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EDITORIAL

Evolving sensor systems

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The general availability of low cost sensors, short range radio technology and advances in the Internet of Things (IoT) and wireless networking are enabling the wide spread use and deployment of sensors. Reasoning with sensor data is increasingly an important componant of intelligent system where actionable insights must be discovered to support decision making. Advances in sensor technology is driving the adoption of ubquitous and pervasive computing systems in a wide range of industry sectors from sensing environmental phenomena such as weather events, air quality analysis; to wearable sensors that provide analysis of human movement, posture and general well-being; to industrial sensing for predictive maintenance, condition monitoring and industrial asset management.

Traditional sensor-based systems are convenient for static world-models. However, the real-world is far from static and is often characterised by variety and dynamism. For example, wearable sensors for recognising human activity are typically trained on a predefined, closed set of activity classes e.g. sitting, running, and walking. However, natural human activities are much more varied than these predefined set. Thus, for a human activity recognition system to have full utility in a natural setting, it should be able to recognise new activity types as it encounters them. Another example application of evolving sensor systems is intelligent and autonomous driving. Due to the variety in road circumstances and terrain, intelligent vehicles often need to be trained from live driving data. Thus, the sensors in such systems take in real-time data in order to update the knowledge model to handle new situations. As such the ability to adapt is crucial when reasoning with sensor data.

Evolving systems are inspired by the idea of system models that change and adapt in a dynamic environment. The aim of evolving systems is life-long learning and self reorganisation in order to adapt to unknown and unpredictable environments through gradual change, system structure evolution and parameter adaptation. An important consideration is the ability of such systems to balance the ability to learn new concepts whilst selectively forgetting the past.

This special section includes contributions on evolving sensor systems. We have carefully chosen three different applications that present algorithms and methods that allow the refinement and adaptationof learnt models in order to evolve to changing physical and environmental circumstances.

The first paper "Predictive Intelligence to the Edge: Impact on Edge Analytics" by Natascha Harth Christos Anagnostopoulos, and Dimitrios Pezaros addresses the problem of efficient contextual data analysis in which processing and inference is performed on the sensing devices at the edge of the Internet of Things (IoT) instead of transmitting data to a centralized computing environment/Cloud. The authors propose a lightweight, distributed, predictive intelligence mechanism that supports communication, efficient aggregation and predictive modelling within the edge network. The approach is based on the capability of the edge nodes to monitor the evolution of the sensed time series contextual data, locally determine (through prediction) whether to disseminate contextual data in the edge network or not, and locally re-construct undelivered contextual data in light of minimising the required communication interaction at the expense of accurate analytics tasks. The authors conducted a comprehensive experimental evaluation of the proposed mechanism over two real multidimensional contextual datasets for aggregation and linear regression analytics tasks. The results reported in the paper demonstrate the efficiency of the proposed approach in supporting high quality edge analytics by tolerating a relatively low error despite a significant reduction of the communication overheads in an edge network.

The second paper "Multistatic Radar Classification of Armed vs Unarmed Personnel Using Neural Networks" by Jarez Patel, Francesco Fioranelli, Matthew Ritchie, and Hugh Griffiths investigates the potential of deep neural

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networks (DNNs) for improving the classification performance of radar processing, in the specific case of identifying armed vs unarmed personnel. Real world-data human micro-Doppler radar data were collected using multistatic radar system. The main advantage of using DNNs is the ability to automatically extract relevant features from the raw data and the experimental results shown in the paper confirm the potential of the proposed approach in real world scenarios.

The third paper "Evolving ANN-based Sensors for a Context-Aware Cyber Physical System of an Offshore Gas Turbine" by Farzan Majdani, Andrei Petrovski and Daniel Doolan presents a novel adaptive multi-tiered framework for designing a context-aware cyber physical system for smart data acquisition and processing. There are three phases in the proposed framework: processing, predication and anomaly detection. The processing phase aims to minimise the data volume and processing cost by analysing only inputs from easily obtainable sources using context identification techniques for finding anomalies in the acquired data. In the prediction phase, future values of each of the sensors are estimated using a linear regression model. During the anomaly detection phase potential anomalies in the operation of the cyber physical system under monitoring and control are identified. The proposed framework is applied to the implementation of a context-aware cyber physical system for condition monitoring of a gas turbine on an offshore installation. The developed system utilises an evolving sensor and it is capable of highly accurate predictions of the gas turbine status.

We hope that you will find the papers interesting. The Guest editors wish to thank all the authors and reviewers that contributed to this special issue, and to the editors-in-chief and editorial office of the Evolving Systems journal for their support.