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INNOVATIONS IN PUBLISHING, PRINTING AND MULTIMEDIA TECHNOLOGIES 2026

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19th International scientific-practical conference
22-23 April, Conference Hall 1-57,
Pramonės pr. 22, Kaunas, Lithuania

PROGRAMME

Wednesday April 22, 2026	Re:Connect Event for students and graduates dedicated to celebrating the 20th anniversary of Multimedia Technology studies at Kauno kolegija HEI
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10.50 – 11.10	Who Is Telling the Story? Creativity and Storytelling in the Age of AI *Roberto Valdes, En Rival Productions, Mexico, Kauno kolegija HEI, Lithuania (in person)*
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RANDOM FOREST-BASED WASTE PREDICTION IN SUSTAINABLE GRAPHIC PRODUCTION WITHIN INDUSTRY 4.0

Diana Bratić[1], Suzana Pasanec Preprotić[1], Denis Jurečić[1], Jana Žiljak Gršić[2]
[1]University of Zagreb, Croatia
[2]University of Applied Sciences, Croatia

Relevance and aim of the research: Graphic production systems generate significant material waste due to defective prints, registration errors, inefficient material utilization, and suboptimal energy management. In printing processes, waste levels can exceed 10%, contributing to environmental burden and increased operational costs. Within Industry 4.0 environments and ESG-oriented production management, companies require measurable, data-driven mechanisms for resource optimization. The aim of this research is to develop and evaluate a Random Forest-based predictive model for production waste forecasting in sustainable graphic systems using key performance indicators (KPIs) as operational inputs.

Methodology: A supervised Random Forest regression model was developed to predict waste levels. Because publicly accessible industrial datasets are unavailable due to confidentiality constraints, simulated KPI data was generated to reflect realistic production variability. Input variables include material waste percentage, machine efficiency, number of defective prints, energy consumption, and equipment downtime. The synthetic dataset incorporates controlled variability and inter-variable correlations to approximate real production conditions. Data was divided into training and testing subsets, and cross-validation was applied to ensure model robustness. Performance was evaluated using mean absolute error (MAE), mean squared error (MSE), and coefficient of determination (R^2).

Results: The Random Forest model achieved an R^2 value of 0.89, indicating strong explanatory power, with an overall prediction accuracy of 87.32% and a mean absolute error of 3.17%. Simulation scenarios demonstrate substantial waste reduction potential under AI-supported optimization. In the printing process, waste levels decreased from 12.7% to 5.8%, representing a 54.3% reduction. Early detection mechanisms identified 36% of potential waste events prior to occurrence, enabling proactive intervention. Additional simulation results indicate projected improvements in energy efficiency (8%), defect prevention (12%), and overall cost reduction (6%).

Conclusions & practical implications: The findings confirm that Random Forest-based predictive modeling can function as an operational tool for ESG-aligned waste management in Industry 4.0 graphic production. KPI-driven monitoring combined with predictive analytics enables early identification of inefficiencies, improved production planning, and systematic reduction of material losses. The model is suitable for integration with sensor systems and production management platforms in smart manufacturing environments, supporting both environmental sustainability and economic performance.

Keywords: ESG framework, Industry 4.0, KPIs, Random Forest, waste prediction

THE USE OF ARTIFICIAL INTELLIGENCE SERVICES IN GENERATION OF ILLUSTRATIONS FOR CHILDREN'S LITERATURE

Daria Yerokhina, Nonna Kulishova
Kharkiv National University of Radio Electronics, Ukraine

Artificial intelligence (AI) tools have been rapidly developed and disseminated, so their applications can be seen in many fields of activity, including graphic design. Generative services for image creation have become more accessible and relatively easy to use, resulting in a mass emergence of AI-generated illustrations that are now easily recognizable. The designer's role is changing, he/she becomes a "manager" and AI becomes an "assistant" that accelerates/optimizes the process of creating sketches or whole images but requires refinements (modifications), the level of which is determined by several factors. The aim of this study is to understand whether generative services can be used in the process of creating narrow-focus images, namely illustrations for children's literature.

This research is mainly based on the analysis of existing AI services and their potential for use in creating illustrations used in children's literature. The practical part is aimed to create the illustrations themselves: in one case as a designer's vision, in the other as an artificial intelligence product. Tools such as Adobe Illustrator were used by the artist and two types of AI models were taken for comparison.

A number of images were created using Adobe Illustrator, taking into account the wishes of the author, but at the same time approached the general style of the whole series. After conducting an analytical study of AI services, two types were selected in which a series of illustrations was generated using a created prompt with a clear structure. The images obtained in this way confirmed the possibility of using services to optimize the creation process, but also confirmed the fear of their use, which made it possible to make recommendations for their application.

Analysis of the capabilities of artificial intelligence tools carried out in the course of the study showed that use of AI services may be present in the process of creating illustrations for children's literature, but to a limited extent and under strict and careful control. In the course of this study, illustrations were created that correspond to the author's vision and on their basis, the possibilities of selected tools were tested and analyzed.

Keywords: AI, generative services, children's literature, illustrations

WHO IS TELLING THE STORY? CREATIVITY AND STORYTELLING IN THE AGE OF AI

Roberto Valdes
Kauno kolegija Higher Education Institution, Lithuania

Relevance and aim of the research: The rapid development of artificial intelligence has transformed creative industries, raising fundamental questions about authorship, originality, and the future of storytelling. While AI offers powerful tools for generating ideas, images, and narratives, it also challenges the role of the human creator. This research aims to explore the evolving relationship between human creativity and AI, focusing on storytelling as a deeply human act. It seeks to examine whether AI enhances or diminishes creative expression, and to redefine the role of the storyteller in an era increasingly shaped by automated processes.

Methodology: This study based on a reflective and practice oriented approach, combines theoretical analysis with professional experience in filmmaking and narrative development. It draws on historical parallels with previous technological revolutions, such as the emergence of the internet and digital editing tools, to contextualize the current impact of AI. The research incorporates conceptual analysis of storytelling structures and the creative process, supported by illustrative examples from cinema and media production.

