# Noninvasive Photonic Sensing of Chemicals in Blood Stream by Using Machine Learning and Artificial Intelligence-Based Speckle Pattern Analysis

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In this paper we will discuss a noninvasive photonic sensing of presence of glucose and alcohol in the blood stream. The sensing mechanism is based upon analyzing the temporal-spatial changes occurring in back or forward scattered photonic speckle field and which is being analyzed by machine learning or artificial intelligence (AI) algorithms.

In the case of glucose concentration this analysis is done while coherent photons (coming from a laser illuminating source) are interacting with glucose molecules in the presence of externally applied alternating magnetic field (of about 150 Gauss). Due to the magneto-optic effect specific to glucose, high sensitivity and high specificity results were obtained both during *in-vitro* as well as *in-vivo* measurements. The results were further enhanced by AI analysis that includes machine learning and deep neural networks. The *in-vivo* measurements were performed both in free space sensing (of glucose in blood stream in a finger) as well as by using a multi-mode fiber sensor (that was touching the skin of a finger) while applying the same sensing methodology. Different concepts yielded different results but the direct approach of the finding glucose concentration from the recorded speckle pattern using the magneto-optic effect enhances the highest detection accuracy of 97.3% in the machine learning case due to the preprocessing of acquired data, which is highly selective at the inferred frequency (of about 100 Hz). The accuracy of the AI deep neural network model was around 90% and it can be further improved with future large-scale sampling study.

In the case of alcohol concentration this sensing is done by combination of machine learning analysis for the system including a laser directed towards the radial artery on the subject's hand and a camera, capturing defocused speckle pattern images of the illuminated area (no AC magnetic field is being applied). Our machine-learning model uses automatic feature selection for classification, achieving a high accuracy of above 87% and sensitivity of above 99%.