

## Human Modelling



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 behavior 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:

- **CognitveIoT** (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
- **LIFAMA** (Lifelong Food and Nutrition Assistance, AAL Programme, 2IME, 2018-2020, Coordinator) – Personalised meal recommendations, food knowledge graph, automated recipe processing with WikiFood tools <https://www.list.lu/en/research/projects/lifama/>
- **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 <https://www.list.lu/en/research/projects/crosscult/>
- **LIFE** (AskReACH) (EU LIFE Programme). See also <https://www.list.lu/en/research/projects/life/>
- **StimE** (Evolution of Semantic Annotations, FNR CoE, 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, 213KEur, FNR-INTER PaLux, Coordinator) – Context-awareness, Intelligent IoT, Smart Home, Multi-Agent Systems

### Main assets:

- Micro-services cloud platform (applied in CrossCult and AskReACH) (TRL8-9)
- Dynacurate ontology management platform (for hospitals) (TRL8-6) <https://2019.semanticweb.org/ontologies/2019/05/ontology-terminologies-mappings-and-semantic-annotations/> <https://www.fr.fr/la/research/maintenance-of-semantic-annotations-2/> <https://www.elisa-project.eu/>
- <https://www.list.lu/en/research/projects/crosscult/>
- Multi-Agent Systems for smart objects in smart homes (TRL2-3) <https://www.list.lu/en/research/projects/crosscult/>
- 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.elisa\\_mobile\\_en\\_US](https://play.google.com/store/apps/details?id=eu.crosscult.elisa_mobile_en_US) <https://www.generatedata.com/ai/research/askre-ach-the-personalized-recommender-system/> <https://www.askre-ach.eu/>
- WikiFood tools for food product, ingredient analysis and automated cooking recipe processing (TRL5-6) <https://www.list.lu/en/> (<https://www.list.lu/en/research/projects/lifama/>)
- WikiFood platform <https://www.list.lu/fr/research/projects/wikifood/>
- AskReACH platform: <https://www.askre-ach.eu/>

### Selected publications:

- Bereket Abera Yima, 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 Yima, 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*, 195508. <https://www.sciencedirect.com/science/article/pii/S09502688203120204>
- C. Stahl, B. Goléati and K. Ferrini, "Experiments on the localisation of cooking recipes content using semantic food descriptions.", 2002 15th International Workshop on Semantic and Social Media Adaptation and Personalization (SMAP'2002), Zakynthos, Greece, 2002, pp. 1-5, doi: 10.1109/SMAP49528.2020.9248466.
- K. Ferrini, C. Stahl, T. Bohm, The Ifilana 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 Anastasio, 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-Norris, Tsvi Kuflik, Manolis Wallace, Yannick Naudet. Special Issue on Personalized Delivery of Cultural Heritage Contents, User Modeling and User-Adapted Interaction (UMUAI), Vol.29, Issue 1, March 2019. ISSN: 1024-1868 (Print) 1373-1391 (Online) <https://link.springer.com/journal/11257/91> [http://www.mediaweb.org/semantic/sem-educ/sem-educ-camp/sem-educ-camp-11257\\_29\\_1](http://www.mediaweb.org/semantic/sem-educ/sem-educ-camp/sem-educ-camp-11257_29_1)
- Andreas Arens-Volland, Patrick Gratz, Alexandre Baudet, Louis Deladèrenne, 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. WASAQWMS 2018. Novi Sad, Serbia. ACM, 2018. DOI: 10.1145/3227609.322768.
- Eric Ras, Frédéric Wieg, 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>
- Zamborini, 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/w7i4\\_145.pdf](http://semantic-web-journal.org/system/files/w7i4_145.pdf)
- Jangiraj Pykowlak and Benjamin Gâteau. Home Computer Network: A New Way of Networking for DRI Internet of Things. *International Journal of Sensors, Wireless Communications and Control*, 6(3), pp. 201-215, 2016. DOI: 10.1214/210279066616092162152
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- Benjamin Gâteau, Mousse Ouedraogo, Christophe Feltes, Guy Guemkam, Grégoire Danoy, Marcin Serdyński, Sameer U. Khan, Djamel Khadirou 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/S026889914000290.

## Partners

The National College UK, University of Peloponnese GR, University of Vigo SP, University College London UK, CRAN, University of Lorraine FR, INTEROP-VLab EU, VU Amsterdam NL, Universität Paris-Saclay FR, DFKI DE, LIH

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