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Original Article

Automatic Text Extraction from a Cockpit Panel through Optical Character Recognition Algorithm using Color-Intelligent RGB to Black and White Conversion Method

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Abstract *- The functionality and failure conditions of Aircraft Systems are displayed by different indicator lights along with appropriate text messages on a Cockpit panel. The text messages from the Cockpit Panel will provide a clear picture of an aircraft system's serviceability, malfunction, and failure. Thus, reading text messages can find the correct cause of an incident or accident in addition to a Flight Data Recorder (FDR). Character recognition of a text message is one of the major research areas in video analytics. The existing Optical Character Recognition (OCR) algorithm provides accurate character recognition in images, but its performance is not adequate for the analysis of video with different Vue and saturation conditions. The reflection and glare present in the video also degrade the performance of the OCR. Recent algorithms use the constant threshold and adaptive (Dynamic) threshold techniques depending on the overall brightness of the frame but fail to meet the accuracy requirements of real-time applications. In this paper, a Color-Intelligent conversion method is proposed, which converts the RGB Color frames into BW (black and white) images. This proposed method understands the Color information, provides channelised RGB to Gray conversion, and then converts it into a black-and-white format using the proper threshold value. This colour-based threshold technique of RGB to BW conversion enhances the character information during conversion. It provides accurate black-and-white image data to OCR to improve the overall accuracy of the text extraction.*

Keywords *- Black and White (BW) Image, Color-based Threshold Method, Constant Threshold Method, Dynamic Threshold Method, Flight Data Recorder (FDR), Gray Image, Optical Character Recognition (OCR).*

1. Introduction

Image Processing is one of the most emerging areas of research and finds a wide range of applications [1,10,14]. Image processing is nothing but processing an image so that noise and unwanted things can be removed and more meaningful data from the image can be obtained [3].

This paper aims at character recognition of a Cockpit Panel by processing an image obtained from a video of a data set consisting of Fifteen (15) different test Images, and 02 Bulk Text Sub Panels are selected for the testing process using OCR. The RGB Color image is an additive mix of three Colors: Red (R), Green (G), and Blue (B).

Using these three Colors, any other Color could be created. The Color feature of an image helps in the recognition and selection of an object in an image [15,17]. The Coloured image obtained from the test video frame of the data set is also called the RGB image, where each pixel denotes three different values of red, green, and blue. Processing an RGB image takes much more memory space than processing a Gray Scale image. All Colors in a Gray Scale image are represented by shades of Gray. Gray Scale image constitutes monochromatic shades from Black to White. To get the advantage of using less memory space and better processing speeds, the Color image is first converted from RGB image to Gray Scale Image and then subjected to OCR. The method used for converting a Color RGB image to a BW image matters in proper image recognition [6]. There are several existing methods of converting RGB images to BW images [7-9,12,16,17,4,5,11,18-22]. In this paper, the conversion of RGB images to Gray Scale Images is tested through three (3) different conversion methods, namely, standard threshold-based RGB to Gray conversion, adaptive threshold RGB to BW conversion, and color intelligent RGB to BW conversion. All three conversion methods are compared, and the most accurate and efficient method suitable for character recognition from an image of a Cockpit Panel is finally arrived at. Figure 1 shows a typical Cockpit panel from which a Validation Data Set of 15 Text messages and two (2) bulk text sub-panels are selected for the processing of Text Extraction through all three techniques. A validation data set of 15 text messages and 02 Bulk Text Sub Panels for the testing process are as detailed below.

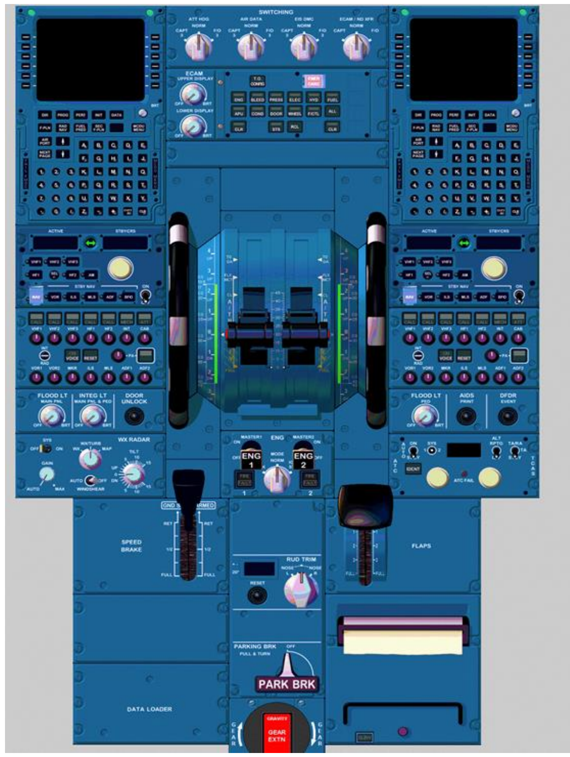
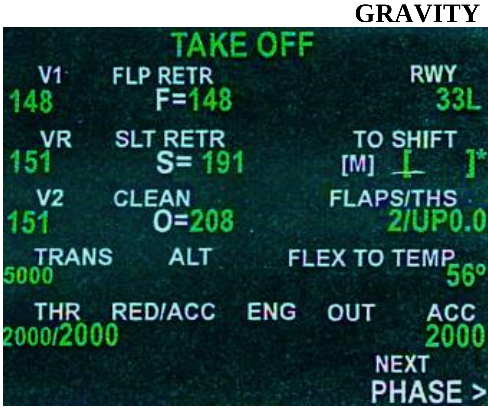


Fig. 1 A sample cockpit panel

HDG, MACH, BARO, ON, OFF, FAULT, CAPT, PUSH, FIRE, << MDDU READY >>, SYS ON, ENG1, +2.5, IN USE, GRAVITY GEAR EXTN.



BULK TEXT # 1 SUB PANEL

BULK TEST # 2 SUB PANEL

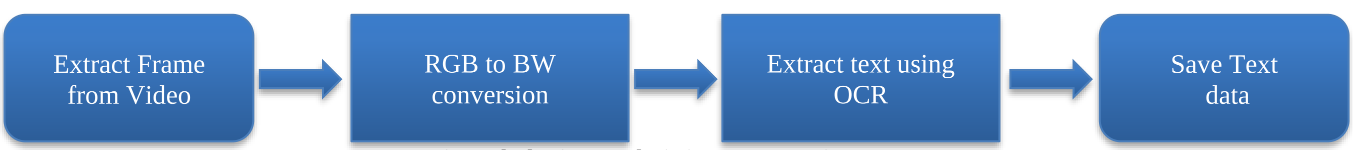


Fig. 2 Block Diagram depicting text extraction process

2. Problem Definition

Existing constant/adaptive threshold-based RGB to BW conversion methods suppress many important metadata features. The objective is to convert the RGB to BW without losing information regarding the small sub-features, such as small text and symbols. It is proposed to develop a Color-based threshold method of RGB to Black and white conversion.

2.1. Implementation Methodology

Figure 2 shows the process of extracting text data from the validation data set of a Cockpit Panel using all three different techniques of converting RGB to BW Images. Firstly, the image (Frame) from the video is extracted and then subjected to the above-mentioned three different RGB to BW conversion methods. Thus, the converted image through each conversion method is processed through the existing OCR separately, and the text data obtained is stored for all three methods. Finally, all the results are compared and arrived at the most suitable method for extracting the most accurate text data from a Cockpit Panel. The goal of this work is the comparison of the Color to BW conversion methods. However, the OCR algorithms are added to the test stack to evaluate the performance of conversion algorithms in terms of both qualitative and quantitative metrics.

2.2. RGB to BW Conversion Method Using Constant Threshold Technique

The constant threshold method of converting RGB to BW image employs extracting a single frame from the test video stream and calculating exact positions of text boundaries by mapping the relative positions with the landmark positions in the frame. Then, text areas are extracted and converted into Black and White shape images. A blockwise OCR algorithm was applied to recognise characters and construct text words [8,9,12,13,16,17]. A comprehensive comparative analysis to measure the confidence and accuracy of the desired text values against the obtained results was conducted at last.

