Digital Book of Abstracts

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Keynotes

From Trustworthy AI to Regulation and Diplomacy

Professor Barry O'Sullivan

Abstract
There has been an increasing interest in the role of ethics in artificial intelligence and in the notion of Trustworthy AI, in particular. The European Commission has invested significant effort in setting out its strategy and its vision for the importance of delivering Trustworthy AI, including the proposal of a new regulatory instrument, the AI Act. In this talk I will give an overview of the policy context in relation to Trustworthy AI. I will give an overview of the current European Union's AI Act and its origins. While most of the discussion around AI tends to be in the civilian domain, I will also give a brief overview of the diplomacy of AI.

Bio
Professor O'Sullivan is an award-winning academic with more than 25 years experience working in artificial intelligence. He is Professor of Constraint Programming at the School of Computer Science IT at University College Cork and a member of its Governing Body. He is founding Director of both the Insight Centre for Data Analytics at UCC and Director of the SFI Centre for Research Training in AI. In July 2018 Barry was appointed Vice Chair of the European Commission High-Level Expert Group on AI. He is a Fellow and a past President of the European AI Association. He is also a Fellow and a member of the Executive Council of the Association for the Advancement of Artificial Intelligence. He is a member of the Royal Irish Academy. He chairs the Advisory Board of the GRACE project at Europol, and advises the institute at KULeuven (Belgium) and the Computational Sustainability Network, a network of universities in the USA. He is Senior Advisor for Technology Policy at INHR in Geneva. In 2019 Professor O'Sullivan was appointed by Ireland's Minister for Health to the Health Research Consent Declaration Committee. In 2020 he was appointed Chair of the Oversight Board of Health Data Research UK (North), led by the University of Liverpool. In 2021 he was, again, appointed by the Minister for Health as Chair of the National Research Ethics Committee for Medical Devices. In 2022 he was appointed by the Minister for Trade Promotion, Digital Company Regulation to the Enterprise Digital Advisory Forum.

The nitty gritty of Principal Component Analysis

Professor Aedín Culhane

Abstract
Principal component analysis (PCA), is a popular matrix factorization method that is often the first step in machine learning pipelines. It is a relatively fast dimension reduction method that can scale to large datasets. I will review PCA, the relationship between PCA and singular value decomposition, the difference between PCA of a correlation and covariance matrix, the impact of scaling, log-transforming, and standardization, and how to recognize a horseshoe or arch effect in a PCA. I will describe extensions to PCA and matrix factorization approaches for the integration of multi modal data. I will discuss why pre-processing or weighting datasets within a joint or multi-dataset decomposition should be considered. These discussions will be applied to high dimensional sparse single cell molecular data in cancer, where datasets are typically thousands of rows by tens of thousands to millions of columns.

Bio
Aedín Culhane is a Professor of Cancer Genomics and Director of the Limerick Digital Cancer Research Center in the University of Limerick, School of Medicine. She is a computational biologist with expertise in multimodal data integration, statistical genomics and clinical bioinformatics. She has over 20 years' experience in cancer genomics, with 15 of these in the Data Science Department at Dana-Farber Cancer Institute and Harvard University. She is a member of the Human Cell Atlas project that will describe the molecular profile of every human cell. This is an enormous undertaking as its estimated there are 37.2 trillion cells in the human body. Aedin is a leader in the Bioconductor community, a global open source, open development platform written in R for analysis of genomics data. She leads the eHealth-Hub for Cancer for federated digital health research in cancer. Her recent research focuses on development of matrix factorization approaches, machine learning and statistical algorithms for integrative analysis of multi-modal high dimensional sparse molecular data.

Google Scholar Link:
`https://scholar.google.com/citations?user=O8OszPcAAAAJ` Twitter: @AedinCulhane LinkedIn: `https://www.linkedin.com/in/aedinculhane/` ORCID iD: 0000-0002-1395-9734
Related reviews articles:
Hsu LL, Culhane AC. corral: Single-cell RNA-seq dimension reduction, batch integration, and visualization with correspondence analysis bioRxiv
doi: https://doi.org/10.1101/2021.11.24.469874

Hsu LL, Culhane AC. Impact of Data Preprocessing on Integrative Matrix Factorization of Single Cell Data. Front Oncol. 2020 Jun 23;10:973. doi:

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R code workshop: Dimension Reduction for Beginners: Hitchhiker's Guide to Matrix Factorization and PCA https://aedin.github.io/PCAworkshop/

Qualcomm - Lindsey Kostas

Lindsey Kostas

Abstract
Since its inception, Qualcomm has led mobile SoC integration with the continuous production of next-generation IP. More recently this leadership in IP and integration has scaled beyond mobile to support everything from automotives to smart cities and home to personal devices with high performance low power on-device intelligence for everything wireless. This talk will highlight the challenges presented in the face of increasingly diverse and complex product applications and customer specifications; how state-of-art machine learning is and can be employed to address these challenges; and how one can prepare themselves to make an impact in the space of ML-based SOC Design.

Bio
Lindsey is a Senior Staff Machine Learning Researcher. She joined a nascent ML RD team at Qualcomm in 2018 and since that time she has led multiple projects in ML-based CAD/EDA which have impacted global SoC design process for teams across the globe leading to significant savings in time-to-market, compute and NRE cost. She holds four pending patents related to this work and consults on a variety of ML-driven initiatives across the company in application ranging from digital and analog design to 5G to licensing. In 2021, she was honored by the Global Semiconductor Association (GSA) as the inaugural Female Up-And-Comer for her exceptional contributions toward the development, innovation, growth, and success in the semiconductor industry. Prior to joining Qualcomm, Lindsey was a 4-year scholarship athlete at Stanford University where she won two tennis national team championships and was honored as an Elite 89 Award Finalist. After graduating with distinction in Economics, she obtained her master's degree in Computer Science with an emphasis in Artificial Intelligence from Stanford University. While in the master's program Lindsey was a teaching assistant and a research associate for Chris Re and Jure Leskovic with an emphasis in deep representation learning.

Oral Presentations

Session 1

ConvNet and machine learning models with feature engineering using motor activity data for schizophrenia classification

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Abstract. The use of wearable sensors such as smartwatches is becoming increasingly popular allied with their increasing functionality and interest in their outputs. This has led to a corresponding interest and increase by researchers to develop tools to analyse the outputted data. In this research, machine learning and deep learning algorithms are applied to classify the presence of schizophrenia using time series activity data. Five machine learning models are trained using these features. These models classify participants into the condition group (with schizophrenia) and the control group (without schizophrenia). A deep learning convolutional neural network (ConvNet) was also developed which also utilized time of day categories. The best machine learning model using 10-fold cross-validation achieved an average precision of 97.6% compared to a baseline of 83.6% from the original paper that analysed this dataset. Using Leave One Patient Out (LOPO) as a validation technique the machine learning model gives an accuracy of 86.7%, with the deep learning model giving an average accuracy of 87.6% which is comparable to the state-of-the-art of 88%-92.5

Keywords: machine learning · convnet · deep learning · feature engineering · classification · time series.

Inter and Intra Signal Variance in Feature Extraction and Classification of Affective State*

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Abstract. Psychophysiology investigates the causal relationship of physiological changes resulting from psychological states. There are significant challenges with machine learning-based momentary assessments of physiology due to varying data collection methods, physiological differences, data availability and the requirement for expertly annotated data. Advances in wearable technology have significantly increased the scale, sensitivity and accuracy of devices for recording physiological signals, enabling large-scale unobtrusive physiological data gathering. This work contributes an empirical evaluation of signal variances acquired from wearables and their associated impact on the classification of affective states by (i) assessing differences occurring in features representative of affective states extracted from electrocardiograms and photoplethysmography, (ii) investigating the disparity in feature importance between signals to determine signal-specific features, and (iii) investigating the disparity in feature importance between affective states to determine affect-specific features. Results demonstrate that the degree of feature variance between ECG and PPG in a dataset is reflected in the classification performance of that dataset. Additionally, beats-per-minute, inter-beat-interval and breathing rate are identified as common best-performing features across both signals. Finally feature variance per-affective state identifies hard-to-distinguish affective states requiring one-versus-rest or additional features to enable accurate classification.

Keywords: Machine Learning · Classification · Psychophysiology · Electrocardiogram · Photoplethysmography · Affective States

* This publication has emanated from research supported in part by a Grant from Science Foundation Ireland under Grant number 18/CRT/6222

A Self-attention Guided Multi-scale Gradient GAN for Diversified X-ray Image Synthesis*

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Abstract. Imbalanced image datasets are commonly available in the domain of biomedical image analysis. Biomedical images contain diversified features that are significant in predicting targeted diseases. Generative Adversarial Networks (GANs) are utilized to address the data limitation problem via the generation of synthetic images. Training challenges such as mode collapse, non-convergence, and instability degrade a GAN's performance in synthesizing diversified and high-quality images. In this work, MSG-SAGAN, an attention-guided multi-scale gradient GAN architecture is proposed to model the relationship between long-range dependencies of biomedical image features and improves the training performance using a flow of multi-scale gradients at multiple resolutions in the layers of generator and discriminator models. The intent is to reduce the impact of mode collapse and stabilize the training of GAN using an attention mechanism with multi-scale gradient learning for diversified X-ray image synthesis. Multi-scale Structural Similarity Index Measure (MS-SSIM) and Frechet Inception Distance (FID) are used to identify the occurrence of mode collapse and evaluate the diversity of synthetic images generated. The proposed architecture is compared with the multi-scale gradient GAN (MSG-GAN) to assess the diversity of generated synthetic images. Results indicate that the MSG-SAGAN outperforms MSG-GAN in synthesizing diversified images as evidenced by the MS-SSIM and FID scores.

Keywords: GANs · Self-Attention · Multi-scale Gradients · Mode Collapse · Diversity · X-ray images · Synthesis · MS-SSIM · FID.

* This work is supported by the Munster Technological University's Risam Scholarship Award

Spot the fake lungs: Generating Synthetic Medical Images using Neural Diffusion Models

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Abstract. Generative models are becoming popular for the synthesis of medical images. Recently, neural diffusion models have demonstrated the potential to generate photo-realistic images of objects. However, their potential to generate medical images is not explored yet. we explore the possibilities of synthesizing medical images using neural diffusion models. First, we use a pre-trained DALLE2 model to generate lungs X-Ray and CT images from an input text prompt. Second, we train a stable diffusion model with 3165 X-Ray images and generate synthetic images. We evaluate the synthetic image data through a qualitative analysis where two independent radiologists label randomly chosen samples from the generated data as real, fake, or unsure. Results demonstrate that images generated with the diffusion model can translate characteristics that are otherwise very specific to certain medical conditions in chest X-Ray or CT images. Careful tuning of the model can be very promising. To the best of our knowledge, this is the first attempt to generate lungs X-Ray and CT images using neural diffusion models. This work aims to introduce a new dimension in artificial intelligence for medical imaging. Given that this is a new topic, the paper will serve as an introduction and motivation for the research community to explore the potential of diffusion models for medical image synthesis. We have released the synthetic images on https://www.kaggle.com/datasets/hazrat/awesomelungs.

