Journal of Computations & Modelling, vol.7, no.1, 2017, 141-169
ISSN: 1792-7625 (print), 1792-8850 (online)
Scienpress Ltd, 2017

The Correction of Gunnery Firing By Image Processing

Panagiotis Milis and Dionysios Kalogeras

Abstract

Field artillery weapons are normally employed in masked or defilade positions to conceal them from the enemy. Placing the firing platoon in defilade precludes direct fire on most targets. Consequently, indirect fire must be used when FA weapons fire on targets that are not visible from the weapons. Thus, the gunnery problem is an indirect fire problem. Solving the problem requires weapon and ammunition settings that, when applied to the weapon and ammunition, will cause the projectile to achieve the desired effects on the target. To achieve accurate first-round fire for effect (FFE) on a target, an artillery unit must compensate for nonstandard conditions as completely as time and the tactical situation permit. If the conditions for accurate predicted fire cannot be met completely, the firing unit maybe required using adjust-fire missions to engage targets. Adjust-fire missions can result in less effect on the target, increased ammunition expenditure, and greater possibility that hostile target acquisition assets will detect the firing unit. The results of each adjust-fire mission maybe collected by the friendly observers

Article Info: *Received* : October 29, 2015. *Revised* : January 18, 2016.
Published online : January 20, 2017.

and/or friendly target acquisition assets (such as uav's) used as the "eyes and ears" of all indirect fire systems. The aforementioned firing results are affected by the nonstandard conditions such as meteorological procedures and area's geomorphology.

In this paper we introduce an image processing method that uses thermal images taken after an adjustive-fire mission in order to assist the correction procedure. For this purpose, we propose the use of a term we called "fire-centroid" computed by a special image segmentation process.

Keywords: image processing; firing; thermal image processing; first fire for effect

1 Introduction

1.1 Research Objectives

The main researching objective of this work is summarised to the following statement: "how can we calculate the centroid of a thermal image taken from a fired target in order to assist the correction procedure".

1.2 Methodology

The methodology used in order to accomplish the aforementioned researching objectives is the following:

- Researching and presenting the theory of image processing focusing on to the image segmentations techniques and the theory of firing procedures.
- The following case study will be analyzed: a target area was fired. An aerial thermal image was taken a short after the shot. The image is processed and

segments in order to define the most thermal object and calculate its centroid.

2 Image Processing

2.1 Theory of image processing

Digital image processing is the use of computer algorithms to perform image processing on digital images [23][24][25][26][27][28][29]. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems [23][24][25].

Digital image processing allows the use of much more complex algorithms, and hence, can offer both more sophisticated performance at simple tasks, and the implementation of methods which would be impossible by analog means [23][24][25].

In particular, digital image processing is the only practical technology for [23][24][25] classification, feature extraction, pattern recognition, projection, multi-scale signal analysis, denoising, restoration, non-uniform illumination, deblurring , etc. More analysis in the image processing theory is not considered to be useful for readers.

2.1.1 Image segmentation

As far as it is concerned the term image segmentation, in computer vision, it is the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels) [1][2][3]. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze [1][2][3][7][9][11].

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation can be defined [19[[21] as the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

2.1.1.1 Image segmentation principles

The basic principles of the image segmentation techniques are the following [4][1][6][9]:

1. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection).
2. In this segments, each of the pixels are similar with respect to some characteristic or computed property, such as color, intensity, or texture.
3. Adjacent regions are significantly different with respect to the same characteristic(s).

2.1.1.2 Image segmentation techniques

The most known and used image segmentation techniques are based on the following concepts [5][7][9][1][11][12][20]:

1. Threshold methods, which make decisions based on local pixel information, are effective when the intensity levels of the objects fall squarely outside the range of levels in the background. Because spatial information is ignored, however, blurred region boundaries can create havoc.
2. Edge-based methods center around contour detection: their weakness in connecting together broken contour lines make them, too, prone to failure in the presence of blurring.

3. Region-based method usually proceeds as follows: the image is partitioned into connected regions by grouping neighboring pixels of similar intensity levels. Adjacent regions are then merged under some criterion involving perhaps homogeneity or sharpness of region boundaries.

2.1.1.4 The base of segmentation algorithms

Segmentation algorithms generally are based on one of 2 basic properties of intensity values [9][1][11][12]:

1. Discontinuity: used to partition an image based on sharp changes in intensity (such as edges). These methods detect the three basic types of gray-level discontinuities of points , lines and edges.

2. Similarity: used to partition an image into regions that are similar according to a set of predefined criteria.

2.1.1.5. Region Segmentation

A segmentation is a partition of an image I into a set of regions S satisfying [9][1][11][12]:

1. I UNION Si = S, meaning that partition covers the whole image.
2. Si cut Sj = f, i not equal to j, meaning that no regions intersect.
3. for every Si, P(Si) = true, meaning that homogeneity predicate is satisfied by each region.
4. P(Si cut Sj) = false, meaning that union of adjacent regions i not equal j, Si adjacent Sj does not satisfy it.

2.1.1.5.1 Main Methods of Region Segmentation

The main methods of region segmentation are the region growing, the clustering, the split and merge ones and the most new differential operators [9][1][11][12].

