EURIPIDES² Penta

CO-LABEL

PROJECT PROFILE

2021028

ECOMAI [Ecological Motor Control and Predictive Maintenance with AI]

Electric motors are everywhere from laptop fans and dishwashers to industrial machinery, robots, public transport and more. A modern car can alone contain about 40 motors for various functions. But these valuable uses come at a cost. It has been calculated that electric motors account for 40% of worldwide power consumption and 20% of CO^2 emissions[1].

To address these issues, the ECOMAI project is developing technologies that enhance electric motor drive systems with an embedded AI system running on a specialised AI hardware platform. These technologies will optimise the efficiency and lifetime of electric motors, thereby reducing energy consumption and enabling development of more 'ecological' systems. They will also lead to market opportunities for applications in numerous sectors including automotive, medical and transportation.

A vital need

Given that electric motors are so ubiquitous, the potential for longer lifetimes and increased energy efficiency is significant. Some studies suggest energy efficiency gains could be as high as 30%[1].

Cars are a prime use case, but there are many others, such as the industrial sector. In the US, 70% of the total industrial electricity demand is generated by electric motors[2] and many of these are induction motors. Worldwide, 80 % of the total AC motors are induction motors[3] and a large proportion operate in harsh conditions that lead to numerous faults and downtime – in turn leading to economic costs and loss of effectiveness. Proper maintenance along with continuous monitoring, detection, and diagnosis of faults could limit these negative impacts. However, condition monitoring of electrical machines, drives and applications is rare. About 99.99% of all motors do not use a monitoring solution.

In industrial settings, and many other applications, electric motors with embedded AI systems provide an ideal solution for optimising motor control and enabling predictive maintenance (avoiding faults before they occur). AI-based solutions are so effective because they are inherently built on learning to facilitate the best possible response. However, there are few dedicated AI chips for motor control applications available, and none make full use of the possibilities AI offers.

AI-enhancement provides cost-effective, flexible solutions

To fill this gap, ECOMAI aims to enhance motor drive systems with an embedded AI system that can support fine-grain evaluation of the motor and drive state through smart sensing, data interpretation and short-time machine learning (ML), and condition monitoring. This will allow for more fine-tuned motor control and predictive maintenance, and so lower energy demand, reduce downtime and increase electrical drive lifetimes.

Moreover, ECOMAI will focus on developing an 'edge' solution. This will not only allow for operation when there is no connectivity for cloud-based solutions, but it will also keep costs competitive, reduce latency and increase security. The AI functions will be directly integrated in the motor control system using the specialised low-power AI hardware platform. This platform will provide both cost-efficient AI functionality and explore advanced accelerator and approximate computing principles.

Furthermore, ECOMAI will deliver an innovative Model-based Design and Automation Framework: a full development toolkit that combines model-based design and an AI compiler for the specialised hardware platform along with a full system modelling and simulation environment. This will make ECOMAI's technologies easily accessible, particularly for SMEs looking to apply them in specialist areas.

Other specific innovations will include:

- **Specialised motor control AI hardware**, including an AI compiler and TinyML methods for evaluating the performance of the ECOMAI **AI hardware chip prototype**.
- Demonstrations of the **ECOMAI Model Based Framework** implementing certain use cases and new modelling techniques.
- **A test environment for dynamic load change motor control applications.**

The ECOMAI technologies will also be tested in a range of use cases in applications in the transportation, power supply, medical and automotive domains.

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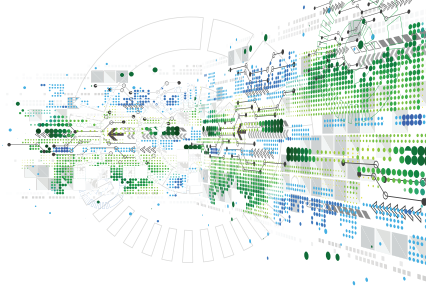

KEY APPLICATION AREAS

- Digital Industry
- Mobility
- Quality, Reliability, Safety and Cybersecurity

ESSENTIAL CAPABILITIES

- Architecture and Design: Methods and Tools
- Artificial Intelligence, Edge Computing and Advanced Control
- Components, Modules and Systems Integration

