



CHIST-ERA Projects Seminar 2022



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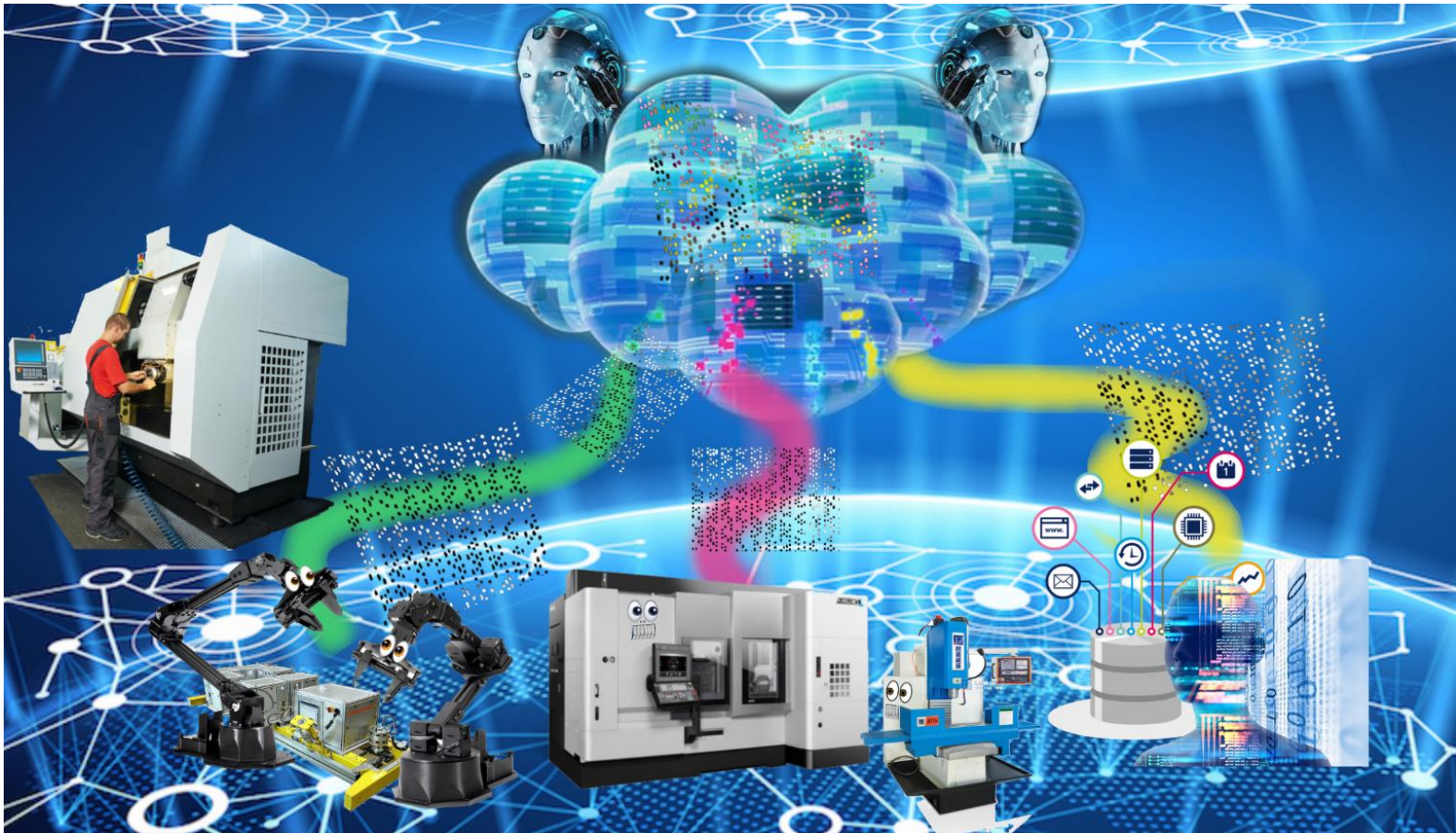
March 29, 2022