2.3. RGB to BW Conversion Method Using Dynamic Threshold Technique

The dynamic Threshold method involves reading Color Image data and then calculating the threshold value using mean brightness. In the next step, the Color-corrected image is converted into a BW image. Applied standard morphological operations. Thus, the obtained BW image is subjected to the OCR algorithm and the text data [4,5,11,18,19,8]. Finally, a detailed comparative analysis was performed with the desired and obtained text values in terms of confidence and accuracy. The performance of the existing character recognition systems/ algorithms depends on the quality of the characters in the given input BW images. Particularly, when the images are taken in dynamic environments under motion, such as aircraft cockpits, the variations in color and brightness levels are high, which leads to poor color-to-BW conversion. Under the effect of colour and brightness spikes/ variations, the performance of the above-mentioned constant threshold and dynamic threshold methods are poor and result in a loss of characters' information during the conversion. This information loss is a critical and paramount factor to consider in improving the recognition performance of OCR systems.

3. Proposed Solution

To extend the capabilities of optical character recognition systems to multiple applications with huge variations in environments, the data pre-processing methods should understand the variations in Colors and brightness levels to provide better BW images to character recognition algorithms for better results. In this paper, the proposed RGB to BW conversion method is Color intelligent and can understand the variations in the environment and improves the quality of BW images by preserving the sharp edges of the characters, which will increase the recognition capabilities of the character recognition algorithms.

3.1. RGB to BW Conversion Method Using Colour-Intelligent Technique

The Color-Intelligent method is employed in reading the Color Image data. Aggregate values of individual Color values, Vue, saturations, and combined brightness of the RGB channels are calculated. The variance and mean of Color channels are calculated. Each Color channel is adjusted using the above-calculated values.

The threshold value using the mean, variance, and brightness values are calculated. The Color-corrected image is converted into a BW image. Automated decision-based morphological operations depend on the mean values of RBG channels, brightness, and variance levels. Finally, the resulting BW image is applied to the OCR algorithm and extracted from the text data. Finally, a detailed comparative analysis was performed with the desired and obtained text values in terms of confidence and accuracy.

4. Dataset Collection and Data Processing

The image datasets used in the work are extracted from the cockpit video. The actual duration of the video is 30 minutes with 30 frames per second. The frames are extracted, and suitable frames with the valid and required information (character/ text on the cockpit panel) are selected for validation and comparison of existing and proposed Color to BW conversion methods and OCR algorithms. After careful selection of frames with variations in Color and brightness, the valid regions are cropped into separate images without pixel loss or blur. These separated images are stored in a folder to provide input to the test stack to validate and compare the performance of the proposed conversion method against the performance of existing methods discussed in Section 2.

5. Results and Discussions

The cockpit optical recorders use a single camera sensor to record the complete panel area. The Text extraction from the Panel frame is a highly difficult task for normal OCR techniques, as many reflections and overlays from LED indicators and display units are present in the recordings.

The standard constant threshold-based RGB to BW image conversion method, advanced adaptive threshold-based RGB to BW conversion method, and proposed Colour-Intelligent RGB to BW image conversion methods are implemented in 'The MATLAB R2021a tool and verified against standard real-time cockpit panel data with different light and glare conditions. All three methods are employed in the conversion of RGB video frames into BW frames and then applied to the standard OCR algorithm to extract the text patterns. The validation image data set consists of fifteen (15) different images with various types of text like numeric digits, alphabets, and symbols and two (2) bulk text sub-panels.

5.1. Validation Data Set

Fig. 3 Images of Validation Data Set

Figure 3 shows the Images of Fifteen (15) text messages and Two (02) Bulk Text panels selected for the testing of Text Extraction.

5.2. Resulted in Texts Extracted through the Constant Threshold, Adaptive Threshold, and Color-based Threshold Methods of RBG to BW Conversion

5.2.1. Resulted in a Text message for "PUSH"

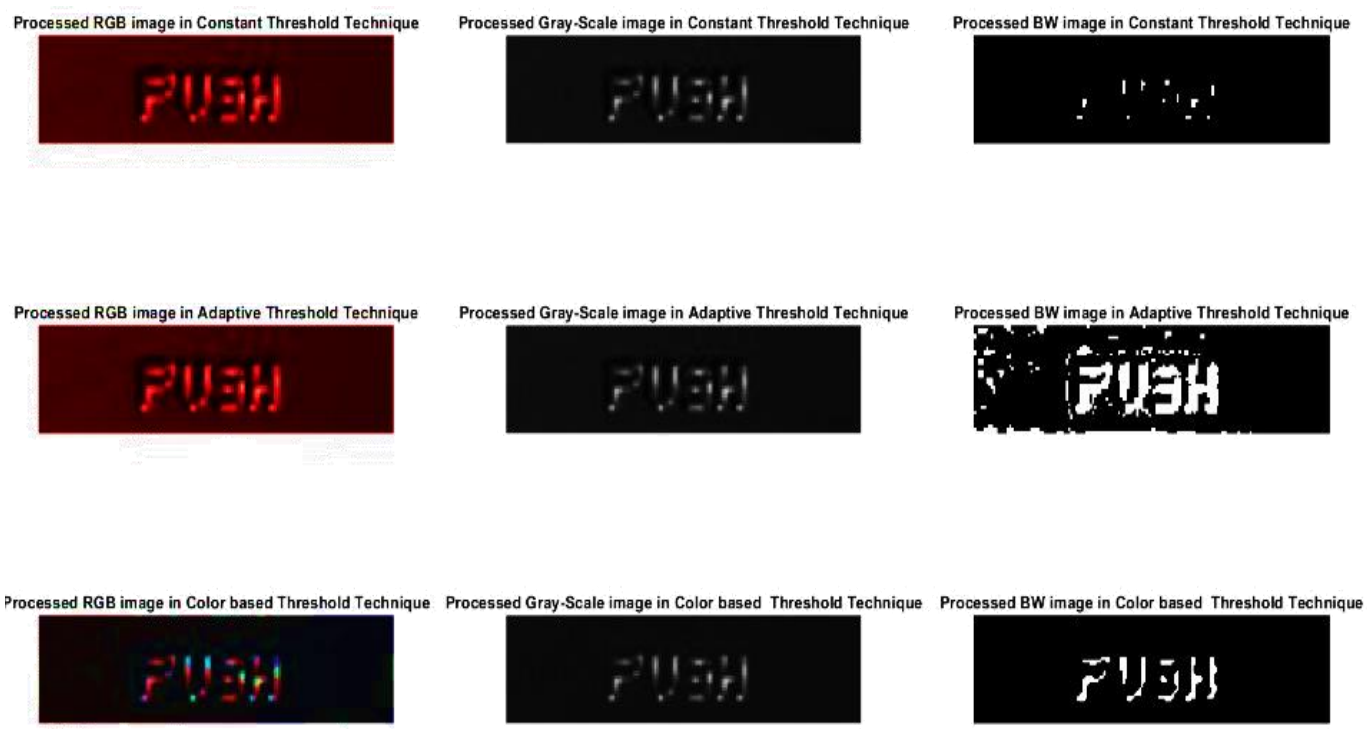


Fig. 4 Resulted in a Text message for "PUSH", obtained through all three RBG to BW conversion methods

