

WHO ARE WE?

MLgroup is a research group working at the *Slovak University of Technology in Bratislava* in Slovakia. It has been active in **machine learning research** since 2008 and primarily focuses on medicine, biometrics and digital cultures. The team comprises 15 researchers, post-docs and doctoral students, led by Prof. M. Oravec and Prof. J. Pavlovičová.



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EXPERTISE

- To potential partners, we offer our rich experience in ML research - we always try to curate our research to the needs of the public and our specific partners, with multiple **notable cooperations**:
 - In cooperation with the **Second Department of Neurology, Medical School of Comenius University and University Hospital in Bratislava**, we have developed an application used for clinical assessment during the finger-tapping test (FTT).
 - In 2020 we created a collaborative workspace with the **National Bank of Slovakia** on multiple research topics, including financial data prediction and analysis of publicly accessible information of financial institutions.
 - In cooperation with **Eye Clinic, Faculty of Medicine, Slovak Health University in Bratislava, Antolská SZU / Ophthalmology Department, Hospital in Malacky** we have developed systems for eye diseases diagnostics on digital images of the retinal background.
- We have experience with creating and curating databases for ML research, and we have multiple **ML datasets** that we can offer:
 - Over **half a million articles** scraped from Slovak online newspapers from multiple sources spanning from 2017 to 2023.
 - **A database of American Sign Alphabet (ASL)** static gestures containing 26 alphabetic and 9 numeric characters stored as color, infrared and depth images (34,125 images in total).
 - In collaboration with the Department of Electronics and Informatics, Vrije Universiteit Brussel, we created a detailed list of existing datasets containing **images of human eyes** (more than 150 datasets available at <https://irisdata.feistuba.sk/>).
 - Annotated **fundus images for diabetic retinopathy** segmentation (by a medical professional).
- We have led and successfully finished **multiple project within national grant schemes** (6 x VEGA, 1 x KEGA, 1x APVV) and our team members have previous experience with **Horizon projects** ([HBB-NEXT project](#) (FP7-ICT-2011-7-287848) and H2020 [Newton project](#) – (ICT-20 2015))

RESEARCH AREAS

AI in medicine

- We are working to employ AI to assist in the diagnosis of diabetic retinopathy through the **detection and segmentation of retinal damage**. Among our achievements we consider the creation of a (professionally labeled) database, the exploration and design of image preprocessing methods, and the training of models to classify and detect retinal disease. With these techniques we have achieved results exceeding the state-of-the-art in the field, which we have [published in Nature Scientific Reports](#), 2021.
- We have also developed the real-time software application to track position of fingertips used for clinical assessment during the **finger-tapping test (FTT)**. We have used the Leap Motion sensor and created a database of measurements on real patients with the aim of applying the latest AI approaches for the differential diagnosis of the Parkinson's disease and dystonic tremor.
- Using an eye tracking technology we successfully deployed NN based approaches in the **detection of different cognitive disorders**, namely detection of Schizophrenia and Dyslexia. Both results represented state of the art results and were separately published in renowned journals.
- We are working on Brain Computer Interface as **assistive technology**. We concentrate on convolutional neural and time-frequency features. The results are encouraging.

AI in robotics and industry

- We focus on **Human Computer Interaction (HCI)** especially: hand gestures, eye tracking and Brain Computer Interaction (BCI). We strive to use the BCI for device control based on EEG and Motor Imagery.
- We have been focusing on creating **robotic welding workplace** with welding quality control using AI tools.
- We have developed a novel general robotic system for creating **realistic pencil drawings** based on image evolution with elements of machine creativity.
- We have explored the SLAM problem using various sensors, notably the Velodyne Puck VLP16 and Google Cartographer system, testing **mapping and robot localization** in diverse settings.
- Our expertise also lies in **detecting vehicle speed** from video records through the application of various image processing methods such as Gaussian mixture models, DBSCAN, Kalman filter, and Optical flow. We have successfully designed and tested an architecture capable of handling diverse driving conditions, vehicle types, and positioning, enhancing the overall robustness and reliability of our speed detection system.
- We have constructed quite competitive system for **violence detection** based on video surveillance camera sources which uses two stage neural network, CNN + LSTM.

