K4A
The Knowledge Company

Hybrid AI Methods for automated E/E-System validation

*K*nowledge 4 *A*utomation

white paper

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Automation – Anomaly detection – E/E-Systems

Ontology – Knowledge Base – Machine Learning – Human in the Loop

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1 K4A Systems

K4A Systems is a provider of knowledge-based systems for the automation of internal business processes. The central element is an ontology-based system that allows a formal description of data and their relationships to each other.

Ontologies are a branch of artificial intelligence. Its strength lies in building networks of information with their logical relationships, so that any term (e.g. an application) can be described by its characteristics (e.g. application type, application date, applicant, and so on) and rules (e.g. laws, regulations, agreements). Thus a network of information is spanned, which covers the meaning of the term (semantics). It is used to store, search for and exchange knowledge in digital and formal form.

Tasks (e.g. check requests, supplement request data, approve request) and responsibilities (e.g. persons with the role X may approve) can be assigned to each term. This enables the system to control processing: it can perform the tasks independently or submit them to the persons responsible for processing.

The ontology system is developed by K4A Systems. It is supported by other cognitive technologies to learn independently. These include technologies such as Natural Language Processing (NLP) for knowledge extraction from texts, Machine Learning (ML) for knowledge extraction from transaction data (inductive closing) or inference machines for problem solving (deductive closing). They are supplemented by interfaces to external systems (e.g. ERP or PDM) in order to use existing data (import) or provide generated data (export). Machine Vision (image analysis) and Program Control (program control) are planned.

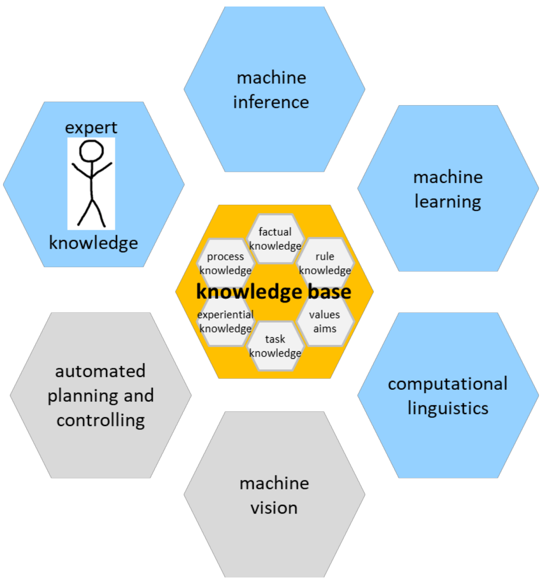

Figure 1: the cognitive building blocks of the K4A system

"Learning" is not programmed, but trained. It enables simple automation even of very complex thinking and routine tasks.

Partnerships exist with the Heinz Nixdorf Institute, University of Paderborn, the Fraunhofer Gesellschaft and the high-tech cluster it's OWL in the action spheres of "Intelligent Technical Systems" and "Industrial Data Science".

2 Use case: Anomaly detection in E/E systems

Testing and validating electrical and electronic (E/E) components in a vehicles electrical system is a challenge for the automotive industry. Rule-based tests are used to validate the functionality of components according to specifications. In order to test the functionality in operation, test runs are performed in which the communication of the E/E components is recorded (data logging). The recorded data allow conclusions to be drawn about the state and behaviour of the E/E-System.

Today evaluation of test drives is carried out by test engineers with aid of engineering specifications and recorded communication data. This is a time-consuming process in which a large number of errors are still not detected. An automated evaluation of test data is not yet possible. This requires the appropriate mapping of expert knowledge, empirical knowledge and their combination with automated procedures for error detection.

Anomaly detection (AD) methods are implemented successfully in industrial context. For that suitable procedures have to be selected and parameterized. Therefor selection and parameterization depend on the characteristics of the signals and the expected anomaly classes. Ontologies offer the possibility for knowledge about arbitrary facts to be mapped and made available in a structured way. Contexts and conclusions can be automatically mapped and generated.

The use of ontologies in combination with machine learning opens up possibilities to automate the selection and parameterization of anomaly detection procedures and to supplement missing knowledge. For this purpose, knowledge about the procedures and their parameterization in the context of signals, their properties and relationships require to be stored in an ontology.

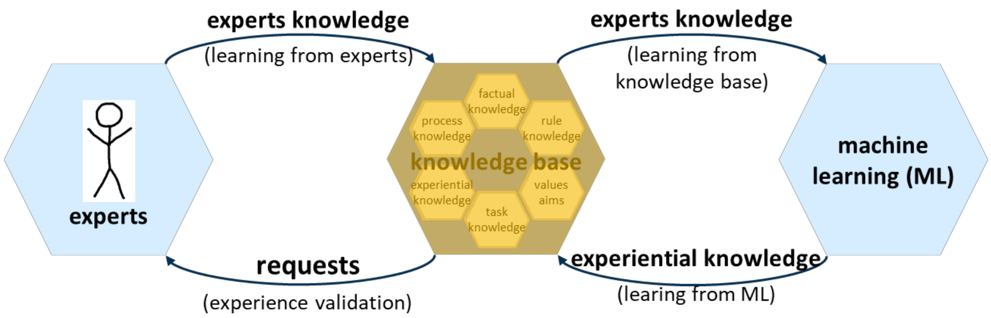

Figure 2: Learning with interactions between experts, knowledgebase and machine learning (Source: K4A)

Further knowledge can be contributed by experts (Human in the Loop). This is useful to evaluate anomalies, validate the results of machine learning or to provide domain knowledge to ontology. In this case, automated methods are target-oriented that provide context-based expert knowledge and subject empirical knowledge to validation.

