Carola van Pul

Peter Andriessen

3.4. NICU VBHC innovations

Roadmap and goal

Preterm infants in the neonatal intensive care unit (NICU) of Carola van Pul and Peter Andriessen at Máxima Medical Centre require continuous monitoring as their life is at serious risk. Current patient monitoring is based on vital signs, however, multiple alarms are generated for the same critical event, causing alarm fatigueness of caregivers and stress in patient and parents. Moreover, detection of clinical deterioration with vitals crossing predefined boundaries can only be done in hindsight, whereas an early warning of such deterioration would be much more valuable. Finally, current monitoring involves a variety of obtrusive sensors and wiring, interfering with the babies' well-being.

As part of the perinatal roadmap, the ALARM project has focused on the solutions to address these limitations in current clinical practice: fusing of information of the vital signs to reduce false alarms, development of machine learning methods to earlier detect deterioration and application of video techniques for robust motion detection and unobtrusive monitoring.

Approach

The project approach has been different for these three topics. In all cases literature studies were performed and brainstorms organised for ideation. For the reduction of false alarms, work shadowing by the industry partner has been performed, and the staff of the NICU was involved to develop an improved workflow. All topics have been discussed in regular meetings with the full time staff, thus allowing for cross-over of relevant information between the different topics, while maintaining focus in work-packages with a smaller group of supervisors. The clinical studies were performed in Máxima Medical Center. The ALARM team was chosen in such a way that clinical, technical and business expertise were available. 2 PhD students and 2 postdocs performed the studies and analyses, always supervised by a team with all three stakeholders involved. Lab and office spaces at all partner locations facilitate progress meetings and the testing of ideas before using them in a clinical study. As part of the study, a new data collection system has been installed and a large dataset of vital signs is collected. Subsets of this large datasets are annotated for machine learning experiments.

Results

The workflow optimization study has led to a significant 30% reduction of critical alarms in current clinical practice while patients were kept longer in their physiological target range for 35% of the time, thus improving patient safety. This had a direct clinical impact and increased value. The optimisation method is published and can be used in all ICU settings to optimize alarm pressure in a safe way. The machine learning models are still in a development phase but developed in such a way that exploiting them in a patient monitoring environment, without complex connections to the EMR, is feasible.

The unobtrusive thermal camera system and algorithms to detect respiration from the videos has not only been shown clinically feasible in a proof-of-concept study but has also led to several patent applications.

Peter highlights the relevance of early detection and prediction: "For me, the true nature of value-based healthcare lies in early prediction of pathological processes like infection, a huge problem with these patients. Gaining a few hours can mean the world: adequate reaction time, quicker treatment and less damage for the child, which in turn means better chances for a future grown-up."

Carola indicates the importance of the e/MTIC partnership in this case: "Earlier detection of apnea, an extremely important indicator in the NICU, was made possible thanks to the profound expertise of Philips and TU/e. Now they are even able to measure baby movement from measurements of the blanket and respiration flow. After the recent completion of the ALARM project, this way of unobtrusive sensing is the next project selected from the roadmap."

Learnings from the e/MTIC approach

The e/MTIC approach, involving hospital, industry and university, ensures that all aspects of health technology developments can be addressed. The expertise in the team is high, the way of working and the relaxed atmosphere creates a friendly environment for the PhD students to work in, allowing them to grow.

In addition, for machine learning large datasets are needed. In an Intensive Care setting, informed consent cannot always be obtained upfront. But with guidance of data (security) officers and legal advice from the regulator team, it was possible to adequately anonymize or, in some cases, decode the signals for further processing within all GDPR rules.

The best results are obtained if focus is kept and expertise further developed. Improvements can still be found in strengthening research lines, better alignment of partner roadmaps and increased sharing of information and expertise across the many e/MTIC projects, further contributing to the fast track to clinical innovation.