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Contents

Editorial

Dear authors, dear readers,

this issue is completed in 2021 after some delay, because of an epidemic situation, which had deleted all scientific and expert meetings for nearly one year period, hence the personal communication ceased. Certainly we keep the amount of two issues of journal per year. The first issue should be every time a collection of publication results at the end of summer, the second issue at the end of the year.

Besides of two promised issues of journal, we would like to produce in the future some additional issues covering some professional events. Another special attempt is to produce monotematic editions of journal, after the negotiation with selected communities of experts.

Your forthcoming papers and contributions are welcomed around the year.

Juraj Štefanovič
ITA Executive Editor

FACULTY OF INFORMATICS IN PAN-EUROPEAN UNIVERSITY IN 2021 OFFERS ONLINE SEMINAR TO STUDENTS ON TRENDS IN 5G AND 6G

Ján Lacko, Eugen Ružický, Peter Farkaš

Abstract:

In this paper an information of International Seminar is given, which is organized by FI PEVS in co-operation with TU Vienna, VUT Brno and STU Bratislava. It has more than 10 Years tradition. In Year 2021 it is held using on/line technology. It documents that FI PEVS is active also in research concerning ICT Technologies including 5G mobile networks.

Keywords:

Seminar, 5G, 6G, ORAN, Drone, software defined networks.

ACM Computing Classification System:

K.3.m

Introduction

This Year the students from Faculty of Informatics in Pan-European University have again an unique opportunity to participate in International seminar which is organized together with IT TU Vienna, VUT Brno and STU Bratislava [1].

The roots of this seminar go back to IWSSIP 2008 in Bratislava during which Prof. Rupp from TU Vienna approached prof. Farkaš with the idea to start it. Some Years Later VUT Brno joint the team.

Till 2019 the seminar was realised each year in 6 weeks so that in each week the Thursday were used for personal mutual visits of students and Professors. Each university organized two seminars. The organization included invitation of renowned guests from industry or European regulation entities as presenters. In Year 2020 only one visit to Vienna took place and then the seminar was scratched because the COVID 19 pandemic did not allow travelling cross borders.

Fortunately in year 2021 the decision was made to continue with the seminar using online tools. Its actual program is as follows in next paragraph.

One can ask what are the lessons learned from the first seminars.

The most important lesson is that the future networks will again change the life of our societies tremendously. 5G will enable new applications in areas which were not able to make profit of the previous mobile communications networks. In first order the Industry and Industrial IoT and critical infrastructure will in future communicate using 5G. This will be thanks to support of ultra-low latency and ultra-reliable applications in 5G. The efficiency, productivity and security will be enhanced in many areas. Nice example is the transport which will be in future based on exploitation of autonomous vehicles.

The second lesson is that the synergy of Cloud technology, machine Learning and Artificial Intelligence will find their way to wireless networks. It is expected that thanks to it new opportunities will be opened not only for operators, but for many other businesses and institutions. These technologies will be probably connected with Edge Computing, fog computing and mobile computing, which are in focus of research at the present time.

The third lesson which is also especially important for students from FI PEVS is that the Software Defined Networks and virtualization of network functions SDN/VFN will probably be important in future networks and will generate many new jobs for software engineers.

Program of Seminar

March 4th, 2021 (host TU Wien - Vienna University of Technology)
Title of presentation: **Introduction to 5G Simulator**
Presenter: **Dr. techn. Florian Kaltenberger**
(Professor at EURECOM, Sofia Antipolis, Graduate School and Research Center in Digital Sciences, France)

March 11th, 2021
(host FI PEVŠ in Bratislava - Faculty of Informatics, Pan-European University in Bratislava)
Title of presentation: **ORAN Access (r)evolution and its potential**
Presenter: **Ing. Martin Mačuha, PhD.**
(Technology Consulting Manager at Accenture)

March 18th, 2021
(host FI PEVŠ in Bratislava - Faculty of Informatics, Pan-European University in Bratislava)
Title of presentation: **ORAN perspectives**
Presenter: **Ing. Matúš Turcsány, PhD.**
(Ericsson Chief Technology Officer for Czech Republic, Hungary, Slovakia, Slovenia)

March 25th, 2021 (host TU Wien - Vienna University of Technology)
Title of presentation: **On the evolution of Fronthaul in Mobile Networks**
Presenter: **Elmar Trojer** (Ericsson Research)

March 25th, 2021 (host TU Wien - Vienna University of Technology)
Title of the presentation:
Learning from Sky: Robot-Aided Mapping, Radio Access and Localization
Presenter: **David Gesbert**
(Head of the Communications Systems Department of EURECOM. He is also heading the Foundations and Algorithms group. EURECOM)

April 15th, 2021 (host VUT Brno - Brno University of Technology)
Title of the presentation: **RF engineering for advanced satellite telecommunication payloads**
Presenter: **Ing. Václav Valenta, Ph.D.**
(European Space Agency)

April 22th, 2021 (host VUT Brno - Brno University of Technology)
Title of the presentation: **Everyday Antennas for Sub-6GHz Applications**
Presenter: **Ing. Michal Pokorný, Ph.D.**
(Simulation Engineer – RF Computational Electromagnetics at Resideo)

In more detail the first recorded presentation was concentrated on description of the open source 5G simulator. Its components were described and because flexibility of the simulator is the necessity that most of the blocks are implemented as software. Also the invitation for collaboration with EURESCOM on research tasks in connection with 5G was disseminated.

The second presentation was very thorough tutorial about the development and present state of ORAN. Open Radio access is at the present time an initiative supported by numerous entities. The goal is via virtualisation and software tools to achieve that the mobile operators will have choice to use or not to use the products of traditional vendors when building or updating their networks. The ultimate goal is to use of the shelve hardware and implement most networking functions as software defined virtualized networks on it.

The third presentation on the other hand showed where the week points of ORAN are at the present stage of development. It also explained that the constraints of the physical laws and know-how of the traditional vendors allows them to provide for some areas of the networks solutions with such excellent parameters that it is difficult to expect that the solutions coming from ORAN initiative will be a serious competition for them in foreseeable future. On the other hand it also showed that the traditional vendors' solutions use software extensively.

The fourth presentation confirmed that a traditional vendor has unique innovation capabilities as well. It is obvious that these capabilities are exploited heavily at the present time when such vendors have to defend their business against the pressure of the competition not only from other vendors but also of the ORAN initiative. Therefore radio networks have seen major updates over their generations in providing higher capacity, lower latency, and in supporting more sophisticated use-cases. Best performance in the radio access network and core requires an underlying transport network that can fulfil the need of the radio interfaces and their supported features. The presentation will highlight the evolution of the RAN transport segment from basic p2p TDM interfaces in GSM to fully packetized mesh networks including wireless transport components in 5G.

The fifth presentation was concentrated on research towards 5G+. The use of flying robots (drones) carrying radio transceiver equipment is the new promising frontier in quest towards ever more flexible, adaptable and spectrally efficient wireless networks. Beyond obvious challenges within regulatory, control, and battery life, the deployment of autonomous flying radio access network (Fly-RANs) also comes with a number of exciting new research problems at the core of which lies the issue of autonomous real-time placement of the drones in a way that can guarantee user and network performance. The presenter did show recent results for this problem in scenarios as diverse as IoT monitoring, mobile broadband access and ad-hoc connectivity. In this talk it was also shown how radio-aided autonomous robots can also be used for mapping and user localization purposes. The approaches developed under leadership of David Gesbert lie at the cross-roads between machine learning, signal processing and optimization. Early-stage practical realizations were also demonstrated.

Behind the basic seminars the students from FI PEVŠ participating in the subjects Trends in ICT got opportunity to participate for free in the 3 Days IEEE Workshop Future Networks Security, which took place from March 22-nd till March 24-th [2].

They also got as recommended to watch individually the following workshops provided by IEEE Connecting Experts webinars:

I.

Title of the presentation: ***Digital Medicine with Wearables: from Resting Heart Rate and Sleep***
(It was co-organized by IEEE Young Professionals Norway and IEEE Communications Society Young Professionals.)
Presenter: **Giorgio Quer**
(IEEE Distinguished Lecturer at IEEE Communications Society, Director of Artificial Intelligence at Scripps Research Translational Institute, San Diego, CA, USA).

This talk presented a research system "DETECT" with 35,000 participants to detect and predict COVID-19 and other viral illnesses. It is based on previous 2-year study of sleep and heart rate changes with age and body mass index for 200,000 individuals [3].

II.
Title of the presentation: ***Toward 6G Networks: Use Cases and Technologies***
(It was co-organized by IEEE Region 8 Young Professionals.)
Presenter: **Marco Giordani**
(Postdoctoral Researcher and Adjunct Professor at University of Padova)

In this talk potential applications for future connected systems were presented as well as the estimation of key requirements such as throughput, latency, connectivity and others. Some use cases were identified for 6G systems which are in focus of research today. Survey was given for emerging technologies, which are not applied in networks at present time, but can be very important for future 6G networks [4].

III.
Title of the presentation: ***O-RAN Tech-Talk***
Presenter: **Ms. Cinzia Sartori**

O-RAN ALLIANCE has become a world-wide community of mobile network operators, vendors, and research & academic institutions operating in the Radio Access Network (RAN) industry. O-RAN aims at designing a smarter, intelligent, open, virtualised and fully interoperable mobile networks enabling faster innovation to improve user experience and efficiency of RAN deployments. The webinar explained in what way O-RAN addresses the trends in the telco industry and provided a comprehensive overview of the O-RAN Architecture, including open interfaces and fronthaul, Non-RT RIC and Near-RT RIC for network programmability as well as addressed Use Cases.

IV.
Title of the presentation: ***6G Research – The Path to the Next Wireless Standard***
Presenters: **Kira Theuer** and **Walter Nitzold** from National Instruments

The presentations reflected 6G technology development cycle in which new creative ideas are generated in academia and industry. Different applications and use cases that could be enabled by 6G were analyzed in heuristic manner as well as the factors which will turn the new ideas into reality. Prevalently the National Instruments (NI) views on open 6G research topics were presented. Also the partnerships between NI and the research community were mentioned, which hopefully will contribute to make the work which is necessary in order to develop the next generation wireless communication standard.

The additional benefit for the participating students is that they got opportunity to write overview papers for Information Technology Applications [5] in which they could use the material gained during the seminars and from additional resources provided by the teacher via the UIS system. Following themes were included into a set from which the student can select:

1. „Future Network Security: Challenges & Opportunities“
2. „6G“
3. „Can AI Applications Help with Covid 19 Pandemic? “
4. “On Selected trends in Blockchain Applications“
5. “On Selected Trends in Deep Learning Applications”
6. “On Selected Trends in Edge Cloud and Fog Applications”
7. “On IoT Security”

8. "On Post Quantum Security"
9. "On Selected Trends in Quantum Computing"
10. "On Quantum Computing Applications in Finance"
11. "ML application in Health Services"
12. "Augmented Reality Glasses Applications"
13. "Trends in Automatic Rumour Detection in Social Networks"
14. "Digital Twins Applications"
15. "Trends in Hyper automation"
16. „Trends in Human Augmentation"
17. "Trends in Autonomous Things"
18. "DNA storage"
19. "AI security"
20. "Rate less Codes"
21. "Network Functions Virtualization/Software Defined Networks"

Conclusion

In a conclusion it is worth to mention, that the field of software defined radio and communication theory as well as Digital communications is not a green field in FI PEVS neither in research area. It is documented by numerous publications of the actual or former teachers at FI PEVŠ [6-19]. This is another benefit for students, because if they wish they could participate in research in these areas as well.

Acknowledgement

The seminar is supported by IT TU Vienna, VUT Brno, FEI STU Bratislava and FI PEVŠ .

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As an IEEE volunteer, Prof. Farkaš was serving in IEEE Czechoslovakia Section Executive Committee in different positions from 1992 to 2014, from 2015 is a vice chair in Computer Chapter in this section and from 2005 to 2006 he served as a chair of Conference Coordinator Subcommittee in IEEE Region 8. He organized IEEE R8 Conference EUROCON 2001 and was chairman of SympoTIC'03, SympoTIC'04, SympoTIC'06 and co-organizer of Winter school on Coding and Information Theory 2005.

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STATE OF-THE-ART IN RESEARCH, DEVELOPMENT AND EDUCATION IN NEW INFORMATION AND COMMUNICATIONS TECHNOLOGIES FOR ADVANCED MANUFACTURING

Štefan Kozák, Eugen Ružický, Alena Kozáková, Juraj Štefanovič and Vladimír Kozák

Abstract:

Information and communication technologies (ICT), automation, and robotics remain key sciences of the 21st century. Currently, manufacturing enterprises are facing challenges with regard to new concepts such as Internet of Things, Industrial Internet of Things, Cyber-physical Systems or Cloud-based Manufacturing. The Industrial Internet of Things (IIoT) is an emerging paradigm in today's control industry comprising Internet-enabled cyber-physical devices with the ability to link to new interconnection technologies. Under this perspective, new industrial cyber-physical "things" can be accessible and available from remote locations; information on them can be processed and stored in distributed locations favouring cooperation and coordination to achieve high performance in real time. The paper presents the state-of-the-art in research, development and education in new information a communications technologies for advanced manufacturing based on intelligent modelling and control methods, and their applications with the focus on new trends declared in Industry 4.0.

Keywords:

ICT, digital Factory, industry 4.0, cyber-physical systems, big data, IoT, IIoT, artificial intelligence.

ACM Computing Classification System:

Command and control, sensor applications and deployments, process control systems.

Introduction

Modern manufacturing industry has been facing several significant challenges including sustainability and performance of production. The marriage of advanced manufacturing processes and techniques with modern ICT is driving another industrial revolution. The challenges are sourced from many real needs and factors such as aging workforce, changes in the landscape of global manufacturing, and adaption of manufacturing by implementing advanced ICT, cognitive robots, virtual and mixed reality and robust and intelligent control methods in manufacturing processes. Industry 4.0 represents the fourth industrial revolution in manufacturing industry and its methodology is a current driving force at the heart of the industry development representing the realization of large-scale changes in current industries [5] including digitization, automation and ICT integration at all levels of control of processes and services.

In recent years, many industrially advanced countries have established initiatives to apply modern ICT based on the Internet of Things (IoT), Industrial Internet of Things (IIoT), smart embedded computers, devices and technologies in the manufacturing industries to improve performance, intelligence, robustness and controllability of the manufacturing process. Relationship between IoT and Industry 4.0 is shown in (Fig.1).

Industry 4.0 is characterized by the following paradigms [4]:

a. Interoperability is the ability of integration and cooperation of intelligent machines, sensors, intelligent methods and human beings to interact through Internet of Things (IoT), Industrial Internet of Things (IIoT) and Internet of Services (IoS).
b. Virtualization is creation of a virtual model (or a copy) of an intelligent factory. Virtualization uses real data obtained from the real plant applied to the intelligent factory model for control and decisions.
c. Decentralization is the ability of each machine to carry out operations and decentralized (autono-mous) control, and to make maximum qualified intelligent decisions on each sub process for optimizing process production.
d. Real time (RT) data collection and analysis. Intelligent production control requires data to be collected and analysed in real time. Based on the information collected, real-time intelligent control and decision-making methods can be used for optimization and reconfiguration taking into account failures and finding optimal solutions such as component and device failures, transfer of production, etc.
e. Service oriented communication and information exchange over the Internet of Things, providing information to other parties of the company's services.
f. Modularity and reconfigurability. The ability of an intelligent business to flexibly adapt to the production situation by changing SW and HW modules, module sharing, and reconfiguring processes (multi-criterial and multi-variant opti-mal intelligent decisions).

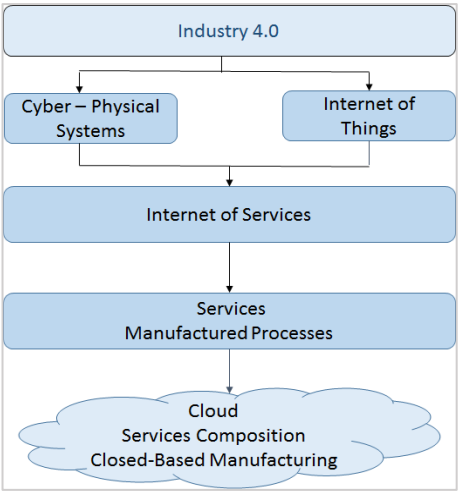

Fig.1. Relationship between IoT and Industry 4.0.

