Fachhochschule Nordwestschweiz
Hochschule für Life Sciences

Analysis of NIRS and LDF Data from the Neurointensive Care Monitoring

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Bachelor's Thesis in Medical Engineering

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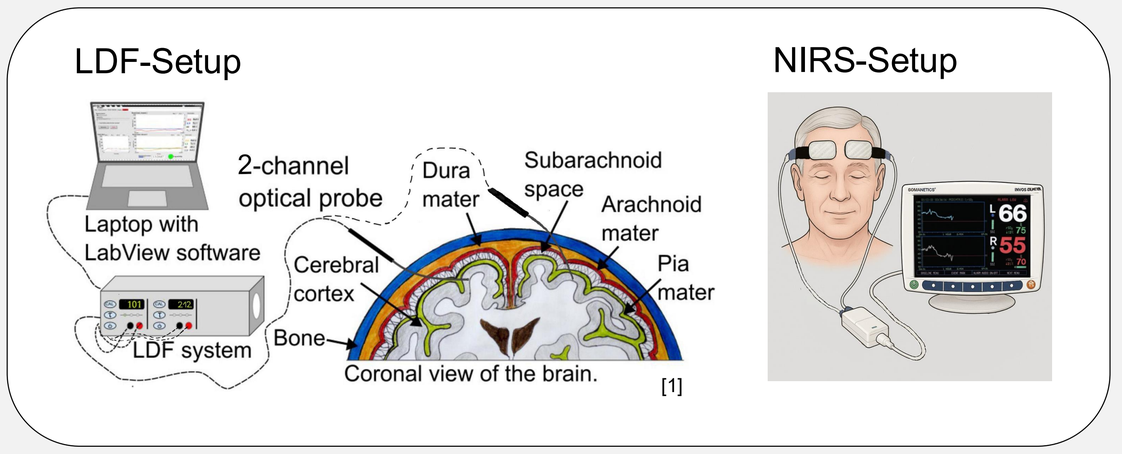
Introduction

Secondary brain injury after a subarachnoid hemorrhage (SAH) is a critical clinical challenge [1]. Continuous monitoring with Near-Infrared Spectroscopy (NIRS) to measure regional oxygen saturation (rSO_2) and Laser Doppler Flowmetry (LDF) for microvascular perfusion is a promising method for the early detection of ischemia [2]. However, a drop in rSO_2 is ambiguous; it can indicate ischemia (reduced oxygen supply) or an increase in metabolic demand [3]. This thesis explores whether combining NIRS and LDF data can resolve this ambiguity,

