Global Journal of Scientific Researches
Available online at gjsr.blue-ap.org
©2016 GJSR Journal. Vol. 4(2), pp. 23-34, 30 April, 2016
E-ISSN: 2311-732X

Detecting people and equipment using infrared cameras in UVAs

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Received: 25 March, 2016 *Accepted: 13 April, 2016* *Published: 30 April, 2016*

ABSTRACT

Thermal imaging systems which are also called thermography are passive systems working in mid-infrared region (infrared mediation) and high electromagnetic spectrum. These systems are used for imaging applications using objects radiation. All objects radiate electromagnetic waves which cover a continuous spectrum and its peak wavelength and emission power depends on objects temperature and according to Planck's law, each object with a temperature higher than absolute zero (273 Centigrade degrees) radiates energy. As far as infrared cameras have many applications in industrial (production line control, trouble-shooting), scientific-medical (scanners, cancer diagnosis), fire's safety (recognition the leakage of combustible material, rescuing) police (chaos control, bomb deactivation) military (watching, photography, camera, Pio-radars) fields, their importance in the human life is significant and in this study, military images taken with infrared cameras are processed with an algorithm, including: 1.image refreshment, 2. Changing color images to black and white,3. Threshold specification, 4.Noise deletion, 5.Image filtering, 6. And finally, edge deletion and combining final image with taken image. Videos are tracking with an algorithm, including: 1. Video refreshment, 2. Making a system for object's geometrical translation, 3. Making a system for object's frame conformation to specify a region having the best function in a video form, 4. Making an object system to show the main and fix videos, 5. Initial numbering of some variables in the processing circle, 6. Using objects for video input stabilization. In fact, captured images with infrared cameras are helpful for better recognition of people and equipment in UVA's and military aircrafts.

Keywords: *infrared, UVA, imaging system, electromagnetic spectrum.*

INTRODUCTION

According to the kind of facilities and equipment, UVA's are able to carry out various intelligence actions, including recognition, surveillance and target detection and electrical overhearing with optimized facilities, especially human resources. In other words, drones are one of the advanced equipment of the current era which would have a special place in future wars. On the other hand, due to the military and intelligent superiority of the powerful countries opposing Islamic Republic of Iran, future wars would be heterogeneous and their victory necessitates exercising tactical innovations and using suitable equipment. So, using UVA appropriate applications could become influential in the defensive system of Iran and consequently would be functional for national security. The main purpose of this study is doing intelligent actions (Identifying and detecting people and equipment) using infrared cameras in UVAs. Therefore, a general definition for infrared waves and infrared cameras are presented and then we talk about its different kinds and their applications in military and medical fields.
Infrared is an electromagnetic radiation with a longer wavelength than visible waves and shorter than radio waves.

Regarding that red color has the longest wavelength, infrared radiation has a wavelength between 750 Nm and 1Mm and uses 3 magnetic processes for data emission. According to the share of infrared waves in colors spectra, these waves have many applications, including destination and target tracing in military fields, temperature remote control, using in wireless applications for short area communication, spectroscopy and weather forecasting. Also, this wave has a very important role in regulating the

Earth's atmosphere. This wave is used for treating some kinds of illnesses. Special kinds of infrared lamps are used for muscular and joint pain treatment, especially back pains. In winter, these waves are used for heating homes. Rackets and other projectile weapons are controlled and guided with infrared waves. Molecular structure of objects is studied using this wave. Objects impurities are also detected using this wave.

2.G-IRS land detection and observation equipment

Detection, surveillance and communication are those actions which combine some parts of the battle to help soldiers, commanders and intelligence forces in collecting, processing, improving environmental awareness, formulating battle programs and doing mutual actions using infrared cameras in GRS systems and they would provide accurate information. ISR systems in land, air, sea and space platforms could be in different kinds, including radar, optical, audio, infrared images or electrical signals and are used for recognizing people, vehicles or other equipment with classic and non-classic structures. But you have to note that "type", "usage" and "accurate combination" of these systems guarantees your success or failure in detecting enemy's position and improving systems performance. Detection and land monitoring (G-ISR) equipment are developed in different kinds of fixed, portable and mobile for actions and in various situations. For example, for important regions, garrisons and boarding protection, fixed equipment is used and for those regions requiring maneuver, transfer and rapid disposition, mobile systems are required beside G-ISR equipment and there are different solutions like using UVAs and air platforms, but using UVAs for continuous and spot surveillance has a number of limitations and no country can control its military and non-military borders using UVAs, rather land surveillance systems have the main role of detection, surveillance and communication. But UVAs, airships and air platforms are supplementing and completing this circle. For example, radars and night/day vision cameras can detect any threat and immediately, counter actions like deploying UVAs are done for target tracing and deleting.

