Chair of Metal Forming and Casting
TUM School of Engineering and Design
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Deformation analysis using Optical Flow

Optical deformation measurement and validation using physics simulation and a virtual lab

Motivation

Optical deformation measurement offers a cheaper and more flexible alternative to LIDAR to track particle flows in images. The central task is to track the movement of a point over time, i.e., over a series of images, taken at different times. Beginning with the Horn-Schunk-algorithm in the early 1980s, a plethora of digital image correlation algorithms have evolved to approximate a solution for the ill-posed problem of matching points in consecutive image frames. It has found diverse applications in material characterization, especially strain analysis and crack detection.

Despite significant progress, critical challenges remain, such as reliable analyses of 3-dimensional objects, optimal selection of parameters, sufficiently precise strain calculation as well as dealing with imprecisions. Moreover, traditional block-matching DIC algorithms fail for discontinuities such as cracks. Specially developed global algorithms that handle discontinuities more successfully, such as TV-regularization, still leak expansion to multi-camera stereo-environments. Moreover, there is no broad validation framework to study the influence of environmental factors such as lighting or geometry onto precision.

Goals

This is precisely the research question that *utg* is pursuing as part of a DFG project. We collect simulated data from the Nakajima experiment, where a stamp applies pressure onto a metal sheet, which deforms and finally cracks under the load. We simulate deformed blade meshes using LSDyna and study deformation and strain with the Total-Variation (TV) DIC-algorithm. In addition, we create a virtual lab, where synthetic images, based on custom lighting conditions and speckle patterns are rendered. The 3-dim. deformation of each point in the sample is projected onto the camera, which leads to a ground truth optical flow image. By comparing it to our computed optical flow we can investigate the precision of our framework. We also perform a 3-dim. reconstruction and visualization via the NCorr-framework and Unity C# in order to visualize and study the surface topology, as well as provide a user-friendly interface. Finally, we investigate, how the lighting conditions and how the speckle size influences the accuracy of the deformation and strain measurements in order to give recommendation on the optimal parameters. Moreover, we analyze the crack formation during the Nakajima experiment.

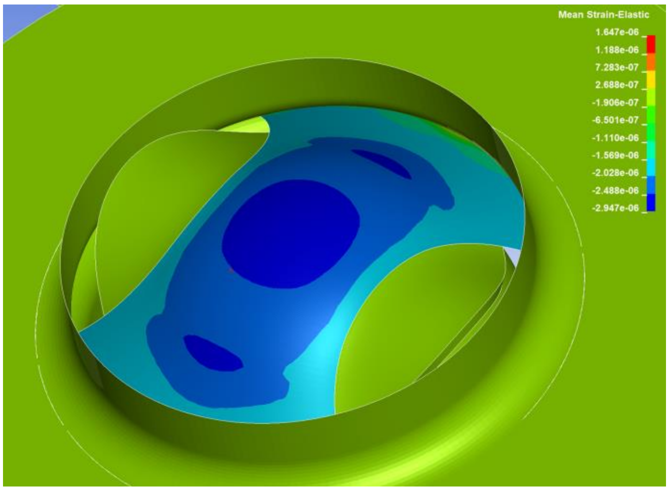

Figure 1: LSDyna: A metal sheet is deformed by a stamp during the simulated Nakajima experiment

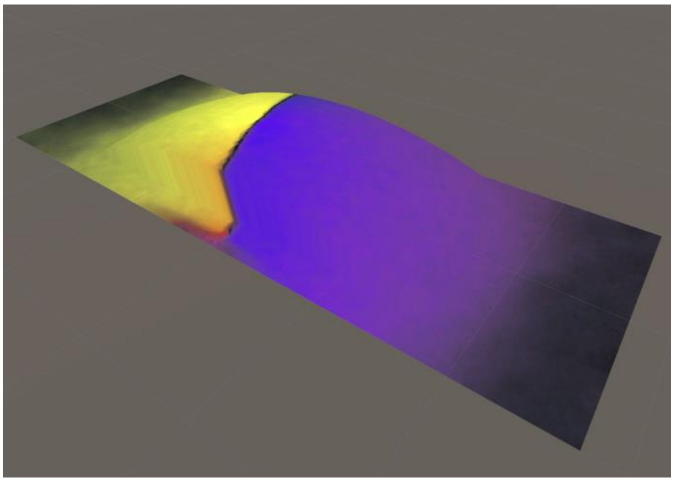

Figure 2: Reconstructed surface of a sample, optical flow is displayed via a color map, where the crack is clearly visible.

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