Optical design improvement for non-contact skin cancer diagnostic device

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Introduction

Different types of skin cancer have seen an increase in incidence across Europe and worldwide. Therefore, there is a need for a fast, non-invasive and inexpensive skin cancer diagnostic methods to increase access and ease of diagnosis. A new device has been created that combines previously studied multispectral diffuse reflectance imaging and autofluorescence photobleaching imaging for automatic classification of skin diseases. The data processing algorithm, however, relies heavily on the homogeneity of irradiation as well as the preservation of polarization of the light incoming to the CMOS sensor. Some possible optical design adjustments are considered for the improvement of this diagnostic method.

Methods and set-up

Specific geometrical and other parameters of the developed prototype were compiled to create a simplified model of the device for calculation and simulation purposes. Calculations were done using *Wolfram Mathematica.*

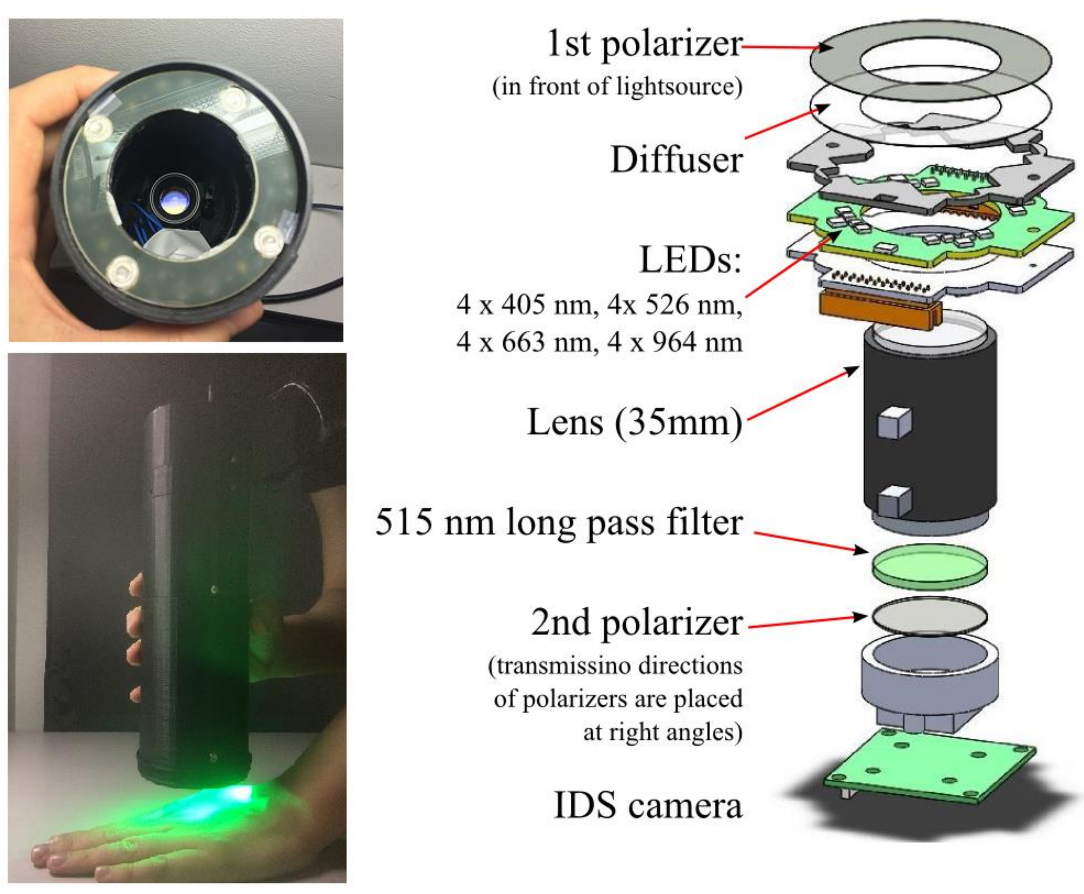

Figure 1. Prototype of the non-invasive skin cancer diagnostic device; its main components.

