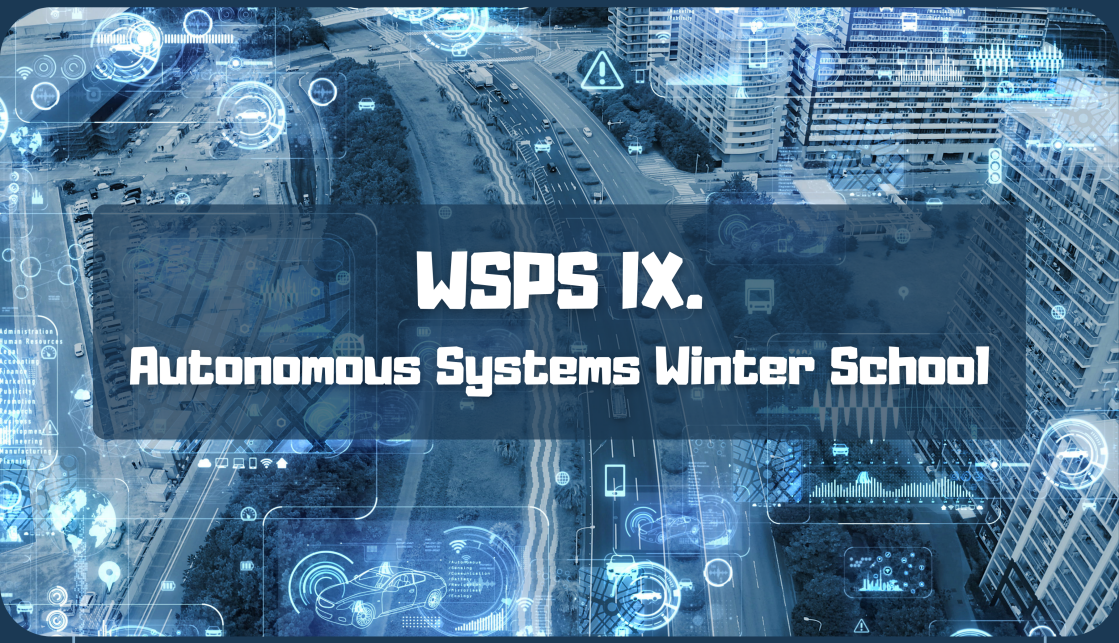

WSPS IX.

Autonomous Systems Winter School

9th Winter School of PhD Students in Informatics and Mathematics

Zalaegerszeg, Hungary
17-19. February 2023

9th Winter School of PhD Students in Informatics and Mathematics

Section of Mathematical and Information Sciences
Association of Hungarian PhD and DLA Students

A pályázat az Emberi Erőforrások Minisztériuma megbízásából az Emberi Erőforrás Támogatáskezelő által meghirdetett Nemzeti Tehetség Program NTP-TK-M-22-0005 kódszámú pályázatitámogatásból valósult meg.

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Foreword

Dear Participant,

On behalf of the Section of Mathematical and Information Sciences of the Association of Hungarian PhD and DLA Students it gives me great pleasure to welcome you to Zalaegerszeg on the occasion of the 9th Winter School of PhD Students in Informatics and Mathematics. The aim of our workshop is to expand the multidisciplinary scientific network of PhD students and improve their professional skills via an intensive course.

The scientific program includes academic and industrial lectures accompanied by an intensive and practical course in the topic of autonomous systems, and a poster session presenting results in various fields of information technology and mathematics.

Let me take this opportunity to wish you an exciting technical meeting at the University of Pannonia and a pleasant stay in the beautiful city of Zalaegerszeg.

Zalaegerszeg, February 2023

Dávid Kis
Section of Mathematical and Information Sciences
Association of Hungarian PhD and DLA Students

Introduction of the Scientific Section

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Section of Mathematical and Information Sciences

Association of Hungarian PhD and DLA Students

Scientific disciplines
Informatics, Mathematics

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Introduction

The Section of Mathematical and Information Sciences of the Association of Hungarian PhD and DLA Students was established in June 2013. The members of the section come from different doctoral schools in information technology and mathematics across the country. The main goal of the section is to support the PhD students with information about conferences, scholarship opportunities and workshops.

