Resumes

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Emilia Pardo is 1st 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 Technologies from Plovdiv University “Paisii Hilendarksi”. Her PhD research interests and activities are in

PARALLELIZING THE NEEEDLEMAN-WUNCH ALGORITHM USING GRAPHIC ACCELERATORS

EMILIA PARDO

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
epardo@tu-plovdiv.bg

Bioinformatics is used to analyze whole-genome sequencing data. It is interdisciplinary field that developes and improves methods for storing, retrieving, organizing and analyzing biological data. Bioinformatics has become an important part of many areas of biology. In the field of genetics and genomics, it aids in sequencing and annotating genomes and their observed mutations. In structural biology, it aids in the simulation and modeling of DNA, RNA and protein structures as well as molecular interactions. This involves algorithm, pipeline and software development and analysis, transfer and database/storage development of genomics data. Genomics applies recombinant DNA, DNA sequencing methods and bioinformatics to sequence, assemble and analyze the function and structure of the gehomes. A typical whole-genome sequencing workflow contains quality control and data grooming, genome assembly and post-assembly analysis. This volume of data is produced from next-generation sequencing platforms is massive.

The Needleman–Wunsch algorithm is an algorithm used in bioinformatics to align protein or nucleotide sequences. The algorithm was developed by Saul B. Needleman and Christian D. Wunsch and published in 1970.The algorithm essentially divides a large problem (e.g. the full sequence) into a series of smaller problems, than optimizes the results. The algorithm is

widely used for optimal global alignment, especially when the quality of the global alignment is of the utmost importance. The algorithm assigns a score to every possible alignment and his purpose is to find all possible alignments having highest score.

The DNA sequences are available in FASTA format, which are stored in NCBI (The National Center for Biotechnology Information). The structure of one FASTA file is presented by a thousand rows – a nucleotid sequences. A large computing resource is required for comparing and searching for matches. The graphical accelerators are suitable for this problem. GPUs (Graphical Processing Units) have thousands of cores,which can be used for parallel comparison. In 2006 appears the CUDA (Compute Unified Device Architecture) architecture, which can be used for parallel programming, using languages like FORTRAN/C, ACC, C++.

Milka Kuceva is second 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 PhD research is related to energy efficiency in Smart Home.

Energy Consumption Prediction by Using Machine Learning for Smart Home

Milka Kuceva

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
m.kuceva@std.tu-plovdiv.bg

Electricity is considered to be the heart of modern social and economic development. Advances in technology tempted us to use electricity-driven elements in every aspect of our life from commercial to domestic sector for shaping our lives to be more comfortable. However new challenges have arisen where further investigation is necessary on how to manage the supply-demand balance of electricity more effectively, securely and reliably along with ensuring a coordinated multi-way communication for better monitoring and control of the network and user assets. The Internet of Things (IoT) is a rapidly emerging field of technologies that delivers numerous cutting-edge solutions in various application domains.

The IoT-enabled Smart Energy Grid system equipped with intelligent two-way data communication can significantly improve the operation and control of the traditional energy grid system. These improvements address the reliability, flexibility, efficiency of the conventional grid system. In a smart grid environment, the system must provide services including the large-scale integration of distributed renewable energy resources, establishment of live, real-time data communication between consumers and service providers regarding tariff information and energy consumption, facility to collect and transfer statistics of system parameters for analysis and infrastructure to implement necessary actions based on those analyses. It can be

used machine learning tasks to predict future energy consumption. Machine learning tasks in ML.NET is the type of prediction or inference being made, based on the problem or question that is being asked, and the available data. Machine learning tasks rely on patterns in the data rather than being explicitly programmed.

The proposed approach for a smart solution is a seven-layered IoT architecture which has a goal to simultaneously display data from many sensors in a web page and dynamically discover their connection/disconnection with the gateway plus providing a way to change the settings of each sensor, filtering the data by the user rights, big data analyzes to determine the daily, monthly or yearly energy consumption, identify energy usage pattern and predict future energy demand using ML.NET for this purpose.