Results: The findings suggest that AI functions most effectively as a tool for ideation and exploration rather than as a replacement for human creativity. While AI can generate content rapidly, it lacks intentionality, emotional depth, and lived experience elements essential to meaningful storytelling. The study highlights that the value of a story does not lie solely in its structure or efficiency, but in the human perspective behind it. AI can expand creative possibilities, but it cannot replicate the subjective vision.

Conclusions & practical implications: The research concludes that the future of storytelling depends on a balanced integration of AI as a creative assistant rather than a substitute. For educators, filmmakers, and content creators, this implies the need to develop critical frameworks that emphasize authorship, intention, and narrative voice. AI should be used to inspire ideas, accelerate processes, and support experimentation, while the responsibility for meaning-making remains with the human creator. Ultimately, the question is not whether AI can tell stories, but who is truly telling them and why that distinction matters.

Keywords: Artificial Intelligence, creativity, film, storytelling

ACCESSIBLE LEARNING RESOURCES: A CASE STUDY OF DIGITAL CONTENT DISTRIBUTION FOR PERSONS WITH DISABILITIES

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[2]Kauno kolegija, Lithuania

Accessible digital resources are an important condition for inclusion in education. However, less attention is given to what type of content is actually available. This study analyses how accessible resources are distributed across different purposes.

The research is based on a case study approach. It explores the ELVIS virtual library, which offers accessible materials for people who cannot read standard printed text. The analysis relies on publicly available data. A qualitative content analysis was used to classify resources into two analytical categories: educational and leisure content. The findings show that accessible content is most widely available for leisure purposes, such as fiction and magazines. Resources directly related to learning, such as textbooks and academic materials, are less represented. Materials for professional development appear in an intermediate position.

These results suggest that accessibility is uneven across different areas of use. While access to cultural content is relatively well developed, access to educational resources remains more limited. This raises questions about equal opportunities in learning environments. The study highlights the importance of ensuring a balanced distribution of content. Expanding accessible educational materials could strengthen educational inclusion and support broader participation.

Keywords: accessibility, disability, inclusive learning, digital resources, accessible content

CO-CREATION IN SOCIAL MEDIA AS A SOURCE OF INNOVATION AND COMPETITIVENESS: THEORETICAL ASPECTS OF PROMOTING USER-GENERATED CONTENT

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Kauno kolegija Higher Education Institution, Lithuania

Relevance and aim of the research: The competitiveness and innovativeness of organizations increasingly depends not only on the organization'–s internal resources, but also on relationships with target audiences – opportunities to collaborate and jointly create value for the market. This encourages business organizations, in a global context, to be innovative not only in terms of technological development, but also in terms of building close relationships with audiences. As there are many unexplored and untested product development prospects in target consumer groups, in order to develop innovative and market-responsive products, organizations must become more open and interactive with target audiences to achieve a breakthrough in the field of product development. Therefore, the target audiences can be considered an innovative source of solution development that helps organizations create value in the business ecosystem. In this place, it would be appropriate to apply the principles of open innovation development, co-creation, and content marketing solutions in social media. Organizational openness and co-creation are not just about creating opportunities to express ideas, they are investments in strengthening the organization's reputation and processes with external audiences. The aim is to reveal features of co-creation in social media, focusing on how user-generated content contributes to innovation and enhances organizational competitiveness.

Research Methodology. Analysis of scientific literature. This method of analysis is used to examine the existing literature on co-creation and user-generated content in social media for organizations' innovativeness.

Conclusions & practical implications: The analysis revealed that the competitiveness of business organizations in a dynamic environment will increasingly be determined by their ability to apply innovations, be open cooperative participants, and co-create with other interested parties. Relevant content, activated on social media, increases consumer engagement and helps business organizations respond more quickly to consumer expectations. Through user-generated content on social media, product credibility is formed for other interest groups as well. Moreover, user-generated content

is considered one of the most reliable forms of communication content. This is particularly relevant in the context of sustainable development, when innovation development aims not only to change organizational behavior in product development, but also to change the culture of product consumption in order to reduce the occurrence of negative consequences of consumption.
Keywords: co-creation, social media, user-generated content, innovation

FROM ANALOGUE TO ALGORITHMIC: THE TRANSFORMATION OF THE DESIGNER'S CREATIVE POSITION AND AESTHETIC DECISION-MAKING IN VISUAL PRODUCTION

Yeter Beris
Istanbul Gedik University

This paper examines the relationship between analogue and algorithmic image production practices in visual communication design, focusing on the transformation of aesthetic decision-making, production methods, and the designer's creative position. Historically, visual design production has been shaped by analogue tools, manual intervention, material engagement, and intuitive decision-making processes. Within this framework, the designer has traditionally functioned as the primary creative subject, constructing the visual language of a design through direct interaction with materials and aesthetic decisions made throughout the production process. However, recently, the increasing digitalisation of production environments and the widespread adoption of algorithmic systems, generative design tools, and AI-supported visual production platforms have led to a significant transformation in visual production processes. The speed-oriented nature of digital communication platforms and the growing demand for visual content have increasingly compressed design processes into shorter time frames. This situation creates a working environment that limits designers' opportunities for research, reflection, and experimental production. As a result, designers often find themselves prioritising the timely completion of work over the careful consideration of aesthetic values. Consequently, this pressure directly affects both the quality of design outcomes and the level of professional satisfaction experienced by designers.

In this context, AI-supported production tools offer significant technical advantages by enabling speed and variation in design processes. However, these systems largely operate through algorithmic production models based on limited datasets. The insufficient representational capacity of algorithmic databases in terms of cultural diversity may lead to the emergence of repetitive formal patterns and increasingly standardised aesthetic tendencies in visual design production. As a result, the designer's capacity to produce original ideas may become constrained, increasing the risk of reducing design to a uniform and artificial visual output.

This study approaches the relationship between analogue production practices and algorithmic visual production systems from a comparative per-

spective, discussing how aesthetic decision-making, production methods, and the designer's creative role within the production process are being redefined. In this respect, the research argues that algorithmic production tools should not be regarded as systems that replace the design process, but rather as supportive tools whose creative value emerges through the designer's critical and creative intervention.