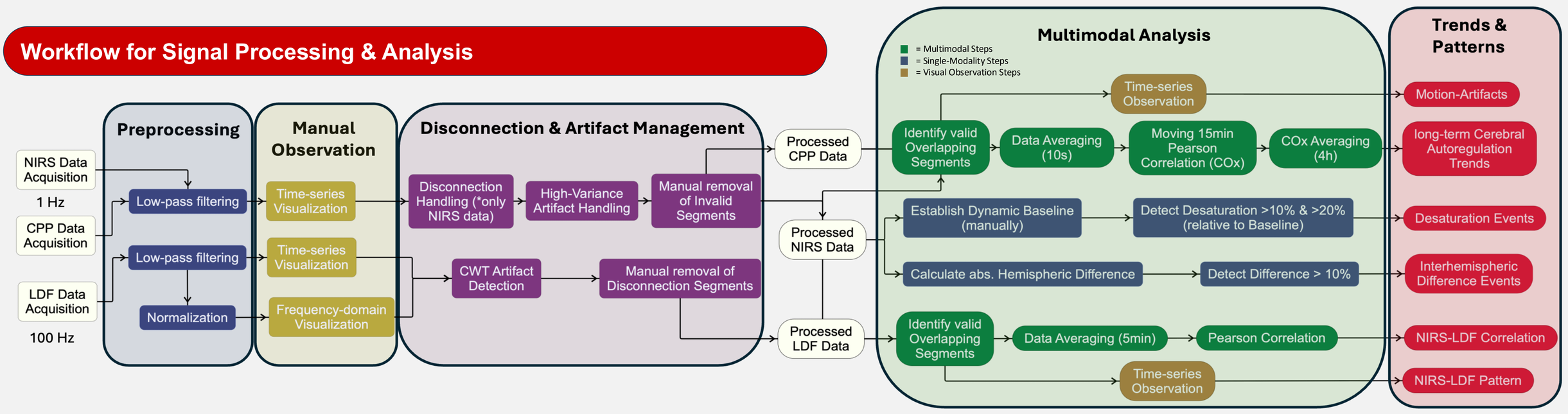
Aim of the Thesis

- Analyse long-term NIRS signals to improve the detection and Interpretation of cerebral oxygenation trends in post-SAH patients.
- Combine NIRS, LDF, and Cerebral Perfusion Pressure (CPP) data in a multimodal approach for a deeper understanding of cerebral hemodynamic.

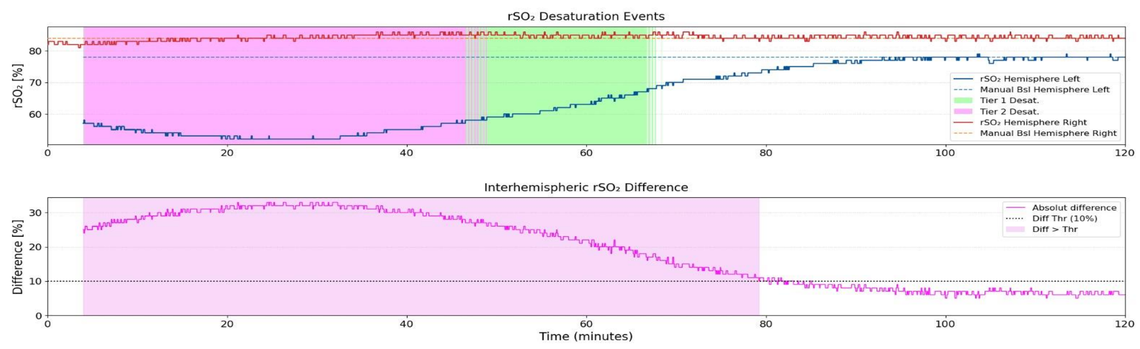


Study Population: Continuous data were acquired from three SAH patients in the neurointensive care unit (NICU).