ML.NET is a machine learning framework for .NET. ML.NET gives the ability to add machine learning to .NET applications, in either online or offline scenarios. Central to ML.NET is a machine learning model. The model specifies the steps needed to transform input data into a prediction. With ML.NET a custom model can be trained by specifying an algorithm, or can be used pre-trained TensorFlow and ONNX models.

Velyo Vasilev is a 2nd 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 3D simulation and intelligent behavior of virtual agents.

New Algorithms And Work Models For Intelligent Assistant Agents in a High-Risk Environment

Velyo Vasilev

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
velyo.vasilev@tu-plovdiv.bg

The aim of the dissertation is to develop and research new algorithms for the work of intelligent assistant agents in a high-risk environment. The research is focused on the modeling of a virtual 3D simulator and virtual 3D intelligent agents to be assistants in an electrical substation or in components of the electrical power system for medium and/or high voltage. To accomplish the training of the virtual agents, it is planned to develop and study the operation of a modified algorithm for Reinforcement Learning, which is expected to be useful for finding the optimal route for evacuation with dynamically occurring accidents.

The model of the environment includes: visualizing the electrical equipment; visualizing sings of damage to the surface of the electric devices, as well as cracks, oil stains, rust and others; visualization and sound signals in case of an emergency situation such as a fire, corona discharge, sparks, a broken circuit and others. It is necessary to research the behavior of intelligent agents in a familiar environment which involves uncertainty and mutability due to randomly occurring problems.

Research in the field of artificial intelligence and intelligent systems such as simulating a “smart” electric substation and virtual electric engineer agents could lead to: improved risk

analysis when working in such environments; increased situational awareness of the personnel as well as assist when making decisions about building and handling electrical devices and components. The research will involve the use of technologies such as artificial intelligence and cognitive systems, machine learning, autonomous agents, simulations, virtual reality, digital platforms and other. The augmented reality(AR), mixed reality(MR) and virtual reality(VR) technologies reveal a continuous stream of opportunities for scientists and scientific research.

Veselka Petrova-Dimitrova is a PhD student 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.

CLASSIFICATIONS OF INTELLIGENCE AGENTS AND THEIR APPLICATIONS

VESELKA PETROVA-DIMITROVA

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
vesi_s_petrova@yahoo.com

One of the goals of artificial intelligence is to create fully autonomous intelligent agents that can cope successfully in their environment, learn and make decisions based on their own experience. They must be able to update and adjust their existing knowledge depending on the dynamically changing environment and to analyze and make adequate decisions when interacting with other intelligent agents working in the same environment.

The main functions of intelligent agents include perception and action. The actions are performed by means of driving mechanisms, and the perception is achieved via sensors. Intelligent agents have the ability to train. This allows them to learn, even while completing their tasks.

Considering the level of the agent‘s perceptivity of the environment, its way of deciding what action to take when interacting with the it there are 5 main types: simple reflex agents, model-based reflex agents, goal based agents, utility-based agents and learning agents. The simplest type of agent is simple reflex agent. They decide what action to take based solely on current perception, but not on knowledge gained from their previous experience. Therefore, they have great speed and are widely used everywhere in practice where an immediate reaction (reflex) and even a survival reaction is needed.

Model-based reflex agents are similar to the ones described above, but there are some

improvements. This type of agents have a model of the work environment. The action they perform is based on this model, the state they are in, the set of rules that the agent has, as well as its previous perceptions when working in the environment.

Goal based agents have not only a model of the work environment, but also a goal that they must achieve. They must anticipate not only the next action, but also all the other actions they must take to reach the goal. The agent's program can combine this with the model to select actions that achieve the goal. Search and planning are part of AI, dedicated to finding sequences of actions that achieve the goals of the agent. Goal based agents always choose the optimal path.

To choose the most optimal path, Utility-based agents use the utility function, which is an essential part of a performance measure. For agents, taking into account utility, explicit goal setting is complemented by a utility function. It introduces a measure of the success of the agent in a given state, in the form of a number. The utility function determines the relative importance of conflicting goals and the degree of success in achieving goals when working with uncertain knowledge. The agent is expected to maximize the utility function.