5.2.2. Resulted in a Text message for "SYS ON"

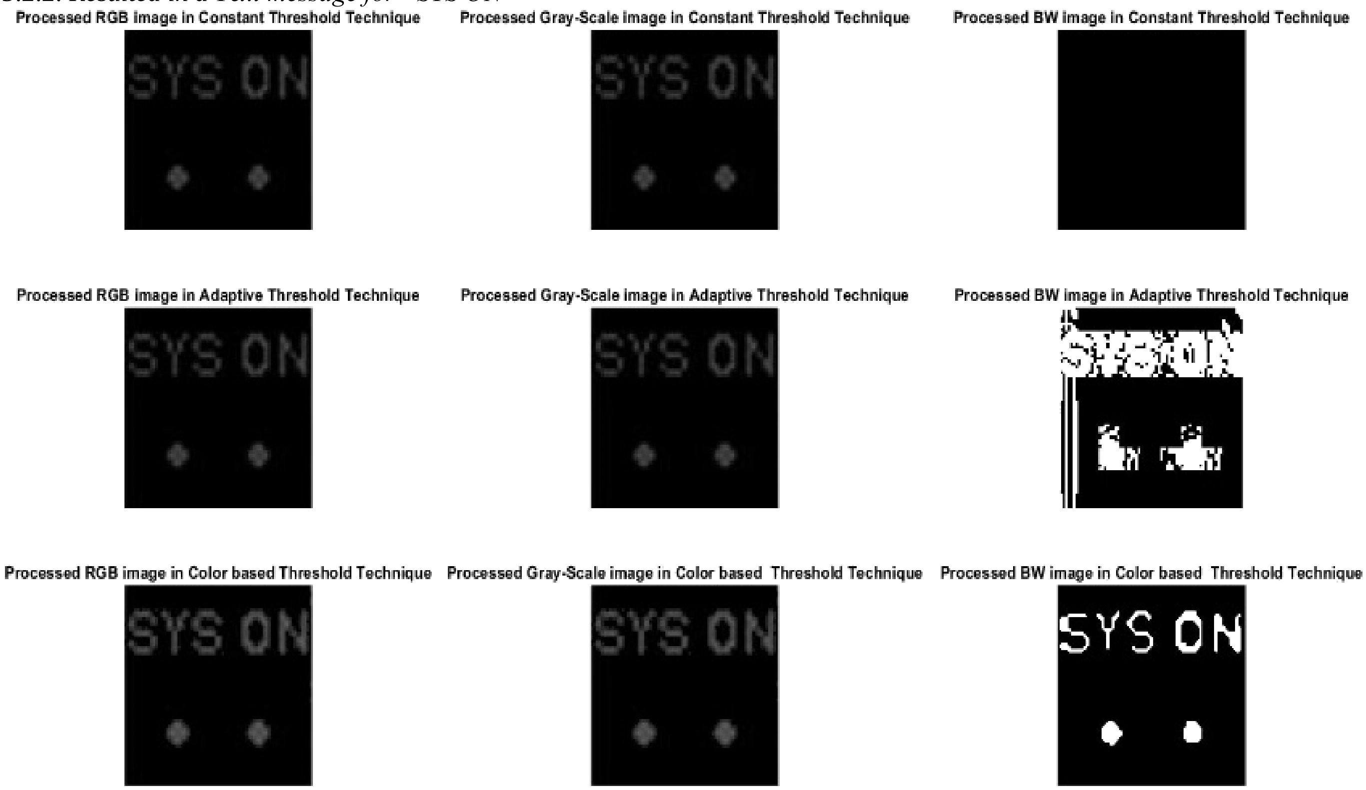


Fig. 5 Resulted in a Text message for "SYS ON", obtained through all the three RBG to BW conversion methods

5.2.3. Resulted in a Text message for "OFF"

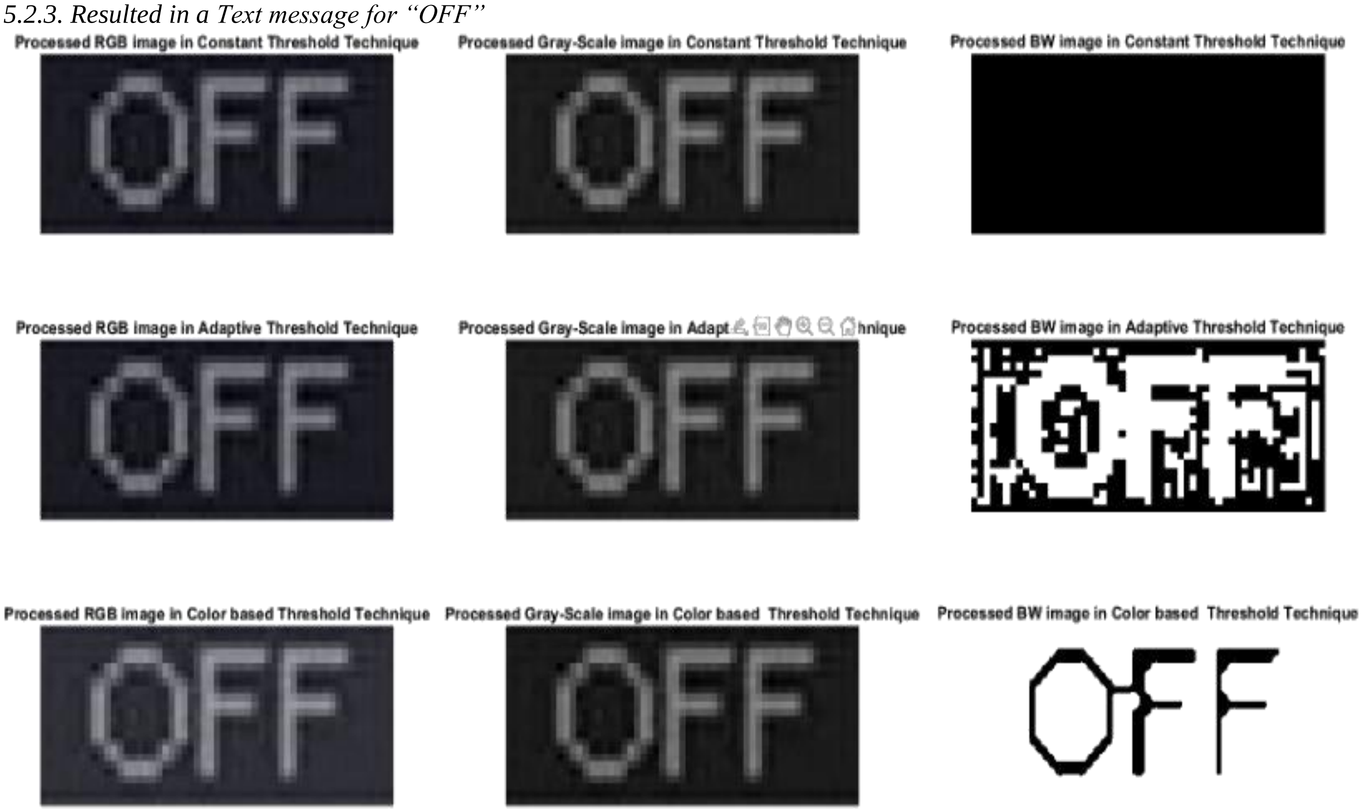


Fig. 6 Resulted in a Text message for "OFF" obtained through all three RBG to BW conversion methods

5.2.4. Resulted in a Text message for “<<MDDU READY>>”

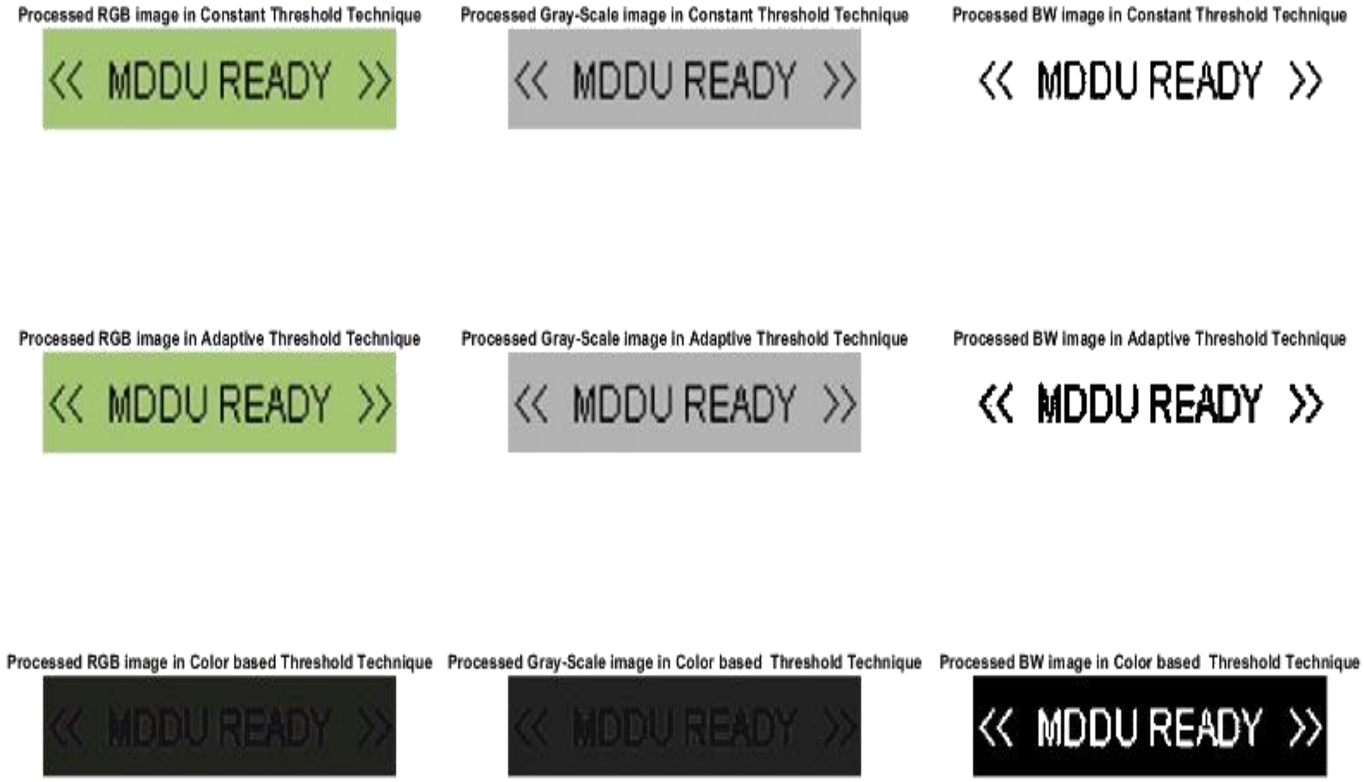


Fig. 7 Resulted in a Text message for “<< MDDU READY>>”, obtained through all three RBG to BW conversion methods