The paper is organized as follows. Section 1 deals with analysis of the current state in development of the Industry 4.0 methodology, cyber-physical systems, IoT, and integration of methods and tools at all levels of manufacturing processes. Section 2 presents research trends in advanced manufacturing. In Section 3, possibilities and new forms of multidisciplinary education for Industry 4.0 are proposed.

1 ICT and Cyber-Physical Systems

Industry 4.0 is the current industrial transformation with complex automation, data exchange, cloud, cyber-physical systems, robots, Big Data, AI, IoT and (semi-autonomous) industrial techniques to realize smart industry and manufacturing goals within the interconnection of people, machines, embedded computers, sensors and new digital elements (Fig.2).

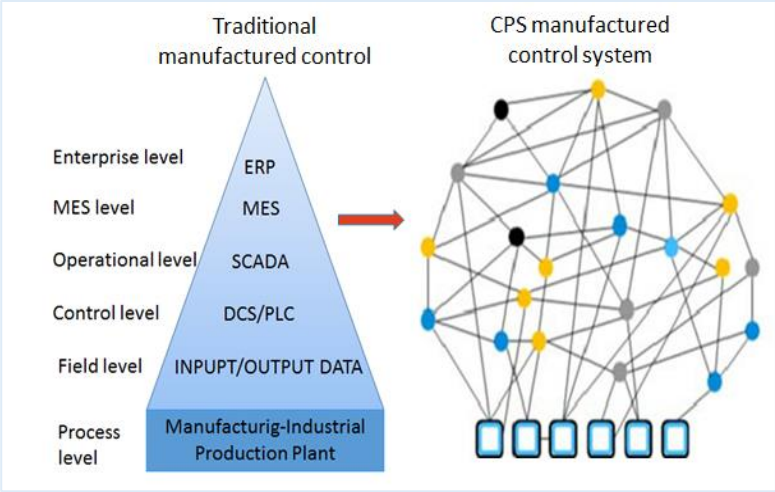

Fig.2. Conventional centralized vs decentralized IoT structure.

Cyber-physical systems (CPS) are engineering, physical and biological systems whose operations are integrated, monitored, and/or controlled by a computational core (an embedded computer system usually demanding real-time response, and most often distributed). Behaviour of a cyber-physical system is a fully-integrated hybridization of computational (logical) and physical action (Helen Gill, US National Science Foundation). CPS are the core of Industry 4.0 challenges (Fig.3) referring to a new generation of systems with integrated computational and physical capabilities that can interact with humans through many new modalities [12]. The ability to interact with, and expand the capabilities of the physical world through computation, communication, and control is a key enabler for future technology development.

CPS examples encompass all fields, e.g. automotive industry, energy optimal buildings, zero-fatality highways, and personalized medical devices. CPS link cyberspace with the physical world through a network of related interconnected elements, such as embedded computers, sensors and actuators, robots, and other computational engines (Fig.3). We assume that these systems are highly automated, intelligent and collaborative.

Nowadays, for most industrial processes, multi-level control structures are used, which are gradually transforming with the development of ICT into modern cyber-physical systems (Fig.4). CPS are engineered systems built from, and depending upon the seamless integration of computational algorithms and physical components. Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will far exceed the simple embedded systems of today.

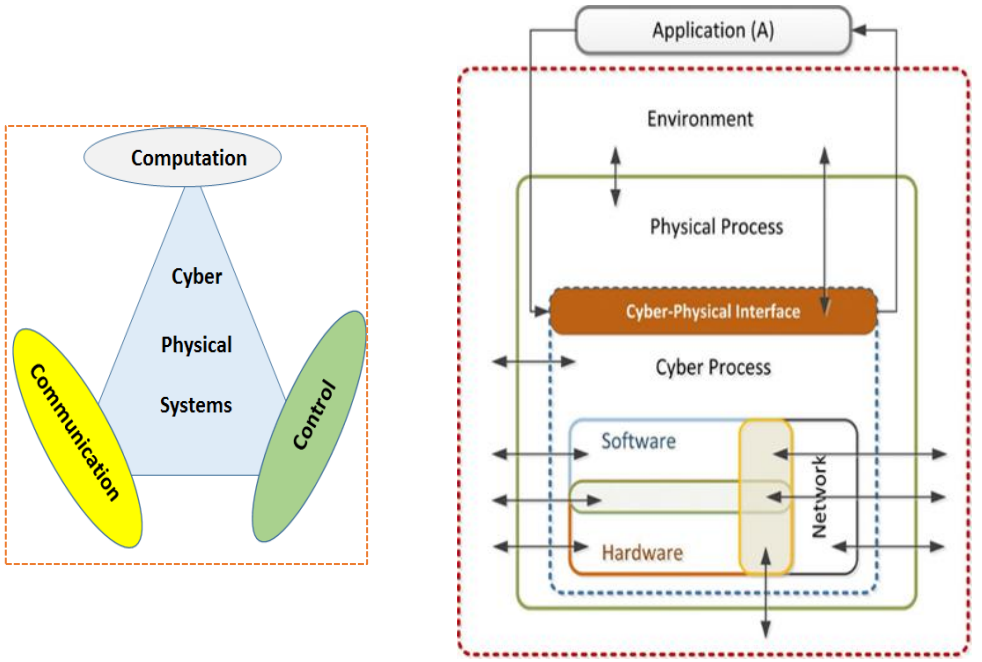

Fig.3. Principal CPS components.

CPS technology will transform the way people interact with engineered systems – just as the Internet has transformed the way people interact with information. A CPS structure can be effectively illustrated by five-level architecture (connection, conversion, cyber, cognition, and configuration) in (Fig.4) [1]:

1. Connection level – devices can be designed to self-connect and self-sensing its behaviour.
2. Conversion level – data from self-connected devices and sensors are measuring the features of critical issues with self-aware capabilities, a machine can use the self-aware information to self-predict their potential issue.
3. Cyber level – each machine is creating its own "twin" by using these instrumented features and further characterize the machine health pattern based on a "Time-Machine" methodology. The established "twin" in the cyber space can perform self-compare for peer-to-peer performance for further synthesis.
4. Cognition level – the outcomes of self-assessment and self-evaluation will be presented to users based on an "infographic" meaning to show the content and context of potential issues.
5. Configuration level – optimization and planning of the overall production system.

The 5-level CPS structure in (Fig.4) provides a step by-step guideline for developing and deploying a cyber-physical system for a smart enterprise. Connection requires acquiring accurate and reliable data from individual machines and their components. Data source can be from IoT-based machine controllers, add-on sensors, quality inspections, maintenance logs, and enterprise management systems such as ERP and MES.

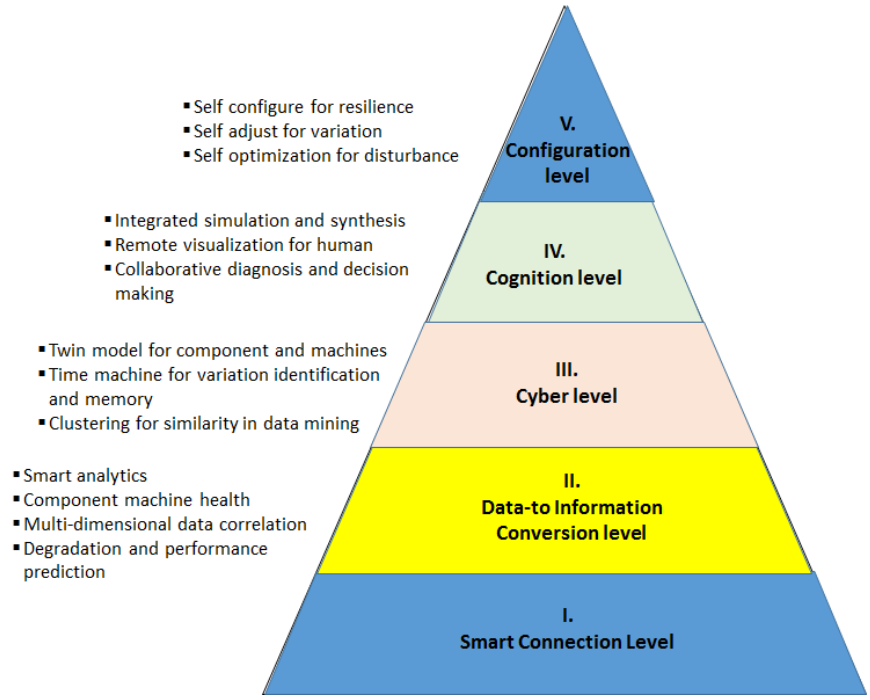

Fig.4. Multilevel architecture for implementation of Cyber-physical System.

New generation embedded ICT systems are interconnected and collaborating through the Internet of Things, providing citizens and businesses with a wide range of innovative applications and services in living and working environments. A CPS is a mechanism controlled or monitored by computer-based control and decision algorithms, tightly integrated with the Internet and its users. In the CPS, physical and software components are deeply intertwined, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioural modalities, and interacting with each other in a myriad of ways that change with context. Application of the IoT to the manufacturing industry is called the Industrial Internet of Things (IIoT).

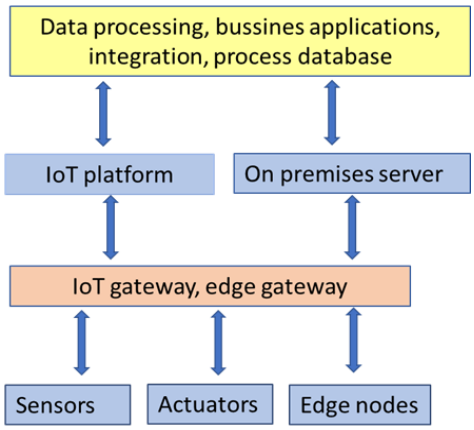

Fig.5. IIoT infrastructure.

IIoT is part of a larger concept known as the Internet of Things (IoT). The IoT is a network of intelligent computers, devices, and objects that collect and share huge amounts of data sent to a central Cloud-based service where it is aggregated with other data and then shared with end-users in a helpful way (Fig.5) [11]. IoT significantly increases the level of intelligent automation in all process industries (power plants, automotive manufacturing, food industry, intelligent homes, schools, stores, etc.).

The Industrial Internet of Things (IIoT) is the use of Internet of Things (IoT) technologies in manufacturing processes. IIoT incorporates machine learning, cloud computing and big data technology, harnessing the sensor data, machine-to-machine (M2M) communication and automation methods and technologies.

The Internet of Things (IoT) for industrial application can be characterized as follows:

- it is the network of physical items equipped with embedded computers, electronics, transducers such as sensors and actuators, connectivity and software to capture, filter and exchange data about themselves and their environment. IoT enables effective interoperability between individual devices, and machines that can be use different protocols and different architectures,
- it can also be effectively used for technological and business purposes,
- it is a significant driver for customer-facing innovation, data-driven visualization and optimization, artificial intelligence techniques, automation, digital transformation and entirely new applications, business models and revenue streams across all sectors,
- modern industrial enterprises are the integration of all recent IoT technological advances in computer networks, control engineering methods, data integration, and analytics to bring transparency to all manufacturing factories.

The driving philosophy behind the IIoT is that smart machines are better than humans at accurately, consistently capturing and communicating data. The IIoT will revolutionize manufacturing by enabling the acquisition and accessibility of far greater amounts of data at far greater speeds and far more efficiently than before.

The Industrial Internet seeks to improve manufacturing and supply chain efficiency via data, information, mathematical modelling, optimal control and effective coordination. General practical structure and components of IoT architecture for Industry 4.0 are shown in (Fig.5).

Individual IIoT levels are the following:

- IoT device. Sensors and actuators with communication interface are considered as an IoT device. The IoT devices can have its certain computational power for basic automation processes control.
- IoT Gateway. The aim is to aggregate measurements and data from IoT devices, and to actuate commands to them.
- IoT Backend. It resides in data centre with scalable CPU power and memory capacity. Its responsibility is to do high level analysis, statistics, actuation, data provision and data interface for end users.

One possible application of IIoT in manufacturing process control is presented in (Fig.6).

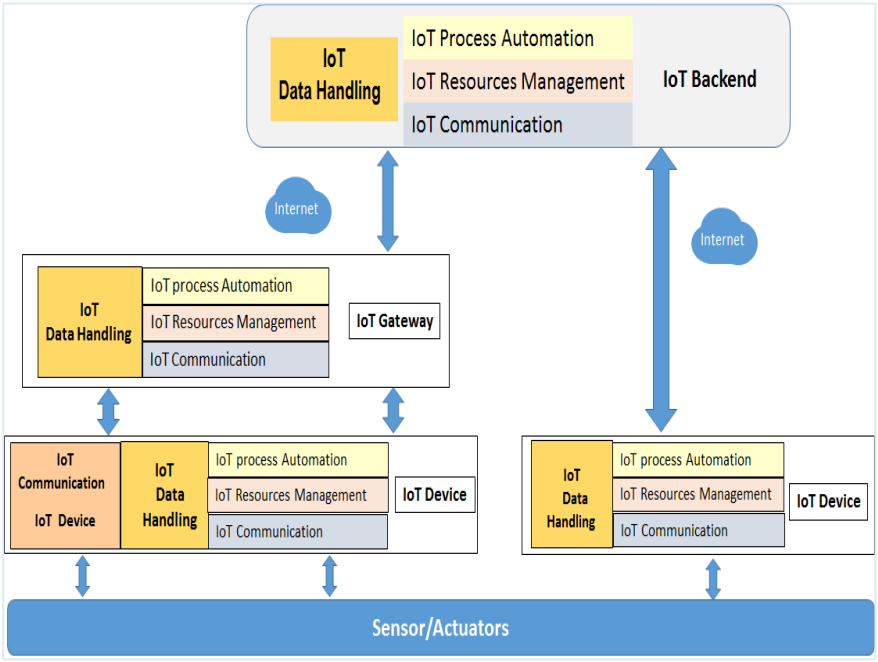

Fig.6. Application of IIoT in manufacturing process control.

2 Research Trends in Advanced Manufacturing

The last ten years have witnessed an explosion of research activity around the CPS, conceived as architectures, protocols, standards, platforms, services and applications with a high level of integration and interaction of software, hardware and physical modules and components [1]. Research of CPS is still open and in its infancy. Professional and institutional barriers have resulted in narrowly defined, discipline-specific research and education venues in academia for the science and engineering disciplines. Research in this field is partitioned into individual sub-disciplines such as embedded computers, sensors, communications and networking, virtual and mixed reality, control engi-neering theory, artificial intelligence (AI), mathematics, software engineering, Big Data, Cloud, RFID and computer science.

Achieving high production quality is not possible without research, development and application of new intelligent modelling and control engineering methods [2],[8] implemented on embedded control systems based on recent technologies of electronic, electrical equipment and components production. Several sectors have lately exploited the enormous benefits foreseen for CPS, from Energy (smart city, smart grids, energy efficiency and optimization for intelligent buildings, agriculture) up to Industry 4.0 (automotive, smart robotics, mechatronics) through Health processes (Body nets, robot surgery), Operations Research (firefighting, disaster missions) or Transport (collision avoidance, driving efficiency) among many others. CPS are composed of intelligent cyber-physical entities (Holon's, physical agents that can cooperate, self-organize, act on their environment and make autonomous decisions) [9].

Computational Intelligence (Soft Computing based on Machine- and Deep Learning techniques) are promising technologies enablers of the intelligence and self-learning capability required in complex CPS. The research fields in the development of advance CPS can be declared as follows:

- Advanced control engineering methods [2] and algorithm development (process level control, process optimization, multi-criterial decisions, pattern recognitions, discrete-time, and discrete-event modelling and control, recognition, modelling and control).
- Advanced control methods research and design as a service (IoT, IIoT, Cloud computing, Proportional–Integral–Derivative (PID) control-ler, Model Predictive Controller (MPC), Linear Quadratic Gaussian Controller (LQG), Artificial Intelligence (AI) controllers).
- Advanced soft computing techniques [2], i.e. fuzzy logic, neural network, hybrid fuzzy-neural and their application to problems related to CPS (multi-criterial decisions, distributed predictive modelling, hybrid optimization algorithms, online learning, collaborative reasoning and weakly/semi-supervised learning).
- Data analytics and scalable/parallel/distributed computing algorithms for CPS.
- Energy efficient methods and paradigms for CPS tackled via Soft Computing (Deep and Machine Learning).
- Distributed computing, data fusion and aggregation over large-scale CPS in industries.
- Predictive and clustering models for CPS self-configuration, self-resilience and self-autonomy.
- Optimization algorithms for optimal manage-ment and multilevel control, intelligent sensor actuation.
- Autonomous computing, inference of human patterns, analysis, monitoring, and situation alertness in CPS.
- Collaborative robots and machine learning and distributed AI.
- Process Controller as a service (Cloud computing, Big Data).

