Internship project: Fighting skin cancer with widefield DRS (Monte Carlo simulations)

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1 Background information

Skin cancer incidence is growing dramatically and threatening to overwhelm hospital care. In the Netherlands, 77000 patients are diagnosed yearly making it the most common cancer as well as the 4th most expensive one [1]. The good news is that skin cancer is highly treatable when caught early. However, current early diagnostic methods lack both sensitivity and specificity resulting in missed cancers as well as many false positive diagnoses. Cancer statistics show that 80% of patients suspected with skin cancer are in fact cancer-free and unnecessarily referred to dermatologists [2], while 20% of skin cancers are still only caught at advanced stages when they are much more difficult to treat [3]. Diffuse reflectance spectroscopy (DRS) has been shown to be effective at detecting and staging skin cancer [4]. However, it is a fiber-based, point measurement which makes it impractical for large area imaging. We propose to perform many DRS measurements simultaneously using a camera and projector and leveraging a concept from information theory called code-division multiplexing (CDM). CDM allows multiple measurements to be performed at the same time without cross-talk. Utilizing diffusion theory it is then possible to extract information about the optical properties of the sample from the measured reflectance signals. These optical properties can then, in turn, inform us on the health status of the biological tissue by assessing physiological properties such as perfusion, blood oxygenation or relative concentrations of various chromophores (e.g. fat, water etc, melanin, etc.).

2 Proposed work

To validate some of the underlying assumptions of this innovative approach, the student will simulate light propagation in biological tissues using forward Monte Carlo simulations [5]. This will provide a detailed understanding of how light interacts with the tissue and help in refining our theoretical models. The student will develop a robust simulation framework based on the Monte Carlo Extreme software to explore various measurement parameters. This includes adjusting frame rate, illumination power, the number of codes, and code length for CDM. Such simulations are crucial for optimizing the performance of the DRS system, ensuring it can accurately and efficiently scan large areas of skin. Additionally, the student will evaluate the system's capability to separate signals and minimize cross-talk. This involves rigorous testing to ensure that multiple measurements can be conducted simultaneously without interference, a key advantage of using CDM. Finally, the student will investigate the operational limits of the proposed methodology. By identifying the boundaries within which the system performs optimally, they will help ensure the reliability and effectiveness of this novel diagnostic tool.

3 Requirements & learning outcome

We are looking for a highly motivated Bachelors/Masters student with a solid background in physics and engineering, and a passion for simulation work. Experience in Matlab programming is essential as our current MCX scripts are in this language. Through this internship, the student will gain a in-depth knowledge into Monte Carlo simulations which are widely used in the field of (biomedical) optics. They will develop valuable, highly transferable skills in modelling, experimental design, and data analysis. Additionally, they will also enhance their abilities in collaboration, scientific writing, and presenting. This internship, expected to last six to nine months (with flexibility to accommodate student needs), offers an exceptional opportunity to contribute to advancements in medical diagnostics at the forefront of the field.

References

[1] E. Noels, L. Hollestein, K. Luijkx, M. Louwman, D. Carin, R. van den Bos, A. van der Veldt, D. Grünhagen, and M. Wakkee, "Increasing costs of skin cancer due to increasing incidence and introduction of pharmaceuticals, 2007–2017," *Acta Dermato-Venereologica*, vol. 100, no. 10, 2020.

[2] G. Argenziano, S. Puig, I. Zalaudek, F. Sera, R. Corona, M. Alsina, F. Barbato, C. Carrera, G. Ferrara, A. Guilabert, *et al.*, "Dermoscopy improves accuracy of primary care physicians to triage lesions suggestive of skin cancer," *Journal of clinical oncology*, vol. 24, no. 12, pp. 1877–1882, 2006.

[3] NKR, "Nkr cijfers (huidkanker)."

[4] A. Garcia-Uribe, N. Kehtarnavaz, G. Marquez, V. Prieto, M. Duvic, and L. V. Wang, "Skin cancer detection by spectroscopic oblique-incidence reflectometry: classification and physiological origins," *Applied Optics*, vol. 43, no. 13, pp. 2643–2650, 2004.

[5] C. Zhu and Q. Liu, "Review of monte carlo modeling of light transport in tissues," *Journal of biomedical optics*, vol. 18, no. 5, pp. 050902–050902, 2013.