Computer Vision-Based Quantification of Wear on Gear Cutting Tools

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Gears are typically soft-machined using manufacturing processes that involve a geometrically defined cutting edge. Regardless of the manufacturing process, the objective of productive manufacturing is to maintain the required workpiece quality while reducing costs. Since tool wear has a significant influence on manufacturing costs, early detection of critical tool wear is a key factor. Tool wear can be assessed directly using optical methods or indirectly by analyzing acceleration or acoustic signals. Although optical measurements are more accurate, they are subject to human interpretation, which introduces uncertainty. Consequently, there have been efforts to use computer vision to detect and quantify tool wear.

In this presentation, an algorithm is introduced to detect and quantify wear on gear hobbing, bevel gear cutting, and gear skiving tools using computer vision methods. In **Figure 1** the algorithm's procedure is depicted. First, microscope images of worn tools are imported and pre-processed. Pre-processing includes scaling, normalization, conversion to grayscale, and padding. Next, a convolutional neural network (CNN) that combines U-NET with EFFICIENTNEt as its backbone is applied to detect the worn area. However, the CNN tends to misidentify light reflections or scratches on the flank face of the tool as wear for example. Therefore, the images are post-processed using OTSU'S method for binarization, as well as connected component and contour detection.

To quantify the wear, pixels in the identified worn area are counted along the width of the image. Using a resolution-dependent conversion factor, the mean wear width VB_m, maximum wear width VB_{max} and the worn area VB_{area} are calculated in micrometers To ensure the algorithm's performance, manually measured wear and wear generated by the algorithm are compared for bevel gear cutting, gear hobbing, and gear skiving tools. For gear hobbing, the mean absolute difference between the manually measured and algorithm generated maximum wear width is $|\Delta VB_{max}|$ = 19.95 µm, for bevel gear cutting $|\Delta VB_{max}|$ = 7.99 µm; and for gear skiving $|\Delta VB_{max}|$ = 37.06 µm.

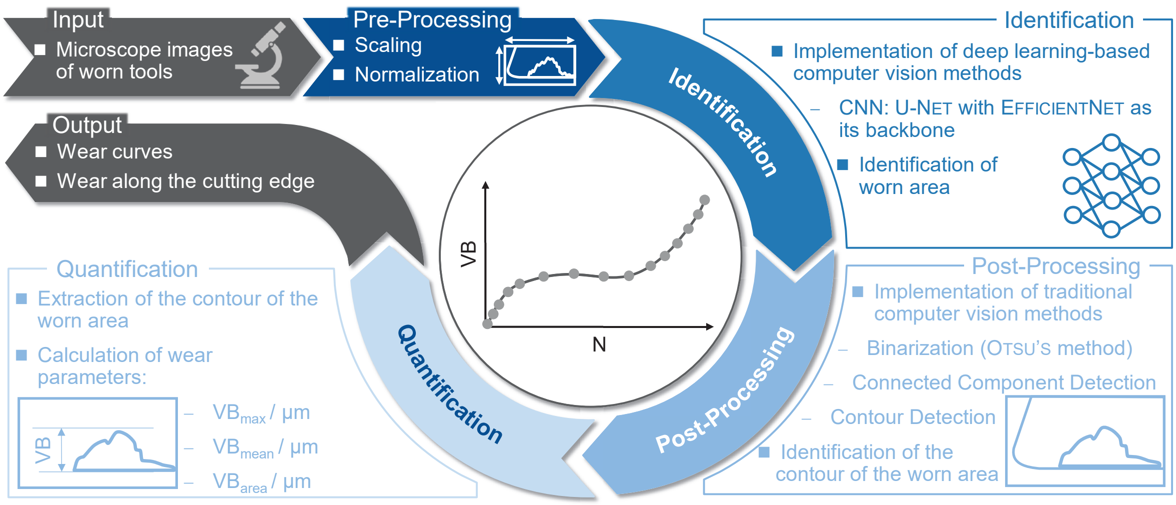

Figure 1: Algorithm Procedure