THE ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING TEAM

ANNUAL REPORT 2022

DEPARTMENT OF COMPUTER SCIENCE

AALBORG UNIVERSITY

BACKGROUND AND PROFILE

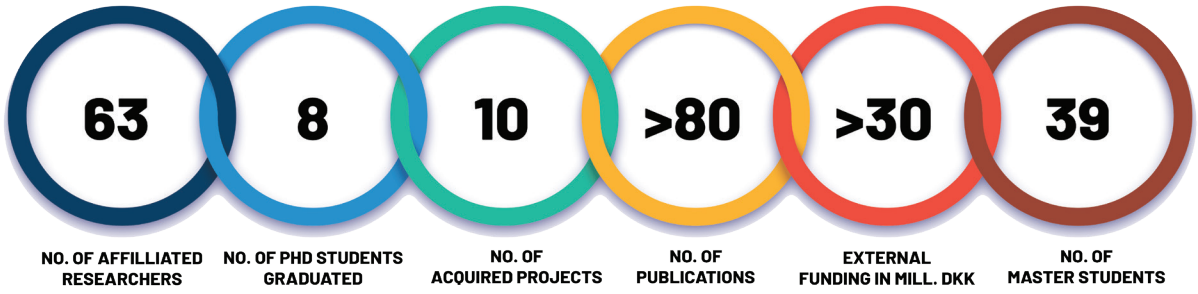
THE ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (AI-ML) TEAM GATHERS RESEARCHERS FROM THE FOUR RESEARCH UNITS AT THE DEPARTMENT OF COMPUTER SCIENCE, AALBORG UNIVERSITY, ALL WORKING WITH DIFFERENT ASPECTS OF AI AND MACHINE LEARNING.

DATA ENGINEERING, SCIENCE AND SYSTEMS	DISTRIBUTED, EMBEDDED AND INTELLIGENT SYSTEMS	DATA, KNOWLEDGE AND WEB ENGINEERING	HUMAN-CENTERED COMPUTING
FULL PROFESSORS CHRISTIAN S. JENSEN TORBEN B. PEDERSEN BIN YANG	**FULL PROFESSORS** KIM G. LARSEN JIRI SRBA	**FULL PROFESSORS** KATJA HOSE TORBEN LARSEN	**FULL PROFESSORS** MIKAEL SKOV PETER AXEL NIELSEN JESPER KJELDSKOV
RESEARCH GROUP COORDINATOR KRISTIAN TORP	**RESEARCH GROUP COORDINATOR** BRIAN NIELSEN	**RESEARCH GROUP COORDINATOR** GABRIELA MONTOYA	**RESEARCH GROUP COORDINATOR** IVAN AAEN

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING
RESEARCH LEADER: THOMAS DYHRE NIELSEN

FURTHER INFORMATION ABOUT THE AI-ML TEAM CAN BE FOUND AT CS.AAU.DK/AI-ML

AI-ML IN NUMBERS FOR 2022



AI-ML RESEARCH HIGHLIGHTS

SELECTED HIGHLIGHTS REPRESENTING ONGOING AI-ML-RELATED RESEARCH ACTIVITIES.

CORRELATED TIME SERIES ANALYSIS

Increasingly massive multivariate time series data, often with temporal and spatial correlations, is available. Ongoing AI-ML research on such data targets primarily forecasting, classification, and outlier detection. Advances in deep learning that aim for deployment on edge devices include more efficient spatial and temporal operators and stacking of these, as well as more efficient ensemble learning. Other advances concern joint neural architecture and hyper parameter search, explainable and robust autoencoder-based learning, and diversity-driven convolutional ensembles.

HUMAN-CENTERED AI

AI technologies often require human interaction or involvement when the AI predicts outcomes or makes algorithmic decisions. Furthermore, often AI technologies affect secondary users when making decisions or recommendations. Our work investigates AI from a human-centered point of view, and we consider how users can be involved in the design and evaluation of AI systems. Our work spans different application domains including search and rescue missions, agriculture over health to publicly available systems.