Keywords: Diffusion models · Generative models · Artificial Intelligence · Medical imaging · lungs · CT · X-Ray

Multi-Graph Convolutional Neural Network for Breast Cancer Multi-Task Classification

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Abstract. Mammography is a popular diagnostic imaging procedure for detecting breast cancer at an early stage. Various deep-learning approaches to breast cancer detection incur high costs and are erroneous. Therefore, they are not reliable to be used by medical practitioners. Specifically, these approaches do not exploit complex texture patterns and interactions. These approaches warrant the need for labelled data to enable learning, limiting the scalability of these methods with insufficient labelled datasets. Further, these models lack generalisation capability to new-synthesised patterns/textures. To address these problems, in the first instance, we design a graph model to transform the mammogram images into a highly correlated multigraph that encodes rich structural relations and high-level texture features. Next, we integrate a pre-training self-supervised learning multigraph encoder (SSL-MG) to improve feature presentations, especially under limited labelled data constraints. Then, we design a semi-supervised mammogram multigraph convolution neural network downstream model (MMGCN) to perform multi-classifications of mammogram segments encoded in the multigraph nodes. Our proposed frameworks, SSL-MGCN and MMGCN, reduce the need for annotated data to 40% and 60%, respectively, in contrast to the conventional methods that require more than 80% of data to be labelled. Finally, we evaluate the classification performance of MMGCN independently and with integration with SSL-MG in a model called SSL-MMGCN over multi-training settings. Our evaluation results on DSSM, one of the recent public datasets, demonstrate the efficient learning performance of SSL-MNGCN and MMGCN with 0.97 and 0.98 AUC classification accuracy in contrast to the multitask deep graph (GCN) method Hao Du et al. (2021) with 0.81 AUC accuracy.

Keywords: Graph modelling · Self-supervised learning · Semi-supervised learning · Breast cancer classification · Graph convolutional neural networks

Session 2

Challenges Associated with the Adoption of Artificial Intelligence in Medical Device Software

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Abstract. The utilization of Artificial Intelligence (AI) has changed and enhanced several industries across the world, such as education, research, manufacturing and healthcare. The potential of AI to create new and enhanced applications that can benefit patients and physicians has created interest and enthusiasm, especially in a Medical Device Software (MDS) context. Although, the adoption of AI in MDS has also brought concerns for regulatory agencies and policymakers. The complexity of AI has challenged the standard requirements set by regulatory agencies, especially in the context of the differences between traditional MDS and AI. Additionally, the unique capacity of AI to continuous learning for optimal performance in real-world settings may also bring potential harm and risk to patients and physicians. The challenges discussed in this paper are in relation to: (1) Software Development Life Cycle (SDLC) frameworks; (2) learning processes and adaptability of AI algorithms; (3) explainability and traceability; and (4) conflictive terminology. At the end of this paper, conclusions and future work are presented to contribute to the safety and methodical implementation of AI in health care settings.

Keywords: Artificial Intelligence, Medical Device Software, Healthcare, Challenges

An Intelligent Empowering Agent (IEA) to Provide Easily Understood and Trusted Health Information Appropriate to the User Needs

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Abstract. Most members of the public, including patients, usually obtain health information from Web searches using generic search engines, which is often overwhelming, too generic, and of poor quality. Although patients may be better informed, they are often none the wiser and not empowered to communicate with medical professionals so that their care is compatible with their needs, values, and best interests. Intelligent Empowering Agents (IEA) use AI to filter medical information and assist the user in the understanding of health information about specific complaints or health in general. We have designed and developed a prototype of an IEA that dialogues with the user in simple language, collects health information from the Web, and provides tailored, easily understood, and trusted information. It empowers users to create their own comprehensive and objective opinion on health matters that concern them. This paper describes the IEA main characteristics and presents the results of subjective and objective tests carried out to assess the effectiveness of the IEA.

Keywords: Digital Health, Patient Empowerment, Intelligent Agents, Tailored Health Communication, Artificial Intelligence, Big Data, Machine Learning.

Comparison and Analysis of 3 Key AI Documents: EU's Proposed AI Act, Assessment List for Trustworthy AI (ALTAI), and ISO/IEC 42001 AI Management System*

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Abstract. Conforming to multiple and sometimes conflicting guidelines, standards, and legislations regarding development, deployment, and governance of AI is a serious challenge for organisations. While the AI standards and regulations are both in early stages of development, it is prudent to avoid a highly-fragmented landscape and market confusion by finding out the gaps and resolving the potential conflicts. This paper provides an initial comparison of ISO/IEC 42001 AI management system standard with the EU trustworthy AI assessment list (ALTAI) and the proposed AI Act using an upper-level ontology for semantic interoperability between trustworthy AI documents with a focus on activities. The comparison is provided as an RDF resource graph to enable further enhancement and reuse in an extensible and interoperable manner.

Keywords: Trustworthy AI · AI management system · ALTAI · AI Act · ISO/IEC 42001 · Ontology · Activity · Comparison.

* This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 813497, as part of the ADAPT SFI Centre for Digital Media Technology is funded by Science Foundation Ireland through the SFI Research Centres Programme and is co-funded under the European Regional Development Fund (ERDF) through Grant#13/RC/2106_P2. Harshvardhan J. Pandit has received funding under the Irish Research Council Government of Ireland Postdoctoral Fellowship Grant#GOIPD/2020/790.

AI and ML in School Level Computing Education: Who, What and Where?*

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Abstract. This paper presents the results of a systematic review of the literature relating to artificial intelligence (AI) and machine learning (ML) education at school level. We conducted a search of the ACM Full-text Collection and 33 papers from the 197 search results were selected for analysis. In this context, we considered the research questions: 1) Who has been the focus of the research?, 2) What course content appears in the research?, and 3) Where has the research taken place? We find that there has been a recent marked increase in research on AI/ML for school level education, although most of this has been based in the United States. The majority of this research focuses on students, with very little specifically addressing teachers, experts, parents, or the wider school community. There is also a lack of attention paid to research focused on women or those from historically underrepresented groups and equity of access to AI/ML courses for school-level students. Finally, the content covered in the courses described in this research varies widely, possibly because there is so little alignment to computer science (CS) frameworks or curricula.

Keywords: AI · artificial intelligence · computer science · education · informatics · K-12 · machine learning · primary · secondary · school

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Author Gender Identification considering Gender Bias

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Abstract. Writing style and choice of words used in textual content can vary between men and women both in terms of who the text is talking about and who is writing the text. The focus of this paper is on author gender prediction, identifying the gender of who is writing the text. We compare closed and open vocabulary approaches on different types of textual content including more traditional writing styles such as in books, and more recent writing styles used in user generated content on digital platforms such as blogs and social media messaging. As supervised machine learning approaches can reflect human biases in the data they are trained on, we also consider the gender bias of the different approaches across the different types of dataset. We show that open vocabulary approaches perform better both in terms of prediction performance and with less gender bias.

Keywords: author gender identification · gender bias · open-vocabulary approach

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WiFi-Based Human Activity Recognition using Attention-Based BiLSTM

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Abstract. Recently, significant efforts have been made to explore human activity recognition (HAR) techniques that use information gathered by existing indoor wireless infrastructures through WiFi signals without demanding the monitored subject to carry a dedicated device. The key intuition is that different activities introduce different multipaths in WiFi signals and generate different patterns in the time series of channel state information (CSI). In this paper, we propose and evaluate a full pipeline for a CSI-based human activity recognition framework for 12 activities in three different spatial environments using two deep learning models: ABiLSTM and CNN-ABiLSTM. Evaluation experiments have demonstrated that the proposed models outperform state-of-the-art models. Also, the experiments show that the proposed models can be applied to other environments with different configurations, albeit with some caveats. The proposed ABiLSTM model achieves an overall accuracy of 94.03%, 91.96%, and 92.59% across the 3 target environments. While the proposed CNN-ABiLSTM model reaches an accuracy of 98.54%, 94.25% and 95.09% across those same environments.

Keywords: WiFi · Channel State Information (CSI) · Human Activity Recognition (HAR)· Deep Learning · Convolutional Neural Network (CNN) · Long Short Term Memory (LSTM)

Session 3

Unimodal and Multimodal Representation Training for Relation Extraction

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Abstract. Multimodal integration of text, layout and visual information has achieved SOTA results in visually rich document understanding (VrDU) tasks, including relation extraction (RE). However, despite its importance, evaluation of the relative predictive capacity of these modalities is less prevalent. Here, we demonstrate the value of shared representations for RE tasks by conducting experiments in which each data type is iteratively excluded during training. In addition, text and layout data are evaluated in isolation. While a bimodal text and layout approach performs best (F1=0.684), we show that text is the most important single predictor of entity relations. Additionally, layout geometry is highly predictive and may even be a feasible unimodal approach. Despite being less effective, we highlight circumstances where visual information can bolster performance. In total, our results demonstrate the efficacy of training joint representations for RE.

Keywords: relation extraction · multimodal deep learning · joint representation training · information retrieval.

Run-time Norms Synthesis in Dynamic Environments with Changing Objectives

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Abstract. Normative Multi-Agent Systems (NorMAS) can model real-world applications as multi-agent systems and facilitate the coordination of the social behaviour of various entities (agents) interacting in an environment using norms. Aligning such norms with the objectives of the agents is crucially important to ensure that applying the norms would not affect the achievement of their objectives. However, when the environment is dynamic, agents can face unseen situations and might need to change their objectives accordingly. Therefore, it becomes more challenging to understand the change, synthesise norms, and align them with such dynamic objectives. This paper introduces a Dynamic Objectives and Norms Synthesizer and Reasoner (DONSR) model to align objectives and norms using a utility-based approach. An ontology-based schema, forward reasoning, and backward reasoning are used to identify the change in the environment and synthesise new objectives. Case-based reasoning enables the dynamic changing and reasoning of previously created objectives and synthesising norms. DONSR is evaluated using multiple simulated traffic scenarios, including different unseen situations (emergency events).
Results show that norms can be synthesised and maintained efficiently while the objectives are being created and changed. Further, DONSR showed its efficacy in handling unseen situations, creating new objectives, and aligning them with the created norms.

