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Recent advances in the development of digital twins for path accuracy and remaining useful life

LEVEL-UP aims at extending the useful life of major capital investments and Large Industrial Equipment and progress has already been made towards that goal. For the refurbishment of a large industrial lathe (SKIQ16[1]) at project partner TOSHULIN, FRAUNHOFER IWU is developing digital twins for path accuracy and remaining useful life to increase the quality and performance of the machine while decreasing downtimes.

The digital twin is based on a mechatronic model describing the structural mechanics of the machine as well as the control loops of all feed drives. The model predicts dynamic displacements at the tool centre point by continuously readout internal control signals such as the commanded and measured position at each feed axis. The transparent visualization of the predicted displacements can be used to **optimise machine parameters** such as the acceleration and jerk of the feed drives resulting in lower cycle times of the processes and/or increased quality of the parts. The identification of the model parameters and verification of the results is done via experiments, where additional sensors are temporarily installed at the machine tool. As a first step, the implementation of the digital twin for path accuracy at a turning milling centre in the laboratory of FRAUNHOFER IWU has now been realized and demonstrated (see Figure 1).

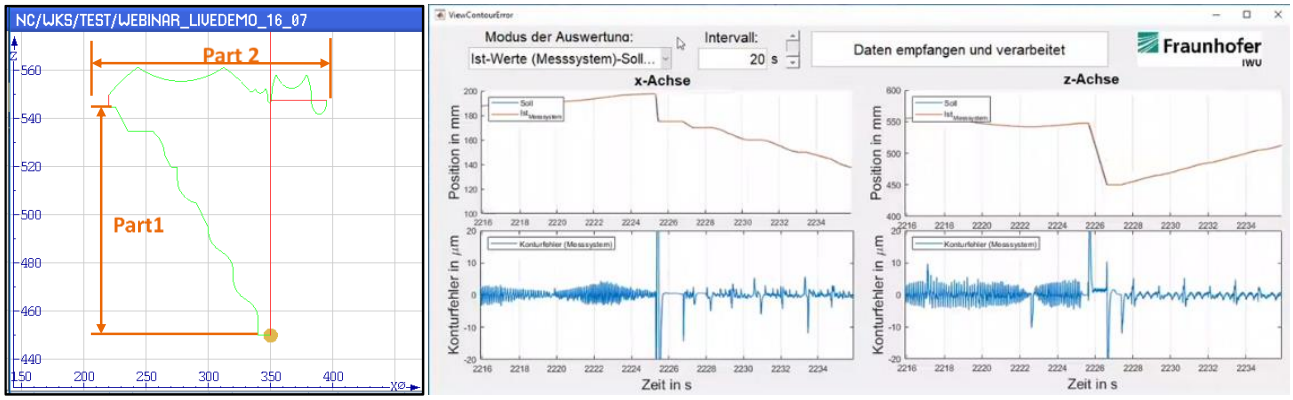

Figure 1: Demo program for the demonstration of the digital twin for path accuracy (left) and graphical user interface depicting the current path accuracy (right)

[1] The TOSHULIN large industrial lathe for metal machining was assembled in 1986 and retrofitted once in 2004. The machine is in constant usage manufacturing larger rotatory parts. Replacing the TOSHULIN equipment by a new machine would lead to a significantly higher investment compared to expected refurbishment costs. Envisaged increase of the lifespan is up to 20 years.

Next steps consist in the qualification of the digital twin for the prediction of the remaining useful life of critical components. In this case, the output of the mechatronic model is the velocity of the axes and the load on the specific components, such as linear or rotary bearings and ball-screws. These quantitative characteristic values will be continuously transferred to the cloud environment and will be further processed to **predict the remaining useful life** of the corresponding component. Again, the input of the mechatronic model are internal control signals such as motor speed and torque. The overall analysis of data from different use-cases will allow for identifying correlations for comparable components as well as pattern identification by machine learning algorithm.

Figure 2: Preliminary experiments for identifying the machine tool dynamics of the industrial lathe at TOSHULIN

After local validation of the digital twins in the lab at FRAUNHOFER IWU the digital twins will be implemented at the large industrial lathe SKIQ16 at TOSHULIN. The first preliminary experiments for the identification of the dynamic behaviour of the machine tool have been already done by Fraunhofer IWU (Figure 2).

About the project

LEVEL-UP will offer a scalable platform covering the overall lifecycle, ranging from the digital twins' setup, modernisation actions to diagnose and predict the operation of physical assets, to the refurbishment and remanufacturing activities towards end of life. In-situ repair technologies and the redesign for new upgraded components will be facilitated through virtual simulations for increased performance and lifetime. LEVEL-UP will therefore comprise new hardware and software components interfaced with the current facilities through IoT and data-management platforms, while being orchestrated through eight (8) scalable strategies at component, workstation and shopfloor level. The actions for modernising, upgrading, refurbishing, remanufacturing, and recycling will be structured and formalised into ten (10) special Protocols, linked with an Industrial Digital Thread weaving a seamless digital integration with all actors in the value chain for improved future iterations. LEVEL-UP will be demonstrated in 7 demo sites from different sectors.

Details

Project title: Protocols and Strategies for extending the useful Life of major capital investments and Large Industrial Equipment

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Project Consortium:

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