KNOWLEDGE AND DATA ENGINEERING

Machine learning techniques support a broad range of applications around knowledge graphs, natural language processing, and recommender systems. The AI-ML team has been working on theoretical methods and practical approaches to support large-scale analytics on graphs, AI-enhanced integration of heterogeneous data, semantic search, decision support, multi-modal representation learning, and Linked Data Science across a broad range of domains including bioscience, sustainability assessment, oceanography, and digital health.

PROBABILISTIC MODELS

The AI-ML team has a long track record in the field of probabilistic models that combine numeric, graphical, and symbolic representations. These models provide an interpretable model structure that together with predictive uncertainty quantification provides a basis for robust and trustworthy AI systems. We work on foundational topics as well as algorithmic approaches for learning these types of (deep) models from both structured and unstructured data as well as domain knowledge.

TRANSPORTATION ANALYTICS

Transportation is an important societal process for which massive data is available. Ongoing transportation-related AI-ML research targets, e.g., vehicle routing, travel time estimation, trajectory and temporal path representation learning, trajectory similarity learning, evolutionary clustering of moving objects, vehicle speed prediction and estimation, distance querying, spatial-object indexing.

VERIFIABLE AND SAFE AI

Machine-learning techniques lead to better products, e.g. in terms of efficiency and usability. However, for safety critical systems (e.g., self-driving cars, medical devices, infrastructures) the need for verification against potential fatal accidents is self-evident and of key importance. A grand research challenge is to extend existing verification techniques to learning-enabled systems. At AAU we work on correctness verification of neural networks, shielded and compositional reinforcement learning of guaranteed safe and explainable strategies. The resulting methods are embedded in the award-winning tool UPPAAL.

APPLICATIONS

The AI-ML team contributes to research in diverse application areas, including Intelligent transport systems (example projects: DiCYPS, MOBISPACES), Energy systems (example projects: FED, DOMOS, FEVER), Bioscience and Digital health (example projects: DarkMatter, DarkScience, EXPLAIN-ME, ISOBEL), Green transition (example projects: CLAIRE, DONUT, DREAMS, HERD, VSAS), and Oceanographic research (ODINI).

Our activities in these domains have resulted in two spin-off companies: IntelliGo and FlexShape.

AI-ML GENERAL RESEARCH THEMES

THE RESEARCH ACTIVITIES OF THE TEAM COVER A WIDE RANGE OF AI AND ML RELATED TOPICS, BROADLY DEFINED BY THE FIVE RESEARCH PILLARS OF THE TEAM:

- **Database technologies:** Spatio-temporal, streaming, time-series, and sensor data; transfer and multi-task learning, outlier detection and prediction, graph embeddings and graph neural networks, predictive and descriptive analytics, in-DBMS analytics, indexing, and big data scalability
- **Formal methods:** Combining logic and probability, verification and model checking, learning probabilistic and timed automata, machine learning for controller synthesis, machine learning for statistical model checking.
- **Human-centered computing:** Human-centered AI, AI Collaboration, AI and fairness, explainability during use and interaction, task and workspace augmentation.
- **Knowledge engineering and Web technologies:** Recommender systems, knowledge graphs, natural language processing (NLP), graph embeddings, web data integration, querying and analytics.
- **Machine learning and probabilistic methods:** Probabilistic graphical models, Bayesian networks, decision graphs, planning, learning of probabilistic models, statistical relational learning, deep probabilistic models, deep learning, AutoML, graph neural networks.

AI-ML STAFF MEMBERS

THE ACTIVITIES OF THE AI-ML TEAM ARE COORDINATED AND ORGANIZED BY 14 STAFF MEMBERS AT THE DEPARTMENT:

- Giovanni Bacci, Associate Professor
- Peter Dolog, Associate Professor
- Katja Hose, Professor
- Manfred Jaeger, Associate Professor
- Peter G. Jensen, Associate Professor
- Christian S. Jensen, Professor
- Kim Guldstrand Larsen, Professor
- Timothy R. Merritt, Associate Professor
- Thomas D. Nielsen, Professor MSO
- Torben Bach Pedersen, Professor
- Christian Thomsen, Associate Professor
- Alvaro Torralba, Associate Professor
- Niels van Berkel, Associate Professor
- Bin Yang, Professor

An additional 49 researchers ranging from PhD students to associate professors also contribute to the activities in the team (see Appendix).