3 Education for Advanced Manufacturing

Modern industries need specialists with skills across a variety of theoretical and practical disciplines. Today, advanced manufacturing incorporates knowledge of many different aspects of engineering to create complex intelligent systems. Modern industries need specialists with skills across a variety of theoretical and practical disciplines. Education institutions and universities have been urged to implement the methodology and elements of Industry 4.0 into the current syllabus to make sure that future graduates will not be taken by surprise with the evolving demands of the industry. CPS are only one of important several current drivers of change in engineering education.

Industry needs new engineers with a knowledge balanced between theory and practice, an attitude of professionalism, experience in multidisciplinary teamwork, and outstanding communication skills [6].

Multidisciplinary form of education requires changing the traditional way of teaching, launching new and modifying conventional courses to adapt them to the requirements of industry. In the forthcoming years, it is inevitable to change teaching technology at universities. Already at the very beginning of the study it is necessary to change the forms and methods of teaching, and the contents especially of basic courses such as Physics, Mathematics, Materials, Electronic, and Electrical Engineering, but also Informatics and Communication Technologies, Virtual and Mixed Reality [13].

These core subjects must be taught in such a way that theoretical knowledge can be demonstrated using directly connected teaching modules (stands) with built-in real components, sensors and embedded computing systems with direct visualization and evaluation of studied phenomena and relations [6].

An important factor of education is teaching students to design and develop new complex systems in environments that are user- friendly, interactive and allow to develop software and hardware modules in parallel. According to the development of new information and communication systems and practical requirements we must not forget the new design trends in manufacturing connected with virtualization and platformization of whole systems, components and modules (the V-form design).

Teaching multidisciplinary knowledge in the bachelor and master studies requires modernization of the research and computing laboratories. These have to be equipped with complex modules, with real components included in the process. This trend is evident in teaching processes in automotive industry using HW and SW modules for modelling, testing and creation of optimal production lines, cognitive robots, communication systems and virtual reality models to demonstrate functionality of individual processes but also to evaluate reconfiguration of processes and impact of smart features and embedded control systems on the design of production processes.

When establishing multidisciplinary education, new forms of teaching are to be launched also at technical universities and directly implemented in cooperation with big, mainly industrial enterprises but also in chemical and biotechnological processes etc. Experience in effective implementation of these new education forms has shown a clear economic benefit in Europe and world-wide. Important factors that support multidisciplinary learning are the new information and communication technologies based on Internet of Things and Big Data, Machine and Deep learning and Cloud computations. Along with applications in collaborative robotics and smart systems for sensing and intelligent automatic control it is necessary to introduce a new system of intelligent communication, solution to complex control tasks, and virtual modelling and platfor-mization in all areas of production.

Thus, implementation of the IoT, Big Data, Virtual and mixed reality, and Cloud computation methodologies in education is an essential part of multidisciplinary learning forms, especially in higher grades of engineering studies. Other important courses in the multidisciplinary education form are soft computing methods that allow to model and control complex non-linear processes. Their implementation into real processes is evident mainly in automotive, aerospace and power industries.

Universities emphasize their role in shaping future technology by being the testbeds for innovation and educating future generations [10]. Traditional education has contributed greatly to the current levels of industrial evolution and technological advancement. However, in order for higher education to deliver future generations with the right set of skills and knowledge, an imperative question has to be asked regarding how higher education institutes would be affected by the Fourth Industrial revolution.

In future, the following main areas for CPS systems teaching are necessary to be incorporated in existing curricula [10]:

- data science and advanced (Big Data) analytics,
- virtual, augmented and mixed reality,
- advanced simulation and virtual plant modelling,
- data communication and networks and system automation,
- novel human-machine interfaces,
- digital-to-physical transfer technologies, such as 3-D printing,
- closed-loop integrated product and process quality control/management systems,
- real-time inventory and logistics optimization systems,
- advanced soft computing methods for modelling, prediction and control in real-time with effective parallel and Cloud computing.

CPS are only one of several important current drivers of change in engineering education.

Modern interdisciplinary education forms for Industry 4.0 (bachelor and master study) is today introduced in many education institutions. Professional (dual) education bachelor and master is a new form of study for effective integration of HW a SW devices and methods (control, optimization, computers, ICT, AI [14]) for practical experience providing ideal start to improve professional career of students at many universities. The most important benefits it brings to both students and industrial partners are practical training in industry companies, opportunity to acquire practical to skills on modern industrial plants and production equipment, as well as to feel how it is to be employed or learn what are requirements and culture of companies.

The proposed study courses (the core) tightly corresponding with future education in ICT for Industry 4.0 are as the following:

Architecture of CPS systems, Embedded computers, Sensors and actuators, Control engineering methods, Additive and alternative technologies, Automation of manufacturing and assembly processes, Computer networks and communications, Communications and networking, Modelling and simulation of complex production systems, Multi-criterial decisions, Pattern recognitions, Decentralized control, Simulation of production processes, Production systems design, Production lines design, Digital twins, Security in industry, Distributed control systems and architectures, Artificial intelligence, Software engi-neering for Industry 4.0 (PLM), Designing IoT and IIoT, Project management techniques, Knowledge and Data, Big Data, Cloud computing, Optimization of manufacturing systems, Industrial cognitive robots and manipulators, Computer vision, virtual and mixed reality, Autonomous devices and systems.

Conclusion

Today, developed countries are flexibly responding to the worldwide challenge for development of industrial productions. In many European countries, large companies develop their own methods, means and strategies to respond to these challenges. The current state in the modern digitized production and business processes forces mainly small and medium-sized companies to adapt to these challenges and build modern digitized factories co-operating with large companies, especially in engineering and automotive industries. In many countries, the Smart Industry concept is a national initiative based on latest research realized at universities and in firms to transform and strengthen the industries using the Industry 4.0 methodology. In the next years based on analysis of the present development in CPS it is necessary to eliminate the gap between theory and practice and prepare new professionals and university graduates with multi-disciplinary skills and knowledge.

Acknowledgement

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INTELLIGENT FUZZY CONTROL FOR NONLINEAR PROCESSES

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Abstract:

The paper deals with the development of a new adaptive fuzzy control method and algorithm for nonlinear dynamic systems based on the hybrid approach using fuzzy logic and genetic techniques. The new hybrid control methodology based on adaptive switching uses the principle of control parameters adaptation for all operating points of a highly nonlinear process. The control algorithm is realized by a fuzzy controller with parameter optimization for different operating points using a genetic algorithm. Proposed theoretical results are verified on a case study dealing with control design for a nonlinear model of continuously stirred tank reactor. Obtained practical results confirm the high performance and possibility of implementation of this methodology for a broad real plants in industry.

Keywords:

Adaptive control, fuzzy hybrid systems, fuzzy logic, genetic algorithms, hybrid intelligent methods, nonlinear systems.

ACM Computing Classification System:

Automated reasoning, machine learning theory, nonlinear equations, artificial intelligence.

Introduction

Automatic control methods and algorithms have developed for a long time from conventional approaches up to modern control methods featuring robustness, optimality and intelligence. In industrial practice, conventional control methods based on PID algorithms (86%), state controllers (5%), as well as new control methods and algorithms based on optimality, prediction, robustness, adaptivity and artificial intelligence approaches are the most applied currently in industry. These modern methods evolved from the latest knowledge in mathematics, informatics, communication and control theory [1]. Development of modern control methods that belong to the soft techniques has allowed further improvement of control algorithms for continuous-time processes, e.g. design and application of algorithms realized on the basis of fuzzy logic (FL), artificial neural networks (ANN), and genetic algorithms (GA). These intelligent control algorithms are designed using expert analysis or by measured input-output data, and are often easier-to-use and provide improved performance compared with control algorithms that are based on differential or difference equations [2].

Hybrid intelligent systems (HIS; neuro-fuzzy, fuzzy-genetic, neuro-genetic, etc.) are another candidate for application of computational intelligence methods which combine benefits of individual intelligent computational methods trying to eliminate their drawbacks. Application of embedded computer systems based on combined hybrid control methods can significantly improve performance, reliability, and safety of operations, systems and devices [3].

Block diagram of hybrid intelligent systems is shown in (Fig.1).

In this paper an effective hybrid intelligent control method is proposed that combines computational intelligence methods and control parameter adaptation for all operating points of a nonlinear system. The proposed approach has been tested on a case study dealing with control of continuously stirred tank reactor (CSTR).

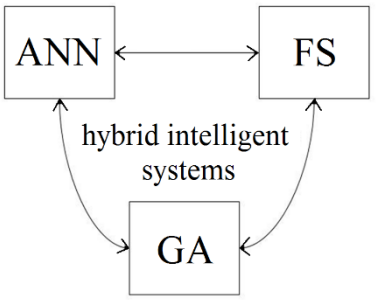

Fig.1. Block diagram of hybrid intelligent systems
(ANN – artificial neural networks, FS – fuzzy systems, GA – genetic algorithms).

1 Problem Formulation

The paper proposes a new control methodology for nonlinear systems with multiple inputs; one of them is a switching control parameter $p(t)$ used for adaptation. The fuzzy control law depends on the adaptation parameter $p(t)$ and the output variable $y(t)$. (Fig.2)

The working space (p, y) consists of a number of operating points (from 50 up to 100) either uniformly distributed or more densely concentrated around designed using genetic algorithm. Parameters of the fuzzy controller are switched during control based on the smallest Euclidean distance between the current position in the (p, y) working space, and the closest operating point.

A. Fuzzy Controller Design

In the adaptive switching hybrid control approach, well-known fuzzy controller types can be used and new types of fuzzy controller can be developed with other inputs and outputs.

Next, the incremental fuzzy PID controller with a 3-D base of rules will be considered, where the I component is realized by the control error $e(t)$, the P component is realized by the first derivative of the output variable $\mathrm{d}y(t)/\mathrm{d}t$, and the D component by the second derivative of the output variable $\mathrm{d}^2y(t)/\mathrm{d}t^2$. Output of the fuzzy controller is the derivative of control action $\mathrm{d}u(t)/\mathrm{d}t$. Inputs and outputs of the fuzzy controller are normalized to be within the range <-1; 1> according to the size of the reference step change; this scaling guarantees that the whole range of the fuzzy controller for any size of the reference step is utilized. Block diagram of the fuzzy PID controller with a 3-D rule base and normalization is shown in (Fig.3).

In this paper, consider the fuzzy inference system to be of Mamdani type [3] where each input and output fuzzy variable has 7 membership functions; for simplicity assume that they have the shape of an isosceles triangle. Example of the membership function layout of the fuzzy input variable is depicted in (Fig.4).

The rule base can be known in advance or be determined together with the parameters of the membership functions.

Consider a beforehand known quasi-linear rule base in which known control rules with fuzzy PID controller are applied, e.g. "*if the control error is large, the change of control action is large*", or "*if the control error is zero and the change of control error (output variable) is zero, change of control action is zero, too*". In this case the rule base contains 343 rules, one rule per each combination of $e(t)$, $dy(t)/dt$, and $d^2y(t)/dt^2$. For defuzzification the center of gravity method has been used.

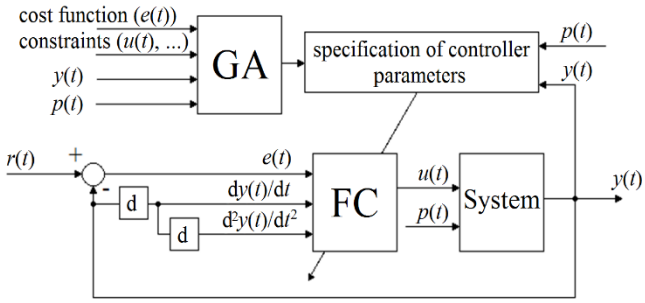

Fig.2. Adaptive switching hybrid control
(FC – fuzzy controller, GA – genetic algorithm, d – derivative,
$p(t)$ –adaptation parameter, $y(t)$ – output variable, $r(t)$ – reference variable).

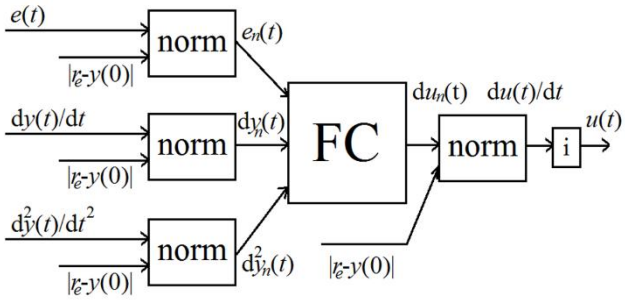

Fig.3. Block diagram of a fuzzy PID controller with 3-D rule base and normalization
(FC – fuzzy controller, i – integration, norm – normalization, r_e – end reference value,
$y(0)$ – initial output value; $e_n(t)$, $dy_n(t)$, and $d^2y_n(t)$ – normalized control error and first and second derivatives of output variable, respectively).

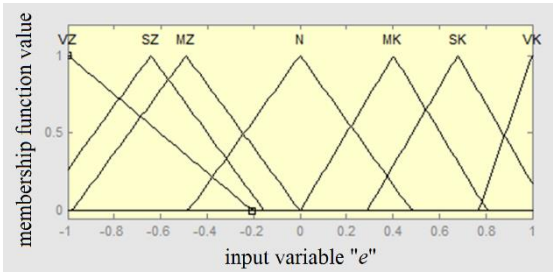

Fig.4. Example of a membership function of a fuzzy input variable
(x – axis: e – control error; y – axis: membership function value).

B. Normalization of Fuzzy Controller Inputs and Outputs

For the fuzzy PID controller normalization is used to get its input and output fuzzy variables in the range <-1; 1>. Input variables are normalized as follows

$$e_n(t) = e(t) / |e(0)| \tag{1}$$

$$\frac{\mathrm{d}y_n(t)}{\mathrm{d}t} = gain_1 \cdot \frac{\mathrm{d}y(t)}{\mathrm{d}t} / |e(0)| \tag{2}$$

$$\frac{\mathrm{d}^2 y_n(t)}{\mathrm{d}t} = gain_2 \cdot \frac{\mathrm{d}^2 y(t)}{\mathrm{d}t} / |e(0)| \tag{3}$$

where $e_n(t)$, $\mathrm{d}y_n(t)/\mathrm{d}t$, and $\mathrm{d}^2y_n(t)/\mathrm{d}t^2$ are normalized values of $e(t)$, $\mathrm{d}y(t)/\mathrm{d}t$, and $\mathrm{d}^2y(t)/\mathrm{d}t^2$, respectively, and $e(0)$ is initial value of the control error for the given reference step change; $gain_1$ and $gain_2$ are parameters of normalization.

Similarly, the output value is obtained from the normalized output of the fuzzy system:

$$\frac{\mathrm{d}u(t)}{\mathrm{d}t} = gain_3 \cdot \frac{\mathrm{d}u_n(t)}{\mathrm{d}t} / |e(0)|, \tag{4}$$

where $\mathrm{d}u_n(t)/\mathrm{d}t$ is a normalized value of $\mathrm{d}u(t)/\mathrm{d}t$ and $gain_3$ is parameter of normalization.

Parameters of normalization $gain_1$, $gain_2$, $gain_3$ are set to selected values to provide fuzzy control in the whole range of fuzzy variables for all operating points at once. They can be proposed also separately together with parameters of the fuzzy system for each selected operating point. In this case, only single values of $gain_1$, $gain_2$, and $gain_3$ are used identical for all operating points and an experimental method is applied to find them.

C. Genetic Control Algorithm

For different operating points (p, y) parameter values of the fuzzy PID controller are designed off-line by genetic algorithm [4].

A chromosome (string) $\bar{x}$ is a set of required parameters of the fuzzy PID controller, which are centers and spreads of membership functions.

Genes of the string are genes of fuzzy variables (fuzzy input variable e, $\mathrm{d}y$, and d^2y, and fuzzy output variable $\mathrm{d}u$), genes of membership functions, and genes of individual parameters of the fuzzy PID controller; the latter ones are the smallest genes and they form the whole string. In population generating, crossovers and mutations, the rules of fuzzy system design are to be taken into account.

At the beginning of the genetic algorithm, the initial population P_0 is generated with a selected number of individuals (strings) in the population. Next steps include repeated chosen number of generations, evaluation of individuals (calculation of the fitness function), selection of the best individuals (group A) and some other individuals (group B) for the new population (generation), and selection of individuals to a working group (group C), their crossover and mutation. The best individual of the last generation is the required set of parameters of the fuzzy PID controller. Block diagram of the genetic algorithm is depicted in (Fig.5).