Region growing techniques start (see Picture 1) [3][5][20] with one pixel of a potential region and try to grow it by adding adjacent pixels till the pixels being compared are too disimilar. The first pixel selected can be just the first unlabeled pixel in the image or a set of seed pixels can be chosen from the image. Usually a statistical test is used to decide which pixels can be added to a region.

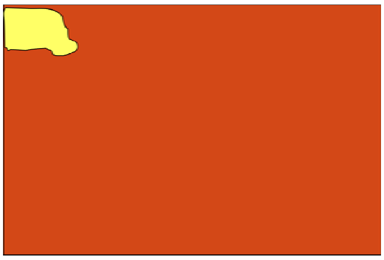

Figure 1: The region growing techniques concept

On the other hand, the clustering concept is based on the following [3][5][20]:

- There are K clusters C1,…, CK with means m1,…, mK.
- The K means clusterig is based on the least-squares error is defined as

$$D = \sum_{k=1}^{K} \sum_{xi \in Ck} || xi - mk ||^2 .$$

- Out of all possible partitions into clusters, choose the one that minimizes D.

The most new differential operators attempt to approximate the gradient at a pixel via masks and to push thresholding to the gradient in order to select the edge pixels one. Some examples are the sobel the Zero Crossing and the Haralick operator that will be analysed in the next paragraph.

2.1.1.2 The Haralick Operator

The Haralick operator, known and as Haralick and Shapiro [3][5][20], is the most known for image segmentation. It is based on the following algorithm:

1. Fit the gray-tone intensity surface to a piecewise cubic polynomial approximation.

2. Use the approximation to find zero crossings of the second directional derivative in the direction that maximizes the first directional derivative.

3. The derivatives here are calculated from direct mathematical expressions.

4. Considered a region to be a set of connected pixels with same mean and variance.

5. The mean and scatter of a region is defined.

6. When a new pixel is added into a region, the new mean and scatter are given.

Some statistical expansion of the aforementioned algorithm is also found [4][6][11]15][17]. This is used to determine if a test pixel is part of the same distribution of a region (should be added into the region) up to some confidence level. In this case an entity called T (from the test pixel) is defined. If T is too high, y (the test pixel) is likely not to be part of the same population of pixels in the region; on the other hand, if T is too high for y and all neighboring regions of y, then y starts as the first pixel in a new region. Besides being close to the mean of a region's distribution (the T test above), could also require that a neighboring pixel have a close enough value to y (which is the main criteria in single-linkage region growers).

In math terms the Haralick region-growing algorithm is given into the frame followed [3][5][20]:

1. T is considered for some fraction called alpha (e.g. 1/20). This alpha is the probability that a T with N-1 d.o.f. exceeds T_{N-1}(alpha), -T_{N-1}(alpha) for a given N-1 and alpha, is a defined quantity

2. if our computed T does exceed this T_{N-1}(alpha) then it is determined that the pixel is significantly different than the population of the region

3. if the pixel really did belong to the same population as the region, then the probability that the test we did was incorrect is alpha (e.g. 1/20)

Haralicks function is defined as [3][5][20]

*int main_haralick (int argc, char * argv[ ]),* where its parameters are provided by

1. input_image: Input image filename.
2. rho_zero: Threshold for the Haralick edge condition.
3. output: Output image filename.

2.2 Firing Principles

Said principles are based on the rules and definitions of science of ballistics, such as:

1. Internal ballistics:

The science which studies factors that affect the movement of the projectile inside the tube. The set of internal factors ballistics determines the speed with which the projectile leaves the inlet tube. This speed is called Initial Speed expressed in meters or feet per second. The initial speed, determined by the number of projectiles shot corrected due influence of external to internal ballistics factors provide the image of the return of that combination gun ammunition.

2. External ballistics:

The science studying factors (severity - atmosphere) which affect the movement of the projectile from the time it leaves the orifice of the tube. At this time the total impact of internal ballistics factors transmitted to the projectile in the form of initial velocity and rotation. The gravity acting on the projectile, causes it to return to the earth's surface. By the influence of atmospheric factors, the trace of the bullet is a composite curve.

Additionally because of the field, the position of the target and parameters related to specific conditions in each shot (eg atmospheric conditions), in shaping the realization framework of a shot, taken into account the following:

1. Odds and dispersion

If the number of projectiles of the same caliber and the same portion of ammunition fired from the same gun with the same firing data (slope and deflection), the projectiles will not fall in the same place but will disperse within an area. This phenomenon is called dispersion shot and layout of drop points on the ground is the trace of the shot dispersion.

2. Vertical shot:

The shot which is performed with elevation greater than the elevation at which the maximum range achieved for a particular filling called vertical shot. The execution of vertical shooting can often be required when the guns is committed to deep 'screen or in residential areas or when firing over high ridges. It may also be required vertical shot, when the target is in countersloping, dense forests and deep soil cavities or ravines, where it cannot be challenged with not vertical shot. Vertical shot has the following advantages:

a. In principle no problem appears immune to attack targets in deep valleys or behind a cover, as well as when firearms are in deep 'screen (eg in ravines, in cities, etc.).

b. It is achieved a higher drop angle in all range. This is particularly useful for the full exploitation of the explosive fragmentation projectile, when unsecured personal insult.

c. For a given load and range, the speed is always greater than that achieved with not vertical shot, which is advantageous when attacked targets in coverage.

