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
- 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)

LED as sensor
- LED in reverse bias
- 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

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

Experiments & Results
- Moving sensor along scale on the back of the hand
- Emitted intensity influences noise and discretisation of the signal, calibration has to be conducted to operate sensing LED in optimum
- Wavelength: slight trend towards visible wavelengths (light-skinned)
- Skin colour: higher emitted intensity needed for dark-skinned people, near infrared wavelengths most promising as less absorbed by melanin

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)

Literature

Figure 1: Working principle of the sensor

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

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

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

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

Figure 6: Normed peak heights for different wavelength

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

Figure 8: Measurement for different sensor heads

Figure 9: Rotating sensor on vein

Skin surface temperature and Tourniquet: showed minor effects on signal