In the process of individuals' evaluation simulation of the control loop with the fuzzy PID controller is performed; fuzzy controller parameters are determined on the basis of the given string from the population, and closed-loop time responses for upwards and downwards step changes in reference value near the operating point are monitored.

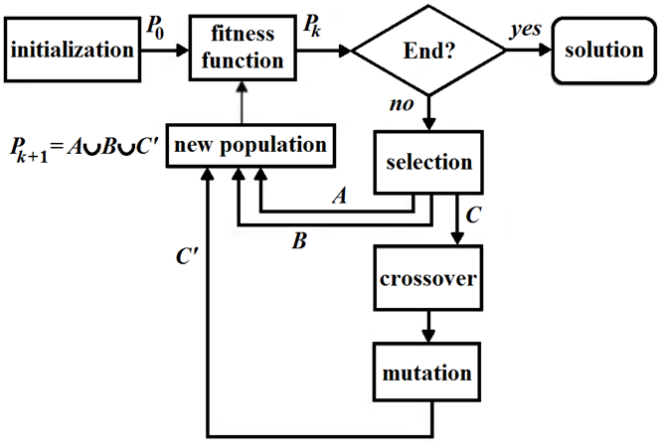

Fig.5. Block diagram of a genetic algorithm
(P_0 – initial population, P_k and P_{k+1} – *k*-th and *k*+1-st population,
A – group of best individuals, B – group of other individuals,
C – working group, C' – modificated working group).

Assume that the cost function $J(\bar{x})$ is the integral or a sum of absolute values of the control error (IAE, SAE) for step change in reference value upwards $J_u(\bar{x})$ and downwards $J_d(\bar{x})$; the fitness function $F(\bar{x})$ is the cost function extended with the limitation functions $L_u(\bar{x})$ and $L_d(\bar{x})$ for step change in reference value upwards and downwards, respectively.

Cost function:

$$J(\bar{x}) = J_u(\bar{x}) + J_d(\bar{x}), \tag{5}$$

where

$$J_i(\bar{x}) = \int_{t=0}^{T} \left| e(t,\bar{x}) \right| \mathrm{d}t \tag{6}$$

and i = u, d is index of the step change in reference value upwards and downwards, respectively, J is cost function, e is control error, $\bar{x}$ is a string, T is final observed time and t is continuous time.

Fitness function:

$$F(\bar{x}) = J(\bar{x}) + L_u(\bar{x}) + L_d(\bar{x}), \tag{7}$$

where i = u, d is index of the step change in reference value upwards and downwards, respectively, F is fitness function, J is cost function, L is limitation function and $\bar{x}$ is a string.

D. Adaptation of Fuzzy Controller Parameters

Adaptation of fuzzy controller parameters is realized by switching fuzzy controller parameters based on minimizing the Euclidean distance between the current operating point and operating points for which the parameters were designed.

At the beginning of the adaptation design, operating points are determined for which fuzzy controller parameters will be designed using genetic algorithm described in the previous section. The adaptation consists in finding such an operating point, for which the fuzzy controller parameters were designed in advance and for which the following applies:

$$\left(p(t), y(t)\right) = \min_{p(t),\, y(t)} \left(\sqrt{\left(p(t) - p_i(t)\right)^2 + \left(y(t) - y_i(t)\right)^2}\right) \qquad (8)$$

where $i \in \{1, 2, ..., N_{OP}\}$, and N_{OP} is number of operating points for which the parameter values of fuzzy controller were designed, $(p(t), y(t))$ is the desired operating point, and $p_i(t)$ and $y_i(t)$ are values of adaptation parameter and output variables, respectively, in the i-th operating point.

2 Case Study: Continuously Stirred Tank Reactor

A. Process Description

Controlled process is a textbook model of continuously stirred tank reactor in which the irreversible reactions are A -> B -> C taking place. The feed stream to the reactor is pure species A, and the maximum conversion to product B is desired. The concentration of the product B (C_B) is measured (output variable $y = C_B$ [mol/l]) and the process is regulated by adjusting the temperature T of the reactor directly by a cascaded control system (control action $u = T$ [K]). Adaptation parameter p is a flow F ($p = F$ [l/min]). The system is governed by the equations

$$\dot{C}_A = \frac{F}{V}\left(C_{Af} - C_A\right) - k_1 C_A e^{-E_1/RT} \qquad (9)$$

$$\dot{C}_B = k_1 C_A e^{-E_1/RT} - k_2 C_B e^{-E_2/RT} - \frac{F}{V} C_B \qquad (10)$$

in which the concentrations C_A (concentration of the species A) and C_B are the state variables and the temperature T is the manipulated variable. V is volume of the reactor, C_{Af} is a first value of species A concentration, k_1 and k_2 are first (A -> B) and second (B -> C) reaction rate constants respectively, E_1 and E_2 are activation energies of reactions one (A -> B) and two (B -> C) respectively and R is a gas constant. E_1/R and E_2/R are proportions of molecules that reach activation energy. Values of the parameters are listed in Table I [5].

The steady state input-output response of the CSTR model with the flows p = 0.001, 0.01, ... 1000 l/min are shown in (Fig.6). It can be seen that the system comprises a static nonlinearity for every given p.

TABLE 1. PARAMETERS FOR THE CSTR MODEL.

Param.	Value	Unit	Param.	Value	Unit
V	100	l	C_{Af}	1	mol/l
k_1	7.2 x 10^{10}	min^{-1}	k_2	5.2 x 10^{10}	min^{-1}
E_1/R	8750	K	E_2/R	9700	K

Step responses for upward step changes in input variable are depicted in (Fig.7). Step responses with initial output value $y(0)$ = 0.4 mol/l and various values of adaptation parameter p are shown. By inspection, the controlled system features dynamic nonlinearity.

It can be seen from the figure, that step responses for step changes in input variable upwards with small adaptation parameter p (p = 1 l/min) are slightly nonlinear and the settling time and system gain are large and the larger is adaptation parameter p, the more nonlinear are the step responses and the shorter is the settling time and the smaller is the system gain.

The CSTR is a system with a positive gain, without undershoot, therefore it is appropriate for the control by the proposed adaptive switching hybrid fuzzy PID control with a 3-D rule base.

B. Control Design

The working space was covered by 6 operating points (p, y): (100, 0.5044), (100, 0.3272), (100, 0.1500), (1, 0.5606), (1, 0.3553) and (1, 0.1500).

Parameters of fuzzy PID controller were designed by genetic algorithm for each of these operating points. The parameters of normalization were set to: $gain_1 = 2$, $gain_2 = 0.0333$, and $gain_3 = 1000$. These parameters have been identified in an experimental way, from responses of the system to PID control and by manual fine-tuning.

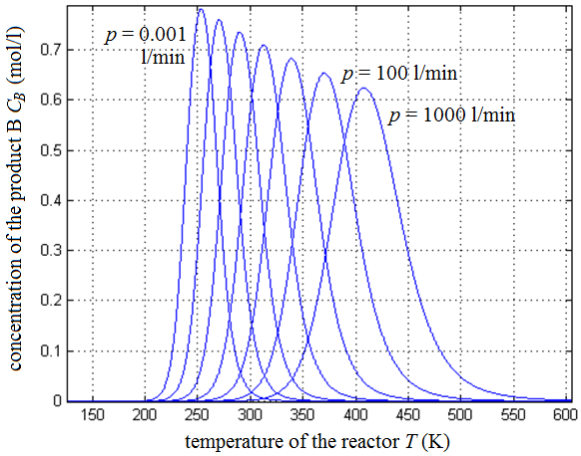

Fig.6. Steady-state input-output response of the CSTR model for different flow values (p).

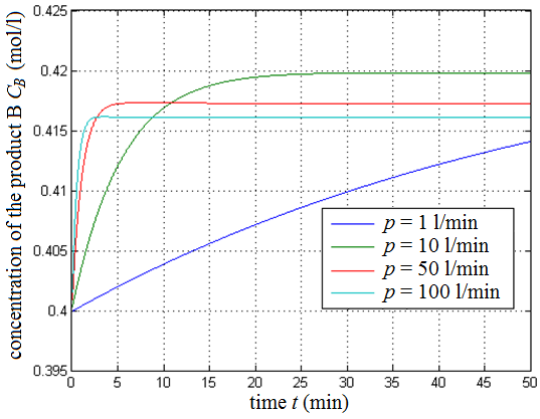

Fig.7. Step responses of the CSTR model for different initial output and flow values $y(0)$ and p, respectively, for upward step changes in input variable.

Furthermore, control parameters were adjusted as follows: sampling time T_s = 0.01 min, simulation time T_{sim} = 50 min, maximum allowed size of control action derivation du_{max} = 600 K, maximum allowed value of overshoot η_{max} = 5%, half value of deadband size δ = 0.5%, and size of step changes in reference value d_{step} = 0.15 mol/l.

Parameters of genetic algorithm were set as follows: number of individuals in population N_i = 10 and number of generations N_g = 10. For working group, there were selected 6 strings: string with the lowest and the second lowest fitness function and 4 strings selected by tournament selection. For new population, there were selected 4 strings: string with the lowest fitness function, one string selected by tournament selection, one by random selection and one new, generated string.

C. Performance Evaluation

The proposed control methodology was tested for reference step change upwards (Fig.8) and downwards (Fig.9).

In (Fig.8) there are shown time responses of controlled output y (concentration of the product B C_B) and control action u (temperature T) for adaptation parameter p = 10 l/min and step change of reference variable r from start reference value r_s = 0.35 mol/l to end reference value r_e = 0.45 mol/l.

In (Fig.9), there are shown time responses of controlled output y and control action u for adaptation parameter p = 80 l/min and step change of reference variable r from r_s = 0.35 mol/l to r_e = 0.3 mol/l.

As it can be seen from the figure, the controlled time is in these cases smaller than 10 seconds and maximum overshoot is under the desired maximum overshoot 5%.

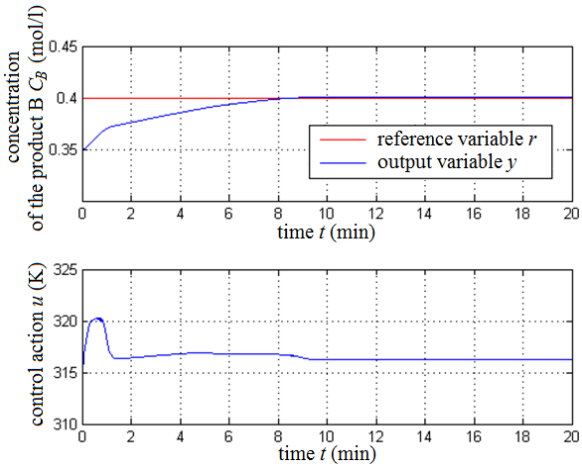

Fig.8. Time responses of controlled output y and control action u for step change of reference variable r upwards (start reference value r_s = 0.35 mol/l, end reference value r_e = 0.4 mol/l, adaptation parameter p = 10 l/min).

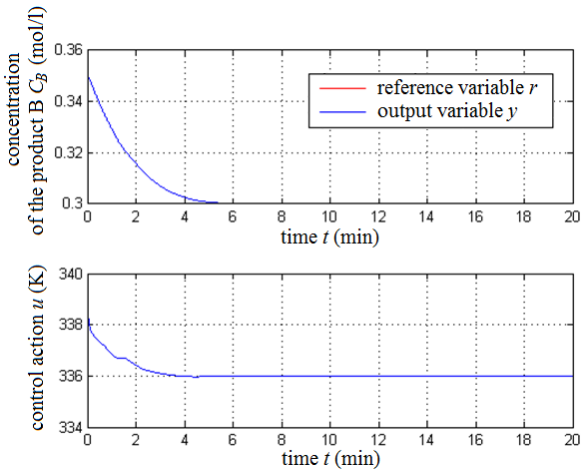

Fig.9. Time responses of controlled output y and control action u for step change of reference variable r downwards (start reference value r_s = 0.35 mol/l, end reference value r_e = 0.3 mol/l, adaptation parameter p = 80 l/min).

Conclusion

Adaptive switching hybrid control is an effective control method that allows controlling nonlinear systems with high-performance control. It provides high quality control at all points of the working space, even if the characteristics of the system in given points are significantly different.

This control methodology and principles based on adaptive switching is open and can be improved and extended to adaptation with continuous change of fuzzy controller parameters, implemented by linear or cubic interpolation, or other type of interpolation or approximation, e.g. artificial neural networks. In the fuzzy controller in addition to the membership functions also the rule base can be optimized. In the fuzzy controller design also the learning ability of the artificial neural networks can be exploited to learn the fuzzy system to existing control by combination of fuzzy systems and artificial neural networks (hybrid soft computing methods).

The proposed methodology can be used for the control of highly nonlinear processes in industries (automotive, robotics, mechatronics, chemical processes, biotechnology etc.).

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EVOLUTION OF MANAGED FILE TRANSFER IN BUSINESS TO BUSINESS

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Abstract:

In an era of digital world, data have became import part of our life. Every single day a tons of data are being exchanged over the internet. As of 2020, everyday 2.5 quintillion bytes of data are being produced and exchanged over internet. A2A, B2B, C2G and G2C rely on huge data exchange. Traditional transfer protocols like FTP, HTTP are not sufficient as they do not comply with security standards and hence a managed centralized system is necessary that not only can exchange data as traditional transfer protocols do but also can perform several other tasks like sending an SMS, sending an email, record activity so that data can be made available for analysis purpose and provide security requirement for authentication for example DFA and MFA. To fulfil the demand of modern world a managed system was created and the system is named as Managed File Transfer. This article describes evolution of MFT and importance of MFT in IoT, B2B and C2G.

Keywords:

Managed file transfer (MFT), B2B, C2G, G2C, A2A, FTP, HTTPS, SFTP, cloud.

ACM Computing Classification System:

Managed file transmission, business 2 business, consumer 2 government.

Introduction

Digitalization created a challenge to computer engineers to innovate technology day by day. In mid 90s people were hardly using computers and internet. Since 2000, internet users started increasing drastically and with the rise of smartphones, usage of internet got quadrupled [1]. Today, there is hardly any household that does not have internet connection. People started communicating digitally with their family, friends and public sectors. Digitalization in one hand made the life easier but on other hand, it raised concerns over data security and data piracy. Internet started being unsafe from data pirates, who were spying on every activity that we exchange. Identifying pirates was not easy so an approach was required to safe transfer of data. Organizations like NIST and PCI-DSS came with an approach and set certain standards that a corporation or an organization should comply with if it is exchanging sensitive data with its consumers. This standard became a must to financial and government sectors. Gigantic companies like IBM, Axway, Google took this opportunity and started developing a software/application. Software was developed to be compatible with both traditional protocols and new security standards and named the system as Managed File Transfers or MFT.

1 Traditional Protocols

Term traditional protocols refers to protocols that were developed in 4th quarter of 20th century and beginning of 21st century. Most common protocols used in transfer of files were FTP, HTTP, SFTP.

1.1. FTP

File Transfer Protocol or commonly abbreviated as FTP is a very common protocol. This protocol was developed in 1971 [2]. FTP is a client-server protocol that means a computer that initiates an FTP connection is called as client and the computer that receives request to establish a session is called as server. FTP requires two ports to transfer data. One port is control port to exchange command between client and server and the other port is data port. Default control port is 21 but data port is dynamic and based on type of mode these ports are agreed in advance before exchanging data.

1.1.1. Active mode

FTP transfer in active mode is controlled by a client machine. At the time of communication between host A to host B, client (host A) sends server (host B) information about data port that will be used by for data exchange. Server on other side checks the port and if the port is not in conflict with other clients, it acknowledges the port and deliver data to client on specified port. Active mode is useful when client and server do not reside behind the firewall, but this raises a concern when Network Addresses Translation (NAT) and firewall are in place. Since client randomly chooses data port, firewall would block the port and that could lead to ftp transmission failure.

1.1.2. Passive mode

FTP transfer in passive mode provides flexibility to the server to decide which port will be used by client for data transfer. Server chooses a random port from its port range and tells client to connect to that port. This is a very practical way of transfer because a port range (range of 100 ports) may be defined on server side and firewall rules may be enabled on both client and server to allow communication only to defined range. This provides an extra flexibility to a corporation to adhere with strict security and compliance rules. Both client and server machine may reside behind firewalls and still communicate with each other under strict security measures.

