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2ND INTERDISCIPLINARY DOCTORAL SCHOOL SEMINAR

2-3 DECEMBER 2020

Doctoral School No. III
Exact Sciences and New Techologies

Warsaw University of Technolody

The 2nd Interdisciplinary Doctoral School Seminar is a joint space for the exchange of scientific experiences between doctoral students of Doctoral School No. 3 and their supervisors, who are also warmly invited to this event. Within two days of the seminar, all doctoral students who have already completed their first year of studies will present short presentations on their doctoral research, having an opportunity to discuss the results with the audience.

Doctoral School No. III

Exact Sciences and New Technologies

Warsaw University of Technology

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PROGRAMME

	THURSDAY, December 2, 2021	FRIDAY, December 3, 2021
09:00	Opening Ceremont with special guest Vice-Rector for Research Professor Mariusz Malinowski, PhD, DSc	Session #7, Chairman: prof. Piotr Gawrysiak
09:15	Session #1, Chairman: prof. Ryszard Piramidowcz	#7.1: Kinga Pilch, Assamese Character Recognition
09:30	#1.1: Mikołaj Koszel, Dual active bridge converter as a part of the DC microgrid	#7.2: Marta Piecyk, Graph homomorphism problem and its variants
09:45	#1.2: Mateusz Kałuża, MIMO-type structures for terahertz band	#7.3: Bartosz Kozłowski, K*(892)^{0} meson production in nucleus-nucleus interactions at SPS energies measured by NA61/SHINE at CERN
10:00	#1.3: Tomasz Wichary, Security controls roles in network slicing management and orchestration	#7.4: Kacper Kania, Low Shot Realistic Human Rendering from Partial Information
10:15	Coffee break	Coffee break
10:30	Special invited presentation Mateusz Spałek, MD, PhD The Maria Sklodowska-Curie National Research Institute of Oncology	Session #8, Chairman: prof. Piotr Gawrysiak
10:45	Session #2, Chairman: prof. Ryszard Piramidowcz	#8.1: Karolina Pawlak, Weak solutions of the fractional Stefan problem
11:00	#2.1: Katarzyna Nałęcz-Charkiewicz, De novo assembly of DNA sequences using quantum annealer	#8.2: Sandhi Wangiyana, Automated Extraction of Building Footprints from Radar Images
11:15	#2.2: Adam Borkowski, D/A converter for quantum computing	#8.3: Wiktor Łodyga, Parallel implementation of Particle-in-Cell algorithm using Julia programming language
11:30	#2.3: Przemysław Nowak, Luck, Reason, and the Price-Pareto type-2 Distributions	#8.4: Paweł Matraś, Subalgebras of matrices satisfying some identities
11:45	#2.4: Witold Sosnowski, Contrastive Learning for Supervised Language Model fine-tuning	Lunch break
12:00	Lunch break	Special invited presentation Paweł Bochniarz Member Of The Supervisory Board of top deep tech startups in Poland and CEE
12:15		
12:30	Session #3, Chairman: prof. Mieczysław Muraszkiewicz	Session #9, Chairman: prof. Jordi Mongay Batalla
12:45	#3.1: Mikołaj Płachta, Detection of Image Steganography Using Deep Learning	#9.1: Tomasz Rudnicki, Radar simulator compatible with IEEE standard for distributed interactive simulation (DIS)
13:00	#3.2: Dominik Kolasa, Detecting malicious clients in federated learning	#9.2: Maciej Pawlik, How social interactions lead to polarized relations?
13:15	#3.3: Mateusz Bartosiewicz, High accuracy image captioning	#9.3: Krzysztof Stasiak, XY-DemoRad - a Compact Fine Resolution Radar Operating in the K- and mmWave-Band
13:30	#3.4: Piotr Zych, Impact of low-voltage electromechanical switches on the electromagnetic environment	#9.4: Marcin Macias, Anomaly class detection and comprehension using segmentation techniques on RGB images
13:45	Coffee break	Coffee break
14:00	Session #4, Chairman: prof. Mieczysław Muraszkiewicz	Session #10, Chairman: prof. Jordi Mongay Batalla
14:15	#4.1: Paulina Komorzycka, Creating the required distribution of the cylindrical modelling index in general interior lighting	#10.1: Mateusz Chiliński, HPC-enabled genomic variant discovery using ConsensuSV
14:30	#4.2: Monika Wysoczańska, EgoNN: Egocentric Neural Network for Point Cloud Based 6DoF Relocalization at the City Scale	#10.2: Wojciech Masarczyk, On robustness of generative representations against catastrophic forgetting
14:45	#4.3: Piotr Łukaszewski, Matrix pencil method in the detection of fault induced travelling waves	#10.3: Paweł Kowaleczko, Fast Fourier Transform based Method of Neural Network Training for Human Re-Rendering
15:00	#4.4: Piotr Fryc, Using AI methods for driving image sensor parameters	#10.4: Anton Safronov, Computation of nuclear effects in MadGraph5_aMC@NLO at Next-to-Leading order accuracy
15:15	Coffee break	Coffee break
15:30	Session #5, Chairman: prof. Marcin Iwanowski	Session #11, Chairman: prof. Ryszard Piramidowcz
15:45	#5.1: Łukasz Lepak, Machine learning for trading	#11.1: Michał Ostapowicz, Resource Allocation in Business Processes Using Deep Reinforcement Learning
16:00	#5.2: Mikołaj Rogalski, FPM app: an open-source MATLAB graphical application for fast, simple and intuitive Fourier ptychographic microscopy data reconstruction	#11.2: Andrzej Polatynski, Modelling of Generic Process Design Kit (PDK) Components for Photonic Integrated Circuits
16:15	#5.3: Tomasz Lehmann, Algorithms for monocular depth estimation using deep neural networks	#11.3: Laboni Manna, Lepton-Hadron collisions in MadGraph5_aMC@NLO
16:30	#5.4: Sebastian Wildowicz, Theory of reconstruction of bipolar ECG signal	#11.4: Milena Ojrzyńska, Characterization methods of 2D materials produced by liquid phase exfoliation
16:45	Coffee break	Wrap-up session and closing remarks
17:00	Session #6, Chairman: prof. Marcin Iwanowski	
17:15	#6.1: Jan Bielecki, Research on Computing Tasks	
17:30	#6.2: Wioleta Rzęsa, Analysis of femtoscopic correlations of pion-deuteron and kaon-deuteron pairs in Pb-Pb collisions in the ALICE experiment at the LHC	
	#6.3: Anna Cichocka, On some subclasses of subalgebras of Leavitt path algebras	
	#6.4: Moncy Sajeev Idicula, Multi-incident holography profilometry	
	#6.5: Jan Sawicki, ARC Welding	
	Backup session	

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POSTERS

- Krzysztof Gromada, Application of artificial intelligence methods in localization of Tactical Unmanned Aerial Vehicles based on vision systems and digital maps
- Emilia Sobieska, Analysis of the effectiveness of lightning and surge protection in a large solar farm
- Robert Kołakowski, Data Plane Traffic Engineering algorithms in future mobile networks
- Tomasz Śmierzchalski, Finding Spin Glass Ground States Through Deep Reinforcement Learning and Graph Neural Networks
- Daniel Mostowski, Laser beam diagnostics systems based on artificial intelligence algorithms
- Karolina Filak, Development of a technology for the production of a multifunctional polymer nanocomposite based on new materials with a 2D structure and its characterization.
- Jakub Łyskawa, Improving the Actor-Critic with Experience Replay
- Agata Daniszewska, Technology of graphene flakes production and its properties characterization
- Anthony Nwachukwu, Algorithms for separable non-convexproblems
- Mikołaj Małkiński, Knowledge transfer methods for classification tasks
- Tomasz Kabala, RF-powered rotary telemetry system for aircraft component testing
- Paulina Tomaszewska, Knowledge transfer - artificial neural networks
- Piotr Różański, HIPIMS based thin film technology for resistive random-access memory application
- Tomasz Kowalski, Concept of the LLRF system for stabilization of accelerating EM fields in the resonant cavities of PolFEL linear accelerator utilizing direct sampling of the RF signal
- Daniela Ruggiano, Two-particle angular correlations of identified particles in pp collisions at the LHC registered by the ALICE experiment.
- Michał Daniluk, Multi-modal recommendation system for e-commerce
- Mikołaj Wieczorek, A comprehensive multimodal recommender system for fashion ecommerce
- Jarosław Miller, Theory-categorical models of concurrent computation
- Adam Mata, The Splitting Theorem for finitely generated Propositional Dynamic Logic
- Paweł Kubik, Automatic Scheduling of Teacher Networks in Knowledge Distillation
- Przemysław Szary, Modern threats and methods of counteracting in the cybersecurity in OT area
- Bartosz Kościug, Security of the Internet Of Things
- Wojciech Wójciak, Optimal sample allocation in stratified sampling schemes
- Krzysztof Dygnarowicz, Photosensors and data acquisition systems for water Cherenkov detectors in high energy physics and astrophysics experiments.
- Jakub Tkaczuk, Sound AI – how AI techniques will drive ultimate listening experience
- Piotr Suchorolski, Influence of ferroresonance oscillations on electric power protection automatics operation
- Przemysław Wrona, Real-Time Public Transport Delay Prediction
- Justyna Stypułkowska, The analysis and selection of digital image processing and analysis algorithms in order to detect and interpret objects of a specific type recorded in photos taken with the Quercus multispectral camera.
- Piotr Marszałek, Digital audio steganography – review of methods and tools
- Tomasz Piechula, Mapping the unstructured temporal data
- Konrad Gobosz, Framework for the Introduction of Vehicle-to-Grid Technology into the Polish Electricity Market
- Marek Kościelski, Embedding of the components into the PCBA

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ORAL PRESENTATIONS

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Dual active bridge converter as a part of the DC microgrid

Mikołaj Koszel

DC microgrid seems to be a solution for boosting transformation to renewable energy sources of energy. Locally installed energy storage can overcome the most significant problem, which is the instability of RES. From a prosumers' point of view, energy storage will help to use more produced energy on theirs' own need and work independently during a blackout. A DC/DC converter is essential for transferring energy between voltage sources (such as photovoltaics) and energy storage. Such a converter should be able to work bidirectionally and provide galvanic isolation. A dual active bridge is a topology with plenty of advantages such as simple structure, easy control of power flow, the possibility of soft-switching commutations, and high power density.

To allow high power flow (e.g., in fast EV chargers), parallel connection of converters is legitimate. Converters should be switched on the microgrid with soft-start algorithms and additional contactors to achieve undisturbed work with minimized overcurrent and overvoltage events. Another essential issue is sharing the power flowing through paralleled connected converters to achieve minimum power losses. Working in light load mode requires the usage of sophisticated control. Simulation designing of the system control should be supported by detailed mathematical modeling.

MIMO-type structures for terahertz band

Mateusz Kałuża

In the twenty first century, the rapid development of terahertz (THz) technologies is evident and finds more and more applications in many fields of science and industry. Some of these applications will be used in future 6G telecommunication systems, where wireless THz MIMO (Multiple-Input Multiple-Output) systems will find their place.

The design of the MIMO-type structures is based on the diffractive solutions. The diffractive optical elements (DOEs) are designed using the algorithms typical for synthetic holograms and use an iterative algorithm (e.g., ping-pong algorithm). Selecting appropriate parameters and predefining desired results according to demultiplexing phenomenon is crucial for proper performance of the DOE. The solution allows to redirect the incident radiation illuminating DOE and focus it into three separated by 25 mm focal spots. The algorithm generated a phase map described by a grey-scale bitmap defining the phase level in the manufactured structure (Fig 1a). The performance of the designed 3in1 structure was verified in numerical simulations (Fig 1b). Subsequently, the 3D model of the structure was created and manufactured using the additive manufacturing technique FDM (Fused Deposition Modelling). The DOE was fabricated using dedicated algorithm to create STL files and examined in optical setup. Different configurations of SIMO (Single-Input Multiple-Output) structures were proposed and experimentally verified.

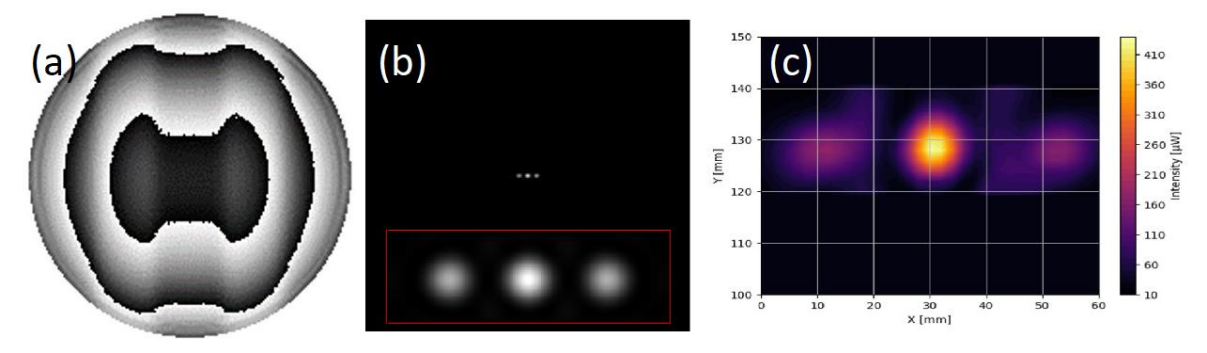

Fig. 1 Synthetic hologram generated by ping-pong algorithm used to redirect radiation into three focal spots, a) grey-scale bitmap corresponding to the phase delay map introduced by the diffractive element, b) simulation results illustrating the three focal spots in the focal plane, c) the experimental results plotting the intensity distribution in the focal plane.