Keywords: Normative Multi-Agent Systems · Norms Synthesis · Dynamic Objectives.

Computational Phenotyping of decision-making over voice interfaces

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Abstract. Research on human reinforcement learning and decision-making behaviour has traditionally used visual-based symbols and graphics in the experimental paradigms. Such research leads to improved understanding of human decision-making and has application in fundamental research in cognitive neuroscience. In clinical domains, the approach holds out the possibility for the development of computationally-derived biomarkers suitable for use in psychiatry. Scaling this experimental approach through pervasive computing can help create larger datasets which will be necessary for normative studies. This will require the expansion of these experimental approaches beyond conventional visual representations. People receive information and interact with their environments through various senses. In particular, our sense of hearing in conjunction with speech represents a ubiquitous modality for learning and for updating our knowledge of the world. Consequently, it represents an important path for the investigation of human decision-making which is now experimentally accessible via rapid advances in voice-enabled intelligent personal assistants (IPAs). Examples include Amazon's Alexa technology and Google's Voice Assistant. However, to date no studies have demonstrated the feasibility of delivering such experimental paradigms over such voice technologies. Consequently in this study, we compared the performance of the same group of participants on the traditional visual-based and for the first time, a conversational voice-based, two-armed bandit task. Reinforcement learning models were fitted to the data to represent the characteristics of the underlying cognitive mechanisms in the task. Both model-independent behavioural measures and model-derived parameters were compared. The results suggest that participants demonstrated higher shifting rates in the voice-based version of the task. The computational modelling analysis revealed that participants adopted similar learning rates under the two versions of the interfaces, but more decision noise was introduced in the voice-based task as reflected by the decreased value of the inverse temperature parameter. We suggest that the elevated shifting rate is derived from the increased noise in the voice interface instead of a change in the learning strategy of the participants. Higher intensity of the control adjustments (click touch versus speak) might be one of the sources of noise, thus it is important to think further regarding the design of the voice interface if we wish to apply voice-enabled IPAs to measure human decision-making in their daily environments in the future.

Keywords: Reinforcement learning · Decision-making · Computational phenotyping · Voice interface.

Iterative Approximation Algorithms for Model-Based Diagnosis

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Abstract. Model-Based Diagnosis (MBD) applications focusing on complex real-world languages, like temporal logics, suffer from intractable inference. We propose a computational framework for MBD that provides significant speedup over traditional approaches through the use of iterative over-/under-approximation techniques. We map a diagnosis formula ϕ to an approximate formula $\hat{\phi}$ that is computationally-simple to diagnose, and then use refined versions of $\hat{\phi}$ to validate these diagnoses. We describe the theoretical underpinnings of this framework, and illustrate its use on examples encoded in propositional and temporal logics.[1]

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Inferring Expected Qualities of Objects with Defeasible Logic

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Abstract. We compare a symbolic inference method, defeasible logic, with previously published results for machine learning models on an object quality inference from incomplete data task. The defeasible theories are induced from training data using a heuristic from the literature. The induction process offers the opportunity for a trade-off between trusting the regularities in the training data, versus imposing a-priori expectations on the produced theories. Results in terms of accuracy and theory simplicity are encouraging, but do suggest that induction from data is slow. We then argue for the benefits of a defeasible logic approach, as opposed to a pure machine learning one, for explainability. We describe how defeasible inference helps answer several explanation-style questions and also how it can suggest what follow-up questions to ask a user when the user intends to amend the knowledge stored in a defeasible theory.

Keywords: Theory Induction · Defeasible Logic · Explainable AI

Session 4

Linguistic Distributional Knowledge and Sensorimotor Grounding Both Contribute to Semantic Category Production

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Abstract. The human conceptual system comprises simulated information of sensorimotor experience and linguistic distributional information of how words are used in language. Moreover, the linguistic shortcut hypothesis predicts that people will use computationally cheaper linguistic distributional information where it is sufficient to inform a task response. In a pre-registered category production study, we asked participants to verbally name members of concrete and abstract categories and tested whether performance could be predicted by a novel measure of sensorimotor similarity (based on an 11-dimensional representation of sensorimotor strength) and linguistic proximity (based on word co-occurrence derived from a large corpus). As predicted, both measures predicted the order and frequency of category production but, critically, linguistic proximity had an effect above and beyond sensorimotor similarity. A follow-up study using typicality ratings as an additional predictor found that typicality was often the strongest predictor of category production variables, but it did not subsume sensorimotor and linguistic effects. Finally, we created a novel, fully grounded computational model of conceptual activation during category production, which best approximated typical human performance when conceptual activation was allowed to spread indirectly between concepts, and when candidate category members came from both sensorimotor and linguistic distributional representations. Critically, model performance was indistinguishable from typical human performance. Results support the linguistic shortcut hypothesis in semantic processing and provide strong evidence that both linguistic and grounded representations are inherent to the functioning of the conceptual system.

Recommendation Uncertainty in Implicit Feedback Recommender Systems

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Abstract. A Recommender System's recommendations will each carry a certain level of uncertainty. The quantification of this uncertainty can be useful in a variety of ways. Estimates of uncertainty might be used externally; for example, showing them to the user to increase user trust in the abilities of the system. They may also be used internally; for example, deciding the balance of 'safe' and less safe recommendations. In this work, we explore several methods for estimating uncertainty. The novelty comes from proposing methods that work in the implicit feedback setting. We use experiments on two datasets to compare a number of recommendation algorithms that are modified to perform uncertainty estimation. In our experiments, we show that some of these modified algorithms are less accurate than their unmodified counterparts, but others are actually more accurate. We also show which of these methods are best at enabling the recommender to be 'aware' of which of its recommendations are likely to be correct and which are likely to be wrong.

Keywords: Recommender Systems · Uncertainty · Neural Networks

Graph-based Diffusion Method for Top-N Recommendation

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Abstract. Data that may be used for personalised recommendation purposes can intuitively be modelled as a graph. Users can be linked to item data; item data may be linked to item data. With such a model, the task of recommending new items to users or making new connections between items can be undertaken by algorithms designed to establish the relatedness between vertices in a graph. One such class of algorithm is based on the random walk, whereby a sequence of connected vertices are visited based on an underlying probability distribution and a determination of vertex relatedness established. A *diffusion kernel* encodes such a process. This paper demonstrates several diffusion kernel approaches on a graph composed of user-item and item-item relationships. The approach presented in this paper, *RecWalk**, consists of a user-item bipartite combined with an item-item graph on which several diffusion kernels are applied and evaluated in terms of *top-n recommendation*. We conduct experiments on several datasets of the RecWalk* model using combinations of different item-item graph models and personalised diffusion kernels. We compare accuracy with some non-item recommender methods. We show that diffusion kernel approaches match or outperform state-of-the-art recommender approaches.

Keywords: Top-N Recommendation · Web-Mining · Random Walk · Diffusion Kernels

CouRGe: Counterfactual Reviews Generator for Sentiment Analysis

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Abstract. Past literature in Natural Language Processing (NLP) has demonstrated that counterfactual data points are useful, for example, for increasing model generalisation, enhancing model interpretability, and as a data augmentation approach. However, obtaining counterfactual examples often requires human annotation effort, which is an expensive and highly skilled process. For these reasons, solutions that resort to transformer-based language models have been recently proposed to generate counterfactuals automatically, but such solutions show limitations. In this paper, we present CouRGe, a language model that, given a movie review (i.e. a seed review) and its sentiment label, generates a counterfactual review that is close (similar) to the seed review but of the opposite sentiment. CouRGe is trained by supervised fine-tuning of GPT-2 on a task-specific dataset of paired movie reviews, and its generation is prompt-based. The model does not require any modification to the network's architecture or the design of a specific new task for fine-tuning. Experiments show that CouRGe's generation is effective at flipping the seed sentiment and produces counterfactuals reasonably close to the seed review. This proves once again the great flexibility of language models towards downstream tasks as hard as counterfactual reasoning and opens up the use of CouRGe's generated counterfactuals for the applications mentioned above.

Keywords: Natural Language Processing · Sentiment Analysis · Language Models · Counterfactual Reasoning · Data Augmentation.

Meme Sentiment Analysis Enhanced with Multimodal Spatial Encoding and Face Embedding*

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Abstract. Internet memes are characterised by the interspersing of text amongst visual elements. State-of-the-art multimodal meme classifiers do not account for the relative positions of these elements across the two modalities, despite the latent meaning associated with where text and visual elements are placed. Against two meme sentiment classification datasets, we systematically show performance gains from incorporating the spatial position of visual objects, faces, and text clusters extracted from memes. In addition, we also present facial embedding as an impactful enhancement to image representation in a multimodal meme classifier. Finally, we show that incorporating this spatial information allows our fully automated approaches to outperform their corresponding baselines that rely on additional human validation of OCR-extracted text.

Keywords: Multimodal Deep Learning · Sentiment Analysis · Internet Memes.

* This work was conducted with the financial support of the Science Foundation Ireland Centre for Research Training in Digitally-Enhanced Reality (d-real) under Grant No. 18/CRT/6224.

Session 5

Intelligent Image Compression using Traffic Scene Analysis

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Abstract. The quantity of images generated at the edge of the Cloud is growing year-on-year, which puts an increasing strain on existing telecommunications infrastructure. There is also an associated increased cost for transmission bandwidth and storage of video images in the Cloud. In our modern society we tend to accumulate data, and are reluctant to throw it away, without asking "what is the value of this data?" and "do we need it?". One of the major sources of video streams are the increasing number of traffic cameras, used to maintain the efficient flow of vehicles on our roads. In this work we focus on images taken from road traffic cameras, and show how their transmission bandwidth and storage requirements can be reduced. By analysing video feeds on a simulated edge device, we have shown that it is possible to extract objects of interest from the image, and discard or dramatically reduce irrelevant information in the content. Our technique also generates associated metadata, in the form of JSON-LD, which annotates the original image and maintains its semantic fidelity and provenance after compression. Our technique is compatible with conventional compression techniques, and thus the potential bandwidth savings would be incremental. We present the potential savings that can be made in the transmission and storage of unstructured data, as well as some of the challenges still to be overcome.