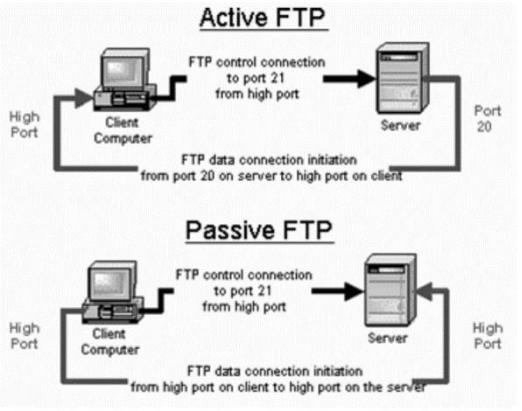

Fig.1. Active and passive FTP flow [3].

1.2. HTTP

Hypertext transfer protocol is an application layer protocol used widely by World Wide Web (WWW). This protocol was invented by Tim Berners-Lee and teams [4]. An HTTP functions as a request-response protocol. Request is initiated by a client machine and response is provided by a server. Client machine initiates a request for contents of a web page via web browsers (internet explorer, Mozilla, safari, opera etc.) and server in response provides the contents. Web page available in server may be of static type (HTML, CSS, JavaScript) or dynamic type (PHP, PERL, PYTHON, etc.).

1.2.1. Static web page

Static web pages use static contents like HTML, CSS and JavaScript. Static content means that data on page does not change. Static pages are simple in nature. Static pages are faster in getting response. These web pages do not use database to fetch data. Example of static website is www.nepslov.sk.

1.2.2. Dynamic web page

Dynamic web pages are written in complex language like PHP, ASP.NET, etc. Dynamic contents are first interoperated at server side and only after that data get fetched on client's browser. Dynamic web page uses database to fetch and store data from client's machine. Example of dynamic website is facebook.com.

1.3. SFTP

SSH File transfer protocol was discovered to ease file transfers from local to remote computer. Traditional FTP raised concerns over security and FTPS implementation was not easy for every user as it requires subscription to digital certificates. To tackle with these problems SSH FTP (SFTP) was invented. SFTP, though in beginning was not as popular as FTP but now a days it is one of the most used protocols. SFTP has replaced FTPS in many commercial and financial sectors. Unlike FTP/FTPS which use two different ports for communication i.e., one for control and one for data channel, SFTP uses only one port and whole communication between client and server is secured via secure channel. Hence, it gained more popularity in corporation where client and server reside behind firewall.

SSH File transfer uses keypairs (private/public) for authentication [5]. Private key resides on machine itself whereas public key is distributed and stored on remote server. When a client initiates a session to the server, server checks if the client's key is in its database or not and if not, session is aborted. If server finds a key in database, it sends a random text by encrypting it to the client. Client on other side decrypts the string using its corresponding private key. If client successfully decrypts the message, then server allows client to establish a session and transfer data. Whole communication between client and server is secured by using cipher suites. Cipher suites comprises these items:

1.3.1. Encryption algorithm

Encryption is a method of converting plain text string to the random string that cannot be decrypted by unauthorized person or computer. There are two types of encryption algorithms which are used in computer science and they are symmetric and asymmetric.

- Symmetric encryption - symmetric encryption uses the same key to encrypt and decrypt data between source and destination. HTTPS browsers use symmetric keys to encrypt/decrypt data between client's browser and web server. DES, DES3 and AES are symmetric encryption methods.
- Asymmetric encryption - asymmetric encryption uses different key to encrypt and decrypt data. SFTP uses asymmetric keys to encrypt and decrypt data between client and server. RSA and ECC are asymmetric encryption methods.

1.3.2. Key exchange algorithm

Key exchange algorithm is an algorithm that allows two machines residing in different location over internet to communicate by sharing a secret key over non-secure channel and allowing those machines to decrypt the secret key via symmetric or asymmetric keys. Diffie Hellman group DH group1, DH group 14 are KEX algorithms.

1.3.3. Message authentication algorithm

Message authentication key is used to check the data integrity. MAC algorithm determines if data received on the other side were manipulated or not. SHA1, SHA2 are MAC algorithms.

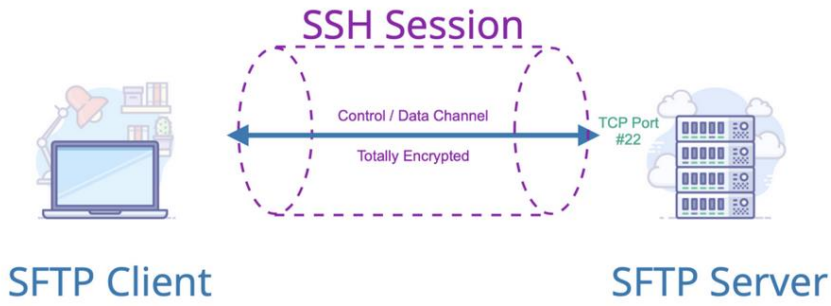

Fig.2. SFTP transfer flow [6].

1.4. FTPS

FTP + SSL or FTPS is an enhanced feature of FTP that is more secure than FTP itself. FTP transfers data in a plain text format and hence poses a security risk when it comes to transfer of sensitive data. To prevent sensitive data from man in the middle, FTP was enhanced with SSL/TLS protocol to encrypt data. TLS protocol uses digital certificates authorized by Certificate Authority (CA) as an identification mechanism. FTP alone is rarely used today and has been replaced by FTPS.

1.5. HTTPS

HTTP+SSL or HTTPS is an enhanced feature of HTTP. HTTP being a non-secure protocol, HTTPS was developed. Like FTPS, HTTPS also secures data by using SSL/TLS protocol. HTTPS uses digital certificate to identify a client and a server. Data between client and server are encrypted via secure channel that guarantees data integrity during entire session.

1.6. SSL/TLS

Secure socket layer also called as Transport Layer Security is a security protocol used by protocols like FTP and HTTP on the top of their own protocol to secure data, that are transferred over the internet. SSL/TLS protocol uses cipher suites and digital certificates (verified by Certificate authority or self-sign certificates). When a client initiates a session with server it provides a list of cipher suites supported by itself. Server checks the list of provided ciphers and checks in its system if it supports those cipher suites and if yes then it agrees with client to use certain cipher suites. Along with cipher suites, server presents its digital certificate to client to validate itself at client's side. Client checks if the public part of digital certificate from server is in its database. If it finds, session is established else session is aborted. Initial communication between client and servers are performed using asymmetric ciphers and once both hosts agree then communication begins with symmetric ciphers.

- Symmetric encryption - symmetric encryption uses the same key to encrypt and decrypt data between source and destination. HTTPS browsers use symmetric keys to encrypt/decrypt data between client's browser and web server. DES, DES3 and AES are symmetric encryption methods.
- Asymmetric encryption - asymmetric encryption uses different key to encrypt and decrypt data. SFTP uses asymmetric keys to encrypt and decrypt data between client and server. RSA and ECC are asymmetric encryption methods.

2 Managed File Transfer

Managed File Transfer or MFT is a software or application that not only consists of and support all traditional protocols but also many other features that traditional protocols were lacking. An organization may have multiple partners that use different set of protocols to transfer files or data. If the organization would use only one protocol it would have difficulties to compete in modern world as today users and organization have flexibility to choose the best and suitable protocols for them and they do not have to limit to one protocol only.

Managed files application developed by different organization support different protocols and different tasks but most common MFT used by financial sectors are Axway Gateway from Axway corporation and Sterling File Gateway from IBM corporation. These applications are not limited to transfer files only and they perform various other tasks that help an organization to compete with partners. Managed file system provides a centralized system to manage files, create report, monitor an events or transfer.

Every organization following ITIL process wants to have a track of number of incidents, problems and changes. Managed file transmission provides a real time analysis of number of incidents that occurred in a certain interval of time. This helps an organization to identify possible cause of those incidents.

Similarly, MFT also provides statistical reports to higher management as per their requirement. Managed file transmission monitors critical files that has Service Level Agreement (SLA) and alerts an admin via email or SMS, if the SLA has been breached. This prevents an organization from paying huge penalty.

Fig.3. MFT centralized system [6].

1.7. SSL/TLS

An admin is a person that is responsible to manage managed file transmission application. This role has a right to add partners, remove partners, configure application, configure monitoring and various tasks that can be setup in MFT application.

1.8. Secure File Transfer

Secure File Transfer is a system that consists of various traditional protocols that are supported by Managed File Transfer system. As an standard, MFT supports FTP, FTPS, HTTP, HTTPS, SFTP and various other protocols. MFT from IBM corporation also support NDM/CD protocol that are useful to transfer data between distributed operation systems like Windows and Linux to mainframe computers and vice-versa.

1.9. Analytics and Reports

Analytics and reports are very crucial to a company to track its system and flow. These reports help an organisation to keep track of incidents, problems, SLA breaches and overall availability of the system. This report serve management to plan revenue and onboard new partners.

1.10. Schedule Task and Automation

Schedule task are tasks that are setup by admin and are configured to run at a particular time. Schedule task can be referred to a SLA check for a file that is supposed to be delivered or received at a certain time interval. Schedule tasks also can be configured for generation of reports to higher management based on requirement. Automation is a task that is configured to execute automatically. If a file has to be received from client A at a certain time and deliver the file to client B, then automation task performs these tasks without manual intervention.

1.11. Database Management System

Unlike traditional protocols, MFT transfers are recorded in Database. Each entry is logged into database. Since each activity is audited, it is very easy to monitor and audit the system.

Any manipulation in system can be easily tracked. Files are stored in DB or data storage servers like Network File Share/Samba Share. Based on archiving policy of an organization, stored file can be easily retrieved at any point of time as per requirement.

Conclusion

Safety of data play an important role for an organization to have trust among clients. It is very crucial for such organization to have a modern and safe system to handle sensitive data of its clients. Traditional protocols do perform the task to transfer files but do not provide safety that is required by NIST or PCI DSS and hence Managed File Transfers systems are the best choice. There are many vendors and many types of MFT systems. An organization can choose an appropriate MFT system based on budget and requirements.

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ABOUT THE POSSIBILITY OF USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES WHEN RECOGNIZING IMAGES OF OBJECTS FROM DRONES

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Abstract:

The problems associated with image recognition have long been solved within various practical tasks. This paper discusses the possibilities of using artificial intelligence technologies for recognizing images of objects from drones. The problem under consideration in this work is of such a type that it is necessary to recognize images of various objects belonging to the same classification and belonging to the same class; a certain number of objects in the image form a scene. In the developed system, a neural network will be used to identify and classify objects in real time from a video stream. The substantiation of the choice of the Caffe library for the system under consideration is given. Several options for constructing a neural network are considered. Empirically, it was found that for the neural network to work correctly, namely to work with the resulting video, the required height is 28.4 meters. After overcoming this height, the video quality deteriorates sharply, which greatly affects the classification of objects. The work of the classifier with other indicators is shown.

Keywords:

Computer network, traffic loading, protocol.

ACM Computing Classification System:

Network protocols, network algorithms, network types.

Introduction

Image recognition is widely used in various aspects of human life, for example, it can be the definition of objects for augmented reality, quality control of the object, definition of obstacles, search for cars and much more.

This paper proposes to use the technology of convolutional neural networks to recognize images received from a camera located on a drone.

The target audience of the system being developed is private users and individuals. Opportunities when using the developed system:

- the ability to determine the scale and type of objects by the drone, change the trajectory based on the data received;
- generation and viewing of a report of the distance traveled and identified objects;
- the ability to work on mobile devices;
- the ability to work on other devices equipped with a video camera and sufficient computing power.

Thus, a natural requirement for the system arises. This requirement, due to the technological features of mobile devices, imposes a number of restrictions on the technologies used, as well as the system architecture.

1 Features of Solving the Problem of Object Recognition from Drones

Drones, or as they are also called, copters, are actively gaining popularity not only among fans of video filming, but also among business structures. Copters take pictures of the area, spray fertilizer in the fields and even paint, in other words, they do all kinds of work. Most of the actions are not done manually, but from the control panel, or performed using the program.

To save money during production, drone manufacturers use cheap components, which entails weak computing capabilities, critically low battery power, no USB inputs for writing their own algorithm, and much more.

There are different kits of drones on the market that you can choose to suit your needs. It is worth noting that there are specialized drones on the market for working with large amounts of data and for performing calculations, the purchase of which can only be purchased by business structures.

For commercial purposes, drones are equipped with good payload, flying elements, the ability to geolocate, work via wireless channels such as Wi-fi or Bluetooth, and an interface for writing programs.

Mobile devices are an essential part of any person. There are many different types of gadgets in the world. Unlike full-size computers, some mobile devices do not have the ability to use powerful graphics modules that will parallelize computations over floating point numbers. The only available graphics processing capability is the compact and cold graphics coprocessors that have limited computational capabilities [1].

Another limitation of mobile platforms is the limited battery life. In this case, it is important not only the operating time length without connecting to the network, but also the intensity of energy consumption. If the battery is discharged too quickly, there is a risk of degradation of the energy cells due to heating.

The third limitation is networking. In unintended places, there is a risk of signal loss and disconnection from cloud resources, which allow shifting computational operations and processing of output data.

The problem under consideration in this work is of such a type that it is necessary to recognize images of various objects belonging to the same classification and belonging to the same class (obstacle, subject, etc.), a number of objects in the image form a scene. If you look for comparisons, then the task being performed can be compared with locating a location in geodesy. In geodesy, any land operation requires a number of documents and expert opinions. It is required to identify objects on the territory, to outline the boundaries. There are no obstacles for a research drone operating in the air, due to this, objects can be identified as accurately as possible. Based on the footage, specialists can make maps for future projects. One of the approaches is the development of an algorithm based on a neural network that can group and classify objects (trees, stones, old buildings, etc.) based on the received video stream from a flying drone, saving time and effort for humans.

In our case, the task is to recognize objects, any obstacles, barriers, to determine the silhouettes of people, as well as the ability to determine a specific scene and those close to it by the same image parameters.

2 Features of the Characteristics of the Applied Convolutional Neural Network

In this system, a neural network will be used to identify and classify objects in real time from a video stream. Thus, the critical conditions for the operation of the system are the following characteristics of the network: the network has a pronounced activation peak on the video stream with the object for which it was trained; and there are no false activations on adjacent and nearby scenes in the panorama.

It is also desirable that the neural network has a minimum or no activations outside the target range, since this positively characterizes the network, allowing to reduce the load on the service modules of the system that perform classification on a mobile device [2].

Below are some libraries on the basis of which the recognition process can be conducted. Fig. 1 shows the architecture of the formed neural network.

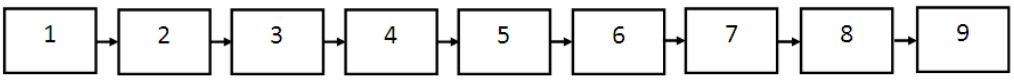


Fig.1. Neural network architecture.
1 - input, 2, 4, 6 - convolutional layers, 3,5 - subsample layers,
7 - a layer of ordinary neurons, 8 - output layer, 9 - image classes

Caffe is a popular library for convolutional neural networks. It was developed by the Berkeley Vision and Learning Center (BVLC). The high speed of work is withered. It is executed on both CPU and GPU. The algorithm is written in C ++, but has Python and Mathlab wrappers.

Deeplearning4j is a Java and Scala library that uses an open source framework to implement Apache Spark's distributed processing of unstructured and semi-structured data. It is a general purpose deep learning library designed to run in a JVM environment. The core of the library is a scientific computing block that is written in C ++. Allows to create layers with specified parameters. Integrated into Hadoop and Kafka packages. Deeplearning-hs is a deep learning library in the Haskell language that supports distributed computing on CUDA technology. MatConvNet is an implementation of convolutional neural networks in MATLAB. Neon - announced by the developers as the fastest framework for convolutional neural networks and deep learning with support for computing on GPU and CPU. The front-end is made in Python, while the algorithms themselves are implemented in a specially developed shader assembler. Developed by Nervana Systems, which was acquired by Intel. TensorFlow is a library from Google that is licensed under the Apache 2.0 license. It supports calculations on CPU, GPU and specially developed by Google TPU (Tensor proceqqing units). Front-end is in Python. It is a popular, well-documented and well-developed library.

Theano is a deep learning library for Python with APIs (for the most part) compatible with the popular NumPy library.

The user can write symbolic formal mathematical expressions from which derived code is automatically generated. Hence, the user does not need to program gradients or back propagation of the error. Such expressions are automatically compiled into shader code for CUDA, to optimize calculations on the GPU.