PHD PRODUCTION

EIGHT PHD DEGREES WERE AWARDED IN 2022, SPANNING FROM HUMAN-CENTRIC AI RESEARCH TO DATA DRIVEN AND MODEL-BASED MACHINE LEARNING:

- **Sean Bin Yang**: Path Representation Learning in Road Networks
- **Maria Hoffmann Jensen:** Value Creation from Big Data Analytics - A systems approach to enabling big data benefits
- **Eike Schneiders:** Non-Dyadic Collaboration in Human-Robot Interaction
- **Christian Tovgaard Aebeloe:** Decentralized Knowledge Graphs on the Web
- **Simon Aagaard Pedersen:** Towards Efficient Stochastic Routing in Road Networks
- **Razvan Gabriel Cirstea:** Model Parameter Generation for Correlated Time Series Forecasting
- **Tiantian Liu:** Spatial Queries for Indoor Location-based Services
- **Tianyi Li:** Aspects of Spatial Trajectory Data Management-Compression and Clustering

AI FOR THE PEOPLE CENTER

The AI-ML team is also part of the steering committee of the **AI for the People Center**, which covers and facilitates AI activities across all faculties at Aalborg University.

As the name implies, the activities in the center focus not only on technical AI, but also on the influence AI solutions will have on individuals and society, and how this should be governed.

EDUCATIONAL ACTIVITIES

At the departmental level, the AI-ML team is responsible for the educational activities related to AI and ML. This includes the Data science and machine learning education (started in 2019) and the Artificial Intelligence and Machine Learning specialization available for Master's students in Computer Science and Software engineering.

Currently, 39 Master's students covering both educations follow this specialization track.

PROJECTS

IN 2022 ALONE, THE AI-ML TEAM SUCCESSFULLY ATTRACTED 10 RESEARCH PROJECTS WITH A TOTAL FUNDING OF MORE THAN DKK 31 MILL.

ALGORITHMIC EXPLAINABILITY FOR EVERYDAY CITIZENS

Despite the ever-increasing impact of AI on our daily lives, everyday citizens need to be more able to understand and interact with algorithmically driven decision-making. In this project, researchers seek to understand the needs of the general public in assessing AI-driven decision-making. Based on these identified needs, they develop and evaluate interactive applications to inform the design and deployment of future AI-driven decision support systems.

FUNDING: DKK 4.2 MILL.
FUNDED BY: CARLSBERG FOUNDATION, SEMPER ARDENS: ACCELERATE

PROJECT OWNER: ASSOCIATE PROFESSOR NIELS VAN BERKEL, AALBORG UNIVERSITY

CERTIFIABLE CONTROLLER SYNTHESIS FOR CYBER-PHYSICAL SYSTEMS

As cyber-physical systems (CPSs) are becoming ever more ubiquitous, many of them are considered safety critical.This project aims to facilitate the construction of control software for CPSs that ticks all the boxes: high efficiency, a very high level of trust in the safety of the system, and the possibility to independently audit the software. To do so, the researchers combine existing methods of controller synthesis, (timed automata) mode checking, and interactive theorem provers.

FUNDING: DKK 67,000
FUNDED BY: INNOVATION FUND DENMARK, THE GRAND SOLUTIONS PROGRAMME (DIREC)

PROJECT PARTNERS: AALBORG UNIVERSITY (POSTDOC MARTIJN GOORDEN) AND AARHUS UNIVERSITY

COST EFFICIENT HEAT PUMPS USING PREDICTIVE DIGITAL TWINS AND REINFORCEMENT LEARNING (CEDAR)

Heat pumps are becoming increasingly popular as a substitute for expensive oil and gas furnaces in private homes, however many heat pump systems are limited in their ability to automatically adjust their operation to accommodate for changes in e.g. weather and fluctuating energy prices. The CEDAR project aims to significantly reduce the cost for homeowners, in part by a more efficient control of air-to-water and geothermal heat pumps and in part by switching energy consumption to low-cost (and green energy) periods.

