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Quantitative colour Schlieren techniques.

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Abstract

Schlieren photography is a common name given to the optical technique of capturing changes in density of transparent media. It is possible that, with the aid of modern numerical solutions, schlieren techniques are able to produce quantitative results. Modern image processing algorithms and techniques allow for a more complex and comprehensive analysis of the flow phenomenon while still remaining non-intrusive. This dissertation describes the potential of a 2-dimensional colour schlieren system for producing quantitative data on the density field within the test section of a shock tube. Density gradient components, magnitude and direction, form the basis of the quantitative evaluation. These are encoded onto an imaging plane by means of a colour coded source mask placed along the optical axis of the schlieren system. Direction is indicated by the relative ratios of the 3 primary colours, Red, Green and Blue (RGB). Magnitude is indicated by the relative intensities of the RGB values. Sensitivity of the system is adjusted by an iris diaphragm placed at the focal point of the second parabolic mirror in the cut-off plane. The schlieren method described is applied to a two-dimensional focusing parabolic model subjected to a shock traveling at between Mach 1.3 and Mach 1.4. The experimental results of the schlieren technique are compared to computational simulations with synthetic two-dimensional colour and magnitude coding applied to the results. Image processing methods are used to determine the density gradients within the experimental images and allow comparisons to computational results. The source masks designed and used herein proved to require a greater intensity light source and thus the design of an LED light was developed. A number of existing circuits are used as building blocks and as a comparison tool in the development of the light source. In-house Computational Fluid Dynamics (CFD) has been developed with emphasis on 2-Dimensional solutions. The CFD solutions did not yield colour schlieren data thus a computational script was designed to convert the results into an image format directly comparable to the photographic images obtained by experimentation. Image processing techniques have been employed to deconstruct photographs to allow for quantitative comparisons with a calibration lens. Density gradient direction has been conclusive, however density gradient magnitude is not yet accurately determined due to light source constraints.