Doctoral Thesis Topics 2025/2026

1.

Supervisor: prof. Ing. Petr Doležel, Ph.D., email: petr.dolezel@upce.cz

Multimodal Analysis of Temporal and Spatial Movements of Objects in Video Sequences

The dissertation will focus on the development of advanced methods for analyzing the movement of individuals and crowds in videos, with an emphasis on temporal and spatial aspects. The goal is to analyze not only the overall movement of individual objects (e.g., walking persons), but also the detailed movements of their parts (e.g., hands, head) during various activities using computer vision methods. The interactions between individuals in crowds and their influence on behavior will also be studied. The work may focus on applications such as security monitoring, sports performance analysis, or interactions in social situations. The aim of the dissertation is to design, implement, and validate new approaches for combining temporal and spatial analysis of individuals' movements, their parts, and groups of individuals. Emphasis will be placed on developing techniques that enable detailed motion tracking in real-time, particularly in dynamic scenes with multiple objects. The project also explores how to better interpret the results for behavior prediction and anomaly detection. Methods of deep learning (e.g., Long Short-Term Memory and Transformer-based architectures) will be used for temporal analysis, and convolutional neural networks will be employed for detecting objects and their parts. Hybrid methods integrating spatial and temporal analysis will also be applied, including advanced techniques for pose estimation, optical flow evaluation, and object tracking. Modifications of these methods will aim to improve both accuracy and processing speed. The results will be verified through experiments on publicly available and custom datasets focused on movement analysis in various environments. Comparisons will be made with results from other authors in similar areas using standard metrics such as detection accuracy, processing speed, and prediction capability.

2.

Supervisor: prof. Ing. Antonín Kavička, PhD., email: antonin.kavicka@upce.cz

Methodology for rapid prototyping of agent-based simulators

The objectives of the thesis are to design and test a methodology for rapid prototyping of software agent-oriented simulators reflecting service, transport or logistics systems. The rapid prototyping of simulation models will be based on the application of declarative approaches (based, for example, on Petri nets) applied in the formalization of the agent-oriented simulators being built. For the verification of the proposed methodology, it is assumed to use a custom software demonstrator, which will include a suitable integrated development environment supporting both the rapid construction of the corresponding simulation system and its formal verification and subsequent implementation of simulation experiments. In solving research and development tasks related to the dissertation, it is expected that the following methods and formalisation approaches will be used: computer simulation; Petri nets; mathematical statistics. The proposed methodology will be validated on a non-trivial case study focused on the construction and application of a simulator of a selected operational system.

3.

Supervisor: doc. Ing. Dušan Kopecký, Ph.D., email: dusan.kopecky@upce.cz

Supervisor - specialist: Ing. Tomáš Zálabský, Ph.D., email: tomas.zalabsky@upce.cz

Adaptive signal generation for pulsed radar systems

The dissertation will aim to propose algorithms for the adaptive generation of pulse signals with intra-pulse modulation for contemporary primary monostatic radar systems. The optimal design of transmitted radar signals is based on design criteria (required radar parameters such as range, range resolution, speed resolution, and many others) but also, to a significant extent, on models of the radar targets of interest, their environment, and interference. The assumption for adaptive radar systems is that clutter is dependent on the transmitted signal. These are mainly reflections of the signal from the ground (ground clutter) and the surrounding environment (spatial clutter). Therefore, the amount of clutter can be varied depending on the transmitted signal. Therefore, the student will focus in their dissertation on the use of currently applied design criteria, which are based on the maximum Signal-to-interference plus Noise Ratio (SINR), Maximum Detection Probability (MDP), Minimum Mean Square Error (MMSE) or Maximum Mutual Information (MMI). Based on the selected criteria, an algorithm will be designed for the joint optimization of the transmitted pulse signal waveform with intra-pulse modulation in time while optimizing the impulse response of the receiver.

4.

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Radar resource allocation optimization

The dissertation aims to find a suitable radar resource allocation algorithm for modern multifunction radar systems. Such radar systems can perform multiple radar functions simultaneously. An example is tracking multiple targets (with different effective reflecting surfaces - aircraft, drones, missiles, etc.) simultaneously in combination with active search of the area of interest. If multiple tasks are required to be performed simultaneously, resources (frequency band, power, time and spectrum waveform, shape and deflection of antenna beams, etc.) must be allocated to these tasks in a structured manner. As such, Radar Resource Management (RRM) requires task prioritization and scheduling, parameter selection, and resource allocation within a multifunction radar. The student will focus on so-called adaptive algorithms, applying elements of artificial intelligence and machine learning within the framework of their dissertation. In this area, algorithms based on fuzzy logic, methods based on information theory, algorithms based on dynamic programming, algorithms based on QoS (Quality of Service) optimization and algorithms adaptively shaping the transmitted signal appear to be promising. Thus, the output will be an optimized algorithm adaptively assigning radar sources to a sequence of radar tasks.

5.

Supervisor: prof. Ing. Jan Mareš, Ph.D., email: jan.mares@upce.cz

Supervisor - specialist: Ing. Jan Kohout, Ph.D.

Analysis of Motion Data and EMG Signals Using Machine Learning Methods

The aim of this dissertation is to design and implement a system for the analysis of motion data and EMG (electromyography) signals to improve diagnostics and rehabilitation processes. The system will utilize modern machine learning methods, including deep learning, to analyze complex datasets obtained from measurements of muscle activity and motion sensors. Data will be sourced from clinical sources and experimental measurements at the University Hospital of Královské Vinohrady and the Hospital of the Pardubice Region. The resulting system will serve as a support tool for healthcare professionals in assessing muscle dysfunctions and designing optimized rehabilitation plans.