FUNDING: DKK 1.5 MILL.
FUNDED BY: INNOVATION FUND DENMARK, THE INNOEXPLORER PROGRAMME

PROJECT OWNER: ASSOCIATE PROFOSSOR PETER GJØL JENSEN, AALBORG UNIVERSITY

DATA MANAGEMENT, FUNDAMENTAL ALGORITHMS, AND MACHINE LEARNING FOR EMERGING PROBLEMS IN LARGE NETWORKS

Applying AI and machine learning techniques to analyze vast amounts of data, e.g. within medical diagnostics, is not new. However, in a 5-year research project, researchers apply ML to new types of data in order to generate better results when analyzing the data. It is foundational research which may be applied to several domains, however, this project looks mainly at applications within medical diagnostics and biology.

FUNDING: DKK 10 MILL.
FUNDED BY: NOVO NORDISK FOUNDATION RECRUIT GRANT

PROJECT OWNER: ASSOCIATE PROFOSSER ARIJIT KHAN, AALBORG UNIVERSITY

ILLUMINATING MICROBIAL DARK MATTER THROUGH DATA SCIENCE

Microbial communities play a vital role in most processes in the biosphere and are essential for solving numerous challenges, incl. developing new antibiotics. Together with colleagues, researchers from CS have demonstrated how the integration of long-read DNA sequencing and graph-based deep learning can go beyond the current state of the art in bacterial genome recovery and metagenomic binning. In this project, the researchers continue this work and develop technologies to integrate external data, provide novel analyses, and support microbial genome data and metagenomic binning at an unprecedented scale.

FUNDING: DKK 7.5 MILL.
FUNDED BY: VILLUM FOUNDATION, THE VILLUM SYNERGY PROGRAMME

PROJECT PARTNERS: AALBORG UNIVERSITY, DEPT. OF COMPUTER SCIENCE (PROFESSOR KATJA HOSE AND PROFOSSOR WITH SPECIAL RESPONSIBILITIES THOMAS DYHRE NIELSEN) AND DEPT. OF CHEMISTRY AND BIOSCIENCE.

MOBISPACES

An increasing number of ubiquitous sensors collect vast amounts of mobility data - however, data is only meaningful with efficient data governance. In the EU project Mobispaces, a joint effort of 25 partners, will leverage data sharing and interoperability to enable a compliant, secure and trustworthy solution that optimizes the complete Data Path, minimizing its environmental footprint.

FUNDING: DKK 2.4 MILL.
FUNDED BY: THE EUROPEAN UNION, HORIZON EUROPE PROGRAMME

PROJECT PARTNERS: AALBORG UNIVERSITY (PROF. WITH SPECIAL RESPONSIBILITIES KRISTIAN TORP, PROF. CHRISTIAN S. JENSEN), AMT - AZIENDA MOBILITA E TRASPORTI, ATOS, AUSTRIAN INSTITUTE OF TECHNOLOGY, BOSCH, COMMPLA, DANISH GEODATA ACENCY, DIGITAL SYSTEMS 4.0, EMISIA, ENGINEERING, FREQUENTIS, FUJITSU, GFT, LEANXCALE, MARINETRAFIFIC, NETCOMPANY – INTRASOFT, NET-U CONSULTANTS, SIEMENS, TRUST-IT SERVICES, UBITECH, UNIVERSITE LIBRE DE BRUXELLES, UNIVERSITY OF PIRAEUS RESEARCH CENTER, UNPARALLEL, WHITE LABEL CONSULTANCY.

MULTIMODAL DATA PROCESSING OF EARTH OBSERVATION DATA

The Danish Partnership for Digitalisation has concluded that there is a need to support the digital acceleration of the green transition. In this project, researchers, domain experts, and end-users explore methods for multimodal processing of Earth observation data using advanced and efficient big data management, software engineering, IoT and machine learning. The project will create societal and business value by providing the foundation for the Blue Denmark to reduce environmental and climate impact.

