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Holographic Interferometric Tomography for Reconstructing Flow Fields

by

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Holographic interferometric tomography is a technique for instantaneously capturing and quantitatively reconstructing three-dimensional flow fields. It has a very useful application potential for high-speed aerodynamics. However, three major challenging tasks need to be accomplished before its practical applications.

First, fluid flows are mostly unsteady or at least non repeatable. Consequently, a means for instantaneously recording three-dimensional flow fields, that is, a simple holographic technique for simultaneously recording multi-directional projections, needs to be developed. Second, while holographic interferometry provides enormous data storage capabilities, expeditious data extraction from complicated interferograms is very important for timely near real-time applications. Third, unlike medical applications, flow tomography does not provide complete data sets but instead involves ill-posed reconstruction problems of incomplete projection and limited angular scanning.

During this summer research period, new experimental techniques and corresponding hardware were developed and tested to address the above-mentioned tasks. The first task was achieved by diffuser illumination. This concept allows instantaneous capture of many projections with a conventional setup for single-projection recording. For the second task, a phase-shifting technique was incorporated. This technique allows one to acquire multiple phase-stepped interferograms for a single projection and thus to extract phase information from intensity data almost at real-time. For the third task, the research that has been extensively conducted previously was utilized. In this research period, a complete experimental setup that provides the above three major capabilities was designed, built, and tested by integrating all the techniques. A simple laboratory experiment for simulating wind-tunnel testing was then conducted. A test flow was produced by employing a relatively simple device that generate a gravity-driven flow. The flow was then experimentally investigated to check the viability of the holographic interferometric tomographic technique before wind-tunnel application.