Security controls roles in network slicing management and orchestration

Tomasz Wichary

The network slicing concept requires the main key objectives: integrity and confidentiality of the data in the slice and ensure the slice availability in the whole network. When it attaches security to the slice, it turns out that it is a dynamic process that requires robust management and orchestration.

The author in this research work aims to deliver a security model in the context of network slicing. The network slice controller needs to understand how to define and describe the resources from high to low layers of the network. Therefore, the crucial security challenge is to mitigate attacks at different levels due to weak resource isolation levels. The way to mitigate the vulnerabilities mentioned above is to activate security controls. The author, during research, classified them as easy to develop based on the current standards and security trends. The classification is guided by isolating resources at different levels and fair resource allocations to respond to DDoS attacks without service degradation. In this context, the proposed isolation level model better describes and structured security controls and attributes representing security constraints.

The presented isolation classes and classification based on security domains in conjunction with hierarchical management and orchestration allow a better understanding of security needs and select proper security controls for the whole end-to-end network slice.

De novo assembly of DNA sequences using quantum annealer

Katarzyna Nałęcz-Charkiewicz

De novo assembly is an inherent step in sequencing the genomes of new organisms and studying structural genomic changes. The currently used methods of assembling readings from sequencers by their computational requirements are currently a bottleneck in the entire processing process, implying the need to develop more efficient algorithms. One possible approach, which is still little explored, is the use of quantum computing.

We present the PoC of de novo assembly algorithm, using the formulation of the assembly problem as an optimization task. Namely, for each pair of DNA reads, previously converted to signals, the Pearson cross-correlation coefficient is computed. The problem of sequence assembly in such a defined task comes down to the problem of finding in the similarity matrix a path meeting the minimum distance criterion (Traveling Salesperson Problem). Computations performed for artificial and real DNA sequences on a classical computer were compared with the results obtained by a hybrid method combining CPU and QPU (quantum annealer by D-Wave company) calculations. The solution was scaled to the size of viral genomes.

The research results are promising and allow us to hope to use the quantum computing paradigm as an alternative to computing performed on the GPU or High Performance Computing.

D/A converter for quantum computing

Adam Borkowski

Silicon Quantum Computers use the principle of quantum mechanical phenomena such as superposition and entanglement to perform quantum operations based on wide spread and matured Silicon technologies. Like digital computers characterized by classical bits 1 and 0, quantum computers also process information through qubits. Critical parameter of such arrays of qubits is coherence time. They also need very fast pulse based classical control circuitry for the initialization , control and readout of their states. A low power D/A converter operating at or below 4.2K will serve this purpose.

In the current application, control is performed with discrete electronic system on the PCB. This causes a lot of issues. The main problem is large size of the PCB. Therefore, the system must be located outside the cryochamber and the signals must be led by wires. These conductors introduce a considerable capacity, which results in high power consumption of the DACs. Possible solution is to use dedicated integrated circuit, which can be placed inside the cryochamber. This allows to significantly reduce the number of external connections, which facilitates maintenance of low temperature inside the chamber. In addition, the loading capacitance of the transducer drops drastically, which gives opportunity to reduce the power consumption. Additionally, the benefit is a drastic reduction in thermal noise generated in the drivers DAC due to the fact that they operate at a very low temperature.

Luck, Reason, and the Price–Pareto type-2 Distributions

Przemysław Nowak

Price's model for the growth of a bibliographic network is a known approach since 1965. In our case we distribute citations using both preferential attachment (also known as rich get richer) and random attachment rule. Applying the new method based on rank-size distribution we show that Price model can be described with Pareto-type 2 distribution.

Moreover, knowing of this Pareto-Price relation we perform different estimators of the underlying model parameters, based on DBLP database.

Contrastive Learning for Supervised Language Model fine-tuning

Witold Sosnowski

Natural language processing (NLP) is a rapidly growing area of machine learning with applications wherever a computer needs to operate on a text that involves capturing its semantics. It may include text classification, translation, abstraction, question answering, dialogues. All these tasks are upstream and depend on the quality of the text representation. Many models can produce such text representations, from Bag-Of-Word or Word2Vec word embedding to the state-of-the-art language representation model BERT with variations in most NLP tasks. The best performance is obtained when the model is first trained on a general knowledge corpus to capture semantic relationships between words and then fine-tuned a domain corpus with cross-entropy loss. Driven by the intuition that good generalization requires capturing the similarity between examples in one class and contrasting them with examples in other classes, we propose a supervised contrastive learning objective for the fine-tuning stage. It transforms the embedding space so that points from the same class can form separable subspaces, stabilizing and generalizing the language model fine-tuning process. Our new loss function can improve the model fine-tuning process by making it more generalizable and robust to noise in the training data.

Detection of Image Steganography Using Deep Learning

Mikołaj Płachta

Information security is becoming an increasingly important issue in our world. Therefore, more and more sophisticated attack methods are emerging, among them the methods using digital image steganography. Therefore, in the first part of my research for my doctoral thesis, I focused on the methods of automatic detection of digital steganography. The main part of my research is the use of machine learning methods, in particular deep neural networks. For data discovery methods, a couple of methods were tested. The first was the analysis of the discrete cosine transform and an attempt to teach a neural network to classify JPG images. The next steps were to use different coefficients that can extract the relevant information from the pictures and help to make the detection. For this, we used DCT Residuals (DCTR) and Gabor Filter Residuals (GFR). The set of BossBase, known in the world of steganography, was used for the tests. It consists of carefully selected black and white images in the amount of 10,000. On its basis, files with encrypted data were generated using the jUniward and nsF5 algorithms. Pairs of pictures (without steganography and with hidden data) were used to train and verify the network. The obtained results and conclusions will be presented during the presentation.

Detecting malicious clients in federated learning

Dominik Kolasa

Federated learning is a process where many clients contribute to the global model. In this scenario I found that some of the clients may intentionally or by a mistake provide wrong updates to the global model. I address this issue to filter such contributions. I am trying to answer the question of how to compare the models and provide only useful updates. In developed a new method where no testing data is required. I can assure security and minimize any mistakes with the dataset itself. For wrongly labeled or bad quality datasets the client's model will differ from all the other models trained using proper data. My algorithm can detect such clients and do not include their contribution to the global model. The global model will learn the most common pattern along all the clients. The research shows that the method works for different setups, filters out malicious clients accurately when compared with other methods and does not require any data to run.

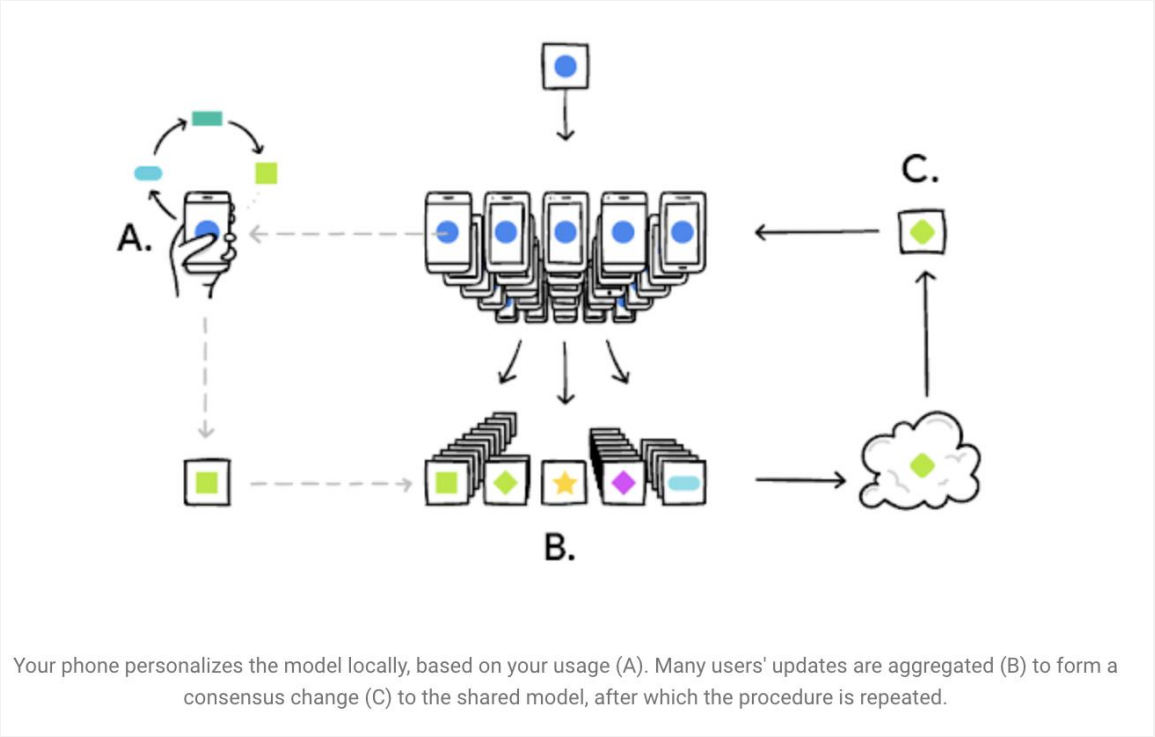

Fig. 1 Federated learning with mobile phones.
[https://ai.googleblog.com/2017/04/federated-learning-collaborative.html]

Federated learning is a new way of distributed machine learn-ing multiple clients. It can be used to train models using mo-bile phones, IOT devices and any device which has the power to compute a training round. All of them collaborate to build a global model. In my research I am trying to resolve problems with malicious updates which may affect federated learning process and cause the global model to predict even randomly.

High accuracy image captioning

Mateusz Bartosiewicz

Image captioning focuses on generating sentences, describing content of the given image. Two types of description can be distinguished. First, when sentences are formulated from direct positions of objects on the image and second one, when algorithm tries to guess what happened on the scene.

During research work, these two motifs were raised. First is focused on generating sentences from detected objects on the image. Proposed method calculates relative bounding box positions in the fuzzifications process and stores it in fuzzy mutual position matrix, which allows representing image complexity in the 2-D structure. Finally, most relevant predicates on the saliency-based criteria are extracted to be passed to the language model to formulate semantically correct and human friendly sentences.

Second motif is the end-to-end solution, where neural network is trained on large amount of images and corresponding captions. Moreover, mostly researched is English language, which is relatively semantically simple language, in the compare with Polish models. In this regard, experimental study, that examined application of neural image captioning methods to Polish language, was conducted. The paper present results of using generative model to produce sentences in Polish. What is more usage of automatically translated Flickr8k dataset was investigated.

In the next step, model that integrates direct object position recognition on the image, with Transformers architecture will be developed.

Impact of low-voltage electromechanical switches on the electromagnetic environment.

Piotr Zych

Nowadays we are using more and more electric and electronic devices. However, we also have increasingly electromagnetic disturbances. Electronic devices are required to test electromagnetic compatibility (EMC) to ensure reliable work and not cause interference to other equipment. One of them is a series of electrical fast transients. The popular name of them is burst. It is a broadband pulsed disturbance occurring very quickly (of the order of a few nanoseconds), having a low energy charge but a high repetition rate. The standard which describes them is PN-EN 61000-4-4. Checking for resistance to them is mandatory in the EMC test procedure. For example, these disturbances arise in low-voltage electromechanical switches. This disturbance is accompanied by sparking, which in the literature is called showering arc. This research focuses on theoretical analysis, numerical analysis, and exponentiation verification with low-voltage electromechanical switches. The result of this work will be to propose better attenuation solutions. To verify disturbances, it was necessary to design and build a test bench with low-voltage electromechanical switches to observe EFT/burst and check attenuation solutions. I will present theoretical background, test bench and progress in my research work.

Creating the required distribution of the cylindrical modelling index in general interior lighting

Paulina Komorzycka

Indoor general lighting should be neither overly directional nor overly diffused. Ensuring a balance in the directivity of lighting in the interior reduces the undesirable effects of too sharp shadows and monotony in the illuminated space. One of the measures used to assess the effect of directionality of lighting in rooms is the modeling index (MCY), defined as the ratio of the values of cylindrical and horizontal illuminance at a point on the reference plane. The paper demonstrates that the achievement of the required MCY index in general interior lighting is significantly limited. According to the simulation results, the influence of the room size (RI), reflection coefficients (RO), the class of the luminaire (CL), downward luminous intensity distribution (LID) and the arrangement of the luminaires (SH) on the value of the MCY index was determined.

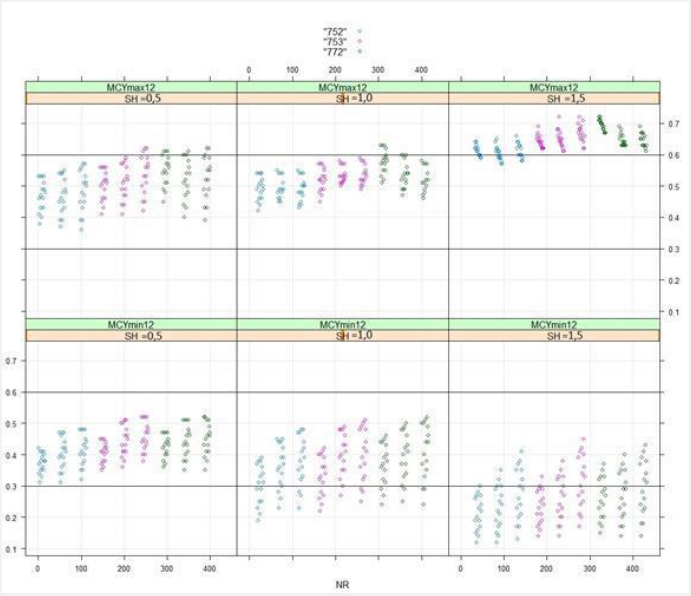

Fig. 1 Distribution of minimum and maximum values of modelling index for h = 1.2 m conditioned by SH and grouped by RO.