FUNDING: DKK 1.8 MILL.
FUNDED BY: INNOVATION FUND DENMARK, GRAND SOLUTIONS PROGRAMME (DIREC)

PROJECT PARTNERS: AALBORG UNIVERSITY (PROF. WITH SPECIAL RESPONSIBILITIES KRISTIAN TORP AND PROF. CHRISTIAN S. JENSEN), UNIVERSITY OF SOUTHERN DENMARK, THE ALEXANDRA INSTITUTE, DANISH GEODATA ACENCY, DANISH ENVIRONMENTAL PROTECTION AGENCY AND GEO.

MULTILINGUAL MODELLING FOR RESOURCE POOR LANGUAGES

Language is the key to accessing the modern technology on which our society relies. However, out of the over 7,000 languages worldwide, only a handful have access to such technology. In this project, researchers make use of the fact that languages often have systematic similarities with one another, aiming to increase technological access to billions of speakers of resource-poor languages. This requires a solid foundation in linguistic theory, artificial intelligence, and machine learning.

FUNDING: DKK 5 MILL.
FUNDED BY: CARLSBERG FOUNDATION, SEMPER ARDENS: ACCELERATE

PROJECT OWNER: ASSOCIATE PROFESSOR JOHANNES BJERVA, AALBORG UNIVERSITY

NEURO-SYMBOLIC CAUSAL REASONING ON LEGAL CONTRACTS (NESCON)

Contract review costs humans substantial time, money, and attention (many law firms spend approximately 50% of their time reviewing contracts, costing hundreds of thousands of dollars). The project investigates information extraction methods and semantic knowledge representation methods for legal documents, and in particular for legal contracts in order to develop novel neuro-symbolic causal reasoning algorithms to assist contract reviewing.

FUNDING: DKK 105,000
FUNDED BY: ADOBE INC.

PROJECT OWNER: ASSISTANT PROFESSOR MATTEO LISSANDRINI, AALBORG UNIVERSITY

RE-USE OF ROBOTIC-DATA IN PRODUCTION THROUGH SEARCH, SIMULATION AND LEARNING

Compared with other AI application domains, e.g., computer vision, the robotics domain has yet to realize the potential of reusing and leveraging data collections from past operations and across domains. This project aims to analyze the underlying scientific and technical challenges and associated legal, and privacy issues of data reuse in robotics applications.

FUNDING: DKK 57,600
FUNDED BY: INNOVATION FUND DENMARK, THE GRAND SOLUTIONS PROGRAMME (DIREC)

PROJECT PARTNERS: AALBORG UNIVERSITY (ASSO. PROFESSOR ANDRES MASEGOSA, PROF. WITH SPECIAL RESPONSIBILITIES THOMAS DYHRE NIELSEN, AND ASSOCIATE PROF. ALVARO TORRALBA), UNIVERSITY OF SOUTHERN DENMARK, UNIVERSITY OF COPENHAGEN, NORDBO ROBOTICS, NOVO NORDISK, ODENSE ROBOTICS, ROCKWOOL INTERNATIONAL, AND WELLTEC.

PUBLICATIONS

THE MEMBERS OF THE AI-ML TEAM HAVE PUBLISHED EXTENSIVELY IN HIGH-QUALITY OUTLETS IN THEIR RESPECTIVE RESEARCH FIELDS.

IN 2022, MEMBERS OF THE TEAM HAVE PUBLISHED MORE THAN 80 AI AND ML-BASED RESEARCH PAPERS.

A FULL LIST OF PUBLICATIONS CAN BE FOUND IN THE APPENDIX. THESE INCLUDE:

- Fišer, D., Torralba, A., & Hoffmann, J. (2022): ***Operator-Potential Heuristics for Symbolic Search.*** In Proceedings of the AAAI Conference. Outstanding Paper Award, Honorable Mention.
- Tianyi Li, Lu Chen, Christian S. Jensen, Torben Bach Pedersen, Yunjun Gao, Jilin Hu: ***Evolutionary Clustering of Moving Objects.*** ICDE 2022: 2399-2411. ICDE best paper award.
- Kristian Otte, Kristian Simoni Vestermark, Huan Li, Daniele Dell'Aglio (2022): ***Towards A Question Answering System over Temporal Knowledge Graph Embedding.*** In Proceedings of the Workshop on Deep Learning for Knowledge Graphs (DL4KG 2022) co-located with the 21th International Semantic Web Conference (ISWC 2022). Best paper award.