Relevance and aim of the research: The rapid expansion of artificial intelligence and algorithmic production tools in visual communication design has significantly altered contemporary design environments. Despite the growing use of AI-supported visual production systems, the implications of these technologies for aesthetic decision-making and the creative role of the designer remain insufficiently examined. This study aims to analyse how the transition from analogue to algorithmic visual production reshapes design processes and redefines the designer's creative position within contemporary visual communication practices.

Methodology: The study adopts a qualitative and conceptual research approach based on comparative analysis. It examines analogue visual production practices and algorithmic image generation systems within the framework of visual communication design. Through theoretical discussion and comparative evaluation of production processes, the research analyses how aesthetic decision-making, production methods, and the designer's creative role are transformed in algorithmic production environments.

Results: The analysis demonstrates that algorithmic visual production systems significantly influence the speed, structure, and organisation of design processes. While these tools enable rapid generation of visual variations, they also tend to reproduce recurring aesthetic patterns due to their reliance on existing datasets. Consequently, the designer's role shifts from purely manual production toward decision-making, selection, and critical evaluation of algorithmically generated outputs.

Conclusions & practical implications: The findings suggest that algorithmic production tools should not be interpreted as systems that replace the designer, but rather as technological instruments that gain creative value through the designer's critical interpretation and intervention. Understanding this evolving relationship between human creativity and algorithmic systems is essential for evaluating the future of visual communication design and for developing more reflective and responsible design practices in AI-supported production environments.

Keywords: aesthetic decision-making, AI-supported visual production, algorithmic visual production, designer's creative position, visual communication design

3D PRINTING TRAINING IN A DIGITAL VR-BASED ENVIRONMENT

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[2]Kauno kolegija Higher Education Institution

Relevance and aim of the research: Virtual reality (VR) environments have been used for a variety of training purposes both in academia and industry. The present paper examines the key stages of the 3D printing process and explores the use of VR technology for the development of a structured digital training environment for both entry-level and advanced participants.

Methodology: Users are led through a digital roadmap with the aim of following a structured training course in 3D printing technology, while guiding messages are presented through the course. First, a series of educational materials introduces the 3D printing technology along with the appropriate fabrication parameters needed. Next, the evaluation of the 3D printed models, together with the presentation of possible malfunctions, offers advanced knowledge to experienced users on how to identify and avoid common printing pitfalls. In addition, computer aided design (CAD-BlenderTM) and slicing (Ultimaker CuraTM) pieces of software are presented to stress the appropriate file formats used in the whole process.

Results: Users can virtually observe the 3D printing simulation based on the generated G-code and select different layers of the geometry to be presented i.e. infill, support, skin, skirt. Finally, the preparation and execution of the printing process enable users to learn the operation of a specific large-scale fused filament fabrication (FFF) 3D printer. An early evaluation of the trainees' satisfaction is conducted to assess the effectiveness of the training approach.

Conclusions & practical implications: more 3D printing pieces of equipment from different OEMs can be used to expand the platform's capability. Additional material can enrich the current version of the VR application built and expand the user experience (UX) offered.

Keywords: Virtual Reality, 3D printing, Additive Manufacturing, training, immersive technologies, User Experience (UX)

A HYBRID MACHINE LEARNING AND DEEP LEARNING SYSTEM FOR PHISHING EMAIL DETECTION IN WEBMAIL PLATFORMS

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University of Tirana, Albania

Phishing emails continue to represent a major cybersecurity threat, exploiting social engineering and deceptive language to compromise users, credentials, and organizational systems. In response to the increasing sophistication of phishing campaigns, this work presents a hybrid phishing email detection framework that combines classical machine learning and deep learning methods for deployment in webmail platforms. The study aims not only to improve detection performance, but also to demonstrate the operational feasibility of integrating intelligent detection directly into a real email environment.

The proposed framework is built on a multi-source dataset of more than 11,000 labeled emails, balanced between legitimate and phishing messages. The dataset combines benign emails from the Enron corpus with phishing samples from public repositories and AI-generated phishing emails, allowing the system to capture diverse attack styles and evolving phishing patterns. To support robust classification, the approach integrates textual representations from email subject and body with engineered indicators such as suspicious domains, URL entropy, keyword flags, subdomain counts, and other structural features.

Two modeling pipelines were developed. The first uses classical machine learning algorithms, including Logistic Regression, Random Forest, and Support Vector Machine, combined with TF-IDF and engineered features. The second employs deep learning architectures, specifically Bi-LSTM and DistilBERT, to capture semantic context and sequential or contextual language patterns often present in phishing emails. DistilBERT was selected in particular for its favorable balance between predictive power and computational efficiency, making it suitable for near real-time deployment in practical email systems.

Experimental evaluation compares the ML and DL models using standard classification metrics, including accuracy, precision, recall, F1-score, and ROC-AUC. The results show strong phishing detection performance and confirm the value of combining semantic text modeling with engineered metadata features. The best-performing model was integrated into a Round-

cube webmail environment, where incoming messages are classified in real time and suspicious emails can be automatically redirected to a dedicated phishing folder. This demonstrates the practical applicability of hybrid AI-based detection for strengthening email security in operational settings.

Keywords:Phishing Email Detection; Cybersecurity; Machine Learning; Deep Learning; Webmail Security

PROJECT-BASED LEARNING WITH AI IN MEDIA DESIGN EDUCATION

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Artificial Intelligence (AI) is reshaping animation, visual effects, and digital media production. As industry workflows continue to evolve, media education must respond by preparing students for technology-driven creative environments. This presentation discusses the implementation of a Project-Based Learning (PBL) approach supported by AI tools within an undergraduate Media Design and Animation program, designed to align classroom practice with current industry expectations.

The teaching model is structured around industry-style production pipelines where students complete projects from concept to final output. The process includes pre-production planning, asset creation, animation, editing, compositing, and final presentation. Students work with professional tools such as Autodesk Maya, Adobe Premiere Pro, Adobe After Effects, Adobe Photoshop, Adobe Illustrator, Adobe Substance 3D Painter, ZBrush, and Nuke, along with DSLR-based photography and videography practices. AI tools are introduced to assist with idea generation, visual enhancement, workflow efficiency, and rapid experimentation, while encouraging critical thinking and responsible use.

