CANOLA AND MUSTARD SEED RECOGNITION USING IMAGE PROCESSING

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INTRODUCTION

The past decade has seen incredible technological advances in automating the handling and transportation of grain [Candlish, 1984]. Yet, inspection and grading systems are mainly based on the visual assessment of numerous grading factors. The foremost problem with the current grading system is that a substantial degree of human judgment is required to assess these visual features. These evaluations are very laborious, repetitive, and subjective. A subjective grading system leads to: (1) a lower reputation in the export market, (2) disputes among producers, and (3) uncertain purity levels for seed buyers and growers. The deficiencies in the current grain grading systems have facilitated research into an objective technique for quality measurements.

The development of computer vision technology holds great potential for identifying the characteristics of a sample of grain and thereby determining its quality and value [Canada Grains Council, 1982]. Computer vision maybe defined as the union of camera and computer for acquiring and analyzing images. Computer vision is well suited for the task of automated grain inspection since it is capable of working continuously without fatigue and makes decisions based on objective measurements of surface features which is consistent with current visual grading systems. Churchill [1990] showed that a machine vision system is capable of making more precise seed measurements than human inspectors, in about one-third of the time. While the advantages of using computer vision in grain inspection system are obvious, few implementations have been reported. Recent advances in cost effective hardware and software are some of the major factors contributing to the growing interest in agricultural applications of machine vision.

This paper describes the components of a computer vision system developed at the Department of Agricultural Engineering in the University of Saskatchewan. The system has been used in a preliminary investigation of the identification of canola and mustard seeds. Canola (*Brassica*) is a major oilseed in Canada accounting for more than 3 million tonnes annually [Canada Grains Council, 1989]. One of the prime determinants in the grade assigned to canola is the amount of an inconspicuous admixture in the sample, or the foreign seeds that are not readily distinguishable from canola [Canadian Grain Commission, 1987]. A weed seed that falls into the inconspicuous category is wild mustard (*Sinapis arvensis*). Oriental Mustard (*Brassic Juncea*) is considered to be a conspicuous admixture in canola and can also seriously degrade the quality of the sample. Since canola and mustard are very similar in size, shape, and color, it is difficult for inspectors to separate these seeds. There are some subtle shape and surface feature differences between the seeds which are not visible to the human eye, but could readily be detected by a computer vision system.

HARDWARE AND SOFTWARE

Computer

In our experiment, a Macintosh IIfx serves as the engine for the computer vision workstation. The system runs at 40MHz and is configured with 8Mb's of RAM, 160 Mb harddisk, 24 bit display card (8*24), and an ethernet card. Display is achieved on a 13" RGB color monitor and a 2-page display monitor. Hard copy printouts are done on Laserwriter NT.

Image Processing Hardware

The Macintosh IIfx has been converted into an image processing workstation by adding a framegrabber, a camera and optics system, and some image capture and processing software. Figure 1 shows the schematic of the front end or image input system.

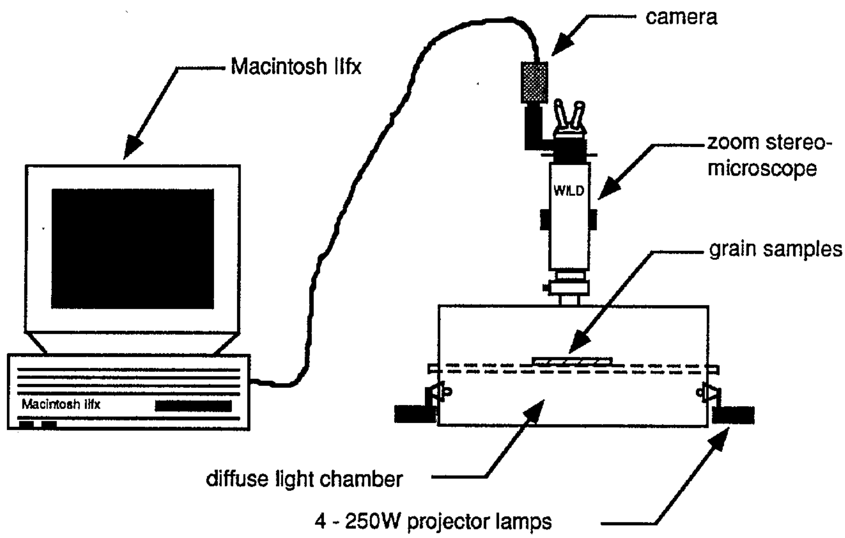

Figure 1: Schematic diagram for image input hardware.