But the point to consider is that ISR land systems are usable for those regions under the control of friend forces and are not practical for detection and surveillance of those regions under the control of enemy (those systems that are not portable by human) and for these actions, UVAs and air platforms are concerned.

1.2. In order to become familiar with G-ISR equipment, a summary introduction of some of these systems is presented in the following:

Figure 1. SR Hawk land surveillance radar

SR Hawk land surveillance radar is one of the best systems in its class that is produced and supported by SRC American Company and presents a remarkable combination of performance and usage in size and weight amounts and portable packets. This radar can cover 360 degrees of lands, ports, vehicles, navy and some flying objects in low height and there's no need for specialized and multiple systems.

All these capabilities has caused that this system has multiple applications in land, border and air surveillance and supporting UAS-opposition actions. High accuracy in the area using automatic EO/IR cameras and audible warnings, some targets could be detected and classified and the operator is able to focus on the threat.

3-Image processing using MATLAB software

1.3. Images Searching

Regarding that people and equipment detection using infrared cameras in UVAs is for military purposes, so in this study military images have been used.

Figure 2. Humans.png

Figure 3.Ship.tif

Figure 4. US_Navy_p-3c-Orien-maritime.jpg

Figure 5. Military-FIR-jpg

4-Algorithm

1- Image refreshment in the first stage
2- Threshold determination for image
3- Changing image to black and white
4- Noise deletion: Generally, for Salt and Pepper Noise Deletion, median filter is better than averaging and this is done in 3*3 window and its equation is as the following:

Equation (1-2) □f^(x,y)= median{ g(s,t)} (s,t)□Sxy

5- Images sharpening and removing borders blackness: usable filter could be designed by the user and its matrix would be introduced to the software or known filters in image processing with their matrix in MATLAB software could be used. Some examples are: averaging filter, median filter, Gaussian filter, Sobel filter and knight filter. In this situation, with the help of Special function, the current pre-designed filters could be selected and be used in an image. As an example, using knight filter in an image, border details would be become more cleared. Knight filter is for contrast improvement and its dimensions are always 3*3 and the Alpha is adjustable. Alpha controls Laplacian figure and it has to be between 0 and 1 and its assumed amount is /2. Also, note that in filtering, for repairing assumed points outside image border, a method has to be used with assumed pixels side image borders and equal the nearest neighbor pixel and in this way, borders blackness is resolved.

6-In this stage, image borders are removed as the following: 1-input image with Gaussian filter is smoothed. 2- Radian and angle is measured. 3- Non-maximum hiding is performed with radian size. 4-Dual thresholding and connection analysis is used for borders conjunction and detection.

Suppose that F(x,y) and G(x,y) show image and Gaussian function, respectively:

Relation (2-2)

G(x,y)= e- x2+y2/2□2

With G and F twist, a smoothed image with fs (x,y) is made.

Relation (3-2)

Fs(x,y)= G(x,y)□ f(x,y)

Radian amount and direction (angle) is computed as the following.

Relation (4-2) and (5-2)

M(x,y)=(gx2+gy2)½

α(x,y)=tan-1[gy/gx]

According to (6-2) and (7-2) relations, gx and gy is computed.

$\mathbf{g_x = \partial f_s / \partial x}$

$\mathbf{g_y = \partial f_y / \partial y}$

According to (7-2) and (8-2) relations, borders are recognized and connected.

$\mathbf{g_{NH}(X,Y) = g_N(x,y) \geq T_H}$

$\mathbf{g_{NL}(x,y) = g_N(x,y) \geq T_L}$

After thresholding, gNH (x,y) has less non-zero pixels in comparison to gNL (x,y), but all non-zero pixels would be in gNH (x,y) and gNL (x,y), because the second image is made with a lower threshold. In gNL (x,y), all non-zero pixels are deleted as the following.

$\mathbf{g_{NL}(x,y) = g_{NL}(x,y) - g_{NH}(x,y)}$

At the end of this method, output image of the algorithm is made by adding all non-zero pixels from gNL (x,y) to gNH (x,y).

