Extending Vital Signs Monitoring, Neonatal Intensive Care Unit Study

Using novel non-contact vital signs technology, pre-infants were successfully monitored in a real-time, hospital environment, at the John Radcliffe Hospital, Oxford.

Summary

Pulse Oximetry has been the de facto technology for monitoring infants in a Neonatal Intensive Care Unit (NICU) for nearly 30 years. However, the sensors need to be in direct contact with the infants' skin, causing stress, pain, and damaging pre-term infants' fragile skin.

Oxehealth's software, Oxecam, turns standard digital cameras into health monitors, enabling non-contact monitoring of patients, including pre-term infants. The study, a first of its kind, used the software to monitor 30 pre-term infants at the NICU, John Radcliffe Hospital, UK.

The study results showed that it was possible to continually monitor heart rate and breathing rate using the non-contact technology, for several hours in the hospital setting without affecting patient care. Furthermore, we demonstrated that non-contact monitoring of oxygen saturation was possible using a single video camera, which we believe to be the first report of such results.
Clinical study: why continuous non-contact monitoring of pre-term infants is crucial

Since the advent of pulse oximetry – approximately 30 years ago – the monitoring of infants in an NICU environment has hardly changed. Not only this, current technologies used to continuously monitor the vital signs of pre-term infants require constant contact, with adhesive electrodes or sensors, habitually causing stress and pain, and damaging the pre-term infants’ fragile skin.

Non-contact technology enables monitoring of key pre-term infant vital signs, which is crucial to detecting any problems with automated physiological functions, to be done without distress or pain to the infant, allowing for easier treatment and recovery, as well as supporting nursing staff by reducing false alarms due to infants’ natural movement.

Oxecam can detect a face within a video image and identify parts of the face where strong physiological signals, such as heart rate and breathing, are present. This enables the technology to be taken out of the lab and applied to the real world including in the NICU.

The study

The clinical study has been undertaken in the high-dependency care area of the Neonatal Intensive Care Unit (NICU) at the John Radcliffe Hospital, Oxford, UK. During the study, 30 pre-term infants are placed one-by-one in a virtually unmodified incubator (a 3 cm diameter hole was cut in the top of the incubator canopy, to allow the camera to view the infant).

The camera is mounted at the end of a specially designed arm, to minimise disturbance to the care of the infant, and videos are captured with a resolution of 1620 × 1236 pixels, with 8 bits per pixel, at 20 frames per second.

The video camera has three separate CCD sensors to measure red, green and blue light intensity independently, and Oxecam acquires images via a Xilinx Spartan Field Programmable Gate Array (FPGA) board and a workstation running the Fedora Linux operating system.

Once stable periods are identified, two regions of interest (ROI) are computed. From one region such as the face, head or neck the changes in colour and volume with every heart
beat can be estimated. From a background region, the artefacts associated with strong light sources can be identified and minimised.

**Challenges and results**

Below are the results from two of the infants in our study. The table shows that the ‘stable periods’ during which ‘valid camera data’ are available amount to 66.5 per cent of the total recording time (24.9 h). For 33.5 per cent of the time, the infant was out of the cot (kangaroo care) or the cot was covered up during a period of quiet time or a clinical procedure was being carried out.

![Table 1Summary of each vital-sign monitoring session for two infants, each monitored on four consecutive days during the daytime](image)

**Conclusion**

Successful results from this study have demonstrated the abilities of Oxecam to monitor heart rate, respiratory rate and changes in oxygen saturation continuously in the NICU, with an accuracy that is clinically useful.

To our knowledge, this is the first study establishing the feasibility of continuous non-contact monitoring of cardiorespiratory vital signs in hospital using a digital video camera and regular ambient light, for several hours, without affecting patient care. We also believe this to be the first report of non-contact monitoring of oxygen saturation, in the NICU, using ambient light and a single video camera.

As a result, continuous non-contact vital sign monitoring in the NICU using ambient light is feasible, and the study demonstrates that clinically important events, such as bradycardia accompanied by a major desaturation, can be identified using Oxecam’s algorithms for processing the video signal.

This opens the door to a whole new world of neonatal camera-based health monitoring possibilities.