SUCCESS STORY

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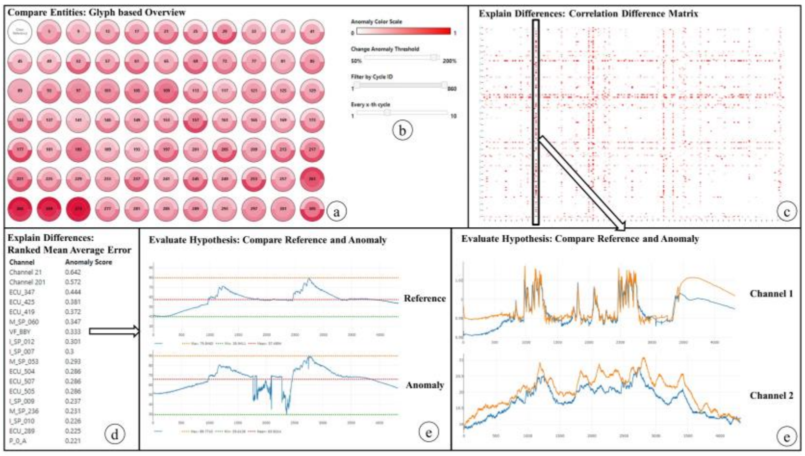

SCALABLE CONDITION MONITORING SYSTEM FOR TEST ENVIRONMENTS

Industry 4.0 is considered as the "fourth industrial revolution" that fully automatizes the production in the manufacturing industry. It is a large-scale digitalization of manufacturing, where the machines are connected producing large amounts of products with low costs. To achieve this, they are endowed with sensors which, in real time, collect, produce and exchange data (machine-to-machine, machine-to-human) with the purpose (i) to identify e.g., trace parts and subassemblies, (ii) to adapt the production to changing requirements and individual needs, and (iii) to optimize the production processes. However, the amount of data generated within production can be overwhelming for the human beings. First, the data has to be monitored and recorded using methods that can handle huge datasets. Next, the collected data has to be analyzed (often in real time) (i) to identify e.g., undetected process correlations, (ii) to gain an overview about the production, and (ii) to extract essential information. Finally, using this information the human being should be able to define prediction (e.g., about production issues) that aid the decision-making process. This becomes more significant, when the production process is divided into specific tasks and each task is repeated many times (=cycles) producing vast amount of data. For instance, in so called "durability test" in automotive industry, the engineers investigate the condition of an engine by using multiple sensors and defining and performing repeating tasks. What significant here is, that such a test can take thousands of hours, with up to twelve hours per cycle, which makes it quite difficult for the engineers to collect and monitor the data (time series data) of each iteration and to explore if there are any deviations between them. Yet, to tackle this issue, one can use an interactive visual analytics tool.

Visualizations have shown to be effective in dealing with huge datasets: since they are grounded on visual cognition, people understand them and can naturally perform visual operations. Concretely, by assigning data to visual characteristics people can intuitively extract valuable information and perceive properties of their data (outliers, patterns, etc.) which might remain undiscovered by other means of analyzing

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them. Returning to our example with the durability test, a visualization tool would imply that data being collected by the sensors in each cycle is transferred to the engineer in a way so that the engineer can readily obtain insights and draw general conclusions out of it.

In this project, we propose an interactive visual analytics tool that displays the iterations of a durability test as a collection of color-encoded cycle glyphs. To do so, we aim to help the engineers to readily monitor the test and to detect potential anomalies. To achieve this, the engineer selects one glyph (or iteration) and the color of the remaining glyphs (or iterations) shows how much they deviate from the selected one: the darker the color of a glyph is the more it deviates from the selected one. For the calculation of the anomaly score, we use data simultaneously collected by ~500 sensors, times series data respectively. Another important factor what has to be taken in account is, the time series data we deal within the scope of our work, is multivariate due to dependencies between the individual attributes.

Impact and effects

We performed a pair analytics evaluation with three testbed engineers, to investigate how the engineers work with the proposed visual analytics tool on their daily condition monitoring analysis goals. The study has revealed that our tool aids the daily work in automotive testbed environments for two reasons. First, the visual analytics tool helps engineers to analysis the entire testbed dataset and not only a subset of well-known sensors. To do so, the engineers are able to investigate the correlation between the attributes (e.g., temperature and pressure sensor) and not only each attribute on its own. Second, using our tool the engineers are able to readily detect anomalies and explore their sources. Summarized, our visual analytics tool provides promising methods to address the specific problems associated with automotive testbeds: analyzing multivariate time series and finding anomalies in reoccurring processes.

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