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Page Classification for Print Imaging Pipeline

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Abstract

Digital copiers and printers are widely used nowadays. One of the most important things people care about is copying or printing quality. In order to improve it, we previously came up with an SVM-based classification method to classify images with only text, only pictures or a mixture of both based on the fact that modern copiers and printers are equipped with processing pipelines designed specifically for different kinds of images[1]. However, in some other applications, we need to distinguish more than three classes. In this paper, we develop a more advanced SVM-based classification method using four more new features to classify 5 types of images which are text, picture, mixed, receipt and highlight.

1.0 Introduction

1.1 General Introduction of the Project

In everyday life, people have all kinds of images which they want to scan or print. That is why digital copiers or all-in-one printers are needed. And one of the most important things people care about is the printing quality of digital copiers or all-in-one printers.

In order to optimally process different kinds of input images, modern copiers and printers possess multiple processing pipelines. Each one of these pipelines are designed specifically for one type of image based on their unique features. For text images, we require the text area to have clear, sharp edges and also high contrast. But for picture images, we do not want them to have high contrast. Instead, we want them to be more blurred. If an image is copied or printed by the right pipeline, people will get the image of the best quality. However, if an image is copied or printed by the wrong pipeline, the image of significantly bad quality will be produced. For example, if a text image is processed by a picture pipeline, the text area in the output image will have blurred edges and comparably low contrast which is not satisfactory[2]. Figure 1 illustrates an example that a text image is processed by both picture and text pipelines. It is obvious that the text image is more clear and has better edge sharpness when it is processed by a text pipeline which is more desirable. So in order to increase the copying or printing quality, we want to come up with a method to classify the images going into copiers or printers and process them in different ways. According to the previous research work done by Cheng Lu from our group, we have already had a SVM-based classification method to classify three types of images: text, picture and mixed and we have three features to train the classifiers[1]. In this paper, we develop four new features to classify two new image classes which are highlight and receipt.

In this paper[1], we develop four new features to classify two new image classes which are highlight and receipt.

For the rest of Section 1, we introduce five types of images and the related work. Section 2 describes four new features. Section 3 describes the classification structure as well as the feature selection. Experiment results are included in Section 4 and finally Section 5 is the conclusion of the paper.

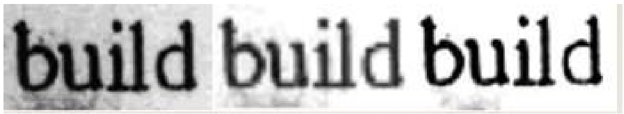


Figure 1: Image quality of original image/ picture mode image/ text mode image.

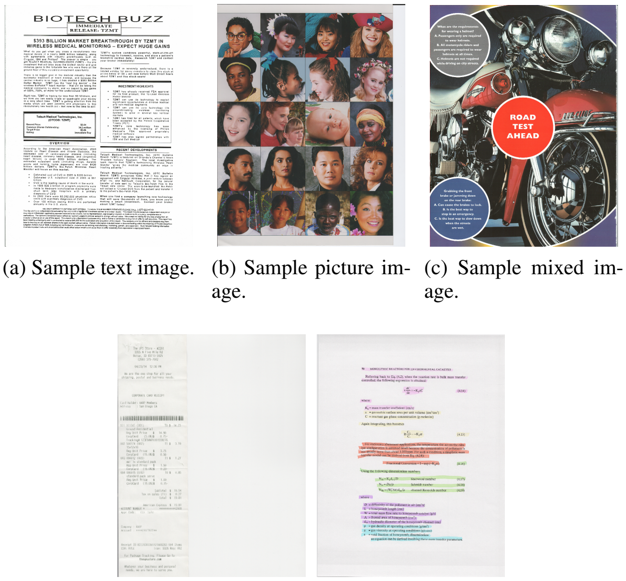
1.2 Five Types of Images

We classify all images into five classes which are shown in Figure 2: Text, Picture, Mixed, Receipt and Highlight to reach optimal printing quality. And misclassification may cause image quality degradation. Text images contain only text. Picture images contain only pictures. Mixed images contain both text and pictures. Receipt images contain scanned receipts and Highlight images contain highlighted text or pictures. All the input images are scanned at 300 dots per inch (dpi) and the output result is one of the five classes.

Note that the receipt class and the highlight class are newly added. Receipt class represents a type of document images which have very low contrast and faded text which is shown in Figure 2(d). Its corresponding processing pipeline needs very strong contrast enhancement and text recovery to guarantee the readability of the copy[3][4]. Compared with example given in Figure 1, receipt type needs even stronger enhancement for better quality. Highlight class typically contains colors that are more saturated compared with color in the natural images. An example is people using fluorescent pen to highlight text line in a document image. Highlighters usually produce very saturated color in order to attract the attention of readers. However, these saturated colors[5][6] are sometimes difficult to be captured by the scanning devices. Or they are sensed as less saturated colors by the scanner. Figure 2(e) shows an captured image with highlight colors, which illustrates the vision of our device when sensing those colors. We can tell the colors in the upper half of the image are very weak from the view of scanners which is not desirable, but colors in the lower half are much more visible. So if we can tell the input image is a highlighted text document, we can produce more saturated color when generating output to match the appearance

[1] Research supported by HP Inc., Boise, ID 83714.

of actual highlighter ink. This can improve the user experience when copying highlighted document pages for better readability while at the same time preserving important area in the page.


(a) Sample text image. (b) Sample picture image. (c) Sample mixed image.

(d) Sample receipt image. (e) Sample highlight image.

Figure 2: Five types of images.

1.3 Related Work

There has been a significant amount of research work done by Cheng Lu from our group which is related with an SVM-based classification[7] of three types of images: text, picture and mixed. And he has already developed four features which are Histogram Flatness Score, Color Variability Score, Text Edge Count and Text Color Variance to train the classifiers. For the first feature which is the Histogram Flatness Score, typically, the histogram for a text image tends to have sharper and narrower peaks than the histogram for a non-text image such as a picture image. For the second feature which is the Color Variability Score, it is reasonable to assume that the non-text region of a text document contains only a few gray level values. So we build a block-mean histogram for the image to calculate a Color Variability Score. For the third feature which is the Text Edge Count, we calculate the number of text edges in an image based on the fact that the number of text edges in a text image is more than it is in a picture image. And for the last feature which is the Text Color Variance, we assume that text pixels in one image should have close luminance intensity values. Large variance in a certain area suggests that its a non-text region[1].

The new features are developed based on these four old features.

2.0 Features

2.1 Chroma Histogram Flatness

Although both natural images and highlighted text have chroma information, a very significant difference between natural color image and highlight text is that highlighted text tends to include only one or few color while natural images have richer color information. This can be illustrated in Figure 3 where we can find only pink in highlighted text image while chroma in natural image is very rich. Then we need a numerical value to represents this difference.

