Initial value estimation using feature-based clustering in DIC for measuring large deformations

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Abstract. An accurate initial value of displacement plays a vital role in investigating the deformation parameters of a soft material that undergoes discontinuous deformation. There are various techniques for estimating the initial displacement from which feature-based approaches are prevalent due to their invariance to scale and rotation. However, feature-based methods use the correspondences of feature points as a source to identify the seed point and then calculate the displacement of the seed point from the reference image to the deformed image by using affine transformation. This strategy consumes more time and increases the computation cost if the seed points are more than one, such as in large deformations. Thus, this study develops a feature-based clustering (FBC) approach that can directly identify the displacement of the seed point in the deformed image by employing KAZE feature detectors and descriptors. The FBC requires at most four feature points to measure the coordinates of seed points in the reference image and can accurately deduce the seed point location in the deformed image with at least one corresponding feature point. Thus, this method reduces the computation complexity and time.

Possible Sessions

<u>19.</u> Optical and DIC techniques, <u>21.</u> Soft Matter

Introduction

Accurate measurement of the deformation vector is crucial for investigating the large deformation of soft materials [1,2]. An initial deformation vector incorporates pixel-level displacement of the seed point, calculated using initialization methods. The sub-pixel level registration algorithms utilize this initially estimated seed point displacement value to calculate the higher-order deformation parameters of the target subset in the deformed image [3]. Moreover, various feature-based initialization methods have been implemented for measuring initial displacement due to their invariance to scale and rotation. However, transferring displacement of the seed point as an initial guess to neighboring points would be ineffective if the deformation is discontinuous. Besides this, feature-based initialization methods tend towards biased seed point estimation due to the sparse and non-uniform distribution of feature points [1,3]. This study aims to develop a feature-based clustering (FBC) initialization method, an extension of the feature-based template (FBT) initialization method that encompasses a cluster of four interest points (IP) instead of a single interest point for measuring the initial value of the deformation of each subset. It can accurately predict the displaced location of the seed point in the deformed image without affine transformation. The proposed FBC method determines a cluster of IPs using a KAZE feature detector and descriptors within each subset. It can determine initial displacement even if only one corresponding cluster IP among all four IPs is available in the deformed image. This characteristic of the FBC makes it independent of the feature distribution, which can effectively handle the insufficiency of corresponding feature points. In addition, the performance of FBC is enhanced through parallel processing to measure the full-field displacement of soft materials.

Methodology and Preliminary Results

The developed method applies FBC to the reference image, where it first identifies the four nearest KAZE interest points w.r.t the center coordinate of the template. Now, the algorithm calculates the orientation and distance of the center coordinate from each of the four identified IPs. These orientations and distances assist in estimating the location of the displaced seed point. Fig.1 illustrates the developed methodology for calculating the initial displacement of the seed point. The FBC treats each subset center as a seed point and computes its corresponding location in the deformed image. The S(x,y) represents the coordinates of the seed point, and S(x',y') denotes the coordinates of the deformed seed point. Here, each I and I' represent the IP detected by the KAZE in reference and deformed images, respectively. The displacement prediction strategy of the seed point can handle the lack of correspondence between the images, i.e., it does not require all four interest points to be always available (refer to Fig.1 where S(x',y') can be estimated even through three, two and one cluster points)**.**