3. Not vertical shot:

The track with great shooting angle and sharp curvature. The not vertical shot generally has the following advantages in relation to the vertical:

a. For a given range, the path length is shorter and therefore the shot ends faster.

b. The rectangular dispersion for a given range is less. Therefore facilitate the regulation and the shots of friendly proximal sections are safer.

The preparatory work, which take place from the staff of an artillery unit and is required to make successful shots on the target, are the following hierarchy:

1. Calibration

Calibration is invited to compare the ballistics power given gun with ballistics force another firearm used as a basis for comparison. With calibration enable grouping of firearms given caliber so that the guns have the same ballistics power and reduce the frequency of cases in which it is necessary to identify and implement specific corrections in firearms.

2. Identification of objectives

One of the main requirements for performing accurate shot is the precise goal which is to be challenged. The satisfaction of that requirement implies ammunition economy, speed and efficiency in the shot. Common Assay Methods Goals are the below:

a. With polar coordinates.
b. With rectangular coordinates.
c. With the number of target or a known point.
d. In correlation to known point

3. Observation

This activity is the main instrument through which the artillery units collect information about the enemy and the only means by which performs adjustment of fire. The observation of Artillery distinguished in sight observation, the observation by electronic means and indirect observation:

a. The sight of observation distinguished on terrestrial and aerial. The aerial observation ensured by aircraft and helicopters supplied by the Army Air Force.

b. The observation by electronic means about radar, sound labeling devices and unmanned air vehicle (UAV).

c. The indirect observation is achieved with the study and analysis of aerial photographs.

4. Election ammunition

When an object is determined by artillery unit, it should be fixed the way of shot in which is possible to be achieved the best results. The knowledge of available ammunition and their capabilities, will allow rapid selection of the most appropriate combination of projectile - fuze. The purpose of the mission, usually determine the desired effects on targets, which are destruction, neutralization or suppression.

5. Regulation firing

The observer performs Regulation when it cannot determine the target with sufficient accuracy, which justifies the infringement of a directly effective shot. The lack of precision in the determination of the target may be due to poor visibility, elusive ground, inaccurate maps or difficulty of the observer in determining the target. This firing is necessary to adapt the fire to the target, when the necessary conditions are not met for execution directly active shot.

6. Active shot

This shot is conducting phase of the shot, when sprayed on the target volume of fire required to achieve the desired tactical result. During the active shot, observers monitor the target, in order to ascertain whether achieved the desired result. Because it is the only one who sees his goal, can direct the shot and report the results of the Artillery Unit. This report should include the most accurate estimate of losses and damages, including any required corrections to the shot to make it as efficient as possible.

2.3.1 Targeting correction procedures

The observation is a prerequisite for the fulfillment of the mission of Artillery Battle. Used to search for targets, regulation of the shot, when required, surveillance of active fire and surveillance of the battlefield. The relevant elements of the objective mentioned in the Artillery Unit, which uses them to calculate firing data.

Because artillery is an indirect fire weapon system, the guns are usually in non line-of-sight of their target, often located kilometers away. The observer serves as the eyes of the guns, by sending target locations and corrections to the fall of shot. An artillery observer is responsible for directing artillery fire.

The observer sometimes has command authority and orders fire, including the type and amount of ammunition to be fired, or on the other hand the observer requests fire from an artillery headquarters, which decides if fire will be provided, by which batteries, and the type and amount of ammunition to be provided.

The observer sends a request for fire, usually to his battalion or battery Fire Direction Center (FDC). The FDC then decides how much fire to permit and may request additional fire from a higher artillery headquarters. FDC convert the observer's target information into firing data for the battery's weapons.

The purpose of a fire is to cover the target area with sufficient ammunition to achieve the best results in the target. When the observer has identified precisely the target requesting active shot, otherwise requested firing procedure (regulation firing). The regulation is the movement of disrupting a projectile or projectiles media group drop point is placed on or near the target. Then the observer requesting active shot just finished the regulation.

3 The problem and solution

3.1 The problem

As already presented in the introduction, the gunnery problem is an indirect fire problem. Solving the problem requires weapon and ammunition settings that, when applied to the weapon and ammunition, will cause the projectile to achieve the desired effects on the target. Adjust-fire missions can result in less effect on the target, increased ammunition expenditure, and greater possibility that hostile target acquisition assets will detect the firing unit. The results of each adjust-fire mission maybe collected by the friendly observers and/or friendly target acquisition assets (such as uav's) used as the "eyes and ears" of all indirect fire systems. The aforementioned firing results are affected by the nonstandard conditions such as meteorological procedures and area's geomorphology.

Even though the images taken from the target fired, it is considered to be very difficult to estimate the grade of success. The blast's power is expanding to target's area with a not normal distribution making also inaccurate the exact calculation of the losses made.

In order to overcome with this problem, this paper proposes an image processing method to find the most energetic spots of the target's area after a hit. In this case, a term called centroid is used to present the centers of the areas hit more. By the term centroid, blast's zone more destroyed-hit points are considered.

3.2 The method

As it has already been said, this work aims to find the blast's effects by calculating the centroid of the area hit. This idea is expected to override the problems connected to the observer's information about the firing results, as also the simplified targeting correction by using an aerial image. In the base of this idea, it is found risky to define a single centroid spot, since blast may be the result of multiple gunshots taken by the artillery unit. Consequently, to define its centroid to a multilevel entity, it expected to be more useful. This entity consists of the partial centroids of the most hot areas of the blast, where is expected to be distributed the greater part of the energy. The results will be presented by a sum of marks framing the multilevel blast's centroid.