1.4- First stage

In the first stage, image is refreshed. Standard image files (BMP, JPEG, TIFF and etc.) could be refreshed using MATLAB (imread) function. The type of returning data using this command depends on the refreshed image and is shown with (imshow) command. Before performing these 2 commands, all open windows could be closed (close all).

Another way for showing images is (imview) command. Using this command, we can observe an image and by moving on that region, RGH amount of each pixel could be observed.

(Montage) command is another way to show some frames of an image beside each other.

2.4- Second stage

In this stage, in order to determine the concerned points of an image, a threshold is considered and after writing the concerned threshold for showing image using previous commands, a part of image is shown which was cut using the threshold.

3.4- Third stage

All captured images are colored, even black and white images, because they are used in black and white images domain (gray), so in this stage, the image color is changed to gray using (rgb2gray) command.

After changing image color to gray, it is shown by previous commands.

4.4- Fourth stage

In this stage, image noise is deleted and therefore, noise nature has to be recognized and then be deleted using spatial and frequency methods. The important point in noise deletion is that added noisy information to image would be deleted as much as possible and its important information (including borders) could be conserved. The most common noise in images are impulsive (salt-pepper) and Gaussian noises.3 kinds of filtering is introduced in this toolbox including line filtering, median filtering and conformational filtering.

Salt-pepper noises are observed as black and white points in image and their different brightness with neighboring points is a suitable criterion for their detection and deletion. In deleting theses noises, median filters have the highest competence. Gaussian and other kinds of noises could be deleted using smoothing with averaging or conformational filters. As an example, in an image with added pulsed noise (with imnoise command), the influence of averaging and median filters with (filter 2) and (medfilter2) commands in its deletion could be studied.

After deleting image noise, using previous commands, the image is shown.

5.4- Fifth Stage

Convolution is a neighboring practice in that the output amount of each input is the sum of weighed neighboring pixels. The matrix of the concerned weights is called convolution nucleus or filter. Using (imfilter) command, different line filters could be enforced with different sizes of the desirable window.

In this stage, more sharpened borders and borders blackness is removed and the main purpose of sharpening is increasing transitions (leaps) in severity and therefore, those commands represented in algorithm are used.

After this stage, using previous commands, the image is shown.

6.4- Sixth Stage

At the last stage, image borders are removed and this is done using mentioned commands in algorithm and then it joins the main image and finally, using previous commands, the final image is shown.

5-First Image

5-1. First Stage

In this stage, using previous commands, the image is refreshed and the result is presented as the following (figure 1-1-3).

Figure 6. Refreshed image

5-2. Second Stage

In this stage, using previous commands for threshold determination, after running, a part of image was cut and the result is shown as the following (figure 2-1-3).

Figure 7. A part of cut image

5.3- Third Stage

In this stage, using previous commands, the colored image is changed to black and white (gray) and the result is presented as the following.

Figure 8. Grayed image (black and white)

5.4-Fourth Stage

In this stage, using previous commands (filters), image noise is deleted and the result is presented as the following.

Figure 9. An image with deleted noise

5.5. Fifth Stage

In this stage, using previous commands and after running, image borders are more sharpened and borders blackness is removed and the result is shown as the following.

Figure 10. An image with more sharpened borders

5-6. Sixth Stage

In this stage, using previous commands and after running, image borders are deleted and the result is presented as the following.

Figure 11. The final image with deleted borders

6. Second Image

6.1- First Stage

In this stage, using previous commands and after running, the image is self-refreshed and the result is presented as the following.

Figure 12. Refreshed Image

6.2- Second Stage

In this stage, using previous commands (threshold determination) and after running, a part of image is cut and the result is presented as the following.

Figure 14. A part of cut image

6.3- Third Stage

In this stage, using previous commands (rgb2gray) and after running, colored image is changed to black and white and the result is shown as the following.