Torch (torch.ch) is a scientific computing framework with broad machine learning support written in C and Lua. This framework is currently used by the research unit in the field of artificial intelligence of Facebook, as well as by Twitter to implement systems for automatic classification of user-generated content [3].

The main approach is to write a highly efficient library core that executes the algorithm itself in a low-level language (C, C ++, Python). Then, to ensure usability and readability of the code, the user is presented with a high-level frontend from where, using a more convenient syntax, calls to the library core can be made [4]. The following criteria for evaluating the technologies used can be formulated:

- The shell of the library used for image recognition must be written in a programming language, the code of which can be executed on a mobile device and supported by the drone system;
- The core of the library should be easy (without long additional configuration) to compile for processors of the ARM architecture;
- The kernel must effectively use all the capabilities of modern GPUs for parallelizing computations on the training server;
- The technology must be popular, supported, documented and have a developed active developer community;
- Ability to control the aircraft (drone) from the phone.

Table 1. Compliance of popular libraries with evaluation criteria.

Library (framework)	Easy to launch the shell on a mobile device	Easy of building the core for ARM	Optimization for GPU	Popularity
Caffe	-	+	+	+
Deeplearning4j	+	-	+	+
deeplearning-hs	-	-	+	-
MatConvNe	-	-	+	+ -
Neon	-	-	+	+
TensorFlow	+	-	+	+
Theano	-	-	+	+
Torch	-	-	+	+

All this is necessary for ease of obtaining technical advice on the implementation of a demonstration project.

From (Tab.1) you can see that none of the options meets all the criteria. In order for the project to be successfully completed, you will need to independently supplement the technical solution with the necessary tools. The last step is the selection of criteria that can be implemented with less effort.

It is undoubtedly easier to add a wrapper to a kernel that builds well on the target platform than patching a kernel written in a low-level language for another platform.

As a result of the evaluation and analysis, it was decided to use the Caffe library. To complete the project, it was required to execute the library frontend in a high-level language and implement the call mechanism into the library core code.

Neural network training is directly dependent on properly selected training data. Poor data or misrepresentation of data will lead to incorrect results. Submitting one image to the input, for example, an image of a car, does not give complete confidence that now the neural network will easily detect all cars.

In order to identify an object without errors, thousands of test cases are needed to be processed, it is also necessary to select the edges of images (the so-called silhouette of an object, consisting of digital values and stored in a text document). (Fig.2) shows a visual representation of ANN training.

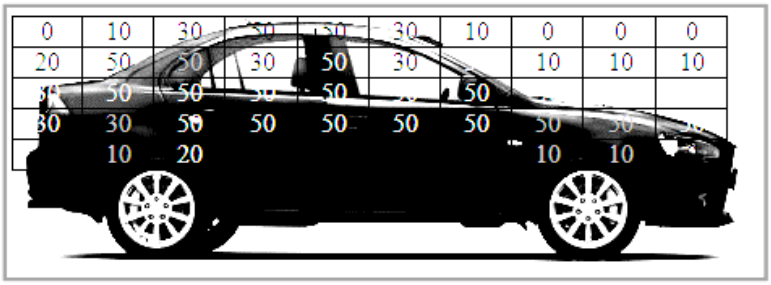
The first stage of training is a convolution layer, another name is feature maps, at this stage the existing features in the image are highlighted (a 5x5 kernel runs over the entire image and there is a matrix from 0 to 255 corresponding to the color of pixels).

The second stage of training (Fig.3). If at the previous stage of convolution detailed features of the image were revealed, then for further processing such a detailed image is no longer required, it is compressed to a less detailed one. In addition, filtering out unnecessary parts helps not to re-train. Then there is one more layer of convolution to highlight new features.

Original

First phase

Fig.2. Learning object detection.



Second phase

Fig.3. Second stage of training.

Third stage of training. Attaching Fully Connected Layers is all about referring to the output of the previous layer and defining properties that are more related to a specific class. In other words, if the program predicts that there is a car in the image, the property maps that reflect high-level characteristics such as 4 wheels, body, 4 doors, etc. should have high values. The fully connected layer looks at the fact that high-level features are strongly associated with a certain class and have certain weights.

The last stage of training is the output layer, the stage at which the ANN gives an answer to what is located in the image.

The training of the neural network has not finished yet, since only one example has been demonstrated, the network may well define the car object, but only the one in the example, other cars have a different structure and different features. The complete algorithm of the neural network will be demonstrated below.

For the first training of a convolutional artificial neural network, a data set was manually formed, consisting of images obtained on specialized torrent trackers. The advantage of these torrent trackers is that the image is initially divided into categories, which greatly reduces the amount of manual moderation. (Tab.2) contains image samples for ANN training.

Table 2. Sample of images for training ANN.

	Valid images	Not valid images	Valid images with deliberate modification
Trees	1080	1201	448
Stone barriers	1361	1480	396
Cars	1516	1906	243

When forming the training set, 3 categories of images were identified for comparative analysis - valid, invalid and valid images with deliberate change. The category of valid images includes photographs of people, images of cars, trees, large stones. Photos of poor quality (blurring, etc.) or photos that do not contain the desired object are invalid. Valid images with deliberate modification are a category of valid images in which random patterns were applied to the desired object using the Paint application.

Any change in the image, even a minor one, should be perceived by the neural network as a new drawing, so we can check the network's learning ability. The main goal of the study is not to determine such detailed parameters as the make and model of the car, type and type of tree, the main goal is to determine the classification possibilities [5, 6].

Solving a specific problem is an iterative process consisting of the following steps:

1. Designing network architecture;
2. Realization of the network;
3. Network setup;
4. Network training;
5. Testing the network.

If the test results are completely unsatisfactory (the network is retraining, the network cannot find the local maximum, continuing to change the weights in the range of values, etc.), then a new iteration is resumed from step 1.

If the network reacts to the data, but the accuracy and error do not allow achieving the target parameters, we can assume that the architecture is selected and a new iteration is resumed from step 3

To determine the criteria for testing a network, it is required to describe the scenario of its use.

Thus, a sufficient condition for the network to work is the following - the value of the network output on frames with a recognizable object should be the largest among all images presented to it.

Also, the criterion for the quality and applicability of the network will be the following condition: the next largest values of the network output after the values corresponding to the recognized object should be separated from the latter by a statistically significant, well-distinguishable distance, which will reliably distinguish the activation of the network on the object from the rest of the weaker activations.

The behavior of the network on the overview file depends not only on its architecture and settings, but also on the training examples that were presented to it at the training stage. Empirically, it was found that all tested networks learn better in some examples.

To train the neural network on real images, we selected videos filmed with the aircraft used in this work and a mobile phone. It was decided to use the fragments filmed in the central park "Dynamo" in Voronezh in several locations in different weather and time of day.

3 Research Results

To test each of the 4 options for neural network architectures, the following sequence of steps was used:

1. Splitting the corresponding survey video files into frames and defining the frame range in which the object appears, which the tested network was trained to recognize;
2. Testing the network on survey video files checking for the presence of the most pronounced peak in a certain range at the first stage;
3. Checking that there are no higher peaks outside this range;
4. Fixation for subsequent analysis of lower, but pronounced peaks outside the range, although they were not false network activations;
5. Testing the network on its own training set of images to check for failures;
6. Checking the network on files captured in other locations, with a large number of false activations or suspicion of retraining, to clarify whether the activation correlates with location signs (clouds, paving stones, the shape of windows in cars) or the network is, in principle, activated on the widest image classes (Tab.3).

The quadcopter has several important functions:

- Follow me - a function that allows you to follow the operator through the use of navigation systems;
- Fly by waypoint - a function that allows you to follow the points indicated before the flight (smartphone required);
- Follow to point - a function that allows you to direct the quadcopter to a specific point (smartphone required);
- Return home.

The quadcopter requires a smartphone. To use the functions, you need to install a free app from PlayMarket for Android or AppStore for iOS.

After connecting the copter to a smartphone, you need to carry out standard settings: authorization, connection to a smartphone, setting the GPS error (for accurate localization). Then in the settings you can add an additional host (server \ PC) for video transmission, but this will significantly affect the performance and battery life.

The laptop of the Lenovo series model IdeaPad310 was chosen as a server:

1) CPU - Intel core i3;
2) RAM - 8GB;
3) Solid State Drive - SEAGET;
4) Video card - Nvidia 910m.
5) Wi-fi module - BCM943142HM 802.11B / G / N + BT4.0 (1 * 1) [0C011-00041300]

Notebook was not subjected to certain settings, it was decided to use the standard settings of the Windows 10 operating system.

To work with the quadrocopter, the QuadraPlan software was installed, the settings were carried out via a mobile phone.

The drone operation algorithm has a list of standard actions:

1 Checking components - checking the connection to the mobile device, as well as the connection to the server, checking the battery charge, the functioning of the controls (blades);
2 Launching a video stream on the server and mobile phone;
3 Takeoff;
4 Checking the presence of a route (in this version it is better to indicate the route in advance, since when the drone is in the air, the check can cause a fatal error);
5 Flight to the specified point;
6 Checking the route - it was decided to check the current location with the planned route every 30 seconds.
7 Signaling of the successful achievement of the set route;
8 Return to the starting point;
9 Landing.
10 Uploading the received data.

Table 3. Network test results.

Network Option	Peak activations (when shooting)	False activations (when shooting)	Other peaks, peaks / frames (frames)	Activations on the training set are below 50%	Activations on data from other locations
1	23	0	4\85	0	2
1	105	2	2\506	0	
2-1	154	2	2\746	0	2
2-1	96	2	2\663	0	
2-2	31	0	2\50	0	0
2-2	72	0	3\183	0	
3	45	0	0	0	0
3	100	2	1\134	0	

It is worth noting that this model is a budget model, so it is severely limited not only in terms of internal indicators, but the possibilities are also severely curtailed, for example, at the peak of a heavy load, the copter was active for only 10 minutes, the range was no higher than 130 meters, going beyond threatened with artifacts on the video, and control failures were also noticed. Also, when the battery was low, the drone stopped responding to signals from the mobile phone. A full description of the drone algorithm is shown in (Fig.4).

The most difficult thing in setting up the drone and the artificial intelligence (AI) module was to teach it to determine where the obstacle (object) is and to maneuver. The ANN came to the rescue, since by classifying the object (after each convolution layer in the image, unnecessary elements are removed), it determines its localization in the image. The image obtained in this way passed through a function written in Python, which changed the resolution of the resulting image to 1280x720, a visual example is shown in (Fig.5).

If the object occupies the area of one of the indicated letters, the drone will maneuver in the opposite direction. The whole essence of the object analysis algorithm for AI is to check the conditions, whether the object has occupied the A - B field, etc.

Empirically, it was found that for the correct operation of the neural network, namely work with the resulting video, the required height is 28.4 meters. After overcoming this height, the video quality deteriorates sharply, which greatly affects the classification of NS objects.

The maximum speed of the drone used is 50 km/h, when this speed is reached and ascending to a height of 28 m, large objects remain distinguishable, such as cars, food stalls, large stones. Objects (People), captured in this mode, acquire the effect of "spots", it is difficult to answer the question of whether they can be classified, since they were not identified during the test.

The viewing angle of the drone's webcam is 180 degrees, so it was decided to build a route, following which the same number of objects would be constantly encountered. The flight was built through a mobile app to reduce the risk of altitude and speed changes. The tests were carried out at the car park of the Dynamo park in Voronezh; cars (20 units), bystanders, a brick fence (2 units), which was identified as an obstacle, were chosen as objects for testing. During the tests, the cars and the fence did not move, the number of people in the frame during some tests increased, or they were absent.

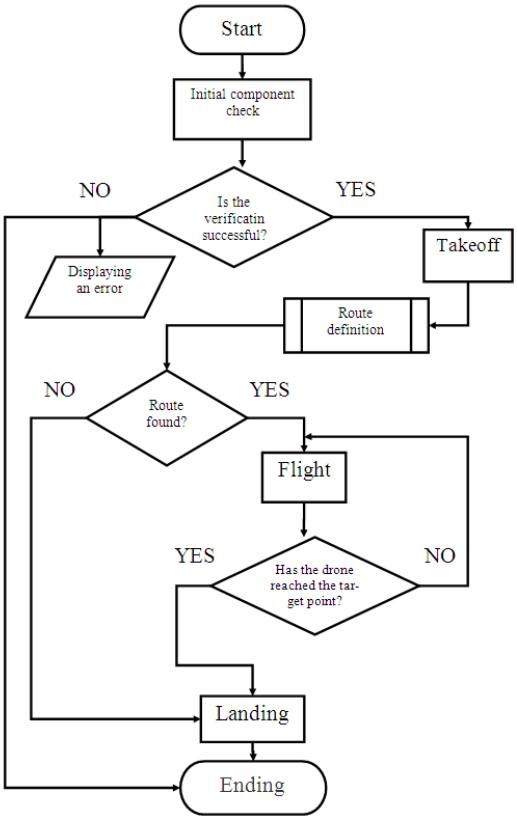


Fig.4. Algorithm of drone actions.

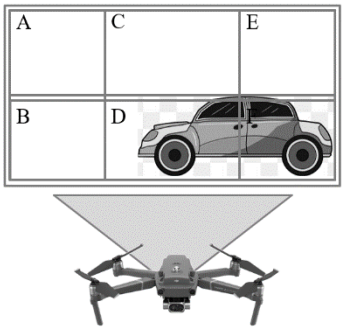


Fig.5. Object definition area.

(Fig.6) shows the route, crosses show the location of the objects (the number of crosses in the figure may not exactly coincide with the objects during testing).

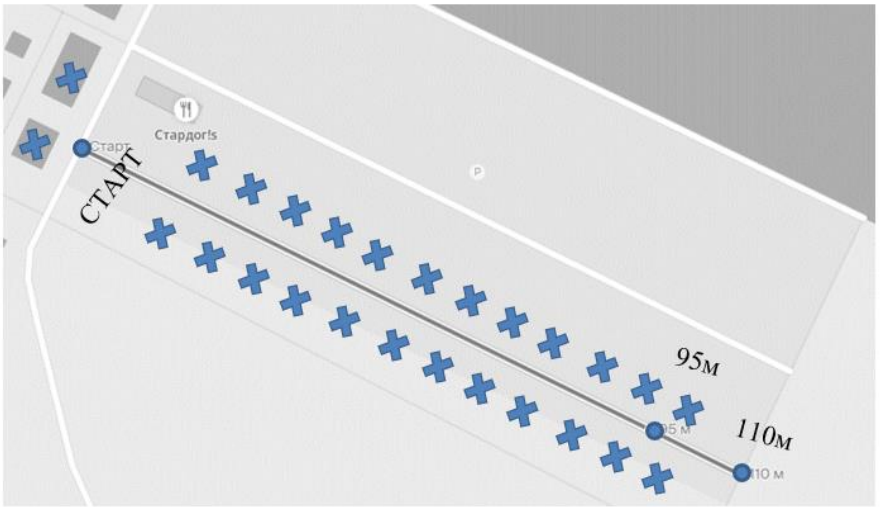


Fig.6. Test area (Park "Dynamo", car parking), starting point on the left side.

The webcam built into the drone records video in 720p (1280x720) quality. The range of the signal from the drone is 130m (in good weather conditions), after the drone crosses the 150m mark, malfunctions are possible. (Tab.4) shows at what indicators the operation of the ANN classifier becomes impossible, where 100% is a complete classification of objects, 0% is the definition of objects is impossible, the drone's performance is impaired [7].

Based on the presented table, we can conclude that the maximum permissible height and speed for the successful operation of the classifier is an altitude of 60-80 m and a speed of 30-40 km/h, at which most of the objects were successfully classified (from 20 to 27 objects out of 30).

Table 4. Work of the classifier with other indicators.

	Speed 0-10 km/h	Speed 10-20 km/h	Speed 20-30 km/h	Speed 30-40 km/h	Speed 40-50 km/h	Speed 50-55 km/h
Height 0-20 m	97.3%	93.7%	87.3%	83.1%	81.1%	73.3%
Height 20-40 m	87.1%	83.9%	80.6%	80.6%	77.4%	77.4%
Height 40-60 m	87.1%	83.9%	80.6%	77.4%	64.5%	61.3%
Height 60-80 m	87.1%	83.9%	77.4%	64.5%	61.3%	58.0%
Height 80-100 m	64.5%	64.5%	58.0%	58.0%	0%	0%
Height 100-280 m	0%	0%	0%	0%	0%	0%

Conclusion

As a result of writing a scientific work, the set goal was achieved - to study the possibilities of using neural networks for recognizing images received from drones.

