Machine Learning Algorithms in Image and Signal Processing

Special Session along with PESARO 2017, April 23 - 27, 2017 - Venice, Italy

https://www.iaria.org/conferences2017/PESARO17.html

Michael Huebner
Chair for Embedded Systems of the Information Technology (ESIT)
Faculty for Electrical Engineering and Information Technology
Ruhr-University Bochum
Germany

***Abstract*— Machine learning algorithms are currently a hot topic in research and development for academic and industrial teams. The roots of these algorithms reach even back to the seventeenth century where Bayes theorems were published. However, since this time, changes in the application domains as well as the target hardware platforms have led to an increased interest in these techniques. Domains like automotive, process automation etc. reach out for these methods and already deploy systems exploiting machine algorithms e.g. for image processing and scene analysis. This means, machine learning met the Embedded System domain where almost endless possibilities for the deployment of these algorithms can be found. Trends like the Internet of Things and Cyber-physical Systems even underline the demand of these novel techniques. This paper is the editorial to the special session Machine Learning Algorithms in Image and Signal Processing (MAIS) which was embedded into the Seventh International Conference on Performance, Safety and Robustness (PESARO).**

Keywords—Machine learning, image processing, reconfigurable hardware, deep learning,

I. INTRODUCTION

Cyber-physical Systems (CPS) are a big step forward from the basic data-gathering networks, and they are said to be the fourth industrial revolution [1]. Therefore, the important contribution of CPS is its integration and connection of the hardware elements, e.g. sensors, actuators and computing units, with the software functionalities, e.g. automated routines and supervisor software, to perform energy efficiency and simultaneously keeping safety requirements. Many fields employ CPS into their operations [2], e.g. transportation, defense, energy and industrial automation, health and biomedical, agriculture and critical infrastructure, in order to automate the processes, the data gathering and the actions it can perform, while also lowering the quantity of human-made errors during run time. Furthermore, critical applications that must deal with several challenges find in CPS a powerful ally, since the system's level of automation and independence is higher than those of basic manually supervised networks.

The domain of Cyber-physical Systems is currently in a process using novel algorithms to perform their applications. The domain of close control loop technology for example uses model predictive closed control loops to predict systems states before they happen. They use models of the real world application and provide this model sensor values to see, what could happen in the future time. According to this, a prediction into future system states can be made and a reaction can be derived. This leads to a very smooth control of systems where problems with an overswing of an actuating variable can be avoided. Other approaches use machine learning in a very exotic way [3]. Here, a trained network is used to predict the parameterization of a cache memory for an embedded system. The approach allows to react to requirements of an application many clock cycles ahead in time to parameterize a cache in an optimal way. The investigation shows, that the trained algorithm parameterizes the cache as optimal, as a static offline parameterization can do. That means, that this neuronal network can react dynamically to changing requirements of algorithms and perform a cache optimization during run-time.

Regarding the hardware architecture, more and more processors are available which are tailored to the demands of neuronal networks. In [4], a Tensilica processor is presented, which provides specific DSP features to support the data processing in convolutional neuronal networks. These processors have the ability to process the data highly efficiently in terms of throughput and power consumption / energy consumption respectively. One can see the benefits of these processors if the application "Hololens" is taken into account. Here 24 Tensilica processors perform the signal processing of the different sensors used to provide the features given with this modern application.

Recently ST Microelectronics presented a novel hardware platform at the International Solid-State Circuits Conference (ISSCC 2017). This chip, the deep convolutional neural network System-on-Chip, is tailored to perform highly efficiently the algorithm for a deep CNN [5]. More chips like this one will come. More applications will adopt the paradigm of machine learning. Machine learning is no longer a domain

of high performance computing. It already entered the domain of embedded systems tremendously.

II. PAPER OF THE SPECIAL SESSION

This special session includes two excellent contributions which show different views to the deployment and the general usage of machine learning algorithms. The paper "Shift-Invariant Motif Discovery in Image Processing" authored by Sahar Torkamani et. al. presents an algorithm which is applied in the domain of image processing. The specialty with the proposed algorithm is, that it is more robust as other techniques described before due to the specific usage of several image filtering methods. The paper includes several use cases which underlines the excellent performance of the used methods.

In the second paper provides a survey about Deep Neural Networks (DNNs) and Recurrent Neuronal Networks (RNNs). The authors selected these two types of neuronal network since the domains where they can be deployed are currently highly interested in this approach. DNNs are regularly used in signal and image processing algorithms whereas RNNs are more used in industrial control applications. The paper presents a view of the current landscape of research and deployment of both methods.

III. CONCLUSION AND OUTLOOK

In is not exaggerated to say, that neuronal network is currently a megatrend in research and technology. Large companies like Google, Intel, IBM, Apple, ST and so forth have found this research topic to use it in their products. Research groups all over the world do research in novel applications, algorithms and hardware platforms. Neuronal networks are back, and more than ever they will have a great impact in our technology and even in the society. New applications in our daily live will use the neuronal network and provide us with features within applications which we never expected not long time ago. The Internet of Things will definitely adopt this very soon and also small embedded systems will use more and more the trained networks to detect events and to decide if a message goes to another node or e.g. a base station. Definitely all in all, this trend is an excellent source for research and therefore many special sessions, conferences and workshop will follow to provide the community a platform which enables discussion and exchange of experience. The organizers of this special session thank to the PESARO conference to enable this session and enable therefore the scientific discussion within their excellent event.

REFERENCES

[1] E. Geisberger and M. Broy, agendaCPS: Integrierte Forschungsagenda Cyber-Physical Systems. Springer-Verlag, 2012, vol. 1.

[2] PricewaterhouseCoopers AG WPG, "Industry 4.0: Opportunities and challenges of the industrial internet," http://www.pwc.de/en/digitaletransformation/ pwc-studie-industrie-4-0-steht-vor demdurchbruch.jhtml, December 2014

[3] Osvaldo Navarro, Javier Hoffmann, Fabian Stuckmann, Michael Hübner, Jones Yudi Mori Alves da Silva - 13th International Symposium on Applied Reconfigurable Computing (AR-C2017).
A Machine Learning Methodology for Cache Recommendation

[4] Samer Hijazi, Rishi Kumar, and Chris Rowen
Using Convolutional Neural Networks
for Image Recognition
Cadence IP-Group, White Paper, 2015.

[5] G. Desoli, N. Chawla, T. Boesch, S-P. Singh, E. Guidetti, F. De Ambroggi, T. Majo,
P. Zambotti, M. Ayodhyawasi, H. Singh, N. Aggarwal
A 2.9TOPS/W Deep Convolutional Neural Network SoC in FD-SOI 28nm for Intelligent Embedded Systems
International Solid-State Circuits Conference, ISSCC 2017