Towards Earth Resources:

Perspectives

Proceedings of workshop TER2024

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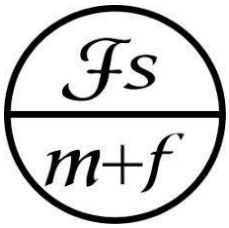

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Editorial

Dear participants of the workshop and other readers!

You are currently opening the booklet of abstracts from the event entitled *Towards Earth Resources: Perspectives* (TER2024). In 2021 we started a tradition of annual workshops dedicated to earth resources. The first one, *Towards Earth Resources* (TER2021) was subtitled *Challenges of the Automotive Industry*. Its success as well as a number of hitherto undiscussed topics related to earth resources encouraged us to organize the second volume of the workshop in 2022 entitled *Towards Earth Resources: Innovations* (TER2022). The third volume entitled *Towards Earth Resources: Sustainability* (TER2023) took place in Herľany in 2023. This year we continue with the tradition of organizing the series of *Towards Earth Resources* workshops by the forth volume.

The aim of the workshop is to discuss current results, problems and issues related to perspectives within the topic. The important is the presence of participants from the university and research environment as well as industry at this event. Thanks to the hybrid form of the workshop we can welcome here participants from Ethiopia, Germany, India, Poland, Slovakia, Ukraine and United Kingdom of Great Britain and Northern Ireland.

The workshop TER2024 is organized by the Slovak Society of Applied Cybernetics and Informatics (SSAKI) a member of the Association of Slovak Scientific and Technological Societies, namely, the branch office of SSAKI by the Institute of Control and Informatization of Production Processes (SSAKI URIVP) of the Faculty of Mining, Ecology, Process Control and Geotechnology of the Technical University of Košice, Košice, Slovakia. It is also co-organized by the Union of Slovak Mathematicians and Physicists which operates as a science unit at the Slovak Academy of Sciences.

On the behalf of organizers of the event, let me express the hope that you will enjoy the TER2024 workshop and that it will lead to fruitful discussions and results.

Erika Fecková Škrabuľáková - Editor

Contents

Event Program

9:00 a.m. - 9:20 a.m.	Registration of participants
9:20 a.m.	Opening of the event
9:20 a.m. - 10:40 a.m.	1st block of lectures
10:40 a.m. - 11:00 a.m.	Coffee break, refreshment
11:00 a.m. - 12:20 p.m.	2nd block of lectures
12:20 p.m. - 1:20 p.m.	Lunch
1:20 p.m. - 2:40 p.m.	3rd block of lectures
2:40 p.m. - 3:00 p.m.	Coffee break, refreshments
3:00 p.m. - 4:00 p.m.	4th block of lectures
4:00 p.m. - 5:00 p.m.	Problem section, brainstorming
5:00 p.m. - 5:30 p.m.	Round table discussions, summary, conclusions
5:30 p.m.	Closing of the event

Schedule of Lectures

1st block of lectures **Chairmen: Erika Fecková Škrabuľáková, Svitlana Shvydka**
Gabriela Bogdanovská and Dagmar Bednárová: Analysis of Defects and their Causes in the Production of Compressors in a Selected Company
Dagmar Bednárová and Gabriela Bogdanovská: Quality Process Improving in a Manufacturing Company
Beáta Stehlíková: Analysis of Processes for Establishing a Classification Procedure Based on Their Attributes
Mária Lukáčová-Medvid'ová: Dissipative Solutions of Compressible Flows

2nd block of lectures **Chairmen: Aleš Jandera, Mária Ždímalová**
Miroslav Stehlík: Practical Applications of IoT in Everyday Life
Ladislav Drančák: Practical Use of the Pandas Deep Learning Library in Python
Beáta Stehlíková: Current and Emerging Technologies for Household Energy Harvesting: Optimization, Environmental Impact, and Sustainable Solutions
Mojmír Stehlík: Comparative Study of Affective Polarization and Environmental Policy Preferences in Three European Countries

