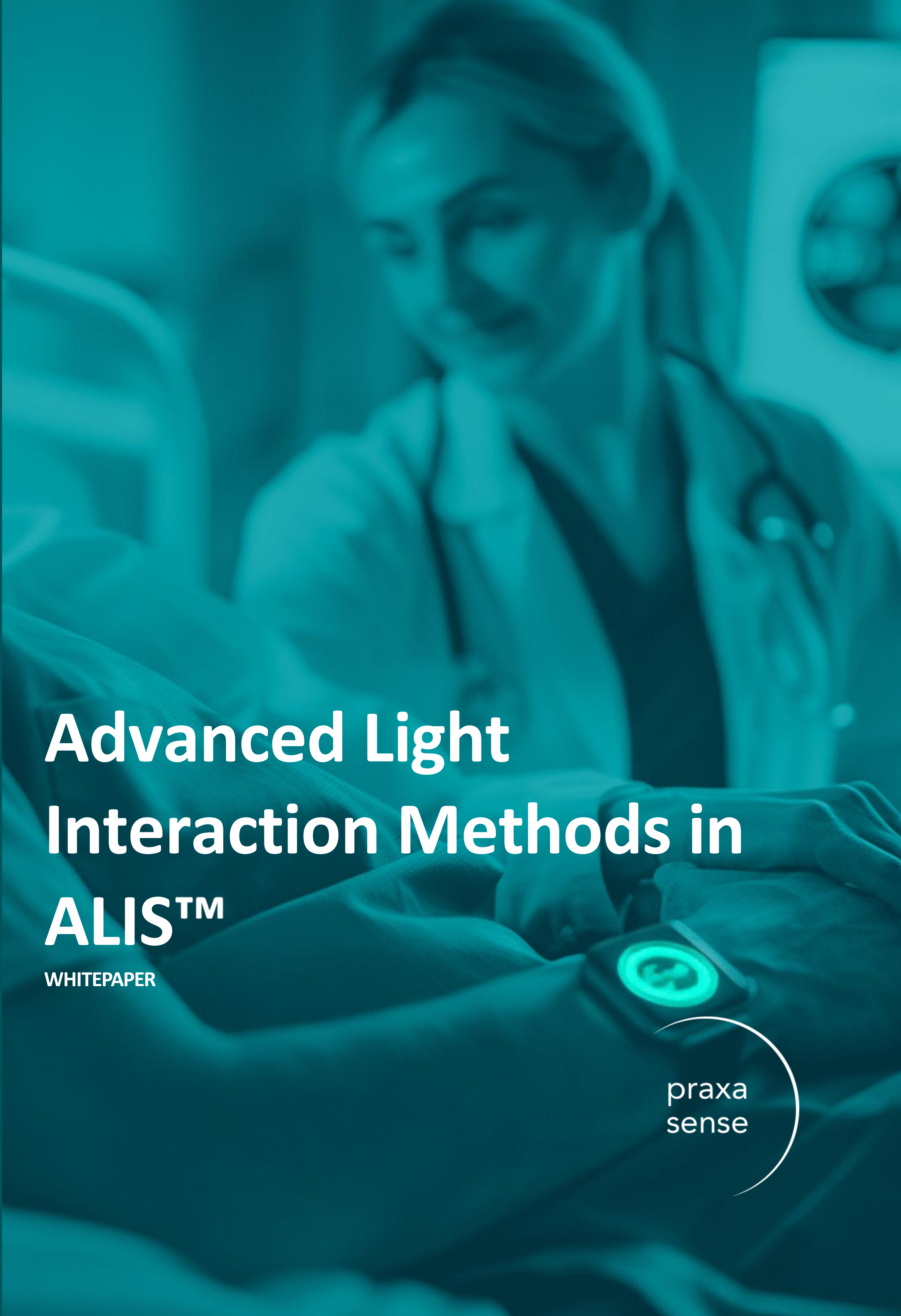

Advanced Light Interaction Methods in ALIS™

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Summary

The increasing demand for remote health monitoring (RHM) has highlighted the importance of reliable sensors in wearable devices. Photoplethysmography (PPG), a widely used technique, measures light absorption to monitor vital signs but faces challenges such as susceptibility to external light fluctuations.

Praxa Sense has developed a novel sensor, ALIS™, that integrates the measurement of both light absorption and scattering. Alongside the traditional PPG signal, it provides an additional Blood Flow index (BFi). Experimental results show that the ALIS™ scattering-based BFi signal is robust to external light fluctuations, enhancing reliability in ambulatory settings. This positions ALIS™ as a powerful tool for advancing RHM.

Background

As the healthcare system faces increasing pressure, the demand for remote health monitoring (RHM) methods is rising. In recent years, optical technologies have become essential in the field of RHM.

One of the most widely used optical methods is photoplethysmography (PPG), a simple, low-cost, non-invasive technique that utilizes a light emitting diode (LED) and photodiode to monitor vital parameters like heart rate and peripheral oxygen saturation. PPGs simple configuration allows a high degree of miniaturization and easy integration, which has made the technology very popular for wearable devices. The principle of PPG is based on light absorption, where light is emitted from the LED into the skin, and the variations in light absorption during the cardiac cycle are measured to assess vital parameters.

Although PPG technology has advanced significantly, like all biosignals it still faces inherent challenges. PPG signals are influenced by noise artefacts, particularly in ambulant conditions, complicating interpretation and analysis. Moreover, the full physiological origins of the signal remain an area of ongoing research. [1] These factors highlight the complexities of using PPG to develop reliable algorithms for predicting advanced vital parameters.