The proposed method is the following:

1. It considered easy to have an aerial thermal image taken during blasting.
2. The image is processed digitally by the Haralick algorithm.
3. The data produced is used to define image's main segments.

4. From those segments the "hottest" one is selected.
5. The hottest segment is processed in order to find its own segments.
6. The centroids for its segments are calculated and presented.

This work studied thermal images digital processing used a known segmentation algorithm in action in order to find information about the firing results.

3.3 The solution

3.3.1 The algorithm

The algorithm used for this is the following:

STEP 1: CHOOSE IMAGE FILE

Choose the image file and save it as variable A.

STEP 2: FILE INITIALIZATION

1. Choose variable A.
2. Convert variable to a binary file (array).
3. Locate the mean value of the binary file, and normalize it. In image processing, normalization is a process that changes the range of pixel intensity values. Normalization is sometimes called contrast stretching or histogram stretching [29] [30].
4. Save the normalization result as file A1.
5. Apply Haralick algorithm to A1.

STEP 3: IMAGE SEGMENTATION

Objects segmentation

1. Based on the information retrieved by the step 2, locate the objects that have size at least 150 pixels. This value was selected by a practical point of view. If it is considered that an aerial thermal image concerning a blast area has size equal to 800x600 pixels, then it is more that possible that the blast area's size is greater than 150 pixels.

2. Divide these objects to team according to their values of sumentropy and sumVariance. The function variance (A) returns the variance of the elements of A along the first array dimension whose size does not equal 1. Here, A is a multidimensional array, then var(A) treats the values along the first array dimension whose size does not equal 1 as vectors. The size of this dimension becomes 1 while the sizes of all other dimensions remain the same. By default, the variance is normalized by the number of observations, to the value:1. The sumVariance returns the summary of the variance values [22].

3. Save results in memory.

Locate firing segment

1. Create a windows 10x10 pixel.
2. Start from the beginning of the image file and sort the objects according to their value of entropy E. The function entropy returns E [22], a scalar value representing the entropy of grayscale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as E=sum(p.*log2(p)), where p contains the histogram counts returned from mishits. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays. It can be a multidimensional image. If It has more than two dimensions, the entropy function treats it as a multidimensional grayscale image and not as an RGB image [22].

Locate the hottest objects of the firing object and find the centroid elements

1. Select the hottest object.
2. Divide it to its elements.
3. Find the centroids of its elements and present them.
4. The results are presented with a cross.

3.3.2 The Graphical User Interface

The above algorithm was programmed in Matlab environment. For user convenience an easy Graphical interface unit was implemented, as shown in the following image. The graphical user interface has two main columns. In the left column user can find the steps needed for taking the results. Following from top to down user can select:

1. To upload an image for processing.
2. To initialize the image.
3. To process the image and see the final results.

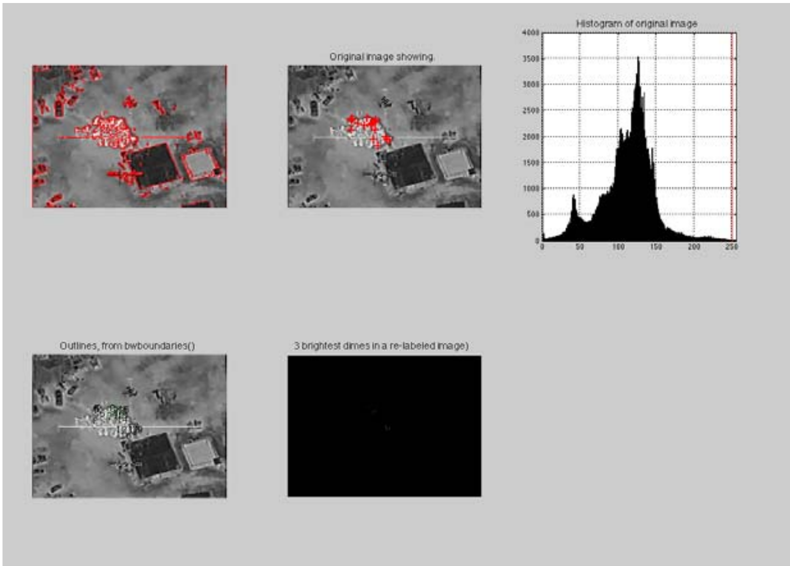

Figure 2: Present the results screenshot

The above figure is a subplotting presentation of the results. Readers can see the following informational images:

1. The image with the segmentation results (image at the top left)
2. The image with the centroid elements (image at the top center)
3. The histogram of the image that assisted the finding process of the centroid elements (image at the top right)
4. The image with its centroid elements numbered (image at the bottom left).
5. The most bright centroid elements. These are considered to be the spots hit most, since image processing finds them to be the most energetic (image at the bottom center).

3.4 Simulation

In order to simulate the application, 3 different images used. These images were selected from the google-images by searching with the keywords *aerial thermal images from artillery shot*s. The original ones are attached as Appendix A.