3rd block of lectures **Chairmen: Zuzana Šárošiová, Radoslav Buša**
Monika Ivanová and Erika Fecková Škrabuľáková: On Environmental Burdens as Consequences of Industrial Activity and Reuse of Waste Materials in Industrial Production
Erika Fecková Škrabuľáková and Aman Upadhayay: On the Concept of Modeling the Extraction of Land Resources
Mária Ždímalová et al.: Segmentation and Analyses of Cracs in Technical Materials and Building through Segmentation Mathematical Techniques: Perspectives in Research
Oleksandr Semko et al.: On the Issue of Determining the Dependence of Masonry Strength on the Degree of its Damage

4th block of lectures **Chairmen: Marcela Lascsáková, Nataliia Mahas**
Aleš Jandera: Algorithms for Deep Learning Model Size Optimization in Mineral Resource Evaluation
Zuzana Šárošiová: Optimizing Neural Networks for Geosciences using Vertex and Edge Colorings
Andrea Feňovčíková: Graph Colorings Induced by Graph Labeling

Problem section, brainstorming **Chairmen: Matúš Fecko, Zdenka Jeremiášová**

Round table discussions, summary, conclusions **Chairmen: Andrea Feňovčíková, Ladislav Drančák**

Abstracts of Contributions

Quality Process Improving in a Manufacturing Company

Dagmar Bednárová[1] and Gabriela Bogdanovská[1]

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Improving the quality of production processes brings many benefits to companies. These include, for example, increasing the efficiency and performance of production, reducing costs, increasing customer satisfaction, increasing competitiveness, contributing to the sustainability of implemented processes, as well as improving the overall awareness and position of the company in the market.

The aim of this paper is to design and implement improvements to the compressor manufacturing process in a company engaged in the production of refrigeration equipment. Based on an initial analysis of the defects, the identification of their possible causes was carried out. Subsequently, corrective and preventive measures were proposed. The objective of implementing these measures is to eliminate the occurrence and impact of these causes, thus reducing the overall incidence of errors in the stator manufacturing process. Finally, the effect and effectiveness of some of the proposed measures that have been successfully implemented into the process were evaluated.

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Analysis of Defects and their Causes in the Production of Compressors in a Selected Company

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In this contribution we deal with the analysis of defects in the production of compressors.

The analysis of defects and their causes in any production process is typically the initial step towards subsequent improvements. The identification of errors and their causes, as well as their consequences, can be followed by a phase of design and implementation of measures to eliminate the occurrence and effect of these errors and, consequently, to achieve process improvement, increasing its efficiency and effectiveness.

In this analysis, we have addressed the identification and causation of the main errors arising in the production of compressors. We examined various factors of the given production process — technical, technological, and labor-related — that may influence the occurrence and manifestation of these defects. Their correct identification at the next stage will subsequently allow us to design and implement effective measures to eliminate them and thus optimize the production process.

Acknowledgements: This work was supported by the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences under grants VEGA 1/0264/21 and VEGA 1/0039/24, by the Cultural and Educational Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic under grant KEGA 020TUKE-4/2024, and by the Slovak Research and Development Agency under grant APVV-22-0508.

Practical Use of the Pandas Deep Learning Library in Python

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The Pandas library in Python has established itself as one of the most powerful tools for data manipulation and analysis. For advanced users, Pandas offers a wide range of features and options that allow to dive deep into data and gain valuable insights.

In this contribution we will discuss its powerful data operations, deep integration with NumPy and integration with other libraries. We will also talk about its customization, integration, time series, panel data, its advantages in financial analysis, scientific research, machine learning, as well as geospatial analysis and web scraping.

Pandas allows to perform complex operations on large data sets, including vectorization, aggregation functions and group by operations and offer special structures and functions for analyzing panel data that contain multiple variables for multiple subjects over time. It allows creating custom functions and methods that can be applied to data frames and series. Pandas is an important part of the process of preparing data for machine learning algorithms, including feature creation, normalization, and the creation of training and test sets and it can also be used to extract data from web pages and then analyze it. Pandas team works closely with the NumPy team, enabling seamless integration of the two libraries and the use of powerful numerical computations.

The Pandas library offers advanced users a wide range of options for in-depth data analysis. Its flexibility, power, and integration with other tools make it an ideal tool for data scientists, analysts, and researchers who want to get the most out of their data.