Useful types of luminaires and their layout have also been identified in terms of achieving the desired modelling effect in general interior lighting. Multiple linear regression models for MCY indicators were developed, taking into account the parameters of the room RI, RO, and the luminaires and their arrangement CL, LD, SH. The possibilities of using the obtained results in the practice of designing general interior lighting were presented. The limitations and directions of continuing the research were indicated.

EgoNN: Egocentric Neural Network for Point Cloud Based 6DoF Relocalization at the City Scale

Monika Wysoczańska

I will present EgoNN: a deep neural network-based method for global and local descriptors extraction from a point cloud acquired by a rotating 3D LiDAR.
The descriptors can be used for two-stage 6DoF relocalization. First, a course position is retrieved by finding candidates with the closest global descriptor in the database of geo-tagged point clouds. Then, the 6DoF pose between a query point cloud and a database point cloud is estimated by matching local descriptors and using a robust estimator such as RANSAC.

Our method has a simple, fully convolutional architecture based on a sparse voxelized representation.

It can efficiently extract a global descriptor and a set of keypoints with local descriptors from large point clouds with tens of thousand points.

Matrix pencil method in the detection of fault induced travelling waves

Piotr Łukaszewski

The aim of my work is to develop an algorithm for the detection and identification of travelling waves resulting from short-circuits in medium-voltage grids. In the future, such an algorithm could be used in fault locators and in protection relays responsible for elimination of faults.

In the case of medium-voltage (MV) grids, the issue of travelling wave detection is more difficult than in the case of high-voltage (HV) grids because the instrument transformers used in the automation of these grids are mainly located in HV/MV substations and they are the only measurement points. Furthermore, MV grids, due to their shorter lines, are characterised by shorter wave propagation times and therefore require more precise detection methods in order to avoid mistakes caused by short time intervals between arriving waves and their interference. Greater precision is also a requirement resulting from the need to keep the relative error of locating faults small.

A novelty in the field of detection of travelling waves in electrical power system is the matrix pencil method, which has already been proposed for use in HV grids. This method can meet the requirements set out earlier. Unfortunately, the applications of this technique in protective relaying so far lack the automation aspect of its operation and are limited to theoretical considerations only. This presentation aims to propose automation of the use of the matrix pencil method for the detection of traveling waves in MV grids.

Using AI methods for driving image sensor parameters.

Piotr Fryc

Television Image Sensor as the input element of a TV camera system needs to be driven in a way that achieves best output signal quality. There are few parameters to be driven e.g exposition time. Achieving correct sensor parameters is no trivial task. There are numerous algorithms in use that base on image statistics.

In my study I explore the use of AI methods to drive the image sensor parameters. The goal is to achieve correct image in numerous scene and light conditions. For this, the strict definition of the image correctness should be adopted. The work is conducted using the Python PyTorch package. PyTorch capabilities were extended and published as open source for the purpose of dealing with video datasets. To gain understanding of a sequence of events in the video, the extension extracting optical flow from video will be prepared. To achieve suitable and repeatable conditions for testing, the TV camera simulator is being prepared as a Python package. AI methods such as 3D-ConvNet, Two-Stream (with Optical Flow data) are to be evaluated.

The plan is to publish a paper about using fully functional software TV camera simulator as a testbench for family of algorithms driving image sensor parameters. The simulator itself will be published as an open source Python package. Series of known algorithms (conventional and AI based) will be evaluated.

The next step is to develop my own, AI based methods of driving image sensors, evaluate them using the simulator and publish.

Machine learning for trading

Łukasz Lepak

The presentation focuses on using machine learning methods for creating trading strategies using forecasts. The main focus is given to the energy market and the prosumer operating on this market. The prosumer buys energy from the market, sells energy he generated, and also stores energy in batteries for his own needs or for further trading. The goal of the prosumer is to maximize his profit by creating appropriate transaction orders on the energy market - selling for a high price and buying for a low price. The model adopted for this problem is Partially Observable Markov Decision Process (POMDP). The presentation describes this model, defining actions, observations, and rewards for reinforcement learning agent representing the prosumer, and also shows how weather forecasts can be used to help the agent create a better trading strategy. Some constraints regarding the prosumer's operation on the market are also discussed.

FPM app: an open-source MATLAB graphical application for fast, simple and intuitive Fourier ptychographic microscopy data reconstruction

Mikołaj Rogalski

In modern day medicine there is a need for large space-bandwidth product (SBP) cells bioimaging, i.e., imaging with both: large field of view and high resolution. One of the several techniques that can provide this is the Fourier ptychographic microscopy (FPM), which combines the information from multiple microscope images, each one collected at different illumination angle, to improve the resolution of a single image. Moreover, FPM iterative algorithms allow also for restoring the measured object phase i.e., the information about how much the light was delayed when passing through the sample (crucial in transparent samples imaging). Furthermore, FPM hardware can be straightforwardly assembled – in its basic configuration it requires only to modify a classical brightfield microscope by replacing its illuminator with a LED array.

However, despite hardware simplicity, FPM suffers from complex software implementation and up to this day, there wasn't released any open-source algorithm allowing for its usage for a non-expert user. To fill this gap, as a part of this work there was developed an open-source MATLAB GUI application called the FPM app that allow for simple and intuitive FPM reconstruction. Moreover, inside the FPM app there were introduced several own modifications into the FPM processing path, that made it to perform faster and to be more automatic and robust. Its performance was also tested on experimental and synthetic datasets to confirm reconstruction correctness.

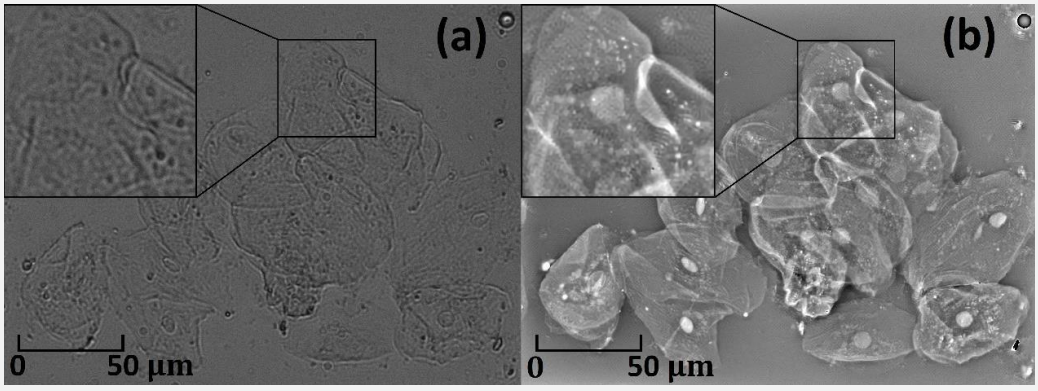

Fig. 1 Cheek cells intensity image obtained on classical brightfield microscope (a) and phase image obtained on same microscope with FPM app reconstruction (b).

Algorithms for monocular depth estimation using deep neural networks

Tomasz Lehmann

Monocular depth estimation from images is applied in many applications and computer vision tasks. Nowadays there are many convolutional neural network based architectures for computing a high-resolution depth map given a single RGB image. The state of the art for one of the most popular databases dedicated to the depth estimation problem – NYUv2 - is set up by dense vision transformers and encoder-decoder structures. Inspired by solutions used in the image super resolution tasks I made a decision to implement Deep Recursive Residual Network and Enhanced Super Resolution Generative Adversarial Network to generate predictions with realistic textures during single image depth estimation. The first of mentioned architectures contain almost 150 times less parameters than auto-encoders usually used for depth estimation while the gargantuan potential of GANs seems to be an interesting alternative for the most popular solutions. Both architectures made a significant contribution in the image restoration problem. The achieved results are very preliminary and at this time it is hard to predict if the proposed methods will outperform others in any of NYUv2 metrics but there is still a long way ahead to optimize calculations by choosing suitable loss function and network modification experiments.

Theory of reconstruction of bipolar ECG signal

Sebastian Wildowicz

This thesis presents a minimal model, which allows reconstruction of bipolar ECG from a chosen model of the single myocyte action potential. The example shown below (Fig. 1) confirms the ability of the model to reconstruct the bipolar ECG, as the amplitudes of the QRS complex are correctly reconstructed.

The work concerns the issues of modelling the electrical activity of the heart and the development of techniques for the reconstruction of the signal source state. This research is aimed at developing new methods of signal analysis and numerical modelling, the aim of which is to develop medical diagnostics in the area of cardiology and neuroinformatic. The work focuses on Gaussian parameters and how to fit them to recreate the electrocardiographic (ECG) signals, which provide information about the heart's electrical activity and enable the diagnosis of heart diseases. The algorithm is based on the convolution of Gaussian curves with single ventricular action potential as opposed to what is currently developed as methods of signal reconstruction which focus on the reconstruction of epicardial potentials based on known potentials from the thoracic surface. Maps such as the map of electrical activity or isochrones of the activation front of the myocardial surface are used here.

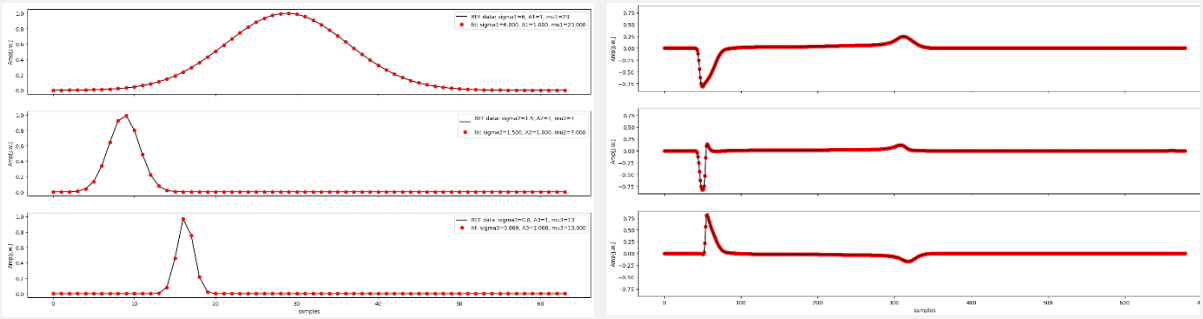

Fig. 1 Fit gaussian curve parameters and bipolar ECG reconstruction result.

Research on Computing Tasks

Jan Bielecki

The research focuses on the Big Data field's part, which is computing tasks (programs written in the functional paradigm and executions of such programs).
I conduct my research on the BalticLSC system but keep it the most general and one can use the results in different systems or cases. BalticLSC is a platform that uses a new visual language (CAL) to solve some of the High-Performance Computing problems. It uses high-level abstractions to define the flow of data and the execution of computation modules in a distributed computation environment.

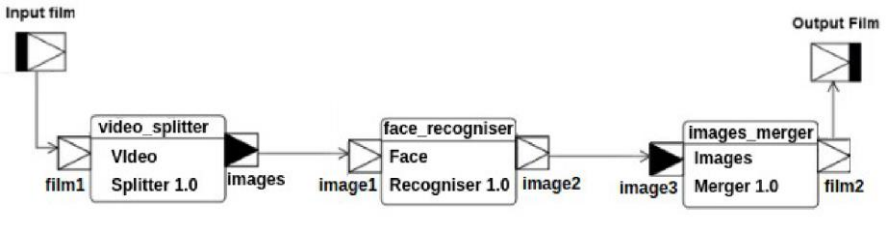

Fig. 1 Face recogniser scheme. Application written in the CAL language.

The first part of my research focuses on the estimation of execution time for computing tasks. The proposed approach is to create machine learning models using historical data. The models use program metadata and parameters of the run-time environment as their explanatory variables. Moreover, while creating the model, one can expand the set of variables with additional parameters of the specific programs. Each module (computing task) has its model.

I researched the process of training and validation for several different computation modules and discussed the suitability of the proposed models for ACET estimation in various computing environments. Experiments were carried out using SVR and KNN algorithms.

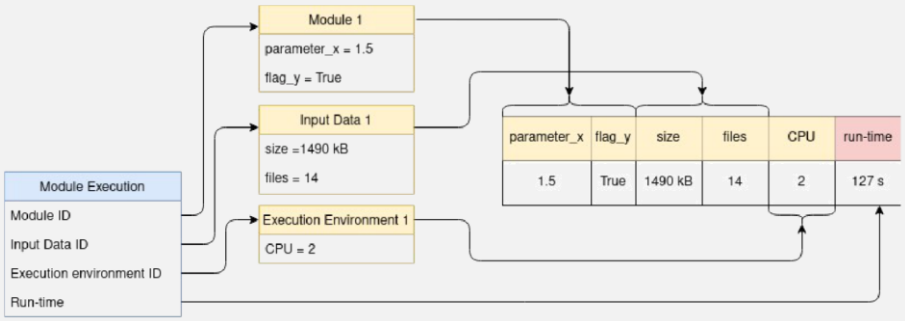

Fig. 2 Extracting a data point from the module (computing task) execution.

Further work will concentrate on static analysis of programs code. Based on the control flow graphs of the programs, one can translate its structure to vector. Such vectors could be an issue as the parts of input data for the already checked models or help build more sophisticated models.