5.2.5. Resulted in a Text message for “MACH”

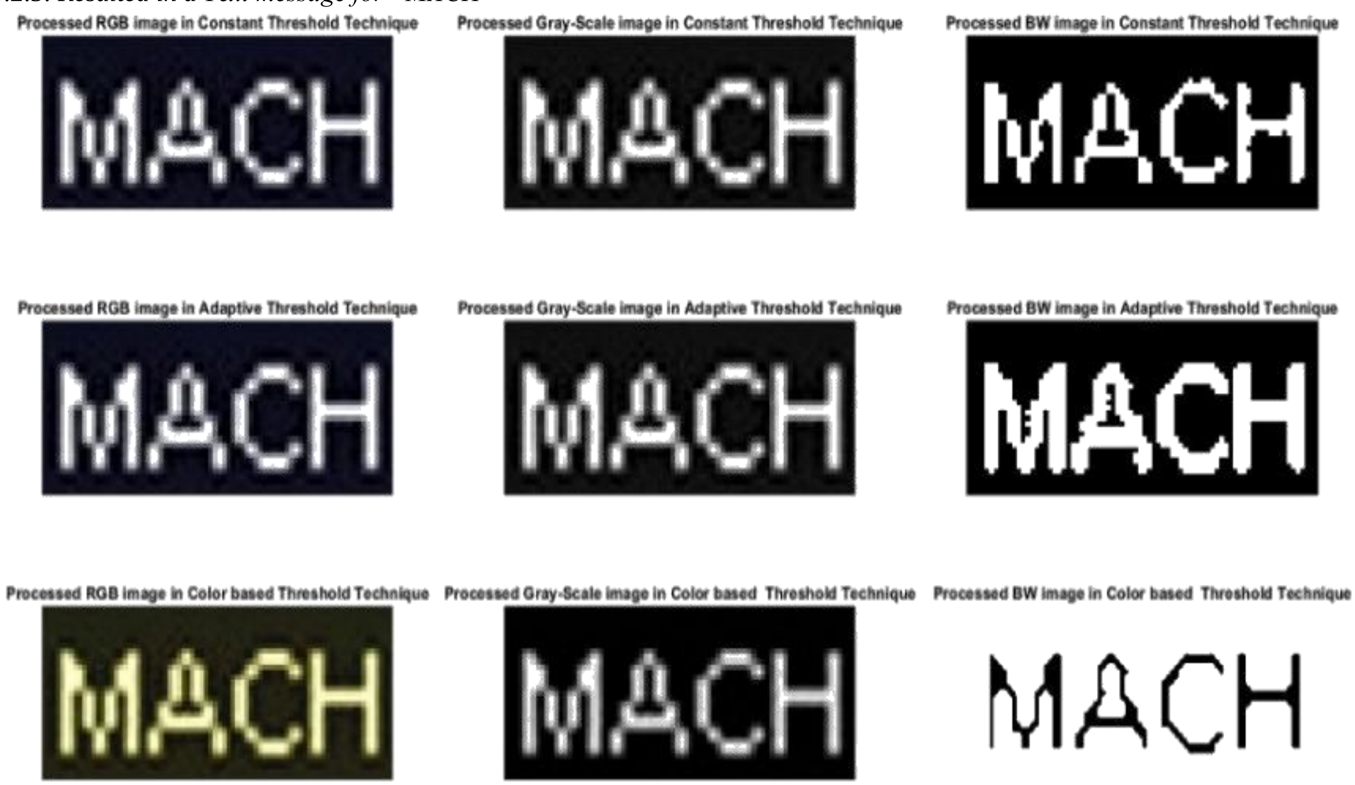


Fig. 8 Resulted in a Text message for “MACH”, obtained through all three RBG to BW conversion methods

5.2.6. Resulted in a Text message for "IN USE"

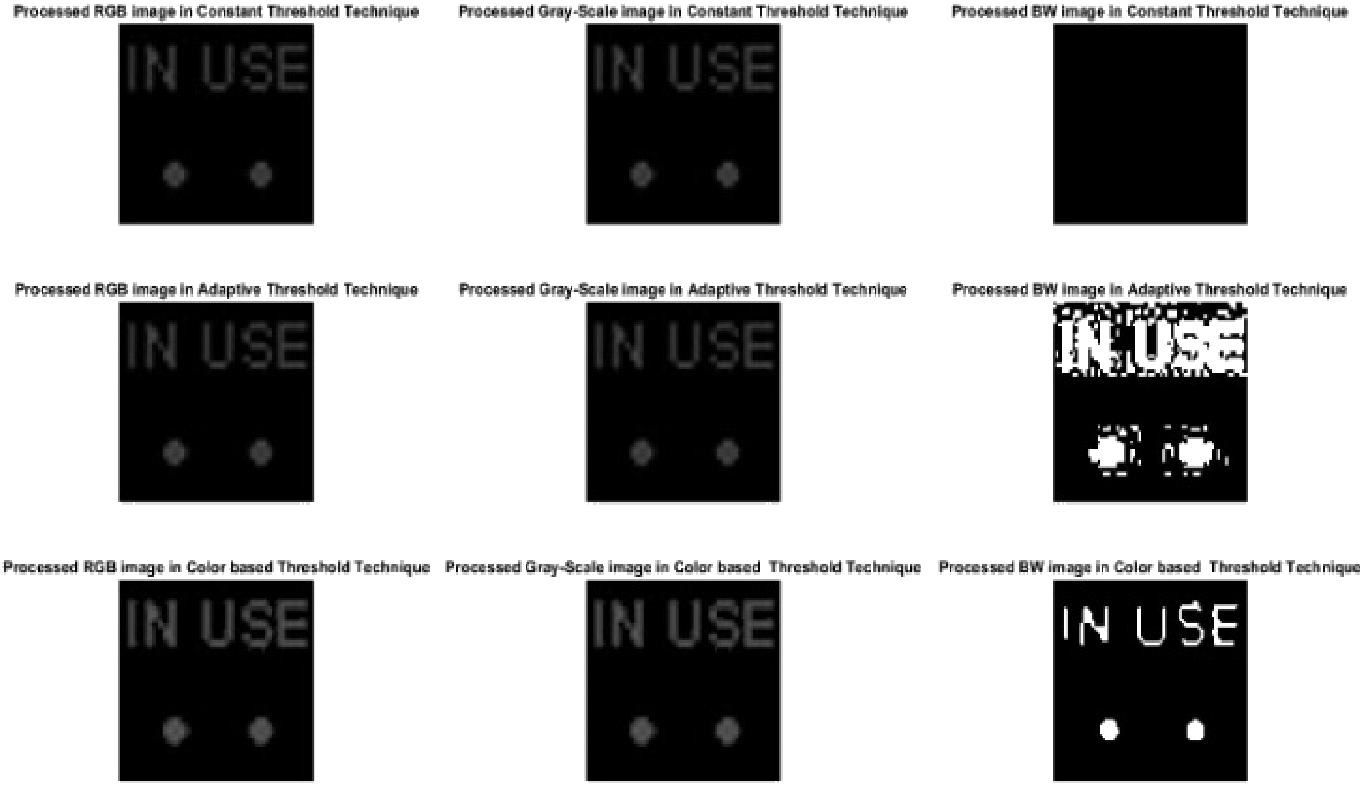


Fig. 9 Resulted in a Text message for "IN USE", obtained through all three RBG to BW conversion methods

