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Spectral reflectance estimation with an optical non contact device for skin assessment

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Outline

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Motivation

- skin assessment important for early detection of diseases
- expensive, bulky multispectral devices allow objective asessment
- spectral estimation allows smaller, cheaper easy to use devices
- SkImager is a proposed non contact optical skin assessment device

Scientific contribution

- realizing of a spectral estimation workflow for SkImager
- comparison of spectral estimation approach to the state of the art SkImager implementation
- basic measurments and classification of the SkImager

Outline

spectral measurments

- measured spectrum of an object is result of 3 things
- Spectral Power distribution of the Illumination
- Spectral reflectance spectrum of the object
- Spectral responsivety of the sensor

spectral measurments

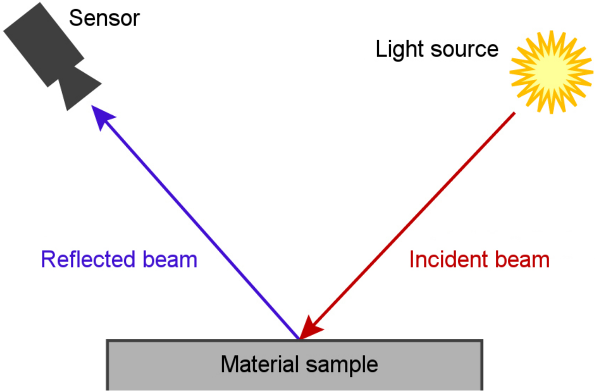


Figure: spectral measurment concept

spectral measurments

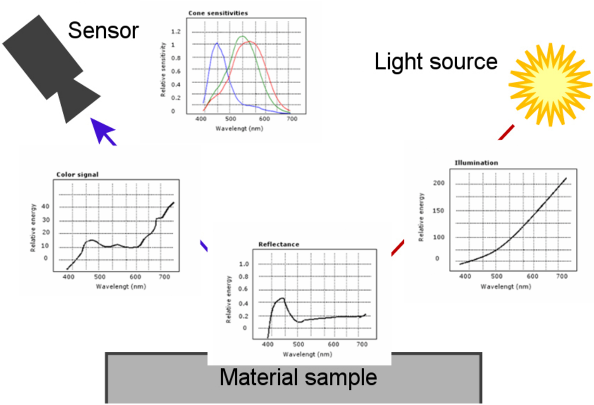


Figure: spectral measurment concept with spectra illustrated

Multispectral measurment devices

- measures the spectral reflectance accurately
- good results reliable objective results for Skinassesement
- Bulky, expensive devices
- often slow measurment process

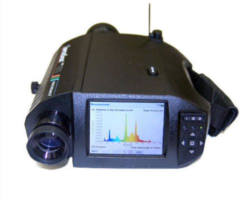
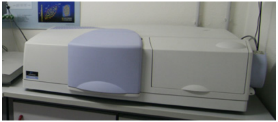
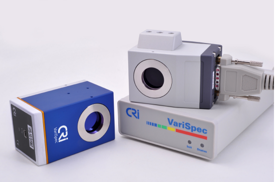
spectroradiometer	spectrophotometer	LCTF camera
		
• relatively fast	• slow	• slow
• expensive	• very expensive	• affordable
• big, bulky	• big	• relatively small
• spot measurment	• absorbance	• spatial

Table: examples of multispectral measurement devices

spectral estimation

- approach to obtain (multi)spectral measurements with standard camera
- only an estimation
- allows use of inexpensive sensor
- requires selection of suitable sensor and illumination
- requires measurement of a reference data set (ground truth data)

Outline

The SkImager

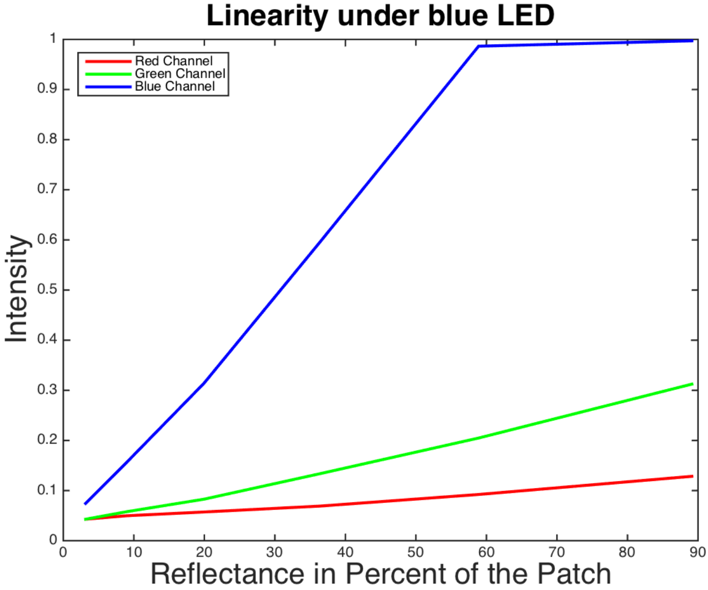
Figure: SkImager earlier proposed skin assesment prototype, polarized illumination 5 LEDs, cross polarized CMOS Sensor