Aerial object detection for water-based search & rescue

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Abstract. Responding to a water rescue situation is challenging. First responders need access to data as quickly as possible to increase the likelihood of a successful rescue. Using aerial imagery systems is especially useful in a search and rescue scenario because it provides a higher dimensional view of the search environment. Unmanned aerial vehicles can be easily used to acquire aerial image data. During water-based search and rescue scenarios, first responders sometimes deploy an inflatable marker called a rescue danbuoy. The danbuoy is fitted with a small conical sack known as a drogue, this ensures that the marker is not blown off course by the wind and instead follows the flow of the body of water. Tracking the danbuoy as it moves is of utmost importance in a water rescue. We present a new data-set "VisBuoy" with imagery containing instances of danbuoy markers and boats in real-world water-based settings. We also show how using various deep learning-based computer vision techniques, we can autonomously detect danbuoy instances in aerial imagery. We compare the performance of four state-of-the-art object detectors Faster RCNN Retinanet, Efficientdet and YOLOv5 on the "VisBuoy" data-set, to find the best detector for this task. We then propose a best model with a precision score of 74% which can be used in search and rescue operations to detect inflatable danbuoy markers in water-based settings.

Keywords: Deep Learning · Convolutional Neural Network · Object Detection · Search and rescue.

Identity Term Sampling for Measuring Gender Bias in Training Data

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Abstract. Predictions from machine learning models can reflect biases in the data on which they are trained. Gender bias has been identified in natural language processing systems such as those used for recruitment. The development of approaches to mitigate gender bias in training data typically need to be able to isolate the effect of gender on the output to see the impact of gender. While it is possible to isolate and identify gender for some types of training data, e.g. CVs in recruitment, for most textual corpora there is no obvious gender label. This paper proposes a general approach to measure bias in textual training data for NLP prediction systems by providing a gender label identified from the textual content of the training data. The approach is compared with the identity term template approach currently in use, also known as Gender Bias Evaluation Datasets (GBETs), which involves the design of synthetic test datasets which isolate gender and are used to probe for gender bias in a dataset. We show that our Identity Term Sampling (ITS) approach is capable of identifying gender bias at least as well as identity term templates and can be used on training data that has no obvious gender label.

Keywords: Machine Learning · Gender Bias · Evaluation.

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Cryptocurrency Volatility Index: An Efficient Way to Predict the Future CVI

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Abstract. The Cryptocurrency Volatility Index (CVI index) has been introduced to estimate the 30-day future volatility of the cryptocurrency market. In this article, we introduce a new Deep Neural Network with an attention mechanism to forecast future values of this index. We then look at the stability and performance of our proposed model against the benchmark models widely used for time series prediction. The results show that our proposed model performs well when compared to popular methods such as traditional Long Short Term Memory, Temporal Convolution Network, and other statistical methods like Simple Moving Average, Random Forest and Support Vector Regression. Furthermore, we show that the well-known Simple Moving Average method, while it has its own advantages, has the weak spot when dealing with time series with large fluctuations.

Keywords: cryptocurrencies · volatility · CVI · LSTM · attention mechanism

Session 6

Latent Space Cartography for Geometrically Enriched Latent Spaces

⋆

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Abstract. There have been many developments in recent years on the exploitation of non-Euclidean geometry for the better representation of the relation between subgroups in datasets. Great progress has been made in this field of Disentangled Representation Learning, in leveraging information geometry divergence, manifold regularisation and geodesics to allow complex dynamics to be captured in the latent space of the representations produced. However, interpreting the high-dimensional latent spaces of the modern deep learning-based models involved is non-trivial. Therefore, in this paper, we investigate how techniques in Latent Space Cartography can be used to display abstract and representational 2D visualisations of manifolds.

Additionally, we present a multi-task metric learning model to capture in its output representations as many metrics as is available in a multi-faceted fine-grained change detection dataset. We also implement an interactive visualisation tool that utilises cartographic techniques that allow dimensions and annotations of graphs to be representative of the underlying factors affecting individual scenarios the user can morph and transform to focus on an individual/sub-group to see how they are performing with respect to said metrics.

Keywords: Latent Space Cartography · Geometrically Enriched Latent Space · Disentangled Representation Learning · Fine-Grained Change Detection · Multi-Task Metric Learning

⋆ This work was supported by the Science Foundation Ireland under Grant No. 16/RC/3918 (CONFIRM).

A Large Neighborhood Search Approach for the Data Centre Machine Reassignment Problem*

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Abstract. One of the main challenges in data centre operations involves optimally reassigning running processes to servers in a dynamic setting such that operational performance is improved. In 2012, Google proposed the Machine Reassignment Problem in collaboration with the ROADEF/Euro challenge. A number of complex instances were generated for evaluating the submissions. This work focuses on new approaches to solve this problem.
In particular, we propose a Large Neighbourhood Search approach with a novel, domain-specific heuristic for neighborhood selection. This heuristic uses the unbalanced resource usage on the machines to select the most promising processes in each iteration. Furthermore, we compare two search strategies to optimise the sub-problems. The first one is based on the concept of Limited Discrepancy Search, albeit tailored to large scale problems; and the second approach involves the standard combination of constraint programming with random restart strategies.
An empirical evaluation on the widely studied instances from ROADEF 2012 demonstrates the effectiveness of our approach against the state-of-the-art, with new upper bounds found for three instances.

Keywords: LNS · Neighbourhood Selection · Machine Reassignment Problem · Limited Discrepancy Search.

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Bayesian Optimization With Multi-objective Acquisition Function for Bilevel Problems*

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Abstract. A bilevel optimization problem consists of an upper-level and a lower-level optimization problem connected to each other hierarchically. Efficient methods exist for special cases, but in general solving these problems is difficult. Bayesian optimization methods are an interesting approach that speed up search using an acquisition function, and this paper proposes a modified Bayesian approach. It treats the upper-level problem as an expensive black-box function, and uses multiple acquisition functions in a multi-objective manner by exploring the Pareto-front. Experiments on popular bilevel benchmark problems show the advantage of the method.

Keywords: Bayesian Optimization · Bilevel Optimization Problems · Multi-objective Acquisition · Multi-objective Optimization

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Explaining the Effects of Preprocessing on Constraint Satisfaction Search

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Abstract. Preprocessing constraint satisfaction problems is a much studied method for improving the performance of subsequent solution search. The traditional explanation for its beneficial effects is "problem reduction", where possible values that cannot take part in a solution are discarded, leaving fewer possibilities to explore during search. Here, we show that this is not the only or even the main factor when dynamic variable ordering heuristics are used. Multiple lines of evidence indicate that under these conditions domain reductions effected by preprocessing serve to inform the heuristic as to which variables should be chosen for instantiation before others. It is suggested that an information transmission model is needed to account for such effects, and it is argued that an extension of this approach can incorporate simple domain reduction effects as well.

Keywords: Constraint satisfaction · Preprocessing algorithm · Arc consistency · Neighbourhood singleton arc consistency

Variable-Relationship Guided LNS for the Car Sequencing Problem*

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Abstract. Large Neighbourhood Search (LNS) is a powerful technique that applies the "divide and conquer" principle to boost the performance of solvers on large scale Combinatorial Optimization Problems. In this paper we consider one of the main hindrances to the LNS popularity, namely the requirement of an expert to define a problem specific neighborhood. We present an approach that learns from problem structure and search performance in order to generate neighbourhoods that can match the performance of domain specific heuristics developed by an expert. Furthermore, we present a new objective function for the optimzation version of the Car Sequencing Problem, that better distinguishes solution quality.
Empirical results on public instances demonstrate the effectiveness of our approach against both a domain specific heuristic and state-of-the-art generic approaches.

Keywords: LNS · Neighbourhood Selection · Car Sequencing Problem.

* Supported by SFI Centre for Research Training in Artificial Intelligence under Grant No. 18/CRT/6223 and SFI under Grant No. 12/RC/2289-P2, co-funded under the European Regional Development Fund.

Session 7

A Transformer Architecture for Online Gesture Recognition of Mathematical Expressions

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Abstract. The Transformer architecture is shown to provide a powerful framework as an end-to-end model for building expression trees from online handwritten gestures corresponding to glyph strokes. In particular, the attention mechanism was successfully used to encode, learn and enforce the underlying syntax of expressions creating latent representations that are correctly decoded to the exact mathematical expression tree, providing robustness to ablated inputs and unseen glyphs. For the first time, the encoder is fed with spatio-temporal data tokens potentially forming an infinitely large vocabulary, which finds applications beyond that of online gesture recognition. A new supervised dataset of online handwriting gestures is provided for training models on generic handwriting recognition tasks and a new metric is proposed for the evaluation of the syntactic correctness of the output expression trees. A small Transformer model suitable for edge inference was successfully trained to an average normalised Levenshtein accuracy of 94%, resulting in valid postfix RPN tree representation for 94% of predictions.

Keywords: Online Gesture Recognition · Transformer · Multilevel Segmentation · Expression Tree · Transfer Learning · RPN

Analysis of Attention Mechanisms in Box-Embedding Systems

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Abstract. Large-scale Knowledge Graphs (KGs) have recently gained considerable research attention for their ability to model the inter- and intra- relationships of data. However, the huge scale of KGs has necessitated the use of querying methods to facilitate human use. Question Answering (QA) systems have shown much promise in breaking down this human-machine barrier. A recent QA model that achieved state-of-the-art performance, Query2box, modelled queries on a KG using box embeddings with an attention mechanism backend to compute the intersections of boxes for query resolution. In this paper, we introduce a new model, Query2Geom, which replaces the Query2box attention mechanism with a novel, exact geometric calculation. Our findings show that Query2Geom generally matches the performance of Query2box while having many fewer parameters. Our analysis of the two models leads us to formally describe the interaction between knowledge graph data and box embeddings with the concepts of semantic-geometric alignment and mismatch. We create the Attention Deviation Metric as a measure of how well the geometry of box embeddings captures the semantics of a knowledge graph, and apply it to explain the difference in performance between Query2box and Query2Geom. We conclude that Query2box's attention mechanism operates using "latent intersections" that attend to the semantic properties in embeddings not expressed in box geometry, acting as a limit on model interpretability. Finally, we generalise our results and propose that semantic-geometric mismatch is a more general property of attention mechanisms, and provide future directions on how to formally model the interaction between attention and latent semantics.

Keywords: Box Embeddings · Knowledge Graph · Question Answering · Attention.

A Machine Learning Approach to Industry Classification in Financial Markets

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Abstract. Industry classification schemes provide a taxonomy for segmenting companies based on their business activities. They are relied upon in industry and academia as an integral component of many types of financial and economic analysis. However, even modern classification schemes have failed to embrace the era of big data and remain a largely subjective undertaking prone to inconsistency and misclassification. To address this, we propose a multimodal neural model for training company embeddings, which harnesses the dynamics of both historical pricing data and financial news to learn objective company representations that capture nuanced relationships. We explain our approach in detail and highlight the utility of the embeddings through several case studies and application to the downstream task of industry classification.

