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Title: A thesis on the Development of an Automated SWIFT Edge Detection Algorithm

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Introduction

Throughout the world, scientists and engineers such as those at Los Alamos National Laboratory, perform research and testing unique only to applications aimed towards advancing technology, and understanding the nature of materials. With this testing, comes a need for advanced methods of data acquisition and most importantly, a means of analyzing and extracting the necessary information from such acquired data.

Swift for Shock Wave Propagation

At Los Alamos National Laboratory (LANL) exists, Detonator Technology (Q-6), a group with a strong foundation in both research and design. Detonator Technology currently operates a unique detonator test laboratory which utilizes high speed diagnostics and further supports other Los Alamos explosive test facilities with designing, deploying, and maintaining timing, firing, and integrated safety systems, as well as providing technical detonator support in fielding and executing integrated weapon experiments.

Ongoing research is aimed at understanding high explosive materials (HE) and characterizing their performance. This research is conducted using various techniques including high speed diagnostics. One specific technique is known as Shock Wave Image Framing Technique (SWIFT), and was designed by Ph.D. Michael Murphy, an R&D Engineer at Los Alamos National Laboratory. This technique involves using a SIMD16 Ultra High Speed Framing Camera coupled with Schlieren optics and a spoiled-coherence laser backlighting to image explosive output within transparent media with high image quality and multi-frame resolution. [1] This technique is used to perform observations of the temporal and spatial evolution of shock waves propagating from detonation events confined within the transparent media and displayed as a simple flow of visualizations. [2] The ability to conduct such observations using an ultra-high-speed device allows for qualitative information such as two-dimensional shock position, displacement, and velocity to be obtained from the characterization of two-dimensional shock-front geometries using SWIFT images. The primary goal of this thesis is to introduce methods for an automated edge detection and point extraction algorithm as a means for extracting qualitative information within datasets produced by SWIFT.