The PBL framework emphasizes learning through practice, teamwork, and continuous feedback. Students work on real-world style briefs that simulate professional studio environments, helping them understand deadlines, collaborative workflows, and creative problem-solving. Regular review sessions and milestone-based assessments ensure steady skill development and reflective learning.

Early observations indicate noticeable improvement in portfolio quality, technical confidence, and independent creative decision-making. Students demonstrate a balanced approach to AI, using it as a supportive tool rather than a replacement for creativity. The structured project environment also strengthens communication skills, production discipline, and interdisciplinary collaboration.

This presentation shares the curriculum design, implementation strategy, assessment approach, and challenges encountered. The study highlights how AI can be effectively integrated into project-based media education while preserving strong artistic foundations and maintaining industry relevance.

Keywords: Project-Based Learning; Artificial Intelligence in Media Education; Media Design Pedagogy; Experiential Learning; Digital Production Workflows

COLOR FUNDAMENTALS IN 20 MINUTES OR LESS

Uldis Cerbulis
Heidelberg Baltic Finland

Extensive experience in the printing industry suggests that the number of true color experts remains disproportionately small. A larger group of practitioners demonstrate strong competence in color management; however, their performance often becomes inconsistent when confronted with more complex or unfamiliar challenges. This recurring difficulty indicates a common underlying issue: gaps in foundational knowledge of color science.

While it is neither practical nor necessary to return professionals to formal education, there is a clear opportunity to address these deficiencies through a concise and accessible format. To this end, a series titled "Color Fundamentals in 20 Minutes or Less" is proposed. The initiative would adopt a micro learning approach, delivering focused, digestible sessions.

The initial module would introduce core concepts, including the nature of light, the electromagnetic spectrum, human visual perception, and the chromaticity diagram. Even at this introductory stage, it becomes evident that color is a complex domain, characterized by nonlinearity and the absence of idealized conditions.

Drawing on marketing experience, the material will be presented in a manner that is clear, concise, and engaging, without sacrificing conceptual rigor. Should the series prove effective, subsequent modules could expand into topics such as color appearance, RGB and CMYK systems, pigment behavior, measurement techniques, and quality control, eventually progressing to more advanced and specialized subjects.

Keywords: light, spectrum, vision, eye, chromaticity diagram, light sources, color space

A COMPLEX DESIGN PROJECT IN HIGHER EDUCATION AIMED AT DEVELOPING STUDENTS' PRACTICAL SKILLS IN THE FIELD OF PRINT COMMUNICATION

Csaba Horváth, László Koltai
Óbuda University, Hungary

Relevance and aim of the research: A detailed description of a practical student project integrated into the final semester of a bachelor's program specializing in print communication, to be completed across multiple courses. The student project itself involves the tasks of establishing a printing-related business – conceived by the students – which they must carry out as a group project.

Methodology: This presentation introduces a student assignment – used in the graphic communication technologies undergraduate program at Óbuda University – that requires a holistic approach and closely mirrors real-world industrial practices and business life. The print communications industry is fundamentally built on small and medium-sized enterprises. The extremely rapid changes in the technological and business environment often require the creation of new businesses or their complete overhaul. The practical assignment to be presented prepares students for such future challenges. Students must complete the complex tasks involved in founding a "conceptualized" business venture as part of the "Production Planning" workshop course. The task includes drafting the articles of incorporation, the brand concept, the investment, technology, and logistics plans, market research, the business plan, and the human resources plan. Students complete this work in groups under the guidance of a selected "company manager." Two courses – taught in the same semester – support the students' work: "Operation and Maintenance of Printing Presses" and "Production Management in the Printing Industry." Thus, the individual sub-solutions also facilitate the mastery of these subjects. The evaluation of the completed assignments also influences the grading of these two subjects. The students themselves participate in the evaluation of the completed work.

Results: Based on experience, this teaching method – which has been in use for 10 years – is popular among students because of its real-world relevance, despite the amount of work it requires. It stimulates their creativity, encourages innovation, and fosters teamwork. Many interesting and valuable ideas and concepts have emerged during the development of student assignments. Students participate enthusiastically in the work, and according

to both their direct experiences and surveys, they find this specific form of knowledge transfer and assessment very useful.

Conclusions & practical implications: Feedback from graduates and the positive responses during alumni meetings have also confirmed the usefulness and practical relevance of this form of instruction and assessment. Numerous examples demonstrate that students have carried forward and applied the ideas and experiences gained while working on assignments throughout their careers.

Keywords: Print communication education, Complex student's tasks, Student teamwork, Education experiences in higher education of Graphic Communication

FROM SOCIAL INTERACTION GRAPHS TO KNOWLEDGE GRAPHS: ENABLING GRAPHRAG FOR LLM-BASED ANALYSIS OF ONLINE CONVERSATIONS

Arber Ceni
University of Tirana, Albania

Relevance and aim of the research: Large language models (LLMs) increasingly support the analysis of social media data, yet they often struggle to provide grounded and reliable answers when reasoning over social network structures. This limitation stems from their reliance on unstructured text and incomplete contextual representations, which can lead to hallucinated or superficial interpretations of complex interaction patterns. While retrieval-augmented generation (RAG) improves grounding by incorporating external information, existing approaches primarily operate over document collections and fail to exploit the inherently relational and temporal nature of social media data. The aim of this research is to propose a framework for transforming social interaction graphs into knowledge graphs that can serve as context graphs for GraphRAG, enabling more faithful and interpretable LLM-based reasoning over online conversations.