Keywords: Machine Learning · Latent Space Embeddings · Knowledge Graphs · Financial Markets

A Machine Learning Approach for Modeling and Analyzing of Driver Performance in Simulated Racing

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Abstract. The emerging progress of esports lacks the approaches for ensuring high-quality analytics and training in professional and amateur esports teams. In this paper, we demonstrated the application of Artificial Intelligence (AI) and Machine Learning (ML) approach in the esports domain, particularly in simulated racing. To achieve this, we gathered a variety of feature-rich telemetry data from several web sources that was captured through MoTec telemetry software and the ACC simulated racing game. We performed a number of analyses using ML algorithms to classify the laps into the performance levels, evaluating driving behaviors along these performance levels, and finally defined a prediction model highlighting the channels/features that have significant impact on the driver performance. To identify the optimal feature set, three feature selection algorithms, i.e., the Support Vector Machine (SVM), Extreme Gradient Boosting (XGBoost) and Random Forest (RF) have been applied where out of 84 features, a subset of 10 features has been selected as the best feature subset. For the classification, XGBoost outperformed RF and SVM with the highest accuracy score among the other evaluated models. The study highlights the promising use of AI to categorize sim racers according to their technical-tactical behaviour, enhancing sim racing knowledge and know how.

Keywords: Telemetry, Sim racing, Artificial Intelligence, Machine Learning

Rapid Quantification of NaDCC for Water Purification Tablets in Commercial Production Using ATR-FTIR Spectroscopy Based on Machine Learning Techniques

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Abstract. Accurate, fast and simple quantitative analysis of solid dosage forms is required for efficient pharmaceutical manufacturing. A spectroscopic analysis in ATR-FTIR (Attenuated Total Reflection-Fourier Transform Infrared) mode was developed for NaDCC (Sodium dichloroisocyanurate) quantification. This fast and low-cost method can be used to quantify NaDCC solid dosage forms using ATR-FTIR in absorbance mode in conjunction with partial least squares. A simple sampling procedure is included in the proposed experiment by just dissolving the samples in deionized water. An algorithm pipeline is also included for data cleaning, such as outlier removal, scatter correction, scaling, and mapping of the sample's spectrum to a NaDCC concentration. In addition, a simple model based on Beer's law was evaluated on a sub-range of $1220 - 1830 cm^{-1}$. Furthermore, a variable selection algorithm shows minimum excipient interference from the sample matrix in addition to visual analysis. A statistical analysis of the proposed method shows that it demonstrates a promising result with a regression coefficient of 0.996 ($R^2 = 0.996$) and recovery range of $95.5\% - 107\%$. As a result of the positive correlation of ATR-FTIR with NaDCC concentration, and in conjunction with the proposed method, this can serve as a clean, fast, affordable and eco-friendly method for pharmaceutical analysis.

Keywords: Machine Learning · ATR-FTIR · chemometric

Machine Learning Models for Depression Detection using the Concept of Perceived Control

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Abstract. In this paper, machine learning techniques are used to detect and predict the mental health status of individuals based on the concept of Perceived Control using a mobile app. Perceived control has long been established to have a strong link with an individual's mental health. Individuals with a high level of perceived control seem to have good mental health while those with low levels of perceived control usually suffer from depression, anxiety and stress. In the proposed method, an individual's measure of perceived control is solicited by allowing them to download and install an android app called the Judgement App. The users then participate in an experiment, where they perform a number of trials and make a judgement after 8 trials. The data generated is then analysed and used to train supervised machine learning models to predict whether an individual is suffering from depression or not. Data generated for internal and external perceived control were of both tabular and time-series types. The data is labelled by the subject's Beck Depressive Inventory (BDI-II) score, which is performed by the individual answering the 21-questions before the experiment begins. Due to the imbalanced nature of the data available, Synthetic Minority Oversampling Technique(SMOTE) and some of its variants were used to process the training data before being used to train ML algorithms. A simple evaluation criteria consisting of Precision, Recall, F1-score and an overall model efficiency was used. The evaluation was completed by analyzing 274 samples from 140 participants. Out of the 274 samples, 54 were labelled as mildly depressed and 220 as non-depressed.

Keywords: Perceived Control, Internal Control, External Control, contingency, trial, judgement, depression

Poster session

Student track

Brain Tumor Synthetic Data Generation with Adaptive StyleGANs

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Abstract. Generative models have been very successful over the years and have received significant attention for synthetic data generation. As deep learning models are getting more and more complex, they require large amounts of data to perform accurately. In medical image analysis, such generative models play a crucial role as the available data is limited due to challenges related to data privacy, lack of data diversity, or uneven data distributions. In this paper, we present a method to generate brain tumor MRI images using generative adversarial networks. We have utilized StyleGAN2 with ADA methodology to generate high-quality brain MRI with tumors while using a significantly smaller amount of training data when compared to the existing approaches. We use three pre-trained models for transfer learning. Results demonstrate that the proposed method can learn the distributions of brain tumors. Furthermore, the model can generate high-quality synthetic brain MRI with a tumor that can limit the small sample size issues. The approach can addresses the limited data availability by generating realistic-looking brain MRI with tumors. The code is available at: https://github.com/rizwanqureshi123/Brain-Tumor-Synthetic-Data.

Keywords: Brain tumor · Deep learning · Generative models · Computer Vision · MRI

Safe Lane-Changing in CAVs using External Safety Supervisors : A Review

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Abstract. Connected autonomous vehicles (CAVs) can exploit information received from other vehicles in addition to their sensor information to make decisions. For this reason, their deployment is expected to improve traffic safety and efficiency. Safe lane-changing is a significant challenge for CAVs, particularly in mixed traffic, ie. with human-driven vehicles (HDVs) on the road, as the set of vehicles around them varies very quickly, and they can only communicate with a fraction of them. Many approaches have been proposed, with most recent work adopting a multi-agent reinforcement learning (MARL) approach, but those do not provide safety guarantees making them unsuitable for such a safety-critical application. A number of external safety techniques for reinforcement learning have been proposed, such as shielding, control barrier functions, model predictive control and recovery RL, but those have not been applied to CAV lane changing.

This paper investigates whether external safety supervisors could be used to provide safety guarantees for MARL-based CAV lane changing (LC-CAV). For this purpose, a MARL approach to CAV lane changing (MARL-CAV) is designed, using parameter sharing and a replay buffer to motivate cooperative behaviour and collaboration among CAVs. This is then used as a baseline to discuss the applicability of the state-of-the-art external safety techniques for reinforcement learning to MARL-CAV. Comprehensive analysis shows that integrating an external safety technique to MARL for lane changing in CAVs is challenging, and none of the existing external safety techniques can be directly applied to MARL-CAV as these safety techniques require prior knowledge of unsafe states and recovery policies.

Keywords: Connected Autonomous Vehicles · Lane Changing · Multi-agent Reinforcement Learning · Safe Reinforcement Learning

Exploring Abstractive vs. Extractive Summarisation Techniques for Sports News

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Abstract. The high demand generated by the information age has led to recent breakthroughs in both extractive and abstractive text summarisation. This work explores the algorithms that were the product of these advances, focusing on the domain of sports news summarisation. By creating a new hybrid evaluation system that incorporates automatic evaluation metrics, such as ROUGE and BLEU scores, with human evaluation, we observe that abstractive techniques return the best results in the sports domain. This also generalises to the domain of political articles. However, here the metrics report lower scores across most algorithms. Another finding is that the algorithms considered perform independently of the dialect of English used.

Keywords: Summarisation · Performance · Extractive · Abstractive

Automatic Linking of Podcast Segments to Topically Related Webpages

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Abstract. Podcasts are becoming an increasingly popular source of information. However, they often rely on the topical knowledge of the listener in order for them to be fully understood. We describe an investigation into methods to augment the contents of podcasts with related information from the Web. We seek to identify webpages related to segments within a podcast. NLP techniques are used to analyze audio podcast transcripts and link these to related content. We propose and examine 10 methods for automatically generating search queries from transcript segments, which are then used to search for related content on the web. The relevance of retrieved webpages to retrieved content is evaluated using crowdsourcing via Amazon Mechanical Turk. Extracting key phrases directly from the podcasts using YAKE was the most successful approach with more than 90% returned pages assessed as relevant, with precision at rank 1 and rank 3 above 0.9.

Keywords: Automatic Content Linking · Key Phrase Extraction · Podcast Summarization · Automatic Query Construction

Entity Resolution for Multiple Sources with Extended Approach*

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Abstract. Entity Resolution is a technique to find similar records that may refer to the same entity from one or many resources. It is mainly used in data integration or data cleaning with the existence of Big Data. It not only helps organisations have clean data, but it also provides a unified view of their data for later analysis. However, there is no one solution fitting all duplication issues. Because of the fact that the data itself is heterogeneous and varied. This paper focuses on finding the answers to the usefulness of a combination of different matching approaches, token blocking versus standard blocking and how other domain runs by examining how well they perform in different scenarios. To achieve these answers, this paper outline details and setups for these experiments to execute. A detailed evaluation demonstrates the effectiveness of the approaches with multiple datasets.

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Automatic Vehicle Ego Body Extraction for Reducing False Detections in Automated Driving Applications

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Abstract. Fisheye cameras are extensively employed in autonomous vehicles due to their wider field of view, which produces a complete 360-degree image of the vehicle with a minimum number of sensors. The drawback of having a broader field of view is that it may include undesirable portions of the vehicle's ego body in its perspective. Due to objects' reflections on the car body, this may produce false positives in perception systems. Processing ego vehicle pixels also uses up unnecessary computing power. Unexpectedly, there is no literature on this relevant practical problem. To our knowledge, this is the first attempt to discuss the significance of autonomous ego body extraction for automobile applications that are crucial for safety. We also proposed a simple deep learning model for identifying the vehicle's ego-body. This model would enable us to eliminate any pointless processing of the car's bodywork, eliminate the potential for pedestrians or other objects to be mistakenly detected in the car's ego-body reflection, and finally, check to see if the camera is mounted incorrectly. The proposed network is a U-Net model with a Res-Net50 encoder pre-trained on ImageNet and trained for binary semantic segmentation on vehicle ego-body data. Our training data is an internal Valeo dataset with 10K samples collected by three separate car lines across Europe. This proposed network could then be integrated into the vehicles existing perception system by extracting the ego-body contour data and supplying this to the other algorithms which then ignore the area outside the contour coordinates. The proposed network can run at set intervals to save computing power and to check if the camera is misaligned by comparing the new contour data to the previous data.

Keywords: Autonomous Vehicles · Computer Vision · U-Net · ResNet · Semantic Segmentation · Vehicle ego-body · Region of Interest (ROI) · Fisheye.

