Resumes

from PhD Scientific Seminar

Faculty Eletronics and Automation

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I’m Bozhidara Nedelcheva and I’m 1st year PhD student at the Technical University Sofia branch Plovdiv, Department of Control Systems. I have a MSc and BSc degree in Automation from Plovdiv branch of Technical University of Sofia. My PhD research interests and activities are in robots, to learn and to control them.

NEW ALGORITHMS FOR INTELLIGENT CONTROL OF MOBILE ROBOTS IN A SHARED WORKSPACE

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While robotic technologies and applications have experienced accelerating advances, with robots vacuuming homes, assembling automobiles, exploring planets and oceans, and performing surgeries, their potential remains limited by their ability to effectively interact with people and to work in shared workspaces. It becomes clear now that the fields of applications for robotics will influence not only industrial applications and domestic activities but also entertainment, education, monitoring, security, and assistive living, leading robots to frequent interactions with untrained humans, or with other robots in unstructured environments. It can be concluded that the level of comfort and safety experienced by the users during the interaction with robots will play a fundamental role in this process. This requires the development of new learning and adaptation methods and autonomous behaviours to ensure that robots are fully involved not only in a structured industrial environment but also in shared workspaces. The fact that the EU's the USA’s industrial development strategies identifies this areas as a priority, gives us a reason to believe that the proposal is in line with the main priority lines in the development of research at regional, national and European level.

This PhD work focuses on the development of algorithms for learning and adaptation of intelligent behaviors of autonomous/mobile robots. The goal is to use approaches and technologies related to artificial intelligence, cyber-physical systems, sensory information, digital models and simulations, big data - to achieve higher functionalities of robots and their application in a shared working environment. Research addresses both the concepts of collaborative robots in the industry and the service robots operating in the human environment.

For the realization of this common goal, the work identifies a number of specific research areas that would greatly help to make the behaviors of robots in a shared work environment more flexible, more useful, and safer:

1Using natural interfaces for human - robot communication.

2Study of learning and adaptation algorithms and their application to robot control in a shared environment.

3Investigation of algorithms for multi-agent robot control.

Milka Kuceva is first year PhD student at the Technical University of Sofia, branch Plovdiv, Faculty of Computer Systems and Technologies. The subject of her PhD thesis is „Methods and tools for building cloud-based intelligent sensor systems". Milka holds a MSc degree in Computer Science from the same university. Her interests are in Smart Home, Cloud Computing and Internet of Things.

A Smart Solution for Electrical Power Monitoring Based on MCP39F501 SENSOR

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Internet of Things (IoT) is a fast-growing topic because the concept of IoT can potentially affect the way we live, but it also affects humans at work. IoT provides a powerful tool not only connected with wireless communication devices but wireless sensors for utilities needed in homes are better for managing energy use. Technology that is growing rapidly makes a role in building dream homes to increase the comfort and safety of residents. Home automation systems are currently very popular and widely used by many people. Human needs for electricity are also very high, almost all household appliances use electricity. Many people cannot control electricity usage in their own homes. In addition, the use of electric power cannot be seen in detail but can only be seen as a whole when paying electricity bills. Another thing that might happen is an electric leak that is unknown to the user. Smart House can be one solution to the problems described above. Using Smart home, we can also monitor household appliances remotely.

The striving to reduce energy consumption and associated gas emissions is one of the reasons for the development of Smart Home concept as part of Smart Cities and its associated Smart Grid. This is achievable by conducting smart metering and using smart meters to monitor energy usage and indoor environmental conditions in homes and residential buildings. The first step to start with for developing energy management systems in buildings, is energy consumption monitoring using smart meters and smart devices. Smart meters can provide cus-

tomers with detailed electricity consumption data of every appliance in real time thus helping the users to evaluate the overall power consumption in their home. Installation of the smart metering system is necessary and beneficial for consumers who would like to monitor and track consumed energy with the aim to reduce it.

The proposed approach for a smart solution for AC power metering can be easily integrated with the home monitoring and management systems in smart homes. It employs a sensor MCP39F501 for real-time electrical power measurement and implements the IoT concept based on three-layer architecture. The developed IoT solution is based on an open source hardware ESP32-EVB development board and a home gateway. The measured data could be displayed on a developed web page in two modes - as a dynamic chart for real-time data and as a static chart for the data stored in the database.

