Digital image correlation for strain measurement on notched and welded specimens

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Abstract.
Measurement on the edge of the specimen became a significant challenge in the field of digital image correlation displacement and strain measurement. Even more challenging is a measurement on geometrically non-described surfaces e.g., welds. There are many approaches to solve this problem. Mesh based DIC as well as the extrapolation method not always reports a satisfactory result. Possible solution comes with the stereo DIC systems ability to measure on non-planar surfaces. Therefore, arises a demand for a measurement on difficult and complex shapes such as the cylindrical shape of the hole (Fig. 1, Fig. 3). Problems of measurement on notched specimen can be divided in three main groups. First is the well-known problem of boundary subsets. To prevent this scenario, stereo DIC could be used. Second problem arises in the region of sharp strain peak e.g., notch root. In these regions peak strain values are reduced due to the over-filtering. This effect occurs especially by measurement of small notches such as welds or cracks. Small number of pixels per notch radius leads to small number of grid points. This leads to filter sensitive and inaccurate results. Another, and even more severe problem occurs at large camera angles with respect to the measured surface. Different camera positions and angles with respect to the specimen significantly effects the measurement accuracy. This situation is quite common by open-hole tensile test (Fig. 3). By evaluation should be this effect considered and the strain concentration peak value should be exported from appropriate point. Larger subsets are always linked to more precise displacement results. Subset size is often related to grid size and to spatial resolution. Therefore, the main aim of the study is to define the optimal parameters of the measurement, such as speckle pattern quality [2,3,4] and minimum number of pixels per notch radius necessary for satisfactory precise results. Speckle pattern quality has been evaluated by using the sum of square of subset intensity gradient (SSSIG) parameter [4]. Other parameters such as Mean intensity gradient (MIG) [7], mean subset fluctuation [6] does not report higher effectivity [3]. The Number of pixels per radius parameter is based on the comparison with analytical solution [5] and numerical results from FEM analysis [1]. Measurement of open-hole tensile test (Fig. 1, Fig. 3)., which is low-cost and simply feasible, has been chosen. Measurement has been performed on multiple specimens with different hole diameter i.e., different number of pixels pre hole radius, different camera configurations and angles. Results are indicating a notch radius interval limit of for filter quasi-independent measurement. Therefrom, the minimum number of pixels per radius for valid measurement has been derived.

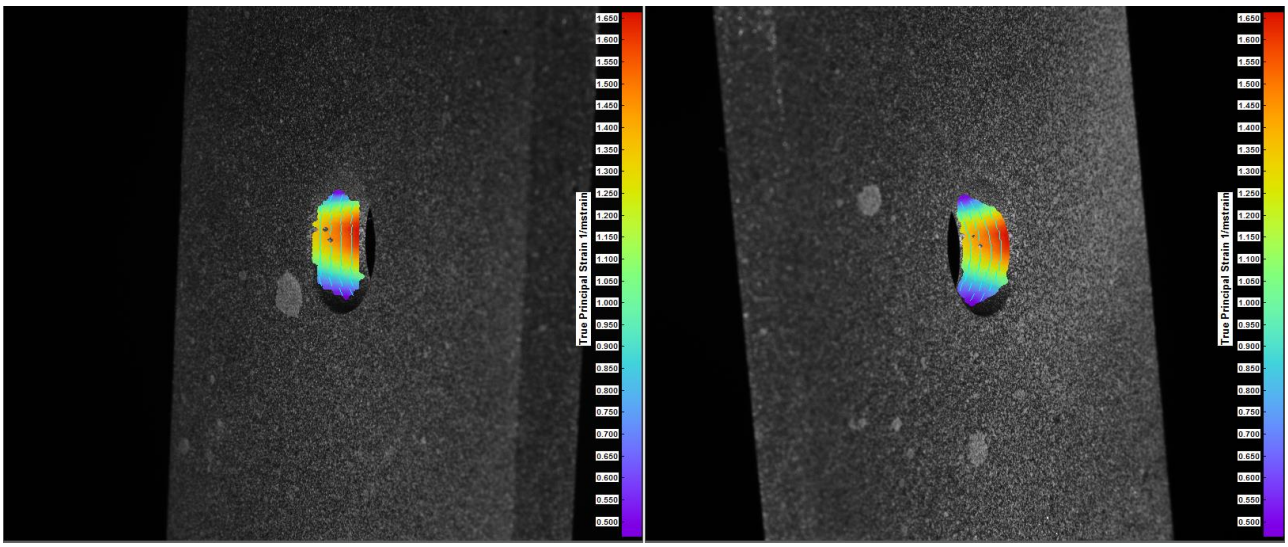

Figure 1: Principal strain on cylindrical sha

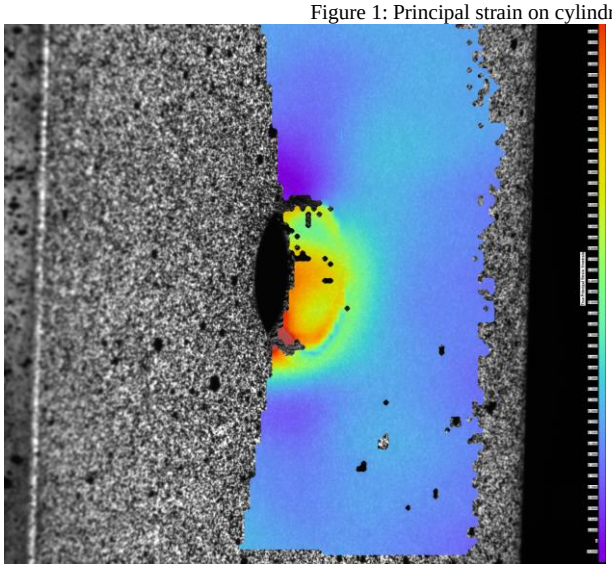

Figure 3: Principal strain on open-hole specimen, side-view, visible strain gradient in the hole due to the large angle of cameras

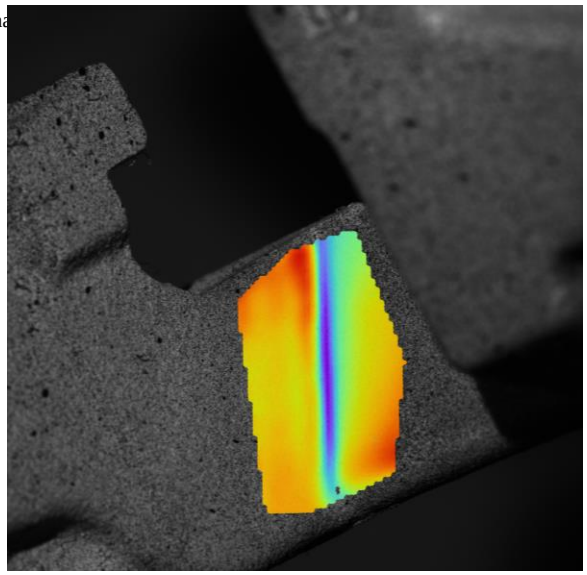

Figure 2: Brake component first principal strain distribution

Conclusion Z

The minimum number of pixels per radius for valid measurement in the notch has been defined. The obtained result can be utilized in wide range of industrial applications. Knowledge gained by measurement of geometrical defined specimens can be utilized for measurement of geometrically non-described geometry. Geometrical notch stress concentration factor of the welded specimen has been measured as an example of the direct application. Moreover, notch stress concentration on automotive brake system component (Fig. 2) was measured as well.

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