Analysis of the Crack Growth Behavior in a Double Cantilever Beam Adhesive Fracture Test using Digital Image Processing Techniques

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ABSTRACT

Digital image processing (DIP) techniques offer interesting possibilities in various fields of science. Automated analyses may significantly reduce the necessary manpower for certain cumbersome tasks. The analysis of large series of images may be done in less time, since automated image processing techniques are able to work efficiently and with constant quality 24h per day. In this work, a series of images obtained by a high-speed camera is analyzed in order to determine the crack growth behavior during a double cantilever beam (DCB) test [1]. The present work represents a contribution to the effort of automatizing the crack growth measurement, comparing various different techniques which may later be optimized for a specific task.
Detecting cracks automatically from test images obtained by a digital camera is a difficult task, since the quality of crack images depends on the test conditions. The roughness of the specimen surface, luminance condition, and the camera itself may influence the detection quality. The specimens tested in this work where painted with white colour since this was found to lead to the best contrast for crack detection. High accuracy may only be expected if a sufficiently high resolution is acquired by the camera and if the available lens setup is optimized for the specific task.
The DCB test is performed in order to obtain the experimental compliance-crack length curve of a polymeric adhesive. Accurate and reliable crack length measurement is indispensable for the generation of the previously mentioned compliance-crack length curves. It should be noted that due to the lenses used, unlike shown by Ryu [2], the distance to the specimen is higher than 800 mm. This distance has to be reduced by the use of a different lens setup in order to get a better accuracy of the results. Nevertheless a comparison between different DIP methods is possible. Four different algorithms were developed using *The MathWorks MatLab*, Massachusetts [3] in order to automatically measure the crack length and a comparison of the obtained results is made.
Algorithm A is based on thresholding [4] each image of the sequence in order to detect the white painted region around the crack. In algorithm B, the image sequence is processed by a filter which reinforces horizontal lines such as the crack, and then isolated pixels are removed from the images using morphological cleaning [4]. In algorithm C, the first of two consecutive images is subtracted from the second one in order to detect the crack as a difference between both images. Algorithm D is based on the optical flow concept developed by Horn [5]. The basic idea is to determine the velocity of each pixel in the image when this changes its position from one image to the next in the analyzed sequence, and relate this information to the growing

crack.
For verification, manual measurements of the crack tip on the images was performed and all algorithms were compared against this data. Figure 1 shows this comparison.

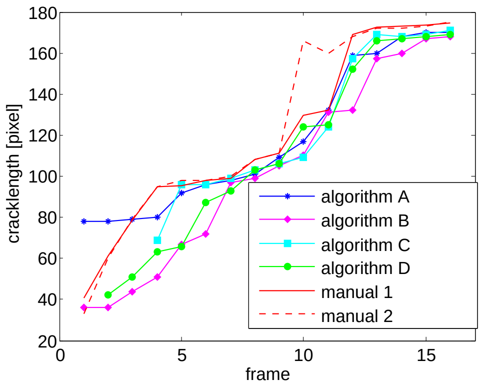

Figure 1: Comparison of the detected crack length for the different algorithms developed.

It should be noted that even the best working algorithm developed cannot detect the crack tip correctly all the time if the images to be analyzed have not enough resolution. Therefore, a more sophisticated experimental setup would be needed to fully demonstrate the capabilities of the presented algorithms. Nevertheless, it has been shown that the algorithms are capable of detecting the crack tip to the same level of accuracy as the human eye based on the available images.

References

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