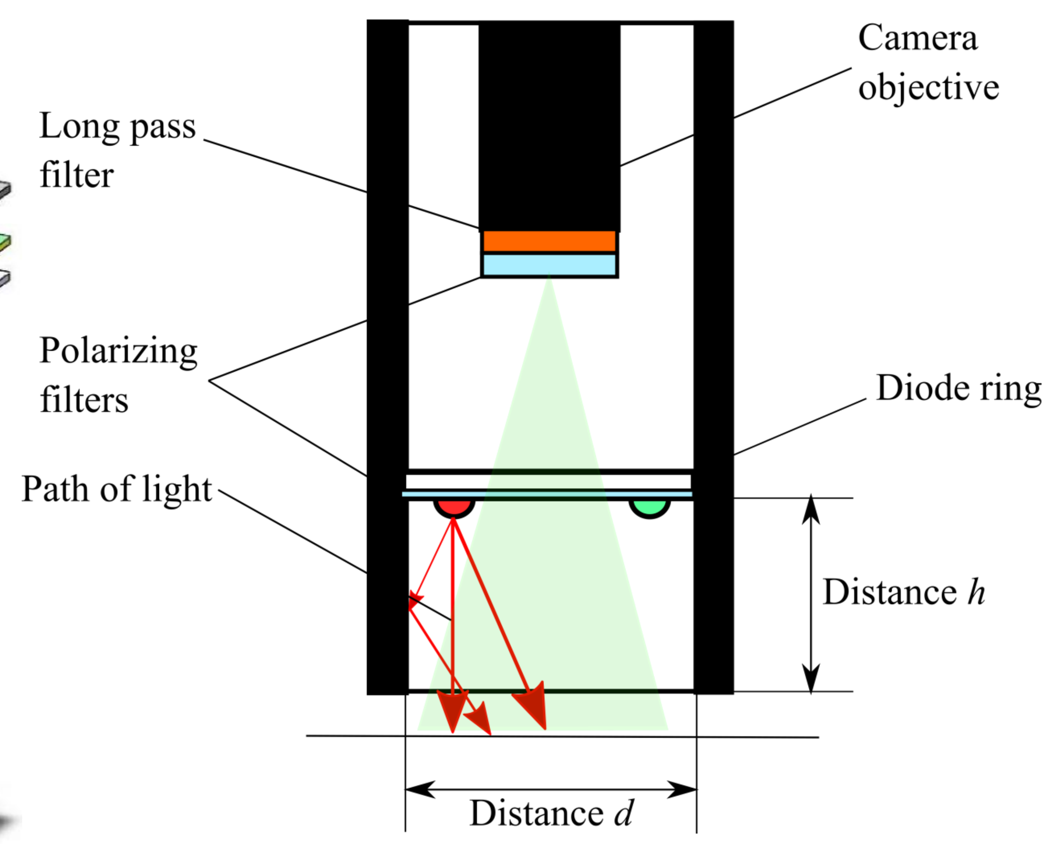

Figure 2. Simplified setup of the simulation based on the developed prototype. The green triangle represents the viewing angle of the objective lens.