Analysis of femtoscopic correlations of pion-deuteron and kaon-deuteron pairs in Pb-Pb collisions in the ALICE experiment at the LHC

Wioleta Rzęsa

This contribution presents the analyses of two-particle femtoscopic correlations of pion-deuteron and kaon-deuteron pairs produced in Pb-Pb collisions with energy $\sqrt{^{S}NN}$ = 5.02 TeV, that were registered by the ALICE experiment at the LHC. The analyses are based on the femtoscopy technique which allows studying the properties of matter under extreme conditions produced in high-energy heavy-ion collisions. The femtoscopic correlation function depends on both, the properties of the particles emitting source created after the collision and the two-particle final state interactions. Particles considered in this work are electrically charged hadrons which interact thus via the strong and Coulomb forces. However, neither the parameters describing the strong interaction of both considered particle pairs nor the creation mechanism of (anti)deuterons in heavy-ion collisions are known.

The study of pion-deuterons and kaon-deuterons pairs presented in this contribution contains the methodology of selection of particle samples and the first calculations of the correlation function for these pairs of particles.

On some subclasses of subalgebras of Leavitt path algebras

Anna Cichocka

The history of Leavitt path algebras dates back to the 1960s, when William G. Leavitt asked the question about the existence of R rings satisfying the equality $R^i \cong R^j$ as right-hand modules over R.

The first time Leavitt path algebra was defined the first time in years 2005-2007. Their construction was introduced to algebraize combinatorial objects related to Cuntz-Krieger algebras and C^* - algebras. Their subject matter is of interest to both mathematicians dealing with algebra and those interested in functional analysis, in particular C^* - algebras. Due to the flexibility of Leavitt path algebras construction, they are the source of various examples of algebras with fixed properties. The matrix algebras $M_n(F)$ dimension n *times* n over a field F for $n \in \mathbb{N} \cup \{ \infty \}$ (where $M_\infty(F)$ are infinite matrices of countable size with finite number of non-zero elements in each column) are an special example of Leavitt paths algebras. During the presentation, I will present Leavitt algebras and their properties will be presented. Next I will demonstrate the construction of some of maximal commutative subalgebras Leavitt paths algebras. Finally, I will display the construction of its maximal commutative subalgebra, inspired by some known maximal commutative subalgebra of the matrix algebra with the greatest dimension.

Multi-incident holography profilometry

Moncy Sajeev Idicula

Digital holographic microscopy (DHM) is a profilometric tool used to reconstruct the object's topography under observation. Here topography is reconstructed by obtaining the complex field from the captured phase map. However, this method's main limitation is that when the object under the observation has a high gradient or higher surface discontinuities than $\lambda/4$ (reflective), there will be an error in the retrieved phase map recorded equal to multiple of 2π.

Multi-angle digital holographic profilometry (MIDHP) is a combination of coherence holography and multi-angle profilometry. This method enables to enlarge the measurement range and high axial resolution. it requires a certain number of holograms needed that are processed using longitudinal scanning function (LSF). The topography of the object is recovered by finding the maxima of the LSF.

Firstly, to reduce the time for capturing the hologram, we introduce a single-shot capture strategy. Based on MIDHP, using an appropriate illumination strategy, the object was reconstructed using a single hologram. Secondly, for an object with low or high surface gradient problems faced are 1.) finding accurate focus position for getting good reconstruction of topography and 2.) calculation of LSF is very time-consuming. In this work, we worked on an autofocusing method and a new strategy for quicker calculation of LSF without compromising accuracy. These proposed methods were verified numerically and experimentally.

ARC Welding

Jan Sawicki

The subject of the doctoral dissertation is 'ARC Welding' - Analysis of Reddit Communities Welding. The prime goal of the research is the process of finding similarities of online communities and producing meaningful connections between them, which may have possible applications in marketing and public relations. In order to achieve the goal, the process follows four main steps: dataset gathering, natural language processing, network construction and fusion ("welding").

The research determined that the most suitable dataset is Reddit for its online community representation, topical categorization and free and easy accessibility. Its posts and their metadata will be mined for key user interests, using state-of-the-art NLP techniques (e.g. neural networks with attention, i.e. the transformers model like Bert, GPT). The artifacts such as named entities will be converted to real networks. The final product of the process is the "fusion" of the networks, that is finding the similarities between them. These are not only the commonly named entities but also their surroundings and community attitude towards them. The technology used in the project is exclusively Python to maintain an heterogenous and natively compatible environment.

The project is at the stage of finalizing literature review regarding Reddit and NLP and gathering the dataset. In the upcoming steps the dataset will be mined for its features and used to construct networks. The research proceeds according to schedule.

Assamese Character Recognition

Kinga Pilch

Optical character recognition (OCR) is the oldest branch of pattern recognition. It refers to the conversion of handwritten letters or symbols in general to machine-coded text.
Much work has been done on OCR in Western scripts and popular languages like Chinese, Indian or Japanese. However the main Indian language in the northeast is still not examined. Assamese is spoken by over 14 millions of people. There were some attempts but the researchers achieved an accuracy of up to 90%. In their work, the major limitation of neural networks is their inability to capture spatial features in images. This problem can be omitted by using convolutional neural networks. CNNs eliminate the need for manual feature extraction as they learn features directly during training. Since no standard image data set for Assamese characters was available the co-authors have collected and generated handwritten drawing samples with over 12000 images.

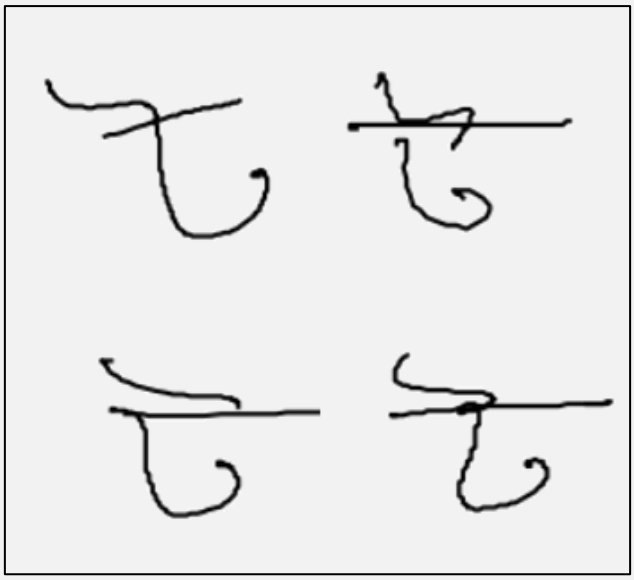

Fig. 1 Examples of Assamese letters.

The aim is to create the best possible solution for Assamese characters recognition. So far the dataset was created, images were preprocessed using different methods such as otsu binarization, normalization or image smoothing. Moreover, many models were tested, both created by myself or available online (like DenseNet 201). The best obtained result is ~94% so far but there are many areas where this score can be improved for example by meta-models or transfer learning.

Graph homomorphism problem and its variants

Marta Piecyk

A homomorphism f from a graph G=(V(G),E(G)) to a graph H=(V(H),E(H)) is an edge-preserving mapping from V(G) to V(H), i.e., for every edge uv of G, it holds that f(u)f(v) is an edge of H.

For a fixed graph H, in the Graph Homomorphism problem, denoted by Hom(H), we are given a graph G, and the task is to determine, whether there is a homomorphism from G to H.

One of the well known variants of Hom(H) is the List Homomorphism problem, denoted by LHom(H). In the LHom(H) problem, the graph G is given along with the lists L: $V(G)->2^{V(H)}$, and the task is to determine, if there exists a homomorphism f from G to H, which additionally respects lists L, i.e., for every v in V(G) it holds that f(v) is in L(v).

Hom(H) and LHom(H) have been widely studied and their computational complexity - in classical sense of being polynomial-time solvable or NP-hard - has been fully classified (Hell & Nešetril, Feder & Hell & Huang).

In my talk I will focus on NP-hard cases of those problems, i.e., cases that we belive cannot be solved in polynomial time.

I will show how the complexity of the problems depends on some structural parameters of the input graph G.

K*(892)^0 meson production in nucleus-nucleus interactions at SPS energies measured by NA61/SHINE at CERN

Bartosz Kozłowski

The NA61/SHINE is an experiment studying hadron production in proton-proton, nucleus-proton and nucleus-nucleus collision at the Super Proton Synchrotron (SPS) at the European Organization for Nuclear Research (CERN). The physic program is focused on study of the properties of the onset of deconfinement and searching critical point of the strongly interacting matter. A two-dimensional scan of the strongly interacting matter is done by changing energy of colliding ions and system size.

Analysis of the production of short-lived particles called resonances help in studying the dynamics of heavy-ion collisions. In particular, it was predicted that in dense nuclear matter their properties (e.g., widths, masses) can be modified as a result of the partial chiral symmetry restoration. The analysis of the production of K*(892)^0 meson can also help in estimating the time between chemical (end of inelastic interactions in the system) and thermal (end of elastic interactions) freeze-outs.

Using data collected by the NA61/SHINE experiment and template method used in analysis of K*(892)^0 resonance production in proton-proton interaction at 158 GeV/c beam momentum, analysis of the production of K*(892)^0 meson in Ar+Sc inelastic collision at SPS energies will be performed. The aim of the analysis is to determine widths and masses, calculate mean multiplicity of K*(892)^0 resonances and estimate time interval between chemical and kinetic freeze-outs in nucleus-nucleus collisions.

Low Shot Realistic Human Rendering from Partial Information

Kacper Kania

High-quality human-like animations are required for many different applications. In video gaming, many popular games involve controlling and interacting with humanish characters. In AR and VR a core component is realistic rendering and animation of other people's avatars. In filmmaking, CGI often involves generating footage for sequences that involve the human characters in the film. The common methods used for creating and animating digital characters are both time-consuming and difficult to scale. The creation process usually begins with a 3D scan of a real person's face or body performing various actions. The scan requires specialized equipment and needs to be further processed by artists. To animate the model in a realistic way an actor needs to perform the desired sequences in a motion capture studio. This effort is extremely time-consuming and expensive.

During my session, I will present the progress in my research on human rendering and describe two articles submitted to a top-tier conference. One of the works focuses on controlled human animation while the other on realistic controlled human rendering. Both works bring us closer to creating complex realistic animations and enable advanced post-processing of photographs using hand-held devices that we use on a daily basis.

Weak solutions of the fractional Stefan problem

Karolina Pawlak

The fractional Stefan problem is a free-boundary problem of evolution type. It describes a change of phase in medium e.g. melting of solid. In the classical formulation there exists an interphase which separates the solid and liquid parts.
During the process of melting the interphase is moving and we have two unknowns: the temperature and the function describing the interface.

We focus on the one dimensional problem. Moreover, we consider the one phase problem i.e. we assume that the temperature in solid part is equal to zero. The mathematical formulation is based on the principle of energy conservation, where the flux is given by the Riemann-Liouville fractional derivative of temperature gradient. Due to this form of the flux, the model exhibits memory effects. It means that the total enthalpy in the domain at time t is a sum of the initial enthalpy and the time-average of differences of local fluxes at the endpoints of the domain.

During the presentation, I will briefly present the definitions of the fractional operators and I would like to discuss the derivation of the fractional Stefan problem. Furthermore, I am going to introduce the weak formulation of the one dimensional, one-phase fractional Stefan problem. In the weak Stefan problem there is only one unknown: the enthalpy. We assume that the enthalpy jumps at the change of phase. As a result, the transformation process from solid to liquid occurs through the mushy region and no interphase is formed.

Automated Extraction of Building Footprints from Radar Images

Sandhi Wangiyana

Remote sensing images are valuable for geospatial analysis of a large area, such as finding the polygons of buildings from an aerial view. Optical data is usually preferred, but it requires good sunlight and little cloud coverage. Synthetic Aperture Radar (SAR) has the benefits of providing remote sensing data in all weather conditions. This is valuable in situation where prompt analysis is needed such as in aiding disaster response. But the unique properties of the radar image pose challenges in image analysis, requiring the domain knowledge of SAR experts and advanced processing tools to interpret the image.

With many satellite constellations we have currently and more in the future, the amount of SAR data is growing fast. Convolution Neural Network (CNN) can be used to augment or automate the process of SAR analysis, utilizing the massive collection that we're storing each day.

We studied how SAR resolution impacts a model's performance in segmenting building footprints. To achieve this, we used the publicly available SpaceNet 6 dataset and applied low pass filters with varying strength to create datasets with different SAR image clarity. We train the dataset variations on 2 encoder-decoder architectures: Feature Pyramid Network (FPN) and U-Net. We obtained interesting findings where FPN's performance drop slightly as stronger filter is applied, while U-Net had slight performance gain when weak filtering is applied.

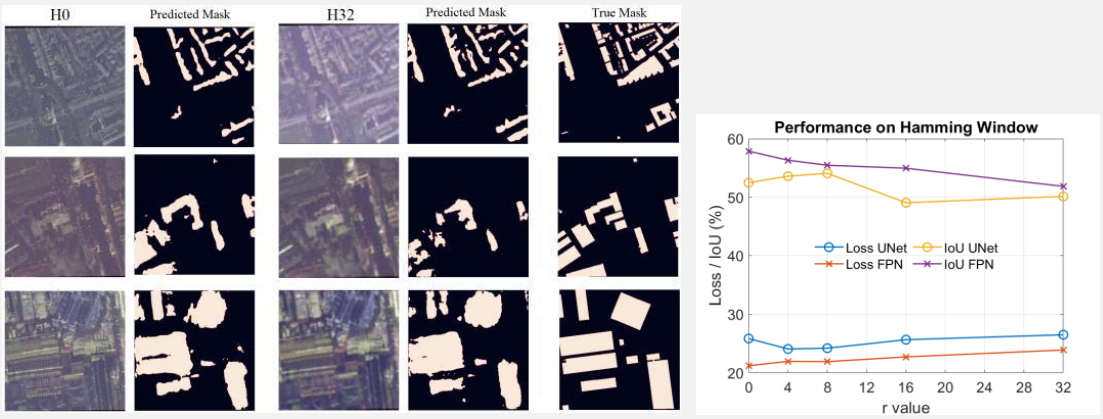

Fig. 1 Left: prediction results from the model on original dataset (H0) compared to dataset with hamming window filtered applied (H32). Right: Model's performance based on Intersection over Union (IoU) and loss metric.