Travel information

The easiest way to the campus from the train station is by bus 10/11 which runs quarterly and you should hop off at "Platán sor - Gasparich utca". From the bus station either take the bus 26 to "Gasparich utca" or the bus 10 from "Kovács Károly tér" to "Platán Sor - Gasparich utca" The tickets are 250HUF.

Online map with POIs.

Lecture details

Research challenges of autonomous ground and air vehicles
(Bálint Vanek PhD, SZTAKI)

Autonomous vehicles, both on land, water or in air have very common building blocks and associated challenges. The main challenges and associated state-of-art solutions for sensing, planning and execution will be highlighted within the presentation. The on-board sensory, computing and actuation solutions as well as supporting ground infrastructure will be detailed. Safety aspects are key in autonomous vehicles, hence various certification related issues including simulation based testing will be shown. Autonomous vehicles also needs public acceptance what is often fueling discussions about the interaction of technical and ethical considerations. Based on the different approaches manufacturers tackle the autonomy problem an interactive discussion will be initiated to see the opinion of the audience.

Parameter identification of nonlinear dynamic models for autonomous vehicles (Máté Fazekas, SZTAKI)

The state estimation has a critical responsibility in the control program of an autonomous system, thus the integrated models have to be as accurate as possible. However, the parameter identification of nonlinear dynamic systems using noisy input-output measurements remains a challenge from several aspects. Due to the nonlinear system, the formed optimization problem is a non-convex one that requires linearization, parameter initialization, and recursive estimation. In this case, the initial states of the dynamic model have to be initialized with the noisy measurements as well, but these are affected by the nonlinearity, thus its impact on the measured output is no longer familiar with the Gaussian framework. In the lecture, these impacts are examined in detail in MATLAB using real measurements from an autonomous vehicle, and possible compensation algorithms are presented.

Structured control design for a highly flexible flutter demonstrator
(Tamás Luspay PhD, Béla Takarics PhD, SZTAKI)

The model-based flight control system design for a highly flexible flutter demonstrator, developed in the European FLEXOP project, is presented. The flight control system includes a baseline controller to operate the aircraft fully autonomously and a flutter suppression controller to stabilize the unstable aeroelastic modes and extend the aircraft's operational range. The baseline control system features a classical cascade flight control structure with scheduled control loops to augment the lateral and longitudinal axis of the aircraft. The flutter suppression controller uses an advanced blending technique to blend the flutter relevant sensor and actuator signals. These blends decouple the unstable modes and individually control them by scheduled single loop controllers. For the tuning of the free parameters in the defined controller structures, a model-based approach solving multi-objective, non-linear optimization problems is used. The developed control system, including baseline and flutter control algorithms, is verified in an extensive simulation campaign using a high fidelity simulator. The simulator is embedded in MATLAB and a features non-linear model of the aircraft dynamics itself and detailed sensor and actuator descriptions.

Program

9th Winter School of PhD Students in Informatics and Mathematics

University of Pannonia, Zalaegerszeg

17th-19th February, 2023

Day 1 - Friday, February 17, 2023

13:30 – 14:30	Registration *University Building F - Ground floor*
14:30 –	Departure for track visiting *University - in front of Building F*
15:00 – 16:30	Track Visiting *ZalaZone*
17:00 – 17:30	Opening Ceremony *University Building F - 001*
17:30 – 19:00	Research challenges of autonomous ground and air vehicles **Bálint Vanek PhD, SZTAKI** *University Building F - 001*
19:20 – 20:30	Dinner *University Building F*

Day 2 - Saturday, February 18, 2023

8:00 – 10:00	Breakfast *University Building F - Campus Café*
10:00 – 11:30	Structured control design for a highly flexible flutter demonstrator I. **Tamás Luspay PhD, Béla Takarics PhD, SZTAKI** *University Building F - 228*
11:30 – 11:50	Coffee Break *University Building F*
11:50 – 13:20	Structured control design for a highly flexible flutter demonstrator II. **Tamás Luspay PhD, Béla Takarics PhD, SZTAKI** *University Building F - 228*
13:40 – 14:50	Lunch *Napfény Étterem*
15:10 – 16:40	Cultural Program
16:50 – 17:00	Group photo *University Building F*
17:00 – 18:30	Poster section *University Building F*
19:00 – 21:00	Gala Dinner *Véndiófa Étterem*