On the Concept of Modeling the Extraction of Land Resources

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On August 1, 2024, the world commemorated the Earth Overshoot Day [1]. That means that we used up all the renewable resources that were supposed to last the whole year. While in the 70s this day fell on December, it gradually moves closer and closer to the months with a lower serial number. This year Slovakia reached the level of ecological debt even earlier [2]. The situation is worrying worldwide, so it is necessary to perceive the extraction of both renewable and exhaustible resources in a global context. This point of view is necessary, despite the fact that the data relevant to the given raw material are usually presented in different measurement units. The question is how to compare individual levels of parameters and express their interrelationships. Our goal is to use unusual methodological approaches (e.g. three-dimensional graphic design with computer support or acoustically modulated data perception techniques) to look for new possibilities of comparison of otherwise difficult to compare [3].

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Graph Colorings Induced by Graph Labeling

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Let f be an edge labeling of a graph G. The weight of a vertex is defined as the sum of labels of all edges incident with that vertex.

Consider such a labeling f where the weights of any two adjacent vertices are distinct. In this case, the labeling f induces a proper vertex coloring of G, where the color of a vertex is its vertex weight. This naturally leads to the concept of the corresponding chromatic number.

In this talk, we present several concepts of graph colorings induced by graph labelings.

Graph theory tools are widely used to model many real-life situations due to their capability to model and analyze spatial relationships efficiently. They play significant role in geospatial sciences. The widespread use o graphs can be find in geographic information systems, in location-based services and analysis, network analysis, spatial connectivity and similar.

On Environmental Burdens as Consequences of Industrial Activity and Reuse of Waste Materials in Industrial Production

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The contribution focuses on the evaluation of selected environmental problems, such as industrial waste dumps and by-products of industrial activity. These contaminate the soil for many years and negatively affect the agricultural activity in the region, as well as the surrounding environment. Many of these dumps have existed for several years, but due to significant problems in their removal, legislation, as well as ownership conditions, their situation is not resolved. Hence, landfills remain in the country in the form of environmental burdens. Our contribution is not only a blunt statement of the current unflattering state, but in the case of existing industrial units, it outlines the possibilities of secondary processing of waste material. In the case of the company US Steel Košice, our research confirmed that secondary raw materials such as dust and sludge can be reprocessed. Reducing pollution by reusing waste from the steel industry can lead to sustainability and conservation of natural resources.

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Algorithms for Deep Learning Model Size Optimization in Mineral Resource Evaluation

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As deep learning models grow in complexity and size, optimizing their memory footprint and computational efficiency becomes increasingly critical. This contribution presents a comprehensive overview of algorithms designed to reduce the size of deep learning models without significantly compromising their performance. We explore various techniques including pruning, quantization, knowledge distillation, and low-rank factorization, highlighting their impact on model size, inference speed, and accuracy. The discussion also covers recent advancements in neural architecture search (NAS) and automated machine learning (AutoML), which have introduced new ways for optimizing model architecture.

Practical applications in resource-constrained environments, such as edge computing and mobile devices, are examined, demonstrating the real-world benefits of these optimization algorithms. The contribution concludes with a discussion on future trends and the potential of these techniques to enable more sustainable and accessible AI solutions in mineral resource evaluation – see e.g. [1], [2], [3].

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Dissipative Solutions of Compressible Flows

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We introduce a new concept of very weak solutions of compressible flows. The latter are fundamental to model and simulate various problems arising in physics, engineering or biology and medicine. We concentrate on the inviscid flows, the Euler equations of gas dynamics, and mention also the relevant results obtained for the viscous compressible flows, governed by the compressible Navier-Stokes equations. The existence of dissipative solutions will be showed by the convergence analysis of suitable, invariant-domain preserving finite volume schemes [1], [2], [3], [4]. In the case that the strong solution to the above equations exists, the dissipative solutions coincide with the strong solution on its life span [2]. In this case we can also apply a novel tool of the relative entropy to derive rigorous error estimates between numerical solutions and the exact strong solution [5].

The present results have been obtained in the collaboration with E. Feireisl (Prague), H. Mizerová (Bratislava), B. She (Beijing), and Y. Yuan (Nanjing).