Parallel implementation of Particle-in-Cell algorithm using Julia programming language

Wiktor Łodyga

The purpose of this study was to create an original GPU implementation of a Particle-in-Cell (PIC) algorithm, which is a versatile method for simulating charged particles. Presentation covers the results achieved with the standard, collisionless form of algorithm. Starting from serial CPU implementation the work has been carried out to speed up the computation, especially for the problems of bigger size. Measurements of the performance and assessment of the correctness of the implementation has been performed using a simple 1D problem of two counter-propagating streams of charged particles. The final results of multithreaded implementation, were compared with initial, serial CPU code. Both implementations has been written solely in Julia programming language. The CUDA.jl library was used to prepare the GPU-specific code. Thanks to the features of CUDA.jl, such as the original compiler for writing CUDA kernels in pure Julia or user-friendly array abstractions, the two-language problem, could have been solved. The study takes advantage of library and shows how, the codebase developed for the CPU can be easily re-used for the GPU computations. In order to assure reasonable GPU utilization, a kernel profiling has been performed in NVIDIA Nsight Compute tool. During the final experiments a series of simulations, with the increasing number of particles in the system, have been performed. The resulting speedups over initial CPU-specific implementation are presented.

Subalgebras of matrices satisfying some identities

Paweł Matraś

We will be interested in subalgebras of nxn matrices with entries in field F. It is structure closed on multiplication and substraction which is also linear subspace. Elements of it are some nxn matrices.

Classical theorem gives bound on dimension of commutative subalgebra of nxn matrices. Any elements x, y of it satisfies xy = yx. Defining [x,y] = xy-yx we say that commutative subalgebra satisfies identity [x,y] = 0.

We present some results generalizing above theorem by considering other identities of similar type. We also give some examples of subalgebras with maximal dimension. Specially we will explore identity [x1,y1][x2,y2]...[xk,yk] = 0, which is satisfied by upper triangular matrices kxk. Moreover it was shown that other identities of upper triangular matrices are consequence of such identity.

Other motivations are connected with Lie nilpotency and Lie solvablity. Such properties are important in theory of Lie algebras. They are defined in terms of similar identities and some results from this theory are useful for us.

Lastly for matrices over algebras satisfying similar to written identity we can get theorem generalizing Caley-Hamilton theorem for matrices over field. This subject was explored in quite recent paper.

Radar simulator compatible with IEEE standard for distributed interactive simulation (DIS)

Tomasz Rudnicki

Distributed interactive simulation (DIS) provides the infrastructure to build large-scale simulations by connecting autonomous simulators via network. The standard defines data exchange protocols that is used for communicating ground truths and methods of limiting the network traffic. The standard requirements and their influence on the radar simulator architecture are presented. Versatility of the proposed simulator architecture and data structures is studied. In the recent years, usage of the IEEE standard for DIS has become norm in the military community. Dangers that come with the opportunity of multi-nation military exercises are considered.

How social interactions lead to polarized relations?

Maciej Pawlik

In the age of social media there is more and more need to understand how do people create relations using those. The objective here was not only to look if relations are being created as a consequence of social interactions, but also to separate emergence of positive and negative relations. The knowledge we can gain here could benefit a wide spectrum of applications - from purely scientific to business.

In this work two datasets were used - Epinions and NetHealth. Epinions was a site where users could upload reviews of goods, vote on others reviews and declare trust/distrust towards users. The trust network was used to develop a network of polarized relations and votes were treated as interactions. In NetHealth experiment students were asked, among other information, to declare people, with whom they have been in their opinion interacting more in last months. 8 such surveys were delivered within 4 years. Researchers were also tracking smartphone communication – calls, SMS, MMS and WhatsApp messages, which were used as interactions by us. Neutral relations were also possible and they were used as a benchmark for comparing with positive and negative relations. It was also important to filter out relations, which were developed before students had the opportunity to declare them, e.g. families. This research focuses on interactions exchanged before the relation was established.

This research received funding from National Science Centre, Poland Grant No. 2019/01/Y/ST2/00058.

XY-DemoRad - a Compact Fine Resolution Radar Operating in the K- and mmWave-Band

Krzysztof Stasiak

The paper presents the XY-DemoRad - a miniature, fine-resolution FMCW (Frequency-Modulated Continuous-Wave) radar sensor capable of operating in the K-band and with a carrier frequency of 120 GHz. The radar is built around highly integrated radar modules allowing for achieving high waveform bandwidth and low power consumption. In contrast to other radar sensors utilizing such modules, the XY-DemoRad provides access to the raw radar data along with full signal processing in real time. The system is equipped with two exchangable RF (Radio Frequency) boards, allowing for selection of the operating frequency band. Technical description of the system is provided, covering the hardware, sensor's firmware and PC software. The results of system validation and performance evaluation are also featured in the text. Finally, the paper presents the sensor usability in numerous applications such as short-range surveillance with microDoppler-based target classification, drone detection, gesture recognition, detection and tracking of cars or ground-based and airborne SAR (Synthetic Aperture Radar) imaging. The paper is concluded with a summary of achieved capabilities and discussion of further development possibilities.

Anomaly class detection and comprehension using segmentation techniques on RGB images

Marcin Macias

During this seminar I will present the main research area of my work, the overall idea and possible obstacles that I need to overcome.

The main goal of my Ph.D. thesis is to improve existing algorithms or propose new ones that can be used in the problem of automatic detection and comprehension of small objects on the RGB images. The real life example of such classes that I want to focus on involves labels used in the retail store that contain price information about the presented product. Those labels can be treated as anomalies on the initial image, if we compare their size with rest of the image. However, they carry a lot of valuable information that we want to collect and analyze. Additionally, this data is usually easily noticeable by a human eye, which suggests that saliency methods used for the eye tracking and gaze analysis may be integrated into this processing pipeline to improve its efficiency. My task requires usage of different image analysis, segmentation and processing techniques and each of those methods has some known drawbacks and minor imperfections that I hope to improve. After complex research of the existing literature in the first semesters of my Ph.D. studies I have moved to the implementation of the prototype of processing pipeline that will include aforementioned algorithms and my improvements. I am also in the process of collecting a real life dataset that is necessary for the future experiments and validation.

HPC-enabled genomic variant discovery using ConsensuSV

Mateusz Chiliński

Each individual in the human population is characterised by its genomic sequence, the same in all cells of their body. The differences in our personal DNA sequences are what distinguish us from each other and provide variability required for the evolutionary processes. We distinguish 3 major types of genomic variants - Single Nucleotide Polymorphisms (SNPs), which are changes of one base pair (bp) in the sequence, Indels, which are small genomic rearrangements of up to 50bps, resulting in insertion of novel sequence or deletion of sequence, and Structural Variants (SVs), which are large (>50bps) rearrangements of various types, including Insertions, Deletions, Inversions, Duplications and many more. All of those variants are established in comparison to an artificial reference genome, which was created for the ease of the comparative analysis of the common variants between humans. With the decrease of the costs for the next-generation sequencing (e.g. Illumina, PacBio), precision medicine and the discovery of the reasons behind many single-gene and complex genetic diseases is currently being extensively studied. We observe today the fundamental shift toward the whole genome sequence studies, which allow the study of the regulatory regions of human DNA. However, with the amount of the sequencing data at the whole genome and the population scale, the main bottleneck for the data processing and discovery of novel, potentially pathogenic variants is often linked not only to the samples collection and wet lab experiments but also its bioinformatic analysis. In many research studies, such massive analysis of the data is not simple - the complex algorithms and software behind the discovery of variants are often hard to install, satisfying dependencies, then run and finally understand the results in terms of their clinical and biological relevance. In this work, we present ConsensuSV, a software package for the discovery of all types of genomic variants - Structural Variants, Indels, and SNPs, that is highly automated and high-performance computing (HPC) enabled. The software is divided into two main modules - ConsensuSV-pipeline, which is based on the luigi framework and takes care of running the specific tasks in the appropriate order, visualisation, and control of the status for the particular tasks. The second module, ConsensuSV-core is machine learning (ML) enhanced software that provides a meta caller for Structural Variants (SV). In the default version, it takes ConsensuSV-pipeline generated output of 8 SV callers and merges them using neural networks. The software is much easier to use than its competitors - FusorSV and MetaSV, simultaneously achieving high levels of SVs discovery sensitivity and selectivity in comparison to other state-of-the-art tools.

On robustness of generative representations against catastrophic forgetting

Wojciech Masarczyk

Catastrophic forgetting of previously learned knowledge while learning new tasks is a widely observed limitation of contemporary neural networks. Although many continual learning methods are proposed to mitigate this drawback, the main question remains unanswered: what is the root cause of catastrophic forgetting? In this work, we aim at answering this question by posing and validating a set of research hypotheses related to the specificity of representations built internally by neural models. More specifically, we design a set of empirical evaluations that compare the robustness of representations in discriminative and generative models against catastrophic forgetting. We observe that representations learned by discriminative models are more prone to catastrophic forgetting than their generative counterparts, which sheds new light on the advantages of developing generative models for continual learning. Finally, our work opens new research pathways and possibilities to adopt generative models in continual learning beyond mere replay mechanisms.

Fast Fourier Transform based Method of Neural Network Training for Human Re-Rendering

Paweł Kowaleczko

Novel view synthesis is one of the generative imaging issues in which Generative Adversarial Networks (GANs) can be applied. One of such tasks is also human re-rendering from a single image. The goal of such an algorithm is to generate a human picture in a target pose using only the source image of this person in a different pose. The current state of the art is presented in the paper "Neural Re-rendering of Humans from a Single Image" by Sarkar et al. We reimplemented this paper and identified its main drawback - low quality of rendered images in the areas of high-frequency details like hair, faces, hands etc. We slightly modified the architectures of baseline models and investigated the influence of operations on Fourier spectra of the images, which we believe may be the solution to the main issue of missing quality of high-frequency details. In particular, we proposed the Discrete Fourier Transform loss function (DFT loss) and investigated how this loss function influences the visual quality and evaluation metrics values for the rendered images.

Computation of nuclear effects in MadGraph5_aMC@NLO at Next-to-Leading order accuracy

Anton Safronov

Automated perturbative computation of cross sections for hard processes (for example, charm and bottom quarks production) in nuclear proton+nucleus and nucleus+nucleus collisions at the next-to-leading (NLO) order will provide powerful tools for various applications, such as predictions for new experimental programs, the phenomenology of heavy-ion collisions, and the exploration of the LHC data. Such a goal can be achieved using MadGraph5 aMC@NLO, a well-established tool for automatically generating matrix elements for High Energy Physics processes, such as decays and 2→n scatterings, computations of cross sections, generation of hard events and their matching with event generators for High Energy Physics processes in elementary collisions. My project aims to extend MadGraph5 aMC@NLO capabilities by implementing computations for asymmetric (nuclear) collisions, for example, p+Pb, or Pb+W reactions. In the future, this new tool will be included in the virtual access NLOAccess (https://nloaccess.in2p3.fr) project within the integrated European initiative STRONG-2020.

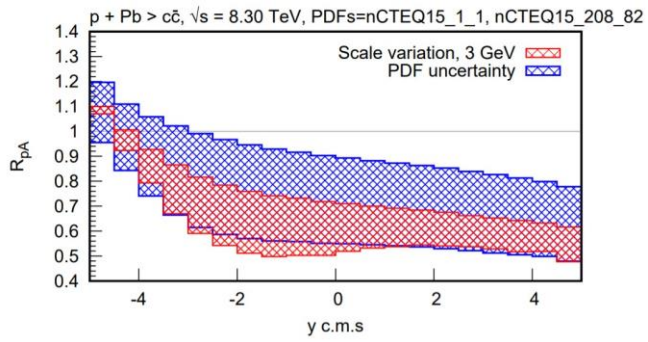

Fig. 1 Nuclear Modification Factor as a function of y(c.m.s).

In my talk, I will present the objectives of the NLOAccess initiative and the status of my project, including results for heavy flavour (charm, bottom and top quark) or SM bosons (H, Z) production in p+Pb collisions at the LHC.

Resource Allocation in Business Processes Using Deep Reinforcement Learning

Michał Ostapowicz

Assigning resources during the execution of business processes is a repetitive task that can be effectively automated. However, various automation methods may give suboptimal results. Proper resource allocation is vital as it leads to significant cost reductions and increased effectiveness, resulting in increased revenues. During the talk, an original representation that allows a multi-process environment modeling with different process-based rewards will be presented along with the simulation engine developed specifically for this purpose. Considered business processes usually share resources that differ in their eligibility.

This work will propose a method utilizing double deep reinforcement learning for an online resource allocation for multiple-process and multi-resource environments. Due to the usage of tabular algorithms, previous approaches using data in the form of event logs or applying online learning were limited by the exploding computational complexity when the number of possible states increased.

This presentation also shows the entire experimental setup. It compares results achieved using reinforcement learning and two popular strategies, namely Shortest Processing Time (SPT) and First-In-First-Out (FIFO), widely used in the industry. As a presentation summary, It is planned to show plans for future research, e.g., comparing reinforcement learning with more complex heuristics such as Monte Carlo tree search (MCST).