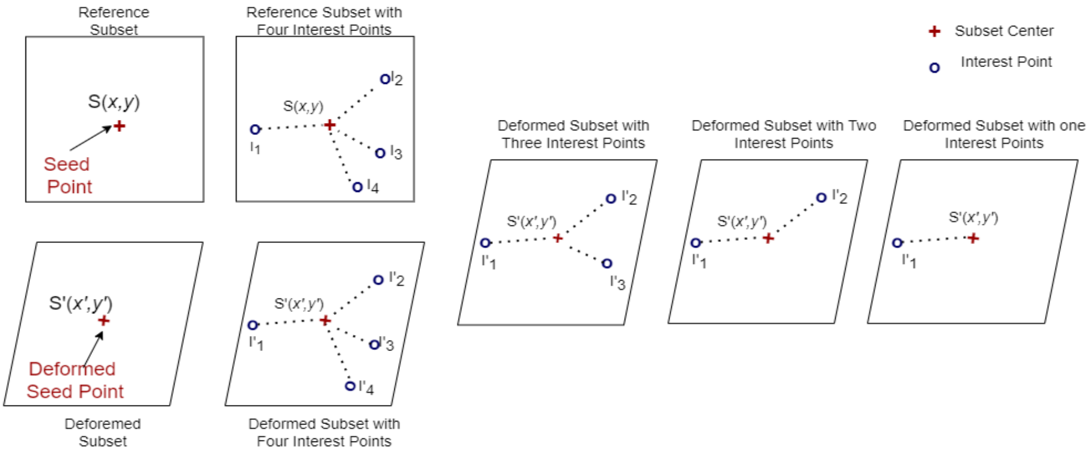

Fig 1. A feature-based Clustering approach for detecting the displaced position of the seed point in the deformed image.

Hence, at least one interest point (I') among all the IPs is required in all subsequent images to accurately predict the initial value of displacement.

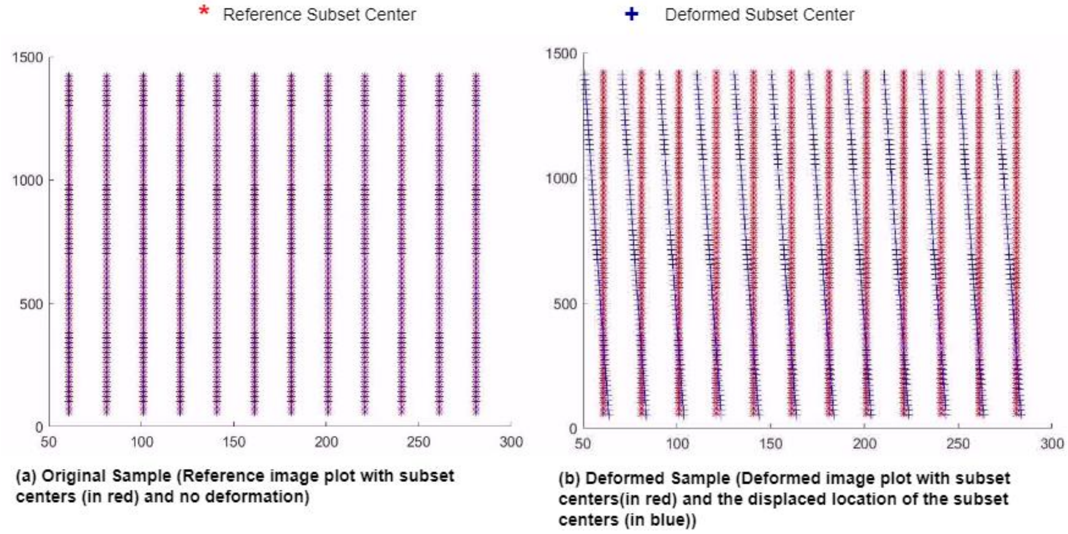

Fig 2. Preliminary results of the proposed FBC algorithm for investigating the deformation of soft material under load.

Fig.2 illustrates the preliminary results obtained from the FBC algorithm, where Fig.2(a) represents the reference sample without any load. Here, each * (in red) denotes the center of the subset, and each + (in blue) denotes the center of the displaced subset of the deformed sample. Moreover, Fig.2(b) represents the deformed image where the change in the shape of the original sample can be easily seen from the blue markers, which have moved diagonally towards the left. The developed approach increases the accuracy of the initial guess and decreases the computation time with lesser dependency on the feature distribution and matched feature points.

Conclusion

A feature-based clustering (FBC) approach is illustrated in this work to determine the initial value of displacement for measuring the deformation vector of the seed points in the deformed images. The developed FBC method can accurately investigate large deformation of soft materials. This method initially requires four interest points (IP) in the reference image to calculate the distance and orientation of the original seed point w.r.t each IP, which enhances the accuracy of evaluating the deformed location of the seed point. This strategy enables FBC to work efficiently even if there is a lack of correspondence between the images, i.e., at least one IP is necessary among all the four IPs in all the subsequent images for better performance. Thus, the developed approach is independent of the feature distribution and can utilize parallel computation for fast and efficient processing.

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