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SEQUENTIAL CLASSIFICATION AND CLUSTERING METHODS APPLIED TO DIGITIZED PHOTOGRAPHS

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ABSTRACT

This paper presents a system for object detection and counting from transparencies digitized using a scanning microdensitometer. Classification and clustering methods are applied sequentially to digitized transparencies of an orange tree and a low altitude color infrared aerial photograph of a citrus orange. The objective is to count oranges on the digitized ground transparency and to count fruit trees on the digitized infrared aerial photograph. This general flow can be applied to any type of spectral data for object detection and counting.

An 11 x 1 vector X is measured on each point. The vector X is composed of eight spectral variables, two spatial variables, and a label variable.

$$x = \begin{cases} 8 \times 1, \text{ spectral component vector} \\ 2 \times 1, \text{ spatial component vector} \\ 1 \text{ dimensional label variable} \end{cases} \quad (1)$$

Discriminant analysis is first performed on the eight spectral variables using the groups identified by the label variable. Once each point has been classified, only these points classified as oranges (or trees) are clustered using the spatial variables. A graph theoretic clustering method was applied to the classified data. The graph theoretic clustering yields a measurement vector which characterizes the cluster shape. The cluster measurement vector is:

$$Y = \begin{cases} \text{Cluster diameter} \\ \text{Cluster size} \\ \text{Cluster average edge length} \\ \text{Cluster standard deviation} \end{cases} \quad (2)$$

This vector Y is then used as the measurement vector to classify clusters as either tree or non-tree (or orange and non-orange). The summary from the discriminant analysis gives an estimate of the number of trees (or oranges).

AUTOMATED GROUND COORDINATE SAMPLING

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ABSTRACT

Analytical techniques have been designed, tested and implemented that provide automated procedures for referencing terrain locations defined by ground coordinates in digital images. Based on principles of analytical photogrammetry, these techniques, termed projective sampling, rigorously account for camera position and orientation. Corrections for lens distortion, atmospheric refraction, film deformation and other sources of systematic distortion can be incorporated. A ground coordinate data base, an image digitizer which also serves as a comparator and well-defined imaging geometry, such as that of frame cameras, are required.

Operational feasibility of projective sampling has been verified on NASA high-altitude (18.5 km) photography. Analysis of metric color and color infrared photography resulted in root-mean-square errors for referencing specified ground locations by projective sampling of less than six meters in both X and Y.

Projective sampling has been used to automate a novel crop classification strategy. For a Maricopa County, Arizona test area defined by a ground coordinate data base, seven sets of multiband photography obtained from January to July 1970 were sampled to form a spectral/temporal feature vector for each field. Boolean decision rules based on phenological criteria were then used to successfully classify the five major crop types present.