Modelling of Generic Process Design Kit (PDK) Components for Photonic Integrated Circuits

Andrzej Polatynski

Recent developments in versatile Photonic Integrated Circuit (PIC) technologies and hybrid integration processes offer a flexible and cost-efficient way for creating very complex photonic components and integrated circuits for many applications. The fast and efficient test, optimization and verification of new ideas requires an automated and reproducible simulation and design process supporting flexible layout-aware schematic-driven methodologies. When considering very complex designs, even small fabrication tolerances of one building block could make a significant difference in the performance and manufacturability of the whole structure. To reduce the risk of failure and to make performance predictions by virtual prototyping reliable, the simulation model of each single building block needs to be working correctly based not only on the appropriate mathematical and physical equations but also on adequate information provided by the foundry where the final structure will be manufactured.

Within the MIRPIC project, we address these design challenges and establish a new versatile integration platform working at the Mid-Infrared wavelength range covering numerous photonics applications in the sensing market. In this presentation, I will present our methodologies for modelling and prototyping optical elements, including simulation techniques for extracting crucial parameters from fabricated devices and test structures. I will demonstrate how the seamless integration between photonic circuits and foundry knowledge enables the rapid virtual prototyping of complex photonic components and integrated circuits.

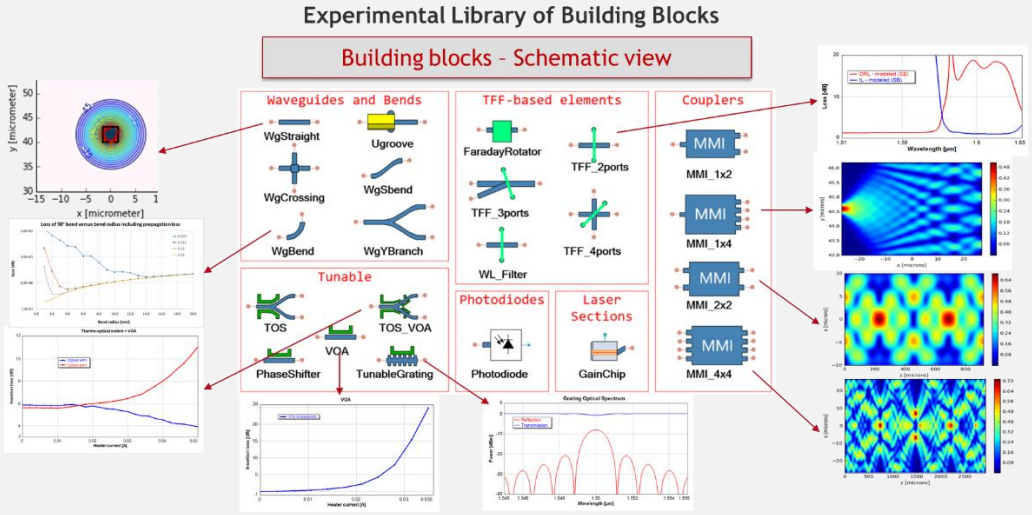

Fig. 1 Exemplary simulation library of PDK components.

Lepton-Hadron collisions in MadGraph5_aMC@NLO

Laboni Manna

The overall objective of my research is to deepen our understanding of the internal structure of nuclei and nucleons. In the coming years, the Electron-Ion-Collider (EIC) in the United States will enable researchers to study lepton-hadron collisions with unprecedented precision. In particular, it will be the very first collider of leptons and nuclei. Its first objective is to advance our knowledge of the partonic content of the hadrons. In order to plan and optimize various measurements, it is essential to include radiative corrections in our simulations for the lepton-hadron reactions. For the time being, there does not exist any automated simulation tools including even only next-to-leading order (NLO) radiative corrections. A NLO code such as this is however vital in light of the development of the EIC in the coming decade.

MadGraph5_aMC@NLO (MG5) is a framework that aims at providing all the elements necessary for the standard model and beyond standard model phenomenologies, such as the computations of cross sections, the generation of hard events and their matching with event generators, and the use of a variety of tools relevant to event manipulation and analysis. The code allows one to simulate processes in virtually all configurations of interest, in particular for hadronic and e+e- colliders.

My work aims at implementing lepton-hadron collisions in MG5 which are not implemented yet in this framework. It can currently work for the proton-proton and electron-positron collisions but when it comes to the context of lepton-hadron collisions it would not work. The reason resides in the phase-space integration. In the case of electron-proton, it should be handled differently rather than the proton-proton case in MG5.

Until now, I have worked on specific photon-proton collisions where the photon is coming from an electron. This work does not require any change in the phase-space-integration part, though it required some other changes which I have done to work it properly within the MG5 framework.

After this development, my next work is to concentrate on the lepton-hadron collisions part in MG5.

Characterization methods of 2D materials produced by liquid phase exfoliation

Milena Ojrzyńska

Technological improvement of 2D, nano and micro size materials flakes requires establishing of statistical characterization methods of large numbers of flakes – especially their thickness as well as lateral size, defects and chemical composition. Comparison of the results from spectroscopic and microscopic characterization methods should allow to develop a statistical method of verifying the properties of these materials, which will be crucial for the development of their production and applications. Different methods of producing 2D materials leads to various properties of the final product and hence the applications. Characterization of selected layered materials before, during and after exfoliation process, especially their physical properties such as size and thickness, can be carried out on Raman, UV-Vis and FTIR spectroscopy, SEM and AFM. Analysis of more advanced structures, such as edge and surface functionalization or intercalated compounds, requires combination of chemical and physical characterization methods. The aim of this presentation is to get near the subject of 2D, nano and micro size materials statistical characterization methods and their combination in order to find quick and easy procedure of selecting their properties.

IDSS

2ND INTERDISCIPLINARY DOCTORAL SCHOOL SEMINAR

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POSTER PRESENTATIONS

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Exact Sciences and New Techologies

Warsaw University of Technolody

Application of artificial intelligence methods in localization of Tactical Unmanned Aerial Vehicles based on vision systems and digital maps.

Krzysztof Gromada

Unmanned Aerial Vehicles are the fastest-growing segment of the military aerospace market. Their popularity rapidly increases in civil, commercial usage, and national security agencies for search-and-rescue or environment protection missions. A wide range of UAV payloads (including electro-optical visible/infrared light (EO/IR) cameras, Synthetic Aperture Radars (SAR)) is systematically enriched and introduced to the market.

Due to higher system integrity and reliability demand in the market, new localization systems need to be implemented for GPS (and other radio-based localization systems) signal unavailability scenarios. These can occur when a GPS signal is jammed, damned by nearby objects/terrain, or disabled with the conflict declaration.

Presented work defines an approach to localization of the UAV based on Visible Light and/or Thermal and SAR Imagery analysis. The central element of the systems is a set of algorithms that conduct segmentation tasks on given images. For SAR imagery is used as well as deep neural networks For optical, near-infrared and thermal cameras segmentation Deep Neural Networks are used, while for the SAR imagery additionally a dedicated histogram-based segmentation method was developed. The resulting segmentation mask allows for global UAV positioning on digital maps using optimization algorithms and stereometrics.

Analysis of the effectiveness of lightning and surge protection in a large solar farm

Emilia Sobieska

Photovoltaic systems are designed for a service life of up to 30 years, during which they are exposed to direct and indirect effects of lightnings. It is estimated that in Poland the number of stormy days ranges from 15 on the coast to 33 in the south-eastern regions of the country. Therefore, since the chances of a lightning event occurring are considerable, it should be considered to equip the facilities with a comprehensive lightning protection system. Its task is to protect against the effects of a direct lightning strike on an element of a photovoltaic installation and from the impact of phenomena induced by a lightning electromagnetic pulse (LEMP). Due to various technical conditions, it may implement this protection in multiple ways, which may translate into the effectiveness of protection.

The article is devoted to the qualitative analysis of various lightning protection configurations of a large photovoltaic farm. The authors presented an analysis of the lightning current flow in the conductive elements of the installation and the distribution of the magnetic field for a configuration with an integrated and free-standing lightning rod. They also performed an analysis of the effect of the grounding configuration on the electrical potential distribution on the earth's surface. In theoretical scope, a discussion of the presented solutions, including the obtained voltages induced in the assumed worst case of PV cabling, was presented, and finally conclusions were drawn.

Data Plane Traffic Engineering algorithms in future mobile networks

Robert Kołakowski

The future mobile networks (5G+, 6G) are expected to support a much wider range of services with diverse and elevated requirements for user data transmission (bandwidth, delay, reliability) in comparison to the previous network generations. The broad spectrum of applications incorporates i.a., Industry 4.0, Smart Cities, road safety services, drone-based services, and entertainment (augmented and virtual reality). As a result, effective handling of user traffic ensuring required Quality of Service becomes problematic. One potential solution to satisfy the mentioned requirements is utilizing the Software Defined Networks (SDN) architectural approach in which network devices have separate control and data plane functionalities. Such separation enables dynamic reconfiguration of network components and facilitates control of user data flows within the network.

This research is focused on developing traffic engineering algorithms that will leverage the concept of the distributed SDN network and enable scalable and effective traffic handling in future mobile networks. To this end, apart from the traffic engineering applications, the full support for user mobility, including additional in-network mechanisms such as, e.g., Forked Routing or Source Routing, is planned to be provided.

Finding Spin Glass Ground States Through Deep Reinforcement Learning and Graph Neural Networks

Tomasz Śmierzchalski

Spin glasses are disordered magnets with random interactions that are, generally, in conflict with each other. Finding the ground state of a spin glass is not only an important problem in modern physic but is also connected to a wide array of hard optimization problems (such as travelling salesman). It is still an unsolved problem, but there are many heuristic algorithms useful in finding an approximate solution.

One of such is recently developed DIRAC - a deep reinforcement learning framework, which can be trained purely on small-scale spin glass instances and then applied
to arbitrarily large ones. Connected with it is SGNN (Spin Glass Neural Network), a graph neural network used to encode spin glass instances. This poster will be focused on describing SGNN and DIRACT, theirs scalability and potential shortcomings.

Laser beam diagnostics systems based on artificial intelligence algorithms

Daniel Mostowski

Development of a technology for the production of a multifunctional polymer nanocomposite based on new materials with a 2D structure and its characterization.

Karolina Filak

The discovery of new materials drives the economy, which constantly requires more efficient solutions with extreme properties. Along with the continuous development of technology in various sectors of the economy, there are newer threats, and thus the possibilities of their solutions. Materials with a two-dimensional structure appear to be ideal candidates for achieving excellent characteristics. These materials implemented in composites are advanced materials and thanks to their properties, including low weight, thermal and electrical stability or shielding of electromagnetic radiation have a wide range of applications.

Fig. 1 Manufactured nanocomposites that initially meet the assumed requirements as to physical properties

The research goal was to develop composite materials (Fig. 1) producing method consisting of thermoplastic polymers and fillers. It is crucial that this method is cheap, uncomplicated and scalable. It was assumed to develop nanocomposites that will show an EMI shielding efficiency of minimum 20 dB, a thermal conductivity of at least 1 W/mK and the lowest possible volume resistivity. Research is being carried out on the selection of an appropriate filler and its concentration in order to achieve the assumed goal. The previous research activity has included the production of composites from various polymers and fillers, as well as various concentrations of these fillers. In addition, new methods of producing composite materials were developed that improved the electrical and thermal properties of nanocomposites.

Improving the Actor-Critic with Experience Replay

Jakub Łyskawa

Actor-Critic with Experience Replay (ACER) is a Reinforcement Learning algorithm based on the Actor-Critic algorithm. It was adapted to be used with deep neural networks and to increase its sample efficiency by storing and replaying collected experiences. In my work, I research possibilities to improve the quality of this algorithm, both in general and with a focus on robotic control.

In my previous work in collaboration with other researchers a novel algorithm was introduced - the Actor-Critic with Experience Replay and Autocorrelated Actions. It is based on the ACER algorithm and utilizes autocorrelation to improve the smoothness of the control signal without decreasing exploration intensity. It yields better results in robotic control environments than both ACER and selected state-of-the-art algorithms. Its relative performance is even higher when applied to environments with finer time discretization.

In another work, I explore the possibilities of improving the performance of the ACER algorithm by increasing the informativeness of the estimation of future rewards. The method that I applied is quantile regression. It improves the stability of learning and has a lot of potential for further improvements as, instead of just the expected value estimated in the most common approach, it allows to estimate the whole distribution.

Technology of graphene flakes production and its properties characterization

Agata Daniszewska

The purpose of the research is the development of a technology for the production of new materials with a 2D structure adapted to the industrial scale and testing the physico-chemical properties of the materials. The technology is to be based on a method of bulk material exfoliation in aqueous solution using shear forces without the use of any harmful chemicals. Following problems are being solved: the possibility of the process scalability and its capability, improvement of the structural quality of the material, defect testing, reduction of the production price due to the absence of harmful factors, the possibility of production processes optimization, control of structure of the obtained material.

A series of experiments of graphite exfoliation in liquid phase were carried out using high pressure homogenizer. The quality and the structure of the produced material were tested using Raman spectroscopy, UV-VIS spectroscopy, atomic force microscopy, scanning electron microscopy and thermogravimetric analysis. Preliminary optimization of the process parameters has been performed (e.g. type of input material and solvent, concentration, pressure, number of passes at given pressure).

Algorithms for separable non-convexproblems

Anthony Nwachukwu

We considered several algorithms used to solve separable, nonconvex problems and implemented five of them, Bertsekas, Tanikawa-Mukai, Tatjewski, Arnold, et al. and ADMM using MATLAB. Experiments were performed using the implementations on a machine learning convex problem, the ridge regression for model fitting using an artificially crafted dataset. From the experiments, we observed that although the work of Tanikawa-Makai obtained convergence in a slightly smaller iteration than the rest, it takes a longer time per iterations compared to some others. Also, ADMM and Bertsekas achieved convergence at a close number of iterations, while Tanikawa-Mukai has the advantage of shorter run-time. We concluded that Bertsekas gave the best performance given the problem considered while Arnold and Tatjewski gave the worst performance.