Privacy-enhanced ZKP-inspired Framework for Balanced Federated Learning

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Abstract. Federated learning (FL) is a distributed machine learning approach that enables remote devices i.e. workers to collaborate to compute the fitting of a neural network model without sharing their data. While this method is favorable to ensure data privacy, an imbalanced data distribution can introduce unfairness in the model training, causing discriminatory bias towards certain under-represented groups. In this paper, we show that imbalance federated data decreases indexes of equity i.e. differences in treatment for underrepresented classes. To address the problem, we propose a federated learning framework called Z-Fed that 1) balances the training without exchange of privacy protected data using a zero knowledge proof (ZKP) technique, and 2) allows for the collection of information on data distributions based on one or more categorical features to produce metadata about population proportions. The proposed framework infers the precise data distribution without exchanging knowledge of the data categories and uses it to coordinate a balanced training set. Z-Fed aims to mitigate the effect of imbalanced data in FL while respecting privacy and without using mediators or probabilistic approaches. Compared to a non-balanced framework, Z-Fed improves fairness and equality measured in equal opportunities (EPD) by 53.54%, equal odds (EOD) by 56.41%, and statistical parity (SPD) by 46.1% on imbalanced UTK datasets, reducing biased predictions among subgroups. EPD, EOD, and SPD measure the disparity of treatment between privileged e.g. over-represented and non-privileged groups. Given the results obtained, Z-Fed can reduce discriminatory behaviors and enhance trustworthy of federated learning.

Keywords: Federated learning · Zero knowledge proof · Unbalanced data · Fairness · Privacy · Bias

Personalised Filter Bias with Google and DuckDuckGo: An Exploratory Study

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Abstract. Personalisation in search has improved performance, focus, and user experience to a great extent, however, it also arguably polarises informational perspectives. This paper seeks to illustrate an experimental methodology to quantify how three situational user variables affect personalisation across two search engines: Google and DuckDuckGo. We find that the presence of cookies and prior search history markedly affect the first page of search results on both platforms, but that prior (shallow) browsing history has no observable effect. We also find that there is very little in common between the results of both search engines. We argue that these results advocate more consideration of how personalisation fosters filter biases.

Keywords: Personalisation · Filter Bias · Simulation Experiment · Search Engine

How Augmented Reality Beauty Filters Can Affect Self-Perception

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Abstract. Augmented reality is used on visual social media platforms such as Snapchat and Instagram with filters that can be applied to the user's face. These filters detect and transform facial features by overlaying digital masks on moving faces. Augmented reality beauty filters (ARB filters) alter the appearance of the face by conforming it to current beauty ideals. Prior to the development of ARB filters selfies could only be enhanced by retroactive photo editing. However, ARB filters adapt to facial features in real time, resulting in a unique digital beautifying process. This qualitative study explores how the use of ARB filters impacts people's perceptions of themselves. It is based on online interviews that were conducted with eight individuals. The results are analysed within the frameworks of Extended Mind Theory and Enactivism and indicate that ARB filters may have a greater impact on people's self-perception than retroactive photo editing.

Keywords: Augmented Reality · Beauty Filters · Self-perception · Social Media · Extended Mind Theory · AI Technologies

A Data-Driven Analysis of Formula 1 Car Races Outcome

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Abstract. There are a range of factors that affect the outcome of Formula 1 (F1) car races. Today, it is reasonable to say that F1 races are first won at the factory, and then on the track. F1 teams accumulate enormous amounts of data during races. In this paper, we propose a data-driven approach to identify the most important factors that contribute to the overall points scored by each driver in a F1 season. We perform a correlation analysis along with a principal components analysis (PCA) to identify the factors that are closely related. Furthermore, using PCA, we efficiently reduce our 21 input variables into a lower-dimensional subspace, that can explain most of the variance in our data and which is easier to comprehend. We obtain 5 years (2015-2019) of data explaining the F1 car characteristics from a publicly available website `https://www.racefans.net/`. We use this web-scrapped F1 race study to understand the impact of the different car features on the total points scored by a driver in the season. To the best of our knowledge, our work is the first of its kind in the area of F1 car races.

Keywords: Formula-1 · feature analysis · data analytics · open-source code.

* Authors contributed equally.

Nectar track

Industrial Data Analytics Improvement Cycle and it's Application in Industrial Fault Detection and Diagnosis

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Abstract. This paper discusses the Industrial Data Analytics Improvement Cycle (IDAIC). The main theme of this paper is the integration of domain expertise in industrial data analytics applications. To provide context for the IDAIC framework, two case studies are presented. The Fault Detection and Diagnosis(FDD) case study for Fan Coil Units (FCU) discusses how domain knowledge is used in the grey box model building process. This study leverages the data farming methodology to obtain data on various fault scenarios. Grey box models require both domain knowledge and data driven aspects which contributes to its suitability as a relevant case study. The other case study presented here concerns the development of an expert system to enhance the productivity of industrial machining operations. An expert system is particularly relevant when historical data is not available. The study aimed at providing decision-support for CNC machine operators. A set of IF-THEN rules which constituted the expert system for decision-support in this study was derived from expert knowledge, which makes it a relevant case study.

Keywords: Industrial Data Analytics, CRISP-DM, Fault Detection and Diagnosis, Expert Systems

Advances in Neonatal Seizure Detection

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Abstract. In recent years machine learning and deep learning algorithms are enabling clinicians to detect seizures in newborns. This work introduces a novel deep neural network that harnesses the most recent advances in the deep learning image recognition area. Data augmentation techniques, residual connections and a more responsive optimizer enable a deeper model to be trained on a large dataset. The proposed network is tested on a separate large continuous dataset and the publicly available Helsinki dataset, giving increased performance in overall ROC-AUC. More recent research will also be introduced.

Keywords: Seizure Detection, Deep Learning, Neural Networks, Machine Learning, Signal Processing, Pediatrics, Brain Modeling, Electroencephalography

Predicting carcass cut yields in cattle from digital images using artificial intelligence

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Abstract. Deep Learning (DL) is a successful tool for many image classification problems but has yet to be applied to carcass images. The aim of this study was to train DL models to predict carcass cut yields and compare predictions to more standard machine learning (ML) methods. Three approaches were undertaken to predict the grouped carcass cut yields of Grilling cuts and Roasting cuts from a large dataset of 54,598 and 69,246 animals respectively. The approaches taken were (1) animal phenotypic data used as features for a range of ML algorithms, (2) carcass images used to train Convolutional Neural Networks, and (3) carcass dimensions measured directly from the images, combined with associated phenotypic data and used as feature data for ML algorithms. Results showed that DL models can be trained to predict carcass cuts yields but an approach that uses carcass dimensions in ML algorithms performs slightly better in absolute terms.

Keywords: Deep Learning, Image segmentation, Machine Learning, Machine Vision, Cattle, Meat Yield

Extended Abstracts

An Ontology-based Augmented Observation for Decision-making in Multi-agent Systems

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Abstract. Decision-making is challenging for agents operating in partially observable environments. In such environments, agents' observation is often based on incomplete, ambiguous, and noisy sensed data, which leads to perceptual aliasing. This means there might be distinctive states of the environment that appear the same to the agents, and agents fail to take suitable actions. Currently, machine learning, collaboration, and practical reasoning techniques are used to improve agents' observation and their performance in such environments. However, their long exploration and negotiation periods make them incapable of reacting in real-time and making decisions on the fly [1]. The Ontology-based Observation Augmentation Method (OOAM) proposed here, improves agents' action selection in partially observable environments using domain ontology. OOAM generates an ontology-based schema (i.e., mapping low-level sensor data to high-level concepts), and infers implicit observation data from explicit ones. OOAM is evaluated in a Job Shop Scheduling (JSS) environment, where machines' data can be delayed or corrupted (see Fig. 1). Increased average utilization rate and the total processed orders show that the agent's decision-making process is improved significantly by the augmented observation compared to a well-known baseline algorithm Trust Region Policy Optimization (TRPO).

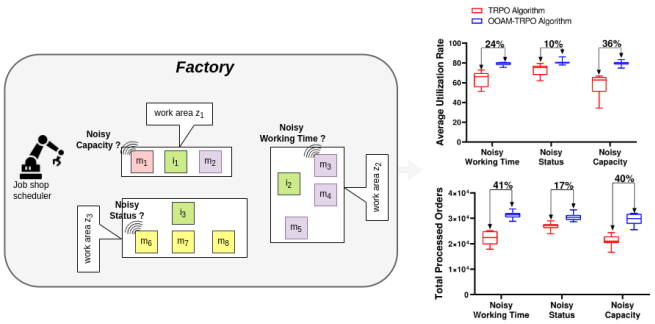

Fig. 1. JSS environment - The TRPO algorithm and the OOAM-TRPO algorithm.

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R-AdWOrch: A Robust Adaptive Workload Orchestration in Pure Edge Computing*

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Abstract: Resource allocation and handling real-time user's requests are crucial challenges in Pure Edge Computing (PEC). However, in PEC, devices can be mobile or stationary, and the generated tasks vary in urgency and priority, which includes Hard-Real-Time (HRT) tasks related to monitoring vital signals of bedridden patients, Soft-Real-Time (SRT) tasks such as processing camera data, and Non-Real-Time (NRT) tasks such as historical data analysis. In such a dynamic environment a robust adaptive workload orchestrator is required to manage users' demands. R-AdWOrch is proposed to minimize task's deadline misses and data loss for healthcare application area. R-AdWOrch uses Reinforcement Learning (RL) for resource allocation [1] and improves the robustness of task allocations in a PEC environment by defining task priority at the edge device execution queue, reallocation strategy, and reshaping the Q-function of RL to decrease delay time in HRT and SRT tasks. The results show that R-AdWOrch outperforms AdWOrch [1] in HRT and SRT success rates (Fig. 1) and decreases the delay time for these task types.

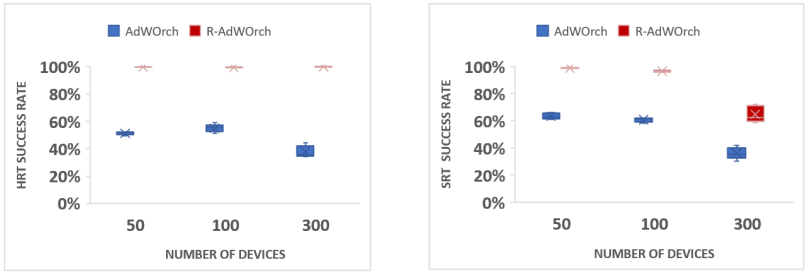

Fig. 1: The simulation results for different scenarios.