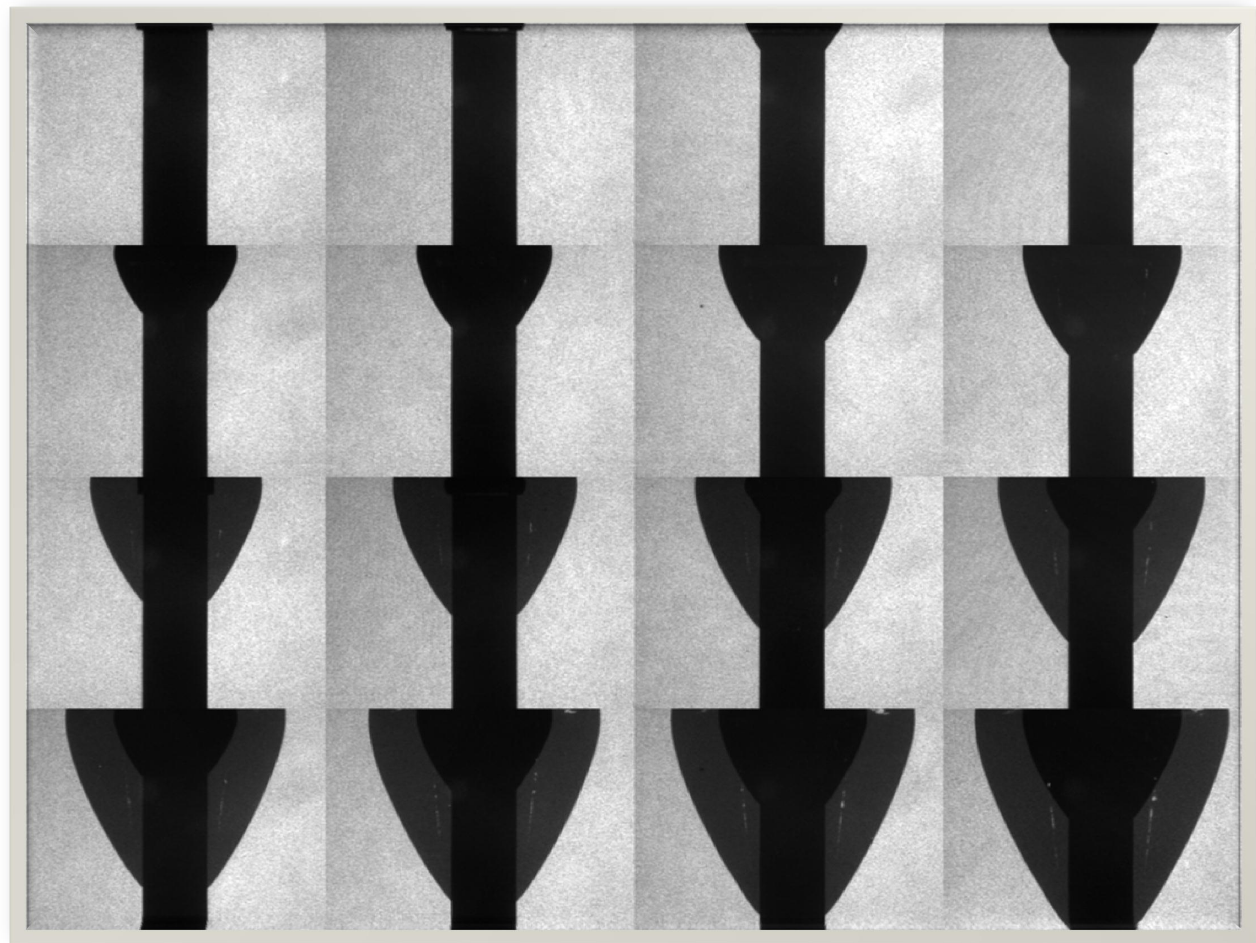

Figure 1. Sample data set produced using SWIFT image diagnostics.

Previous Work

Current techniques employed to analyze datasets produced by SWIFT have proven to be unprogressive. These techniques involve an individual to manually locate the shock propagation edges and note any points of interest for every image within the dataset. This method has proven to be time-consuming, undesirable, and can produce a degree of inconsistent results from person to person.

In this thesis, I aim to produce an automated method implementing advanced image processing techniques and tools to analyze SWIFT image datasets for Detonator Technology at Los Alamos National Laboratory. Such an effective method for edge detection and point extraction can prove to be advantageous in analyzing such unique datasets and provide for consistency in producing results.