In Section 1.3, we introduce the Histogram Flatness Score in the luminance channel and it assumes that a text image has more peaky histogram. Similarly, if we build a histogram for a highlighted text in chroma space, we can expect that there is a single or few peaks, while the histogram for a natural image is more flat. Different from luminance histogram, chroma histogram is two-dimensional. Since our input image can be either RGB or LCH color space, we need to build histograms correspondingly. For RGB input, we transform it into YUV space and build a histogram on UV plane. For LCH input, we can build a histogram on CH space directly. As shown in Figure 4(a), UV space is in Cartesian coordinate system so we can uniformly partition it into 8×8 areas and build a histogram based on that. However, CH space is described in polar coordinate system so we need to partition it differently. We uniformly divide the hue and chroma into 8 segments respectively, and thus giving us 64 areas which are not uniform in terms of space. LCH partition for building histogram is shown in Figure 4(b). For every input image, we cut it into 32×32-pixel blocks and build a histogram for pixels in the block i which is denoted as h_i. The Chroma Histogram Flatness for the block i is denoted as f_i which is shown below:

$$f_i = \frac{\sqrt[N]{\prod_{n=0}^{N-1} h_i(n)}}{\frac{\sum_{n=0}^{N-1} h_i(n)}{N}} \tag{1}$$

which is the geometric mean over the arithmetic where N = 60 for YUV and N = 56 for LCH in our case. It is worth noticing that we do not use all the bins of histogram to calculate f_i. That is because we should only focus on the chroma flatness and exclude those areas which are close to gray. Highlight-text will also have very low flatness if we consider those gray pixels which correspond to black text and white background. For YUV space, we ignore the central 4 bins and for LCH space we ignore the central 8 bins that are inside the smallest circle.

The Chroma Histogram Flatness F for the entire image is define as maximum fi of all blocks in the image:

$$F = max(f_i) \tag{2}$$

Because we do not expect seeing flat histogram of any block in the highlighted text image.

2.2 Chroma Around Text

On top of Chroma Histogram Flatness, we design another feature to detect chroma information of highlighted text image. Typically, we can expect that people use highlighter to emphasize text information, which means text strokes are usually covered and surrounded by highlight colors as shown in Figure 5. However for natural images, chroma information does not necessarily exists around edges. Given the fact, we can try to detect if there is chroma existence along the text edges in the image.

To find chroma around text strokes, we first need to find text edges in the image blocks. We follow the method introduced in Sec. 1.3 to find text edges. However, we need to note that reverse contrast text should not be considered any more. That is because it is rare that people mark light text with darker highlight which will cause poor readability. After finding a text edge, we search along its luminance increase direction to find if there is any chroma existence. Then we calculate chroma strength (c) for two pixels along the luminance increase direction outside of text edge. In YUV space, chroma strength of a target pixel at position of (m, n) is defined as

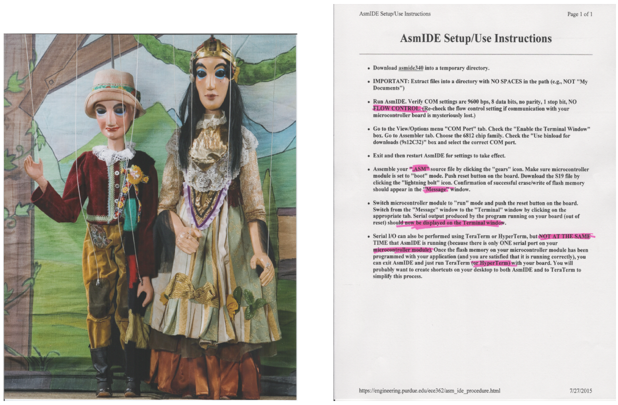
$$c(m,n) = u(m,n) + v(m,n) \tag{3}$$

Note that we use simple summation of u and v here as approximation for faster computation. In case of LCH space, chroma strength is equivalent to $c(m,n)$. The process can be illustrated in Figure 6 after finding a text edge.

Similarly, we cut the input image into blocks with 32×32 pixels and then find $c(m,n)$ for all pixels outside text edges. Chroma Around Text (c_i) of a block i is defined as:

$$c_i = \frac{mean(c(m,n))}{std(c(m,n))} \tag{4}$$

We also consider standard deviation of $c(m,n)$ because highlight should be consistent in a single block. Small $std(c(m,n))$ indicates that this block is more likely to contain highlight color.


AsmIDE Setup/Use Instructions Page 1 of 1

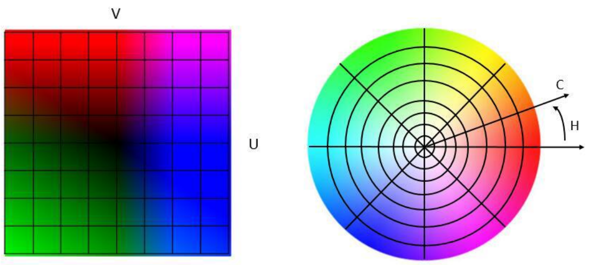
AsmIDE Setup/Use Instructions

- Download asmide340 into a temporary directory.
- IMPORTANT: Extract files into a directory with NO SPACES in the path (e.g., NOT "My Documents")
- Run AsmIDE. Verify COM settings are 9600 bps, 8 data bits, no parity, 1 stop bit, NO FLOW CONTROL. (Re-check the flow control setting if communication with your microcontroller board is mysteriously lost.)
- Go to the View/Options menu "COM Port" tab. Check the "Enable the Terminal Window" box. Go to Assembler tab. Choose the 6812 chip family. Check the "Use binload for downloads (9s12C32)" box and select the correct COM port.
- Exit and then restart AsmIDE for settings to take effect.
- Assemble your ".ASM" source file by clicking the "gears" icon. Make sure microcontroller module is set to "boot" mode. Push reset button on the board. Download the S19 file by clicking the "lightning bolt" icon. Confirmation of successful erase/write of flash memory should appear in the "Message" window.
- Switch microcontroller module to "run" mode and push the reset button on the board. Switch from the "Message" window to the "Terminal" window by clicking on the appropriate tab. Serial output produced by the program running on your board (out of reset) should now be displayed on the Terminal window.
- Serial I/O can also be performed using TeraTerm or HyperTerm, but NOT AT THE SAME TIME that AsmIDE is running (because there is only ONE serial port on your microcontroller module). Once the flash memory on your microcontroller module has been programmed with your application (and you are satisfied that it is running correctly), you can exit AsmIDE and just run TeraTerm (or HyperTerm) with your board. You will probably want to create shortcuts on your desktop to both AsmIDE and to TeraTerm to simplify this process.

https://engineering.purdue.edu/ece362/asm_ide_procedure.html 7/27/2015

(a) Natural image. (b) Highlighted text.

Figure 3: Natural image v.s. Highlighted text.