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An AI-enabled Approach to Improve Sensorimotor Efficiency During Human Computer Interactions

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1 Background and Purpose

Effective human-computer interactions have been, and continue to be, a significant challenge that demands an appreciation of the entire human perceptual-motor system. To date, human-computer interactions (HCIs) have largely been accomplished through use of a mouse to control an onscreen cursor, where control can be individually facilitated through systematic sensitivity adjustments. However, these adjustments have always been subjective to each user and can perturb HCIs, requiring an adaptation period. This is increasingly observed during video gaming, where accurate and precise HCIs to control on screen cursors is paramount to gaming performance. Despite the growing need for research on this important topic, extremely little research exists to date has investigated how software can facilitate users when performing targeting skills. This study addresses that gap by proposing an autonomous adjustment method for mouse sensitivity using an AI technique to establish one's motor variability when controlling a cursor using a computer mouse.

2 Method

The research method is based on a multi-staged, interactive framework. It moves from parsing the raw sensory-motor input to interpreting the user's motions to building a machine learning model of the user's current motor-cognitive state. Following an incremental agile development process, we will design and develop an open-source software package with the Unreal Engine 4 game engine, along with API tools developed in C++ and Python

3 Results and Conclusion

While we firstly propose establishing the software's efficacy during cursor targeting for computer gaming, this research provides potential impact in many different adaptive and intelligent HCI domains, including health and performance, computer graphics, and Computer Aided Design. Furthermore, this software solution could be adapted to reduce the detrimental effect that large motor variability can have on the gaming and general computer experience of individuals with neuromuscular disorders such as parkinson's disease, cerebral palsy and dystonia.

BLE Servers and Ubiquitous Analytics AAS*

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Reconfigurable manufacturing is aimed to cost-effective, quick reaction to context/market changes. Ubiquitous software installation, (re)configuration and operation as a Service (AAS) is part of it. Soderi et al. are being developing a software framework for Edge-to-Cloud reconfigurable [1] Big Data engineering [4], visualization [3] and analytics [5] as a Service; a demo is available [2]. Recently, a module was added to turn any device equipped of a Docker engine and a Bluetooth Low Energy (BLE) adapter into a remotely reconfigurable BLE server, and a demo is proposed that involves a peripheral device, a central device, and a mobile app. Data assessments/clustering take place both in the peripheral, and in the central device (Cloud-based), and are displayed on the app. All software is installed and configured from scratch via API calls. All artifacts are available open-source on GitHub, and Docker Hub. Reconfigurable communication and ubiquitous analytics add unprecedented resiliency upfront to unforeseen service disruptions due to natural events, sudden failures, and cyber attacks.

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Mitigating Negative Bias in AI

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Systems that heavily rely on Artificial Intelligence (AI) are becoming more involved in, and having an increasing impact on, our day-to-day lives. While such systems can offer great benefits, they can also pose serious potential ethical risks such as the unwanted effects of negative bias. If a system is detrimentally biased against an individual or group, the use of such a system may be deemed unfair, unjust, unethical or illegal.

To prevent or mitigate biased judgments from an AI system, we must be able to measure how fair the system is. Fairness can be measured using a variety of metrics including disparate impact, demographic/statistical parity, equalized odds or equal opportunity. The choice or combination of fairness metrics will depend on the specific algorithm, the context of use and the potential risk to the impacted stakeholders.

Detrimental bias can be caused at any stage in an AI system including through the data, the algorithm itself or user interaction. Bias mitigation techniques can be divided into three categories according to their stage of intervention: ***Pre-processing, In-processing,*** and ***Post-processing***. No one technique performs better than others across all fairness measures and datasets, each has its benefits and drawbacks. Pre-processing techniques such as data pre-processing, sensitive features replacement, reweighing and diverse dataset collection are good as they are employed early in the life-cycle, although such techniques are not always possible. In-processing techniques work within the system using methods such as classification, regression, attribution regularization, prejudice remover, and adversarial learning. Post-processing techniques are used at the end of the lifecycle, which is not ideal but often the only possibility. Such techniques include word embedding, calibrated distribution, and calibrated equalized odds.

There are a number of systems and toolboxes that detect, classify and mitigate bias in many ways including analysing the importance of data features, and visualizing model behaviour. We are currently reviewing, comparing and contrasting the functionality of a selection of such systems across a number of datasets. Initial results show that these toolkits detect, classify and mitigate bias to varying degrees. The aim of this research is to develop previous work to create a system, incorporating a Generative Adversarial Network in alignment with the forthcoming IEEE P7003 standard, which can detect and mitigate the effects of detrimental bias. The system will be designed to mitigate unwanted bias while limiting the deterioration in the accuracy of the results.

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Transfer of Personality through Text Style*

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The style of generated text is how something is said rather than what is said. We hypothesize that changing the style of generated text can change the perceived personality of the text generation agent. Dialogue systems that aim to imitate a human agent can appear to have a consistent personality through a consistent, controllable style of conversation. Some recent work on the style of generated text [1] performs impressively in the small number of domains selected for their experiments using transformer and LSTM-based models. Lin et al. [1] used weak supervised learning as their data set lacks parallel data. The model reconstructs a given sentence using the style of another sentence in the same domain. While our work is still in progress, we see the principle of automatically learning styles from text types and applying them to new information sources as having great application potential in the long run. However, to test the scalability and generalisability of these methods we selected a large, multi-domain data set, ToTTo [2]. ToTTo is comprised of Wikipedia tables paired with descriptions and has 120,000 training examples. We transformed the data set into a format suitable to retrain Lin et al.'s [1] model using automated extraction techniques.

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Impact of Character n-grams Attention Scores for English and Russian News Articles Authorship Attribution *

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Language embeddings are often used as black-box word-level tools that provide powerful language analysis across many tasks, but yet for many tasks such as Authorship Attribution access to feature level information on character n-grams can provide insights to help with model refinement and development. In this paper we investigate and evaluate the importance of character n-grams within an embeddings context in authorship attribution through the use of attention scores. We perform this investigation both for English (Reuters_50_50)[1] and Russian (Taiga)[2] news authorship datasets. Our analysis show that character n-grams attention score is higher for n-grams that are considered to be important for authorship identification for humans. Beyond specific benefits in authorship attribution, this work provides insights into the importance of character n-grams as a unit within embeddings. To further explore attention score, it was decided to have a look at attention scores for word-level tokenizer. The main findings are in line with n-grams' findings, namely at the word level there are some words that are related to author distinction.

Keywords: Character n-grams, Authorship Attribution task, attention score

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Alt-tech topic modeling with coherence similarity measure for model selection

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1 Introduction

Alt-tech platforms have seen a rise in their popularity as a result of tightening of content moderation policies on mainstream social media platforms. Alt-tech platforms provide a relatively free environment where misinformation and hate speech can take place without risk of deplatforming.

The study herein, employs topic modeling to inspect text data collected from six Alt-tech Telegram platforms as follows: 1) Computing Forever, 2) Lawyers for Justice, 3) Ireland on Lockdown Voice Chat, 4) The Truth about Covid-19 Plandemic, 5) Anti-lockdown Ireland, 6) Reclaim Ireland Chat. These platforms were identified in Telegram and the data was crawled through an extensive data collection procedure.

2 Methodology and Evaluation

Topic modelling refers to a successful family of text mining statistical tools for analysing text corpora. This study employs Term-Frequency Inverse-Document-Frequency (TF-IDF) text information retrieval method and Non-Negative Matrix Factorization (NMF) technique for topic representation of the cleaned corpus.

The topic N-gram defines how many tokens per term of a topic are assigned to be extracted. A coherence based model selection algorithm is proposed in this study to choose a topic model with a specific N-gram range as the best performing model. The common dictionary concept facilitates computation of cosine similarity coherence metric between pairs of topics and their corresponding documents.

Topics from the best and worst performing selected models are evaluated qualitatively by a domain expert. During the extensive qualitative evaluation for each topic model, topics are evaluated for their three most relevant documents and rated as +1 for relevant topics, 0 for non-relevant topics or -1 for a non-topic. The model selection procedure proved effective scoring models in line with ratings from a human expert.

Keywords: Topic Modeling · Model Selection · Coherence Similarity · Natural Language Processing · Alt-tech

Application of the Matrix Profile for Outlier and Recurrence Detection across Real-World Noisy Domains *

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1 Overview

We examine a series of data-sets across diverse and noisy domains to assess matrix profile (MP) performance when applied to noisy real-world scenarios. This study suggests that MP can efficiently identify areas of time series with characteristically similar and recurrent behaviour even when the data is noisy. We find that MP also offers the ability to explore underlying characteristics or events of different nature, within a time series.

2 Analysis and Outlook

Case Study 1: Keystroke Dynamics Timing Information: Our results show that keystroke timing values obtained from less frequently occurring bigrams as well as 'double letter' bigrams should be used to identify and classify typing patterns. This discovery changes the perceived wisdom used in other work which used bigram timing information to analyse cognitive state or stress levels.
Case Study 2: Movement Sensors on New-Born Calves: Results indicate that the normal pattern of movement for a calf is in fact not uniform in terms of the the MP value, in that they move randomly, resulting in irregular *Amag* values over time. On the other hand, abnormal behaviour in a calf would show a pattern, signalled by a low MP value. This could mean that if a calf was sick or their normal random movement behaviour changed, they are less active or lie down for longer periods.
Case Study 3: Traffic Volumes Across Dublin City: MP was able to detect abnormal traffic flows around Dublin city caused by high-profile events and occasions happening at that time, showing it had a causal consequence on the remaining districts from where they were based. Road closures, collisions and traffic signal defects were identified with extremely high MP discords, which enhanced the argument that the continuous surveillance instrument of using streaming SCATS traffic management data can offer exception detection in real time to enable Dublin City Council for example to offer real time responses.

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Utilization of GAN for Automatic Evaluation of Counterfactuals: Challenges and Opportunities*

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Abstract. Over the past few years, Explainable Artificial Intelligence (XAI) has grown significantly due to the fact that successful deep learning models are still difficult to understand and interpret. XAI aims to enable better interpretability of the classifications made by the neural networks for humans. In XAI research, counterfactual explanations are proven to be very effective in explaining the model's mistakes, describing what changes should be applied to a particular input (image in our case) to attain the correct classification [1]. However, systematic evaluation of counterfactuals is challenging and requires substantial human input.
In this work we focus on evaluating semantic textual explanations (expressed as attribute-value pairs) on birds classification (CUB-200-2011 [2] dataset). Being textual and not visual, the explanations are hard to systematically validate through the CNN. To tackle this problem, we experimented on the use of Generative Adversarial Networks (GANs) to modify a misclassified image based on a textual counterfactual. The resulting counterfactual image generated affected the original misclassification outcome but not as strongly as we expected. We believe this could be due to the known problem of poor resolution in GAN-generated images, and the challenge of multiple attribute modifications.
This paper reports on the challenges of using GANs to systematically assess the quality of textual counterfactuals via counterfactual image generation.