Learning agents have the same capabilities as other intelligent agents, but they also have the ability to self-train. They use their perceptions not only to determine the appropriate actions, but also to improve their capabilities. Learning agents have initial knowledge, which is subsequently improved and supplemented. In this way, they increase their autonomy.

Intelligent agents are widely used in the modern world. Their ability to learn, to make independent decisions, to comply with consumer requirements, to compromise when there are conflicting goals, to reason and draw logical conclusions makes them indispensable in many areas, including training, medicine, e-commerce, implementation of agents for smart shopping, industry, tourism, games, disaster relief and much more.

Antoniy Petrov is 1st year PhD student at the Technical University Sofia branch Plovdiv, Control Systems Department. He has a Msc degree in Software technologies from University of Plovdiv and BSc degree in Electronics from Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in Development of Algorithms and Programs in Control and Automation systems.

Algorithms and Programs development to Ensure Production System operation with Network Communication

Antoniy Petrov
Control Systems Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
a.petrov@std.tu-plovdiv.bg
antoniy.petrov@gmail.com

The field of information and communication technologies is defined as one of the current areas of development of science and innovation in the world. Modern industrial automation is based on the integration of achievements in the fields of information, control and communication technologies. In this meaning, the work is focused on developing solutions, algorithms and programs to ensure the operation of intelligent production systems with network communication. The tasks are aimed at designing specialized modules for data collection and processing for diagnostics and notification in the maintenance and management of production processes. The research and analysis provided in the dissertation are focused on developing a comprehensive system for predictive support to help operators to make adequate decisions based on the accumulated, summarized and stored in a special database experience. It is planned to analyze in detail the existing methods for maintenance of technological facilities and sites, and their positive and negative sides will be analyzed. Existing software systems and standards for predictive diagnostics and maintenance will be thoroughly researched and analyzed. Based on the requirements for the predictive support system, the aim of this dissertation will be formulated. A widely used approach is based on data from previous developments and the current state of the forecasting process to determine how much time is left before failures occur. The time remaining until the failure occurs is called "Remaining Useful Life (RUL)", which means "remaining useful time". Predictive maintenance is based on the condition, performed as a result, of a prognosis ob-

tained from the analysis and evaluation of significant parameters of degradation of an element of the facility. It is planned to develop a software module to support decision-making on the condition, using intelligent methods for predictive diagnostics. The idea is to develop a module for analyzing production and reducing losses by using various algorithms and methods. The prognosis development for of the RUL, the ways of decision-making in the presence of alternatives and proposals for a model will be goal finding solutions and applying to the industrial system. The requirements for automated systems are becoming higher, and their performance is improved through the methods of self-optimization, self-configuration, self-organizing logistics, adaptive diagnostics.

Katya Madzharova - Atanasova is 1st year PhD student at the Technical University Sofia branch Plovdiv, Department of Control Systems. She has a MSc and BSc degree in Automation, Information and Control Equipment from Plovdiv branch of Technical University of Sofia. Her PhD research interests and activities are in "New algorithms for intelligent control of industrial robots in a shared workspace".

ARTIFICIAL INTELLIGENCE SYSTEMS

KATYA MADZHAROVA-ATANASOVA

Control Systems Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
kmadzarova@tu-plovdiv.bg

Research in the field of collaborative robots is a new and promising scientific field in which research centers and leading manufacturers of robots and manipulators from Europe occupy leading positions. The topic of ensuring the safe execution of tasks when sharing workspace by several robots and operators is becoming more and more relevant. This is where the approaches of artificial intelligence could find their place, which, thanks to their adaptive properties, can ensure intelligent behavior of robots when working in a shared environment.

