RESEARCH GROUP

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Knowledge-based And Context-aware Adaptive Systems

The ADAPT group develops technologies, including algorithms, methods, tools, applications and platforms, for building human-centered, highly personalised software systems with adaptation capabilities for situation awareness and autonomous problem-solving in Cyber-Physical-Social Systems.
Our research is at the crossroad of Distributed Artificial Intelligence, Human Computer Interaction and Cognitive Computing, focusing on Knowledge Engineering and Symbolic AI, Multi-Agent Systems, Human and Context Awareness and Internet of Things, supported by Edge and Cloud computing. Building on our main expertise fields, we investigate several research challenges as listed below, and we explore new research areas such as:

- The Human Digital Twin, modelling all relevant aspects (skills, body fatigue, etc.) of humans that are part of a Smart Environment, to allow a true human-in-the-loop approach for Digital Twins.
- Agent-based Cognitive IoT, Distributed and Collective AI and Distributed cognitive Systems, to bring collective intelligence capabilities to connect things, increasing their autonomy and decision-support possibilities. Increase resilience, avoid single point of failure of centralized, cloud-based analysis and control.
- Hybrid logic-based – Machine Learning (ML) approaches, exploring the mix of knowledge representation / reasoning and other AI approaches (Intelligent Agents, Neural Networks) including ML techniques, for example when not enough training data is available for deep learning, or explanations are desired for agent decisions.

Main expertise fields:

- Cyber-Physical Social Systems and Systems theory
- Personalised recommender systems (graph and semantic –based)
- User Modelling
- Knowledge modelling and formalisation (Ontologies, Knowledge graphs)
- Knowledge Representation and reasoning
- Knowledge discovery, revision, evolution, fusion
- Natural Language Processing for Knowledge Management
- Multi-Agent Systems

OUR RESEARCH CHALLENGES

- How to design computer systems that are able to self-adapt to users and context, taking into account the dynamics and complexity of multi-user environments and heterogeneous knowledge sources?
- How to handle systems impacted by the behaviour of individuals, balancing the interests of the individuals and the system?
- What model for a human digital twin to implement the human-in-the-loop paradigm in smart environments?
- How to manage knowledge graphs and knowledge-based reasoning in dynamic and distributed systems?
- How to bring cognition capabilities to IoT objects in complex cyber-physical-social spaces, supported by hybrid edge-cloud IT infrastructures, to ensure natural interaction with humans?
- How can Multi-Agent Systems and Knowledge-based Reasoning support cognition and collaborative intelligence in Cyber-Physical and Social systems?

APPLICATION areas:

- Health Techs
- Industry 4.0/5.0
- Education Technologies
- Digital Twin
- ICT
- RegTechs

Main projects:

- CognitiveIoT (Intelligent Agents for IOT, LIST, 2020, Coordinator) – Cognitive IoT, Human Digital Twin, Agent platforms for IoT and Digital Twin, Human-Cognitive Thing Interaction
- Maisa (Maintenance of Semantic Annotations 2, FNR PoC, 2020, Coordinator) – Ontology evolution
- LIFANA (Lifelong Food and Nutrition Assistance, AAL Programme, 2M€, 2018-2020, Coordinator) – Personalised meal recommendations, food knowledge graph, automated recipe processing with WikiFood tools
  https://www.list.lu/en/research/project/lifana/
- CrossCult (Empowering reuse of digital cultural heritage in context-aware crosscuts of European history, H2020, 3.7MEur, 2016-2019, Coordinator) – Personalised crowd systems, smart guiding, Knowledge-Based Recommender Systems, Micro-services Cloud Platform
- LIFE AskREACH (EU LIFE Programme). See also this link
- Elisa (Evolution of Semantic Annotations, FNR CORE, 2015-2018, Coordinator) – Semantic interoperability, Semantic Web, Ontology evolution, semantic annotation, medical informatics
- Goliath (Goal Oriented Layered system for Interoperable Activities of Things, 2014-2016, 211KEur, FNR-INTER PoLux, Coordinator) – Context-awareness, Intelligent IoT, Smart Home, Multi-Agent Systems

Main assets:

- Micro-services cloud platform (applied in CrossCult and AskREACH) (TRL8-9)
- Dynaccurate ontology management platform (for hospitals) (TRL5-6)
  https://2019.semantics.cc/dynaccurate-%E2%80%93-tool-deal-evolution-terminologies-mappings-and-semantic-annotations
  https://www.fnr.lu/projects/maintenance-of-semantic-annotations-2/
  https://www.elisa-project.lu
  https://www.list.lu/en/technology-portfolio/technology/dykosmap/
- Multi-Agent Systems for smart objects in smart homes (TRL2-3)
  https://www.list.lu/en/research/tis/project/goliath/
- Knowledge and graph–based algorithm for object and path recommendation (TRL5)
- Personalised Mobile apps (e.g. museum visit, city/POI discovery, gender-awareness for teachers, scan4Chem app) (TRL5-6)
  https://play.google.com/store/apps/details?id=eu.crosscult.pilot1.ng&hl=en_US
  https://play.google.com/store/apps/details?id=eu.crosscult.p4&hl=en_US
  https://www.genderdstem-project.eu/teaching-assistant#the-genderdstem-recommender-system/https://www.askreach.eu/app/
- WikiFood tools for food product ingredient analysis and automated cooking recipe processing (TRL5-6)
  https://www.lifana.eu/ (https://www.list.lu/en/research/project/lifana/)
- WikiFood platform
  https://www.list.lu/fr/technologies/technologie/wikifood/
- AskREACH platform:
  https://www.askreach.eu