We analyzed the available libraries and frameworks for designing ultra-precise neural networks that implement deep learning algorithms, searched for a neural network architecture that solves the problem, tested the neural network and conducted tests using a quadcopter.

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SAML SSO Design

Patrik Rodný

Abstract:

Software companies are experiencing a persistent business demand for new software projects. Even though a sophisticated software product can utilize its modularity with intention to improve in specific area, every change with higher complexity may cause that the software project lowers its success by exceeding planned time and resources. The situation is no different in the field of economic and juristic applications. The intent of this paper is to mention a description of security solution design to create possibilities for company collaboration, to enhance the identity security and to improve the usability. Within the design phase there is an opportunity to reuse existing and proven standard solutions. The presented example of Security Assertion Markup Language Single Sign-On (SAML SSO) design deals with securing several multidomain web applications with a common user base. Within the design, Spring Security is highlighted for its reinforcement in modularity and strong popularity within Java programmers. Considering different design views using the methodology MMDIS, the SAML SSO design is prescribed to unite the existing software projects with the goal to offer complex, usable, and secure products to customers.

Keywords:

SAML, SSO, Spring, security, MMDIS.

ACM Computing Classification System:

Security and privacy, security services.

Introduction

This paper presents the design of SAML solution as a key to accomplish higher success in comparison to case when complex changes to the existing project cause the software project to exceed expected time and budget. The intent of this paper is to answer a question whether we can utilize the security standard, proven by time, to solve a problem with lack of clients of multiple economic and juristic organizations, as well as to increase the security and usability of the products. Modeling and analysis are combined so that a design substantiation could support the programmers in their future projects. For detailed characteristic of a solution please refer to my bachelor's thesis [5].

The purpose of SAML is to outline a communication between systems offering services (service providers - SP) and trustworthy system (identity provider - IDP) [6]. Trustworthy system is the one on which is the authentication, or alternatively also authorization delegated. IDP must be well secured and trustworthy in providing identities to SP.

The goal of secure design is that minimal information is to be sent, and the identity identifiers always reach their destination unmodified and unrelieved by the attacker. This can be considered as a safe state. By this manner, the attacker could be eliminated from the dangerous communication game. By implementing SAML SSO we secure the sent identity information using a pair of public and private key and reduce the total number of times when the password is sent over the network.

Apart from securing the application, we may also think about usability and user experience. In direction of providing the necessary comfort and easy choices to the application user, we assume that lesser the authentication procedures the user goes through, the more stamina he could utilize while using the application. Security authentication schemes like Single Sign-On or Single Log-Out may be considered also as a tool providing user a relief from unnecessary actions.

1 Situation in Regard to Authentication Mechanism with SAML

Today, many applications step aside from duplicating the stored identity information across multiple systems [5] [6]. A SAML scheme can be used as a special case of SSO, where the participants or parties are operating under different domains create a so-called federation. Special agreements and standards must be applied to the federation so that an access could be granted for a user across multiple simultaneous applications. In case of cloud environment, we can talk about federated groups created to protect identities or user credentials. A standard called Federated Identity Management (FIdM) describes how the identity management information is transferred between domains so that the user party can benefit from the application and its resources without the need to discover the detailed identity of application user [4].

In terms of FIdM, there are three most popular security standards. One of them is SAML. Another standard for delegation authentication is called Open Authentication (OAuth). The last one, OpenID Connect (OIDC) is simply only an identity layer on the top of OAuth 2.0 authentication protocol. These standards use tokens which can also partially represent an encrypted digital identity of application user [4].

In oppose to SAML, the OIDC alternative offers better functionality than it was before. It is simple and easy to implement its specification because the communication is using RESTful APIs. Its target usage is web, cloud, mobile devices and IoT. It is still a developing standard, where for instance Facebook and Twitter are using their own altered versions of OIDC. The next generation authentication protocol requires time for its acceptance in business applications. [4] While in the long run the federated authentication protocol is expected to change from SAML to OIDC. [2]

SAML is a recognized standard as it is being successfully and widely accepted for enterprise business usages. Major international companies such as VMware, IBM, and Google have adopted it successfully. [1] Despite the wide usage we must say that SAML has negatives concerning mobile devices and IoT because of the high XML verbosity compared to JSON. [4] Another thing worth mentioning is that SAML is relatively difficult to implement, configure and maintain as a security solution.

For the current systems there are possible approaches how to support both SAML and OIDC by implementing token translation. There have been more solution proposals introduced in the past. One of the solutions was introduced in 2019. The solution proposal includes 5 main participants [2]:

1. User Agent
2. OIDC Client
3. OIDC Broker
4. SAML Proxy
5. IDP

The goal is that the User Agent is authenticated by SAML IDP while using OIDC standard. The IDP cannot reply to OIDC client with SAML message directly. There is a translation logic between the OIDC identity information format and SAML identity information format. For this purpose, is the OIDC Broker introduced. OIDC Brooker does not connect to identity provider directly, but it utilizes another component called SAML Proxy. SAML Proxy is using HTTP redirects to pass the identity information from IDP to the OIDC Brooker. From the SAML perspective it acts as middle peace (behaves like both - identity provider and the service provider), but it additionally provides multiple microservices like User Consent, Discovery Service, and OIDC Interface. In case of OIDC request, the OIDC interface does the OIDC token to SAML AuthRequest conversion. [2]

Even though the encryption and signing offers good level of protection, weaknesses have been shown on the side of identity providers where the authentication is being performed. [3] SAML SSO can decrease the amount of entered authentication information, however it cannot eliminate the danger of Man-in-the-Middle attack. To improve in this area, it is suggested to utilize Multi-Factor Authentication (MFA) which is usually not a common practice in many IDP implementations because of the fact, it is not a part of Standard Operating Procedures. [3] Multifactor authentication stands from a definition for a combination of something you possess, something that you grasp and something that you constitute. It is the goal of the designer to find the proper ratio between the usability and security of different authentication methods. [3]

Many existing commercial SAML IDPs are ready for deployment and only need to be properly configured. On the site of SP, a programmer can choose from variety of security libraries which can be included into the application. To introduce a specific library, a security library from Spring Security project was chosen. This library was included into the Spring Security project only recently. [5] Even though we can observe an increase in length of the encryption/decryption keys, the long living concepts like RSA keys continue to provide security for exchanged information. The theory remained because efficient approach to break this cryptographic problem is out of actual human knowledge. [5]

The two most known types of attacks to SAML systems are Denial-of-Service (DoS) and Man-In-The-Middle (MITM) Attack. DoS is when the attacker tries to flood IDP with requests from stolen authentication information. MITM is when the sent messages are captured and misused.[4]

The research discussing about how is the SAML testing, and code audit performed, reveals a sad news. The usually used semi-automated code audits of SAML solutions lack efficiency and are less reusable in comparison to sophisticated testing methods. For this purpose, lets mention a testing framework that can deal with it. [1]

There are two different approaches of testing SAML SSO systems [1]:

- a model oriented and
- an implementation oriented.

In case of implementation-oriented style, we consider the specific code implementation and vulnerabilities. This approach has shallow viewpoint in the way that it is difficult to discover vulnerabilities because of the absence of global abstraction. On the other hand, in case of model-oriented style, the system specifications are converted into the state machine. Within the model-oriented approach, we can distinguish 2 models. The first one is responsible for catching sent data during a successful login scenario. Afterwards the second model tries to alter the data while assuming unexpected behavior. The data alternations can include randomly inserting enclosing html element tag or inserting malicious JavaScript or SQL scripts into the message or its header. [1]

The increase in software projects caused the number of application users to rise rapidly. From the usability perspective, the application has special constrains to the passwords which has ongoing negative effects for application user. We can talk about stress to fulfill the security expectations. Single Sign-On (SSO) solutions also provide an ease of application use and improve the user's experience while working with multiple applications. [3]

2 Proof of Concept - SAML Single Sign-On Design

Many companies today take advantage of e-business to improve communications with their customers through sophisticated applications. Each business does its activity to maximize profit, but it must respect the boundaries of laws in the country in which it is performed.

In this research the firms are divided into 2 categories. In the first category there are economic and juristic firms. These firms offer software products for the second category. To the second category they belong for instance companies with focus on civil, mechanical, electrical, chemical engineering or healthcare. The firms in the second group are supposed to be clients of the first group.

The law and economic firms with their software have their own clients which does not necessarily have to be distinct. The firms are speculating on how to be more supportive for a larger user base.

Can we utilize an existing proven solution within the design to solve the problems of enhancing security, improving usability and support the collaboration of juristic and economic firms? We can have a closer look at proving the answer to the hypothesis by modeling an example of SAML solution.

Each company is offering services while having their own database of clients and these databases are not shared in between companies. From this we presume duplicities across different databases.

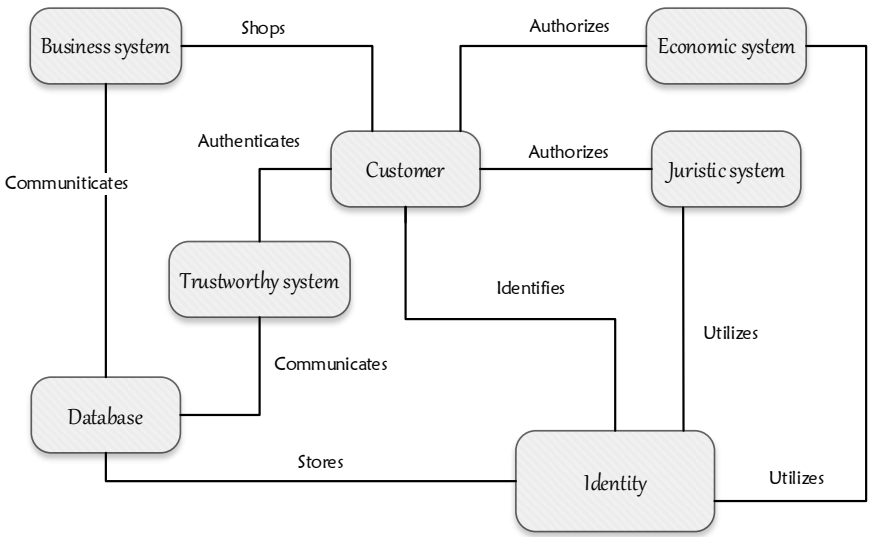

Fig.1. MMDIS Conceptual class model [5]

The design idea is that the economic and juristic firms could create a pact to offer complex products to their customers. We can look at each of software system as if it would be an SP instance. To design SAML standard, two other systems would be trustworthy system (identity provider - IDP) and a business system which would serve as a common gate to selling a license to economic and juristic applications. The cooperation between the systems could be secured by a common database which would store the user identities. [5]

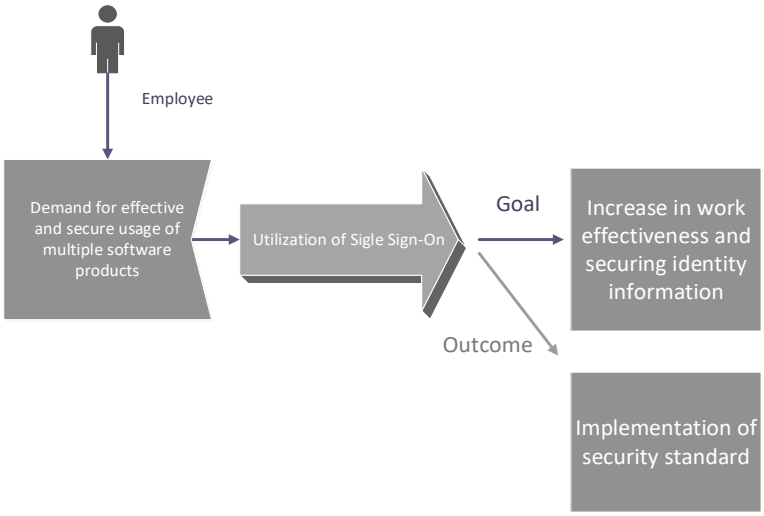

Fig.2. MMDIS Process model [5]

Providing that the budget allows it, there is a possibility to choose from many commercial IDP implementation like Octa or Microsoft ADFS, or to satisfy with open-source alternatives like Shibooleth or Keycloak. [5]

On the side of the service provider, is Spring Framework considered to be a focal point in security solution design. Spring framework is suitable because of the modularity of Spring Security components. So, after the different authentication mechanism are applied, authorization can be effectively handled.

The Spring support for SAML started with an extensions project. [5] The problem with this was a library that utilized a lot of dependencies on which were vulnerabilities discovered. The Spring decided to discontinue the support of the extension library and only recently introduced SAML library in the Spring Security project itself. To get a sense of some discovered vulnerabilities please refer to table below presenting an analysis from 1st of May 2021:

Table 1. Overview of analysis with OWAPS Dependency Checker 6.1.6 for vulnerabilities reported by NIST.

Library (groupId, artifactId, version)	Unique dependencies count	Vulnerable Dependencies	Vulnerabilities Found
org.springframework.security.extensions:spring-security-saml2-core:1.0.0.RELEASE	25	13	49
org.springframework.security.extensions:spring-security-saml2-core:1.0.10.RELEASE	33	10	13
org.springframework.security:spring-security-saml2-service-provider:5.4.6	23	5	9

In case of spring-security-saml2-service-provider all the 5 vulnerable dependencies have published a new version, where the vulnerability problems are fixed. From this perspective can be the latest library considered as secure. In the testing phase, it would be not good to stay at implementation testing, but also perform a model testing.

Discussion of Results, Recommendations or External Links to Details

Even though that within the Federated Identity Management design IDP we usually send only a fraction of identity information, like for instance belonging to some user group. In case of my bachelor's thesis minimal 3 key identity attributes are sent. The user group is represented by business category. Company registration number is expected to be used within both IDP and economic and juristic SPs and therefore it can strengthen the condition. The last of the sent attributes is the value contract validity which prevents from creating a session in case of not paid subscription. [5]

Despite of difficulties to implement, configure and maintain SAML, it is a standard that offers high level of security and can create a sense of trust between different parties by securing the sent data with signing and encryption.

From the consistency perspective the SAML messages are in format of XML which is likely to be used by older enterprise applications. In case some application would need to support a mobile device, SAML is not optimized in the way of performance for mobile devices. Even though the JSON serialization and deserialization is usually faster that the equivalent operation with XML, there are solutions for token translation where we can use both SAML and OIDC clients.

Spring Framework was chosen for its strong modularity support and its popularity within the community of Java programmers. SAML itself is not dependent on any specific platform or implementation.

To support the idea of economic firms using software based on Spring Framework, lets mention for instance an Open-Source ERP software called Metasfresh. It has a simple accounting capability and is based on Spring Framework.

While selecting the most suitable IDP, we should consider the possible Man-in-the-Middle attack and choose a solution that supports Multi Factor Authentication.

The most recommended testing is the model-oriented testing because it provides the necessary abstraction in form of state machine.

The Spring library selection was performed based known vulnerabilities of its dependencies. OWASP project contains the list of rules denoting the known vulnerabilities of web applications. These rules are updated every 2-3 years. [5] One of the tools to perform Software Composition Analysis (SCA) for checking the published vulnerabilities within the project dependencies. It is called OWASP Dependency Check. Before analysis, the tool updates itself with the most recent database from an online NIST data source.

Conclusion

Within this article I summarized the state of art concerned to SAML. The intention of this article was to bring in the SAML design topic elaborated within my bachelor's thesis. The abstract design can serve the programmer in the implementation phase and it could support him in improving fruitfulness of the future software projects. The hypothesis that security solution may help to unite multiple companies was outlined using MMDIS models. The presented solution design ought not only support collaboration, extend the user base, but also it should protect the user identity, enhance the system security, and improve the user experience while using multiple application simultaneously.

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MOBILE APPLICATION TO SUPPORT E-LEARNING AND QUIZZES DURING COVID-19

Csaba Farkaš, Eugen Ružický

Abstract:

The COVID-19 pandemic has changed the way we are taught in all types of schools. However, education has significantly affected those universities where there is also a form of practical verification of knowledge, such as in medical faculties. We selected 3 studies that discuss e-learning in medical schools during the pandemic. We made the selection based on different cultures as well as religious customs. We used the mentioned experience in the design of a mobile application, which was used by medical students of the Medical Faculty of Comenius University in Bratislava for the subject of Biochemistry in the form of e-learning and quizzes. Subsequently, we modified the application for the general use of any object. The modified application is in testing at the Faculty of Informatics, Pan-European University.

Keywords:

COVID-19, Quizzes, testing, e-learning, applications in medicine.