Georgi Iskrov is PhD student in his first year at the Technical University of Sofia – branch Plovdiv, Faculty of Electronics and Automation (FEA). He has a MSc degree in Automation and System Engineering from the Aviation Faculty "Georgi Benkovski" of the National Military University. His PhD research interests and activities are in the security provided by blockchain technology.

RESEARCH AND IMPLEMENTATION OF BLOCKCHAIN-BASED NETWORK SECURITY

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Initially, the Internet was conceived as an environment for discrete internal communication. No malicious actions were foreseen for the users. The peer-to-peer (P2P) term was first used by IBM in 1984 to develop a network architecture to dynamically route traffic through computer networks with random topology (Advanced Peer to Peer Networking).

Blockchain – It is a chain or records stored in the forms of blocks which are controlled by no single authority. A blockchain is a distributed ledger that is completely open to any and everyone on the network. Once an information is stored on a blockchain, it is extremely difficult to change or alter it.

Each block in a blockchain network stores this information along with the hash of its previous block. A hash is a unique mathematical code which belongs to a specific block. If the information inside the block is modified, the hash of the block will be subject to modification too. The connection of blocks through unique hash keys is what makes blockchain secure.

While transactions take place on a blockchain, there are nodes on the network that validate these transactions. In Bitcoin blockchain, these nodes are called as miners and they use the concept of proof-of-work in order to process and validate transactions on the network. In order for a transaction to be valid, each block must refer to the hash of its preceding block. The transaction will take place only and only if the hash is correct.

Blockchains are decentralized in nature meaning that no single person or group holds the

authority of the overall network. While everybody in the network has the copy of the distributed ledger with them, no one can modify it on his or her own. This unique feature of blockchain allows transparency and security while giving power to the users.

With the use of Blockchain, the interaction between two parties through a peer-to-peer model is easily accomplished without the requirement of any third party. Blockchain uses P2P protocol which allows all the network participants to hold an identical copy of transactions, enabling approval through a machine consensus

The immutability property of a blockchain refers to the fact that any data once written on the blockchain cannot be changed. If you try to change the data of one block, you'll have to change the entire blockchain following it as each block stores the hash of its preceding block. Change in one hash will lead to change in all the following hashes. It is extremely complicated for someone to change all the hashes as it requires a lot of computational power to do so. Hence, the data stored in a blockchain is non-susceptible to alterations or hacker attacks due to immutability.

The purpose of this dissertation is to make the protection provided by blockchain in the business environment applicable. Blockchain can be used as a voting system. Blockchain can be used as a system for storing important registers, such as the property register, or the register of current status of business companies.

The essence of using blockchain to store large amounts of data of any format is that it is not necessary to store all the information in the blockchain itself. To prove that the file has not changed since it was inserted into the blockchain system, it is not necessary to compare bytes with the original. It is enough to calculate and save the hash of this file in blockchain, and store the file itself separately and under the control of the same program responsible for the placement and reporting of the files.

Radoslav Furnadzhiev is a 2nd year PhD student at the Technical University Sofia branch Plovdiv, Faculty of Computer Systems and Technologies. He has experience with rapid development of enterprise applications for Continuous Integration & Deployment. His PhD research interests and activities are in exploring Orchestration and Coordination architecture patterns for achieving scalability and availability in modern containerized applications. Radoslav holds an MSc degree in Computer Science from the same university.

A SURVEY OF METHODS AND ARCHITECTURES FOR DEPLOYMENT AND TESTING OF CONTAINERIZED MICROSERVICES.

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Cloud computing has gained a major foothold in information technology in recent years. It has allowed for easy on-demand access to computational resources and provides many advantages to its users like automatic scaling, web-based control & interfaces, and dynamic resource pooling. Several architectural styles have been developed that leverage these technologies regarding development and delivery of complex software solutions.

As a rapidly adopted architectural approach, microservices have important benefits in the development of large scale applications. Microservice architectures distribute the application into small modules, each of which can be deployed and scaled independently of each other. Those design principles consisting of small collaborating services, each running in its own process and communicating with lightweight mechanisms, intend to overcome the drawbacks of monolithic architectures where all of the application's logic and data are managed in a single deployable unit. However, this transition to microservices brings a wide range of infrastructural orchestration challenges. To combat this problem several deployment technologies have emerged, such as container-based virtualization and container orchestration solutions. The use of containers is considered a lightweight virtualization, allowing small and loosely coupled modules to be deployed and scaled independently and compose a cloud-native application. These technologies allow us to efficiently exploit cloud platforms, providing a high degree of scalability, availability, and portability for microservices.