Day 3 - Sunday, February 19, 2023

8:00 – 10:00	Breakfast *Campus Café*
10:00 – 11:30	Parameter identification of nonlinear dynamic models for autonomous vehicles I. **Máté Fazekas, SZTAKI** *University Building F - 228*
11:30 – 11:50	Coffe Break *University Building F*
11:50 – 13:20	Parameter identification of nonlinear dynamic models for autonomous vehicles II. **Máté Fazekas, SZTAKI** *University Building F - 228*
13:40 – 14:50	Lunch *Napfény Étterem*

Rendering implicit surfaces using Hermite interpolation

BÁN Róbert[1]

[1] **Eötvös Loránd University, Faculty of Informatics**

Computer graphics plays a crucial role in defining, storing, and rendering three-dimensional objects. One popular representation of these objects is through implicit surfaces, which are defined as the zero level sets of scalar-valued functions in 3D space. In practical applications, these implicit surfaces need to be discretized and stored, and the common approach is to sample the function values on a grid and use trilinear filtering for reconstruction. However, using higher order data, such as the gradient, can lead to a better reconstruction through Hermite interpolation, and result in lower storage costs [1]. By only storing the cells that contain parts of the surface, storage can be further reduced. This work presents a method for detecting empty cells, and a simple yet accurate and high-performance ray intersection algorithm for rendering the implicit surface.

[1] Valasek, G. and Bán, R. (2023) 'Higher Order Algebraic Signed Distance Fields', Computer-Aided Design and Applications, pp. 1005–1028. doi: 10.14733/cadaps.2023.1005-1028.

Supported by the ÚNKP-22-3 New National Excellence Program of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund.

We would like to thank Visual Concepts for providing the AMD GPU used in the tests.

A Uniformly Random Solution to Algorithmic Redistricting

CAI Jin-Yi[1], KRUSE Jacob[2], SZABO Daniel P.[3]

[1] **Department of Computer Sciences, University of Wisconsin-Madison.**

[2] **Geospatial Data Science Lab, Department of Geography, University of Wisconsin-Madison**

[3] **Department of Operations Research, Eötvös Lóránd Tudományos Egyetem**

Gerrymandering is the act of drawing voting district boundaries to gain a partisan advantage. This process of drawing boundaries subject to some political constraints is known as redistricting, and one of the few ways to detect gerrymandering is by algorithmically sampling redistricting plans. Previous methods to sample from this space have been unable to get a representative sample of the entire space, only some poorly defined local neighborhood. We present a subexponential time algorithm to uniformly sample from the space of all possible k-partitions of a planar graph, and with this construct a representative sample of the entire space of redistricting plans. Our method generalizes an algorithm to count self-avoiding walks on a square to paths that split general planar graphs into k regions and uses this to sample from the space of all k-partitions of a planar graph.

The work is supported by the University of Wisconsin 2020 WARF Discovery Initiative funded project: Multidisciplinary approach for redistricting knowledge. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the funder.

An Overview of Display Parameters and Devices that Affect Egocentric Distance Estimation in Virtual Environments

GUZSVINECZ Tibor[1], SZŰCS Judit[1], PERGE Erika[2]

[1] Department of Information Technology and its Applications, Faculty of Information Technology, University of Pannonia, Hungary

[2] Department of Basic Technical Studies, Faculty of Engineering, University of Debrecen, Hungary

The skill of estimating egocentric distances is crucial as it is required for various tasks. Since cognitive functions can be stimulated by virtual reality, this skill can be improved. However, the estimation process can be affected by the composition of virtual environments (VEs) [1]. Thus, we developed a VE that has changeable parameters and can either be used by non-immersive or head-mounted displays (HMDs). We measured the skills of 239 users with this VE. In conclusion, several factors can affect egocentric distance estimation, and the process is quicker with HMDs, although underestimations occur more often using them.

[1] Naceri, A., Chellali, R., Hoinville, T., Depth perception within peripersonal space using head-mounted display, Presence: Teleoperators and Virtual Environments Vol. 20 (3)(2011), 254–272.

The first author was supported by the ÚNKP-22-4 New National Excellence Program of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund. This work has been implemented by the TKP2021-NVA-10 project with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the 2021 Thematic Excellence Programme funding scheme.