(a) YUV space partition. (b) LCH space partition.

Figure 4: LUV and LCH color space histogram.

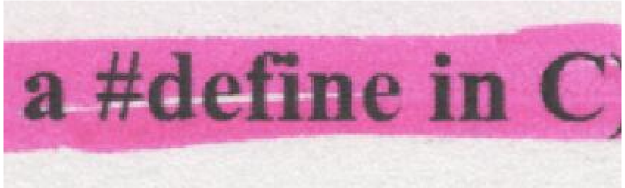

a #define in C

Figure 5: Highlighted colors around text.

Similarly, chroma around text (C) of an image is defined as the maximum value of c_i of all blocks:

$$C = max(c_i) \tag{5}$$

2.3 Color Block Ratio

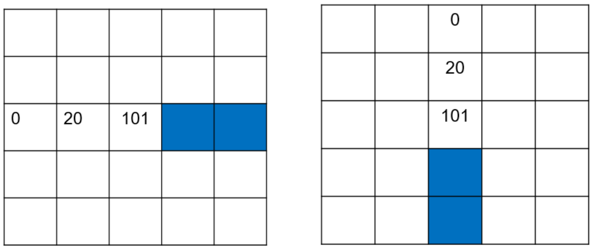
Chroma Flatness and Chroma Around Text together can provide good discriminative power for detecting highlight image. However, they are not capable of handling text image with color background. One such example is given in Fig. 3.7. According to our feature design in Sec. 2.1 and Sec. 2.2, both features would strongly indicate that Figure 7 should be classified as highlighted text image. It is because both features only focus on local chroma and ignore global information.

To address this problem, we introduce another feature called Color Block Ratio. We calculate the number of color pixels in every 32×32-pixel block. A pixel is defined as color if its chroma strength is greater than a threshold value T_c = 10. The chroma strength is defined in Equation 6 for YUV space. In LCH space is simply C channel. A block i is considered a color block if 10% of its pixels are colored. We set m_i = 1 if the block is colored otherwise m_i = 0. Color block ratio (R_c) of an image is defined as:

$$R_c = \frac{\sum m_i}{\sum i} \tag{6}$$

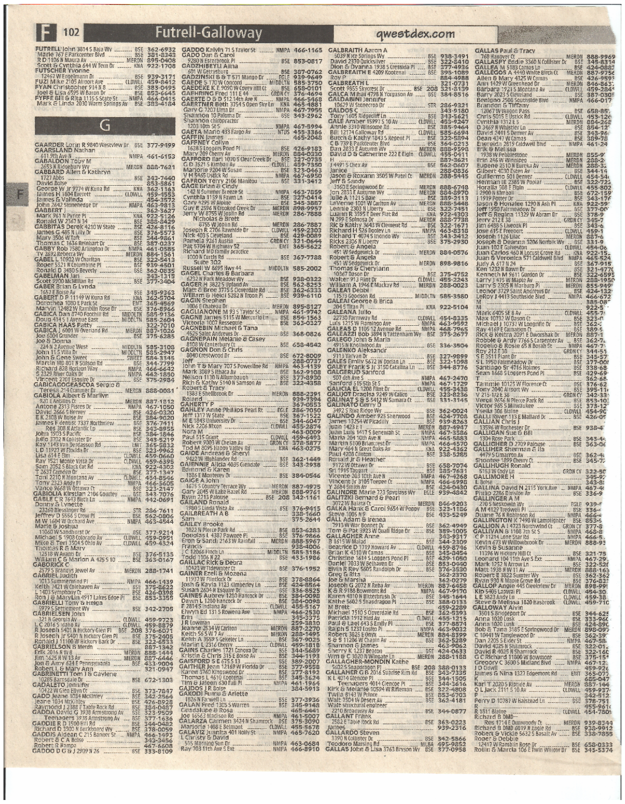
2.4 White Block Ratio

Compared with text image, receipt typically only occupies a small part of area on flat-bed scanner. An example is given in Figure 2 which shows that a scanned receipt only occupies upper-left corner of the plane. Utilizing this difference, we design the White



(a) Horizontal direction. (b) Vertical direction.

Figure 6: Calculate c(m, n) of two pixels which are cover by blue.



