Software for Acquiring Image Data for PIV

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PIV Acquisition (PIVACQ) is a computer program for acquisition of data for particle-image velocimetry (PIV). In the PIV system for which PIVACQ was developed, small particles entrained in a flow are illuminated with a sheet of light from a pulsed laser. The illuminated region is monitored by a charge-coupled-device camera that operates in conjunction with a data-acquisition system that includes a frame grabber and a counter-timer board, both installed in a single computer. The camera operates in "frame-straddle" mode where a pair of images can be obtained closely spaced in time (on the order of microseconds). The frame grabber acquires image data from the camera and stores the data in the computer memory. The counter/timer board triggers the camera and synchronizes the pulsing of the laser with acquisition of data from the camera. PIVPROC coordinates all of these functions and provides a graphical user interface, through which the user can control the PIV data-acquisition system. PIVACQ enables the user to acquire a sequence of single-exposure images, display the images, process the images, and then save the images to the computer hard drive. PIVACQ works in conjunction with the PIVPROC program — described in prior *NASA Tech Briefs* articles — which processes the images of particles into the velocity field in the illuminated plane.

This program was written by Mark P. Wernet of **Glenn Research Center** *and H. M. Cheung of the University of Akron and Brian Kressler of Cornell University. Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland Ohio 44135. Refer to LEW-17373.

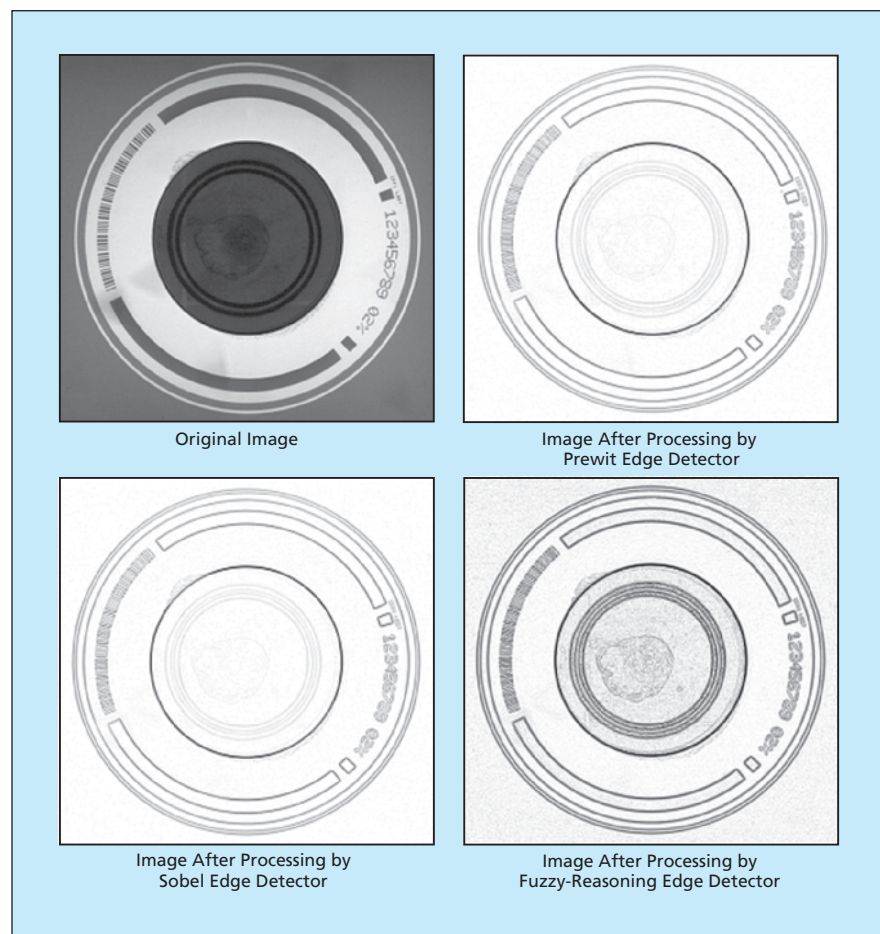# Detecting Edges in Images by Use of Fuzzy Reasoning

Human visual processing is partly imitated in order to harness some of its power.

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A method of processing digital image data to detect edges includes the use of fuzzy reasoning. The method is completely adaptive and does not require any advance knowledge of an image.

During initial processing of image data at a low level of abstraction, the nature of the data is indeterminate. Fuzzy reasoning is used in the present method because it affords an ability to construct useful abstractions from approximate, incomplete, and otherwise imperfect sets of data. Humans are able to make some sense of even unfamiliar objects that have imperfect high-level representations. It appears that to perceive unfamiliar objects or to perceive familiar objects in imperfect images, humans apply heuristic algorithms to understand the images.

Fuzzy reasoning is a suitable means of heuristic processing of incomplete and otherwise imperfect data. Most prior edge-detection methods require the selection of parameters (e.g., thresholds in gradient edge-detection algorithms) — a difficult task when little or nothing is known about an image in advance. Moreover, prior edge-detection methods based on mathematical models can detect only specific kinds of noticeable edges: For example, an optimal mathematical-model-based step edge detector can be ineffective in detecting ramp edges. Relative to methods that involve mathematical models and advance selec-

Original Image

Image After Processing by Prewit Edge Detector

Image After Processing by Sobel Edge Detector

Image After Processing by Fuzzy-Reasoning Edge Detector

An **Image of a Compact Disk** was processed by a fuzzy-reasoning edge detector and by the Prewit and Sobel edge detectors.

tion of parameters, the present method and possibly other methods of processing image data in partial imitation of image processing in the human brain and eye offer greater flexibility and the potential for superior performance.

In the present method, a window of 3 by 3 pixels is scanned over the whole image. An optimal intensity gradient based on the central pixel is found through a heuristic analysis. A crisp cen-

tral-pixel value is generated after a fuzzy membership function is evaluated by use of the optimal intensity gradient.

The method has been implemented in a C-language computer program. The method was tested by applying the program to an image of a compact disk. As shown in the figure, this method performed better at detecting edges than did computer programs that implemented two prior edge-detection methods known

as the Sobel and Prewit methods. The program of the present method even detected a dark central spot containing narrow edges that the programs of the Sobel and Prewit methods did not detect at all.