Video images are obtained using solid state RGB color camera (Javelin JE3462RGB). The camera has a resolution of 760(H) x 485(V) pixels and can produce both RGB and NTSC video output. Only NTSC luminance has been utilized for this project. The camera is positioned on one of the binocular tubes of a microscope (WILD M8 Zoom Stereo-microscope) using a photo tube and C-mount adapter. The photo tube allows for manual control of the aperture. The microscope zoom control allows for stepless magnification control from 2.4 to 256 times.

Diffuse incident light was provided by a diffuse light chamber [Paulsen and McClure, 1986]. The chamber was constructed from a 63cm length of 25cm ID white PVC pipe. The inner surface of the pipe was abraded to provide a diffusing surface. A hole was drilled in the upper center of the tube to provide a vantage point for the camera. Illumination was provided from both ends of the tube by two 250W projector lamps mounted on heat sinks.

The framegrabber board (Data Translation-QuickCapture) resides in one of the Nubus slots in the Macintosh. The framegrabber can capture images at a rate of 30 frames per second. It is capable of accepting up to four camera inputs by using a 4 channel multiplexer. The board has eight 256 x 8 input look-up tables and a 640 x 480 x 8 bit high speed memory-mapped frame buffer. Since the board has an 8 bit A/D (256 gray levels), the four channel multiplexer is necessary for color acquisition from RGB cameras. The software required to capture color images from the R, G, and B channels has not yet been developed, so the vision system is presently limited to 256 gray levels. Gray scale images are attained, from the NTSC signal of the color camera, by enabling a chrominance filter on the QuickCapture board to strip off the color information. The framegrabber and camera both have square pixels so there is no need to deal with an aspect ratio.

Image Processing Software

The image processing software [Automatix-Image Analyst/Source,1990] operates at two levels. The upper level is a menu-driven package designed to process both live video and stored image files, and to extract quantitative data. This package maybe used as is or modified using a high-level language called MacRAIL. The MacRAIL environment allows users access to the complete vision library; add custom algorithms, interface to serial, digital, and analog I/O; and to generate other customized applications. The capabilities of Image Analyst and its flexibility in adapting to specific applications makes it an outstanding software platform for conducting agricultural related vision research.

EXPERIMENTAL

Material

Certified seed samples representing five varieties of Canola: Westar, Tobin, ACS Parkland, OAC Triton and Delta, were obtained from the Canadian Grain Commission. The material originated from certified seed growers in Ontario, Alberta, and Manitoba. Currently only Westar and Parkland canola has been examined, the other varieties will be investigated in future work. Wild mustard samples were also obtained from the Canadian Grain Commission. The origin of the wild mustard seed is from a certified seed grower in Manitoba. A representative sample of oriental mustard was obtained from the Agriculture Canada Research Station in Saskatoon, Saskatchewan.

Object Presentation

Based on initial observations it was determined that a viewing distance of 87 mm would be appropriate. Viewing from this distance provided a FOV of 10mm x 13mm and a spatial resolution of 2350 pixels/mm^2. The seeds were viewed under incident light in the diffuse light chamber. The light intensity was held constant throughout the experiment at a level that neither enlarged nor eroded the seed profile. Calibration of the image analysis system for both physical units and reflectance has been described previously [Hehn and Sokhansanj, 1990]

In order to facilitate rapid measurements a seed holder was designed. The seed holder was fabricated from a flat plate black acrylic material and contained 54 holes in groups of nine holes each. This ensured that nine seeds would be in the FOV at one time and that none of the seeds would be contact with each other. Seeds were randomly selected from pure samples and placed on the seed holder. The seed holder could then be shifted along the FOV as the test progressed. Plans are to fabricate a vacuum seed holder to automatically position the seeds.

Feature Extraction

Initial measurements were taken on a training set of 927 randomly selected seeds from pure samples of westar canola (n=216), parkland canola (n=270), oriental mustard (n=225) and wild mustard (n=216). Broken or damaged seeds were removed from the samples prior to taking measurements. An appropriate threshold for separating the seeds from the background was manually selected using information from initial trials. The software reported feature measurements on light objects with a minimum blob area of 1500 pixels. Any object having an area of less than 1500 pixels was considered to be noise in the background and therefore ignored. Images were captured, analyzed for connectivity, and the features were saved on diskettes as text files.

The data acquired using Image Analyst was then imported by a Macintosh spreadsheet (Wingz). The spreadsheet was used to filter the data and compile a large database on each variety of seeds. The data filtering process comprised of the following; removing unnecessary information, transposing the data, and standardizing column widths. The transposing and standardizing of data was necessary to provide a data set suitable for importing by the SAS statistical package. Table 1 shows the measured features used in this initial discrimination study.