Keywords: Explainable AI (XAI) · Counterfactual explanations · Generative Adversarial Networks (GAN) · Computer Vision.

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Short-term Trajectory Prediction for Autonomous Vehicles*

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Abstract. Autonomous short-term trajectory forecasting is important for lane merge and change , speed control and exiting motorways. Currently, the majority of commercial automated vehicles use state machine based algorithms to predict the short term trajectory of the ego vehicle. This involves two stages: firstly, a deep learning based perception system is used to detect the other agents in the traffic - vehicles, pedestrians, traffic lights, stop signs, and so forth. Secondly, state machine based probabilistic models are used to forecast the trajectory of the ego vehicle by minimizing the risk of accidents. These end to end differentiable data driven systems solutions can be limited as most of the model designs are limited by the datasets, i.e. the data is limited to generic scenarios with a limited number of corner cases. Therefore, there is a need for more substantive datasets that correspond and reflect complex scenarios found in the real world. A proposed solution detailed in this paper is to use a CARLA simulation based synthetic dataset for short term trajectory prediction tasks. Specifically, the dataset consists of 6K perspective and orthographic view images and corresponding Inertial Measurement Unit (IMU) odometry information for each frame. Importantly, these datasets contain real world use cases: for example, pedestrians crossing the road, vehicles overtaking and stop and start scenarios. An end to end short term trajectory prediction model consisting of Convolutional Neural Networks (CNNs) and Long short-term Memory (LSTM) has also been developed (Fig 1). Furthermore, this model removes the need for explicit encoding of the surroundings knowledge into the model by inducing safety constraints into the loss function. It is shown that this complete data driven implicit system understands corner case scenarios such as slowing down near the zebra crossings and stopping when pedestrians cross the road. This dataset and model will be released to help the research community in accelerating their research in short term vehicle trajectory forecasting.

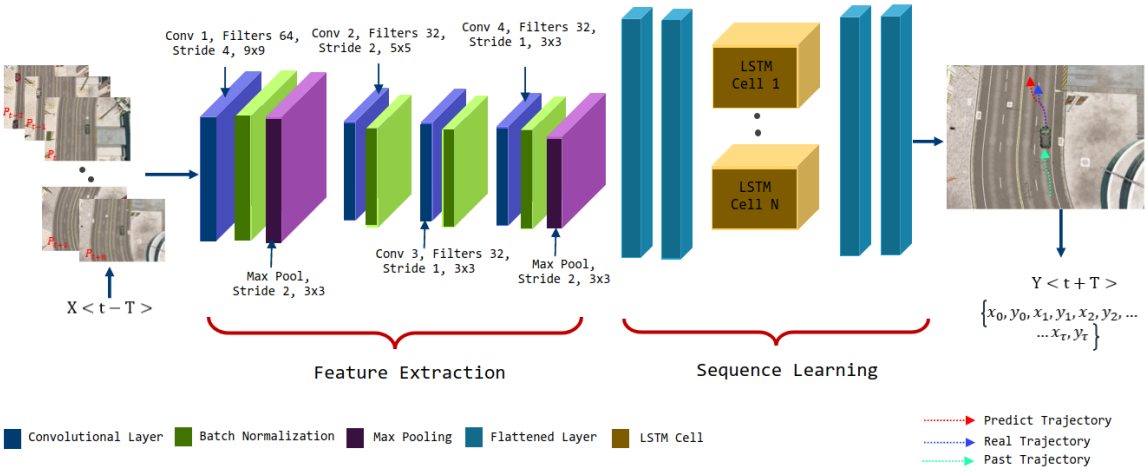

Fig. 1. Architecture topology diagram. Sequences of n images are fed into the CNN on the left side of the diagram. The estimated trajectory is displayed on the right.

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Self-Attentive Transformer Model for Answer Correctness Prediction

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Abstract. The Transformer Deep Learning (DL) model is currently receiving attention due to its ability to weigh various parts of input sequences through the use of an attention mechanism. While Transformers are widely used in language translation, document summary, document generation and sentiment analysis, there is currently a paucity of research on their application in predicting learner performance. The attention mechanism in transformers allows the establishment of a strong binding among input features, which can be used to predict the next answer correctness. With the introduction of self-attention and positional embedding techniques they have outperformed DL models such as Long Short-Term Memory (LSTM), Recurrent Neural Networks (RNN), Convolutional Neural Networks (CNN), etc. in almost all fields. In this study, we present a Self-Attentive Transformer Model (SATM) for predicting whether or not the next answer attempted by the learner will be correct. The SATM uses an encoder and decoder architecture. The encoder extracts features from the learner's online interaction (i.e. content, prior question elapsed time, prior question explanation). The decoder uses these features to generate an answer correctness prediction in the form of 0 and 1. The attention mechanism determines the relative importance of features. The most important features that have a significant impact on the final performance are given more importance in predicting the final answer. The SATM can be used by instructors to highlight potential problems and introduce interventions to support potentially struggling learner.

Keywords: Encoder, Decoder, Self-Attention, Transformer, prediction, performance classification, deep learning

Automatic Segmentation of the Paediatric Femoral Head*

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Developmental dysplasia of the hip (DDH) is a developmental deformity occurring in 0.1-3.4% of infants [1]. Surgical intervention can ameliorate the condition and reduce future cases of osteoarthritis and total hip replacement. However, current definitions of DDH are subjective [2], and thus would benefit from a more objective and reliable assessment tool. Since the shape of the femoral head and its congruence with the acetabulum is impacted by DDH [3], automated segmentation and analysis of the femoral head, specifically the secondary ossification centre, could potentially play a role in the development of novel objective morphological metrics to improve the detection and management of DDH. Therefore, this paper aims to segment the paediatric femoral head from radiographs, which has not been attempted before in the chosen focus age group (1-16 years) where the pelvis undergoes significant development.

U-Net models are developed using 720 paediatric anteroposterior pelvic radiographs, both with and without the use of data augmentation, which included contrast adjustments, rotation, and horizontal flipping. The models are evaluated using 5-fold cross-validation. The U-Net with data augmentation achieved the best results with a Dice score of 0.94±0.021 and a femoral head centroid median error of 0.32mm and a 95% range of [0.10mm, 1.72mm]. Future work will use this femoral head segmentation algorithm in the development of novel clinical metrics to characterise hip joint morphology, and subsequently inform decisions in the management of DDH.

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Application and Scope of Graph Neural Networks for Medical Images*

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Abstract. Graphs are data structures that consist of nodes (vertices) and their relationships (edges). The expressive power of graphs has made them popular for modeling complex phenomena in physics, chemistry and social sciences. They have been successfully applied to solve protein-protein interaction, drug interaction problems and complex computer vision problems. In our work we have explored the expressive power of GNNs (Graph Neural Networks) against that of DNNs (Deep Neural Networks). GNNs are not limited to the input spaces of images and word sequences used by CNNs but accept more general input spaces and have shown promising results for histopathological image classification, pulmonary artery-artery vein separation and other medical imaging tasks. We propose a model which uses the Graph Convolutional Neural Network (GCNNs) along with Edge convolutions (GCNN-EC) for a medical image data classification task on the MedMNIST dataset. The MedMNIST dataset consists of 10 pre-processed datasets from selected sources covering primary data modalities like X-ray, Magnetic Resonance Imaging (MRI), etc. It contains 12 2-D datasets with 708,069 images. To simplify the problem of comparing DNNs with GNNs, our focus is limited to 6 classes (AbdomenCT, BreastMRI, CXR, ChestCT, Hand, and HeadCT), containing a total 58,954 images. Our model outperforms ResNet18 and EfficientNet for some classes. The results are promising as the DNN models used were pre-trained and have a very high number of parameters, **11,689,512** for ResNet18 and **4,014,658** for EfficientNet, whereas our GCNN-EC models only used **24,967** parameters but gave similar performance. Since availability of labelled data in medical imaging domain is rare and acquisition of such data is expensive, a model that can be trained on less data is attractive.

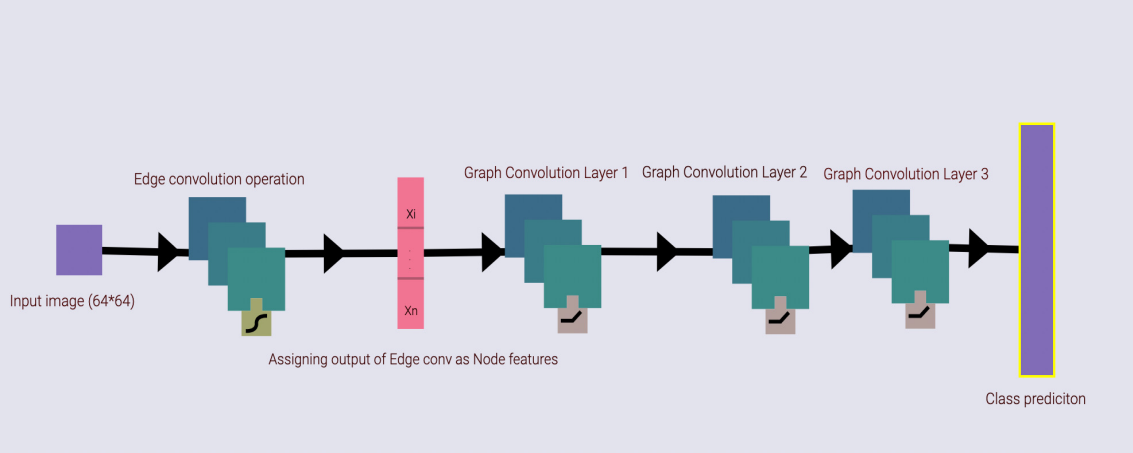

Figure 1. Our GCNN-EC model architecture

Table1. Comparison of DNNs with our GCNN-EC

Methods	AbdomenCT		BreastMRI		CXR		ChestCT		Hand		HeadCT		Parameters
	AUC	ACC	AUC	ACC	AUC	ACC	AUC	ACC	AUC	ACC	AUC	ACC	
ResNet18	0.900	0.839	0.897	0.899	0.972	0.842	0.701	0.940	0.915	0.921	0.867	0.762	11,689,512
EfficientNet	0.991	0.907	0.975	0.918	0.978	0.960	0.813	0.948	0.997	0.991	0.974	0.894	4,014,658
GCN-EC(ours)	0.876	**0.882**	**0.983**	**0.985**	0.957	**0.965**	0.748	0.813	**0.936**	0.905	**0.899**	**0.874**	**24967**

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