5.2.7. Resulted in a Text message for "GEAR EXTN"

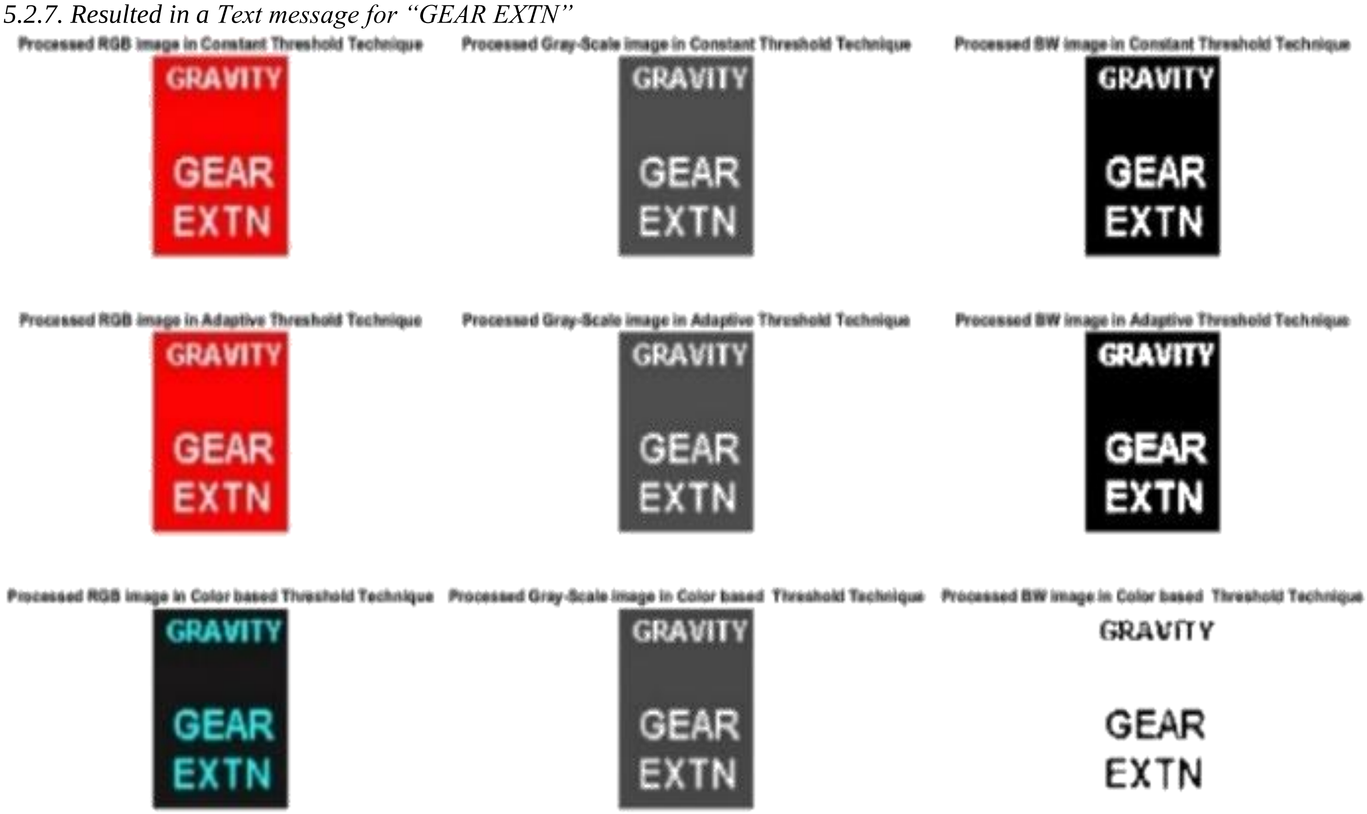


Fig. 10 Resulted in a Text message for "GRAVITY GEAR EXTN", obtained through all the three RBG to BW conversion methods

5.2.8. Resulted in a Text message for "FIRE"

Fig. 11 Resulted in a Text message for "FIRE", obtained through all the three RBG to BW conversion methods

5.2.9. Resulted in a Text message for "FAULT"

Fig. 12 Resulted in a Text message for "FAULT", obtained through all the three RBG to BW conversion methods

5.2.10. Resulted in a Text message for "ENG 1"

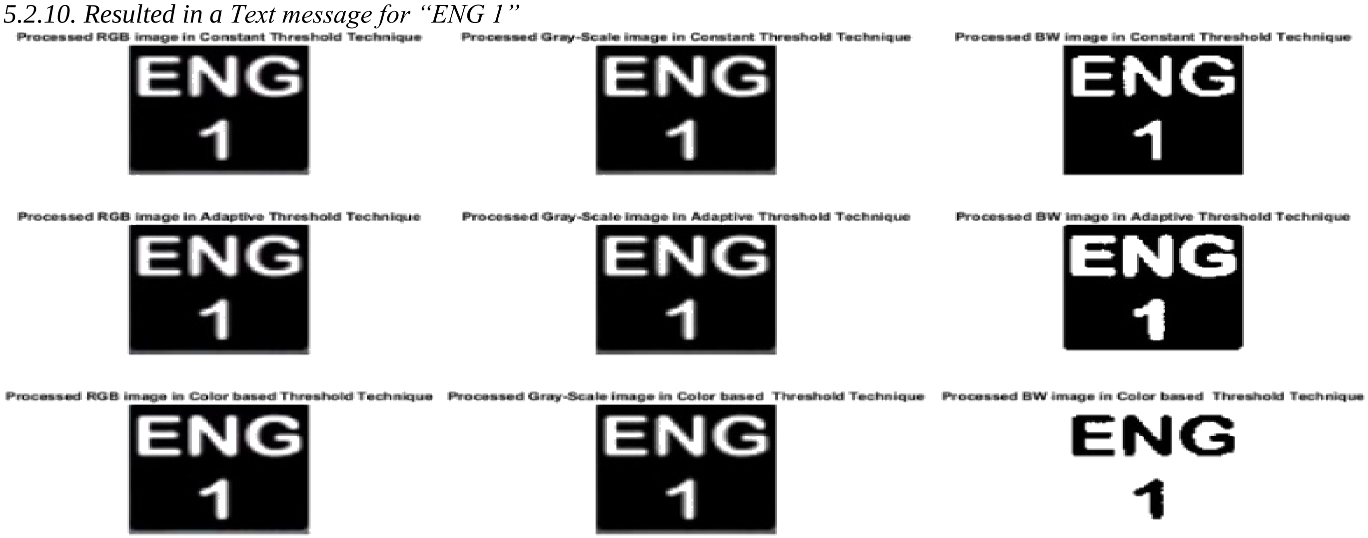


Fig. 13 Resulted in a Text message for "ENG 1", obtained through all three RBG to BW conversion methods

