Full-field Measurement of Contacts/Impacts in Multibody System Using Digital Image Correlation

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Contacts/Impacts usually happen between moving bodies in many engineering applications, such as spacecraft docking process [1], pantograph-catenary interaction [2] and so on. However, contacts/impacts are still not fully understood due to their complexity. The experimental investigations of impact problems are very important to understand the physical process of impacts. The main difficulty of conducting an impact experiment is that the impact duration is very short and the frequencies of impact responses are extremely high. A lot of work has been done in this field. Early researchers mainly used strain gauges to measure transient strain response of several points during impact process [3]. Khemili et al [4] used an accelerometer to measure the acceleration of the slider in a flexible slider-crank mechanism with clearance. With the advancement of laser techniques, some impact experiments were conducted using Laser-Doppler-Vibrometers (LDVs) which reveal the wave propagation phenomenon caused by impact load. Seifried et al [5] designed impact experiments between bodies with different geometrical shapes to validate their theoretical models, Dong et al [6] designed a longitudinal rod-rod impact experiment to obtain the velocity jump coefficient. However, only a few specified locations on the contact bodies can be measured in the above mentioned experiments.

To avoid the shortcomings of traditional measurement methods, the use of Digital Image Correlation (DIC) is explored as a new means of measuring the deformations due to contacts/impacts. DIC is a non-contact optical deformation measurement technique used to estimate the three-dimensional, full-field deformation of target objects [7]. It works by constructing a mapping of pixel intensity from reference to target image, where the mapping parameters are identified using a Least Squares approach. DIC is widely used in structure measurement including static deformation and dynamic vibration, but is still rarely used in low-velocity impact experiments due to very short impact duration and very small deformation.

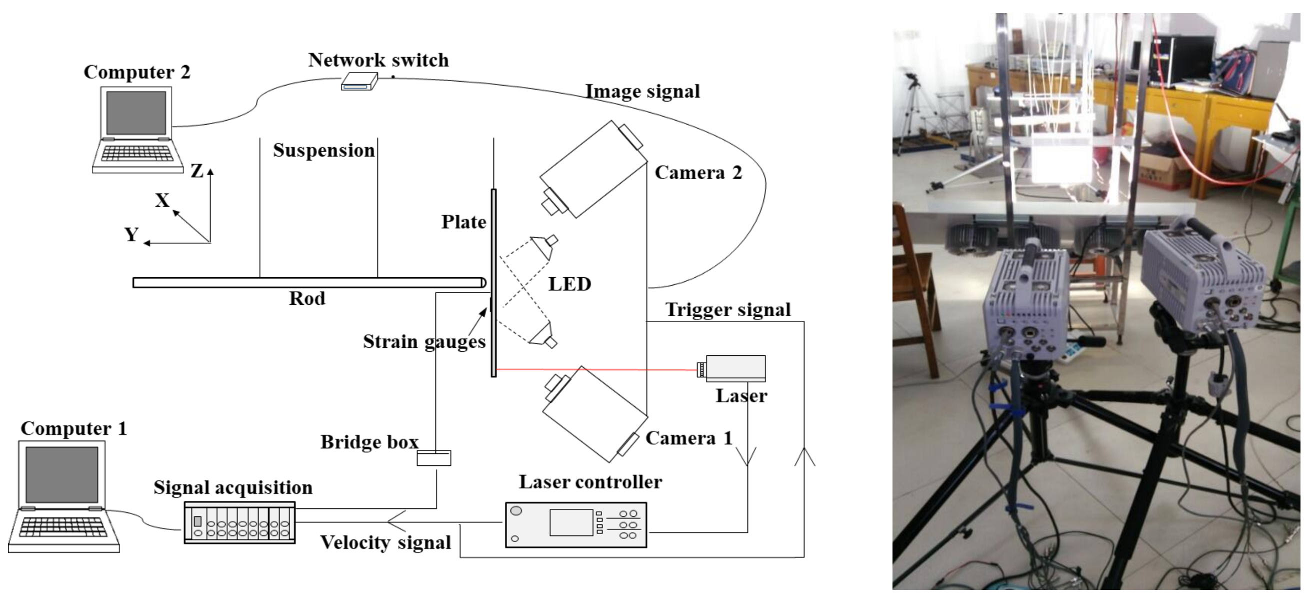


Fig. 1: Experiment set-up

In this work, an impact experiment of a rod on a plate was designed and performed using DIC technique. The schematic diagram of the impact experiment and an overview of the experimental setup are shown in Figure 1. A cylindrical steel rod with hemispherical tip is used to strike an aluminum plate. The two colliding bodies are suspended by two sets of thin wires with "V" shape. The rod is set free form a specified height and impacts the center of the plate. Two high speed cameras of type Photron FASTCAM SA-X2-1000k-M2 are set up perpendicularly to the plate surface. Four strain gauges are pasted on the back surface of the plate, which are located 10mm from the contact point in different directions. Besides, a LDV of type Polytec OFV-3000 is used to generate a signal to trigger the camera. The experimental results are then compared with numerical simulation results. Figure 2 shows that the strain of the contact point measured by DIC is approximately consistent with the measurement by strain gauge and the simulation result. Figure 3 shows the contour of strain field measured by DIC also agrees well with the simulation. It is indicated that DIC is an effective method for measuring the full-field responses of impact problems.

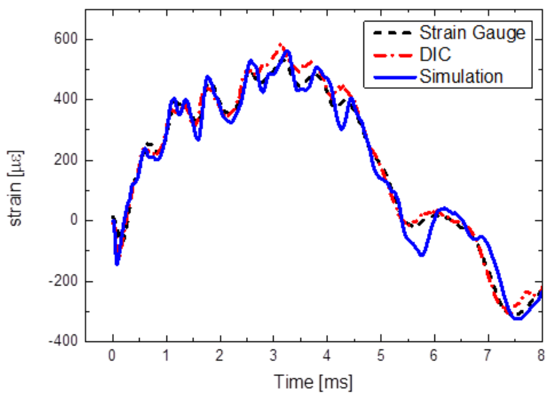
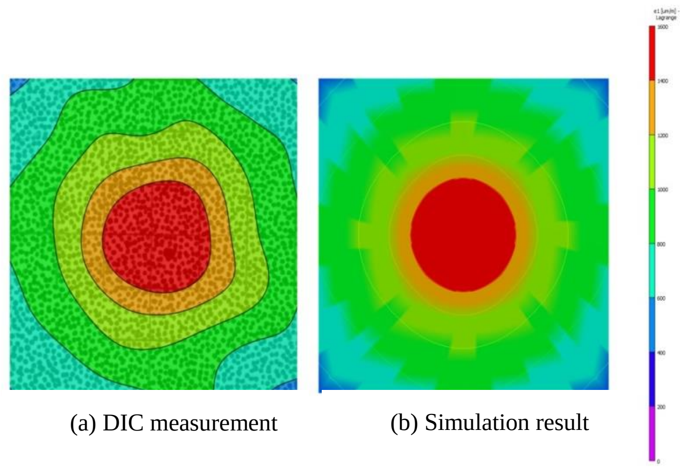


Fig. 2: Strain of contact point



(a) DIC measurement (b) Simulation result

Fig. 3: Full-field principle strain

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