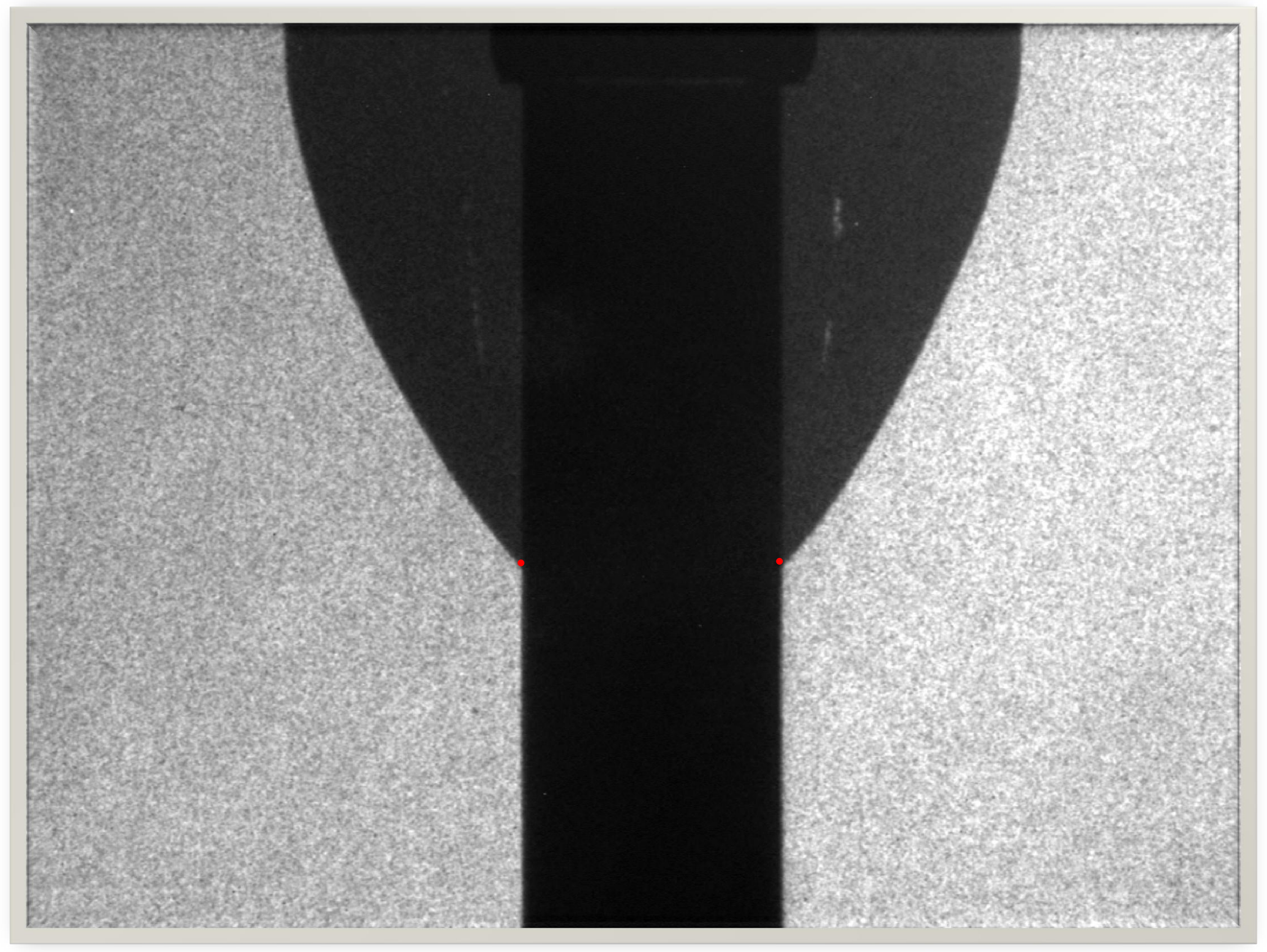

Figure 2. Sample data image produced using SWIFT image diagnostics.

Proposed Algorithm

The proposed algorithm, Active Contours Without Edges (ACWE) is a model based on partitioning an image into regions based on their homogeneity of intensities. This algorithm uses a predefined initial curve, C, and propagates that curve either inward or outward towards the normal directions until the defined energy is minimized. When the fitting energy is minimized, then the propagating curve C is said to be on the boundary of the object.

Current results have proven to be superior over other edge detection algorithms, such as the Canny edge detection algorithm. ACWE can be implemented on raw data images without the need for preprocessing techniques for noise reduction.