Workflow for Signal Processing & Analysis

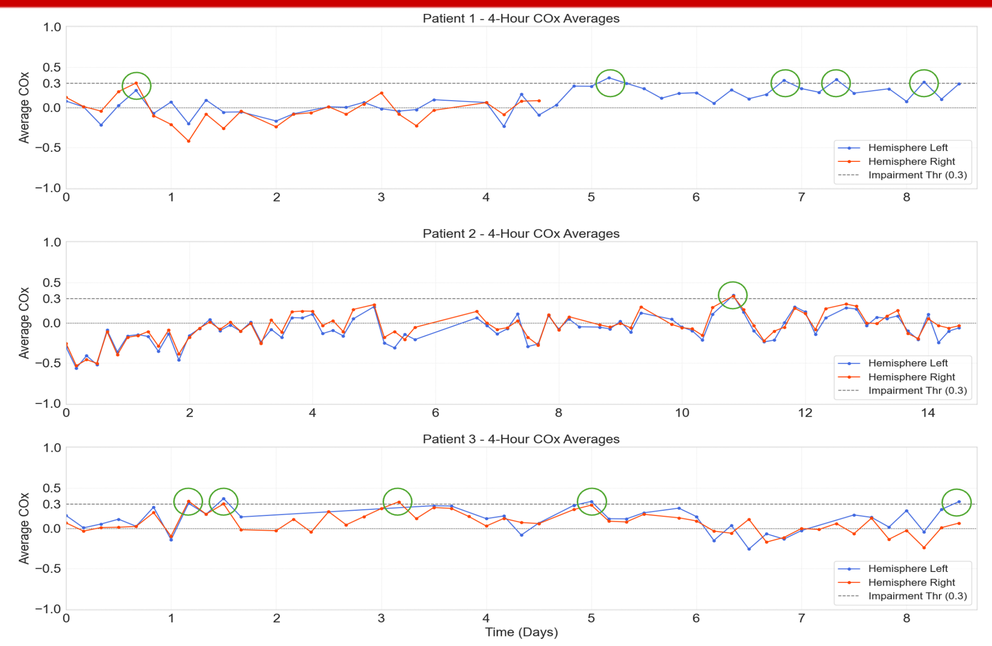


A. Identifying Critical Oxygenation Trends



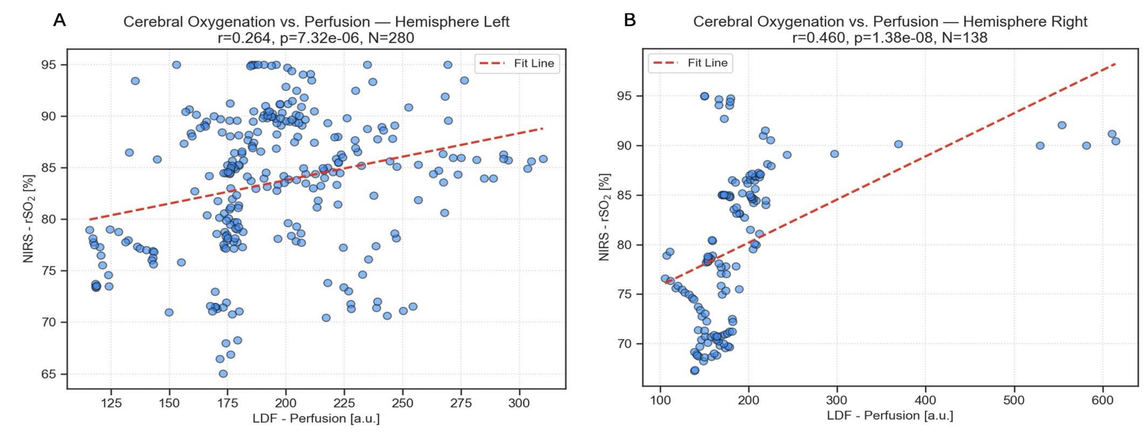
Signal processing enabled the detection of clinically relevant events. Patient 1 exhibited a profound, unilateral desaturation, with rSO_2 dropping over 20% below baseline for more than an hour, creating a >30% interhemispheric difference.

B. Long-term Cerebral Autoregulation Trends



Analysis of the Cerebral Oximetry Index (COx) revealed frequent and sustained periods of impaired autoregulation indicator (highlighted in green circles)

C. NIRS-LDF Relationship is Weak Overall...



Overall correlation between 5-minute averaged NIRS and LDF data for Patient 1 shows a weak linear relationship for the left r = 0.26 (A) and right r = 0.46 (B) hemisphere.

Conclusion

- Signal processing enables the detection of NIRS trends (desaturations, interhemispheric differences, impaired autoregulation), indicating potential secondary brain injury.
- A weak overall NIRS-LDF correlation is explained by fundamental mismatches in measurement volume (superficial vs. deep) and physiology (oxygen balance vs. oxygen supply).
- Direct bedside integration of NIRS and LDF to resolve desaturation ambiguity is currently not feasible due to these differences.

LINKÖPINGS UNIVERSITET

References
[1] S. Mauritzon, F. Ginstman, J. Hillman, and K. Wårdell, "Analysis of laser doppler flowmetry long-term recordings for investigation of cerebral microcirculation during neurointensive care", Nov. 2022.
[2] T. Y. Abay and P. A. Kyriacou, "Comparison of nirs, laser doppler flowmetry, photoplethysmography, and pulse oximetry during vascular occlusion challenges", Mar. 2016. .
[3] A. Ghosh, C. Elwell, and M. Smith, Cerebral near-infrared spectroscopy in adults: A work in progress, Dec. 2012.