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Acknowledgements: This research has been partially supported by TRR 146 Multiscale simulation methods for soft matter systems and SPP 2410 Hyperbolic Balance Laws funded by the German Science Foundation and by the Gutenberg Research College.

On the Issue of Determining the Dependence of Masonry Strength on the Degree of its Damage

Oleksandr Semko[1], Olena Filonenko[1], Oleg Yurin[1], Tetiana Ilchenko[1], Volodymyr Semko[2], Mária Ždímalová[3], Roman Rabenseifer[4], Nataliia Mahas[1,4], Sk Md Obaidullah[5,6], and Erika Fecková Škrabuľáková[7]

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During the technical assessment of the brick structures of existing buildings, damage to the masonry from various factors, including the effects of various types of moisture, is detected and recorded. Also, when assessing and determining the technical condition, and checking the bearing capacity of the masonry, it is necessary to determine the strength of the bricks, mortar, and masonry as a whole. Strength can be determined by non-destructive methods, for example, by the IPS-MG4.03 device, designed for operational non-destructive testing of strength and uniformity by the method of shock impulse, applying up to 15 blows to the controlled areas. The electronic unit evaluates the hardness and elasticity properties of the test material (brick)

based on the shock pulse parameters coming from the sclerometer and converts the pulse parameter into strength. The determination of the load bearing capacity of masonry in existing structures is not an easy task, even for experienced surveyors. For its assessment, it is necessary to know the compressive strength of the masonry units and mortar.

The masonry of one wall can cause different degrees of damage across the facade area. Therefore, when determining strength by non-destructive methods, different values of brick and mortar strength are usually obtained, which will then affect the strength of the masonry. Thus, during the assessment of the building of an educational building in Poltava, the strength of the brick wall bordering the ground was measured in the basement. Depending on the damage to the brick, its strength varied from 8.1 mPa to 19.5 mPa, and the brick's moisture content varied from 3% to 8%.

In our work, we will try to determine which of the masonry strength values should be used in the verification calculations: the minimum value obtained in the worst place, the maximum value with a reduction coefficient, or the average value. We also open new not answered question in this area and we will try to develop computer methods helping to improve non-destructive methods, as well.

Acknowledgements: This work was carried out within the framework of the applied research "Resource-saving structures and planning solutions of composite steel and concrete structures systems for civil protection structures in new and reconstructed buildings", which was financed from the state budget of Ukraine. Mária Ždímalová was funded by the Slovak national research grant VEGA 1/0036/23 of the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences. Roman Rabenseifer was funded by the Slovak national research grant VEGA 1/0322/23 of the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences. Nataliia Mahas was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V01-00036. Erika Fecková Škrabuľáková was funded by the grant VEGA 1/0264/21 of the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences as well as the KEGA project No. 006TUKE-4-2024 of the Cultural and Educational Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences.

Practical Applications of IoT in Everyday Life

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This contribution focuses on practical applications of the Internet of Things (IoT) in everyday life, with a special emphasis on services and solutions provided by a local provider. The discussion centers on specific IoT devices that enhance convenience, safety, and efficiency in households.

Key IoT devices covered include a smart lock that enables remote control of home access, boosting both security and convenience. Phone and PC integration is highlighted for its ability to simplify control for disabled users who may have difficulty using touchscreens, thereby enhancing accessibility and independence. The contribution also discusses smart lighting systems and smart switch controls, which allow for the automation and remote control of household lighting. These systems contribute to energy savings and the creation of customized lighting environments, enhancing both comfort and functionality in the home.

In terms of home management, the paper explores smart appliances such as a smart washing machine and a smart refrigerator, which enable efficient remote management and monitoring of household devices. The inclusion of a robotic vacuum cleaner showcases the automation of home cleaning tasks, saving both time and energy. Additionally, a remotely controlled thermostat is covered for its ability to optimize heating and cooling, leading to significant energy savings and improved home comfort.

The contribution also covers the video doorbell connected to a mobile device or PC, which increases household security by enabling communication with visitors and control of entry points without the homeowner needing to be physically present. This system is particularly beneficial for enhancing security and convenience, especially for elderly or frequently absent residents.

An overview of how IoT technologies can transform daily life, simplifying routine tasks and improving the overall quality of life is presented too. The current trends and challenges within the IoT sector, presenting practical examples of applications available in our region, are identified, as well.