A complimentary approach can be the use of a sensing technique based on diffusing-wave spectroscopy (DWS) methods. DWS utilizes a coherent light source and rather measures the dynamics of scattering than absorption in the skin. [2] Based on these methods, Praxa Sense has developed a novel wearable sensor called ALIS™. The sensor quantifies both absorption and scattering and delivers the traditional PPG data along with a Blood Flow index (BFi), enabling the measurement of physiological features related to respectively mainly blood volume and blood flow velocity. ALIS™ aims to harness the strengths of both technologies, enhancing the accuracy and reliability of vital parameter monitoring in remote health applications.

Light Interaction Methods

ALIS™ integrates two distinct and complementary techniques to analyze the behavior of light in the skin. To understand the difference between the PPG signal and the BFi signal, it is essential to consider the two primary interactions that light undergoes within the skin: absorption and scattering. Light absorption is measured directly through changes in light intensity, which forms the basis of the PPG signal. Scattering, on the other hand, results in chaotic self-interference patterns. The scatter dynamics are derived by analyzing the correlation of these interference patterns, which serves as the foundation of the BFi. [2]

Effect of External Light

Because the BFi signal is propagated differently in light, its response to varying environmental light conditions also differs. To assess this effect, a simple experimental setup was designed to evaluate how ALIS™ PPG and ALIS™ BFi signals respond to external light fluctuations.

Measurements were conducted on the finger using an ALIS™ prototype, recording ALIS™ PPG and ALIS™ BFi measurements simultaneously. After approximately six seconds an oscillating current was introduced to an external LED to mimic fluctuating environmental light conditions with a frequency of 1Hz. The outcomes of this experiment are presented in Figure 1.

It is evident that the PPG signal is significantly affected by the oscillating external LED light, with heartbeat peaks being largely obscured by LED induced fluctuations. The ALIS™ BFi, shown in the top graph, does not seem to be affected by these external light fluctuations.

These results suggest that the ALIS™ BFi is less susceptible to variations in environmental light conditions, indicating enhanced robustness for everyday applications of RHM. This could potentially contribute to a reduction in motion artefacts and greater consistency across different skin types, addressing common challenges in ambulatory optical sensing. Furthermore, the specialized hardware in ALIS™ allows for enhanced optical filtering techniques to improve the BFi signal, which is not possible when using common PPG hardware. These enhancements offer greater control over the interaction between light and tissue, further improving signal quality and reliability in diverse conditions. This flexibility underscores the potential of ALIS™ technology to push the boundaries of non-invasive monitoring.

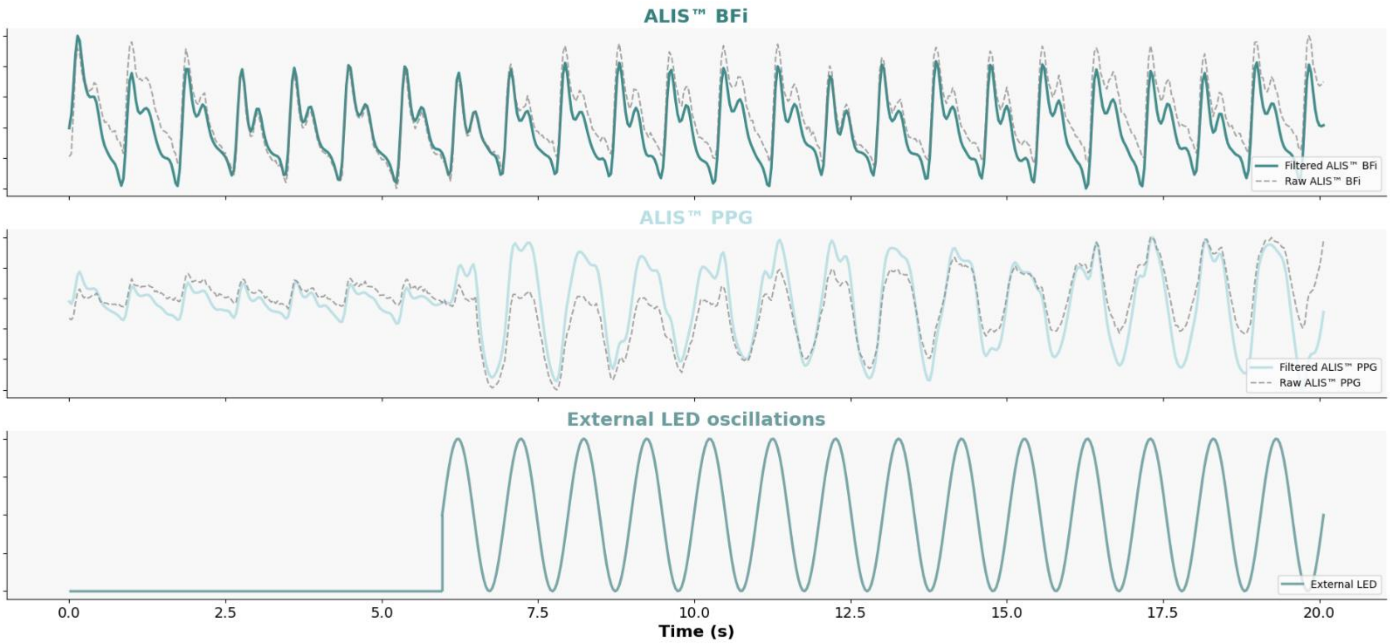

Figure 1. Top: ALIS™ Blood Flow index response; center: ALIS™ PPG response; bottom: External LED oscillations.

References

1. Kyriacou PA, Allen J. Photoplethysmography [Internet]. San Diego, CA: Academic Press; 2021. Available from: http://dx.doi.org/10.1016/c2020-0-00098-8

2. Berne BJ. Dynamic light scattering. Dover Books on Physics. Mineola, NY: Dover Publications; 2000.