PARTNERS

ALBAYRAK Makine Elektronik Sanayi ve Ticaret A.S.
FEAAM
Ilmenau University of Technology
Infineon Technologies AG
Moteon GmbH
neuroConn GmbH
SparxSystems Software GmbH
Technical University of Munich
usePAT GmbH

COUNTRIES INVOLVED

- Austria
- Germany
- Turkey

PROJECT LEADER

Fabiola Bermudez-Elsinger
Company : Infineon

KEY PROJECT DATES

Start: 01 May 2022
End: 31 April 2025

'Ecological' use cases:

- An **automotive compressor system** demonstrating the potential of AI to deliver better control performance.
- An **electrical bike testbench** for intelligent sensorless electric bike traction applications, incorporating an AI-based torque control algorithm.
- A **test environment for a robotic rehabilitation system for mobility impaired people**, exploring, amongst other functionality, capabilities for neuro-feedback.

Condition monitoring and predictive maintenance:

- A **railway Platform Screen Door (PSD) system**, including AI-enhanced PdM algorithms and the TinyML edge device developed by ECOMAI to prolong operational availability.
- An ultrasonic traducer, using AI to understand which changes of the driving signal will be the result of certain alterations in a structure or volume when excited by the ultrasound: a motor, a battery or another complex medium for ultrasonic-based condition monitoring.

Collaboration from research to end-products

To meet its ambitious goals, ECOMAI brings together expertise spanning hardware design, edge AI, AI applications, electrical motor drive system design and predictive maintenance. Moreover, with partners ranging from research institutions to suppliers of end-products, the project's innovations will have potential to move quickly into commercial applications.

Growing markets and greener drive systems

Indeed, as there are currently very few motor and drive systems that provide AI enhancements at the drive control level, ECOMAI offers excellent business opportunities. Moreover, by creating a solution based on a specialised AI hardware platform, the project is following the wider move away from GPU AI chips to dedicated ASICs. It is likewise aligned with the shift to edge computing – the market for AI accelerators on the edge / customer premises is predicted to exceed the market for accelerators in the cloud by a factor of 3.5 in 2025[4].

Overall, the market for AI chips, motor control chips and motor systems in general is expected to grow rapidly as electric motor and drive systems are fundamental to all modern systems that involve movement. For instance, the number of electronically controlled electric motors in passenger cars is expected to grow from 2.53 billion motors per year in 2021 (approximately 30 motors per car) to 3.74 billion per year in 2030[5]. More widely, recent studies indicate that the global electric motor sales market will reach 155 billion Euro in 2025, which represents an annual growth rate of almost 8%[6]. All this suggests strong market demand for the technologies delivered by ECOMAI and the products it enables.

Importantly, the ECOMAI project will also contribute to the objectives of the European Green Deal by enabling more 'ecological' solutions now and paving the way to further energy saving options in the future.

In short, ECOMAI offers a basis for Europe to establish a leading role in AI-enhanced electrical motor drive technology – from hardware to applications – through solutions that support the green and digital transitions.

[1] D. W. E. Dr. Patrick Plötz, „Zukunftsmarkt Effiziente Elektromotoren (German), Fraunhofer Institut für System - und Innovationsforschung (ISI)," 10 2011. [Online]. Available: https://www.hannover.ihk.de/fileadmin/data/Dokumente/Themen/Energie/Fallstudie_Elektromotoren.pdf.

[2] L. Bin and V. C. Gungor, "Online and Remote Motor Energy Monitoring and Fault Diagnostics Using Wireless Sensor Networks," IEEE Transactions on Industrial Electronics, vol. 56, no. 11, pp. 4651-4659, 2009.

[3] Z. Hosseinpoor, M. M. Arefi, R. Razavi-Far, N. Mozafari, and S. Hazbavi, "Virtual Sensors for Fault Diagnosis: A Case of Induction Motor Broken Rotor Bar," IEEE Sensors Journal, pp. 1-1, 2020.

[4] Semiconductor Engineering, "AI Chip architectures race to the edge", https://semiengineering.com/ai-chip-architectures-race-to-the-edge/

[5] Based on consolidated market studies from Infineon Technologies AG

[6] https://www.grandviewresearch.com/press-release/global-electric-motor-market

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PENTA purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

EURIPIDES² promotes the generation of innovative, industry-driven, pre-competitive R&D projects in the area of Smart Electronic Systems.