5.2.11. Resulted Text messages in the Bulk Text #1 Sub Panel

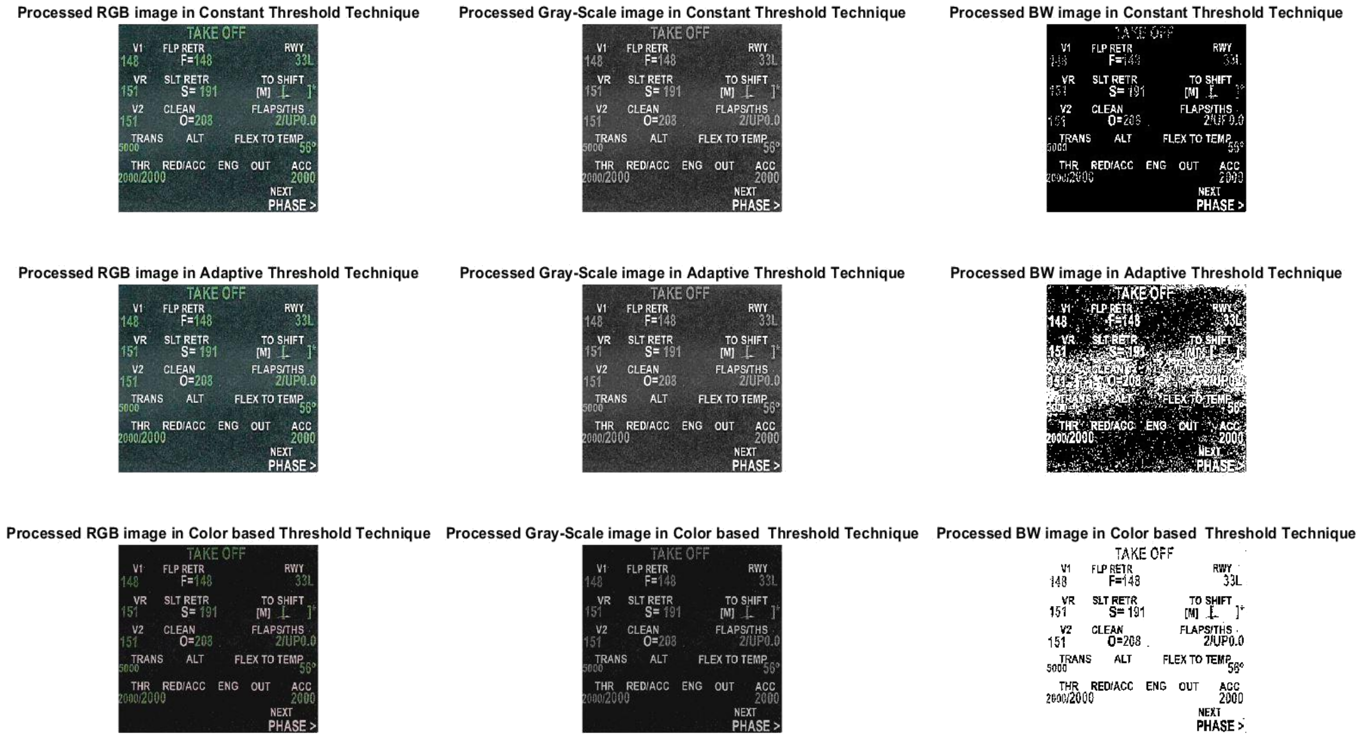


Fig. 14 Resulted Text messages in the Bulk Text #1 Sub Panel, obtained through all the three RBG to BW conversion methods and finally subjected to OCR

5.2.12. Resulted Text messages in the Bulk Text # 2 Sub Panel

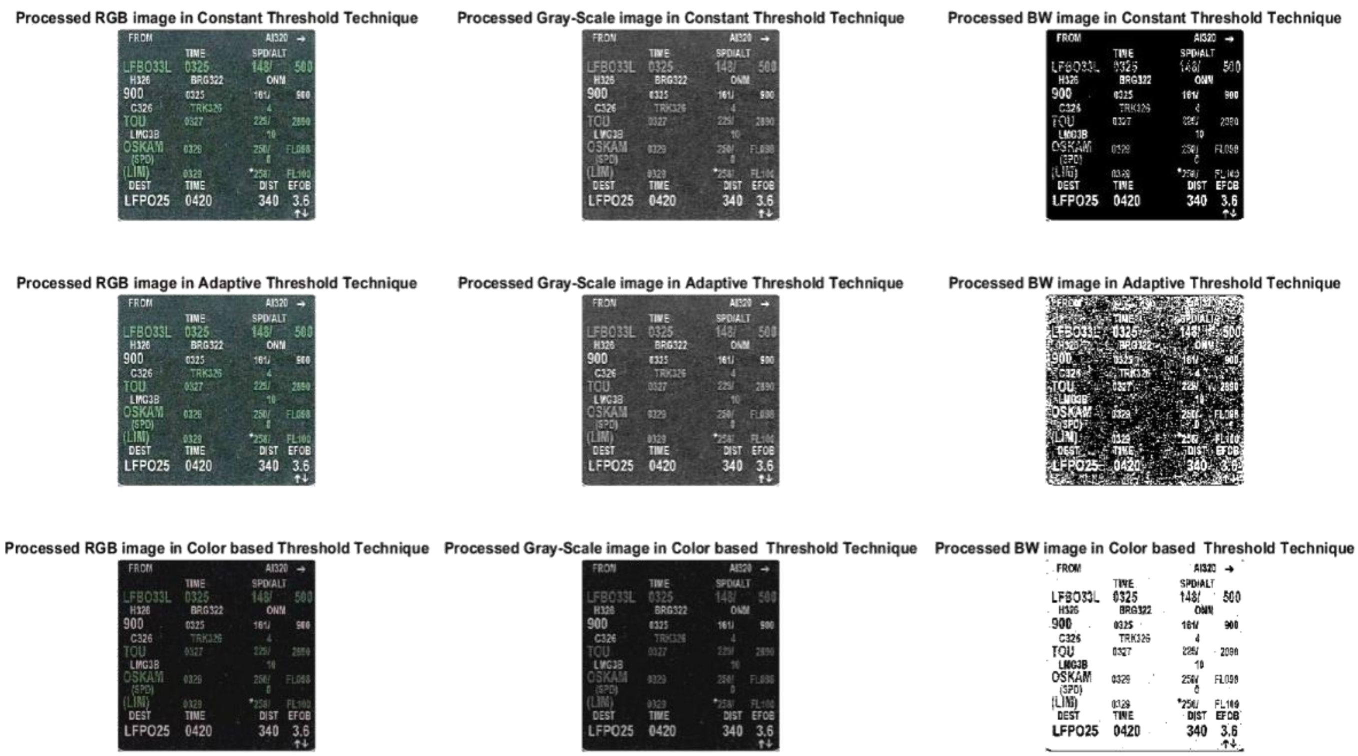


Fig. 15 Resulted Text messages in the Bulk Text # 2 Sub Panel, obtained through all the three RBG to BW conversion methods and finally subjected to OCR

5.2.13. Command Windows for Threshold-based and Color-based conversion methods

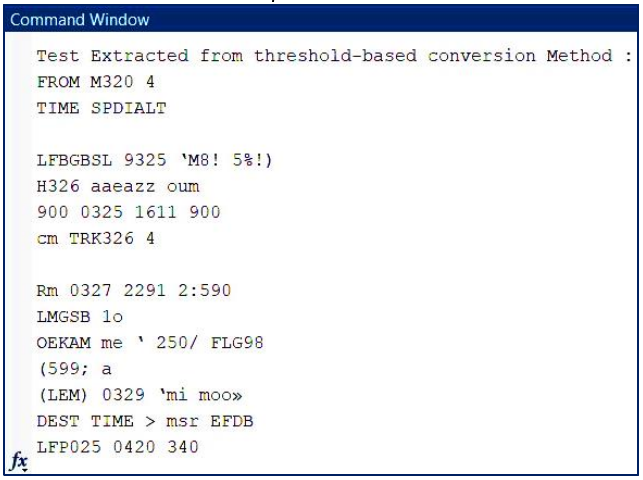


Fig. 16 Command Window for the Threshold-Based Conversion Method

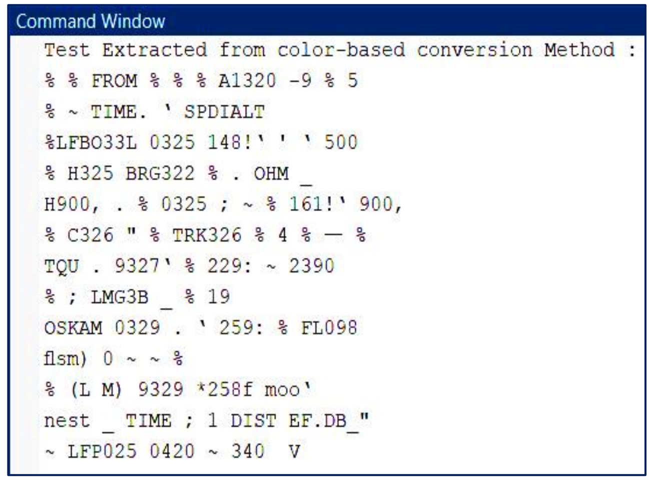


Fig. 17 Command Window for the Color-Based Conversion Method

5.2.14. OCR Output of Text Messages from the Bulk Text # 1 Sub Panel, obtained through the Threshold-based and Color Intelligent RBG to BW Conversion Methods

