

Future work

- Identify vein patterns with sensor by mechanical scanning or LED array
- Automated intensity calibration
- Miniaturisation using SMD components
- Proper contact to skin surface (no compression of veins)
- Examine if venous depth and size can be obtained by signal's height and width (skin phantom)

Experiments & Results

Moving sensor along scale on the back of the hand

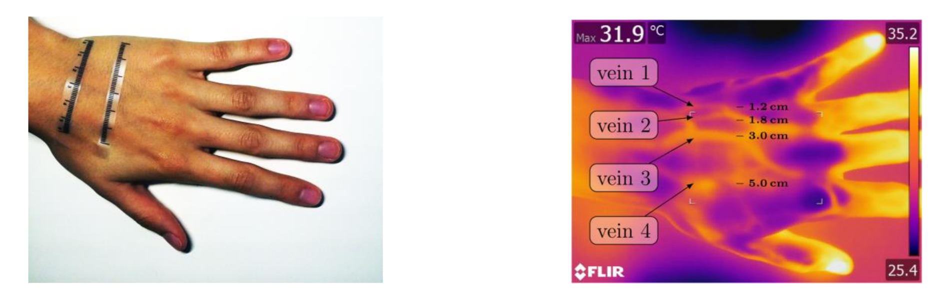

Figure 4: scale on back of the hand and thermal image of veins

Emitted intensity: influences noise and discretisation of the signal, calibration has to be conducted to operate sensing LED in optimum

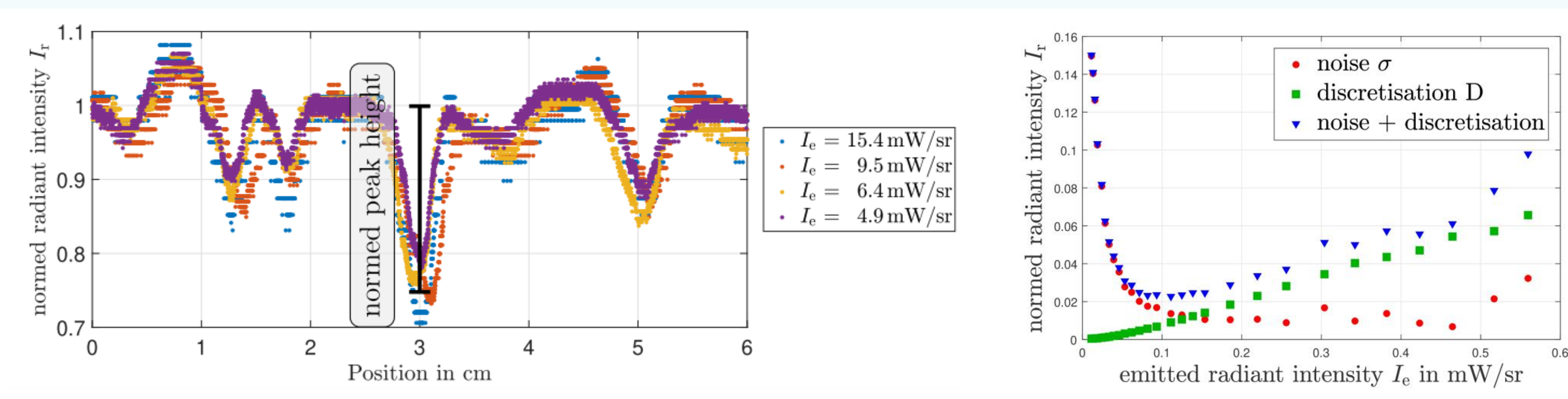

Figure 5: normed measurements for different intensities and relationship between emitted intensity, noise and discretisation

Wavelength: slight trend towards visible wavelengths (light-skinned)