Methodology: The proposed approach starts from a social interaction network constructed from X (formerly Twitter) data, where nodes represent users and edges capture interactions such as mentions, replies, retweets, and quotes. This interaction graph is transformed into a heterogeneous, tweet-centered knowledge graph that explicitly models authorship, conversational structure, and temporal dynamics. The schema introduces entities such as tweets, users, hashtags, URLs, and conversations, and defines relations including authored, mentions, replies to, retweets, and quotes. Additional semantic enrichment is incorporated through entity extraction and linking, as well as metadata such as timestamps and community membership. The resulting knowledge graph can be used as a context graph within a GraphRAG pipeline, where relevant subgraphs are retrieved and provided to an LLM for question answering.

Results: While this work focuses on the conceptual design of the framework, illustrative examples demonstrate how the proposed representation enables multi-hop reasoning over social interactions. Compared to plain LLM-based analysis, the use of a structured context graph allows queries about relationships, conversation dynamics, and information flow to be grounded in explicit graph structures. The approach is expected to reduce

hallucinations by constraining the LLM to operate over retrieved subgraphs and to provide more transparent and explainable answers.

Conclusions & practical implications: This research highlights the potential of integrating social network analysis with knowledge graph construction to enhance LLM-based analysis of social media data. By transforming interaction graphs into temporally enriched knowledge graphs, the proposed framework enables structure-aware retrieval and reasoning, improving the quality and interpretability of generated responses.

Keywords: GraphRAG, knowledge graph, large language models, social networks, X (formerly Twitter)

REAL TIME MEDIA BIAS AND FRAMING DETECTION USING LLMS

Klesti Hoxha
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Online news has become a primary source of information in the digital age. In today's sometimes hectic modern lifestyle, we often rely on traditional news websites or their social media channels to get informed on the go. However, biases in coverage and non-factual framing, combined with click-based impression boost algorithms, contribute significantly to the spread of disinformation. In this work, we propose an architecture that utilizes LLMs to detect bias and framing on individual news articles and across news providers.

Methodology: Media bias can be quantified by monitoring the frequency of specific actors and topics within news coverage. Additionally, framing can be analyzed by examining the sentiment and tone of the associated content. These tasks can be successfully handled as Named Entity Recognition (NER) and sentiment analysis problems. Drawing on current literature, the proposed pipeline architecture includes ingestion, LLM-driven analysis, and comparative synthesis that tracks tonal trajectories and entity appearances to identify "separate realities" across providers. Instead of providing static bias ratings, this architecture enables real-time monitoring of editorial shifts. By automating the extraction of key bias metrics, the system allows for a direct comparison of how different news providers "gatekeep" information.

Results: Manual media analysis is resource-intensive, time-consuming, and highly prone to bias. Instead of relying on human annotation, an LLM-driven pipeline system can process big datasets that were previously unmanageable, producing a continuous, real-time view of the media landscape. This automated approach enables the monitoring of editorial shifts across news providers as they occur. Ultimately, the proposed architecture enables automatic detection of bias patterns and real-time visualization of the insights generated. In terms of costs, the system can rely on lightweight open models.

Conclusions & practical implications: In this work, a system is proposed that replaces traditional media bias research from manual, small-scale analysis to an LLM-driven, real-time monitoring infrastructure. Selection and framing biases can be detected through mention and sentiment analysis. It provides a low-cost, efficient tool that continuously monitors the various bi-

ases observed in news publishing and integrates them into news aggregators and similar apps, thereby increasing user awareness. After the pipeline is implemented, it is crucial to validate LLM performance against multi-modal news formats and expand the architecture to analyze cross-platform bias in social media algorithms.

Keywords: media bias; news framing; news processing pipelines; LLMs

LOCAL COLOR CORRECTION FOR WEB-PAGES CONTENT HARMONIZATION

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Relevance and aim of the research: Modern web interfaces increasingly rely on dynamic visual content such as images, banners, and user-generated media. Unlike static layouts, these systems must maintain visual consistency despite continuous changes in content. A common issue arises from the mismatch between predefined interface color palettes and the arbitrary colors of embedded images, leading to visual inconsistency and reduced aesthetic quality. Existing color harmonization methods mainly focus on transferring color characteristics between images or improving internal coherence. However, they typically ignore the constraints of interface design systems and do not consider the semantic importance of different image regions. As a result, such approaches may distort visually significant elements while attempting to achieve global color consistency. The aim of this research is to propose a semantic-aware approach to color harmonization of dynamic visual content that adapts image colors to a predefined interface palette while preserving the semantic integrity of key elements.

Methodology: The method operates in the CIELAB color space, where color relationships can be represented geometrically on the chromatic plane. The proposed method includes several stages. First, the interface palette is analyzed and a base color is selected. Then, dominant colors are extracted from the image, and the image is divided into semantically significant and secondary regions. A target harmonic scheme is defined using angular relationships relative to the base color. Color transformations are applied selectively, with stronger adjustments in secondary regions and constrained modifications in important areas. To ensure natural results, harmonic relationships are treated as tolerance regions using the ΔE metric rather than strict constraints, allowing flexible adaptation while maintaining perceptual consistency.

Results: Experimental evaluation on real-world web elements demonstrated improved visual integration. Quantitative analysis showed that the proposed method reduced the average ΔE value from 12.02 to 6.25, indicating closer alignment with the target harmony. Importantly, semantically sig-

nificant regions, such as skin tones, were preserved with minimal perceptual distortion (average ΔE 3.36), confirming that the method maintains the natural appearance of critical objects.

Conclusions & practical implications: The proposed approach supports semi-automatic color correction of dynamic content, reducing the need for manual adjustments and improving visual coherence in web interfaces. The method provides a practical basis for the development of automated design systems and can be integrated into existing professional workflows to maintain brand consistency across dynamic content.

Keywords: color correction, color harmonization, semantic segmentation, CIELAB color space, web interfaces.

COMPARATIVE ANALYSIS OF INK TRAPPING ON PACKAGING BOARDS

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Relevance and aim of the research: In multi-color offset printing, one of the main parameters that defines print quality is ink-to-ink adhesion. The ink-to-ink adhesion is used to determine the amount of the second ink deposed on top of the first ink during offset printing. This qualitative parameter, also known as ink trapping, depends on several parameters that have to be in balance. The key parameters that influence ink trapping are properties of the ink that is used (ink stickiness), the sequence of colors on the printing machine and printing speed, and the properties of the printing substrate (substrate absorbency). Ink trapping is expressed as the percentage of the second ink's adhesion on the first. Ink trapping directly affects color reproduction (the mixing of CMY colors) as well as the overall quality and stability of the printing process.

