POTENTIALS AND CHALLENGES IN USING AI FOR UNDERSTANDING AND PREDICTING SLIDING WEAR MECHANISMS

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ABSTRACT
It is inarguable that the type of interactions of two contacting sliding bodies' materials play a significant role in the resulting friction and wear. Fundamental studies on friction and wear mechanisms have been carried out extensively, and typically at a relatively small scale. While a strong effect of material reactions and interactions – including wear – on the friction coefficient is clearly observed, no fundamental and general correlation between friction signal and wear mechanisms has been found, due to the high number of influencing parameters acting in different tribosystems. This is unfortunate, since knowing and understanding wear mechanisms allows to apply targeted countermeasures, and to optimize a tribosystem.

Novel, data-driven methods are a promising opportunity to address the intrinsic complexity of tribological problems. Various approaches are possible in this field, and several groups and initiatives are working on the development of methods of machine learning and artificial intelligence for use in tribology.

The aim of the presented project is to use machine learning to automatically identify wear mechanisms acting under sliding wear and recommending suitable countermeasures, with the long-term goal of making this expert knowledge easily and widely available.

One widely used method to distinguish wear mechanisms is to structure them into four main groups, namely adhesion, abrasion, surface fatigue and tribochemical reactions. Such mechanisms are to date determined by examining the worn surfaces using scanning-electron-microscopy (SEM). In a first step in this project, a convolutional neural network was designed and trained to classify SEM images obtained in a variety of tribology projects in the past years, according to the presence of specific wear mechanisms [1]. The results proved the general feasibility of this approach [2]. Still, several factors were observed to lead to erroneous classifications. E.g. similar damage characteristics may appear quite different on different materials, often several mechanisms concur in close proximity, or simply differences in magnification and contrast settings of the images lead to wrong classifications.

In addition to these mentioned challenges, obtaining SEM images from worn surfaces is a relatively complex and expensive method, and can only be carried out ex-situ. It is therefore desirable to understand the acting wear mechanisms directly from data measured while the tribosystem is in operation. The following steps focus on identifying features and drawing information from time series data of normal and friction forces measured during laboratory sliding wear tests. While it is found to be quite easily possible to classify the difference in e.g. friction force signal of materials with significant differences in mechanical strength and deformation behavior, identifying the four conventionally used main wear mechanisms remains a challenge. Still, specific wear appearances can be identified from friction and/or normal forces, and will be used in the future for automatic classification. It is quite probable, that the use of machine learning will result in new clusters of mechanisms of wear, and a deeper understanding of damage processes in materials that affect force signals in a specific way.

REFERENCES
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