Currently microservice-oriented decomposition of an application is a challenging task that plays a crucial and prerequisite role in developing microservice-based systems. I intend to research microservices architectural design along with the various advantages, disadvantages of containerized microservices and investigate solutions and mechanisms to address security problems while designing microservice-based systems.

Teodora Mecheva is 2nd year PhD student at the Technical University Sofia branch Plovdiv, Department of Computer Systems and Technologies. She has a MSc and BSc degree in Computer Systems and Technology from Plovdiv branch of Technical University of Sofia. Her PhD research interests and activities are in the area of Intelligent transportation systems.

DESCRIPTIVE MODEL OF THE ROAD TRAFFIC IN THE CENTRAL PART OF PLOVDIV

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Simulation is a key tool for testing road traffic management approaches. Simulation models are used to describe and monitor traffic, as well as to test the effectiveness of new approaches to organization, awareness and safety. The present work aims to build a descriptive model of the main road arteries of the central part of the city of Plovdiv on the basis of real data from road cameras and AIMSUN traffic simulator.

One of the main reasons for choosing AIMSUN for road traffic simulator are: the possibility to use a free student license and a license for scientific purposes; its flexibility - there is an opportunity to build macro, meso and micro models, as well as hybrid models; it can represent different vehicles, including user defined classes of vehicles, as well as pedestrians and cyclists; the traffic lights can work both in static and in dynamic, adaptive mode (as is the case with the traffic lights in Plovdiv); it is possible to add adaptive road signs, as well as to simulate accidents and construction works and their impact on road traffic.

One of the easy options in AMSUN was used to build the road network - importing the map in OSM (Open Street Map) format. Additional manual tuning is also needed: traffic rules at intersections need to be adjusted; it is necessary to delete a large part of the secondary and tertiary road network (which are beyond the scope of the experiment) due to the limitation of the student license. The studied part of the road network covers the area between the boulevards Ruski - Iztochen and 6-th September - Hristo Botev. The focus of the study are the main

intersections of these boulevards, as well as of the boulevards Tsar Boris III and Kn. Maria Louisa and Gladstone Street, which fall into the described area.

The input data provided by the municipality of Plovdiv cover the period from 15.01.2021 to 27.01.2021. The data is extracted through virtual detectors built on the basis of road cameras. Via Python script the raw data is converted to CSV origin-destination matrices. For each time interval is created OD matrix. OD matrices are the input data for AIMSUN simulation.

Veselka Petrova-Dimitrova is a PhD student in her third year at the Technical University of Sofia, branch Plovdiv, Computer Systems and Technologies Department**.** She received M.Sc. degree in “Computer Systems and Technologies” at Technical University of Ruse. Subject of her PhD work is “Modelling and analyzing the behavior of intelligent cognitive agents”. Her research interests are in analyzing the methods of knowledge representation and decision making algorithms, agent’s learning algorithms and their usage in modeling rational behavior of intelligent agents.

REINFORCEMENT LEARNING ALGORITHMS USING FOR AGENT BEHAVIOR MODELING AND RESEARCHING

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The purpose of the thesis is to model and explore the behavior of cognitive agents (CA). CAs that are programmatically realized, rational and autonomous are considered; with a graphically visualized head and/or body; which exist in a 2D or 3D virtual environment; who interact with their environment, users and other intelligent virtual agents; can adapt to changes in the environment, make decisions, have a goal that is achieved with maximum efficiency.

Achieving autonomy and rational behavior, especially when the environment is complex, partially observable or dynamic, or unfamiliar, requires the inclusion of machine learning methods.

In Reinforcement learning, the way the agent behaves at all times is determined by its policy. Policy is the correspondence between the environmental conditions that the agent perceives and the action he takes to achieve the goal. The goal is defined by the reward function. As a result of his experience during the learning period, the agent changes his policy and maximizes his numerical reward. This determines the appropriateness of each pair of state-action.

Therefore, the Reinforcement learning is appropriate for modeling and studying the behav-

ior of cognitive agents. During this seminar will be analyzed the most interesting algorithms for the implementation of Reinforcement learning, and their classification.