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Scientific background

SOON: Social network of machines

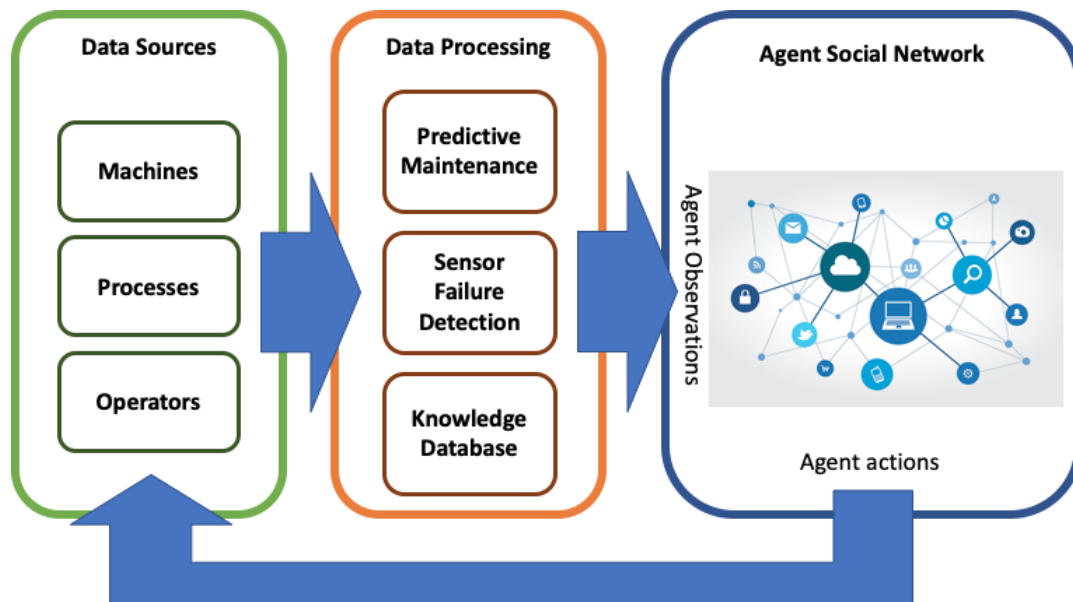


Scientific background

- **Context: Industry 4.0**
- **Goal:**
 - Optimization of industrial flows and processes
 - Reduce impact of failures
 - Design of evaluation benchmark
- **How**
 - Social Multi-Agent System (MAS)
 - **Machines, sensors and operators modelled as Agents**
 - Big data technology and Machine Learning
 - Models for *predictive maintenance*
- **3 applied industrial scenarios**
 - Machine tools: precision mechanics
 - Recycling industry: plastics recycling
 - Steel-making: wire rod and hot strip mills



Key challenges and potential impact of the project



Challenges:

- MAS design
- Predictive and smart maintenance
- Early failure detection, including sensors failure
- Efficient failure mitigation (knowledge database)

Impacts:

- Reduction of unplanned production downtime
- Intelligent guide for human operators
- Production lines autonomization

4 Academic partners



Universidad de Oviedo



UNIVERSITATEA DE MEDICINĂ,
FARMACIE, ȘTIINȚE ȘI TEHNOLOGIE
„GEORGE EMIL PALADE”
DIN TÂRGU MUREȘ

3 Industrial partners

TORNOS



ArcelorMittal



HE-Arc (HES-SO) - Project Coordinator

- Data analytics group: AI & Machine learning
- Experience with AI applied to machine tools' processes and predictive maintenance algorithms
- Industrial Partner: Tornos



Institute of Informatics of the Slovak Academy of Sciences

- Research Groups: Parallel and Distributed Computing & Modelling and Control of Discrete Processes
- Expertise: AI, intelligent agents, data collection & aggregation
- Industrial Partner: Mat-Obaly Ltd.



Universidad de Oviedo

University of Oviedo

- Project Engineering Research Group: multidisciplinary research group (project management / sustainable engineering / data modelling)
- Expertise: process modelling and data analysis for the industrial sector
- Industrial Partner: ArcelorMittal



UNIVERSITATEA DE MEDICINĂ,
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DIN TÂRGU MUREȘ

University of Medicine, Pharmacy, Science and Technology of Târgu Mureș

- Research group: Industrial Informatics, Industrial Processes Modeling and Control and Intelligent systems
- Expertise: Computational Intelligence, Data Acquisition and Signal Processing
- Lead the activities in cyber-physical modelling and testbed development.