F 102 Futrell-Galloway qwestdex.com

FUTRELL John 3814 S Baja Wy	BSE	362-6932
Marie 767 E Parkcenter Blvd	BSE	381-8343
R D 1106 N Maura Av	MERDN	895-0408
Scott & Cynthia 644 W Tern Dr	KNA	922-1708
FUTSCHER Yvonne		
12467 W Engelmann Dr	BSE	939-3171
FUZI Mike 2105 Airport Ave	CLDWLL	459-8412
FYAN Christopher 914 N 8	BSE	383-0495
Joel & Lisa 6595 W Baron Dr	BSE	853-6645
FYFFE Bill & Rita 1115 S State St	NMPA	466-0415
Mark & Linda 2030 Warm Springs Av	BSE	383-4184
G		
GAARDER Lorin R 9840 Westview Dr	BSE	377-9499
GAARSLAND Nathan		
611 9th Ave N	NMPA	461-6153
GABALDON Toby M		
2653 N Ridgebury Wy	MERDN	888-7621
GABBARD Allen & Kathryn		
1727 Abbs	BSE	343-7440
David Boise		853-5861
George W Jr 9774 W Kuna Rd	KNA	362-1163
James H 1804 Everett	CLDWLL	459-4553
James & Valinda		454-3572
John 2642 Stonehedge Dr	NMPA	463-9813
GABBERT J		362-3627
Mark 961 N Pyrite Pl	KNA	922-5126
Ronald W 2367 N 34	BSE	388-8429
GABBITAS Derek 4210 W State	BSE	426-8116
James G 485 N Lilly Dr	BSE	376-5573
Mary 3506 W Taft	BSE	344-9861
Thomas C 1636 Reinhart Dr	BSE	387-0237
GABBY Rob 7580 Arlington Dr	NMPA	461-0585
Ty 2692 Rebecca Wy	MERDN	884-1561
GABEL L 10902 W Charlton	BSE	322-5413
Roger 5521 N Columbine Pl	BSE	939-4501
Ronald D 3480 S Beverly	BSE	362-0835
GABELMAN Jan		343-1315
Scott 9900 McMillan Rd	BSE	377-3404
GABER Brian & Lynda		
1657 E Boise Av	BSE	345-9363
GABERT D P 11149 W Kuna Rd	KNA	362-5704
Dorothea 1080 E Park St	EMT	365-4569
Marvin 12482 W Ramblin Rose Dr	BSE	376-8966
GABICA Dan 8740 Foothill Rd	MIDDLTN	585-9136
Doug 414 S 1 Avenue East	MIDDLTN	585-2604
GABICA HAAS Patty		322-7010
GABICA J 6001 W Overland Rd	MERDN	887-1026
Joe 6004 Grunder	BSE	375-6285
Joe & Donna		
224 N 2 Avenue West	MIDDLTN	585-3108
John 11 S Villa Dr	MIDDLTN	585-2947
John & Gene Sweet	SWEET	584-3345
Martin MD 801 N Stilson Rd	BSE	344-7799
Richard 828 Horizon Way	NMPA	466-6642
S 2329 River Oaks Dr	NMPA	442-1850
Vincent 2701 Esquire Dr	BSE	375-2984
GABICAGOGEASCOA Sergio &		
Teresa 214 Cranmer Dr	MERDN	888-0081
GABIOLA Albert & Marilyn		
920 E Antilles Ct	MERDN	887-1812
Antone 2313 Pisces Dr	NMPA	467-1050
David 2666 S Hervey	BSE	426-0320
E K 2108 W Boise Av	BSE	384-9020
James F dentist 7337 Northview	BSE	376-7411
Res 308 N Atlantic Lp	BSE	343-8955
John 1903 S Pacific	BSE	384-1846
Julio 3702 N Collister Dr	BSE	343-5219
Kay 1143 Van Derdasson Rd	EMT	365-5832
L D 11927 W Florida Dr	BSE	323-9962
Lisa 614 E Elm	CLDWLL	459-0660
Ray 1521 Monte Vista Dr	CLDWLL	459-6395
Sam 2052 S Black Cat Rd	KNA	922-4302
T 2637 Camden Dr	BSE	377-1347
Toni 2210 N Montana Av	CLDWLL	454-8546
Tony 2323 Andy Pl	NMPA	466-5605
Vance 9668 W Ottawa Ct	BSE	323-2147
GABIOLIA Kirstian 2106 Gourley	BSE	343-7076
GABLE C R 7643 Birch Ln	NMPA	442-0691
Donny & Lynette		
23260 Blessinger Rd	STR	286-7611
Jeffrey D 5556 S Crow Pl	BSE	562-0806
M W 1604 W Orchard Ave	NMPA	463-4544
Marie & Joshua		
11060 W Sandhurst Dr	BSE	377-9214
Michael S 1908 Colorado Av	CLDWLL	459-0951
Mike & Teri 3504 S Ohio Av	CLDWLL	459-4324
Thomas R & Mary		
12518 W Avanti Dr	BSE	376-5135
William C & Marion A 425 S 10	BSE	363-0167
GABORICK C		
2579 S Brandys Jewel Av	MERDN	288-1741
GABRIEL Judith		
1013 Summerwind Pl	NMPA	466-1439
Keith 7421 W Colehaven Av	BSE	375-8622
L 1403 Symphony Ct	BSE	426-0398
Ron J & MaryLin 4917 Lakes Edge Pl	BSE	853-3355
GABRIELLI Tony & Helga		
5979 S Settlement Wy	BSE	342-2705
GABRIELSEN John		
321 N Georgia Av	CLDWLL	459-9723
L C 2016 S Idaho Av	CLDWLL	459-8879
R Joseph 5401 N Hickory Glen Pl	BSE 208	376-6071
R Joseph Jr 5401 N Hickory Glen Pl	BSE	375-2405
Ronald J 11100 W Hickory Bark Dr	BSE	322-6533
GABRIELSON B Merdn		887-1342
Erik 2016 N W 8	MERDN	888-1444
Jim 1625 N W 13 Av	MERDN	887-6446
Jon & Amy 624 E Pennsylvania	BSE	433-9004
Robert L & Mary Ann		321-0947
GABRINETTI Tom J & Gaylene		
10285 Barnsdale Dr	BSE	672-1303
GADALETO Jennifer		
10422 W Glen Ellyn Ct	BSE	373-7847
GADD Jeane 1034 McKinley	BSE	342-2564
Jeane 1034 McKinley	BSE	426-8928
Raymond J 2388 E Table Rock Rd	BSE	384-0487
GADDA David G 3938 Armstrong Av	BSE	323-9509
Teenagers 3938 Armstrong Av	BSE	377-1636
GADDIE R D 1500 Hill Rd	BSE	344-0482
Richard D 3500 N Buckboard Wy	BSE	378-0059
GADDIS Aldean C 215 Banner St	NMPA	466-1493
Robert & C A Boise		343-3456
Robert R Nampa		467-6608
GADDO D G & J 2909 N 26	BSE	333-8109