FURTHER INFORMATION ABOUT THE AI-ML TEAM CAN BE FOUND AT CS.AAU.DK/AI-ML

APPENDIX

A: RESEARCHERS AFFILIATED WITH THE AI-ML TEAM

- Alvaro Torralba
- Anders Læsø Madsen
- Andres Masegosa
- Antheas Kapenekakis
- Arijit Khan
- Bin Yang
- Carlos
- E. Muniz Cuza
- Chenjuan Guo
- Christian S. Jensen
- Christian Schilling
- Christian Thomsen
- Dalin Zhang
- Daniele
- Dell'Aglio
- Daniele Toller
- Dario Garigliotti
- David Gonzalo Chaves Campos
- Emil Riis Hansen
- Giorgio Bacci
- Giovanni Bacci
- Hua Lu
- Jilin Hu
- Joel Wester
- Johannes Bjerva
- Jonas Brusokas
- Kaixuan Chen
- Katja Hose
- Kim Guldstrand Larsen
- Kristian G. Olesen
- Kristian Torp
- Manfred Jaeger
- Matteo Lissandrini
- Mikael B. Skov
- Naja Kathrine
- Kollerup Als
- Nguyen Thi Thao Ho
- Niels van Berkel
- Per Printz Madsen
- Peter Axel Nielsen
- Peter Dolog
- Peter Gjøl Jensen
- Sander de Jong
- Shagen Djanian
- Sigmundur Vang
- Søren Kejser Jensen
- Theis Erik Jendal
- Thomas Dyhre Nielsen
- Timothy Robert Merritt
- Tomer Sagi
- Torben Bach Pedersen
- Tung Kieu
- Weizhu Qian
- Xinle Wu
- Yan Zhao
- Yunyao Ch

B: PUBLICATIONS (FULL LIST)

AN INVESTIGATION OF SAFE AND NEAR-OPTIMAL STRATEGIES FOR PREVENTION OF COVID-19 EXPOSURE USING STOCHASTIC HYBRID MODELS AND MACHINE LEARNING
Bilgram, A., Jensen, P. G., Jørgensen, K. Y., Larsen, K. G., Mikučionis, M., Muñiz, M., Poulsen, D. B., & Taankvist, P. (2022). An investigation of safe and near-optimal strategies for prevention of Covid-19 exposure using stochastic hybrid models and machine learning. *Decision Analytics Journal, 5*, [100141]. https://doi.org/10.1016/j.dajour.2022.100141

EFFICIENT DISTRIBUTED CLUSTERING ALGORITHMS ON STAR-SCHEMA HETEROGENEOUS GRAPHS
Chen, L., Gao, Y., Huang, X., Jensen, C. S., & Zheng, B. (2022). Efficient Distributed Clustering Algorithms on Star-Schema Heterogeneous Graphs. *IEEE Transactions on Knowledge and Data Engineering, 34*(10), 4781-4796. https://doi.org/10.1109/TKDE.2020.3047631

EXPLAINING AUTOMATED DECISION-MAKING: A MULTINATIONAL STUDY OF THE GDPR RIGHT TO MEANINGFUL INFORMATION
Dexe, J., Franke, U., Söderlund, K., van Berkel, N., Jensen, R. H., Lepinkäinen, N., & Vaiste, J. (2022). *Geneva Papers on Risk and Insurance - Issues and Practice, 47*(3), 669-697. https://doi.org/10.1057/s41288-022-00271-9

FACTORS AFFECTING INTER-RATER AGREEMENT IN HUMAN CLASSIFICATION OF EYE MOVEMENTS
Friedman, L., Prokopenko, V., Djanian, S., Katrychuk, D., & Komogortsev, O. V. (2022). Factors affecting inter-rater agreement in human classification of eye movements: a comparison of three datasets. *Behavior Research Methods.* https://doi.org/10.3758/s13428-021-01782-4

