ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME

ERCIM
European Research Consortium
for Informatics and Mathematics

Scientific Report

First name / Family name	Noha El-Ganainy
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Period of the fellowship	01/11/2018 to 31/10/2020

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

My research plan is a part of the evolution of digital healthcare where advanced analytics are employed to improve the healthcare. The aim was to develop a clinical decision support tool able to provide real time decisions on specific clinical problems based on machine learning. The proposed clinical decision support tool is mainly analysing the patient's vital signs on the form of streams. The first phase of my project was to investigate different machine learning methods for stream learning. I have started by studying a new machine learning algorithm namely the hierarchical temporal memory (HTM). The algorithm is capable to learn the stream's temporal pattern in an unsupervised manner and provides predictions several steps into the future in real time. It doesn't need to store the stream and the analysis is done in real time in a continuous and incremental way. I have compared this algorithm with the state-of-the-art algorithms such as the long short-term memory (LSTM) to investigate the prediction efficiency in terms of the error metrics. The results showed that HTM leads to more accurate predictions. As I am studying clinical applications, I have used medical streams in my simulations. Both HTM and LSTM were assigned to predict anomalies in different monitored streams in real time. The streams represent the

patient's vital signs. Next, I have developed a new clinical decision support tool using a new machine learning structure for critical care units. The proposed machine learning structure is composed of two stages; HTM and a classifier to provide an early decision on specific clinical status in real time. Early decisions are very important in clinical practice as they allow timely targeted therapies and lifesaving interventions. The proposed framework was compared to the state-of-the-art frameworks using logistic regression. The results showed that the proposed structure leads to improved performance and more accurate decisions with a large decision-to-event time. We therefore has proofed that the proposed framework leads to improved results and performance compared to the currently employed frameworks.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

"On the performance of Hierarchical temporal memory predictions of medical streams in real time"

Noha El-Ganainy, Ilangko Balasingham, Steinar Halvorsen, and Leiv Arne Rosseland.

13th International Symposium on Medical Information and Communication Technology (ISMICT), pp.157- 163,May 2019. DOI: 10.1109/ISMICT.2019.8743902

(accepted and published)

"Machine learning is widely used on stored data, recently it is developed to model real time streams. Applying machine learning on medical streams might lead to a breakthrough on emergency and critical care through online predictions. Modeling real time streams implies limitations to the current state-of-the-art of machine learning and requires different learning paradigm. In this paper, we investigate and evaluate two different machine learning paradigms for real time predictions of medical streams. Both the hierarchical temporal memory (HTM) and long short-term memory (LSTM) are employed. The performance assessment using both algorithms is provided in terms of the root mean square error (RMS) and mean absolute percentage error (MAPE). HTM is found advantageous as it provides efficient unsupervised predictions compared to the semi-supervised learning supported by LSTM in terms of the error measures. "

"A new real time clinical decision support system using machine learning for critical care units"

Noha El-Ganainy, Ilangko Balasingham, Steinar Halvorsen, and Leiv Arne Rosseland.

IEEE Access, Vol. 8, pp. 185676 – 185687, October 2020.

DOI: 10.1109/ACCESS.2020.3030031 (accepted and published)

"Mean arterial pressure (MAP) is an important clinical parameter to evaluate the health of critically ill patients in intensive care units. Thus, the real time clinical decision support systems detecting anomalies and deviations in MAP enable early interventions and prevent serious complications. The state-of-the-art decision support systems are based on a three-phase method that applies offline training, transfer learning, and retraining at the bedside. Their applicability in critical care units is challenging with delay and inaccuracy. In this paper, we propose a real time clinical decision support system forecasting the MAP status at the bedside using a new machine learning structure. The proposed system works in real time at the bedside without requiring the offline phase for training using large datasets. It

thereby enables timely interventions and improved healthcare services. The proposed machine learning structure includes two stages. Stage I applies online learning using hierarchical temporal memory (HTM) to enable real time stream processing and provides unsupervised predictions. To the best of our knowledge, this is the first time it is applied to medical signals. Stage II is a long short-term memory (LSTM) classifier that forecasts the status of the patient's MAP ahead of time based on Stage I stream predictions. We perform a thorough performance evaluation of the proposed system and compare it with the state-of-the-art systems employing logistic regression (LR). The comparison shows the proposed system outperforms LR in terms of the classification accuracy, recall, precision, and area under the receiver operation curve (AUROC).»

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

In January 2019, I have attended the Milan critical care datathon and the European society of critical care data talks in Milan, Italy.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

I have done the REP at Simula Labs, Norway. The 2 weeks focused on machine learning applications for streams and medical images.