Table 1: Measured seed features

Parameter	Definition
AREA	area (mm^2)
PERIM	perimeter (mm)
ROUND	roundness = $(4*\pi*AREA)/ PERIM^2$
PERINVAR	perimeter invariant = $PERIM^2/AREA$
RADRATO	ratio of the minimum and maximum radius from the center of the area to the perimeter
AXERATO	ratio of the lengths of the major and minor axis of an equivalent ellipse (an ellipse with the same second moment of the area)
BOXRATO	ratio of the blob AREA to the area of a box enclosing the blob
GRAY2	average gray value of the blob
STD2	standard deviation in the average gray value of the blob

Statistical Analysis

Varietal databases were merged and sent to a mainframe (VAX 8600) computer, via an ethernet link, for statistical analysis. Multivariate statistical techniques in SAS (1985) were used to recognize and evaluate patterns in the data. The procedures used are similar to those described by Zayas, et.al [1990]. The procedure STEPDISC (stepwise discriminant analysis) was used to determine an optimal discriminating feature set and the procedure DISCRIM (discriminant analysis) was used to evaluate the performance of the discrimination model.

Table 2: Summary of classification results

From class	N	Into class				% Correctly Classified
		Oriental Mustard	Parkland Canola	Westar Canola	Wild Mustard	
Oriental Mustard	54	47	7	0	0	87
Parkland Canola	54	5	49	0	0	90.1
Westar Canola	54	0	0	53	1	98.2
Wild Mustard	54	0	0	2	52	96.3

RESULTS AND DISCUSSION

A discriminant analysis was performed on the training set in order to develop functions which maybe used to classify seeds as either canola or mustard. The analysis determined the useful features and ranked them in their order of importance as: GRAY2, PERIM, AXERATO, STD2, ROUND, PERINVAR, and AREA, according to their ability in discriminating the seeds. The classification results of the discriminant functions tested on a new randomly selected sample of 216 seeds (n=54 of each variety) is shown in Table 2. It can be inferred that with the exception of the classification of Parkland canola from oriental mustard, all other results were satisfactory. The performance could be improved by considering other features such as seed texture and color.

CONCLUSIONS

The computer vision workstation developed in the department of Agricultural Engineering at the University of Saskatchewan will provide the facilities necessary to conduct agricultural related vision research. The research to date shows that the workstation provides great promise in automating the inspection and ultimately grading of grains and oilseeds. The study of mustard seeds in samples of canola could easily be extended to include other common noxious weed seeds. The development of algorithms to measure seed color will not only provide better classification results but could also be used to quantify the degree of disease, mold, heat and frost damage, and amount of immature or green kernels.

Work is ongoing to develop and implement algorithms which may be used to quantify seed texture and color. Techniques of this nature are extremely complex and demand more computing power, yet they may prove extremely valuable in identifying degrading surface features. The development of this objective visual classification system may eventually lead to a robotic sorting system.

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REFERENCES

Automatix, 1990. Image Analyst Users Manual Rev 7.2. Automatix Inc., Billerica, MA 01821.

Candlish, V.E. 1984. Computers in elevators. Presentation to Canada Grain Council, Edmonton, Alberta CA. Nov 14, 1984.

Canada Grains Council.1982. Grain Grading for Efficiency and Profit. Canada Grains Council, 760-360 Main Street, Winnipeg, Manitoba. R3C 3Z3.

Canada Grains Council, 1989. Grains Industry Statistical Handbook 89. Canada Grains Council, 760-360 Main Street, Winnipeg, Manitoba. R3C 3Z3.

Canadian Grain Commission. 1987. Official Grain Grading Handbook for Western Canada. Canadian Grain Commission, Winnipeg Manitoba R3C 3G8.

Churchill, D.B., 1990. Comparsion of machine vision with human measurement of seed dimensions. ASAE Paper No. 90-7519, ASAE, St. Joseph, MI 49085.

Hehn, J.L., and Sokhansanj, S. 1990. Canola and mustard seed identification using Macintosh based imaging system. ASAE Paper No.90-3534, ASAE, St. Joseph, MI 49085.

Paulsen, M.R., and McClure, W.F., 1986. Illumination for computer vision systems. Transactions of the ASAE 29(5):1398-1404.

SAS Users Guide: Statistics, Version 5 edition, SAS Institute Inc., Cary, NC, 1985.

Zayas, I, Converse,H., and Steele, J. 1990. Discrimination of whole from broken corn kernels with image analysis. Transactions of the ASAE 33(5):1642-1646.