Emphasis will be placed on two main groups of Reinforcement learning algorithms: model-based and model-free. Model-free algorithms are older and their agents do not have an environmental model. They learn how good is the taken action for a state through trial-and-error training. There are many existing model-free algorithms. The most widely used algorithms will be considered: Q-learning, SARSA, Monte Carlo etc. Some newer model-based algorithms also will be considered, in which the agent can use an environmental model to make decisions, select and plan actions. The model contains information about the consequences of each action as well as the rewards it will receive, which helps to achieve an optimal policy. An advantage for the agent is the presence of a model, as this gives him the opportunity to predict what will happen for a number of future choices and to find the best solution. It also speeds up the learning process.

Hybrid approaches are often used in multi-agent systems. They include both model-based and model-free algorithms. The model is built on the basis of existing information, and the already trained agent improves his knowledge through additional training cycles.

Stefan Lishev is PhD student at the Technical university of Sofia - branch Plovdiv, Faculty of Electronics and Automation (FEA). He received B.Sc. degree in “Computer Systems and Technologies” in 2008 and a M.Sc. degree in 2010. The subject of his PhD thesis has been “System for automation of scientific experiments with remote and mobile control” but now it is changed to “System with remote and mobile access for automation of thermal fields and fluid streams measurements”. He works now at the Department of Computer Systems and Technologies. His main interests are embedded systems, artificial intelligence, digital signal processing, Internet of Things. Stefan has five published articles in the field of his PhD thesis.

System with Remote and Mobile Access for Automation of Thermal Fields and Fluid Streams Measurements

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In the recent years researchers are on the quest for reliable wireless sensor networks in which sensor nodes are energy efficient and have long lifetime. One of the main areas of research for this goal are effective communication protocols, routing algorithms, QoS and low energy consumption nodes. There are different applications that require better and efficient networking - vehicular network, biomedical sensor networks, UAV’s and so on.

The focus of the work for now is defining the requirements of a wireless sensor network for measuring flight parameters of UAV during test flight or stationary test. Different wireless protocols are examined in terms of energy efficiency, data rate, latency and coverage.

For measurements of the flight parameters is used the velocity field in the work chamber of the wind tunnel ULAK -1. The measurements are done using five-hole probe in a plane located behind the subject of study. In measuring the magnitude and direction of the air flow velocity in low speed wind tunnels the probes with a spherical end portion are used. The five-

hole probe is applied in this case. Other parameters that are measured are temperature, orientation in space, voltage from different sensors and power supply, barometric pressure.

In the recent years the focus is mainly on developing and testing new protocols and algorithms for communication, as well as investigating existing ones between embedded devices that use different types of communication – wired and wireless. The challenge for the design of a WSN is the optimization of critical parameters – network consumption and latency. Different scenarios are going to be test via simulating different kinds of networks of devices with the help of Network Simulator 3 and similar tools. After doing simulations the promising solutions will be tested as real systems.

Vasil Tsvetkov is a PhD student in his 3rd year at the Technical University of Sofia – branch Plovdiv. His PhD research interests and activities are embedded systems, Internet of Things, cloud based intelligent sensor systems. Vasil holds a MSc degree in Computer Science from the same university.

WIRELESS SENSOR NETWORKS: FAST, RELIABLE OR FREE M2M COMMUNICATION

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The advancement of technologies over years has poised IoT to scoop out untapped Information and Communication technology opportunities. It is anticipated that IoT will handle the gigantic network of billions of devices to deliver plenty of smart services to the users. Undoubtedly, this will make our life more resourceful but at the cost of high energy consumption and carbon footprint.

Consequently, there is a high demand for green communication to reduce energy consumption, which requires optimal resource availability and controlled power levels. In contrast to this, IoT devices are constrained in terms of resources- memory, power and, computation. Low Power Wide Area (LPWA) technology is a response to the need for efficient utilization of power resource, as it evinces characteristics such as the capability to proffer low power-connectivity to a huge number of devices spread over wide geographical areas at low-cost.

Various LPWA technologies like LoRa, SigFox, etc. exist in the market, offering a proficient solution to the users. However, in order to abstain the need of new infrastructure (like Base Station) that is required for proprietary technologies, a new cellular-based licensed technology, Narrow Band IoT (NBIoT) is introduced. This technology presents a good candidature to handle LPWA market because of its characteristics like enhanced indoor coverage, low power consumption, latency insensitivity and massive connection support towards NBIoT.

My goal is to analyze the communication protocols, network architecture, microcontroller and sensor specifics and present the possible solutions for some of the most common cases in

the Smart Home technology.

Georgi Pazhev is 4th year PhD student at the Technical University Sofia branch Plovdiv, Department of Computer Systems and Technologies. He has a MSc and BSc degree in Computer Systems and Technology from Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in methods and utilities for building smart home.