Hypergraph-based Modeling of the Cognitive Capabilities of Autonomous Systems

HAJDU Csaba[1], CSAPO Adam[2]
[1] **Széchenyi István University**
[2] **Óbuda University**

Autonomous systems have recently appeared in numerous conventional applications and social situations, including autonomous vehicles, humanoid robot assistants, and other intelligent agents. People interact with these systems in an increasing number of situations that are becoming more complex in behavior and structure. At the same time, autonomous systems constantly exchange data with each other, which can be semantically described using graph-based models. However, with the growing list of applications, information schematics diverge, occasionally obstructing communication even between systems of the same kind (e.g., between two robots of the same purpose). A prominent example is the compatibility issues between autonomous vehicles and exterior-use assistance robots. Furthermore, users frequently face issues while interacting with and supervising autonomous systems. This research addresses these problems by providing a novel transformation from disjoint information representation formats to a common computationally processable representation suitable for visualization, monitoring, and control applications. The presented approach focuses on the transformation of complex hypergraph-based [1] information between actors into a computational and representational view used at different levels of autonomous tasks (e.g., perception, planning, visualization) [2]. The representational view is a grammar tree-based approach for the dynamic handling of fluctuating semantic information and semantic association of intermediate computational values. Alternatively, the computational view is based on a tensor-based representation (based on E-cut adjacency tensors [3]) to perform metrical and algebraic com-

putations efficiently suitable for planning, visualization, inference, and control tasks. The ultimate goal is to create a distributed connectionist memory as part of a cognitive architecture for intelligent and autonomous systems, which can be simultaneously stored as semantic graph-like structure and a computationally efficient tensor-like format and provides an interface for other cognitive entities. The nomenclature and the foundational definitions are based on the multidisciplinary field of Cognitive Infocommunications [4] (CogInfocom), recently extended with further concepts [5].

[1] Bretto, A., Hypergraph Theory: An Introduction., Springer Publishing Company, Incorporated (2013)

[2] Hajdu, Cs., Csapo, A., Tensor-based Format for Exchanging Hypergraphs between Cognitive Entities, 2022 IEEE 1st International Conference on Internet of Digital Reality (IoD) (2022), 000033-000038

[3] Ouvrard, X., Le Goff, J.M., Marchand-Maillet, S., Adjacency and Tensor Representation in General Hypergraphs Part 1: e-adjacency Tensor Uniformisation Using Homogeneous Polynomials (2017), ArXiv

[4] Baranyi, P., Csapo, A., Definition and Synergies of Cognitive Infocommunications (2012), Acta Polytechnica Hungarica Vol. 9, 67-83

[5] Hajdu, Cs., Csapo, A. Defining Synergies Between Robotics, Cognitive Infocommunications and Internet of Digital Reality., 2022 IEEE 1st International Conference on Internet of Digital Reality (IoD) (2022), 000075-000082

Diagnosing memory errors connected to std::string_view in C++

KOVÁCS Réka[1], PORKOLÁB Zoltán[1]
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C-family programming languages have been famous for easy-to-make memory errors since their inception in the 70's. Since then, the world has undergone an incredible digital transformation and attacks that take control of a computer through a memory corruption bug have steadily increased in their numbers [1]. Industry and academia are hard at work to address this problem through different means.

Our work contributes to the effort of making existing projects more secure: we present a static analysis tool that diagnoses use-after-free errors associated with the Standard Template Library's std::string_view class [2]. It comes packaged together with the popular and open-source Clang compiler, and has found memory corruption bugs in open-source projects such as Ceph, LibreOffice, and LLVM.

[1] Check Point Research Reports a 38% Increase in 2022 Global Cyberattacks. https://blog.checkpoint.com/2023/01/05/38-increase-in-2022-global-cyberattacks/

[2] Jeffrey Yasskin: string_view: a non-owning reference to a string, revision 5. https://isocpp.org/files/papers/N3762.html

Waste Detection and Change Analysis based on Multispectral Satellite Imagery

MAGYAR Dávid[1], CSERÉP Máté[1], VINCELLÉR Zoltán[1], MOLNÁR Attila[2]

[1] **Eötvös Loránd University, Faculty of Informatics, Geoinformatics Laboratory**

[2] **Tisza Plastic Cup Initiative**

One of the biggest environmental problems of our time is the increase in illegal landfills in forests, rivers, on river banks and other secluded places. In addition, waste in rivers causes damage not only locally, but also downstream, both in the water and washed ashore. Previous studies have identified running freshwaters like rivers as the main source of plastic pollution in marine environments [1]. It is estimated that approximately 80% of plastic pollution is carried by rivers into the sea [2], and the annual plastic input into marine environments from rivers is between 1.15 and 2.41 million metric tons worldwide [3].