BULK TEXT # 1 SUB-PANEL

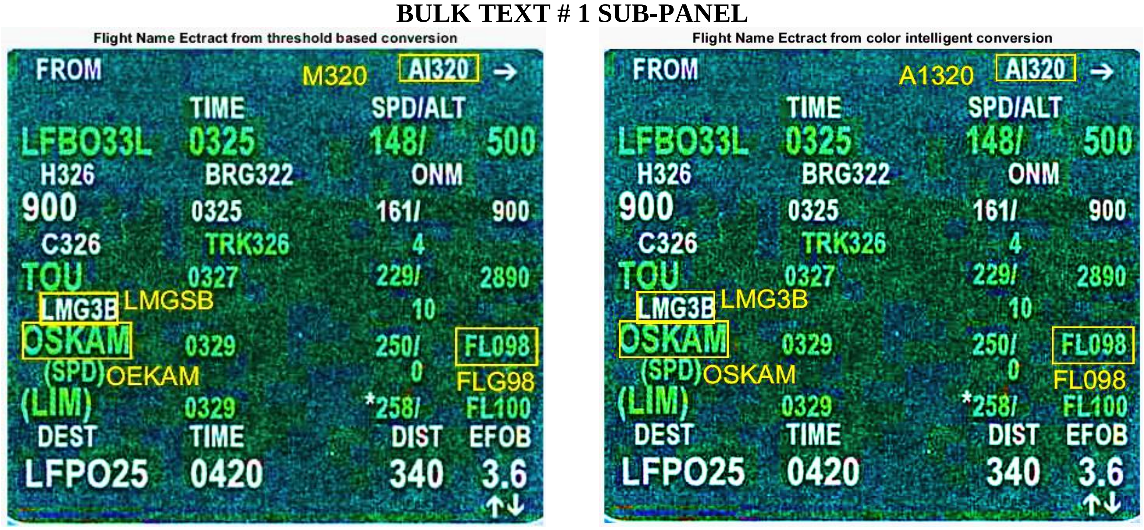


Fig. 18 OCR output of Text messages (Yellow) from the Bulk Text # 1 Sub Panel, obtained through the threshold and Color Intelligent RBG to BW conversion methods

Figure 18 shows the OCR output; the different text messages processed are listed in Table 1. Table 1 indicates the four original text messages in Bulk Text # 1Sub Panel, along with the Extracted Text messages (Yellow) obtained through the Threshold-based and Color Intelligent-based conversion methods. It is evident that the results shown in Table 1 clearly indicate that the Color Intelligent method of converting RGB to BW has given the best results and accuracy.

5.2.15. Extracted Text Messages from Bulk Text # 1 Sub Panel using Threshold based and Color-Intelligent Conversion methods

Table 1. Extracted Text messages from Bulk Text # 1 Sub Panel using Threshold-based and Color-intelligent-based conversion methods

Original Text Message in Bulk Text # 1 Sub Panel	Text Messages Obtained Through Threshold RGB to BW Conversion Method	Text Messages Obtained Through Color Intelligent RGB to BW Conversion Method
AI320	M320	A1320
LMG3B	LMGSB	LMG3B
OSKAM	OEKAM	OSKAM
FL098	FLG98	FL098

5.2.16. OCR output of Text messages (Yellow) from the Bulk Text # 2 Sub Panel, obtained through the threshold and Color Intelligent RBG to BW conversion methods

BULK TEST # 2 SUB-PANEL

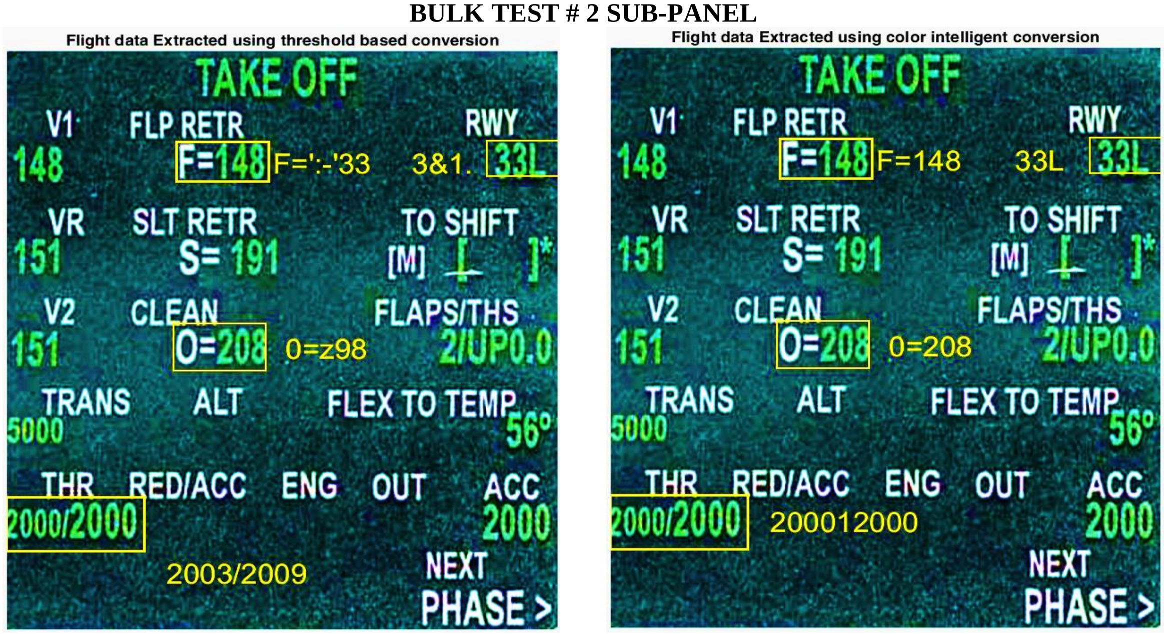


Fig. 19 OCR output of Text messages (Yellow) from the Bulk Text # 2 Sub Panel, obtained through the threshold and Color Intelligent RBG to BW conversion methods

5.2.17. Extracted Text messages from Bulk Text # 2 Sub Panel using Threshold and Color Intelligent based Conversion Methods

Figure 19 shows the OCR output; the different text messages processed are listed in Table 2. Table 2 indicates the four original text messages in Bulk Text # 2 Sub Panel, along with the Extracted Text messages (Yellow) obtained through the Threshold-based and Color Intelligent-based conversion methods. It is evident that the results shown in Table 2 clearly indicate that the Color Intelligent method of converting RGB to BW has given the best results and accuracy.

Table 2. Extracted Text messages from Bulk Text # 2 Sub Panel using Threshold-based and Color-intelligent-based conversion methods.

Original Text Message in Bulk Text # 2 Sub Panel	Text Messages Obtained Through Threshold RGB to BW Conversion Method	Text Messages Obtained Through Color Intelligent RGB to BW Conversion Method
F=148	F=': - '33	F=148
33L	3&1.	33L
0=208	0=Z98	0=208
2000/2000	2003/2009	2000 1 2000

5.2.18. The final extracted OCR output of 15 text messages from the Cockpit Panel using Constant Threshold, Adoptive Threshold, and Color Intelligent RGB to BW conversion methods, along with Confidence and Accuracy levels, are detailed in Table 3

Table 3. Extracted OCR output Text messages from the Cockpit Panel using Constant Threshold, Adoptive Threshold, and Colour Intelligent RGB to BW conversion methods along with Confidence and Accuracy levels

S.No.	Actual Text	The method used for converting RGB image to BW image								
		Constant Threshold-based RGB to BW Conversion Method			Adaptive Threshold-based RGB to BW Conversion Method			Color Intelligent RGB to BW Conversion Method		
		OCR-output Text	OCR Text Confidence	Accuracy of Recognition	OCR-output Text	OCR Text Confidence	Accuracy of Recognition	OCR-output Text	OCR Text Confidence	Accuracy of Recognition
01	ON	' '		0%	' '		0%	ON	0.917	100%
02	OFF	' '		0%	' '		0%	OFF	0.907	100%
03	ENG 1	ENG 1	0.961	100%	ENG 1	0.961	100%	ENG 1	0.953	100%
04	HDG	' '		0%	HDG	0.934	100%	HDG	0.936	100%
05	+2.5	+2.5	0.851	100%	+2.5	0.851	100%	+2.5	0.853	100%
06	MACH	MACH	0.899	100%	MACH	0.899	100%	MACH	0.891	100%
07	PUSH	' '	0	0%	' '	0	0%	PWBH	0.786	50%
08	CAPT	' '	0	0%	' '	0	0%	CAPT	0.868	100%
09	FIRE	' '	0	0%	' '	0	0%	FIRE	0.787	100%
10	SYS ON	' '	0	0%	' '	0	0%	SYS ON	0.848	100%
11	IN USE	' '	0	0%	' '	0	0%	IN USE	0.905	100%
12	FAULT	' '	0	0%	' '	0	0%	FAULT	0.887	100%
13	BARO	' '	0	0%	BARO	0	0%	BARO	0.869	100%
14	<< MDDU READY >>	<< MDDU READY >>	0.973	100%	<< MDDU READY >>	0.973	100%	<< MDDU READY >>	0.961	100%
15	GRAVITY GEAR EXTN	cmwmr GEAR EXTN	0.978	53.33%	cmwmr GEAR EXTN	0.977	53.3%	GRAVIIY GEAR EXTN	0.916	93.33%