Knowledge transfer methods for classification tasks

Mikołaj Małkiński

One of the fundamental goals of Artificial Intelligence is to reach levels of a so-called Artificial General Intelligence (AGI), characterized by autonomous learning systems with close to human-level reasoning capabilities. Among many AGI milestones, in the planned research we are particularly interested in intelligent systems that can autonomously (i.e. without external supervision) learn to solve disparate tasks of a given type with efficacy similar to specialized methods, dedicated to the particular tasks. The goal of the conducted research is to create a novel method of constructing universal systems capable of solving disparate classification tasks based on access to unified resources (e.g. joint system architecture or shared memory) and a uniform meta-learning strategy. One of many possibilities of achieving this goal is by employing deep neural networks and task decomposition techniques, which will constitute the central theme of the oncoming research.

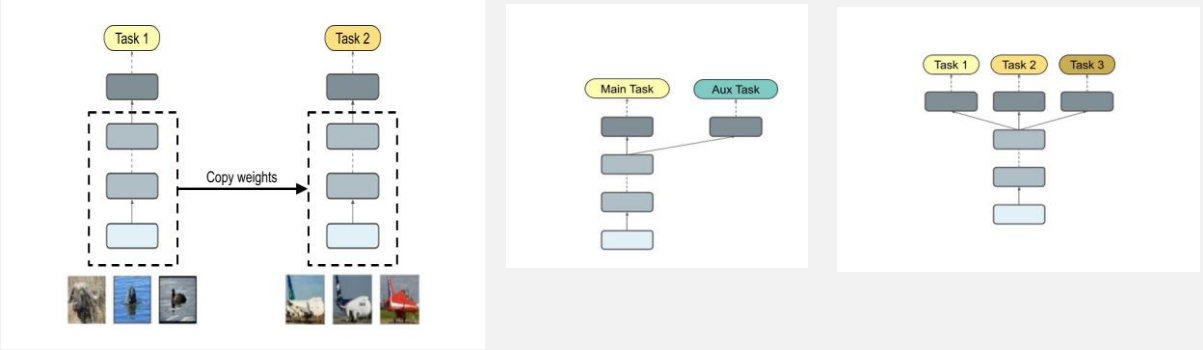

Fig. 1 Examples of knowledge transfer methods. (Left): Inductive transfer learning – a model trained on Task 1 is fine-tuned on Task 2. (Centre): Training with an auxiliary task – a supplementary task is used, which should help the model to discover better features and simplify training. (Right): Multi-task learning – a single model is trained to solve multiple tasks simultaneously.

RF-powered rotary telemetry system for aircraft component testing

Tomasz Kabala

Telemetry systems are one of the most important items during in laboratory testing of rotary aircraft components, which enable engineers to verify processes taking place inside tested modules. Testing and certification of new types of rotary components in laboratory, before usage in aircraft, is extremely important and increase the safety of flying. Unfortunately, most of high-speed rotary telemetry systems which are used in aircraft laboratories are complicated and very expensive. Rapid growth of IoT technology in the last decade brings bunch of new communication techniques and electronic design possibilities, which were not available before. Combination of low power electronic design, low power communication protocols and energy harvesting techniques could bring new quality in remote measurements. The main motivation of research works is to propose design concept of smart telemetry system that could be more affordable, handful and could simplify way of rotary components testing. As a research result, telemetry system in form of light weight, RF-powered, single-PCB, smart transducer was proposed. Project is in the phase of assembly which is performed according to prepared PCB scheme. Preliminary tests show the correctness of the design assumptions. During final tests prototype will be tested in Component Test Laboratory in Łukasiewicz Research Network – Institute of Aviation. All tests will be performed in configuration that will be used in future test campaigns.

Knowledge transfer - artificial neural networks

Paulina Tomaszewska

Artificial neural networks are inspired by the activity of the human brain. People have the ability to reason about the reality that they observe based on previous knowledge. If they already know how a horse looks like, they do not need a lot of learning to properly distinguish zebra. It is enough to get the information that zebra is like a horse with stripes and then the task is easy. The knowledge transfer in neural networks is performed from different angles. It can be implicit or explicit. The key techniques are: transfer learning, continual learning, knowledge distillation, meta learning and multi-task learning.

HIPIMS based thin film technology for resistive random-access memory application

Piotr Różański

This work is devoted to the technology and characterization of thin films fabricated employing reactive magnetron sputtering using HIPIMS discharge. These materials include metal oxides and nitrides, such as titanium nitride (TiN) or titanium oxide (TiOx). The investigated materials play several important functions in various types of devices for novel electronic and photonic devices. The ultimate goal of this work is the examination of mutual dependences between the input parameters of the fabrication process (technological parameters) and the output parameters (properties of the obtained materials) to obtain ultrathin layers for the application of the MIM (Metal-Insulator-Metal) structures. Those structures are the basis of resistive random-access memory (RRAM) devices.

In the first part of this work, optical properties of the fabricated materials will be examined and compared to the layers deposited through the typical pulsed-DC processes. Several oxide materials will be characterized in terms of thickness, refractive indices, transmittance, and reflectance in the UV-VIS range. The resistive switching properties of the MIM structures with the employed oxide materials are dependent of the presence of oxygen vacancies in the layer bulk. In order to monitor the stoichiometry of the oxide layers, MIS (Metal-Insulator-Semiconductor) structures will be fabricated. The analysis of the obtained electrical characteristics will be performed.

Concept of the LLRF system for stabilization of accelerating EM fields in the resonant cavities of PolFEL linear accelerator utilizing direct sampling of the RF signal

Tomasz Kowalski

The Low-Level Radio Frequency (LLRF) control system is one of the fundamental parts of a particle accelerator, ensuring the stability of the oscillating electro-magnetic field, which is produced inside resonant cavities in order to accelerate charged particles. It relies on precise measurement of the field by In-Phase/Quadrature (IQ) detection of an RF probe signal from the cavity, which yields the instantaneous phase and amplitude of the field. The result of this measurement is fed to a digital feedback controller, which calculates an error signal and corrects the field amplitude and phase via an RF actuator, as per Figure 1.

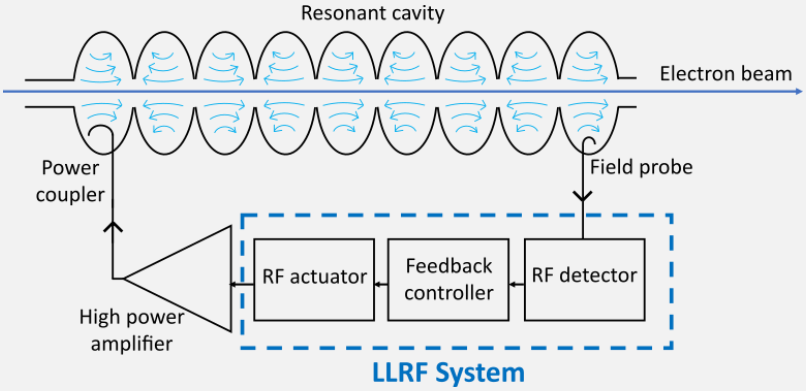

Fig. 1 Block diagram of a LLRF system.

For the purpose of the PolFEL LLRF system, direct sampling is studied for IQ detection of RF signals. This methodology bypasses a downconversion stage, leading to a straightforward implementation without the need for additional calibration. The proposed architecture of the system is presented in Figure 2. It consists of an FPGA Mezzanine Card (FMC) carrier board, implementing the feedback controller and two FMC boards. One of them features a dual digital-to-analogue converter, along with a vector modulator and serves as the RF actuator, while the other houses wide-bandwidth analogue-to-digital converters for direct sampling of RF signals. The system is provided with a single 1.3 GHz reference signal, which is then used to locally synthesise the sampling clock, as well as upconvert the actuator signal to the resonant frequency of the cavities.

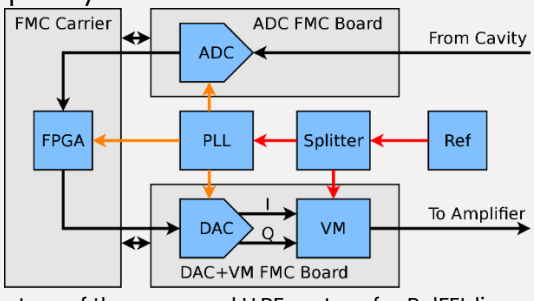

Fig. 2 Architecture of the proposed LLRF system for PolFEL linear accelerator.

Two-particle angular correlations of identified particles in pp collisions at the LHC registered by the ALICE experiment.

Daniela Ruggiano

This contribution focuses on two-particles angular correlation in pp collisions at $\sqrt{s}$ = 13 TeV of identified particles and their antiparticles.

Studying the angular correlations is a useful and powerful tool for understanding the mechanism of particle production in collisions of hadrons and high-energy nuclei.

The correlations between two-particles in relative azimuth (Delta varphi) and pseudorapidity (Delta eta) exhibit different structures that arise from different physical mechanisms that create distinctive structures in Delta eta Delta varphi space.

Each of these effects contribute to the correlation function by showing individual behavior.

The main goal of this study is to decompose and quantify each physical contribution that influences the structure of the correlation functions.

Multi-modal recommendation system for e-commerce

Michał Daniluk

Artificial Intelligence-based recommender systems are present at almost every large e-commerce store and platform, spanning various product sectors from garments, through jewelry to food. It is usually impossible to adjust existing algorithms to include a new modality of data or a new type of attribute. A vast majority of existing recommender systems consider only a single type of interaction, e.g. clicks or purchases.

The goal of my PHD is to study a multi-modal context-aware recommendation system that can be fed with various types of data such as purchases, clicks, page visits, text, image, and other meta-data. The PHD is realized in cooperation with Synerise.

In the first year of my PHD, I proposed a multi-modal recommendation model – EMDE (Efficient Manifold Density Estimator). This work will be presented during ICONIP in December 2021.

Furthermore, I also won three very prestigious Machine Learning competitions:

- Booking.com Data Challenge, which aims to make the best recommendation for the next destination of a user trip, based on a dataset with millions of real anonymized accommodation reservations.
- KDD CUP 2021, which goal was to predict the subject area of the given arXiv papers in a heterogeneous academic graph.
- RecSys Twitter Challenge, which focuses on a real-world task of tweet engagement prediction in a dynamic environment.

A comprehensive multimodal recommender system for fashion ecommerce

Mikołaj Wieczorek

This Industrial PhD thesis, conducted in cooperation with Synerise S.A., focuses on creating a comprehensive multimodal recommender system for the fashion industry.

The system relies heavily on Computer Vision methods to encode and 'understand' images, as clothes are best assessed based on their look. However, the look itself may not suffice; therefore, the system needs additional data about the user, such as a history of transactions and clicked products; some textual description of the products may also be helpful. Images, text and behavioural data makes the system multimodal and best suited to serve personalised recommendations to users.

There are two main research challenges 1) fusion mechanism to combine information from visual appearance, textual data and user behaviour; 2) preparing data and training schema to train a model a notion of 'fashionability' and 'compatibility' for a population/single user.

During the PhD course, two papers were publicised with state-of-the-art results in a fashion retrieval task. Some of the models created so far are currently being prepared to be used by Synerise.

The main goal is to create a comprehensive, production-ready recommender system for fashion retailers. Moreover, each submodule of the comprehensive system is expected to perform on the state-of-the-art level.

Theory-categorical models of concurrent computation

Jarosław Miller

The use of category theory as an abstract description language used in theoretical computer science has gained great popularity in the last two decades because it allows for the unification of seemingly independent fields of computer science. The main goal of my research work is to present new theory-categorical models of concurrent computation that can be placed in the context of other aspects of computation, such as computation with indiscreet time or probabilistic computation. Research focuses on presenting abstract, general extensions of pi-calculus and their semantics.

The pi-calculus is the language of description of processes operating in parallel and communicating with each other. Research on it is one of the core of the development of the field of formal methods and often finds practical applications, e.g. in proving the correctness of cryptographic algorithms. In theoretical and practical considerations on the pi-calculus, its extensions are often introduced, departing from its classical form. In many cases, this requires building a theory from scratch: introducing a new language and its semantics (somewhat different from the classical one), and then proving the correctness of the defined structures. Despite some advantages of this approach, it is not a modular approach. The modular approach is to build a general abstract theory in which new constructs and results would be instances of it.

The Splitting Theorem for finitely generated Propositional Dynamic Logic

Adam Mata

Modal logic as a branch of mathematics has been widely developed during the end of the previous century. It provides multiple tools for different branches of computer science: modelling the progation of knowledge in agent systems, building atomated-proovers, and validating correctness of computer programs. The latter problem has given birth to the extension of Modal Logic – namely Dynamic Logic, which provides machinery for reasoning about logical structures where validity of formula may change dynamically.

Around 1980 the collection of extensions of Modal Logic was examined to find properties which are similar among them. Algebraical methods applied to this issue allowed to, firstly, create a mathematical structure of these extensions – the lattice. Secondly, The Splitting Theorem ocurred, which treats about pairs of extensions which somehow „split" the lattice into two mutually complementing parts.

The recent research concerning the extensions of Dynamic Logic itself has shown that Kleene's Algebras, which are semantical structures for Dynamic Logic, also form the lattice. Nevertheless, there are no results stating about splitting this lattice. The goal of the research is to characterize complementing pairs of finite extensions of Propositional Dynamic Logics, which split the mentioned lattice by algebraical and domain-theory methods.