BIOMETRIC PERFORMANCE AS A FUNCTION OF GALLERY SIZE
Friedman, L., Stern, H., Prokopenko, V., Djanian, S., Griffith, H., & Komogortsev, O. (2022). Biometric Performance as a Function of Gallery Size. *Applied Sciences, 12*(21), [11144]. https://doi.org/10.3390/app122111144

ECONOMIC HEAT CONTROL OF MIXING LOOP FOR RESIDENTIAL BUILDINGS SUPPLIED BY LOW-TEMPERATURE DISTRICT HEATING
Golmohammadi, H., & Larsen, K. G. (2022). Economic heat control of mixing loop for residential buildings supplied by low-temperature district heating. *Journal of Building Engineering, 46*, 1-14. [103286]. https://doi.org/10.1016/j.jobe.2021.103286

VERIFIABLE STRATEGY SYNTHESIS FOR MULTIPLE AUTONOMOUS AGENTS
Gu, R., Jensen, P. G., Poulsen, D. B., Seceleanu, C., Enoiu, E., & Lundqvist, K. (2022). Verifiable strategy synthesis for multiple autonomous agents: a scalable approach. International Journal on Software Tools for Technology Transfer, 24(3), 395-414. https://doi.org/10.1007/s10009-022-00657-z

CORRECTNESS-GUARANTEED STRATEGY SYNTHESIS AND COMPRESSION FOR MULTI-AGENT AUTONOMOUS SYSTEMS
Gu, R., Jensen, P. G., Seceleanu, C., Enoiu, E., & Lundqvist, K. (2022). Correctness-guaranteed strategy synthesis and compression for multi-agent autonomous systems. *Science of Computer Programming, 224*, [102894]. https://doi.org/10.1016/j.scico.2022.102894

VISUALISING THE EFFECTS OF ONTOLOGY CHANGES AND STUDYING THEIR UNDERSTANDING WITH CHIMP
Pernisch, R., Dell'Aglio, D., Serbak, M., Gonçalves, R. S., & Bernstein A. (2022). Visualising the effects of ontology changes and studying their understanding with ChImp. *Journal of Web Semantics, 74:* [100715]. https://doi.org/10.1016/j.websem.2022.100715

A FRAMEWORK FOR DIFFERENTIALLY-PRIVATE KNOWLEDGE GRAPH EMBEDDINGS
Han, X., Dell'Aglio, D., Grubenmann, T., Cheng, R., & Bernstein, A. (2022). A framework for differentially-private knowledge graph embeddings. *Journal of Web Semantics, 72*, [100696]. https://doi.org/10.1016/j.websem.2021.100696

ASSIGNING DIAGNOSIS CODES USING MEDICATION HISTORY
Hansen, E. R., Sagi, T., Hose, K., Lip, G. Y. H., Larsen, T. B., & Skjøth, F. (2022). Assigning Diagnosis Codes Using Medication History. *Artificial Intelligence in Medicine, 128*(1), [102307]. https://doi.org/10.1016/j.artmed.2022.102307

A FOUNDATION FOR SPATIO-TEXTUAL-TEMPORAL CUBE ANALYTICS
Iqbal, M., Lissandrini, M., & Pedersen, T. B. (2022). A foundation for spatio-textual-temporal cube analytics. *Information Systems, 108*, [102009]. https://doi.org/10.1016/j.is.2022.102009

FROM BIG DATA TECHNOLOGIES TO BIG DATA BENEFITS
Jensen, M. H., Nielsen, P. A., & Persson, J. S. (2023). From Big Data Technologies to Big Data Benefits. *Computer*.