GADDO Kalvin 71 S Taylor St	NMPA	466-1165
GADO Dan & Carol		
9280 N Esterbrook Pl	BSE	853-0817
GADZHIBEYLI Alina		
601 W Gettysburg	BSE	387-0762
GADZINSKI B & T 571 Mango Dr	EGLE	939-9649
GAEDE S 170 W Concord	MIDDLTN	585-3750
GAEDEKE K E 9090 W Covey Hill Ct	BSE	658-0101
GAEHRING Fred 111 E 44	GRDN CY	376-4694
GAERTE D & D 512 14th Ave N	NMPA	466-5468
GAERTNER Beth 3754 S Open Sky Ln	KNA	465-4881
Gary G 7207 Lima Dr	NMPA	467-7955
Shannon 10 Paloma Dr	BSE	343-2962
Shannon chiropractor		
1203 10th St S	NMPA	467-5994
GAETA Mario 433 Fargo Av	NTUS	455-3366
GAFFIN James		465-2048
GAFFNEY Collyn		
1628 S Loggers Pond Pl	BSE	426-9183
Mary 209 Cherry Av	MERDN	884-0330
GAFFORD Earl 1070 S Clear Creek Dr	BSE	327-0735
G D 3521 S Kimball Av	CLDWLL	459-7350
Marjorie 9204 W Susan	BSE	323-0463
V H 5465 Ustick Rd	NMPA	467-6950
GAFRON Terry 2106 Manitou	BSE	331-3412
GAGE Brian & Cindy		
142 N Summer Breeze St	NMPA	463-7859
Cynthia 1159 N Fawn Ln	BSE	327-0414
Gary 4295 W Alpine	BSE	345-3887
Guy E 2596 N Crooked Creek Dr	MERDN	898-9957
Jerry W 8755 W Joplin Rd	MERDN	286-7888
Nicholas & Brett		
8755 W Joplin Rd	MERDN	286-7887
Joseph R 2706 Rawhide Dr	CLDWLL	459-2303
Nick 403 S Cleveland	BSE	429-0089
Pamela 9261 Austin	GRDN CY	321-0644
Pat 5704 W Highway 52	EMT	365-5622
Richard MD family practice		
1000 N Curtis Rd	BSE	367-7788
Suite 302		
Russell W 8695 Hwy 44	MIDDLTN	585-2002
GAGEL Charles & Barbara		
6232 N Park Meadow Wy	BSE	938-0322
GAGER H 3822 S Upland Av	BSE	562-8253
Matt & Bree 3775 S Cloverdale Rd	BSE	362-6333
William & Heidi 5282 N Troon Pl	BSE	939-6110
GAGIN Stephen		
1006 E Chateau Dr	MERDN	895-8127
GAGLIANONE M 93 S Taylor St	NMPA	461-9742
GAGNE James 5115 W Mercurio Ln	BSE	854-1563
Victoria 1007 Ressegule	BSE	363-0327
GAGNEBIN Michael & Tana		
4525 Saint Andrews Dr	BSE	368-0826
GAGNEPAIN Melanie & Casey		
8108 W Canterbury Ct	BSE	658-4542
GAGNON Don & Chris		
8040 Crestwood Dr	BSE	672-8009
Jeff		288-0737
John T & Mary 707 S Powerline Rd	NMPA	463-4139
Mark 3089 S Ithaca Av	BSE	362-9108
Nelson 1130 N Allumbaugh	BSE	377-8930
Rich & Kathy 5140 N Samson Av	BSE	322-4358
Robert & Tracy		
1383 E Shellbrook Dr	MERDN	888-2391
Roland		939-7394
GAHERTY P		367-0553
GAHLEY Anne Phillips Pearl Rt	EGLE	286-7050
Jeff 1317 W State	BSE	367-1522
M E 1843 University Dr	BSE	344-6047
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Nora M		463-0009
Paul 515 Grant	CLDWLL	459-6493
Robert 9003 W Chelan Av	GRDN CY	378-5877
Tod M 8095 Happy Valley Rd	KNA	463-0275
GAIDE Andreas & Sheryl		
9422 W Highlander Rd	BSE	362-1449
GAIENNIE Alicia 4035 Glendale	BSE	343-2938
Edmond & Karen		
1886 E Monterey Dr	BSE	384-0546
GAIGE A John		
1675 S Country Terrace Wy	MERDN	887-4975
Gary 2045 W Lake Hazel Rd	MERDN	888-9761
Ryan 2213 Palouse	BSE 208	342-1161
GAILAND Ronald		
1980 S Linda Vista Av	BSE	376-9415
GAILBREATH A B		338-1660
Sam		375-2644
GAILEY Brooke		
7022 N Pierce Park Rd	BSE	853-6283
Douglas L 4387 Pawnee Pl	BSE	376-9866
Eron & Sandi 2163 W Rainfall	MERDN	888-5967
Francis		938-4006
J C 12066 Finch Ln	MIDDLTN	585-3186
Todd 1106 N 22	BSE	433-1986
GAILLAC Rick & Debra		
10423 W Tidewater Ct	BSE	376-1952
GAINER Ezell & Mozena		
11937 W Flintlock Dr	BSE	378-8864
Josh & Kayla 1123 Kimberley Ln	BSE	424-8564
Susan 2604 N Esquire Dr	BSE	336-8525
GAINES Aubrey 1280 Hancock Dr	BSE	384-0098
Dawn L 1280 Hancock Dr	BSE	384-0098
E 2814 S Indiana Av	CLDWLL	455-5167
Elwyn Ed 131 S Rowena Ave	NMPA	466-2530
Erin		345-3375
J R Lowman		259-3830
Jeanne 2534 W Carlton	MERDN	887-2270
Keith 56 S W 7 Av	MERDN	288-1495
Keith A 3559 S Gekeler Ln	BSE	367-9025
Marlin L 2316 Cheny	CLDWLL	459-1818
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Kristin & Chris 315 E Boise Av	BSE	344-1193
GAISFORD S E 675 S 13	BSE	389-2007
GAITHER Jean 12169 W Florida Dr	BSE	377-9558
Karen 3760 Kingswood Dr	BSE	377-8192
Thomas L 4610 Kootenai	BSE	345-3624
Tim & Jaleen 630 Fall Pl	NMPA	461-1964
GAJDOS J R Boise		384-5913
GAKODI Fumu & Ariette		
1826 N Farwell Ln	BSE	377-3936
GALAN Fred 1305 S Warren	BSE	345-9148
Guadalupe & Rosa		465-6441
Joe 16563 Madison Rd	NMPA	461-5007
GALARZA Carmen 3424 N Shamrock	BSE	375-3090
Marjorie 1408 E Belmont	CLDWLL	455-5678
GALAVIZ Juanita 401 Holly St	NMPA	465-7620
L Christy & David		
515 Morning Sun Dr	NMPA	463-0684
Ray 703 11th Ave S Ext	NMPA	466-8910