SMART HOME – METHODS, UTILITIES AND APPLICATION PROTOCOLS

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Smart home, in its essence, is a heterogeneous sensor network based on technologies such as Internet of Things (IoT). They are nowadays equipped with many devices such as smart meter, in-home displays, renewable energy sources and storage, and smart appliances such as washing machine, refrigerators, TV, oven, thermostat, HVAC (Heating Ventilation and Air Condition), lights, and plugs for electrical cars. For transparent communication between these devices it is necessary to use gateways for protocol transformations. There is a two-way communication that is utilized in the demand response, advance metering infrastructure, distributed energy generations and storage.

On one hand, the presence of many gateways complicates the system in the internal network of sensors and actuators. The presence of additional protocol transformations slows its functionality, and in order to reduce their number, it is necessary to select protocols that are compatible with terminal devices with limited computing capabilities. The presence of set of application protocols like STOMP, MQTT and COAP (Constrained Application Protocol) meet the requirements for devices with limited computational resources and are very convenient to use for building an internal sensor network. On the other hand, the system interface with the outside world must be compatible with different utility providers and their communication protocols. The challenges addressed to IoT and their middlewares are related to dynamic heterogeneous resource discovery and composition, scalability, reliability, interoperability, security and privacy. The blockchain technology, with its unified set of protocols and build-in security, could be used not only as an external link to any home-based network within

the house, but also as a distributed database, that stores data contained in each transaction. The Blockchain technology resolves partly the already mentioned challenges of IoT. The challenges associated with the blockchain are associated with the storage capacity and scalability, anonymity and data privacy and security issues like 51% attack and double spending.

Using smart home concept based on two gateways an IoT-based smart home network with integration of blockchain network could be implemented based on IoT-IoT approach. The blockchain smart contracts provide unified interface, which improves smart homes interoperability with the utility providers and user nomadic agents. Using blockchain network the utility provider does not need to install his own smart meter at each home and to provide own secured infrastructure. The smart home could share the sensor data and the actuators state to its own smart contract. The user or utility provider could connect to the corresponding smart home and exchange data with the provided smart contract. Every participant inside the blockchain network needs to create transaction for sending data. Each transaction is digitally signed and encrypted using asymmetric security algorithms. This advantage gives secure connection between the user/utility provider and the home network.

Kamen Ivanov is 3rd year PhD student at the Technical University Sofia branch Plovdiv, Department of Computer Systems and Technologies. He has a MSc degree in Electronics and BSc degree in Optoelectronic and Laser Technology from Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in Uses of Wedge Interference Structure as optical tool for measurements of presence and mercury concentration in the ambient air and light emitting sources

USES OF WEDGE INTERFERENCE STRUCTURE AS OPTICAL TOOL FOR MEASUREMENTS OF PRESENCE AND MERCURY CONCENTRATION IN THE AMBIENT AIR AND LIGHT EMITTING SOURCES

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Optical science is currently built on a foundation that largely assumes the existence of a perfect infrastructure. Optical equipment are fabricated in clean-room environments, tested deterministically, and discarded if even a single defect is uncovered. Entire optical systems will fail if there is a presence of impurity. This foundation will not support the complex and flexibly reliable systems we will need in the future. Completely new approaches that provide easy and simple and cost effective new method to measure the presence and mercury concentration by the means of optical analyses of mercury atom's excitement patterns in the gas discharge in light emitting sources and the ambient air.

Among these new systems is the one based on Wedge Interference Structure, composed of optical layers applied on glass substrate by the means of vacuum magnetron sputtering with known optical property's and characteristics. There are enormous possibilities for application of such systems for defense as well as civilian applications, including environmental monitoring. These systems are now feasible because: 1) They are simple to make when you have the knowhow and this continues to reduce the cost of the Wedge Interference Structure; 2) Wedge

Interference Structure don’t need power to work. 3)They can be in different sizes and they are very light and thin; and 4) WIS are simple to work with ,no special gases need or other chemical materials.

The accurate and exact amount of mercury detected and measured by such systems is currently an unsolved problem, and is the main barrier to effective use of such systems. Clearly, this system must be designed and engineered to deliver accurate and absolute data, but the problem is that the manufacturer of light Emitting Sources often don’t give the precise amount of mercury or it can vary from the datasheet and between two light sources with the same specification from the same or different manufacturer. There is many experiments with promising results with this Optical Structure and with this data we can make the necessary calculation to determine the exact amount and presence of mercury in the light sources and the ambient air. In this manner we can confirm is it safe or not for humans and animals.

