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Guest Editorial: Special Issue on Design and Architectures for Signal and Image Processing 2021

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Signal and image processing systems are an essential component of the industrial revolution that we are currently witnessing. Intelligent sensors, internet of things (IoT), autonomous vehicles (cars, UAVs - Unmanned Aerial Vehicles), advanced robotics - these are just some of the applications that require fast analysis of a large data stream from various types of sensors. It is also worth highlighting the dynamic development of artificial intelligence methods observed in recent years, including the so-called deep neural networks (DNNs) and the increasing attention paid to cybersecurity issues. All these aspects translate into increased computational complexity of algorithms, which is currently a technological challenge. Hence, in addition to work on the development of methods and their optimisation, it is also necessary to look for new methods of modelling and implementation of dedicated computing architectures, which will make it possible to run even complex algorithms, with appropriate speed and within a given energy budget.

This issue consists of 9 papers, that are briefly discussed as follows:

The first step in data processing systems is data acquisition. In addition to traditional RGB cameras, neuromorphic (DVS - Dynamic Vision Sensors) and RGB-Z (depth) sensors are increasingly used in computer vision systems. The latter technology is the subject of the paper "*Color Pixel Reconstruction for a Monolithic RGB-Z CMOS Imager*", which focuses on the issue of colour reconstruction and proposes a demosaicing algorithm adapted to this new type of sensors.

Neural networks have been attracting sustained interest for several years. In addition to the well-known Convolutional Neural Network (CNN) models, other approaches are also being explored, including the so-called Capsule Networks (CapsNet), which are the subject of the article "*Convolutional Fully-Connected Capsule Network (CFC-CapsNet): A Novel and Fast Capsule Network*?. In the paper, the authors propose a new variant, the Convolutional Fully-Connected Capsule Network (CFC-CapsNet), which speeds up both the learning and inference processes in this type of network.

Perception systems in self-driving cars is another very popular and important research topic. The paper "I*mplementation of the PointPillars Network for 3D Object Detection in Reprogrammable Heterogeneous Devices Using FINN*? presents the hardware and software implementation of a network for object detection (vehicles, pedestrians, cyclists) in SoC FPGA based on a point cloud acquired with a LiDAR sensor. The focus of the work was to optimise the computational architecture by, among other things, applying quantisation. The results show how challenging it is to process a large data stream within a limited energy budget.

The paper "*Automotive Perception System Evaluation with Reference Data from a UAV's Camera Using ArUco Markers and DCNN*" deals with the evaluation of autonomous vehicle perception systems (e.g. the aforementioned detection module based on data from a LiDAR sensor) using UAVs. The presented solution is an interesting alternative to expensive systems using precise GPS (Global Positioning System) sensors and shows the advantages and disadvantages of using drones for this type of measurements.

Currently available cameras generate very high resolution video streams. If it is not possible to analyse the images in the camera (so-called smart camera), it becomes

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necessary to transmit the stream to a remote location, but it usually has to be compressed. However, this process can introduce artefacts that have a negative impact on classification using neural networks. In the paper "*Architecture of a Low Latency H.264/AVC Video Codec for Robust ML-based Image Classification*", the authors propose a solution to this problem by modifying the popular H.264/AVC codec, which differentiates the compression ratio, depending on the image content.

Compression issues are also addressed in the paper "*Multiple Transform Selection Concept Modeling and Implementation Using Dynamic and Parameterized Dataflow Graphs*". The authors propose to optimise the Multiple Transform Selection (MTS) module that is part of the Versatile Video Coding (VVC) standard. The use of parallelisation and dynamic reconfiguration allows for a significant acceleration of computations for the implementation on a x86 architecture.

Dataflow is a parallel and generic model of computation that is agnostic of the underlying multi/many-core architecture executing it. In the paper "*The Impact of Cache and Dynamic Memory Management in Static Dataflow Applications*", the authors present the results of a study on the use of cache memory in this type of computations. The results show that more cache memory does not always mean more computational performance. In addition, two memory management strategies Copy-on-Write (CoW) and Non-Temporal Memory transfers (NTM) that reduce computation time and power consumption are analysed.

Cybersecurity is another important aspect of all electronic devices, especially those connected to the Internet - the broadly defined IoT (Internet of Things). In the paper "*DExIE - An IoT-Class Hardware Monitor for Real-Time Fine-Grained Control-Flow Integrity*", the authors propose a lightweight hardware monitor that can be flexibly attached to many IoT-class processor pipelines. It enables to catch both inter- and intra-function illegal control flows in time to prevent any illegal instructions from touching memory while having nor or only a little negative impact on processor performance.

In the paper "*SECURE-GEGELATI Always-On Intrusion Detection through GEGELATI Lightweight Tangled Program Graphs*", the authors focus on network intrusion detection using machine learning methods. The Tangled Program Graph (TPG) machine learning method is applied and is shown to be superior to the Random Forest based approach.

This special issue was preceded by the 14th Workshop on Design and Architectures for Signal and Image Processing held in conjunction with the 16th HiPEAC Conference in Budapest Hungary on January 18?20, 2021 (the event was held in virtual form). The presented articles are extended versions of the presented research. Moreover, one additional article was also invited. All articles have undergone rigorous peer-review according to the journal?s high standards.

The nine contributions cover a wide range of research topics in signal processing - from acquisition, through various applications and their modelling, new computational models to security issues. Collected in the form of a special issue, they show selected trends in this dynamically developing field.

We would like to thank the reviewers very much for their work - valuable comments and suggestions, which helped to improve the discussed articles. We would also like to thank the authors for their good cooperation and efficient preparation of revised versions of the articles. Furthermore, we would like to thank the editors of the Journal of Signal Processing Systems, firstly for the proposal to publish this special issue and secondly for their cooperation at every stage of its publishing. We hope that the reader will benefit from this selection of research highlights from the field of design and architectures for signal and image processing.

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