The aim is through the use of approaches and technologies related to artificial intelligence, cyber-physical systems, rich sensory information, digital models and simulations, large information arrays - to achieve higher functionality of robots and their effective application in shared working environment. Research on the topic is expected to include the development and research of new algorithms for intelligent control of industrial robots working in environments and on tasks requiring cooperation and interaction with humans and other robots. The development of algorithms for adaptation, training and control of robots will seek solutions to build a user-friendly interface for human-robot interaction. For the formation of desired behaviors will rely on summarizing and extracting essential data from information received from the various types of sensors with which the robot is equipped. Modern approaches for the implementation of control algorithms will be applied, including through the application of artificial neural networks and fuzzy logic.

Georgi Iskrov is PhD student in his second 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

GEORGI ISKROV
Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
g.iskrov@std.tu-plovdiv.bg

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.

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.

In the first chapter of my dissertation I have considered: The technology of bitcoin mining; The principle of consensus proof of work (PoW); The principle of consensus proof of stake (PoS); The principle of consensus proof of authority (PoA); The principle of consensus proof of capacity (PoC); The principle of consensus proof of burn (PoB); A comparative analysis of the mechanism of action of Sidechain and Blockchain has been carried out; The decentralised system for transactions between different cryptocurrencies – Atomic Swaps – has been examined; The blockchain transaction model – MimbleWimble has been analyzed; The cryptocurrency storage process – Staking.

Teodora Mecheva is 3rd 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.

ROAD TRAFFIC MODEL SETUP

TEODORA MECHEVA

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
teodora.mecheva@std.tu-plovdiv.bg

Simulation is a basic approach in case real experiments are expensive and difficult to perform. The acceptable degree of correspondence between the real system and the simulation depends on the purpose of further experiments.

Road traffic simulation is one of the most intensive areas of modeling due to the great interest in transport and the many pressing problems in this area. Road traffic models are usually agent-based due to complex relationships and participants in traffic systems. The construction of a simulation model of a section of the road network includes many components - road network, real traffic data, selection of a simulation tool, model of interaction between agents, parameter settings, evaluation and validation. In addition to the models, other approaches are often used to increase the realism of the model - machine learning techniques, emotion-driven models, risk-based models. Model evaluation and calibration are complex and goal-specific.

Traffic simulators are usually agent-based due to the complex relations and actors in road traffic systems. An important factor in choosing a traffic simulator is the way of distribution – free of commercial. Time representation can be discrete or continuous. Granularity is a key feature for classifying traffic simulators. The preferable granularity is micro or meso due to the necessity wide range of assumptions and implications to be taken into account. Macro models used less frequently - for a comparative study or in case the scale of the road network

becomes difficult to handle.

In this study, the road network of central part of Plovdiv is integrated in SUMO. The set of many additional tools and well-organized documentation and support are the main reasons for the popularity of SUMO. SUMO was selected in this study because of the variety of ways to introduce traffic demand (randomization, OD matrices, classical 4 step approach, flow definitions, flow definitions and ratios, data from observation points), variety of output data (aggregated data about traffic, data in certain points, emissions, floating car data, traffic light information).

The data are obtained through virtual detectors built on the basis of road cameras. They are extracted from the database of the Municipality of Plovdiv in the form of Excel reports. Each report contains information about the number of vehicles entered the line of a single intersection per hour. The available reports cover the periods from January 15th to January 27th 2021.

Different routing algorithms and car following models (and their different settings) have been tested and the averaged square of the error has been calculated in order to assess which settings of the current model and input data are closest to the real situation.

Radoslav Furnadzhiev is a 3rd year PhD student at the Technical University Sofia branch Plovdiv, Faculty 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. He has experience with integration and development of enterprise streaming data applications. His PhD research interests and activities are in exploring Orchestration and Coordination architecture patterns for achieving scalability and availability in modern containerized applications.

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

RADOSLAV FURNADZHIEV

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
rfurnadzhiev@tu-plovdiv.bg

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.

Interservice communication is supported by a middleware infrastructure that efficiently interconnects all data flows. To support the information exchange a dynamic and heterogeneous environment satisfactory performance is crucial. Therefore, to plan and support all services it is necessary to investigate the performance and the scaling of the deployment. And design a resource provisioning policy that can find the most cost optimal setup of variety of instances of cloud that can fulfill incoming workload.

