as a heat diffusion process on the network. That is, heat spreads from one node to its neighbours following the network structure. Also, heat spreads faster between nodes with similar attributes than nodes with dissimilar ones. As a consequence, node attributes of anomalous nodes induce bottlenecks for the heat diffusion. At the beginning of the process, each node has maximum heat because nothing has been spread yet. By increasing the time, i.e, the scale, the heat flows from one node to its neighbours with a propagation rate driven by the similarity between the attributes of the adjacent nodes. The flow tends to remain trapped in regions of the graph where nodes are highly similar or strongly connected. In this way, the diffusion flow unveils the modular composition of the network [3], where for small time scales, fine-grained clusters emerge as local contexts for potential anomalies, and larger times uncover coarser clusters as broader contexts for global outliers. Hence, anomalies are scale-dependent, and the time acts as a zooming parameter (as Google maps), to reveal the context in the network where the anomalies make sense.

Our approach has been validated empirically in synthetic and real-life attributed networks (e-commerce and web spam), outperforming many state-of-the-art methods, with the advantage of being highly efficient and parallelisable. Finally, it is worth noting that our approach is applicable on any attributed network independently of its nature or domain. Moreover, we plan to extend this approach in dynamic time-varying networks, where links between nodes change in time or new nodes join the graph dynamically.

Link:
[L1] https://kwz.me/h0T

References:

[1] L. Gutiérrez-Gómez et al.: "Multi-scale Anomaly Detection on Attributed Networks". Proceedings at 34th AAAI Conference on Artificial Intelligence, 2020.
[2] D. Shuman et al.: "The Emerging Field of Signal Processing on Graphs: Extending High-Dimensional Data Analysis to Networks and Other Irregular Domains", IEEE Signal Process, 2013.
[3] R. Lambiotte et al.: "Random Walks, Markov Processes, and the Multiscale Modular Organization of Complex Networks", in IEEE Transactions on Network Science and Eng., 2014.

Please contact:

Leonardo Gutiérrez-Gómez
Luxembourg Institute of Science and Technology (LIST), Luxembourg.
leonardo.gutierrez@list.lu

Non-Contact Vital-Sign Monitoring System for Premature Infants in Neonatal Intensive Care Units

by Péter Földesy, Imre Jánoki, Ákos Zarándy (SZTAKI) and Péter Pázmány (Catholic University, Budapest)

A camera and machine learning based system, developed at SZTAKI and by Péter Pázmány at Catholic University Budapest [L1], enables continuous non-contact measurement of respiration and pulse of premature infants. It also performs high precision monitoring, immediate apnoea warnings and logging of motion activity and caring events.

It is essential within hospitals to be able to continuously and reliably monitor vital signs, like the heart rate and respiration of newborn infants—particularly those in neonatal intensive care units (NICU). The heart and respiration rates can be extracted from the electrocardiogram (ECG), which despite being a non-invasive technique still relies on direct contact with the body. The self-adhesive electrodes are relatively expensive, and more importantly they can easily damage the sensitive skin of preterm infants. Therefore, non-contact monitoring is a daily need in NICUs.

Recent studies have shown that non-contact visual vital-sign monitoring is a reliable and accurate technique [1] although, like traditional contact monitoring methods (e.g. ECG, pulse-oximeter), it suffers from motion artefacts. During periods of caring (e.g. baby is removed, skin-to-skin contact with parent visible, cleaning, nurses change feeding tube, etc.) or intense activity the measurements are inaccurate, so these situations need to be treated separately. Our system can detect and handle common activities, such as infant self-motion, phototherapy treatment and low light conditions with infrared illumination, with a high confidence level. Unlike other systems, our system provides continuous monitoring, not limited to motionless periods. The respiration waveform and rate are calculated directly from the chest and abdomen movements, giving a physiologically and computationally more reliable and more established result than extracting them based on remote photoplethysmography (rPPG), like some existing algorithms do.

In the framework of signal and rate extraction, a top classifier runs, with feature extraction and a neural network classifier, distinguishing events and status of the view. This classifier can detect an empty incubator, an active or passive infant, caring and other motion related situations with 98% precision in real life clinical practice. Whenever the infant is detected, the heart and respiration rates are extracted from the video feed as described below.

The heart rate calculation consists of an ensemble of two networks: (i) the signal extractor network, which derives the pulse-signal from the video input; (ii) the rate estimator network, which calculates the heart rate value from the signal. For the former, the PhysNet architecture [2] is applied and the rate estimator is our own network, named RateEstNet. These networks are fused and trained together after the pre-training of PhysNet. We have developed a novel augmentation technique, called frequency augmentation, which produces a uniform heart rate distribution that results in unbiased training (i.e., the network is not biased towards the average heart rate value).