In order to eliminate the failure of the proposed method it is considered to useful to select different images. The images selected are according to the following criteria we posted:

1. Their shot angle is different.
2. Their intensity or grey scaling must be different
3. Their shot view. As reader can see in Appendix A, image #3 has slightly perspective, since the road line is not vertically to its view field and the smoke has volume.
4. The objects found in each image, as also the distance of the blast area from them.

The simulation's results are presented in the next paragraphs.

3.4.1 The segmentation results

For each one of the pictures processed the segmentation results are given to the next images.

3.4.1.1 Segmentation Results of Image #1

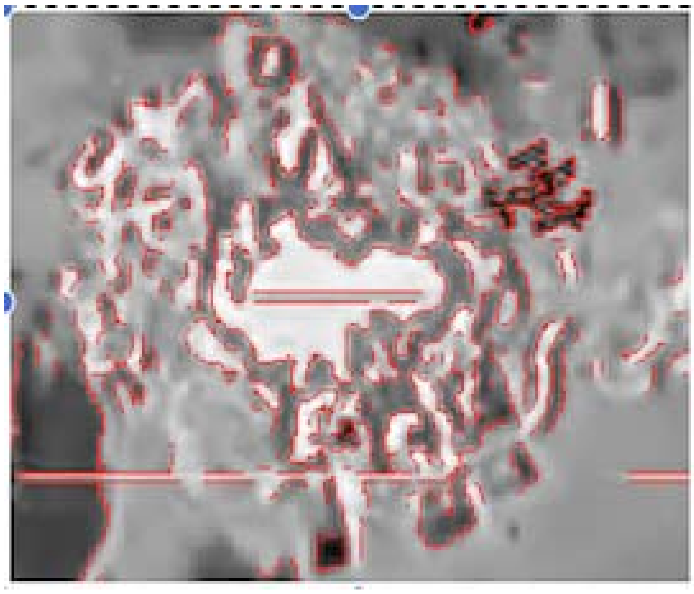

Figure 3: The segmentation results of image #1 zoomed in the area of blast.

This is the zoomed in segmentation results applied to the image#1. It can be seen the main blast area (the larger white one) as also its effects.

3.4.1.2 Segmentation Results of Image #2

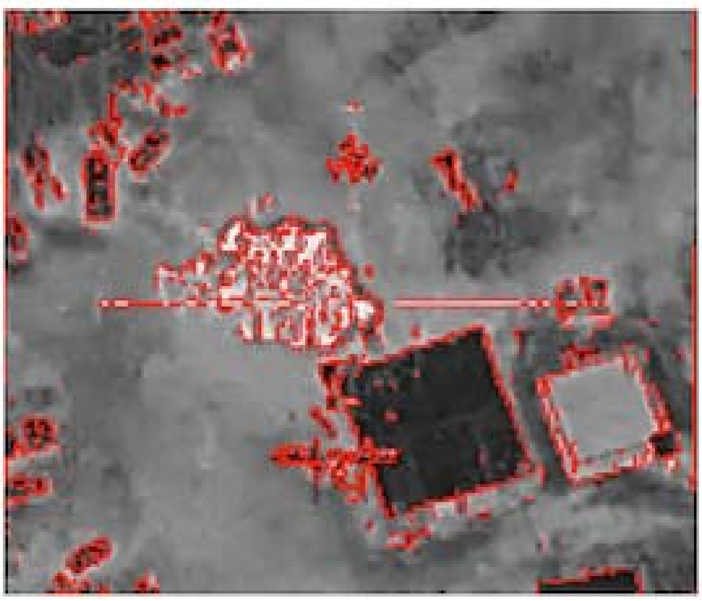

Figure 4: The segmentation results of image #2.

The method's algorithm succeeds to define the main objects of the image used. Reader can see the blasts elements (subobjects) the buildings, some vehicles in the upper left, trees left to the blast etc.

3.4.1.2 Segmentation Results of Image #=3

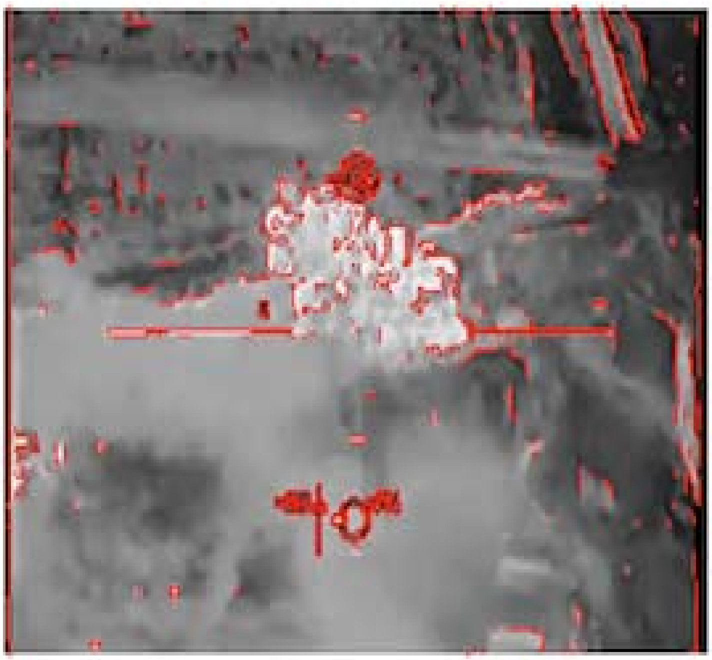

Figure 5: The segmentation results of image #3.