TORNOS

Tornos is a Swiss tool machines manufacturer. Tornos uses a range of machining technologies with swarf removal capabilities to produce parts requiring extreme precision and quality.



MAT-obaly is a Slovak plastic trading and recycling company. It operates its own LDPE plastic sorting and recycling plant. It's products are symbolized by high quality and reliability delivered to domestic and foreign partners. It emphasizes environmental protection practices by fair recycling of plastic.



ArcelorMittal is the world's leading steel and mining company. Guided by a philosophy to produce safe, sustainable steel, it is the leading supplier of quality steel products in all major markets including automotive, construction, household appliances and packaging. ArcelorMittal is present in 60 countries and has an industrial footprint in 18 countries.



Main scientific results, dissemination and other output

Main scientific results

- **Multi-agent “social” architectures**
 - Auction/bidding concept
 - Reinforcement learning
- **Predictive maintenance & Sensor failure detection algorithms**
 - Predict components wear (tools, rolls, etc.)
 - Detect sensor failures using streaming data & algorithms
- **Industrial perspective:** knowledge database
- **Open dataset** with failure data to share with the scientific community (publication is ongoing)

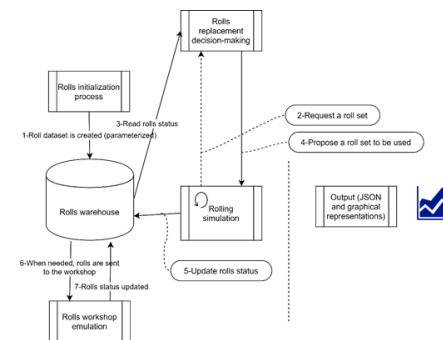
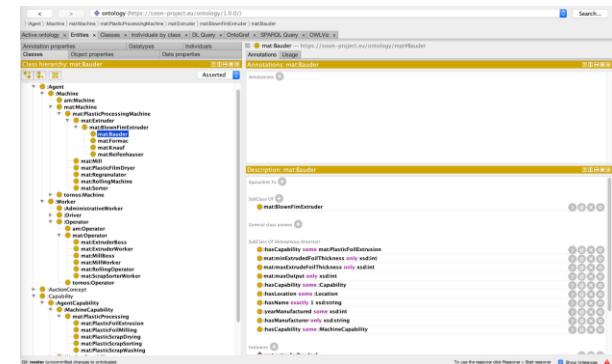
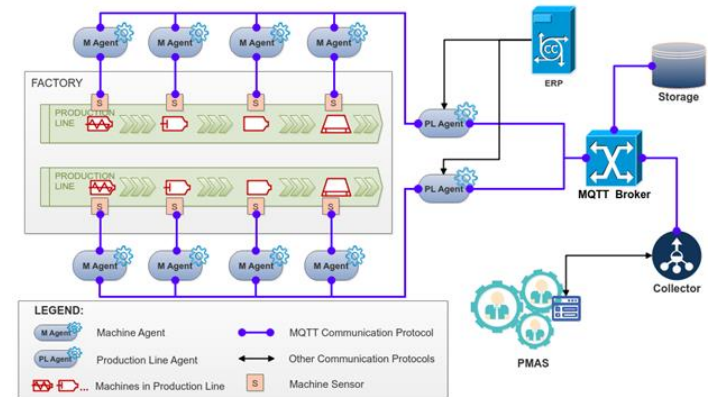




Main scientific results, dissemination and other output

Main scientific results (details)

- **SOON Ontology** (Core + 3 Domain Specific Extensions for Use Cases) w/ social concepts
- Novel **auction/bidding approach** for maximizing the factory production (Real-Time Scheduling of Manufacturing) & **Reinforcement Learning** solution
- **Simulation** of 3 industrial processes using auction agents/RL approaches
- **Software multi-agent architecture** for deployment of agents
- Wire rod mill rolls replacement model using a modified **asynchronous backtracking algorithm (ABT)** approach