Methodology: This paper analyzes the qualitative parameter of ink trapping for prints produced with ink from a single manufacturer, Huber, at a constant speed of 8,000 sheets per hour on a KBA Rapida 105 offset printing press using HH printing plates, D-L 1050×795×0.30. The prints were made on four different types of printing substrates, each with a grammage of 250 g/m² (offset paper, KD paper, GC1 paper, and GC2 paper), which differ in the coating of their printing side. Ink trapping was measured using a Techkon spectrophotometer at M1, 0/45 geometry, and a 10-degree observer angle.

Results: The results show that printing yellow onto cyan produces the highest ink trapping values for all printing substrates, ranging from 78.03% to 85.05%. The lowest ink trapping values for all substrates occur when printing yellow onto magenta, with values from 47.29% to 67.66%. Intermediate ink trapping values are observed when printing magenta onto cyan, ranging from 59.47% to 75.13%.

Conclusions & practical implications: The goal of the analysis is to determine how substrate characteristics influence ink trapping efficiency and to identify optimal conditions for achieving high-quality prints in packaging applications. Among the printing boards, offset board consistently produces the lowest trapping values for all ink combinations, while the KD, GC1,

and GC2 boards exhibit very similar ink-to-ink adhesion characteristics. The results from this analysis may provide valuable insights to improve process control and enhance the overall consistency of multi-color printing systems, thereby supporting higher quality standards.

Keywords: ink trapping, packaging, boards, multi-color printing

ANALYSIS OF THE EFFECT OF PRELIMINARY SURFACE TREATMENT OF CARDBOARD FOR DISPOSABLE TABLEWARE ON THE PH LEVEL

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This paper presents the results of research into changes in the acid-base environment of a cardboard web suspension intended for the manufacture of disposable tableware, following preliminary treatment with the coagulant aluminium hydrochloride (AluPAC). This technological effect manifests itself in the neutralisation of the acid-base environment of the suspension and its impact on the absorbency of the polyethylene coating during subsequent stages of disposable cardboard tableware production.

To ensure the effective use of cardboard sheets for the manufacture of disposable tableware, it is necessary for them to meet the requirements regarding their physical, mechanical and barrier properties.

Thus, manufacturers of disposable tableware and packaging products made of paper and cardboard face certain limitations, namely, the insufficient adhesive properties of the cardboard sheet when bonding the structural elements of the product, which is due to its hydrophilic nature and porous structure. Since manufacturers often use cardboard coated with molten polyethylene for the production of disposable tableware, it is essential to ensure reliable adhesion between the cardboard substrate and polymer melts, particularly polyethylene, in the finished products.

It is known that the degree of adhesion between cardboard and molten polyethylene can be increased by influencing the physicochemical properties and improving the wettability of the cardboard surface.

Ten samples, measuring 210×291 mm, were selected from the manufactured cardboard sheet for the research (samples No. 1 and No. 2). During the research, at the cardboard sheet drying stage, surface modification of cardboard samples No. 2 was carried out by wetting them with an aqueous solution of the coagulant – aluminium hydrochloride AluPAC. pH measurements were carried out using a laboratory pH meter. The contact angle was determined using a goniometer by the lying drop method. The values were calculated in accordance with the procedure described in [3, 4]. The results of the studies are presented in Table 1.

A comparative analysis was carried out on untreated cardboard samples (Table 1, samples No. 1) and samples treated with an aqueous coagulant

solution (Table 1, samples No. 2).

Table 1. pH values of treated and untreated cardboard samples

Cardboard samples, No.	pH level	Contact angle, degrees, after 60 seconds of measurement
1	9,1	120,2
2	8,4	112,1

Analysis of the data presented in the table shows that samples No. 2, which were treated with the coagulant aluminium hydrochloride AluPAC, demonstrate neutralisation of the treated sample suspension ≈ 1. 08 times compared to untreated samples and a reduction in the contact angle of ≈ 1.07 times after 60 seconds of measurement compared to samples No. 1, which were not treated with an aqueous solution of aluminium hydrochloride.

The results obtained demonstrate the positive effect of the aluminium hydrochloride coagulant AluPAC, manifested in the neutralisation of the pH level and the promotion of increased hydrophilicity of the treated cardboard, and, consequently, in increasing the absorbency of the polymer protective coating during subsequent stages of its application to the cardboard substrate of short-term use products.

The results of the research allow us to recommend the use of the aluminium hydrochloride coagulant AluPAC in industrial production for the preliminary surface treatment of cardboard, which contributes to improving the quality of finished short-term use cardboard products, in particular, disposable cardboard beverage containers.

Keywords: AluPAC, cardboard, disposable tableware, treatment

3D GAUSSIAN SPLATTING: PRINCIPLES, METHODS, AND FUTURE DIRECTIONS

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Relevance and aim of the research: The rapid growth of virtual reality, autonomous systems, and digital content creation demands real-time, high-fidelity 3D scene reconstruction. Traditional methods (SfM, MVS) struggle with fine details, while Neural Radiance Fields (NeRF) offer quality but suffer from extremely slow rendering. 3D Gaussian Splatting (3DGS) has emerged as a breakthrough that combines explicit scene representation with real-time performance. This report aims to provide a comprehensive, structured analysis of 3DGS, covering its mathematical foundations, rendering pipeline, key extensions, applications, challenges, and future directions.

Methodology: This report is based on a systematic literature review of scientific databases (arXiv, IEEE Xplore, ACM Digital Library, Google Scholar) covering publications from August 2023 to early 2026. Inclusion criteria prioritized peer-reviewed conference papers, journal articles, and high-impact preprints that directly propose, extend, or apply 3DGS. Selected works were categorized into thematic groups: core 3DGS, compactness (e.g., EGU-GS), geometric accuracy (e.g., 2DGS, SuGaR), dynamic scenes, robotics SLAM, editing, and physical simulation. Key insights were extracted, cross-validated, and synthesized into a structured report with original diagrams and tables.