The method's algorithm succeeds to define the main objects of the image used. Reader can see the blasts elements (subobjects), some vehicles hidden in the bottom, trees left to the blast, and the roadlines.

3.4.2 The centroid elements

The results of the calculation of centroid elements are given to the following images.

3.4.2.1 The centroids of image #1

In this case the analysis provides some remarkable results:

The red crosses are the centroid elements calculated by the algorithm. The main blast volume's centroid is found defined by 3 elements that pointed out with the red arrows. This means that algorithm finds that the energy of the blast is concentrated rather to upper area of the blast, nor to its center where it was expected to be. This fact could be explained by the missiles velocity's vector related to the ground surface as shown in the draft figure 10. It is a rather simple kinematics' subject of interest. This fact is a definitely strong point making our results remarkable reliable and interesting. It is also noticeable some centroid elements pointed with the yellow arrows where are in the perimeter of the ideal center but shows great portion of energy.

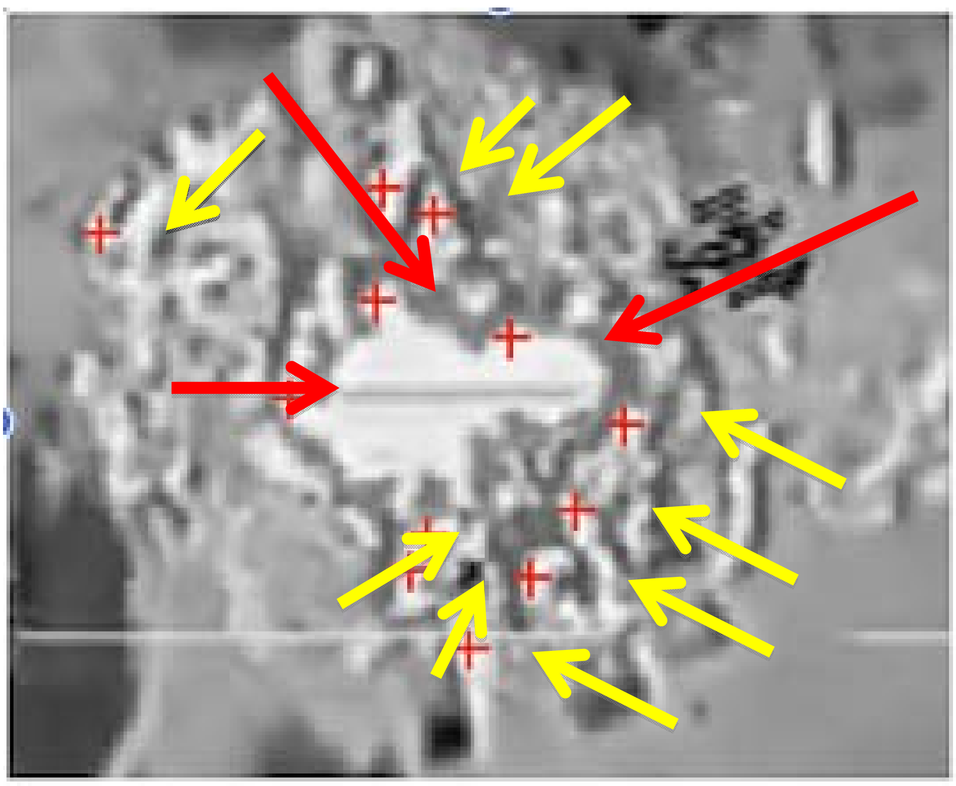

Figure 6: The centroid elements of the image #1

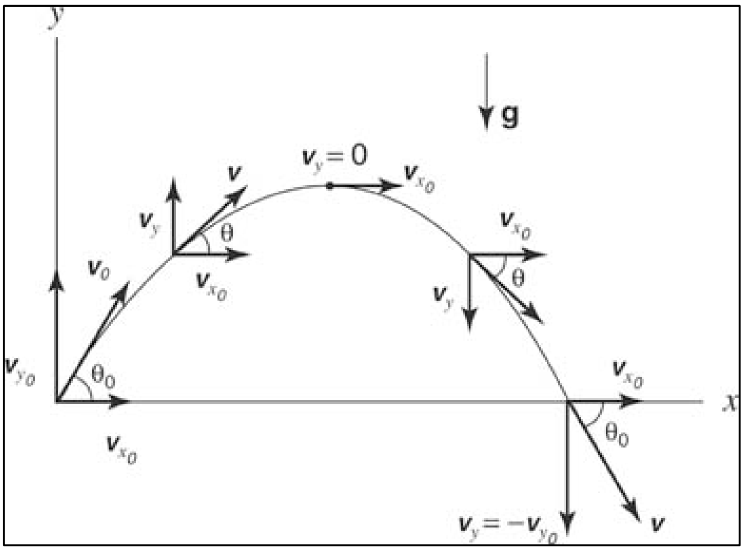

Figure 7: Kinematics velocity and its vectors
(source http://www.wikipedia.org)

In this case, in total 12 centroid elements which defining the blast centroid, there are 4 of them holding the greatest energy (over 90% of the average energy), as shown in Figure 13.