The SkImager

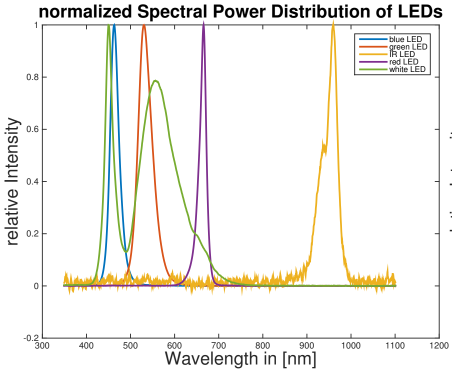
Overview Implementation

- cheap sensor
- multi illumination (5LEDs)
- fast, easy to use,

Linearity of the channels



SPD of the LED's



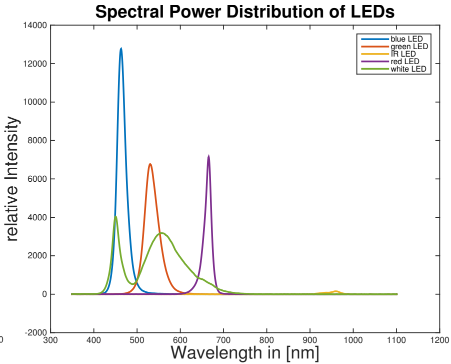


Figure: Spectral Power Distribution of the LED's in the SkImager

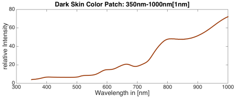
Outline

spectral estimation overview

- spectral measurement of 24 color patches
- SkImager measurements of 24 color patches
- building a matrix to transform 15 dimensional space into full spectra (up to 651 dimensions)

Training Data

Patch1



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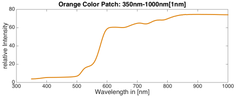
Patch7



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Patch24 ..

$24x81$

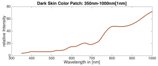
Table: building the groundtruth data reflectance Matrix

Training Data

$$\begin{pmatrix} Patch1 & R_{redLED} & G_{redLED} & .. & B_{IRLED} \\ Patch2 & R_{redLED} & G_{redLED} & .. & B_{IRLED} \\ .. & .. & .. & .. & .. \\ Patch24 & R_{redLED} & G_{redLED} & .. & B_{IRLED} \end{pmatrix}_{24x15}$$

Table: building the ground truth data SkImager Response Matrix

estimation matrix



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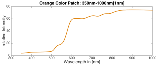

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$$\Big(\;\cdots\;\Big)_{24x81} = \begin{pmatrix} R_{redLED} & G_{redLED} & .. & B_{IRLED} \\ R_{redLED} & G_{redLED} & .. & B_{IRLED} \\ .. & .. & .. & .. \\ R_{redLED} & G_{redLED} & .. & B_{IRLED} \end{pmatrix}_{24x15} * A_{15x81}$$

estimation matrix

$$R_{reflectance\_24x81} = E_{SkImager\_trainresp\_24x15} * A_{15x81}$$

$$A_{15x81} = E^{\dagger}_{SkImager\_trainresp\_24x15} * R_{reflectance\_24x81}$$