GALBRAITH Aaron A		
5039 N Ice Springs Wy	BSE	938-3491
David 2370 Quicksilver	BSE	322-8410
Dion & Dyanna 1938 S Cressida Pl	BSE	377-4936
GALBREAITH E 4209 Kootenai	BSE	395-1089
Roy P		884-4988
GALBREATH L		321-0731
Scott 9855 Skycrest Dr	BSE 208	321-8139
GALCA Mihai 4798 N Yorgason Av	BSE	384-8516
GALDABINI Jennifer		
10629 W Stonecrop Dr	STR	286-9321
GALDOS C		343-9180
Tony 1605 Ridgecliff Ln	BSE	343-5621
GALE Amber 15997 S 10 Av	CLDWLL	453-9247
Annie 3310 Winsome Rd	BSE	385-9464
Bill 12174 Galloway Rd	CLDWLL	585-6694
Butch & Kathy 1843 S Regent Pl	BSE	322-5894
C B 739 E Parkcenter Blvd	BSE	364-0213
Dan 2833 E Autumn Wy	MERDN	888-9598
David D & Catherine 222 E Elgin	CLDWLL	455-0411
H		887-3621
J 4491 S Chex Av	BSE	562-0607
Janice		288-0836
Jason & Roxann 3505 W Patel Ct	MERDN	288-5445
Jeff & Sandy		
3160 E Springwood Dr	MERDN	888-6748
Jon 2833 E Autumn Wy	MERDN	884-8970
Julie A 1121 S Dale	BSE	389-2113
LaVerne 1001 W Carlton Av	MERDN	888-5448
Lennie 2303 N Liberty	BSE	322-7451
Luann R 3595 E Deer Flat Rd	KNA	922-4303
N 299 E Spinosa Dr	MERDN	888-7738
Ric & Kathy 3643 W Clement Rd	BSE	322-1671
Richard H 526 Dooley Ln	NMPA	463-8318
Richard T 4074 S Inondo Wy	BSE	343-2412
Ricks 2306 N Liberty	BSE	375-2930
Robert & Angela		
451 W Sedgewick Dr	MERDN	884-0576
Robert & Angela		
451 W Sedgewick Dr	MERDN	898-9816
Thomas & Cherylann		
10367 Dason Dr	BSE	375-4752
Walter 913 Flint Dr	CLDWLL	455-2243
William A 1946 E Mackay Rd	MERDN	288-0023
GALEA'I Debbi		
11573 Goodson Rd	MIDDLTN	585-3580
GALEAI George & Erica		
204 S Titan Pl	KNA	922-5104
GALEANA Julio		
22730 Farmway Rd	CLDWLL	454-8335
Luis 1215 W Flamingo Ave	NMPA	463-9592
GALEAS D 1105 12 Avenue Rd	NMPA	468-7965
GALEAZZI Bob 3894 N Tattenham Wy	BSE	375-2677
GALEGO John & Maria		
4915 N Knollwood Av	BSE	336-3504
GALENKO Aleksandr		
9113 Yaryan Dr	BSE	327-9899
GALES Emily 5672 W Dorian Ln	BSE	322-1098
GALEY Frank S Jr 3150 Catalina Ln	BSE	344-8776
GALGERUD Sanford		
507 6th Ave S	NMPA	467-2470
Sanford 515 5th St S	NMPA	467-1729
GALICIA EL 1208 Flint Dr	CLDWLL	455-3438
GALIJOT Dragisa 9249 W Calico	BSE	323-8236
GALINAT S & S 5412 W Samara Ct	BSE	331-3145
GALINATO Gerry D		
3492 S Riva Ridge Wy	BSE	362-0024
GALINDO Amber 925 Sherwood	BSE	424-7708
James 13254 W Picadilly	BSE	939-8263
Juan 1423 E 1	MERDN	887-4947
Juan Luis 1417 S Benewah St	NMPA	467-3586
Maria 204 10th Ave N	NMPA	465-5883
Martin 5100 Briarcrest Dr	NMPA	466-4570
Mary 464 N Great Oaks Av	KNA	922-4362
Paul 4208 Clinton	BSE	338-5285
Ronald Jr & Heather		
9172 W Ottawa Dr	BSE	658-7074
Sri 1915 Taggart	BSE	385-7631
Vicente 203 10th Ave N	NMPA	467-4268
Vincent Jr 3105 Teepee Ct	NMPA	466-6998
Y 2684 Smith Av	BSE	424-0430
GALINDRE Marie 723 Spyglass Wy	EGLE	939-4842
GALITZKI Bernard & Pearl		
3072 W Balata Ct	MERDN	846-9203
GALKA Hank & Carol 9654 W Poppy	BSE	323-1186
Steve 1005 N 9	BSE	433-5249
GALL Adam & Irenea		
7913 W War Bonnet Dr	BSE	362-4949
Tom & Pat 3923 W Quail Ridge Dr	BSE	389-1005
GALLAGHER Anne		343-9317
B 1615 W Malad	BSE	344-2309
Beatrice D 1719 Howard Av	CLDWLL	459-8746
Brian K 4310 W Camas	BSE	345-8454
Christine 1614 S Loggers Pond Pl	BSE	429-1050
Daniel 7033 W Belhaven Dr	BSE	853-0440
Elvin R Rev 5605 Randolph Dr	BSE	376-3530
Greg & Rita		362-2370
Joe & Marsha		362-0279
Joseph G 2072 N Reba Av	MERDN	887-6458
K & R 9188 Bowmont Rd	NMPA	467-9170
Karen 4810 N Bitterbrush Dr	BSE	345-1644
Kathe 5602 S Snapdragon Pl	BSE	388-0133
M Brett		459-2289
Michael 7510 S Cloverdale Rd	BSE	362-5393
Patricia 1912 Hird Av	CLDWLL	455-1215
Paul & Lael 643 S Emily Pl	BSE	377-8874
Ralph S 1237 Losito Pl	NMPA	463-9032
Robert 3825 E Onyx	MERDN	884-8399
S & S 11206 W Chapin Av	BSE	362-5289
Shannon & James		463-9062
Sherry K 1237 Beacon	BSE	424-0633
Wm & C 3020 N Wingate Ln	MERDN	288-1188
GALLAGHER-MONDIN Kathe		
5602 S Snapdragon Pl	BSE 208	388-0133
GALLAHER G B 2016 Sunrise Rim Rd	BSE	343-7335
K L 4014 Glencoe Pl	BSE	344-1505
Teenagers 4014 Glencoe Pl	BSE	344-3616
Kirk & Melanie 10594 W Rifleman	BSE	322-4808
Twila 8143 W Prince	BSE	853-6703
Walt 7504 W Desert Av	BSE	362-4181
Walt structural engineer		
2210 Broadway Av	BSE	344-0877
GALLANT Frank		
2582 E Table Rock Rd	BSE	363-0223
James		939-2316
GALLARDO Steven		
3390 N Collister Dr	BSE	342-5866
Teodoro Marsing Rd	MLBA	495-9852
GALLAS John & Lisa 3763 Bryson Wy	BSE	377-0958