Comparative Study of Affective Polarization and Environmental Policy Preferences in Three European Countries

Mojmír Stehlík[1]

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This proposed study will investigate the impact of affective polarization on public attitudes and policy preferences related to the management of Earth's resources, with a focus on critical issues such as climate change, renewable energy, and natural resource conservation. The study will be comparative, examining these dynamics across three European countries: Germany, France, and the United Kingdom. Affective polarization, characterized by the growing emotional and social divide between political groups, increasingly shapes how individuals perceive and respond to policy issues, including those essential to environmental sustainability. Understanding this relationship will be crucial for addressing the challenges of environmental governance in a polarized political landscape.

The research will primarily utilize a literature review and in-depth interviews as its methodological focus. The literature review will comprehensively analyze existing research on affective polarization, environmental attitudes, and policy preferences across the selected countries. This will provide a theoretical framework and contextual understanding of the political and cultural factors influencing public attitudes towards environmental issues in Germany, France, and the United Kingdom.

In addition to the literature review, the study will conduct in-depth interviews with a diverse group of participants, including policymakers, environmental advocates, and members of the public across different political affiliations in the three countries. These interviews will explore the extent to which partisan emotions drive support or opposition to key environmental policies, such as carbon pricing, renewable energy initiatives, and conservation efforts. The qualitative data gathered will offer insights into the emotional and cognitive mechanisms underlying these attitudes.

The anticipated findings are expected to reveal significant variations in environmental policy preferences across these countries, strongly correlated with political affiliation and levels of affective polarization. These insights will be invaluable for policymakers, environmental advocates, and scholars seeking to navigate the complex intersection of political psychology and environmental governance. Ultimately, the study aims to inform strategies for fostering bipartisan support and more effective communication around environmental issues in an increasingly polarized European context.

Analysis of Processes for Establishing a Classification Procedure Based on Their Attributes

Beáta Stehlíková[1]

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This paper focuses on the analysis and classification of technological and other types of processes through the assignment of specific attributes and their values. The objective is to develop a comprehensive framework that enables systematic and precise classification of various processes based on their characteristics. Identified attributes include a broad range of aspects such as the nature of the process, its dynamics, the environment in which it occurs, process conditions, energy requirements, and the methods of measuring physical quantities.

The paper thoroughly addresses the definition and assignment of values to these attributes in order to create a detailed and accurate framework for process classification. Each attribute is analyzed in depth, and the assigned values are designed to effectively capture the essence and variability of the processes. This framework facilitates better understanding of different processes and supports their effective management and optimization.

Particular attention is given to attributes such as the nature of the process (whether manufacturing, natural, or other types), the dynamics of the process (stationary, dynamic, etc.), the environment of execution (internal, external), and process conditions (controlled, natural). Energy requirements and methods for measuring physical quantities are also included, enabling a comprehensive assessment and classification of processes.

The results of this paper provide a valuable framework for further research and application in the field of process analysis, contributing to the development of classification systems and methodologies for effective management of various types of processes across different domains.

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Current and Emerging Technologies for Household Energy Harvesting: Optimization, Environmental Impact, and Sustainable Solutions

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In this contribution we present a review that offers a comprehensive examination of both established and innovative technologies used for energy harvesting in household applications. The discussion begins with an overview of traditional energy harvesting methods, including solar, wind, and thermal systems. It then transitions to a detailed exploration of advanced technologies such as piezoelectric and electromagnetic devices, as well as emerging technologies still under development.

The review delves into various methodologies employed to optimize these energy harvesting technologies. This includes an analysis of how statistical methods, machine learning, deep learning, and reinforcement learning are utilized to enhance system performance. Practical studies demonstrating the application of these techniques will be highlighted.

Additionally, the review addresses the environmental impacts associated with energy harvesting technologies. It provides an in-depth analysis of the ecological benefits and challenges posed by these systems throughout their entire lifecycle — from production to disposal. This section examines the environmental footprint of various energy harvesting technologies, including resource usage, emissions, and end-of-life management.

Strategies for sustainable production and recycling are also discussed, focusing on practices that minimize environmental impact, enhance recyclability, and promote the use of eco-friendly materials. The review considers regulatory frameworks and industry standards that support sustainable development in the energy harvesting sector.