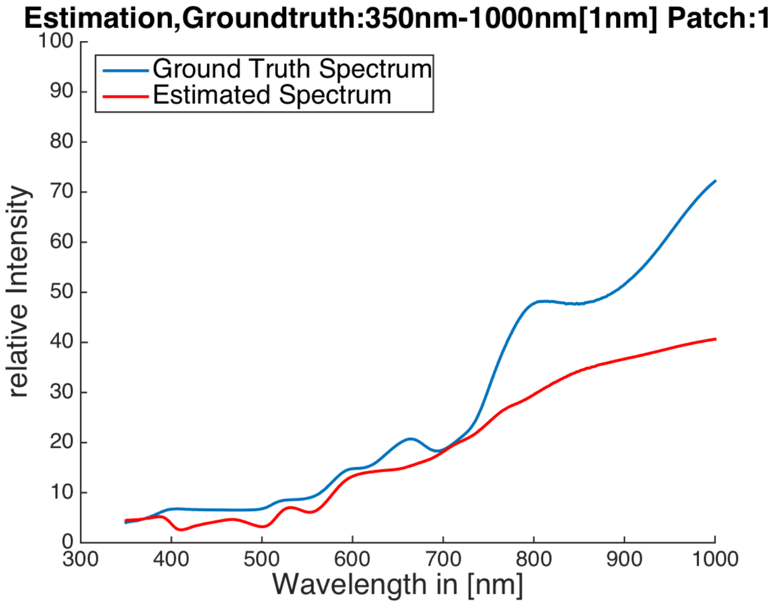
$$Reflectance_{estimated} = E_{SkImager\_TESTresp\_Pixelsx15} * A_{15x81}$$

Test Data

- first test for our estimation: recovering the color Checker reflectances (24 patches)
- ideal test set because close to the training data
- in noise free environment estimation should be perfect
- noise can be further accounted for with more sophisticated estimation methods

Outline

spectral estimation results

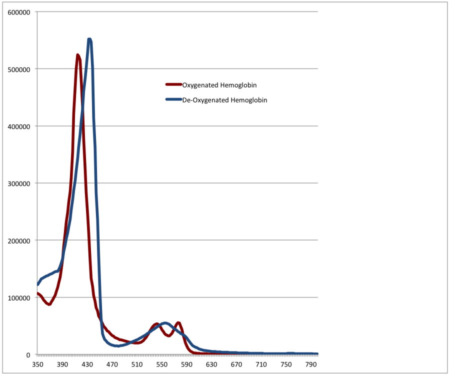


Occlusion Test

- second testing of the estimation
- patients arm was clamped pressure applied to the upper arm
- consecutive measurements over time
- well known measurment with known results
- estimation results for unique wavelength of oxygenated hemoglobin and deoxygenated Hemoglobin were used
- additionally comparing the estimation approach to the state of the art channel analysis

Results

a)



b)

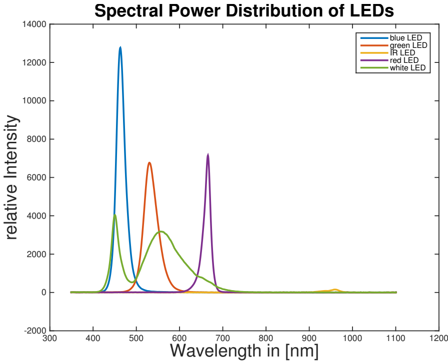
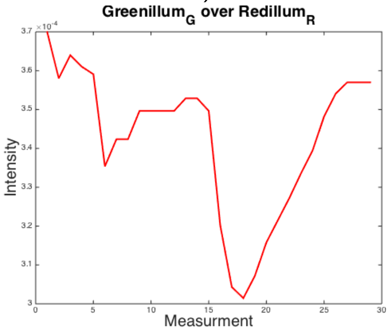


Table: a)Oxygenated and deoxygenated Hemoglobin spectral curves and b) spectral power distribution of the LED's

Results

a)



b)

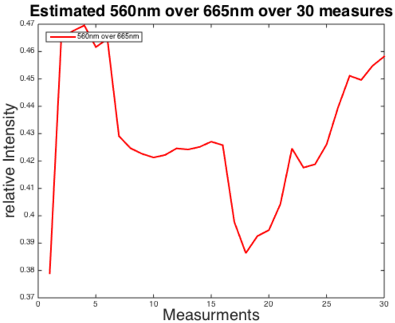


Table: a)conventional approach optimized channels in ratio compared to b) the new spectral estimation approach were specific wavelengths are put in ratios to obtain information

Conclusion

- spectral estimation workflow has been established
- the results are promising
- results are at least comparable to state of the art channel approach
- spectral estimation can be further optimized for these samples
- more unique wavelength in the hemoglobin curves can be used

- Better suited training data shall be aquired
- more sophisticated methods shall be explored
- spectral responsivity of the Sensor shall be measured and accounted for
- mathematical model for penetration depth of wavelength could be formulated

Questions?

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