Teodora Hristeva has a master's degree in "Information technology" from Technical University Sofia, branch Plovdiv. She has more than 15 years of experience in software projects using variety of technologies with a special impact on Java and C#. Currently she is a PhD student and assistant in the Computer Systems and Technologies Department with subject "Parallelizing Deep Learning algorithms using graphic accelerators". Her interests are in big data processing and analyzing, deep learning and image recognition.

APPLICATION OF SUPPORT VECTOR MACHINE ALGORITHM IN BIOINFORMATICS

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One of the main tasks in bioinformatics is to classify and predict biological data. Due to the accelerated increase in the volume of these data, it is important that processes are automated. Machine learning algorithms are used successfully in solving classification problems. Therefore, using algorithms such as Support Vector Machines (SVMs) is very common practice in analyzing genetic data.

The development of technologies and their application in various fields of medicine leads to the accumulation of a huge amount of biological data. The exponential rate at which genetic databases are growing is a consequence of the automation of a number of biological experiments, and this leads to the need to implement various software solutions to deal with these problems quickly and efficiently. Bioinformatics as a part of medicine relies exclusively on different algorithms to process the collected information. This, in turn, leads to the accumulation of more data. Their rational use in order to synthesize new knowledge is extremely important for scientists and engineers working in this field, as well as in the field of programming and informatics.

The deep learning algorithms are successful in situations where it is required to detect different patterns of behavior, relationships and dependencies between different elements in a

given set of data. With their help is generated source code that allows the recognition of these models in the new data.

Bioinformatics is an interdisciplinary scientific field that deals with the study of data from various fields of biology with the help of informatics. It relies heavily on the development of algorithms and software that can be used both to process incoming information and to perform numerical experiments on it.

One of the most widely used representatives of supervised machine self-learning is the so-called Support Vector Machine Algorithm (SVM). It can be used for classification and regression, as well as for outlier detection, which makes it extremely flexible. It is designed to work with complex but small to medium-sized volumes of data. It is effective even with a very large number of features. Like any other algorithm of its kind, the goal of SVM is to create a model based on a training set that is able to determine the class of the elements with the greatest possible accuracy.

Dimitre Kromichev is a PhD student at the Technical University Sofia branch Plovdiv, Department of Computer Systems and Technologies. He has a MSc and BSc degree in Computer Systems and Technology from Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in Field Programmable Gate Array based Canny edge detection.

A SPEED AND ACCURACY FOCUSED APPROACH TO FPGA BASED CANNY EDGE DETECTION COMPUTATIONS

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John Canny's algorithm for contour detection is a precise and reliable image processing technology. Its FPGA inplementation faces two problems: speed and accuracy.

In the publications on Canny there are two general assessments: 1) Canny's mathematics is too complicated to be inplemented in FPGA without approximation; 2) Canny is too slow and, therefore, inappropriate for real time implementation. The objective of this work is to design and explore a new organization of FPGA based Canny computations guaranteeing optimal speed on the basis of total mathematical accuracy.

Explored is the impact of the entire set of approximations on detected contours' precision. This requires the development of a set of tools and methodologies. Both synthetic and real life images are used to prove the strong negative impact of approximations on precision.

Defined and explored are six capital speed parameters of FPGA based Canny computations: embedded memory, pipelining, parallelism, minimum number of uses of a single pixel, integer arithmetic, input data width. Designed is a set of computational algorithms which combine 100% mathematical accuracy with optimal speed. The algorithms' performance is assessed on a comparative basis with respect to maximum clock frequency and minimum number of clock cycles required to compute an accurate result. Presented are the utilized resources. The following Intel (Altera) FPGA platforms are used for the tests: 130 nm – 28 nm

Cyclone I – V and 130 nm – 28 nm Stratix I – V.

Designed and explored is an entirely new approach to the organization of computations in each of the five Canny modules. Experimentally proved is the upper limit of frequency of operation in FPGA based Canny. Speed capabilities are explored on a comparative basis. For the purpose, developed is a specific methodology encompassing Register transfer level modelling, testing detected contours' precision and analyzing the working FPGA based Canny using real life images. Tested and proved is the capability of the proposed organization of computations to guarantee optimal speed and total mathematical accuracy.

The relevant conclusions to the dissertation are drawn. References are updated.

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