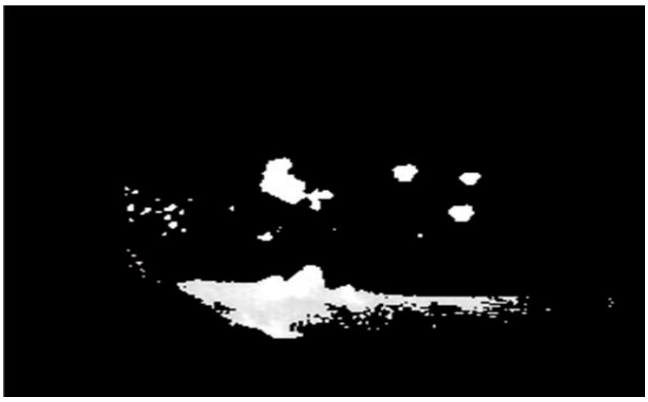


Figure 13. Grayed image (black and white)

6.4- Fourth Stage

In this stage, using previous commands (filters) and after running, image noise is deleted and the result is represented as the following.

Figure 15. Deleting noise from image

6.5- Fifth Stage

In this stage, using previous commands and after running, image borders are more sharpened and borders blackness is removes and the result is presented as the following.

Figure 16. Image border is more sharpened

6.6- Sixth Stage

In this stage, using previous commands and after running, image borders are deleted and finally, the result is shown as the following.

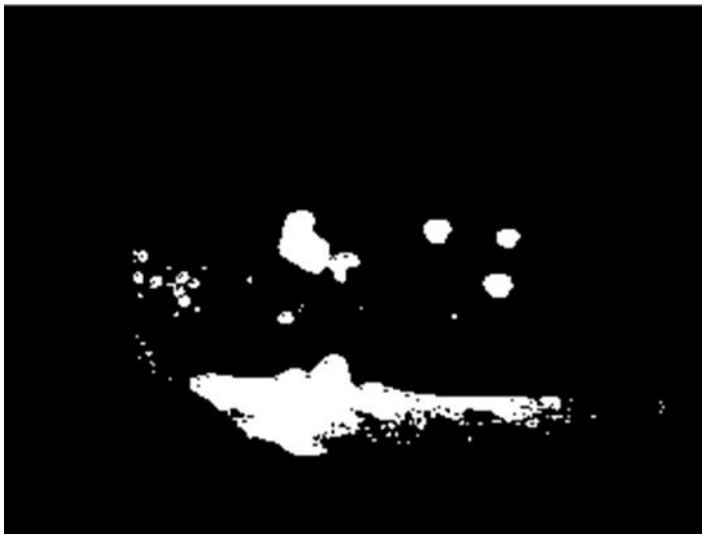


Figure 18. The final image with deleted borders

7. Third Image

7.1- First Stage

In this stage, using previous commands and after running, the image is refreshed and the result is shown as the following.

Figure 17. Refreshed image

7.2- Second Stage

In this stage, using previous commands (threshold determination) and after running, a part of image is cut and result is shown as the following.

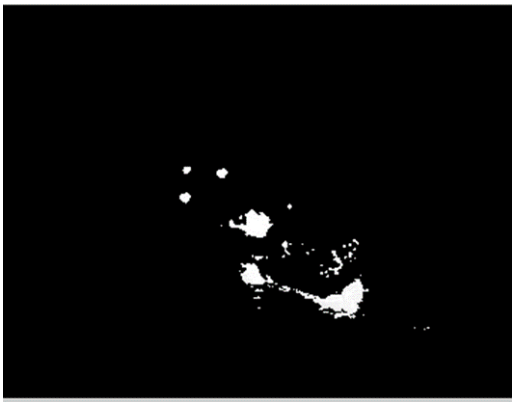


Figure 19. A part of cut image

7.3- Third Stage

In this stage, using previous commands and after running, colored images are changed to black and white (gray) and the result is shown as the following.

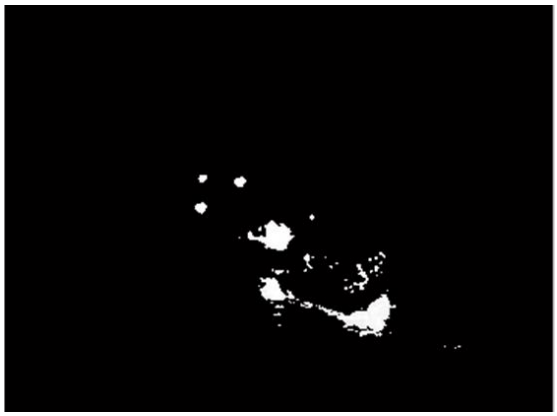


Figure 16. Grayed image (black and white)

7.4-Fourth Stage

In this stage, using previous commands and after running, image noises are deleted and the result is shown as the following.