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 methods of orchestration and scaling that take in consideration resource amount estimation such as computational time, periodic cost and configuration cost of the deployment, lifecycle of each running component and capacity of the cloud.

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

Stefan Lishev

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
stefan_lishev@tu-plovdiv.bg

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.

In Fig. 1 is presented the architecture of the proposed wireless measuring system. Data are collected from heterogeneous smart sensors. They have MCU unit that perform signal conditioning and analog to digital conversion. Depending on the parameters that are measured, some of the measuring nodes have to be able to do some data analyzing, buffering, aggregation and compression.

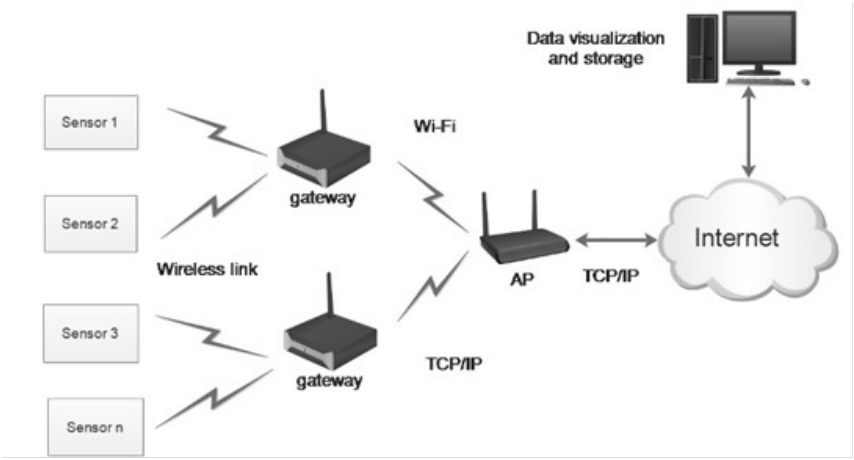

Fig. 1

Data are transmitted using WPAN/WAN protocols to the gateway. The gateway is connected through TCP/IP protocol to the Internet. Users connect to the gateway like client to server. On the side of the sensors the gateway acts as a client and the smart sensors are

servers that listen for requests. The system is intended as a test bed for the used protocols

Here are listed some of the key parameters of interest during design and system identification of UAV and their requirements for the measuring system, of which require low data rate:

- temperature
- barometric pressure
- And high data rate:
- angular velocity
- pressure
- voltage
- force
- digital impulses

To perform measurements on mobile objects like drones and plane prototypes the system have to meet some specific requirements like high throughput, low latency, energy efficiency.

Jordan Genoff is a PhD student at the Department of Computer Systems and Technologies in Technical University of Sofia. He has a MSc degree in Computer Engineering from the Higher Mechanical and Electrical Institute – Sofia (former name of the Technical University of Sofia). His PhD research is in the computational aspects of the biological nano-structures simulations.

Highly Valid Computations in Bio-Nano-Structures Computer Simulations

Jordan Genoff

Computer Systems and Technologies Department
Technical University of Sofia - branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
jgenoff@tu-plovdiv.bg

It may seem at first glance that all issues concerning the computer simulations of biological structures in time at molecular and membrane scales have already been solved. Or at least on a theoretical level. The problem is that there are inherent properties of these systems under simulation, that can impose dramatic degrees of doubt on the validity of the result. On the one hand, they are chaotic by nature, and therefore – sensitive and unpredictable. On the other hand, they are extremely massive physical compositions, which implies the use of validity measures derived from statistical mechanics. As a consequence, it is possible to find claims that obviously distinct in detail simulation results, obtained under the impact of different values of the same destabilizing factors, are all valid. This approach is inapplicable when the main goal of the study is the behavior of a certain individual particle in the system. In such cases the measures of validity must be targeted towards the properties of these single particles.

This research examines the impact of the floating-point computation precision and the iteration time step on the stability of a single chaotic trajectory in a state space. Solutions concerning both the influence of these factors and the measures of validity are proposed.