UNITE - THE BEST OF BOTH WORLDS - UNIFYING FUNCTION-FITTING AND AGGREGATION-BASED APPROACHES TO TRAVEL TIME AND TRAVEL SPEED ESTIMATION.
Jepsen, T. S., Jensen, C. S., & Nielsen, T. D. (2022). UniTE - The Best of Both Worlds - Unifying Function-Fitting and Aggregation-Based Approaches to Travel Time and Travel Speed Estimation. *Transactions on Spatial Algorithms and Systems, 8*(4), [30]. https://doi.org/10.1145/3517335

ROBUST AND EXPLAINABLE AUTOENCODERS FOR UNSUPERVISED TIME SERIES OUTLIER DETECTION - EXTENDED VERSION.
Kieu, T., Yang, B., Guo, C., Jensen, C. S., Zhao, Y., Huang, F., & Zheng, K. (2022). Robust and Explainable Autoencoders for Unsupervised Time Series Outlier Detection - Extended Version. *CoRR, abs/2204.03341*. https://doi.org/10.48550/arXiv.2204.03341

METAGENOMIC BINNING WITH ASSEMBLY GRAPH EMBEDDINGS
Lamurias, A., Sereika, M., Albertsen, M., Hose, K., & Nielsen, T. D. (2022). Metagenomic binning with assembly graph embeddings. *Bioinformatics, 38*(19), 4481-4487. https://doi.org/10.1093/bioinformatics/btac557

SPATIAL DATA ANALYSIS FOR INTELLIGENT BUILDINGS
Li, H., Liu, T., Chan, H. K. H., & Lu, H. (2022). Spatial data analysis for intelligent buildings: Awareness of context and data uncertainty. *Frontiers in Big Data, 5*, [1049198]. https://doi.org/10.3389/fdata.2022.1049198

MOBILITY DATA SCIENCE (DAGSTUHL SEMINAR 22021).
Mokbel, M. F., Sakr, M. A., Xiong, L., Züfle, A., Almeida, J. M., Anderson, T., Aref, W. G., Andrienko, G. L., Andrienko, N. V., Cao, Y., Chawla, S., Cheng, R., Chrysanthis, P. K., Fei, X., Ghinita, G., Graser, A., Gunopulos, D., Jensen, C. S., Kim, J-S., ... Zimányi, E. (2022). Mobility Data Science (Dagstuhl Seminar 22021). *Dagstuhl Reports, 12*(1). https://doi.org/10.4230/DAGREP.12.1.1

HIGH-LEVEL ETL FOR SEMANTIC DATA WAREHOUSES
Nath, R. P., Romero, O., Pedersen, T. B., & Hose, K. (2022). High-level ETL for semantic data warehouses. *Semantic Web, 13*(1), 85-132. https://doi.org/10.3233/SW-210429

FROM ANECDOTE TO EVIDENCE
Russo, D., Masegosa, A. R., & Stol, K. J. (2022). From anecdote to evidence: the relationship between personality and need for cognition of developers. Empirical Software Engineering, 27(3), [71]. https://doi.org/10.1007/s10664-021-10106-1

NON-DYADIC INTERACTION
Schneiders, E., Cheon, E., Kjeldskov, J., Rehm, M., & Skov, M. B. (2022). Non-Dyadic Interaction: A Literature Review of 15 Years of Human-Robot Interaction Conference Publications. *ACM Transactions on Human-Robot Interaction, 11*(2), [13]. https://doi.org/10.1145/3488242

RELATIONAL FUSION NETWORKS
Skovgaard Jepsen, T., Jensen, C. S., & Nielsen, T. D. (2022). Relational Fusion Networks: Graph Convolutional Networks for Road Networks. *IEEE Transactions on Intelligent Transportation Systems, 23*(1), 418-429. [9167450]. https://doi.org/10.1109/TITS.2020.3011799

SPEEDING UP REACHABILITY QUERIES IN PUBLIC TRANSPORT NETWORKS USING GRAPH PARTITIONING
Tesfaye, B., Augsten, N., Pawlik, M., Böhlen, M. H., & Jensen, C. S. (2022). Speeding Up Reachability Queries in Public Transport Networks Using Graph Partitioning. *Information Systems Frontiers, 24*(1), 11–29. https://doi.org/10.1007/s10796-021-10164-2

INITIAL RESPONSES TO FALSE POSITIVES IN AI-SUPPORTED CONTINUOUS INTERACTIONS
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