Such a system does not yet exist. Previous methods of ontology learning are limited to the derivation of knowledge by means of machine learning; the use of knowledge from ontologies for machine learning has hardly been researched yet.

3 Knowledge and learning

In the automotive context, almost every vehicle is unique. Due to the "electrification" of many options, there are countless possible combinations where classical ML methods for big data do not work properly. Procedures supporting "learning with little data", "learning with additional knowledge" and "collaborative learning" should be applied.

The K4A Systems approach requires experts to explicate their E/E knowledge and provide knowledge in the form of configurations (dbc files) or rules (options). Recorded log data can then be formatted with machine learning on multiple levels. First, knowledge is requested from the knowledge base in order to enrich the log data with additional knowledge. In the second step, the data is classified, unattended, and fed to anomaly detection. Then drivers are detected for identified anomalies. Finally, the experience gained is extracted and memorized in the knowledge base.

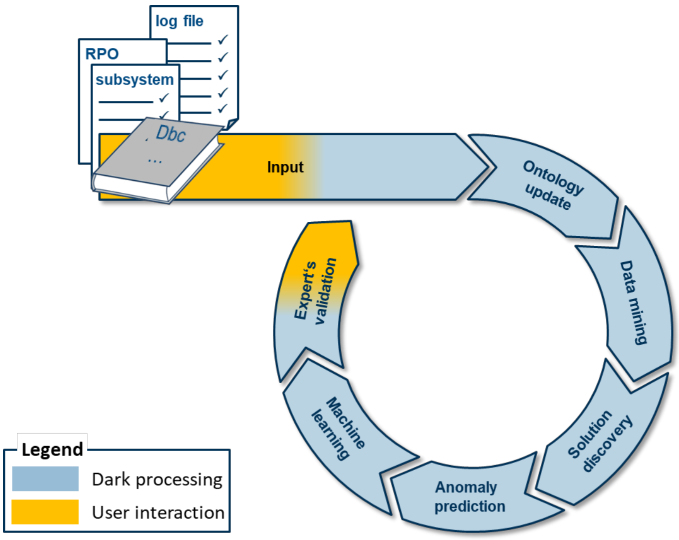

Figure 3: Processing chain of anomaly detection (Source: K4A)

Empirical knowledge is subject to strict requirements. It is only applied if it has been proven. To this end, experts are interviewed to validate empirical knowledge. Of course, experts can also provide their knowledge unsolicitedly.

4 Project

In each project the system fundamentals will be adapted to the specific customer data. This concerns the input with configuration and log data, the modelling of ontology (signals, properties, relationships), the appropriate machine learning methods for classification and detection as well as the interfaces for knowledge transfer and collaboration.

Within the framework of integration, the knowledge and learning components are combined in such a way that complete and smooth dark processing takes place. Finally, anomaly detection is fine-tuned using key figures (e.g. recognition rate, efficiency and performance) by adjustments to data and system.

5 Experiences

The assumption that the hybrid use of AI methods would lead to significantly better predictions has been confirmed: Experience has shown that hybrid learning (HL) do have clear advantages over machine learning (ML) alone:

- With little training data, the predictions of HL are better by a factor of 3 (38:12).
- They are also better if the training data is increased by a factor of 100 (20:12).
- With increasing training data, the prediction quality of HL increases again significantly (20:4).

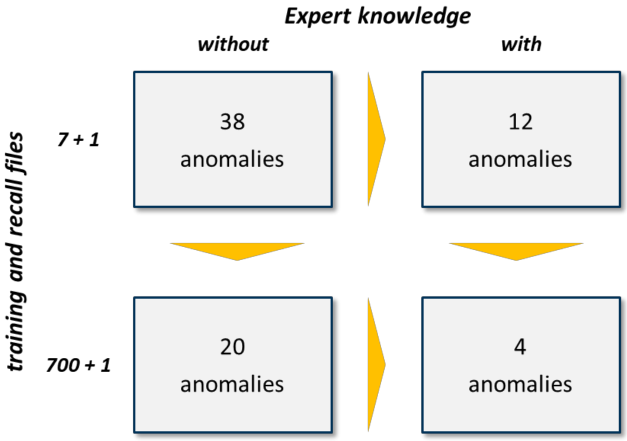

Figure 4: Effects of hybrid learning (Source: K4A)

"Learning with little data", "Learning with foreign knowledge" and "Collaboration" prove to be very powerful methods for anomaly detection within E/E log data. K4A Systems has created the necessary foundations and anchored them in its own system. Parts of the development were supported by the Ministry of Economics, Innovation, Digitisation and Energy of the State of North Rhine-Westphalia.

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