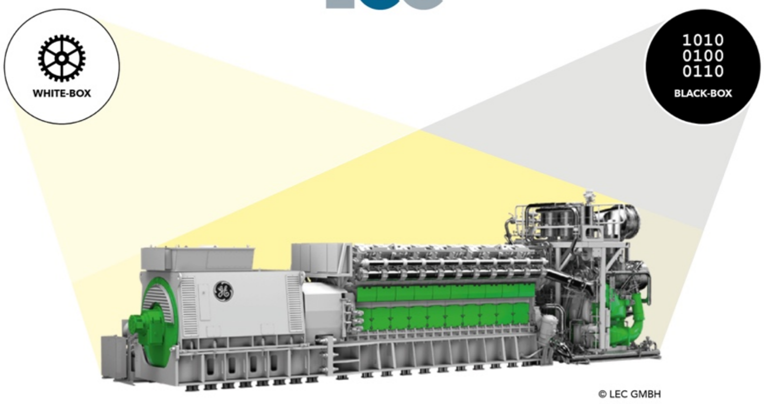
SUCCESS STORY

LEC HybTec
Hybrid Technologies for Enhanced Reliability of Ultra High-performance Engines

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Module

Type of project: strategic
Short title: LEC HybTEc
Duration: 2020-2023



SIGNIFICANT REDUCTION OF 3D CFD SIMULATION COMPUTATION TIME DUE TO HYBRID MODELLING

HYBRID SIMULATION METHODS THAT COMBINE PHYSICAL METHODS WITH DATA-DRIVEN ARTIFICIAL INTELLIGENCE HAVE TREMENDOUS POTENTIAL TO INCREASE EFFICIENCY AND QUALITY, FOR EXAMPLE IN THE SIMULATION OF NEW CONCEPTS FOR LARGE ENGINES.

Today 3D CFD simulations are most commonly used for detailed calculation of highly complex internal engine processes. In order to obtain the most accurate results with these methods, the resolution of the computational grid must be selected correspondingly finely, which can lead to very long computation times of up to several days or even weeks for complex application scenarios. To significantly reduce computation times without loss of quality in the results, the COMET Module LEC HybTec research team uses hybrid modeling as an innovative approach that combines physical and data-driven models. The combination of simulations with coarsely resolved grids with the method of physics-informed neural networks (PINNs) is proving to be a particularly promising method for this type of application.

Physics-informed neural networks (PINNs)

The PINN concept is a new and currently intensively investigated research field with enormous potential for the further develop-

Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology

Federal Ministry Republic of Austria Digital and Economic Affairs

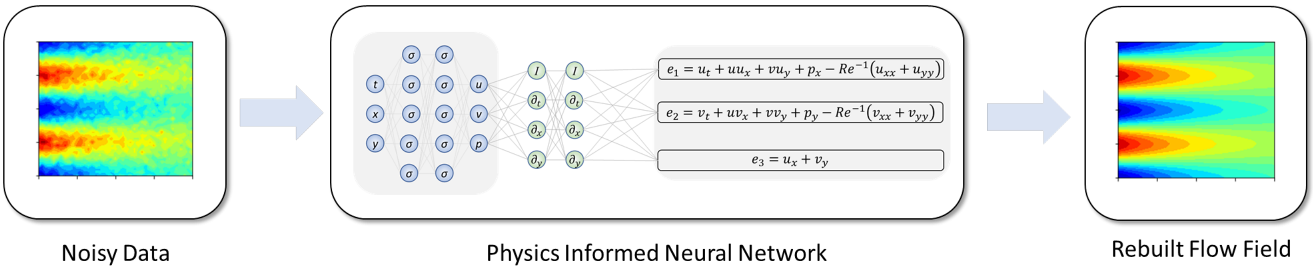
ment of classical simulation methods in numerous scientific disciplines. Based on PINNs, neural networks are coupled with partial differential equations. PINNs allow on the one hand the solution of a boundary/initial value problem by means of a neural network, and on the other hand the parameterization of the differential equation on the basis of available data. This way, high computation times can be shortened tremendously. In addition, the trained model is less dependent on the quality of the training data, so that coarse resolution data can be used to a certain extent without affecting the quality of the results.

Application example: Reconstruction of a flow field

The predictive accuracy of the method was analyzed using a flow field for which an analytical solution exists. In this case, the method was applied in combination with the Navier-Stokes equations, which describe the flow in viscous liquids and gases. The model was trained with synthetically noisy data. The prediction results of the developed hybrid model show that the approach with PINNs is capable of reconstructing flow fields even from highly noisy data. The new method thus offers enormous potential for use in much more complex flow fields, such as those found in engines.

Impacts and effects for sustainable applications in the large engine sector

The transmission of the hybrid approach to extremely dynamic and turbulent conditions in engines will open up new possibilities for simulating highly complex internal engine processes such as knocking, misfiring and cycle-to-cycle variations, in high quality and with greatly reduced computing times. Based on the simulation results, innovative strategies can be derived to avoid these undesirable phenomena and thus ensure the operation of environmentally friendly gas engines with high power and optimum efficiency. The methodology could also offer a high potential for improvement in the field of combustion and pollutant formation simulation.



Copyright © LEC GmbH, Reconstruction of flow fields from noisy data using machine learning

Federal Ministry
Republic of Austria
Climate Action, Environment, Energy, Mobility, Innovation and Technology

Federal Ministry
Republic of Austria
Digital and Economic Affairs

Austrian Research Promotion Agency
Sensengasse 1, A-1090 Vienna
P +43 (0) 5 77 55 - 0
office@ffg.at
www.ffg.at

SUCCESS STORY

Project coordination
Dr. Gerhard Pirker
Area Manager – AreaX
COMET Module Project Manager
LEC GmbH
T +43 (0) 316 873 30130
gerhard.pirker@lec.tugraz.at

K1 COMET Zentrum LEC EvoLET
LEC GmbH
Inffeldgasse 19/2
8010 Graz
T +43 (0) 316 873 30101
office@lec.at
www.lec.at

Project partner

- INNIO Jenbacher GmbH & CO OG, Jenbach, Austria
- AVL List GmbH, Graz, Austria
- KNOW-Center GmbH, Graz, Austria
- Graz University of Technology, Austria

This Success Story was provided by the center's management for publication on the FFG website. The COMET Center LEC EvoLET and the COMET MODULE LEC HybTec are funded by BMK, BMDW and the provinces of Styria, Tirol and Vienna as part of the COMET – Competence Centers for Excellent Technologies. The COMET programme is run by the FFG. Further information on COMET: www.ffg.at/comet