Figure 17. Deleted noise in image

7.5- Fifth Stage

In this stage, using previous commands, image borders are more sharpened and their blackness is removed and after running, the result is shown as the following.

Figure 18. An image with more sharpened borders

7.6. Sixth stage

In this stage, using previous commands and after running, image borders are removed and the result is shown as the following.

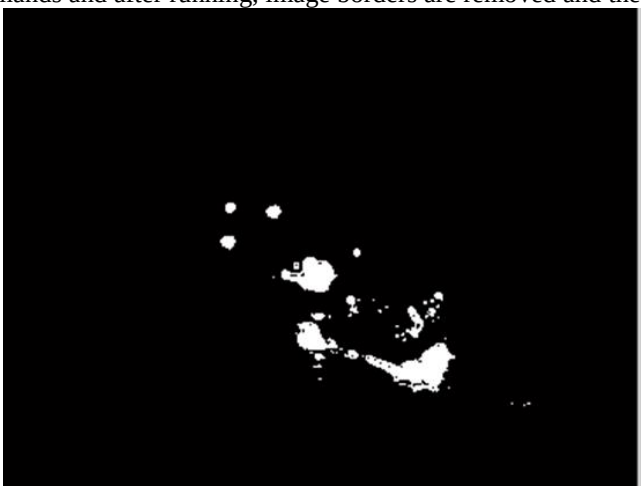
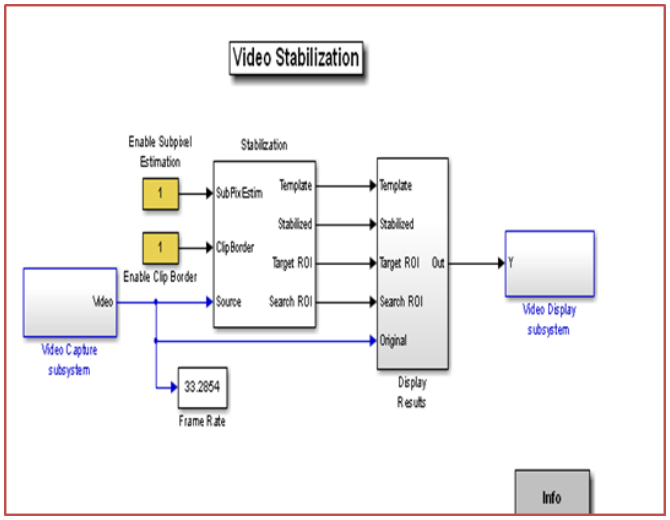


Figure 19. The final image with removed borders

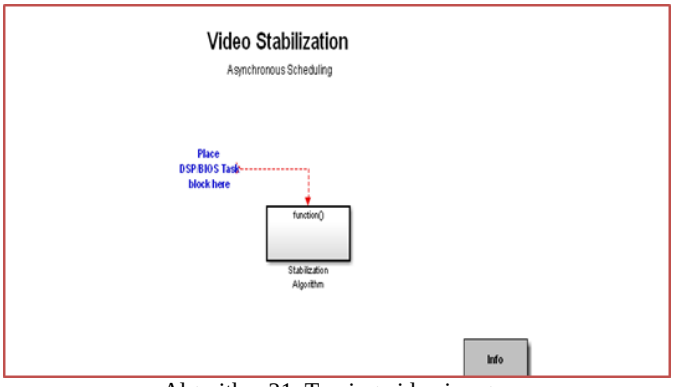
8. Conclusion

As far as red color has the longest wavelength, infrared radiation has a wavelength between 750 Nm and 1 Mm and they use 3 magnetic processes for data emission. Regarding the share of infrared in colors' spectra and using infrared cameras in different military, medical and agricultural fields, we can point to their importance in human life. According to the subject of this study, processing military images with the help of MATLAB software captured by infrared cameras, threshold determination of image for cutting a part of an image, changing image to black and white, noise deleting, image filtering for more sharpness and finally, border removal and showing the main and final image was done.

Then, a video was traced using an algorithm. As an example, we can use the following algorithms for tracing video images and therefore, infrared cameras effectiveness in recognizing objects and equipment is UVAs would be increased. (algorithm 1-4)



Algorithm 20. Tracing video image



Algorithm 21. Tracing video images

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