Therefore it is important that waste collection organizations are able to monitor potential sources of danger. Traditional methods of identifying illegal waste deposits require manual surveys, which is not scalable due to its high demand of human workforce. Remote sensing studies of waste management have so far been underexplored field, due to the spectrally variable and complex nature of different materials (including plastic), and their similarity to other land cover classes.

The goal of our research is to develop an accurate classification method for plastic waste detection to provide a viable platform for repeatable, cost-effective and large-scale monitoring [4]. The proposed solution is based on a machine learning approach, the *random forest classification* algorithm. The developed automated evaluator provides an easy and robust solution to configure territories for continuous observation. The application downloads satellite images from the mentioned sources on a

daily basis (given a relevant new image is available) and compares the amount of waste covered surface to previous images. In case there is a noticeable change, an alert is sent to preconfigured email addresses. A web application also provides information about the status of predefined locations. The goal is to visualize the extent of polluted areas in these locations.

In our research we have focused on Hungary and the surrounding drainage basin territory. The plastic transport of the Danube river is estimated to 4.2 metric tons / day, so the yearly plastic load to the Black Sea is 1500 tons minimum [5]. Hungarian water authorities also revealed that on the river Tisza the frequency of floating bottles can reach 500 bottles per minute leading to the name *plastic flood* and leaving the river Tisza one of the most polluted tributary of the Danube.

[1] Lechner, A., et. al., The Danube so colourful: a potpourri of plastic litter outnumbers fish larvae in Europe's second largest river, *Environmental Pollution*, vol. 188, pp. 177–181, 2014.

[2] Schmidt, C., et. al., Export of plastic debris by rivers into the sea, *Environmental Science & Technology*, vol. 51 (21), pp. 12246–12253, 2017.

[3] Lebreton, L., et. al., River plastic emissions to the world's oceans, *Nature communications*, vol. 8 (1), pp. 1–10, 2017.

[4] Magyar, D., et. al., Waste Detection and Change Analysis based on Multispectral Satellite Imagery, *Proceedings of KEPAF*, 2023.

[5] Lechner, A., Ramler, D., The discharge of certain amounts of industrial microplastic from a production plant into the River Danube is permitted by the Austrian legislation, *Environmental Pollution*, vol. 200, pp. 159–160, 2015.

The research work was supported financially by the ELTE Faculty of Informatics and InforNess Training Ltd. The PlanetScope satellite images were provided by Planet Labs Inc. Education and Research Program. Professional support was provided by the Lechner Knowledge Centre and the Tisza Plastic Cup waste collection organization.

Evaluation of traffic flow measurements made in roundabouts

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[2] **Department of Information Technology, Faculty of Engineering and Computer Science, John von Neumann University, Kecskemét, Hungary**

Although the task seems simple, it is not easy for a roundabout with 3 access roads to continuously monitor the entry and exit points of vehicles coming from 3 directions and intending to proceed in 3 directions. The measurement error level can be kept as low as possible by recording a moving image. This can be manually evaluated, where a staff member participating in the research selects the starting entry branch and simply follows which exit branch the vehicle from the given entry branch continues on. Using this method, the motion picture review must be repeated as many times as there are input branches in the given roundabout. The evaluation of the measurement shows what kind of traffic load the given roundabout is exposed to in a given period. To speed up traffic flow, it can be tested in a simulator that if we control the throughput of input branches with traffic lights, we can reduce the length of the longest congested line on the road leading to the roundabout.

Future of Cognitive Information Systems

PUTNOKI Attila Márton[1], MOLNÁR Bálint[1]
[1] **Eötvös Loránd University, Faculty of Informatics**

Artificial Intelligence (AI) and its applications have grown in popularity in recent years and its applications as Machine Learning (ML) algorithms and developments in Natural Language Processing (NLP) make it possible to construct intelligent systems [1] like Cognitive Information Systems (CIS) that are capable of performing a variety of tasks.