Case studies and practical examples will illustrate successful applications and optimization strategies, as well as how different technologies address environmental concerns. This comprehensive overview aims to provide valuable insights into the current state and future directions of energy harvesting technologies, emphasizing their role in improving energy efficiency and promoting environmental sustainability.

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Optimizing Neural Networks for Geosciences using Vertex and Edge Colorings

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Usage and significance of neural networks are currently growing rapidly in many scientific fields including geosciences – see [1], [2], [3]. Within the geosciences, neural networks are often used to most accurately identify a required output given a set of inputs. Making the right decision based on the right reason is supported by secondary metric - the interpretation of what the network learns [4].

The widespread using of neural networks is reflected in their increasing robustness and complexity, which negatively impacts their response time. However, in solving a complex task, not all of the neurons in a neural network are typically involved. Therefore, to enhance the efficiency of neural networks, our goal is to deactivate neurons that are not contributing to solving a specific task at any given moment.

We propose a new approach by achieve optimization, designing and applying appropriate algorithms, drawing primarily on combinatorial attributes and tools from graph theory, as well as adaptive methods from other scientific disciplines.

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Segmentation and Analyses of Cracs in Technical Materials and Building through Segmentation Mathematical Techniques: Perspectives in Research

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Crack segmentation in computer vision involves identifying and delineating cracks of fractures in various types of surfaces, such as roads, pavements, walls, or infrastructure. This task is crucial for infrastructure maintenance, as it helps in assessing the condition of structures and planning repairs. We focus on cracs in buldings, sicknesses of buildings and also cracs of techical materials. The word 'building" is usually considered to refer to an enclosure within

which activities can be carried out. It is a structure, usually consisting of a roof, walls, floors and openings such as doors and windows that is generally (but not always) positioned permanently in one location. The Building Regulations suggest that the word 'building' refers to: '...any permanent or temporary building but not any other kind of structure or erection'. Buildings deteriorate over time, which can cause structural and performance issues. Building enclosures, which fight against natural forces while also protecting occupants and structural components, become particularly prone to degradation over time, resulting in a large repair and remediation costs. Before severe deterioration and cracs occurs, façades may exhibit early symptoms of anomalies or faults such as cracks, stains, separation, and corrosion. The prompt diagnosis and repair of such obvious faults can successfully protect façade systems from greater breakdowns.

Many mathematical techniques are widely utilized today to visually monitor building envelopes on a regular basis in order to identify potentially dangerous situations or susceptible problems. In order to find anomalies or defects on building facades for reporting and repairs, inspectors must manually go through the massive volumes of high-resolution. The computer vision and mathematical technologies have emerged as promising solutions to automate the image-based inspection process. However, for the detection of façade cracks from images, existing deep learning solutions may not perform well due to the complicated background noises caused by different façade components and materials. We use many mathematical techniqes, algorithms like graph cut, grab cut and random walker methods for segmnetation of the cracs and sicknesses in the buildings, see Figure 1, Figure 2, and Figure 3.

Cracs in materials: Mechanical crack formation in technical materials and crystals is a major problem in technical research. To avoid the cracks, it is essential to understand the origins of their formation. Crack formation is a consequence of alloy segregation. Irrespective of their origins, the cracks in the crystals make the wafers completely unusable for any applications. The cracks cannot be eliminated by thermal annealing of the solidified ingot. Hence, a special growth process needs to be used for avoiding cracks and analysing of cracs formation during technical materials growth. Crack formation due to constitutional supercooling occurs if the growth rate is higher than a critical value.