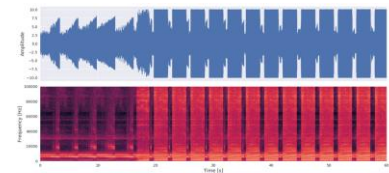




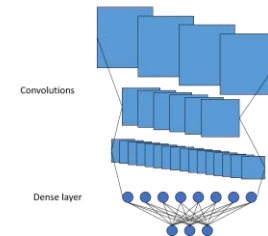
Main scientific results, dissemination and other output

Main scientific results (details)

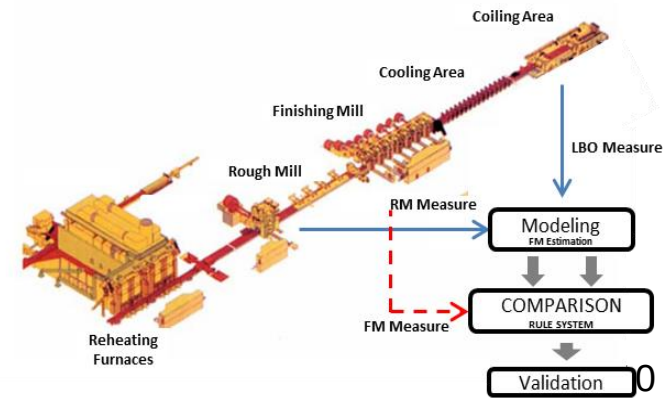
- Machining quality and **tool wear prediction** using AI & multiple data sources (inertial sensors, acoustic emissions and currents)
- **Automatic sensor failure detection** algorithms using **online ML**
- Testbed for electric motor fault detection + **public dataset** (ongoing)
- **Knowledge database** built upon past maintenance interventions to forecast future needs
- **Novel metrics** for measuring machine intelligence



Signal processing



Convolutional analysis of spectrograms





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Main scientific results, dissemination and other output

Dissemination and other output

- Organization of International Workshops: 1st and 2nd International Workshop on Smart Technologies in Industry 4.0 (Rationality 2020) and (Rationality 2022)
 - Joint organization with the FIREMAN Chist-Era project
 - Further editions will be organized
- Editing special issue in *Mathematics* (ISSN 2227-7390), IF 2.258, Q1
 - https://www.mdpi.com/journal/mathematics/special_issue/s/Industrial_Big_Data_Process_Modelling_Smart_Manufacturing
 - Call open until August '22
 - Contributions from other Chist-Era projects welcomed 😊
- CHIST-era video competitions (x2)



SOON
Social Network of Machines

Publications

- ❖ Iantovics, L.B.; Kovacs, L.; Rotar, C.: MeasApplInt - a novel intelligence metric for choosing the computing systems able to solve real-life problems with a high intelligence, *Applied Intelligence*, 49(10), 2019, 3491-3511.
- ❖ Gligor, A., Vlasa, I., Dumitru, C. D., Moldovan, C. E., & Damian, C. (2020). Power demand forecast for optimization of the distribution costs. *Procedia Manufacturing*, 46, 384-390.
- ❖ Iantovics, L.B.; Kountchev, R.; Crişan, G.C.: ExtrIntDetect-A New Universal Method for the Identification of Intelligent Cooperative Multiagent Systems with Extreme Intelligence, *Symmetry*, 11(9), 2019, 1123.
- ❖ Iantovics, L.B.; Rotar, C.; Morar, F.: Survey on establishing the optimal number of factors in exploratory factor analysis applied to data mining, *Wiley Interdisciplinary Reviews- Data Mining and Knowledge Discovery*, 9(2), 2019, e1294.
- ❖ Kenyeres M.; Kenyeres J.: Data Aggregation in Mobile Wireless Sensor Networks Represented as Stationary Edge-Markovian Evolving Graphs, Volume 25, Issue 1, 24 June 2019, 25th International Conference on Soft Computing, MENDEL 2019; Brno; Czech Republic. Code 150403
- ❖ Kenyeres M.; Kenyeres J.: On Performance Evaluation of Distributed System Size Estimation Executed by Average Consensus Weights, Volume 25, Issue 1, 24 June 2019, 25th International Conference on Soft Computing, MENDEL 2019; Brno; Czech Republic. Code 150403
- ❖ Junquera, A. M. V., González, J. G., Balsera, J. M. V., & Montequín, V. R. (2020). A Wire Rod Rolling Mill Digital Twin for the Simulation of the Rolls Replacement Process. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 63, No. 1, p. 13).
- ❖ Bustamante Arias, L., Rodríguez Montequín, V., Villanueva Balsera, J., Mones Bayo, A. (2020). Methodology for the Integration of Data-Based Models in Production Environments. In *Dortmund International Research Conference 2020 Proceedings*