AI is getting more support from businesses because it has helped them be more productive and satisfied with their work. Personalization is one of the tools to successfully build satisfaction using AI, which can be shaped by the specific strategy of Customer Relationship Management (CRM) as a process. Chatbots, language translation tools, and content recommendation engines are among these uses [1]. They help to design a smooth infocommunication process in Human-Computer Interaction (HCI), with Carbon agent (C), Silicon agent (S), main elements Content (CT), Contect (CX), cognitive resonance (r) [2]. In the process of Digital Transformation (DT), the use of AI for business, besides increasing productivity and satisfaction, is aimed at securing processes and reducing costs [3], which requires the use of Intelligent Process Automation (IPA), Robotic Process Automation (RPA) technologies, in addition to Intelligent Data Analysis (IDA). Smart automation can be used to encourage digitization and digitalization, which includes automation of inefficient processes to make efficient use of unique Human Resources (HR). This not only reduces process time, but also ensures and increases process efficiency [4].

Our goal is to centralize AI-based tools, systems and technologies into a next generation Cognitive Information Systems and to hyper-optimize its CT and CX. This requires further research to better understand HCI-based infocommunications.

[1] Lalwani, Tarun, et al. "Implementation of a Chatbot System using AI and NLP." International Journal of Innovative Research in Computer Science & Technology (IJIRCST) Volume-6, Issue-3 (2018).

[2] Mattyasovszky-Philipp, D.; Putnoki, A.M.; Molnár, B. The Unrepeatable Human Mind—Challenges in the Development of Cognitive Information Systems—What Makes a Machine Human? Electronics 2022, 11, 394. https://doi.org/10.3390/electronics11030394

[3] Jha, Nishant, Deepak Prashar, and Amandeep Nagpal. Combining artificial intelligence with robotic process automation—an intelligent automation approach. Deep Learning and Big Data for Intelligent Transportation: Enabling Technologies and Future Trends (2021): 245-264.

[4] Molnár, B., Mattyasovszky-Philipp, D. (2023). Cognitive Resonance and the Architecture Issues of Cognitive Information Systems. In: Klempous, R., Nikodem, J., Baranyi, P.Z. (eds) Accentuated Innovations in Cognitive Info-Communication. Topics in Intelligent Engineering and Informatics, vol 16. Springer, Cham. https://doi.org/10.1007/978-3-031-10956-0_2

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The effectiveness of the Informatics Olympiad preparation and its influence on the future achievements of students in Kazakhstan

SAGYNTAY Yerkebulan[1]

[1] **Eötvös Loránd University, Faculty of Informatics**

This century is the age of competition, knowledge, and information.Most successful programmers work for corporations such as Google,Facebook, Amazon, and other prosperous companies. If someone asks them how they had spent their school years, most of them would probably say that they have participated in programming contests. Moreover, this part was the most unique for them. Preparation for the Olympiad in the initial stages of life is critical to their comprehensive education. Those students who have the necessary knowledge and the necessary skills to solve difficult problems can achieve significant results. However, to achieve these results, students must develop their capabilities through hard work and preparation. Preparation for the Olympiad contributes to developing various personal qualities such as self-confidence, the achievement of results, responsibility, collaboration, and other soft skills. This thesis intends to examine the current situation related to the process of Informatics Olympiad preparation in secondary schools and to study how it benefits learners.

Image Analysis based on Shape Representation

SZŰCS Judit[1], GUZSVINECZ Tibor[1], FEHÉR Gergő[1]
[1] Department of Information Technology and its Applications, Faculty of Information Technology, University of Pannonia, Hungary

In digital image analysis, in many cases, proper classification of images is essential, as well as shape representation and object recognition. There are several suitable approaches for solving these aims. Over the years, a variety of measures have been developed. Area-based measures form one popular category, while boundary-based ones are also frequently used. Other methods use, e.g., simplification of the contour or a probabilistic approach to solve the problem. Classification accuracy can be measured for example using methods based on Quadrant-convexity or texture information. During this research, some of these methods were examined and compared; therefore, the appropriate method for the given purpose can be easily selected.

This work has been implemented by the TKP2021-NVA-10 project with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the 2021 Thematic Excellence Programme funding scheme.

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