GALLAS Paul & Tracy		
768 Hanover Ct	MERDN	888-9969
GALLASPY Eddie 3360 N Collister Dr	BSE	345-8314
GALLEA M 5183 Camas Ln	BSE	424-088
GALLEGOS A 4440 White Birch Ct	MERDN	887-975
Allen & Mary 4325 W Camas	BSE	426-959
Ann 1429 W Greenhead Dr	MERDN	846-863
Barbara 1921 S Montana Av	CLDWLL	459-284
Barry 2023 S Cleveland	BSE	387-030
Benigno 2508 Southside Blvd	NMPA	466-017
Brandon & Tiffany		
12067 W Wagon Pass	BSE	658-85
Chris 5015 E Ustick Rd	CLDWLL	453-126
Cynthia 1312 E 5	MERDN	884-268
D 3469 N Whistler Ln	BSE	854-12
David 2441 S Denver Av	BSE	343-96
Dean 4347 W Camas	BSE	389-78
Enereida 2819 Caldwell Blvd	NMPA	461-24
Erik & Melissa		
1938 W Pebblestone	MERDN	855-9
Erin 246 W Winnipeg	MERDN	288-2
Eugene 2510 N Eureka Av	MERDN	288-32
Gilbert 4030 Esten Av	BSE	344-14
Guillermo 501 Denver	CLDWLL	454-54
Herman III 2385 W Poplar	BSE	322-722
Horalia 508 E Elgin	CLDWLL	455-802
J 2900 N Kimball	BSE	672-159
J 1919 Potter Dr	BSE	343-176
Jason & Honalee 1290 N Ash Pl	KNA	922-59
Jeff 1950 Fairmeadow Dr	BSE	377-00
Jeff & Regina 11329 W Abram Dr	BSE	378-9
Jerry 212 E 38	GRDN CY	345-7
Jim 6488 S Liveoak Pl	BSE	343-6
Jose 615 E Freeport	CLDWLL	459-1
Joseph 1126 Lilac	MERDN	887-6
Joseph & Deanna 3206 Norfolk Wy	BSE	331-9
Juan 102 E Galveston	CLDWLL	454-06
Juan Carlos 460 N Locust Grove Rd	KNA	922-15
Juan & Veronica 571 Caldwell Blvd	NMPA	465-524
Judy A 617 N 24	BSE	367-915
Ken 1232 N Dawn Dr	BSE	321-4770
Kenneth M 9611 Gurdon Dr	BSE	322-6595
Larry J 475 W Maple Av	MERDN	288-1950
Larry S 2305 N Marburg Pl	MERDN	855-949
Leonor 3729 Saint Andrews Dr	BSE	424-132
LeRoy J 4413 Southside Blvd	NMPA	466-672
M		385-08
M		922-5
Mark 6405 SE B Av	CLDWLL	455-7
Max 10732 W Dason Ct	BSE	323-0
Michael J 10737 W Longrifle Dr	BSE	362-
Ray 4169 E Carnation Ct	BSE	389-9
Rick & Keitra 2091 E Dworshak Dr	MERDN	887-1
Robbie & Ardy 7766 S Carpenter Av	BSE	362-7
Rogelio & Rosie 65 N Borah St	NMPA	467-7
Roy 212 E 38	GRDN CY	344-51
S E 3511 Plant Dr	BSE	345-57
S L 1950 Fairmeadow Dr	BSE	377-00
Santiago Sr 4716 Holmes	BSE	338-68
Sean 1668 S Loggers Pond Pl	BSE	429-69
T		362-68
Tammie 10125 W Florence Ct	BSE	376-62
Tony 2040 Airport Wy	BSE	395-11
V 215-1/2 E 38	GRDN CY	342-33
Vergil 9656 N Pierce Park Rd	BSE	853-10
Victor 965 S Milwaukee	BSE	373-12
Ysella 306 Blaine	CLDWLL	454-90
GALLI River 113 E Mallard Dr	BSE	426-0
GALLIAN Chris J		
13596 W Rochester Dr	BSE	938-4
GALLIGAN Sue & Bill		
1304 Rose Park	BSE	343-4
GALLICHER D 2709 Palouse	BSE	363-06
GALLIHER Sherman & Ila		
4479 S Cimarron Av	BSE	362-4
Shontee 1899 Cherry Ct	BSE	345-7
GALLIHUGH Ronald		
5153 W Cody Ln	GRDN CY	322-50
GALLIMORE H		345-9
L Boise		343-8
GALLINA David N 2115 York Ave	NMPA	467-4
Philip 2286 Division Av	BSE	336-9
GALLINGER A M		
270 S Neskowin Wy	EGLE	939-
A M 4129 Tredwell Pl	BSE	336-
Duane 76 N Robinson Rd	NMPA	466-
GALLINGTON K 7498 W Lamplighter	BSE	853-
GALLION A I 4723 Northwind Ct	GRDN CY	377-8
GALLIVAN B 1108 7th St S	NMPA	468-8
C P 11214 Lone Star Rd	NMPA	466-5
Kevin 673 W Willowbrook Dr	MERDN	888-93
Kevin & Susanne		
11396 W Hickory Hill Ct	BSE	321-75
Leonard 104 11th Ave S Ext	NMPA	467-29
Mark 1252 N Arrow Ln	BSE	322-520
Matt 1938 N W 11 Av	MERDN	888-163
Robert E 3822 Sumter Wy	BSE	362-362
Ryan 930 N Maple Grove Rd	BSE	376-83
GALLOP Angie 445 Creekview Dr	MERDN	898-99
Kip 5405 Lapwai Pl	CLDWLL	454-30
L E 3823 Andy Ln	CLDWLL	459-38
Steve & Melissa 1820 Hasbrook	CLDWLL	459-710
GALLOWAY Alvin		
3501 S Bridgeport Dr	BSE	344-625
Anna 1020 Lusk	BSE	333-960
Anna 1020 Lusk	BSE	424-890
Bob & Tana 3185 E Springwood Dr	MERDN	898-097
C 10441 W Tanglewood Dr	BSE	362-39
Dan 2205 S Elder St	NMPA	467-58
David 4025 N Shamrock	BSE	322-01
David R 4025 N Shamrock	BSE	322-160
G C Richard 11800 W Bowmont	BSE	375-15
Gregory C 3600 S Midland Blvd	NMPA	467-12
J D Cldwll		459-92
James & Nina 1327 Edgemont Rd	EMT	365-07
K		685-047
Karl T 2020 S Riptide Av	MERDN	887-144
O L Jack 2111 S 10 Av	CLDWLL	459-937
P		342-512
Perry D 10787 W Halstead Ln	BSE	378-751
R		455-961
R 1811 Blaine	CLDWLL	454-780
Richard B DMD—		
Res 1714 E Dunwoody Ct	MERDN	939-8344
Richard B DMD 6019 N Eagle Rd	BSE	938-9912
Robert & Vickie 5632 S Basalt Av	BSE	338-7855
Roger & Debbie		
12417 W Ramblin Rose Dr	BSE	658-0333
Rollin & Marcia 106 E Twin Willow Dr	BSE	345-5374

Figure 7: Text with yellow background.

Block Ratio feature. Again, we cut the input image into 32×32-pixel blocks. For each block i, we check if 95% of the pixels have luminance value which is larger than 230. If this is true, we consider this block to be a white block with $w_i = 1$, otherwise we set $w_i = 0$. White block ratio (R_w) of an image is defined as:

$$R_w = \frac{\sum w_i}{\sum i} \tag{7}$$

3.0 Classification

3.1 Classification Structure

In order to make a more balanced multi-class classification and for easier tuning, we apply Directed Acyclic Graph-Support Vector Machine (DAG-SVM)[8] to solve the problem. DAG-SVM is a tree-structured classification method that capable of making multi-class classification. Instead of making one vs rest decision, it tentatively make one vs one decision which allows more judgement from lower nodes. DAG-SVM classifiers that we use are shown in Figure 8:

In our case, class 1 stands for mix, class 2 stands for text, class 3 stands for picture, class 4 stands for receipt and finally class 5 stands for highlight. It first decides if the input image is non-mix or non-highlight. If the image is classified as non-mix, then it is sent to the right node, otherwise it is sent to the left node. And the whole process goes from the top all the way to the bottom of the tree-structure.

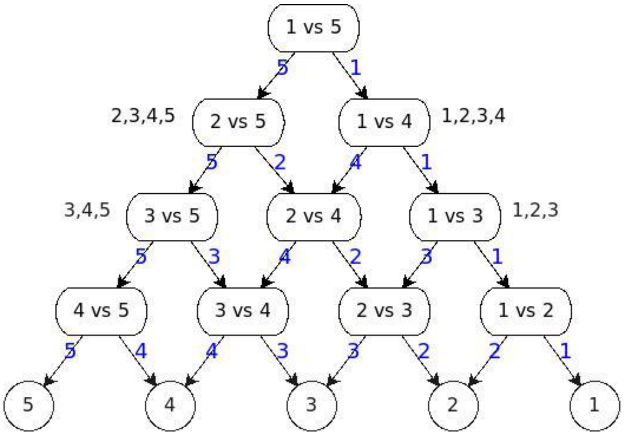

Figure 8: Tree structure of DAG-SVM.