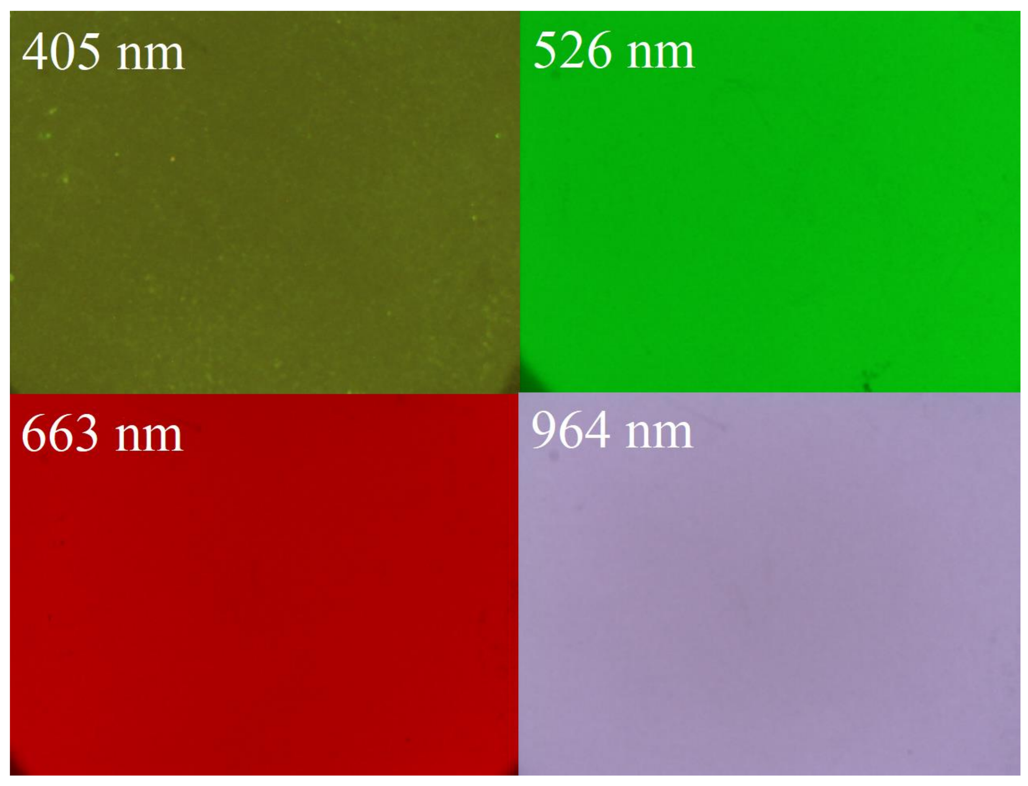

Figure 3. Typical test images captured before each measurement for each LED wavelength.

An equation was devised based on laws of light propagation for the irradiation at every point of the illuminated surface [1]:

$$E_n = \frac{I \cdot h}{(L_n^2 + h^2)^{\frac{3}{2}}}$$

Where $L_n = |n| \cdot d - (x + x_0) \cdot sgn(n)$
or $L_n = |n+1| \cdot d - (x_0 - x) \cdot sgn(n)$;

Homogeneity of the test images was assessed using a gray-level co-occurrence matrix [2]:

$$\sum_{i,j} \frac{p(i,j)}{1 + |i-j|}$$

Results

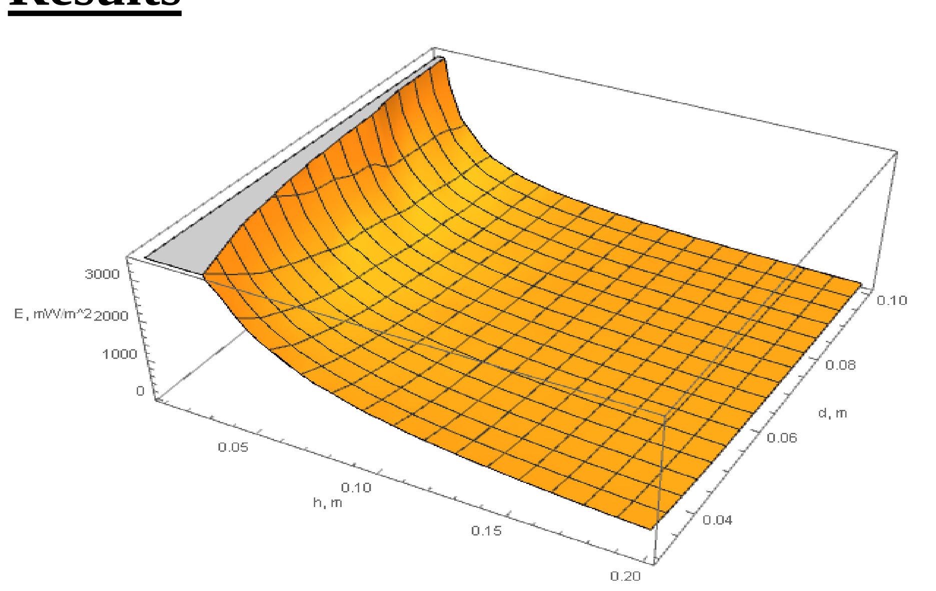

Figure 4. Modeled mean irradiation depending on the width of the spacer cylander *d* and the height between the LED ring and the surface *h*.