5.2.19. The graph was obtained with confidence levels of 15 Text messages of the Cockpit Panel

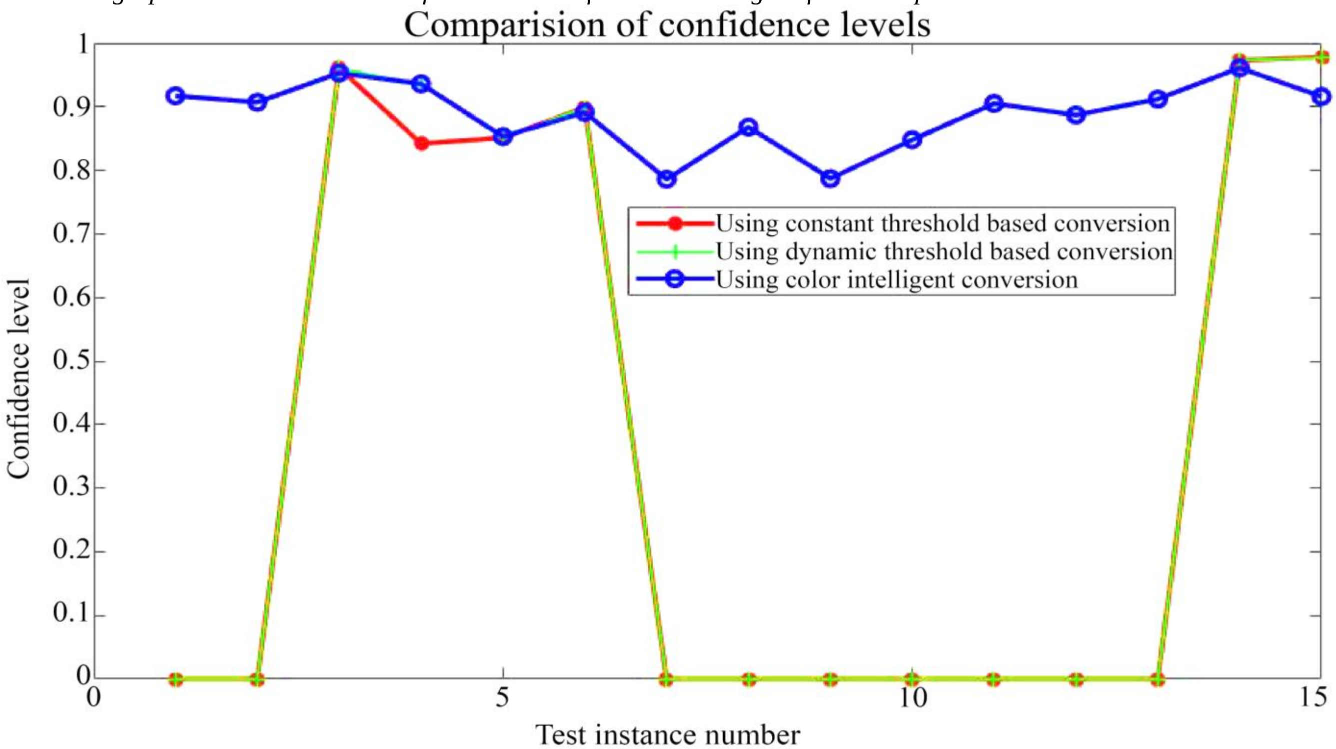


Fig. 20 Graph depicting Confidence levels of 15 Text messages of the Cockpit Panel extracted through Constant Threshold, Dynamic Threshold, and Color Intelligent RGB to BW conversion methods

5.2.20. The Graph was obtained with accuracy levels of 15 Text messages of the Cockpit Panel

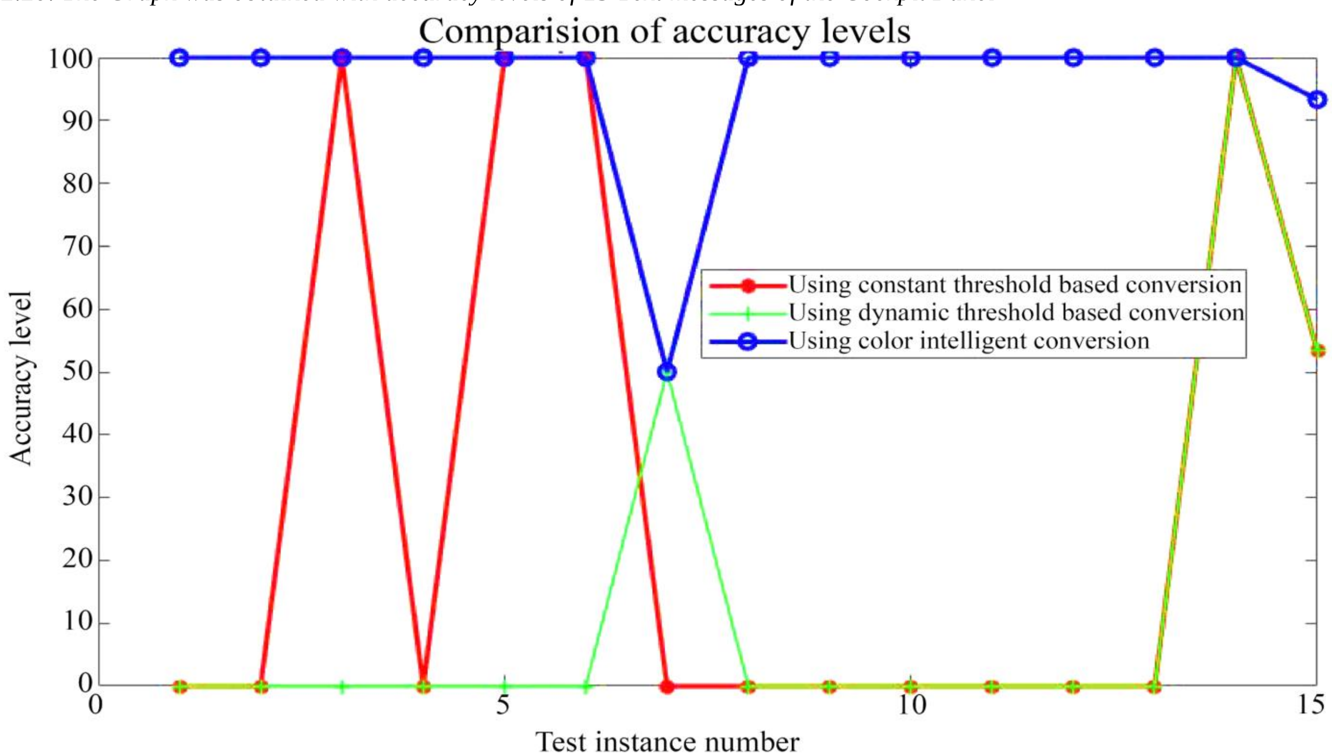


Fig. 21 Graph depicting Accuracy levels of 15 Text messages of the Cockpit Panel extracted through Constant Threshold, Dynamic Threshold, and Color Intelligent RGB to BW conversion methods

The performance of the proposed Color intelligent RGB to Blank and White image conversion is compared against the performance of RGB to Black and White conversions using constant threshold and adaptive threshold techniques. The Black and White images from existing and proposed techniques are applied to the standard Blockwise Optical Character Recognition (OCR) algorithm to extract the characters and construct the words. Fifteen (15) different text Images and two (2) bulk text sub-panels are considered with different brightness, saturation, and Color scenarios to Analyse the robustness of the proposed algorithm. The proposed technique exhibits satisfactory conversion to meet the accuracy constraints of the real-time applications. The proposed algorithm extracts the character shapes in most noisy scenarios like over brightness, over darkness, Color overlays and reflections due to LED rays, Background Color effects due in LCD panels, etc.

6. Conclusion

The Color RGB to BW conversion using all three methods (standard threshold, adaptive threshold, and Color Intelligence) is implemented and verified against different types of Text image data and two (2) bulk text sub-panels of the cockpit panel. The proposed method of Colour Intelligent RGB to BW has yielded the best results, with an average accuracy of the OCR algorithm that improved from 60% to 95%. The accuracy of original text recognition is close to 100%, even for low confidence levels.

Hence, the correct reading of the text messages from a cockpit panel is achieved by the most appropriate reason for the malfunction or failure of all the aircraft systems displayed in a particular cockpit panel. This could help find the correct reason and also aid in improving the technology affected and reducing aircraft incidents or accidents.

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