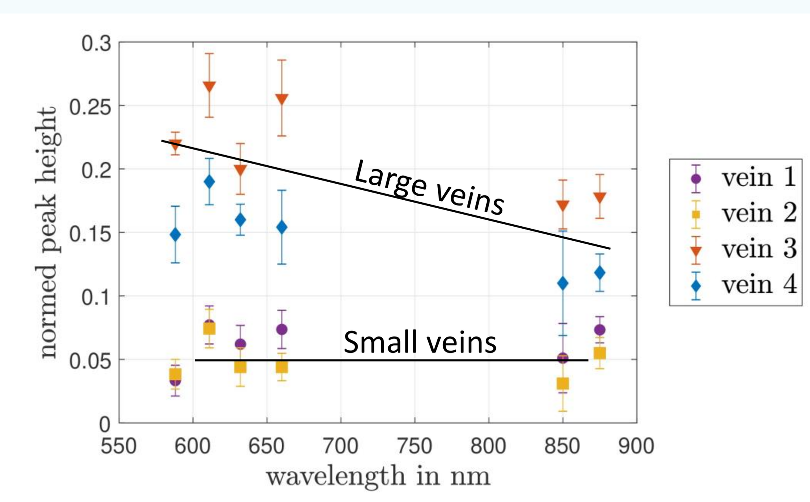

Figure 6: normed peak heights for different wavelength

Skin colour: higher emitted intensity needed for dark-skinned people, near infrared wavelengths most promising as less absorbed by melanin

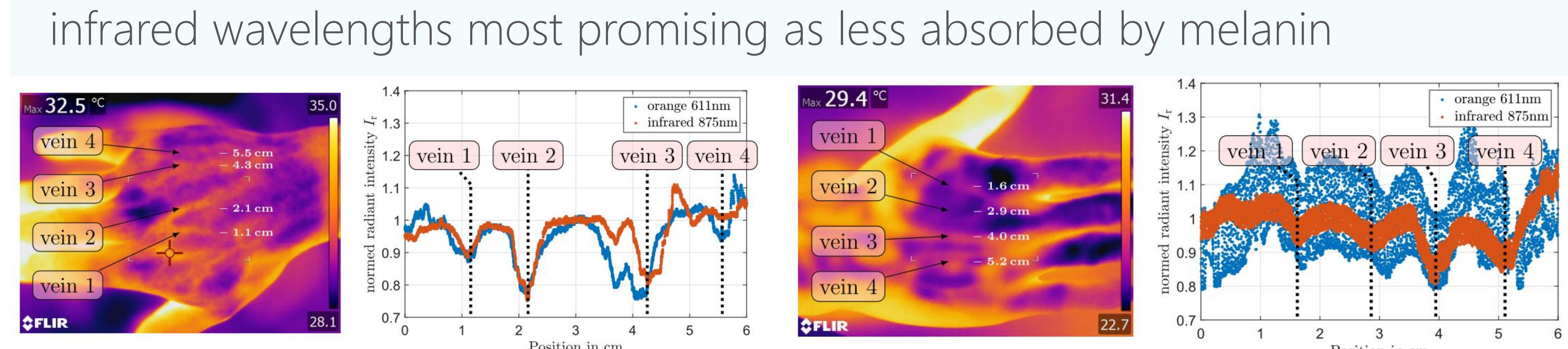

Figure 7: Thermal image and measurement for light-skinned (left) and dar-skinned person (right)

Arrangement of emitting LEDs: showed highest potential to improve signal's height

