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# For Concrete Evaluation

Federal Manufacturing & Technologies

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# An Automated, Image Processing System for Concrete Evaluation

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ABSTRACT:

AlliedSignal Federal Manufacturing & Technologies (FM&T) was asked to perform a proof-of-concept study for the Missouri Highway and Transportation Department (MHTD), Research Division, in June 1997. The goal of this proof-of-concept study was to ascertain if automated scanning and imaging techniques might be applied effectively to the problem of concrete evaluation. In the current evaluation process, a concrete sample core is manually scanned under a microscope. Voids (or air spaces) within the concrete are then detected visually by a human operator by incrementing the sample under the crosshairs of a microscope and by counting the number of "pixels" which fall within a void. Automation of the scanning and image analysis processes is desired to improve the speed of the scanning process, to improve evaluation consistency, and to reduce operator fatigue. An initial, proof-of-concept image analysis approach was successfully developed and demonstrated using acquired black and white imagery of concrete samples. In this paper, the automated scanning and image capture system currently under development will be described and the image processing approach developed for the proof-of-concept study will be demonstrated. A development update and plans for future enhancements are also presented.

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Keyword I: Machine Vision and Image Processing

Keywords II: Classification-Fusion, Computer Vision, Data-Analysis, Data-Fusion, Data-Visualization, Design-Automation, Feature-Extraction, Feature-Identification and Classification, Image-Data Acquisition, Image- Interpretation, Image-Processing, Machine-Vision, Machine-Vision and Image Processing, Matching-Fuzzy, Texture Classification

## Introduction

Automated machine vision techniques are being used with increasing frequency to improve the efficiency, throughput, and accuracy of manual inspection and evaluation processes in a wide variety of applications. Such applications rely on computer- and vision-based software to perform the tedious process of inspection, evaluation, and presentation while freeing the operator for data review and interpretation of the inspection results (Nielson, Hagen, and Muller, 1988). One such application has been prototyped by AlliedSignal FM&T as a result of a request for technical assistance from the MHTD Research Division.

The MHTD currently performs concrete evaluation for the purpose of determining the quality of newly laid concrete, as well as to examine concrete degradation due to aging. In the current MHTD evaluation approach, a concrete sample core is obtained from a section of roadway to be evaluated. The face of core sample is then polished and placed on a linear traverse. The sample is then scanned manually. Voids (or air spaces) within the concrete are detected visually through a microscope by incrementing the sample under the microscope crosshairs and by counting the number of "pixels" which fall within a void. The quality of the concrete is based on a characterization of the air voids existing in the sample. Both the relative percentage of air voids compared to total sample surface area and the distribution of void diameters are used in calculating 16 different microscopic properties of the concrete.

In the MHTD request for technical assistance, FM&T was asked to perform a proof-of-concept study to ascertain if video imaging techniques might be applied effectively to the problem of concrete evaluation, using such techniques to automatically scan concrete samples and determine the microscopic properties of interest. Many imaging techniques exist for applications where objects must be segmented from an image and their shapes characterized (Low, 1991; Ritter and Wilson, 1996; Russ, 1995). FM&T has developed a number of such video imaging and remote sensing applications in past years, successfully integrating data/image acquisition, signal processing, feature extraction, and pattern recognition techniques into user-friendly, automated analysis environments (Baumgart, et al, 1996; Linder, et al, 1998).

Automation of this currently manual process poses the following technical challenges.

- Voids must be detected automatically in the imagery and discriminated from aggregate, sand crystals, and cracks since the number of void pixels must be estimated in the sample.
- Each detected void must be characterized individually since a distribution of void diameters is required.
- Automated scanning of the sample must be performed to high precision to preclude overlap in adjacent fields-of-view.
- Consistency of the scanning and evaluation process is an absolute requirement.

## Proof-of-Concept System Description

The system hardware used for this proof-of-concept study consists of a research grade compound microscope (a Nikon Labophot-2®), a black-and-white CCD video camera (Sony model SSC-M370 c-mount), a video monitor, and a 166-MHz Pentium personal computer equipped with an Alacron video frame grabber for acquisition of 640 x 480 pixel images. An intense light source illuminates the surface of the concrete sample from a very low, grazing angle to accentuate the voids and improve contrast. This system configuration is illustrated in Figure 1.

The fundamental processing steps involve capturing an image from the microscope field-of-view followed by the application of image segmentation and shape feature extraction techniques to the imagery. Each "object" extracted from an image is characterized with a set of shape, intensity, and local neighborhood associated features. These extracted features are then used as input into a

fuzzy logic inferencing procedure that identifies which of the detected objects are actually voids and which are background "clutter" objects (coarse aggregate, sand crystals, cracks, etc.).

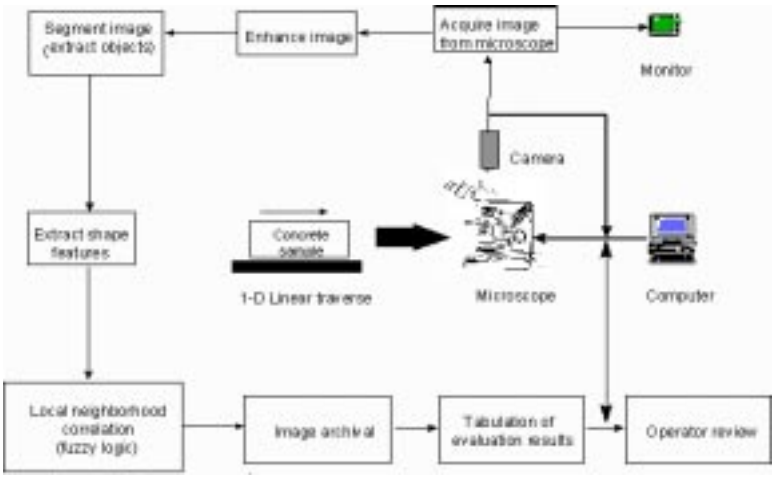


Figure 1. Hardware and data flow concept for automated scanning system.

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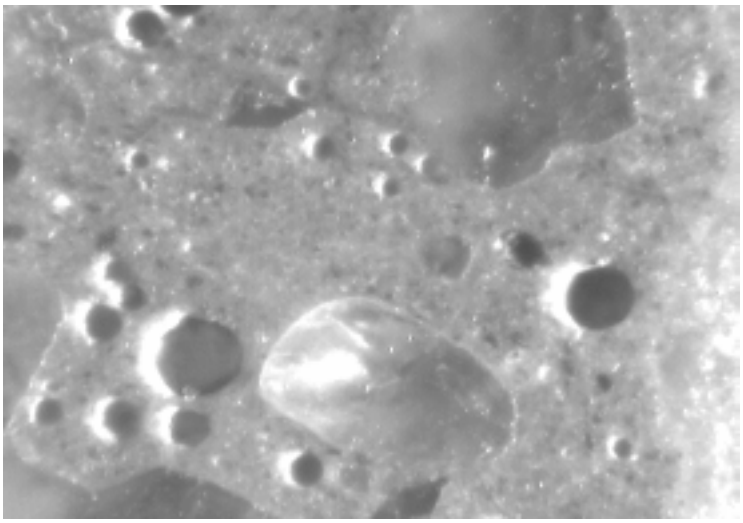

Figure 2. Original image of concrete surface.