For the sake of simplification, the study is done on the Lorentz attractor system, which is proven chaotic and obviously sensitive to the factors in consideration.

Stefan Stoyanov is 1st year PhD student at the Technical University Sofia branch Plovdiv, Department of Computer Systems and Technologies. He has an MSc degree in Computer Systems and Technology from Technical University of Sofia and BSc degree in Computer Systems and Technology from Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in Computer Architectures, Computer Security, RISC-V processors and Machine Learning

Secure Heterogeneous Architecture

Stefan Stoyanov

Computer Systems and Technologies Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
s.stoyanov@std.tu-plovdiv.bg

Embedded processors are the core of smart and IoT devices. For the last two decades, they were primarily ARM instruction set based but since the RISC-V instruction set was introduced 12 years ago, things came to a state where RISC-V challenges ARM supremacy. Due to the open nature of this instruction set, it became popular for both industry and academic studies, as it is enables freedom of design, implementation and scalability.

Along with the benefits, RISC-V becoming mainstream technology leads to increased risk of cyber attacks, necessity for data protection and execution security. Many solutions to these challenges are ported from other platforms, new approaches were introduced and advanced researches are being conducted to handle the ever existing security threads.

The latest technology and future development direction of RICS-V security research are still to be defined.

A common tendency in computer security especially implementing Root-of-Trust is isolation in terms of hardware resources and access to these resources. Best results can be achieved if there's a complete isolation even between the execution flow of user program, kernel and security targeted code which naturally leads to the use of multi-processor systems. Based on

the security level of each processor it might or might not have access to the other processor resources thus defining one of the processors as security core. These processors perform different computations and algorithms. To optimize the device means that these processor cores should not to be identical but to be adequate for the tasks they perform. As RISC-V base instruction set includes just 47 instruction it means that we can have very small cores perform different tasks thus restricting chip size and power consumption.

Cyber-security faces constant attempts to exploit previously undiscovered security holes. While software can easily be patched or misbehavior detected by the user, hardware security issues can only be partially fixed by software means resulting in performance degradation and can go unnoticed by the user. Recent studies suggest the use of AI and Machine Learning for detection of anomalous behavior and preventing undergoing threads. Hardware implemented mechanisms can spot unauthorized code on very low level.

The RISC-V V extension defines vector instructions, one of the key purposes of which is to be used for AI and Machine Learning calculations.

Having a separate RISC-V RoT core with machine learning capabilities to be able to identify security threads can significantly improve the reliability of a RISC-V base heterogeneous computer system.

Pavel Radev is 1st year PhD student at the Technical University Sofia branch Plovdiv, Control Systems Department. He has a MSc and BSc degree in Automation, Information and Control Systems from Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in the field of robotics.

ALGORITHMS AND METHODS FOR INCREASING THE OPERATIONAL EFFICIENCY OF INDUSTRIAL MANIPULATORS

PAVEL RADEV

Control Systems Department
Technical University of Sofia-branch Plovdiv
Tsanko Dyustabanov 25, 4000 Plovdiv, Bulgaria
pavel_radev1@abv.bg

Research related to increasing operational efficiency and efficiency in the operation of industrial manipulators is essential in modern industrial production, which is extremely competitive and dynamic.Many requirements are placed on robotic productions, such as: high productivity (time for execution of operations), high accuracy and repeatability of operations, the highest degree of safety, energy efficiency, spatial optimization and others. Decisions to meet such requirements often lead to mixed results.

In the present dissertation will be considered algorithms and methods to increase the operational efficiency of industrial manipulators, based on the appropriate choice of control laws, technological parameters and modes of operation. The aim is to analyze and evaluate existing dependencies, as well as to propose algorithmic solutions in the field of control of industrial manipulators.

The considered problem is extremely topical with wide possibilities for industrial implementation of the obtained technical solutions. The dissertation would be essential as a theoretical summary and systematization of algorithmic solutions based on rapidly evolving technical solutions in the field of industrial manipulators.