UPDATE ON THE DEVELOPMENT OF A BARK AND GRASS INDICATOR FOR COTTON GINS

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Abstract

This study was initiated to provide the ginner with knowledge of the presence or absence of bark (or grass) in the ginned lint during the ginning process. An existing color/trash meter was connected to a PC in a laboratory environment. Simple "run length" algorithms were developed along with variable threshold techniques, to eliminate the effects of variable lighting and to detect bark. The algorithms will detect bark 90% of the time when the piece of bark is at least one inch in length. The programs had difficulty detecting small pieces of bark (0.2 to 0.5 in). As expected, the programs also had problems distinguishing between large leaf trash and bark. The programs are suitable for incorporation into an existing process control system to aid the ginner in his decision making process. However, the programs are probably not accurate enough for use in cotton classing offices.

Introduction

This is a continuation of the work (Barker and Byler, 1995) reported at the 1995 Cotton Production Research Conferences, which showed that simple "run length" algorithms, using constant thresholds, could detect bark 67% of the time. This work was initiated in an attempt to improve process control systems designed for cotton gins. Process control can range from simple measurements to extensive automatic controls (Anthony and Byler, 1994). Most of the work to date has involved the online measurement of moisture and trash. Current process control technology for cotton gins determines the appropriate number of lint cleaners needed to optimize the returns to the farmer and changes the processing appropriately (Anthony 1990).

The presence of bark and/or grass in the ginned lint is a major problem facing producers and ginners. Ethridge et al. (1992) have shown that, in many cases, the penalty for bark (or grass) in cotton is excessive compared to the actual losses at the mill. Thus process control for gins, in the stripper harvested areas, requires the identification of bark during processing.

The objective of this study was to develop equipment and techniques to indicate the presence of bark in ginned lint at the gin using simplified algorithms which can be implemented in real time. A secondary requirement was that the procedures and techniques would complement existing process control technology.

Procedure

The equipment used for this study included a Motion Control color/trash meter, similar to that used by Anthony (1990), set up in a laboratory environment. This unit consists of a black and white video camera, two color sensors and lights, Figure 1. Neither the Motion Control software nor the color sensors were utilized in this study. The camera was connected to a IBM clone (Intel 486, 66Mhz processor) via a Catenary Systems HRT 512-8 video board. We configured the video camera to scan an area of 2.5458 in. wide by 2.4375 in high which is 470 X 390 pixels. Thus, the pixel size was 0.005416 x 0.00625 in.

The rapid response time required for compatibility with existing process control software and hardware precluded the use of conventional area and perimeter measurements common to most imaging software. Initially, as reported by Barker and Byler (1995), a constant threshold was chosen by trial and error and all pixels with a value less than the threshold were declared as "dark" or "trash". This past year, we modified the original programs to utilize variable thresholding techniques in an effort to increase our accuracy.

The simple run length algorithms check for consecutive dark pixels in the horizontal, vertical and diagonal directions. We arbitrarily defined a piece of bark as being approximately 0.2 in. long or longer. This length was chosen based on our experience that very few trash particles, with larger dimensions, exist in lint which has passed through one or more lint cleaners, except for long stringy particles such as bark and grass. Eight different programs were written to aid in bark detection and to determine the effectiveness of different bark detection algorithms.

The first program uses four algorithms to detect bark in the horizontal, vertical and both diagonal directions. The horizontal and vertical algorithms read every fourth pixel regardless of color and determine if the pixel is dark or light. If the program finds eight or more consecutive dark pixels (while looking at every fourth pixel for a total of 29 or more actual pixels), it defines it as a piece of bark, Figure 2. A white pixel or picture edge is required to terminate the search for bark and increment the bark "counter", thus the "piece of bark" may easily exceed the 29 pixels mentioned above. The diagonal algorithms work in

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a similar manner, except that every third pixel is searched. Again, at least eight consecutive dark pixels are required to define a piece of bark. The algorithms in this program scan every other row, column or diagonal of pixels to reduce computation time.

Program two has 4 diagonal scans in addition to the horizontal and vertical scans. The diagonal scan algorithms actually skip 2 pixels in the horizontal (or vertical) direction and one pixel in the vertical (or horizontal) direction. This gives pixel scans at angles of approximately 30°, 150°, 210° and 240° instead of 45°. The horizontal scans used the same algorithms as the first program.

Programs three and four use the same algorithms as programs one and two, respectively, except that if a piece of bark is found, the program will then skip two rows, columns or diagonals. This procedure reduces the chance of identifying the same piece of bark twice on consecutive scans and reduces computational time.