AI in time-series and sequential analysis

- In our collaboration with National Bank of Slovakia, we have trained, evaluated and deployed multiple models to **cluster data, detect outliers and classify financial time-series**.
- Using web-scraping (both manual and AI automated) we have created a large database of texts, which serves as basis for **sentiment analysis and trend forecasting**. For the task we have employed multiple NLP models, tailoring them for specific use-cases (institution analysis, advertisement detection, etc.) and to (low-resource) Slovak language.
- Leveraging web-scraping and advanced NLP models, we developed a system capable of effectively recognizing and **differentiating between native advertisements and genuine content** within the digital Slovak language sphere, achieving high accuracy.
- We have designed and tested several NN and non-NN based approaches eligible for **classification of genre of text** based using available text datasets in English and in addition to our previous expertise several NN based models and text related features were designed and tested in the **text authorship detection** problem on a conversational dataset in English.

Neural Networks Theory and Application

- In an effort to deepen the fundamental theory of NN a new **Algebraic Zero Error Training Method** for Neural Networks Achieving Least Upper Bounds on Neurons and Layers has been derived whilst performing better than the existing methods in most metrics.
- We investigate [potentiality of increasing the robustness of CNN](#) for image classification using the **concept of fixed filters** in CNN architectures.

Pattern recognition in image and sound

- In **speech emotion recognition** we applied complex neural networks to evaluate different speech features and their settings eligible for this problem. This involved a complex analysis and thorough statistical evaluation using two datasets.
- We designed several non-NN and NN based systems for real-time and off-line text dependent and text independent **speaker recognition** systems. We tested different features and structures and their robustness to the session variability problem.
- In the **speech recognition** problem we designed and implemented CD-HMM systems for recognition of continuous speech (Slovak) as well as several NN based solutions for recognition of isolated words. The main focus was on the structure of NNs and extracted speech features.
- In the domain of the **detection and classification of events** in audio signals both block based and stream based systems were designed and tested using convolutional and recurrent (LSTM) NNs in combination with eligible audio features on known audio event datasets
- We employ 3D convolutional networks to accurately identify and distinguish between various **sports actions**, demonstrating the networks' proficiency in learning from video sequences and recognizing distinct activities.
- We have build a system to **detect and classify weld defects** based on data obtained from industrial sensors and images.
- We have build models **hand gestures recognition** using 3D cameras and deep neural networks.

AI in Biometrics

- We have been focusing on **iris recognition**: in our latest paper ([A Survey of Iris Datasets](#), 2021), we provide a comprehensive overview of the existing publicly available datasets.
- Within HBB-NEXT project, project of 7th Frame Program we have designed and implemented real-time text-independent speaker recognition module and a face recognition module for **multimodal interface** for new generation of HBB (Hybrid Broadcast Broadband) television.
- We have harnessed **Generative Adversarial Networks (GANs) to refine object detection models**, specifically for facial biometrics, improving the critical detection phase through image modifications.
- By using Siamese Convolutional Neural Networks, we can **assess image quality**, crucial in biometrics, comparing image pairs to determine higher quality.
- We scrutinize environmental and camera factors affecting deep-learning-based face recognition system accuracy, and provide optimal values for **quality indicators** to enhance candidate frame selection.
- We specialize in employing deep learning methods, notably ResNeXt, for **person and family recognition based on ear images**. This innovative approach taps into the unique features of the human ear to accurately identify individuals and their familial relations.
- We are skilled in **multimodal family detection** utilizing machine learning methods that leverage facial and ear features. This combined approach allows for an advanced level of accuracy in identifying family connections and individual identification.
- In cooperation with Technical University of Denmark we are working on data collection for the only publicly available **video audio kinship database**. Whilst collecting data, we made sure the database is as fair as possible, with as little bias as possible. This database will be primary used to explore spatio-temporal patterns in kinship recognition.

CONTACT US

More information can be found at <https://uim.fei.stuba.sk/mlgroup/>.

We are interested in offering our expertise and joining a consortium, if you have any question please reach out to us:

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