Results: The analysis shows that 3DGS achieves real-time rendering (100+ FPS at 1080p) with quality comparable or superior to NeRF. Extensions significantly improve the original method: EGU-GS reduces Gaussian count by up to 42% while maintaining quality; 2DGS and SuGaR enable high-quality surface and mesh extraction; SplaTAM and GS-SLAM demonstrate dense real-time mapping for robotics; and PhysGaussian integrates physics simulation with rendering. However, open challenges remain, including handling large-scale unbounded scenes, sparse-view reconstruction (3–5 images), in-the-wild data with transient objects, and anti-aliasing across resolutions.

Conclusions & practical implications: 3D Gaussian Splatting represents a paradigm shift in real-time 3D scene representation, successfully breaking the quality-speed trade-off that limited prior methods. Its explicit, editable nature makes it suitable for immediate practical deployment.

Keywords: 3D Gaussian Splatting (3DGS), Novel View Synthesis, Real-time Rendering, Anisotropic Gaussians, Adaptive Density Control

COMPARATIVE STUDY OF THE APPLICATION OF INKJET AND ELECTROPHOTOGRAPHY FOR FUNCTIONAL PRINT PRODUCTS

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Relevance and aim of the research. Functional printing is currently widely used to apply inks or other materials with specific physical properties onto the surfaces of various products, thereby creating a functional device or component, such as a wiring circuit, sensor, or antennas. Functional printing products are widely used in various fields, such as electronics, optics, or biomedicine. Depending on the application, functional inks containing electrically conductive, semiconducting or insulating particles can be used. This technology is used for the production of smart packaging, labels with integrated sensors that monitor temperature or product freshness. Functional printing can be used to print sensors directly onto the packaging material (paper or plastic). Such sensors could be environment-responsive freshness indicators, using special inks that change color in response to ammonia or other gases released by food spoilage; temperature sensors with RFID function enables tracking whether the cold chain was damaged during transportation; leak sensors – printed elements that signal when the package is broken, etc.

An important area of application for functional printing is to protect various products, such as packaging, from counterfeiting and ensure falsification. These are antennas and microchips (NFC and RFID labels) printed on the packaging, which the buyer can scan and verify whether the product is original; hidden security features printed with fluorescent or magnetic ink, visible only under UV light or readable by special devices; luminous elements on packaging, etc. For this purpose, printed microfonts or very small printing elements, ranging from 0.01 to 0.1 mm, and microline patterns are often used.

In functional printing, microfonts and microlines are critical elements that perform a security function. The main purpose of microimages in packaging (e.g. luxury beverages, medicines or cosmetics) is to protect them from counterfeiting. For this purpose, non-copiable text can be used – text written in microfont 0.1 – 0.2 mm high, which cannot be reproduced in ordinary copiers or scanners, and requires high-precision, special high-resolution printing equipment. Guilloché patterns are also used, complex networks

of microlines that create unique geometric patterns that are also practically impossible to reproduce without losing the sharpness of the details. Microbarcodes are also used to encode information through changes in the density of microlines, which are only visible using special optical scanners or mobile apps with a magnification function. Microline structures can also be used as a digital watermark, integrated into packaging graphics.

Methodology and results: Various printing methods can be applied to print anti-counterfeiting marks with microimages on the surfaces of products, such as screen printing, flexography or gravure printing, as well as digital printing technologies – Inkjet and Electrophotography. This study compares the accuracy of reproducing microimages – microfont and microlines – on paper and plastic surfaces of different roughness when printed on different digital printing machines. The accuracy of microline reproduction in electrophotographic printing has been extensively analyzed in the publication "Study on the quality of reproduction of graphical linear microimages using electrophotographic printing" (D.Sajek et al, 2024).

Since inkjet printing has high resolution due to the extremely small (pico-liter level) ink droplets sprayed, the use of this technology for printing microimages is also widely used. During the study, using the original microline and microfont scale, samples were printed with 3 different ink jet devices and microlines with a width of 0.05 – 0.1 mm and microfont objects with a height of 0.1 mm were measured. These results were compared with the accuracy results of Electrophotographic Printing. The measurement results showed that in most cases, the reproduction of micromarks of 0.1 mm and smaller – both microlines and microfonts – is more accurate in inkjet printing.

Conclusions & practical implications. The results of the study showed that both Inkjet printing and Electrophotography technologies can be successfully applied to print microimages on functional printed products. The accuracy of reproducing micromarks – both microlines and microfonts – is most influenced by the technical parameters (resolution) of the printing equipment, the roughness of the material surface, and also the consistency of the ink; the accuracy of microimages also depends on the nature of their arrangement on the print – frequency and position relative to the printing direction.

Keywords: Electrophotography, Inkjet, functional printing, security printing, microimages.

MULTI-AGENT SYSTEMS FOR PRINTING ORDER AND PRODUCTION MANAGEMENT

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The report presents a practical multi-agent artificial intelligence system for printing enterprises. The purpose of the report is to show how specialized AI agents can support order taking, generation of calculations and accompanying documents, planning of the production process, quality control and service within the framework of one coordinated technological process. The study combines process decomposition, system design and a specific example of implementation based on the CRM system of the Snail Papers printing house (Slovenia). The proposed approach includes an order taking agent, an evaluation agent, a process planning agent, a quality control agent and a customer service agent, connected through an orchestration layer of AI agents and corporate software. The implementation of this approach in practice has demonstrated faster order processing, less rework and optimization of the production process. The results show that the greatest value of AI in printing comes from coordinated operational support, rather than from isolated chatbots and other single AI agents. In the case study, the total savings amounted to about 10% of the company's operating costs.