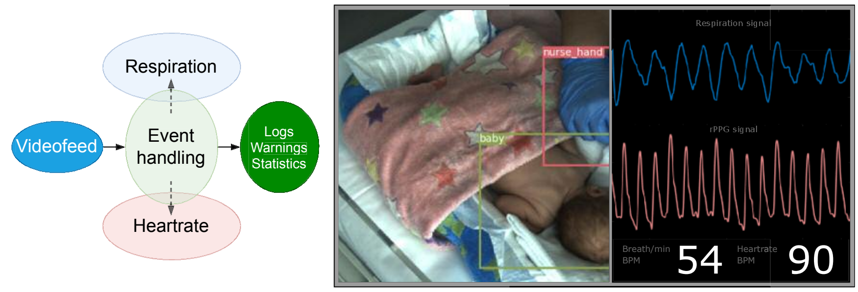

Figure 1: A high-level functional block diagram of our real-time, continuous monitoring system (left), and a typical display view showing the extracted waveforms and rate estimations along with object detection overlay (right).

The respiration rate calculation incorporates the more traditional way of image processing with optical flow and a machine learning approach as well. A dense optical flow algorithm extracts the movements from a series of grayscale images in a time window of about six seconds. The resulting differential sequence is then masked using a U-Net machine learning architecture to filter only the abdomen and chest [3]. The images are summed and processed to get the waveform of the respiration. In a last step, we use a neural network consisting of one-dimensional convolutional layers with a fully connected part at the end to get the respiration rate.

Our system can estimate pulse and respiration rates and can handle medical intervention and heavy motion scenarios built up from an ensemble of hierarchical neural networks (see Figure 1). In physical form the system is under integration into an open incubator pilot product of a leading Hungarian incubator manufacturer, including medically safe night vision illumination and hardware acceleration of the neural networks by a NVIDIA Jetson Nano module.

The method's performance is being evaluated in real-time and on a carefully annotated database collected at the First Department of Neonatology of Paediatrics, Department of Obstetrics and Gynaecology, Semmelweis University, Budapest, Hungary [L2]. The project started in early 2018 and is still running, with further product integration and R&D for extending night vision capabilities, closed incubators, behavioural studies and sleep quality evaluation.

Links:
[L1] https://kwz.me/h4V
[L2] https://kwz.me/h4W

References:

[1] K. Gibson, et al: "Non-contact heart and respiratory rate monitoring of preterm infants based on a computer vision system: a method comparison study", Pediatric research 86.6, pp. 738-741, 2019.
[2] Z. Yu, L. Xiaobai , Z. Guoying: "Remote photoplethysmograph signal measurement from facial videos using spatio-temporal networks", Proc. of BMVC, pp. 1-15, 2019.
[3] R. Janssen, W. Wang, A. Moço, G. de Haan: "Video-based respiration monitoring with automatic region of interest detection", Physiological Measurement, vol. 37, no. 1, pp. 100-114, 2015.

Please contact:

Péter Földesy
SZTAKI, Hungary
+36 1 279 6000/7182
foldesy@sztaki.hu

An Automatic Anomaly Detection System (AADS) for Fully Autonomous Ships

by Bekir Sahin and Ahmet Soylu (NTNU)

Various global factors - including, variability in maritime regulations, technological progress, and ecological and environmental problems - have been converging, pointing to the importance of sustainability in the maritime industry. To reduce maritime accidents and the loss of life and property, sustainability needs to be factored into the design of autonomous ships. During the transition from conventional to autonomous ships, all past experience should be transferred to new systems. An anomaly detection system integrated with big data analysis, inference systems and cloud systems can become quite sensitive to maritime accidents.

The evolution of shipping is a gradual process, with progressive technological advances changing how decisions are made, actions initiated, and initiatives taken during navigation and maritime operations. Ships will evolve from human operated to fully autonomous vessels, authority will evolve from human to software and actions taken will evolve from human to systems.

Autonomous ship design and autonomy optimisation have been among the most popular research topics in the maritime literature in recent years [L1]. Automatic Anomaly Detection System (AADS) is an inevitable requirement for unmanned marine vehicles. For this reason, unmanned surface ships are operated either in places where risk is minimal or in experimental scenarios with managed malfunctions, dangers and accidents [L2].

The marine environment is uncertain, complex, and dynamic, with many parameters at play, and shipping operations involve hundreds of possibilities and risks. In addition, a value that is not determined as a risk for a situation can be very risky in another situation and