Selected publications:

- Bereket Abera Yilma, Hervé Panetto, and Yannick Naudet. "Systemic formalisation of Cyber-Physical-Social System (CPSS): A systematic literature review". In Computers in Industry, Volume 129 :103458, April 2021.
- Bereket Abera Yilma, Yannick Naudet and Hervé Panetto. "Personalisation in Cyber-Physical-Social Systems: A Multi-stakeholder aware Recommendation and Guidance,". In the proceedings of the 29th ACM Conference on User Modeling, Adaptation and Personalization (UMAP '21), June 2021, Utrecht, Netherlands.
- Cardoso, S. D., Da Silveira, M., & Pruski, C. (2020). Construction and exploitation of an historical knowledge graph to deal with the evolution of ontologies. *Knowledge-Based Systems*, 105508.

https://www.sciencedirect.com/science/article/abs/pii/S0950705120300241

- C. Stahl, B. Gateau and K. Ferrini, "Experiments on the localisation of cooking recipes content using semantic food descriptions.," *2020 15th International Workshop on Semantic and Social Media Adaptation and Personalization (SMAP2020*, Zakynthos, Greece, 2020, pp. 1-5, doi: 10.1109/SMAP49528.2020.9248466.
- K. Ferrini, C. Stahl, T. Bohn, The lifana solution: a mobile health personalized nutrition application for promoting healthy diet in elderly people,Clinical Nutrition ESPEN, Volume 40, 2020, Page 586, ISSN 2405-4577, https://doi.org/10.1016/j.clnesp.2020.09.539
- Dimitra Anastasiou, Lou Schwartz, Alexandre Baudet, and Yannick Naudet. 2020. The Role of the Human User in the Cognitive Internet of Things. In Proceedings of the 8th International Conference on Human-Agent Interaction (HAI '20). Association for Computing Machinery, New York, NY, USA, 275–277. DOI:https://doi.org/10.1145/3406499.3418762
- Martin Lopez-Nores, Tsvi Kuflik, Manolis Wallace, Yannick Naudet, Special Issue on Personalized Delivery of Cultural Heritage Content, User Modeling and User-Adapted Interaction (UMUAI), Vol.29, Issue 1, March 2019. ISSN: 0924-1868 (Print) 1573-1391 (Online) https://link.springer.com/journal/11257?wt_mc=alerts.TOCjournals&utm_source=toc&utm_medium=email&utm_campaign=toc_11257_29_1
- Andreas Arens-Volland, Patrick Gratz, Alexandre Baudet, Louis Deladiennée, Marie Gallais and Yannick Naudet, "Personalized Recommender System for Improving Gender-fairness in Teaching", in Proc. of the 14th Int. Workshop on Semantic and Social Media Adaptation and Personalization (SMAP2019), 9-10 June, 2019, Larnaca, Cyprus.
- Benjamin Gâteau. A smart IoT middleware for comfort management based on Multi-Agent-System. WASA@WIMS 2018, Novi Sad, Serbia. ACM, 2018 DOI: 10.1145/3227609.322768.
- Eric Ras, Fridolin Wild, Christoph Stahl, and Alexandre Baudet. 2017. Bridging the Skills Gap of Workers in Industry 4.0 by Human Performance Augmentation Tools: Challenges and Roadmap. In Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '17). Association for Computing Machinery, New York, NY, USA, 428–432. DOI:https://doi.org/10.1145/3056540.3076192
- Zamborlini, V., Hoekstra, R., Da Silveira, M., Pruski, C., Ten Teije, A., & Van Harmelen, F. (2016). Inferring recommendation interactions in clinical guidelines 1. *Semantic Web*, *7*(4), 421-446.

http://semantic-web-journal.org/system/files/swj1145.pdf

- Jarogniew Rykowski and Benjamin Gâteau. Home Computer Network: A New Way of Networking for DIY Internet of Things. International Journal of Sensors, Wireless Communications and Control, 6(3): pp. 201-215, 2016. DOI: 10.2174/2210327906666160923162152
- Mezghani, E., Exposito, E., Drira, K. *et al.* A Semantic Big Data Platform for Integrating Heterogeneous Wearable Data in Healthcare. *J Med Syst* 39, 185 (2015). https://doi.org/10.1007/s10916-015-0344-y https://link.springer.com/article/10.1007/s10916-015-0344-x

- Dos Reis, J. C., Pruski, C., Da Silveira, M., & Reynaud-Delaître, C. (2015). DyKOSMap: A framework for mapping adaptation between biomedical knowledge organization systems. *Journal of biomedical informatics*, *55*, 153-173.

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- Yannick Naudet, Angeliki Antoniou, Ioanna Lykourentzou, Eric Tobias, Jenny Rompa, George Lepouras, *Museum Personalization Based on Gaming and Cognitive Styles: The BLUE Experiment*, International Journal of Virtual Communities and Social Networking (IJVCSN), Special Issue on Social Media and Networks for Multimedia Content Management, pages (23), April-June 2015, Vol.7, No.2, 2015.
- Benjamin Gâteau, Moussa Ouedraogo, Christophe Feltus, Guy Guemkam, Grégoire Danoy, Marcin Seredynski, Samee U. Khan, Djamel Khadraoui and Pascal Bouvry (2015). Adopting trust and assurance as indicators for the reassignment of responsibilities in multi-agent systems. The Knowledge Engineering Review, 30, pp 187-200. DOI:10.1017/S0269888914000290.

Partners

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