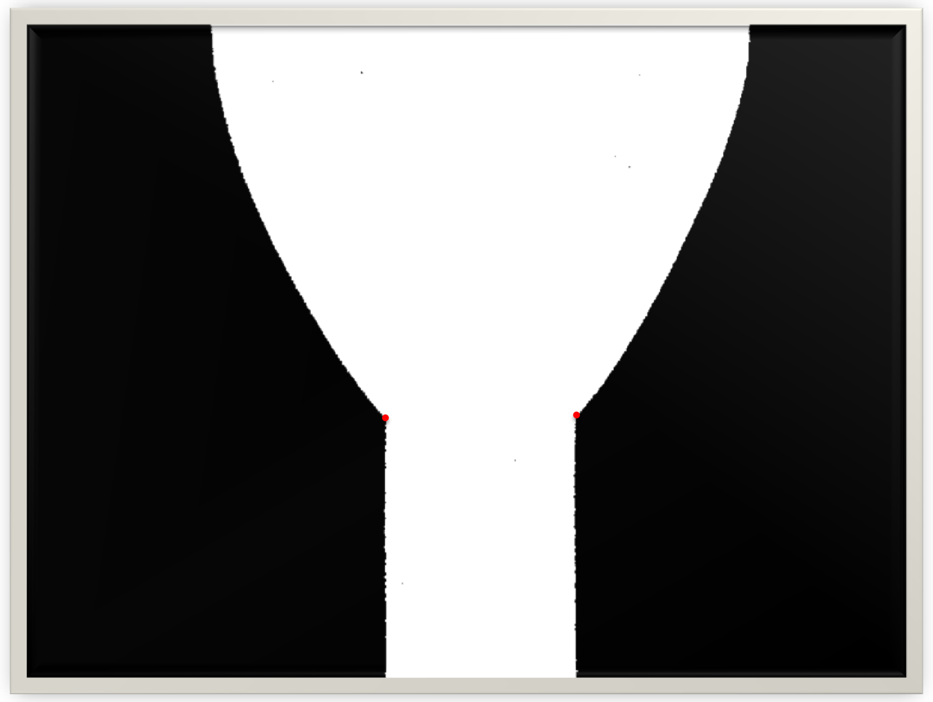

Figure 3. Processed data image produced using ACWE algorithm.

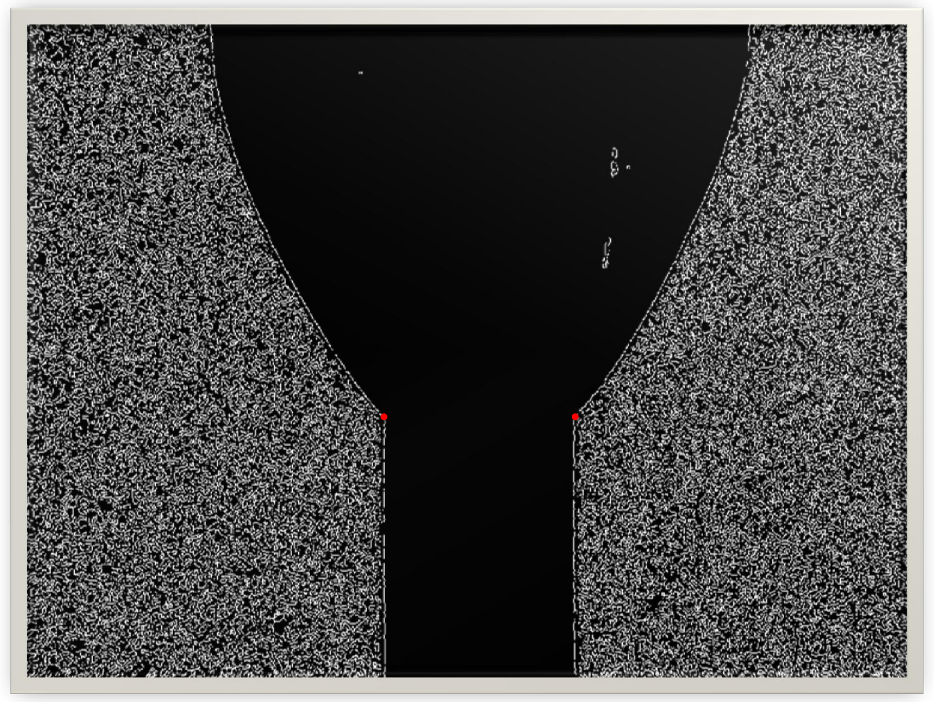

Figure 4. Processed data image produced using Canny edge detection algorithm.

Acknowledgements

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[1] Murphy, M.J. and S.A. Clarke, Ultra-High-Speed Imaging for Explosive-Driven Shocks in Transparent Media, in Dynamic Behavior of Materials, Volume 1: Proceedings of the 2012 Annual Conference on Experimental and Applied Mechanics, V. Chalivendra, B. Song, and D. Casem, Editors. 2013, Springer New York: New York, NY. p. 425-432.

[2] Murphy, M.J., SWIFT and Explosive PIV. 2014, Los Alamos National Laboratory (LANL).