Graphic Procession Unit-Based Parallel Processing for Inverse Computation of Full-Field Material Properties Based on Quantitative Laser Ultrasound Visualization

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Abstract : Motivation and Objective: Ultrasonic guided waves become an important tool for nondestructive evaluation of structures and components. Guided waves are used for the purpose of identifying defects or evaluating material properties in a nondestructive way. While guided waves are applied for evaluating material properties, instead of knowing the properties directly, preliminary signals such as time domain signals or frequency domain spectra are first revealed. With the measured ultrasound data, inversion calculation can be further employed to obtain the desired mechanical properties. Methods: This research is development of high speed inversion calculation technique for obtaining full-field mechanical properties from the quantitative laser ultrasound visualization system (QLUVS). The quantitative laser ultrasound visualization system (QLUVS) employs a mirror-controlled scanning pulsed laser to generate guided acoustic waves traveling in a two-dimensional target. Guided waves are detected with a piezoelectric transducer located at a fixed location. With a gyro-scanning of the generation source, the QLUVS has the advantage of fast, full-field, and quantitative inspection. Results and Discussions: This research introduces two important tools to improve the computation efficiency. Firstly, graphic procession unit (GPU) with large amount of cores are introduced. Furthermore, combining the CPU and GPU cores, parallel procession scheme is developed for the inversion of full-field mechanical properties based on the QLUVS data. The newly developed inversion scheme is applied to investigate the computation efficiency for single-layered and double-layered plate-like samples. The computation efficiency is shown to be 80 times faster than unparalleled computation scheme. Conclusions: This research demonstrates a high-speed inversion technique for the characterization of full-field material properties based on quantitative laser ultrasound visualization system. Significant computation efficiency is shown, however not reaching the limit yet. Further improvement can be reached by improving the parallel computation. Utilizing the development of the full-field mechanical property inspection technology, full-field mechanical property measured by non-destructive, high-speed and high-precision measurements can be obtained in qualitative and quantitative results. The developed high speed computation scheme is ready for applications where full-field mechanical properties are needed in a nondestructive and nearly real-time way.

Keywords : guided waves, material characterization, nondestructive evaluation, parallel processing
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