ACM Computing Classification System:

Document types, communication hardware, interfaces and storage, network architectures, real-time systems, software creation and management, life and medical sciences.

Introduction

By a survey of publications in scientific journals using the keywords ‘covid‘, ‘quiz‘ and ‘e-learning‘ we found 16 relevant articles in Scopus and 5 articles in the Web of Science. With further selection concerning our intention to create an e-learning mobile application for medicine, we have selected three articles that are from different cultural and religious backgrounds. Medical students are the most affected by having no practical experience during this pandemic for more than a year. The first article, "Remote electronic examinations during the Covid-19 pandemic: A cross-sectional study of student preferences and academic dishonesty in medical schools" describes a study from Jordan [2]. It examined the factors for preferred teaching and testing methods as well as their benefits and potential for abuse. The result of the study shows that while distance e-exams and submission of written reports are the least preferred teaching methods, so far 30% of students prefer a combination of exams and quizzes. The second study from the Faculty of Medicine of the University of Geneva entitled "Asynchronous distance learning in the range of stroke scales during the COVID-19 pandemic (E-learning vs Video): Randomized controlled study" compares the effectiveness of the study by watching traditional didactic videos and interactive e-learning videos [3]. The highly interactive module group performed better than the video group. The third article is "Teaching and Studying Postgraduate Medical Physics Using Internet E-Learning During the COVID-19 Pandemic - A Case Study from Malaysia" [1]. The study evaluates feedback from students.

This shows that e-learning has its limitations and the future is hybrid (combined personal and e-learning) learning. These facts also correspond to our experience with a mobile application, which is used to create a quiz for medical students during the COVID-19 pandemic.

Full-time teaching at the Medical Faculty of Comenius University in Bratislava was interrupted in the second week of the winter semester of 2020. It continued in a distance form using the Moodle system and e-learning. Lectures, exercises, and exams take place online via the Internet. Students watch prepared lecture videos of teachers and study from books, scripts, other electronic or paper teaching materials. For example, the students print out the biochemistry test questions without correct answers and exercise the correct answers on paper. They have to sign up to various platforms to access the online learning tools and scientific databases. Teaching and examination create high demands on both high-quality internet connection and computer skills of medics.

Supporting education with a mobile application for learning and testing in the form of quizzes can facilitate the acquisition of the subject and preparation for the exam. The chosen pilot subject is biochemistry which due to the complexity and volume of required knowledge is one of the most demanding subjects of a medical study.

1 Technological Environment of the Application

For the development of the mobile application, we have chosen a specific subject of Biochemistry from the Faculty of Medicine of Comenius University. The application is called BiochemTest. The Android platform was selected. Android is one of the most used operating systems for mobile devices. The native integrated development environment (IDE) Android Studio and Java programming language were used. The most used languages for Android Studio are Java and Kotlin. Google currently recommends Kotlin as the first language for Android but continues to fully support Java and C ++ [6]. The structure of a Java project in AS is shown on the BiochemTest application (see Fig.1).

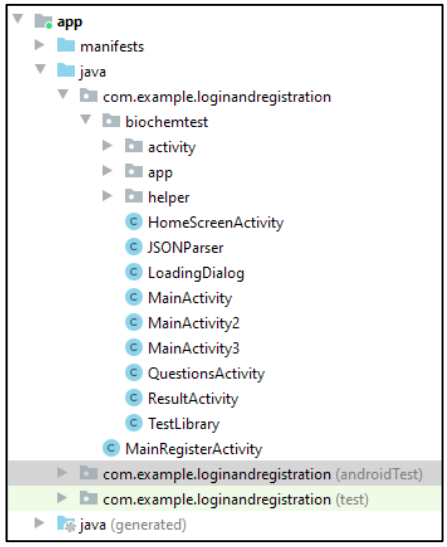

Fig.1. Structure of the BiochemTest project in AS (Android Studio, 2021).

The front-end (UIX) application is implemented on a mobile terminal, which is connected to the back-end relational MySQL database via the Internet. Communication between the database is in JSON format using a PHP interface.

Fig.2. Communication diagram of the application.

Login and registration are implemented according to R. Tamada: Android Login and Registration with PHP, MySQL, and SQLite [4]. The application provides CRUD operations in a distributed REST environment on a Volley database session. The application generates a unique user id in PHP using the 'uniqid' function. Encrypted passwords are stored using the base64_encode method. Each password must have two columns to store in the database. One is the storage of an encrypted password and the other is the storage of a series of random data - cryptographic salt [4] [5].

2 Testing

The functionality of the application was tested by analytical tools, such as the Android Profiler. This provides real-time data on how the application uses CPU, memory, network, and battery resources (Android Developers, 2021).

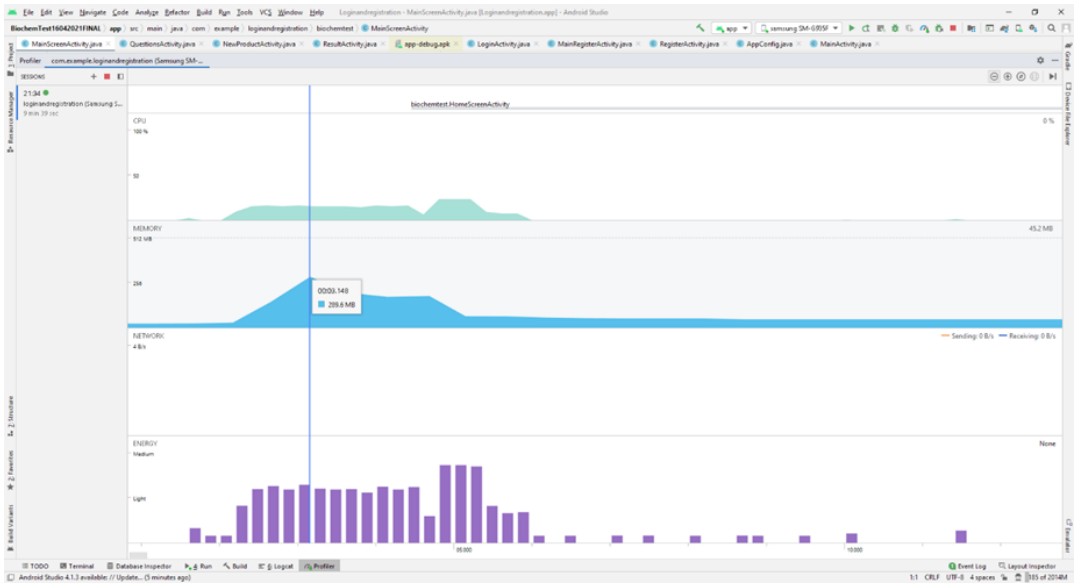

Fig.3. Test output from Android Profiler in Android Studio.

The recording of the BiochemTest starting process after uploading from the ASUS Model X751L notebook to the Samsung Galaxy S7 Edge smartphone shows that the CPU load of the smartphone is less than 25%. The maximum usage of the operating memory of 289.6 MB represents more than half of the memory capacity. After ca 5 seconds it drops to a value of up to 10% of the memory. No network communication was recorded during the start-up process.

The network communication was active later during the communication with the database. In the fine-tuning the parsing processing time measurement was implemented into the code: 'elapsedTime = System.nanoTime () – startTime'. Parsing of text files beginning at a size of several hundred kB had a significant impact on processing time. Measurements of energy consumption showed low to medium data with a decrease to zero.

3 Usage Methodology and Graphical User Interface

Students prepare themself for the biochemistry exam by watching videos from lectures and online presentations, studying books, other study materials, and exam tests. The implemented test of Biochemistry in the BiochemTest application has 984 questions and multiple correct answers out of 8 possible for each question (current test file from the Faculty of Medicine of Comenius University 2021). Each answer is scored separately. The verification on paper is very time-consuming. During the real exam, the students are stressed by time pressure and inaccuracy (about 1 minute for the correct answer for a question with 8 answers). BiochemTest can provide them an effective tool for studying and practicing correct responses.

The target group of the BiochemTest application is medical students and teachers. Users can use the application for the subject of biochemistry in four different scenarios:

Scenario I. – the student will use the application to study, master, and understand biochemistry (see Fig.4). By clicking on the STUDY button, the student will go to the selection of a thematic unit. After pressing the button of the selected topic, the student first reads, analyzes, and then clicks only on the correct answers. The boxes with the wrong answer must be left blank. Clicking the NEXT button will display all the correct answers with an indication of the correctness of the given answer. The student verifies and corrects the incorrectly ticked answers from the available study materials with an emphasis on understanding instead of memorization.

Scenario II. – the student will use the application to practice quick answers, the goal is to increase speed and precision. The student proceeds as in the first scenario, intending to practice answers to 100% success. It is recommended to make a note of critical questions/answers where mistakes occur and find a way to eliminate them.

Scenario III. – the student verifies his knowledge, the goal is to determine his readiness, monitor his progress, and finally take an exam. The student authenticates / logs in to the application with the LOGIN button. If the student does not have login details, he must register first by the REGISTRATION button. By pressing the TEST button, the student goes through the individual test questions and clicks on the correct answers. He must supervise the one-minute time limit per question. At the end of the test, the student presses the RESULTS button and the evaluation screen appears which consists of the CORRECT ANSWERS, INCORRECT ANSWERS, FINAL SCORE. The result can be sent by clicking SEND RESULTS.

Scenario IV. – the teachers/students will use the application for learning and testing. The current result is presented on the activity screen of the application. The historian data is accessible for teachers and students from the MySQL database via an Android or Windows application.

The BiochemTest Graphical User Interface is intuitive and user-friendly. It allows to control the activity screens and to interact with the application using interactive pixels and buttons. The feedback in learning mode is immediate, when moving on to the next question, the correctness is displayed, and the success of the answers is evaluated. Another group of users is teachers, who can use the application to learn and test their student's knowledge. A user-friendly environment is important for them, to create or modify existing questions. The results of the pilot testing by medical students show an improvement in the repeated tests. This gives evidence that the educational target of the application is met.

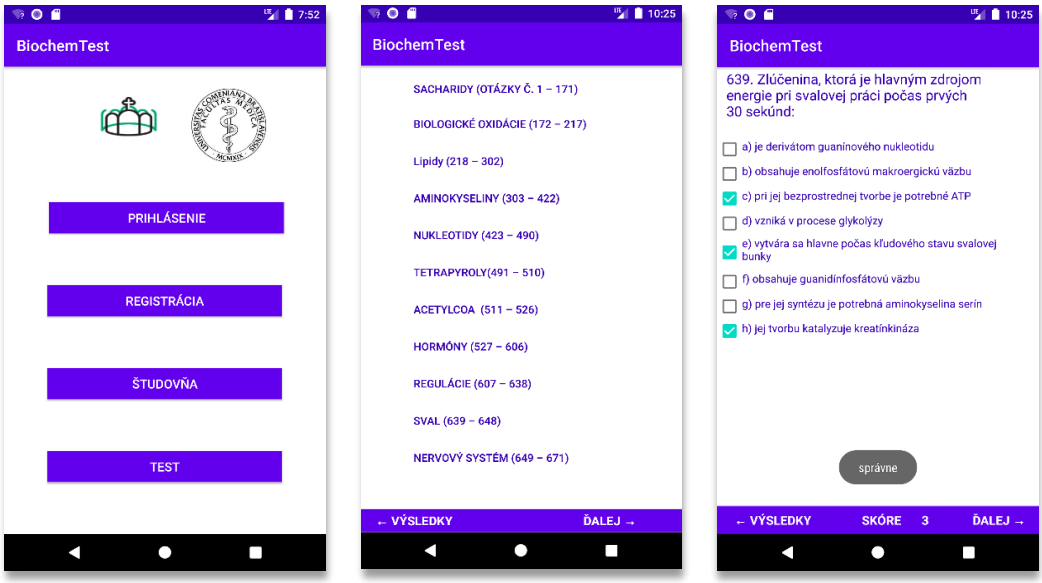

Fig.4. Graphical User Interface of the application.
Left side - four buttons: Login, Registration, Study room, Test.
Right side: A question 639th with a grey evaluation label on the bottom: Right.

4 Enhancements for Any Subject

The BiochemTest application can be used for any other subject as well. This requires changing the database on the local or remote web hosting Wampserver. Loading a new database can be done by phpMyAdmin for MySQL database management. After creating a new database, the Import function and the new data file must be selected. The correct character set has to be adjusted and the data has to be loaded up. The import process was verified by using PHP interface, SQL, CSV, XML, JSON, and Open Document Spreadsheet files.

A file sample (CSV) for direct import of a question into the prepared MySQL table "test_sacharidy" [7]:"

"1", "1. Main substances in the form of which glucose is introduced into the body:", "(a) are monosaccharides such as glucose", "0", "(b) are polysaccharides such as cellulose present mainly in fruit" , "0", "c) are polysaccharides containing alpha 1,4-glycosidic bond", "1", "d) are disaccharides which are absorbed from the GIT into the blood in unchanged form", "0", "e) are disaccharides, eg sucrose, cleaved in the stomach "," 0 "," f) are polysaccharides hydrolysed by pancreatic amylase "," 1 "," g) is a disaccharide containing 1,2-glycosidic bond "," 1 "," (h) are polysaccharides which, after hydrolysis, are absorbed in the form of monosaccharides "," 1 "

Another possibility of inserting new data was tested by a specially developed Java application via MySQL Connector / J in the Apache NetBeans environment. Finally inserting and modifying data from a specially created Word document was tested as well.

5 Further Research

Further research and development are recommended for the extension of the application database for images and videos. We propose to improve the e-learning application with an explanation of the answers with a link to the relevant study resources.

The application BiochemTest allows us to design a more comprehensive educational and testing system that will provide extended functionalities, such as reporting test results. This allows evaluating the performance of the students and the class. The teacher will be able to determine which parts of the course are the biggest problem in the education of students (see Figure 5).

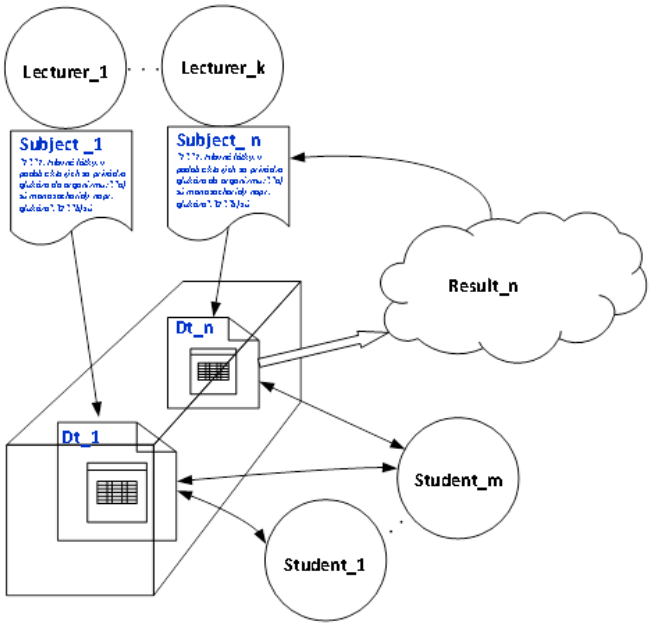

Fig.5. Comprehensive teaching and testing system.

Teachers (1, ..., k) can enter subjects (1, ..., n) into the tables of Dt databases (1, ..., n). The students can learn from the tables or test themselves. The test results will be accessible for the teachers and the students as well. Teachers can evaluate the activity of the whole class and monitor the progress of the individual students. This will improve the learning process and thus the quality of education.

In the future, it will be possible to extend the application so that a list of publications on this topic is available on the Internet for each question or section. A list of publications dealing with the disease after COVID-19 is given in the article [8]. At the Faculty of Informatics of the Pan-European University, we deal with applications of virtual reality in medicine, which can play an important role in the post-COVID-19 syndrome [9].

Conclusion

The selected articles from the survey show the importance of education through tests at medical schools. The mobile e-learning application BiochemTest was developed for the subject of biochemistry of the Faculty of Medicine of Comenius University. The application enables interactive learning in the form of questions and multiple correct answers. It also provides an opportunity for training, self-testing, monitoring the progress in preparation, and testing on exams. The results of the pilot testing by medical students show an improvement in the repeated tests. This gives evidence that the educational target of the application is met. The application database is modifiable for any subject. Currently, the modified application is being tested for the subjects of Applied Informatics at the Pan-European University. We recommend further development of the BiochemTest application towards a comprehensive system for teaching and testing various subjects based on e-learning and quizzes.

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