Programs five through eight are identical to programs one through four except that variable thresholds are used instead of a constant threshold. The variable threshold technique, that we adopted, uses a discrete threshold value for each pixel. The threshold value is determined by scanning a uniform colored tile and storing the value for each pixel.

We obtained cotton lint containing bark from the Lubbock USDA, AMS cotton classing office. We subjected the video system to approximately 100 samples each containing 1, 2, 3, 4, 5 and 6 pieces of bark during the development phase. The operator examined the monitors and determined the number, size, and major orientation of the pieces of bark in the cotton sample. This data was recorded in the output file prior to detection by the eight video programs. The results were analyzed and an appropriate threshold was chosen for the programs.

We tested the programs by scanning 1000 unaltered samples (obtained from the classing office) with the video system using the procedures described above. This data was then used as an input to the bark detection programs.

Results

The equipment and programs appeared to function reasonably after all the corrections and adjustments were made. The programs reported a low of 77% bark (program one) and a high of 97% bark (program five) when the operator reported 1 piece of bark when using the development data set, Table 1. The percent of bark reported increased to 100% as the number of pieces of bark increased, Table 1.

The algorithms used have a very limited ability to count the actual pieces of bark. In fact, a single piece of bark may be reported as 2, 3, or even more pieces, depending on the orientation and size. Program one reported an average of 4.8 pieces of bark where only one piece was observed, compared to 5.7 for program two and 11.8 for program six, Table 2. The increase in detected bark from program one to program two was expected, since program two actually has six scans for bark compared to four for program one. Programs three and four were expected to detect fewer numbers of bark since they have an extra "skip" mechanism built in which takes effect when a piece of bark is identified. This type algorithm does reduce, slightly, the number of pieces of bark reported, Table 2. Programs five through eight detected more bark using the variable threshold than their counterparts with constant threshold.

As expected, the programs did not detect bark as well with the test data as they did with the development data. The constant threshold programs (programs one through four) predicted almost as much bark in samples containing no bark (44-46%) as they did in samples containing bark (50-51%), Table 3. The variable threshold programs showed considerable improvement in the number of samples reported as containing bark when in fact no bark was present (28-29%). They also performed better for the data in which bark was present (55-61%), Table 3.

Further examination of the data revealed that 23% of the samples containing no bark were shown to contain large (sometimes larger than 0.2 in) leaf trash. Table 4 shows the effect of bark size and color on percent of samples reported as containing bark. None of the programs performed very well (reporting less than 50%) when the bark was described as small (0.25 to 0.5 in). The programs reported between 43.5 and 63% of the samples with bark when the bark was described as medium (0.5 to 1 in) and 71 to 90% when the bark was described as large, Table 4. The programs also performed better when the bark was described as dark rather than light colored. Twenty six percent of the samples containing bark were described as small in size and light colored.

Examination of Tables 3 and 4 shows that the variable threshold techniques improved bark detection by about 10 percentage points when bark was present and decreased the number of samples reported as containing bark when in fact no bark was present by about 15 percentage points. Programs six and eight consistently gave the best results, these two programs have four diagonal (30°) scans instead of two and use variable threshold techniques.

The small area scanned, 5.3 in^2, makes the techniques and procedures developed somewhat uncertain in their ability to predict the presence or absence of bark in a processing environment. If the cotton being ginned contains a moderate to large amount of bark, then the variable threshold programs should show the presence of bark. However, if the bark is small and/or light colored, then the system will have difficulty in detecting bark. The data obtained in this study was not correlated with data from the cotton classing office to compare the results with those reported by a cotton classer.

Conclusions

A study was initiated to develop software and hardware for detecting bark in cotton gins. We chose to use an existing Motion Control video color/trash meter. The decision was also made to implement the software and hardware in a such a manner as to complement the existing process control software and hardware. Simple "run length" algorithms combined with variable thresholding techniques were developed which work well when the bark is well defined and of moderate length (>0.5 in). These programs reported bark when none was present only 27% of the time and reported bark, when bark was present and greater than 0.5 in, 90% of the time. The algorithms retain no knowledge of previous pieces of bark, thus, multiple pieces of bark are reported when only 1 piece exists. The addition of 50% more scans increased accuracy and increased the number of pieces of bark reported. The addition of a "skip" factor reduced the number of pieces of bark reported.