Publications

- ❖ Carrino, S., Guerne, J., Dreyer, J., Ghorbel, H., Schorderet, A., & Montavon, R. (2020). Machining quality prediction using acoustic sensors and machine learning. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 63, No. 1, p. 31). <https://www.mdpi.com/2504-3900/63/1/31>
- ❖ Iantovics, L.B. Black-Box-Based Mathematical Modelling of Machine Intelligence Measuring, *Mathematics* 2021, 9(6), 681.
- ❖ Vlasa, I.; Gligor, A.; Dumitru, C.D.; Iantovics, L.B.: Smart Metering Systems Optimization for Non-Technical Losses Reduction and Consumption Recording Operation Improvement in Electricity Sector, *Sensors* 2020, 20(10), 2947;
- ❖ R. Kumar, I. Budinska, Z. Balogh, E. Gatial and T. Matejka, "Discrete event simulation approach for evaluation and estimation of various production parameters," 2020 IEEE 20th International Symposium on Computational Intelligence and Informatics (CINTI), Budapest, Hungary, 2020, pp. 91-98, doi: 10.1109/CINTI51262.2020.9305850.
- ❖ E. Gatial, Z. Balogh and L. Hluchý, "Concept of Energy Efficient ESP32 Chip for Industrial Wireless Sensor Network," 2020 IEEE 24th International Conference on Intelligent Engineering Systems (INES), Reykjavík, Iceland, 2020, pp. 179-184, doi: 10.1109/INES49302.2020.9147189.
- ❖ Junquera, A. M. V., Montequín, V. R., Balsera, J. M. V., & González, J. G. (2022). Asynchronous Backtracking variant applied to a rolls replacement process within a wire rod mill. *Procedia Computer Science*, 196, 159–166.
- ❖ Valdeón Junquera, A. M., Rodríguez Montequín, V., Villanueva Balsera, J. M., & García González, J. (2021). MULTI-AGENT ARCHITECTURE BASED ON AUCTION PROTOCOL FOR A WIRE ROD MILL ROLLS REPLACEMENT SYSTEM. *25th International Congress on Project Management and Engineering, Alcoi, Spain*.
- ❖ Ghorbel, H., Dreyer, J., Abdalla, F., Montequín, V. R., Balogh, Z., Gatial, E., ... & Carrino, S. (2021, September). SOON: Social Network of Machines to Optimize Task Scheduling in Smart Manufacturing. In *2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)* (pp. 1-6). IEEE.



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Sustainability/Technology Transfer/Exploitation

- Direct exploitation by the Industrial partners
 - ArcelorMittal, Mat-Obaly & Tornos
- Integration with the *Micro-lean lab* in Switzerland
 - microleanlab.ch/en
 - Long term project (2030+)
- OpenLab Industry 4.0 for Design, Testing and Evaluation
- Research Center on Artificial Intelligence, Data Science and Smart Engineering (Artemis) from the frame UMFST
- RaD national level projects in the same domain with (other) industrial partners (predictive maintenance, tool wear prediction, etc.)



<https://microleanlab.ch/>



SOON

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Sustainability/Technology Transfer/Exploitation

- Digital Innovation Hubs (1st evaluation ok, participation in progress)
 - Futures of Innovation and Technology (FIT)
- Collaboration with FIREMAN CHIST-Era project
- Open data & open source code of experimental modules and algorithms
 - Real process open data of electric motors and drives systems labeled for different statuses in clear or noisy environment
- Novel classes and teaching activities (student projects, etc.)
 - “Predictive maintenance” class
- An active team:
 - Industrial Social Network of Humans, Robots and Machines for Safe Collaborative Smart Manufacturing (MachiNet)
 - Tactile imaging for quantitative examination of the tissue stiffness and elasticity (HapTouch)



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Thank you!

For any question:
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Or <https://soon-project.eu/contact.html>