3.2 Feature Selection

We introduce four new features to classify receipt and highlight. Together with the features we previously developed, we can represent each image k with a feature vector $f_k \in R^8$. However, we need to evaluate the contribution of each feature to the classification. To test the impact of each feature on the overall classification accuracy and time consumption, we adopt the leave-one-out feature selection.

Because misclassifications are not equally weighted, we need to first consider the metric for feature selection. We define the weighted misclassification rate (W_m) as below:

$$W_m = \frac{\sum_{i,j} w(i,j)n(i,j)}{\sum_j n(i,j)} \tag{8}$$

where $w(i,j)$ is the weight of misclassification given in Table 2 and $n(i,j)$ is the number of images in this corresponding entry. To avoid biased measure due to different size of image set, the weighted sum needs to be normalized by the size of image set of each type. In our case, we have $\sum_j n(i,j) = 100$ for all the five types. But for completeness, we still keep the normalization term in Equation 8.

We first evaluate M_m^8 when we use all 8 features. Then we drop each feature d at a time and evaluate $M_m^{\bar{d}}$. Then the feature impact factor for d is defined as:

$$I_d = \frac{M_m^{\bar{d}} - M_m^8}{M_m^8} \tag{9}$$

According to the Equation 9, the feature with larger I_d is more important to our classification. Also, we measure the time consumption for each feature and take average over all the images. The results are shown in Table 1:

According to Table 1, we find Text Color Variability has the smallest impact on overall classification accuracy and it consumes most of the time. Subsequently, we exclude this feature from our application and the final feature vector of an image k is a 7-dimensional vector $f_k \in R^7$. This f_k serves as the input to the DAG-SVM classifiers discussed in Section 3.1.

Table 1: Feature impact factor and time consumption.

Feature	Histogram flatness	Color variability	Text edge count	Text color variance	Chroma around text	Chroma histogram flatness	White block ratio	Color block ratio
time (ms)	12.01	12.51	14.97	73.92	36.12	11.45	0.67	0.81
I_d	24.61%	13.84%	11.02%	1.9%	10.2%	3.4%	48.43%	13.65%

4.0 Experimental Results

To test the performance of our designed system, we build an image set which includes 500 images scanned by flat-bed scanner. Each type of images has 100 images.

Different misclassifications are weighted differently due to its impact to image quality. Some misclassifications lead to larger image quality degradation and they should be assigned larger weight. Some other misclassifications cause smaller impact on image quality and should be assigned lower weight. The weight table of misclassification is shown in Table 2:

Table 2: Weights of misclassifications $w(i,j)$.

Ground truth	Mix	Text	Picture	Receipt	Highlight
Mix	0	3	5	6	4
Text	3	0	10	6	2
Picture	3	10	0	10	15
Receipt	6	8	3	0	8
Highlight	10	10	10	10	0

To test the performance of our proposed algorithm, we conduct leave-one-out cross validation. We use rbf kernel with σ for every node in Figure 8. Then we do exhaustive search for σ and box constraint C to find the best combination that produces the best cross validation result. The goodness of cross-validation result is measured by weight misclassification rate (W_m) which is defined in Equation 8. When $W_m = W_m^*$ reaches minimum, the corresponding confusion matrix $n(i,j)$ in different color spaces are given in Table 3 and Table 4:

Table 3: Confusion matrix $n(i,j)$ in YUV space.

Ground truth	Mix	Text	Picture	Receipt	Highlight
Mix	78	5	11	2	4
Text	3	68	0	4	25
Picture	5	0	94	1	0
Receipt	0	3	3	88	6
Highlight	4	8	1	5	82

5.0 Conclusion

In this paper, we introduce four new features to handle multi-class classification for AIO printer with scanning functionality. It extends the scope of the topic about the previous research work on SVM-based image classification of three types of images: text, picture and mix. Our proposed algorithm utilizes the chroma information of input image for better classification. Eventually, we use DAG-SVM with seven features to classify five classes of images which are text, picture, mixed, receipt and highlight. And based on the classification result, digital copiers or printers will produce images with better quality by choosing corresponding processing pipelines.

Table 4: Confusion matrix $n(i,j)$ in LCH space.

Ground truth	Mix	Text	Picture	Receipt	Highlight
Mix	76	6	12	1	5
Text	4	72	0	9	15
Picture	7	0	92	0	1
Receipt	0	6	0	89	5
Highlight	3	14	1	6	76

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Shaoyuan Xu is currently a Ph.D. student at Purdue University in the Department of Electrical Engineering supervised by Prof. Jan P. Allebach. He spent his first two years of undergraduate school in Zhejiang University, China. Then he transferred to University of Illinois at Urbana-Champaign and received his B.S. degree in Electrical and Computer Engineering in 2015. His current research mainly focuses on image processing, computer vision and machine learning.

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Cheng Lu received his B.S. degree in Electrical Engineering from Purdue Univer- sity in 2012 and he had been working on his Ph.D. in Electrical Engineering since then. He received his Ph.D. degree in Electrical Engineering from Purdue University in 2016. His research focuses on image processing, computer vision and machine learning. He is now a Sr. Eng with Sony Electronics Inc, Image Sensor Design Center.

Mark Shaw

Mark Shaw received his B.S. in Printing and Publishing Technology from University of Herfordshire in 1997 and his M.S. in Color Science from Rochester Institute of Technology in 1999. Then he went to Boise State University to take Electrical Engineering classes to meet the pre-requisites to study under Prof. Jan Allebach at Purdue. Finally he received his Ph.D. in Electrical and Computer Engineering from Purdue University in 2015. He is now a principal color and imaging master architect at HP Inc.

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Jan P. Allebach

Jan P. Allebach received his B.S. from the University of Delaware in 1972, his M.S. from Princeton University in 1975 and his PhD from Princeton University in 1976. He is now a Hewlett-Packard Distinguished Professor of Electrical and Computer Engineering at Purdue University. Allebach is a Fellow of the IEEE, the National Academy of Inventors, the Society for Imaging Science and Technology (IST), and SPIE. He was named Electronic Imaging Scientist of the Year by IS&T and SPIE, and was named Honorary Member of IST, the highest award that IST bestows. He has received the IEEE Daniel E. Noble Award, and is a member of the National Academy of Engineering. He currently serves as an IEEE Signal Processing Society Distinguished Lecturer (2016-2017). His current research interests include image rendering, image quality, color imaging and color measurement, printer and sensor forensics, and digital publishing.