3.4.2.2 The centroids of image #2

Figure 8: The centroid elements of the image #2

The red crosses are the centroid elements calculated by the algorithm. As shown in this figure, our algorithm finds more elements to define blast's centroid. Similar conclusions are made with the image #1 , that are omitted in the spirit of economy.

In this case there are in total, 19 elements defining the blast centroid, as also as 7 of them hold the greatest energy (over 90% of the average energy) as shown in Figure 14.

3.4.2.3 The centroids of image #3

The red crosses are the centroid elements calculated by the algorithm. In this case it rather difficult to strongly claim if the elements are the requested of the centroid, or the angle of the image makes smoke's height to be calculated as ground effects. This will be definitely could be a future research by testing in the same time the results with real artillery tests.

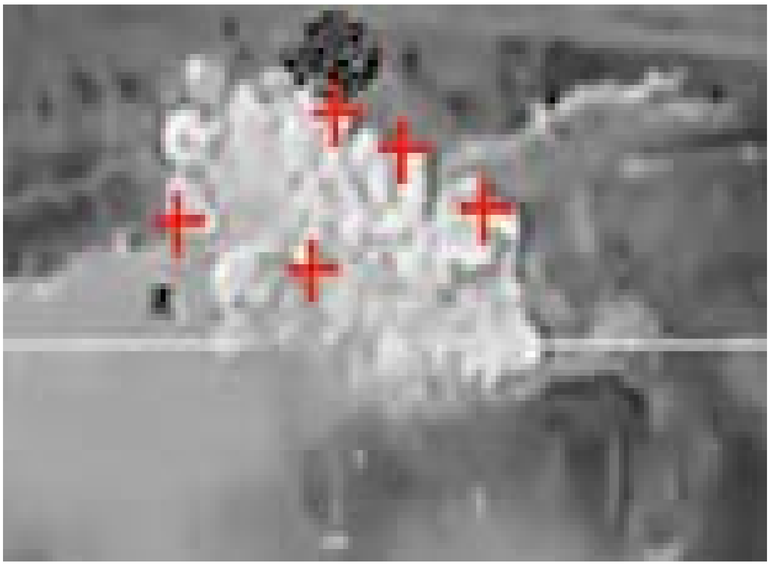

Figure 9: The centroid elements of the image #3, being zooomed in.

In this case there in total, 6 elements defining the blast centroid, as also as 1 of them holds the greatest energy (over 90% of the average energy) as shown in Figure 15.

4 Conclusions

Useful conclusions have come out during this work.

In theoritical point of view, the segmentation of the image as an image processing technique is a way to simplify the representation of an image into something that is more meaningful and easier to analyze. The image segmentation is typically used to locate objects and boundaries in images. The result of the segmentation of the image is a set of regions covering the whole entire image or a set of profiles that have resulted from processing of the image. Each of the pixels is similar in comparison to some characteristic such as color or intensity. Neighboring areas appear significantly different in this particular feature.

Traditionally, observation plays important role in shaping the firing data of a unit of artillery. Through this procedure, the success of fire on the target is controlled and relevant corrections in firearms are conducted. These corrections include adaptation fire on the target to the point of bursting shells are on or near the target.

In the other hand, this work proposed and developed a method and algorithm based on the digital image processing. In the proposed algorithm the results of the shots in accordance can be controlled through an aerial image processing method in order to find the most energetic spots of the target's area after a hit has happen.

This algorithm reduces the risk for misleading results by the definition of the partial centroids of the hottest areas of the blast where it is estimated that there is the greater part of the energy it will be probably more useful. The results presented by a sum of marks framing the multilevel blast's centroid.

By the simulation the following conclusion about algorithm performance must be marked:

a) The proposed method can define accurately the fire's area.
b) It can divide the above area to its segments. In the 3 examples used 12, 19 and 6 periphery centroid elements were found.

c) Some of the rest centroid elements were found in the perimeter of the ideal center that indicate great portion of energy.

d) It was found that the energy of the blast did not concentrated to its ideal center where it was expected to be. This fact could be explained by the missiles velocity's vector related to the ground surface and it is a definitely strong point making our results remarkable reliable and interesting. Moreover other facts can have contributed to this results that their study are not subject to this work.

e) Algorithm's results concerning angled images are under investigation.

4.1 Future Research

Given the results of this case study, it is possible to propose the following topics for future analysis and investigation:

1. The verification of these results by comparing them in real time with real shots adjustment artillery fire tests.
2. The detection of the effect of angle image (e.g. not vertical shooting) in the accurate identification of the spots in the image with the greatest energy.
3. Testing and other image segmentation algorithms for determining the account "hot spots".
4. The evaluation of this method in the modern battlefield as realistic and reliable observation and correction tool of artillery fires that meets the requirements of time constraints.
5. The techno-economic study for the supply of the necessary resources and ensure their availability to implement this kind of observation and correction Artillery fires.

Appendix A

Original Image #1

Original Image #2

Original Image #3

References

[1] Pham, Dzung L.; Xu, Chenyang ανδ Prince, Jerry L., Current Methods in Medical Image Segmentation, *Annual Review of Biomedical Engineering*, **2**, (2000), 315–337, doi :10.1146/annurev.bioeng.2.1.315, PMID 11701515.