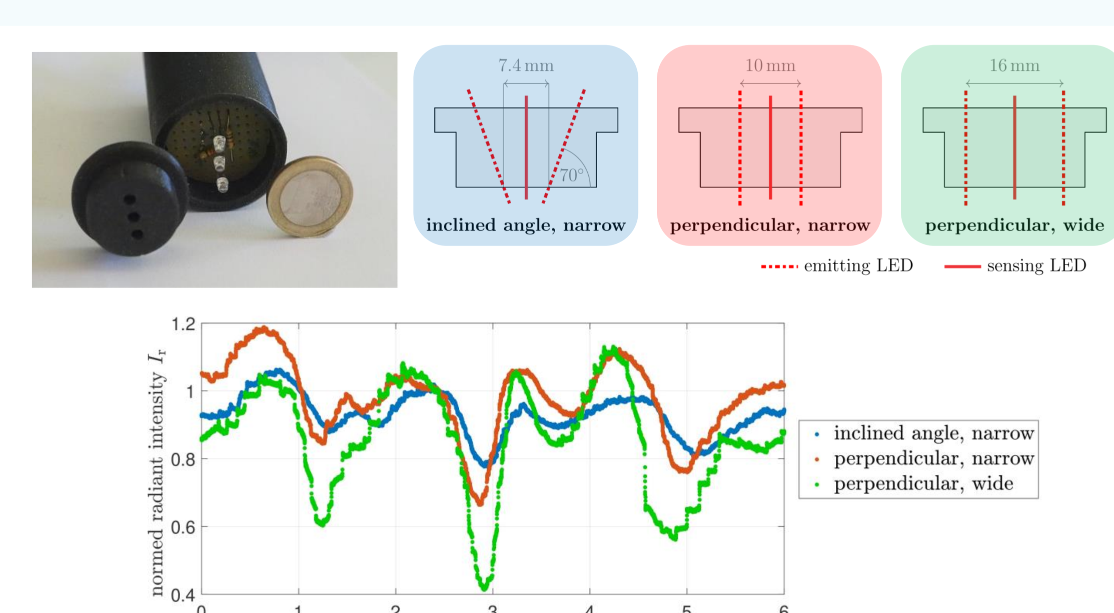

Figure 8: Measurement for different sensor heads

Positioning of LED-row on vein: best signals when LED-row parallel to vein, can be used for determining direction of vein

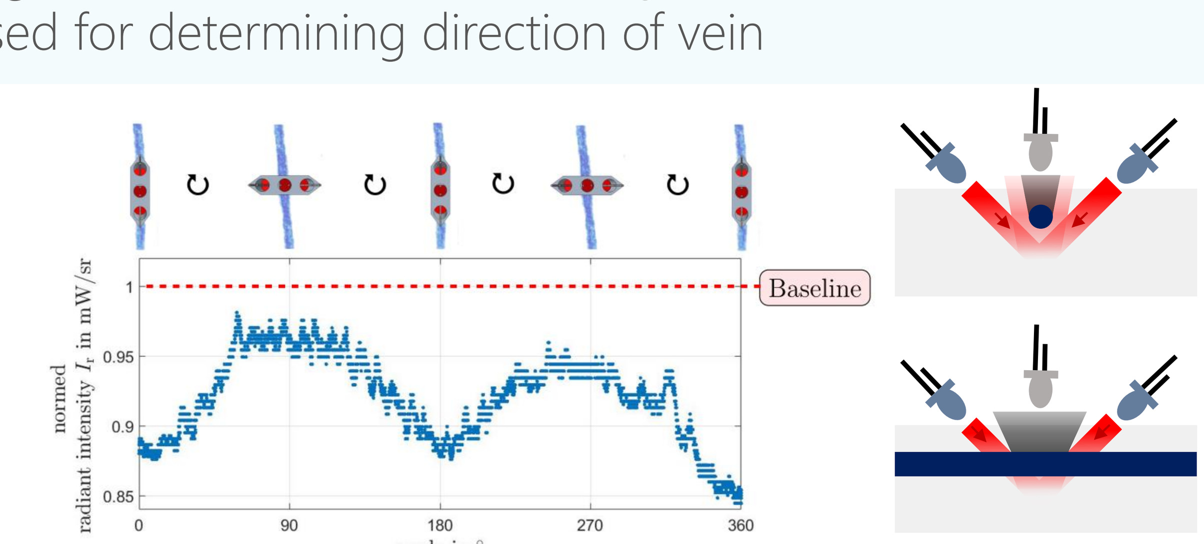

Figure 9: Rotating sensor on vein

Skin surface temperature and Tourniquet: showed minor effects on signal

Literature

1. Simon Juric, Vojko Flis, Matjaz Debevc, Andreas Holzinger, and Borut Zalik. Towards a low-cost mobile subcutaneous vein detection solution using near-infrared spectroscopy. *The Scientific World Journal*, 2014.
2. Paul Dietz, William Yerazunis, and Darren Leigh. Very low-cost sensing and communication using bidirectional LEDs. *In International Conference on Ubiquitous Computing*, pages 175-191. Springer, 2003.