We believe that the programs can be used in a process control environment and will provide valuable additional information to aid the ginner in providing a quality product to the mill. The programs will require some modification depending upon the location of the imaging system in the gin. If the imaging system is located prior to the first lint cleaner, then the length of particle declared as bark will have to be extended to prevent the program from detecting leaf trash as bark.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

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Table 1. Percent of observations reported by the video programs as containing bark when bark was observed using data from the development phase.

Video	Observed pieces of bark					
Program	1	2	3	4	5	6
One	77.3	92.9	98.0	100.0	100.0	100.0
Two	83.5	96.0	100.0	99.0	100.0	100.0
Three	77.3	92.9	100.0	100.0	100.0	100.0
Four	83.5	96.0	100.0	99.0	100.0	100.0
Five	96.9	99.0	100.0	100.0	100.0	100.0
Six	95.9	99.0	100.0	100.0	100.0	100.0
Seven	96.9	99.0	100.0	100.0	100.0	100.0
Eight	95.9	99.0	100.0	100.0	100.0	100.0

Table 2. Mean number of pieces of bark reported by the video programs compared to the observed bark during the development phase.

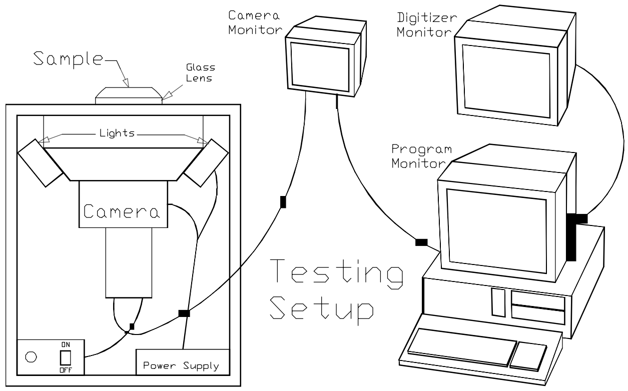
Video	Observed pieces of bark					
Program	1	2	3	4	5	6
One	4.8	11.2	13.7	17.7	21.6	23.4
Two	5.7	13.5	16.4	20.3	25.6	28.2
Three	2.8	6.3	7.7	9.8	12.1	13.2
Four	3.3	7.6	9.4	11.5	14.6	16.2
Five	8.9	20.1	25.3	33.7	39.2	45.9
Six	11.8	25.5	32.9	42.2	50.3	57.1
Seven	5.2	11.4	14.5	19.2	22.5	26.0
Eight	6.8	14.4	18.6	23.9	28.6	32.2

Table 3. Percent of cotton samples detected as containing bark when using unaltered lint samples. The operator indicated that 570 samples contained bark.

Video	Samples Reported as	
Program	No bark	With Bark
One	44.37%	50.35%
Two	46.01%	51.35%
Three	43.66%	49.82%
Four	46.01%	51.05%
Five	27.70%	54.56%
Six	29.11%	61.05%
Seven	27.93%	54.74%
Eight	29.11%	61.23%

Table 4. Effects of bark size and color on the percent of samples reported by the video programs as containing bark using the unaltered lint samples.

Video	Samples Reported as					
Prog.	Small	Med	Large	M+L	Dark	Light
One	45.6%	44.0%	72.2%	54.0%	59.9%	41.0%
Two	47.2%	44.4%	71.3%	54.0%	59.6%	42.7%
Three	45.2%	43.5%	71.3%	53.4%	58.9%	41.0%
Four	47.2%	44.4%	71.3%	54.0%	59.6%	42.7%
Five	39.1%	55.1%	87.0%	66.5%	71.3%	38.2%
Six	46.0%	62.8%	90.4%	72.7%	80.1%	42.4%
Seven	39.5%	55.1%	87.0%	66.5%	71.6%	38.2%
Eight	46.0%	63.3%	90.4%	73.0%	80.5%	42.4%



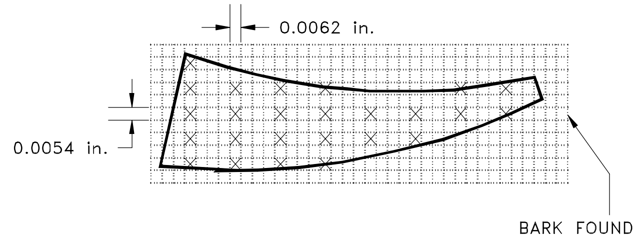


Figure 2. Schematic of pixels, bark, and horizontal scans used to detect bark. The "X" indicates dark pixels actually examined by the program.

Figure 1. Diagram of system used to measure bark.