Printing houses increasingly work with short runs, individual tasks, tight order fulfilment times and variable material costs. Even with CRM, ERP, MIS or MES systems in place, many decisions still depend on manual interpretation of customer requests and fragmented communication between sales and production. The proposed multi-agent model transforms unstructured requests into clear communication and technological processes and supports the entire chain from customer contact to production process coordination and product shipment (Peretz-Andersson et al. (2024)). A central orchestration layer manages the interaction between agents and the company's CRM system and provides support to personnel when there is uncertainty or the order is non-standard. (Mota, T. A et al. (2025)).

Results and conclusions. During the implementation of the system, routine sales activities were partially automated, the average order processing time was reduced from one to two days to several hours, and sometimes minutes (for frequently repeated or standard orders), the proportion of de-

fects or rework decreased from 8% to 2%, and the efficiency of equipment loading increased from 60% to 90%. Internal project estimates also indicate monthly savings of about 50% on management overhead costs (Kostaryev D. et al (2025)). Thus, multi-agent artificial intelligence can be considered a realistic tool for the phased modernization of printing enterprises, as it complements existing digital systems and improves the speed of work, the consistency of interaction between departments and increases the efficiency of resource use.

Keywords: printing industry, AI agents, multi-agent systems, order calculations, production planning.

INVESTIGATION OF THE INFLUENCE OF DIGITAL PHOTOGRAPHY PROCESSING METHODS ON PRINTING QUALITY

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Relevance and aim of the research: The availability of digital photography technologies contributes to the emergence of numerous non-professional (amateur) photographs that require preliminary digital processing before printing. Existing methods for processing digital photography are constantly improving and require less human intervention. In particular, methods for improving photographs using artificial intelligence technologies are quite popular. Therefore, the research aims to compare common methods of digital photo processing by determining their impact on the amount of color distortion (according to ISO 12647-2) in the photo printing process.

Methodology: The methodology of this research is based on photography processing methods using Adobe Photoshop and its automatic photocorrection tools, the CameraRAW tool, and AI-based photo enhancement. The processed photographs were printed on different types of photo paper (super glossy, glossy, semi-glossy, and matte). The print quality was assessed using spectrophotometric measurements of CMYKRGB spot colors on the test scale, followed by the calculation of the color difference value (oE2000) within ISO 12647-2.

Results: In the presented scientific work, the influence of the type of photo paper used on the accuracy of color reproduction for the primary CMYK spot colors in a test image without processing during photo printing was determined. More stable color reproduction quality was found for super glossy paper, for which deviations in the color difference index ranged within $\Delta E = 4–8$. For semi glossy and matte paper, the color difference index was $\Delta E = 5–12$. Relatively larger distortions in color reproduction were found for glossy paper, with $\Delta E = 8–15$. Analysis of the research results revealed that, on average, the greatest distortions of color reproduction in photo printing are observed for photographs processed using the standard automatic correction method of Adobe Photoshop, and the level of distortion can reach $\Delta E = 1–7$ depending on the type of photo paper used. The average level of distortions, at the level of $\Delta E = 0.4–3.8$, is characteristic of photo imprints when using the Camera RAW tool from Adobe Photoshop. The smallest

color distortions, at the level of $\Delta E = 0–2$, are observed when using the auto-correction method based on artificial intelligence technology.

Conclusions & practical implications: For the studied photo printing process, the most stable color reproduction of the primary CMYK colors was achieved when using super glossy paper. Moreover, the level of color distortion for super glossy paper decreased to almost 50 % compared to glossy paper and to 20 % compared to semi glossy and matte paper. The smallest distortions ($\Delta E < 2$) observed for the auto-correction method based on AI technology and super glossy photo paper.

Keywords: digital photography, photo printing, color difference, photo-correction, photo enhancement, AI technologies

MATHEMATICAL MODELLING OF TONE-DENSITY REPRODUCTION IN FLEXOGRAPHIC PRINTING ON METALLIZED FOIL

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Relevance and aim of the research: Metallized foil is a strategically important substrate in the flexible packaging for food and pharmaceuticals due to its superior barrier properties and mirror-like appearance. However, its non-absorbent, highly specular surface creates significant printing challenges, as its optical behavior differs fundamentally from conventional paper. Despite growing demand for color consistency in premium packaging, systematic studies of the full CMYK tone-density response on metallized foil remain scarce. Existing color management protocols, developed for paper, require significant adaptation for specular surfaces. This study aims to provide a comprehensive experimental and mathematical characterization of CMYK tone-density reproduction on metallized BOPP foil under controlled industrial conditions.

Methodology: Low-migration CMYK inks were flexo-printed on metallized BOPP over a white base coat, with 1–100% tone scales for each channel measured via spectrodensitometer per ISO 5-3 and ISO 12647-6. Three complementary mathematical models were applied to analyse the experimental data: the Bouguer–Beer–Lambert law, extended to account for the dual optical path length on specular reflective substrates; the substrate-corrected Murray–Davies equation for optical dot-area estimation and tone value increase (TVI) calculation; and the Yule–Nielsen modified equation with an empirical n-factor fitted independently for each CMYK channel. Additionally, a Boltzmann sigmoidal regression model was fitted to each complete tone-density curve.

Results: The Dmax hierarchy C > M > Y > K resulted from the dual optical path length enhancement on the specular aluminium background, as defined by the Bouguer–Beer–Lambert model. Calculations using the substrate-corrected Murray–Davies equation revealed a significant tone value increase (TVI) of 29–36% in the midtones, which substantially exceeds typical values for paper due to the high reflectance contrast of the foil. Yule–Nielsen n-factors (n = 1.18–1.35) confirmed that light scattering occurs within the ink film rather than the substrate, while the Boltzmann

sigmoidal regression model described the tone-density curves with high precision ($R^2 > 0.997$).

Conclusions & practical implications: The inverted form of this model provides a direct mathematical tool for constructing tone compensation curves applicable in RIP-based colour management and ICC profile generation workflows. The results demonstrate that tone reproduction on metallized foil is governed by substrate-specific optical mechanisms that require dedicated mathematical treatment, and cannot be adequately predicted by models calibrated on paper-based printing systems.

Keywords: flexographic printing, metallized foil, optical density, Murray–Davies equation, Yule–Nielsen model, tone value increase, sigmoidal regression, flexible packaging.

FOR NOTES

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