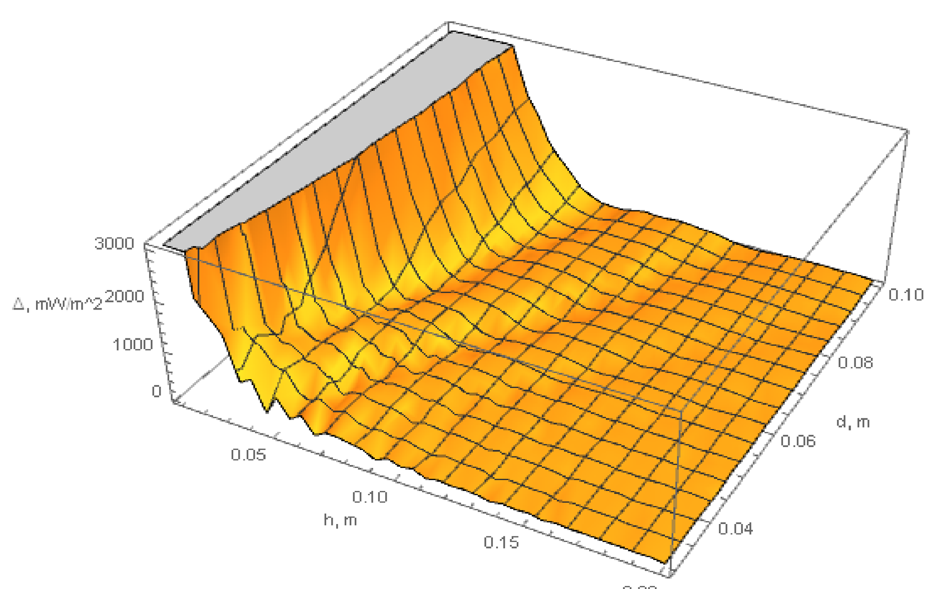

Figure 5. Sum of point deviations from mean irradiance value *Δ* depending on the width of the spacer cylinder *d* and the height between LED ring and surface *h*.

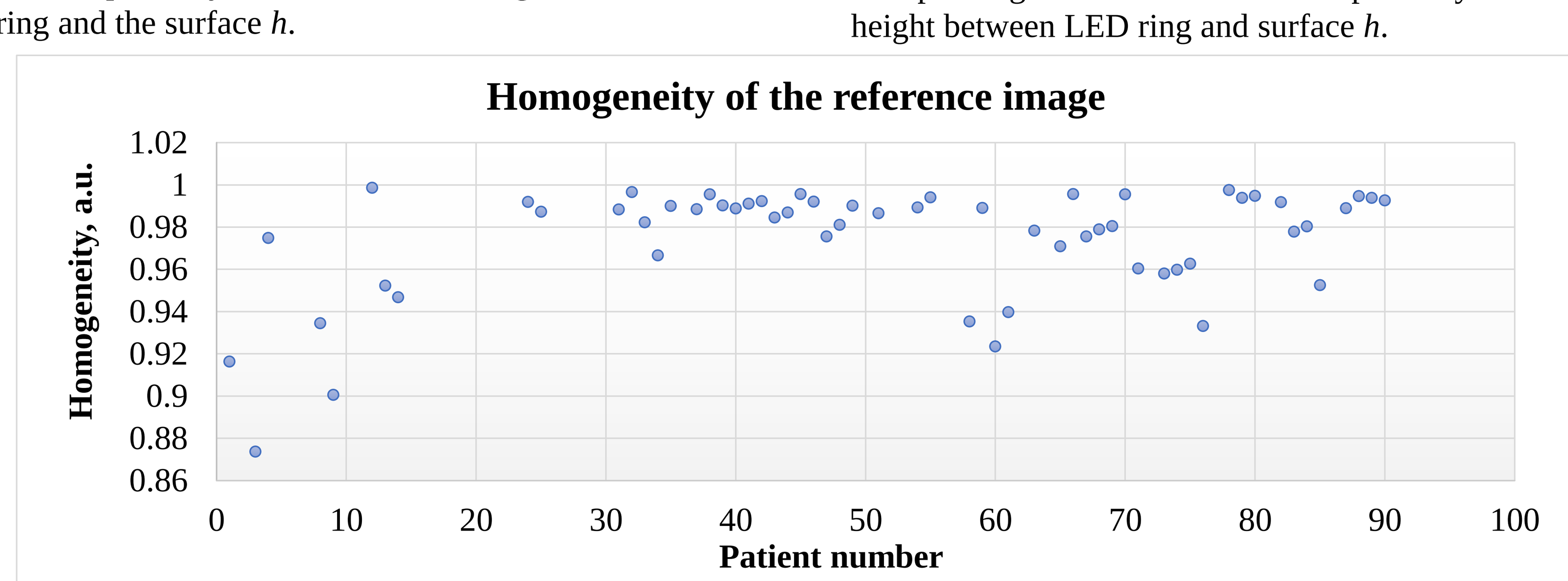

Figure 6. Homogeneity of the reference image taken depending on patient number which corresponds to the time taken during the study

Conclusions

- The simulation method poses many limitations, more parameters of the device and light propagation should be compiled in the calculations as well as the use of more sophisticated simulation software will be considered.
- Based on the calculations, highest homogeneity is achieved using a spacer with a diameter *d* = 54 mm, and the height of LED dioded *h* = 165 mm.
- For most measurements the homogeneity variance does not require additional compensation in the data processing step. It should only be considered when significant structural changes are introduced in the prototype.

References

[1] Ryer, A., [The Light Measurement Handbook], International Light Technologies, 9-39 (1997).

[2] Haralick, R.M., Shanmugam, K., Dinstein, I., “Textural Features for Image Classification”, IEEE Transactions on Systems, Man, and Cybernetics, 3(6), 610-621 (1997).

Acknowledgments

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