[2] Hossein Mobahi, Shankar Rao, Allen Yang, Shankar Sastry and Yi Ma, Segmentation of Natural Images by Texture and Boundary Compression, *International Journal of Computer Vision* (IJCV), **95**(1), (2011), 86-98.

[3] Shankar Rao, Hossein Mobahi, Allen Yang, Shankar Sastry and Yi Ma, Natural Image Segmentation with Adaptive Texture and Boundary Encoding, *Proceedings of the Asian Conference on Computer Vision* (ACCV), H. Zha, R.-i. Taniguchi, and S. Maybank (Eds.), Part I, LNCS 5994, Springer, (2009), 135-146.

[4] Ohlander, Ron; Price, Keith; Reddy, D. Raj, Picture Segmentation Using a Recursive Region Splitting Method, *Computer Graphics and Image Processing*, **8**(3), (1978), 313–333, doi : 10.1016/0146-664X(78)90060-6, 2005.

[5] T. Lindeberg and M.-X. Li, Segmentation and classification of edges using minimum description length approximation and complementary junction cues, *Computer Vision and Image Understanding*, **67**(1), (1997), 88-98.

[6] Forcade, Nicolas; Le Guyader, Carole and Gout, Christian, Generalized fast marching method: applications to image segmentation, *Numerical Algorithms*, **48**(1-3), (July, 2008), 189-211.

[7] Jianbo Shi and Jitendra Malik, Normalized Cuts and Image Segmentation, IEEE *Transactions on pattern analysis and machine intelligence*, **22**(8), (2000), 888-905.

[8] Leo Grady, Random Walks for Image Segmentation, IEEE *Transactions on Pattern Analysis and Machine Intelligence*, **28**(11), (2006), 1768–1783.

[9] Z. Wu and R. Leahy, An optimal graph theoretic approach to data clustering: Theory and its application to image segmentation, IEEE *Transactions on Pattern Analysis and Machine Intelligence*, **15**(11), (1993), 1101–1113.

[10] L. Chen, HD Cheng and J. Zhang, Fuzzy subfiber and its application to seismic lithology classification, *Information Sciences: Applications*, **1**(2), (1994), 77-95.

[11] SL Horowitz and T. Pavlidis, Picture Segmentation by a Directed Split and Merge Procedure, *Proc.* ICPR, 1974, Denmark, 424-433.

[12] SL Horowitz and T. Pavlidis, Picture Segmentation by a Tree Traversal Algorithm, *Journal of the* ACM, **23**, (1976), 368-388.

[13] L. Chen, The lambda-connected segmentation and the optimal algorithm for split-and-merge segmentation, *Chinese J. Computers*, **14**, (1991), 321-331.

[14] S. Osher and N. Paragios, *Geometric Level Set Methods in Imaging Vision and Graphics*, Springer Verlag, ISBN 0387954880, 2003.

[15] James A. Sethian, Segmentation in Medical Imaging, Retrieved 15 January 2012. Leo Grady and Eric L. Schwartz, Isoperimetric Graph Partitioning for Image Segmentation, IEEE *Transactions on Pattern Analysis and Machine Intelligence*, **28**(3), (2006), 469–475.

[16] C.T. Zahn, Graph-theoretical methods for detecting and describing gestalt clusters, IEEE *Transactions on Computers*, **20**(1), (1971), 68–86.

[17] Witkin, AP, Scale-space filtering, *Proc. 8th Int. Joint Conf. Art. Intell.*, Karlsruhe, Germany, (1983), 1019–1022.

[18] Witkin, Scale-space filtering: A new approach to multi-scale description, in *Proc.* IEEE *Int. Conf. Acoust., Speech, Signal Processing* (ICASSP), San Diego, CA, **9**, (Mar., 1984), 150–153.

[19] Koenderink, Jan, The structure of images, Biological Cybernetics, **50**, (1984), 363–370.

[20] Lifshitz, L. and Pizer, S., A multiresolution hierarchical approach to image segmentation based on intensity extrema, IEEE *Transactions on Pattern Analysis and Machine Intelligence*, **12**(6), (1990), 529–540.

[21] Lindeberg, T., Detecting salient blob-like image structures and their scales with a scale-space primal sketch: A method for focus of attention, *International Journal of Computer Vision*, **11**(3), (December, 1993), 283-318.

[22] Solomon, C.J. and Breckon, T.P., *Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab*, Wiley-Blackwell, 2010.

[23] Wilhelm Burger and Mark J. Burge, *Digital Image Processing: An Algorithmic Approach Using Java*, Springer, 2007.

[24] R. Fisher, K Dawson-Howe, A. Fitzgibbon, C. Robertson, E. Trucco, *Dictionary of Computer Vision and Image Processing*, John Wiley, 2005.

[25] Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins, *Digital Image Processing using MATLAB*, Pearson Education, 2004.

[26] Tim Morris, *Computer Vision and Image Processing*, Palgrave Macmillan, 2004.

[27] Bernd Jähne, *Digital Image Processing*, Springer, 2002.

[28] Milan Sonka, Vaclav Hlavac and Roger Boyle, *Image Processing, Analysis, and Machine Vision*, PWS Publishing, 2002.

[29] Rafael C. González and Richard Eugene Woods, *Digital Image Processing*, Prentice Hall, p. 85, 2007.