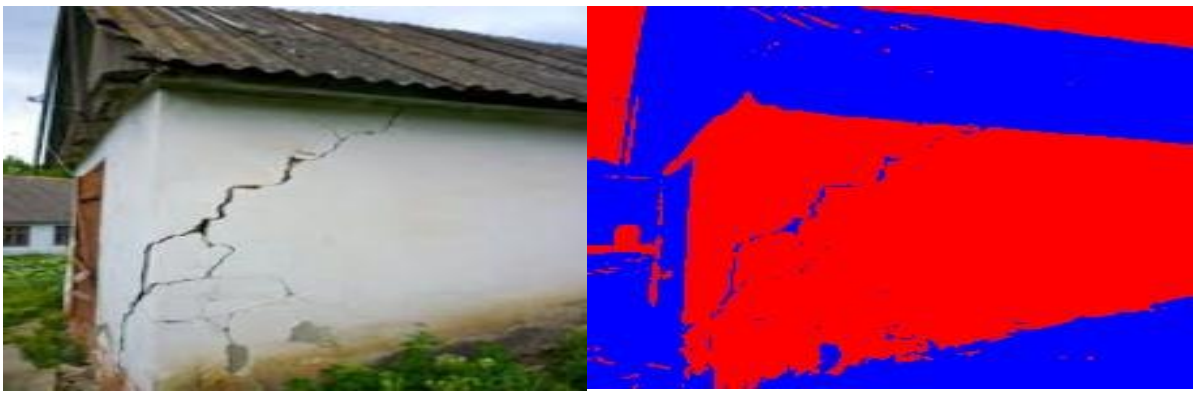

Figure 1: The bulding and segmented cracs

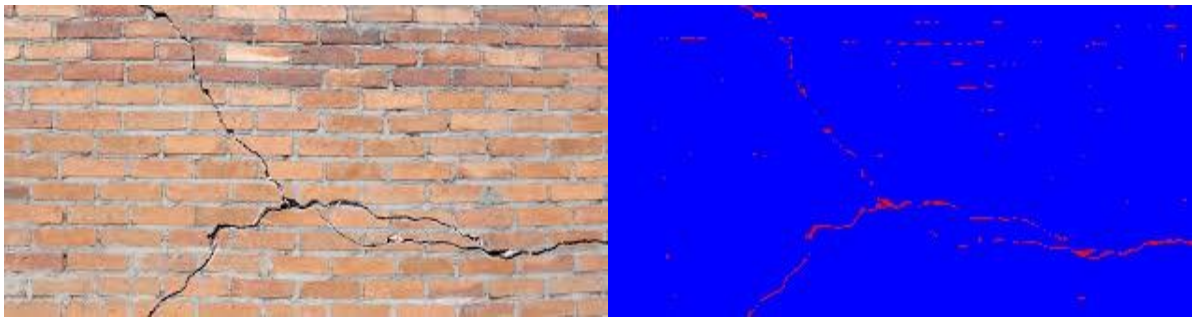

Figure 2: An example of cracs data and segmented cracs

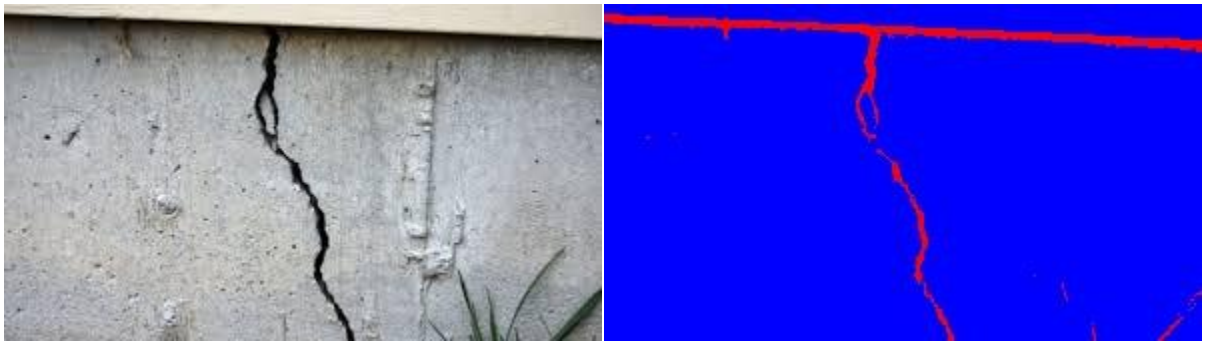

Figure 3: Data of cracs and segmented cracs

Perspectives: We show more mathematical methods for segmentation of cracs in buldings, civil engineering and also technical materials. There is also a big perspective in using neural networks techniques, AL techniqes as well as maschine learning techniques.

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Notes

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