Automatic Scheduling of Teacher Networks in Knowledge Distillation

Paweł Kubik

Knowledge distillation improves performance of a small student neural network with a signal from a larger teacher network. This signal takes the form of a loss function that either supplements or completely replaces a task-specific loss function. While intuition could suggest that selecting a teacher with the highest performance leads to best results, various studies have shown contradictory results. Large discrepancy between the models seems to have a negative impact on the knowledge distillation. To mitigate this, we explore the effect of gradually replacing smaller intermediate teachers with a larger teacher throughout the training. We achieve smooth transitions by mixing the outputs of the teachers with a weighted average. We then replace hand-crafted schedules with an automatic teacher selection mechanism based on gradient descent. We derive a selection weight of each teacher from a trainable parameter. Both the student and the teacher selection mechanism are trained to minimize Kullback–Leibler divergence between the student and the mixed teachers outputs. Surprisingly, the selection mechanism consecutively switches from the smallest to the largest teacher, even though the objective function does not impose any direct incentives for such a behavior.

Modern threats and methods of counteracting in the cybersecurity in OT area

Przemysław Szary

Nowadays, cybersecurity is a more and more popular field of science. It relates to the increasing number of malware attacks in public and private areas. Cybersecurity has many specialization areas, one of them is the industrial system (known as Operational Technology) cybersecurity. It is a young science field, which I will investigate in my industrial Ph.D. thesis.

Cybersecurity in OT is important, especially in the energy sector, because cyber attacks can damage systems responsible for energy transmission in the whole country. The current approach is usually far from providing security in such systems. For this reason, my experiments are focused on inventing completely new attacks vectors and possible methods of avoiding and mitigating them.

I am particularly interested in implementing network steganography in the connection between two industrial systems. What is more, the connection will be established via the data diode (considered a very safe solution). This specific device is a hardware cybersecurity solution that ensures unidirectional information transfer between two networks. After experiments with cyber attacks, I will focus on the defending sites. Thus, in the next steps, I will present the possible counteraction of them.

So far, I have done an overview of the state of art, and I have started building the data diode and implementing the test bed.

Security of the Internet Of Things

Bartosz Kościug

The principal field of the research is the security of the Internet Of Things network. At present, the modern IoT networks such as LoraWAN use i.e. AES - Advanced Encryption Standard, in order to provide the IoT networks with data encryption. These types of the data encryption algorithms were not designed for the usage of low power wide area networks in which we care about low energy consumption. In consequence, nowadays we are looking for more flexible and energy saving infosec solutions. The main goal of the research is to design and implement the data encryption algorithm that would enhance the power consumption of the IoT devices and in the same time ensure that information security is provided. Data confidentiality, integrity and availability are key principals that would be embedded in the proposed solution. Consequently, the node authorization and authentication methods would be also proposed. The results of the research will be tested in the field. The assumed set of the IoT devices to test with customized software are two raw LoraWAN nodes and LoraWAN gateway with access to TTN (The Things of the Network) in combination with one node.

Keywords: The Internet Of The Things, data encryption, energy saving

Optimal sample allocation in stratified sampling schemes

Wojciech Wójciak

Sample allocation is one of the basic issues of survey sampling. It is a procedure of dividing the total sample among disjoint subsets of a finite population such as strata. The allocation procedure is called optimal because in a particular survey sampling design it produces the smallest variance for estimating a population total or mean of a given study variable. A thorough analysis of the literature shows that even for the generic scheme of stratified simple random sampling without replacement in each strata, the optimal sample allocation under lower and upper bounds restrictions imposed on sample sizes in strata remains an important problem which is not well understood and suffers from the lack of satisfactory algorithms.

The main research objective of this work is to solve the problem of optimum sample allocation under lower and upper bounds restrictions imposed on sample sizes in strata for various and important sampling schemes. The generic sampling scheme in this context is the stratified sampling with simple random sampling without replacement in strata. We plan to use and adopt tools and methods of convex optimization theory. The solution to the problem will be the set of so called optimality conditions, given as closed-form expressions, along with new efficient algorithms constructed on their basis. Such approach to the optimal allocation problem is unique.

Photosensors and data acquisition systems for water Cherenkov detectors in high energy physics and astrophysics experiments.

Krzysztof Dygnarowicz

The aim of my research problem relates to the Hyper Kamiokande (HK) project, which is currently constructed in Japan. Main component of HK is an enormous water-Cherenkov detector (H-71m, Æ=68m), which will be filled with 258 kt of ultrapure water, placed underground at a depth of 650 m. The research problems which will be examined by HK include measurements of neutrino oscillation, study of CP-violation, study of cosmic neutrino, proton decay research, dark matter search.
In Poland, we plan to manufacture around 1120 so-called multi-PMT modules – a combined sensor comprising 19 photomultiplier tubes along with associated electronics. These sensors will augment the main photodetection system of the HK, that is built using 50 cm phototubes. The main purpose of the mPMTs will be calibration and they will allow solving some of the degeneracies of the HK detector that would otherwise be impossible to measure (for ex. better study of water properties, better control of direct vs reflected light). Their main advantage compared to 50 cm PMTs are increased granularity, directionality, much better timing resolution. My research task is related to the development of mPMTs modules, which include PMT characterization, developing of data acquisition system (both hardware and digital signal processing algorithms), developing QA scheme and tools for mass production and preparing a model for physics simulations. First pre-production batch of the sensors will be manufactured in 2022.

Sound AI – how AI techniques will drive ultimate listening experience

Jakub Tkaczuk

Artificial Intelligence techniques and its applications do change how we perceive surrounding worlds.

AI algorithms and engines are becoming a standard feature in novel consumer devices. But it is not all about software and deep network architectures as new applications and use-cases requires new hardware platforms that will enable these new experiences. AI is everywhere. We are used to Conversational Agents, Natural Language Processing and other Voice-driven applications. We do acknowledge that Deep Learning techniques significantly changed Computer Vision area and currently machine-learning driven applications do outperform human capabilities. We are all driven by Recommendation services while not only listening or watching multimedia content but in daily tasks as browsing internet and so on.

But can AI change traditional music consumption experience? Design of speaker transducers did not change since many years. Crossovers still do rely on traditional RLC approach. Amplifiers become more efficient but still we cannot say there are intelligent. In this short poster we will review AI techniques that might contribute to next generation listening experience. We will look into Sound Recognition and Deep Signal Processing techniques and try to combine them into the design of next generation, distributed sound reproduction systems.

Influence of ferroresonance oscillations on electric power protection automatics operation

Piotr Suchorolski

The research problem is related to ferroresonance oscillations that appear in medium voltage grids (especially in grids with isolated neutral point) cooperating with wind farms and photovoltaic farms.

As part of the research issue, it is necessary to identify the specific operating conditions of wind farm grid and photovoltaic grid, in which the unfavorable ferroresonance phenomenon may arise. Then, the influence of ferroresonant oscillations on the operation of protection automatics installed in such grids should be investigated and determined. The analysis would cover under investigation those protection functions, that the operation criteria of which turn out to be sensitive to the disturbance (ferroresonance oscillations).

The results of the work would be used to indicate methods to prevent or minimize the adverse impact of the disturbance and to develop algorithm (and device), which can be applied in or cooperate with existing protection devices, that can selectively detect and quckly damp ferroresonant oscillations, eventualy preventing protection relays from false operation.

Real-Time Public Transport Delay Prediction

Przemysław Wrona

The proliferation of various sensor technologies in smart cities, the prevalence of mobile phones, the internet-of-things technology, and networks of sensors has led to an enormous and ever-increasing amount of data that are now more commonly available in a streaming fashion. One type of never-ending stream is sent current localization of public transport such as busses, trams or metro lines.

We present the system for detecting delays in public transport using concept drift detection methods. System integrating raw data from Warsaw Public Transport coming from the data stream with timetables. Based on vehicle arrivals from streams and schedules, there will be calculated delay, which in the future will be used to build a model for predicting delay.

The approach used in the work is the adaptation of traditional machine learning algorithms and artificial neural networks for a non-stationary environment, in which the data for training the model flow in an endless stream.

This work investigates day-to-day variability in public transport travel time using a GPS data set for public transport routes. It explores the nature and shape of travel time distributions for different departure time windows at different times of the day and factors causing travel time variabilities of public transport, such as distance between stops and destination, quality of vehicle number of seats or delay at the previous stop. We demonstrate the system with a real-world use-case at Warsaw city, Poland.

The analysis and selection of digital image processing and analysis algorithms in order to detect and interpret objects of a specific type recorded in photos taken with the Quercus multispectral camera.

Justyna Stypułkowska

The ongoing doctoral thesis focuses on the problem of detection and classification of objects in photos recorded with a multispectral camera. The main objective of the research is, firstly, to select the most effective algorithms for detecting objects on the acquired images, and secondly, to examine the impact of the use of individual spectral channels and appropriate camera settings during image recording on the effectiveness of these algorithms. This will allow for the development and optimization of the entire process not only from the implementation side, which is a common procedure, but also from the hardware side, which will indicate the right direction of the image acquisition method in order to achieve the most effective method of detection and classification of objects recorded on them.

The research uses digital image processing and analysis algorithms, artificial intelligence techniques and deep learning algorithms.

The research is innovative, because so far no one has studied the impact of the use of individual spectral channels on the effectiveness of the detection process and classification of objects in the acquired images.

The results of the conducted research will allow for the proper selection of both algorithms and hardware solutions, which are key at the stage of the image acquisition itself.
The developed solutions will be implemented in the work of the Remote Sensing Department of the Łukasiewicz Research Network - Institute of Aviation.

Digital audio steganography – review of methods and tools

Piotr Marszałek

Steganography is the art of hiding communication without being noticed by a third party. This can be used to provide safe and reliable transmission on public networks, but also brings an opportunity for cybercriminals. For instance, an innocent-looking 'cute kitten' JPEG may have a computer virus embedded or may contain detailed orders for a botnet to attack a given host in cyberspace. Hence, multimedia files are often used as steganographic carriers. However, most of the research carried out on digital steganography focuses on still images rather than on audio data.

There is a lot of methods of embedding hidden data on audio streams and those methods can be grouped into the following three domains: time, frequency, and wavelet. For instance, the most known 'time domain' technique uses the least significant bit (LSB) of each audio sample to store steganographic information. On the other hand, there is a lot of widely available steganographic software that can operate on various well-known file formats e.g., WAV, MP3, FLAC to name a few. However, detailed information about the principle of operation of most of this software remains unknown.

The aim of this work is to explore data hiding techniques utilized by contemporary, online available audio steganographic software, as a preparation for future work on adequate countermeasures to be used in cyber protection.

Mapping the unstructured temporal data

Tomasz Piechula

Unstructured data constitutes today around 90% of data generated by the businesses. Therefore it is of paramount importance to be able to analyze it properly and draw correct conclusions. Moreover, there is a constant flow of new data which needs to be analyzed almost real time.

One method proposed to map such data are knowledge graphs, which were used at greater scale by Google in 2012. Knowledge graphs, known also as semantic networks, represent objects, concepts, situations and events i.e. real world entities as a network and are stored in graph database. However, the standard knowledge graphs are static, i.e. they are unable to account for time factor in embeddings and relations.

One of the most exciting challenges is the graph completion problem, which has been widely studied. On the other hand, the temporal graph completion problem is a very interesting problem which simply enables to predict the future facts, but is still relatively unexplored.

In my research I will explore different algorithms that extract the facts, entities, and relations between them and time using advanced NLP algorithms, time series classification and analysis algorithms, then map the data flow in the form of network (graph).

Ultimately, I will experiment with different temporal knowledge graph completion algorithms and hope to bring some new insight into the field.

Currently I am in the process of literature review.

Framework for the Introduction of Vehicle-to-Grid Technology into the Polish Electricity Market

Konrad Gobosz

The European Union's policy of emission neutrality introduces further restrictions on the use of internal combustion engine (ICE) passenger cars. Importantly, the process of achieving carbon neutrality does not only apply to EU countries. It is a global trend that, apart from efforts in the transport sector, also affects other industry branches. However, it should be kept in mind that the transport sector is a major source of carbon dioxide (CO2) emissions . Therefore, the transformation of public and private transport to zero-emissions has been ongoing for several years. This can be achieved by popularizing electric vehicles. The development of electromobility in recent years has significantly accelerated. With the introduction of electric vehicles into public space, new solutions could be observed, which will contribute to a more efficient use of these vehicles. One of such solutions is Vehicle-To-Grid (V2G) technology.

Vehicle-to-grid (V2G) technology is one of the advanced solutions that uses electric vehicles (EV) to balance electricity demand in the power system. It can be particularly useful in analyzing and then mitigating the risk of not delivering electricity to the end user. Therefore, it is necessary to analyze the possibility of operation of this technology in the legal and technical framework.

Embedding of the components into the PCBA

Marek Kościelski

The now a days trend in electronics is miniaturization. The shift can be seen in the amount of transistor per area or the amount of space used for components. The packages become multi-functional as System in a Package (SiP) is gaining more attention. Also the build up of components in the Z-axis can be seen in packages such as Package on Package (PoP) or the amount of stacked dies especially in the memory chips. All these trends are especially manifested in the mobile devices where minimizing the of the Printed Circuit Board Assembly (PCBA) enables to fit batteries with higher capacity.

All those trends may lead not only to use the Z axis and populate components on top but also embedding them into the Printed Circuit Board (PCB). Such embedding models with a stack-up will be presented. The focus will be the embedding of the passive components such as capacitors and resistors. Exemplary stack-up and lay-out of the PCB are presented below on figure 1.