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Detecting and Estimating the Levels of Crowd Density from UAV Imagery

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ABSTRACT

In recent years, unmanned aerial vehicles (UAVs) have increasingly been used in many civilian applications such as environment monitoring, aerial crop surveys, road monitoring, counting wildlife and fire detection. One of these applications is crowd monitoring and management especially in highly crowded areas such as sporting events and Hajj seasons. In this paper, color-based approach has been employed for detecting and estimating crowd density using UAV images. The Analysis of UAV images were performed under different cases of camera position and orientation including vertical, horizontal and close range camera. The results show that the method was able to detect the crowd among other image objects (e.g., buildings, vegetation and streets). In addition, the results were improved under vertical camera case comparing with those under close range or horizontal cases. This is due to the fact that the camera was focused on the crowd area more than other surrounding environment. Furthermore, the method performed well in Hajj images comparing with other images cases. This is because the number of feature classes was limited (mostly black and white). In order to improve the results, the associated anomalies/outliers have been eliminated from the segmented image through using image enhancement tools.

Keywords: UAV Imagery, Color-Based, Object-Based Image Analysis, Crowd Monitoring.

1. Introduction

In recent years unmanned aerial vehicles (UAVs) have extensively been used in various civilian applications such as environment monitoring, aerial crop surveys, road monitoring, counting wildlife and fire detection. One of these applications is monitoring/managing crowd in highly crowded events (e.g., Makkah during Hajj seasons and sport events). This is because UAVs fly autonomously over areas under consideration and provide high resolution and real-time images. They can also provide geo-referenced images when they are equipped with positioning sensors (GPS/IMU) and vision sensors (digital cameras and laser scanner). Moreover, UAVs bridge the gap between the ground-based surveying and satellites images due to their capability to acquiring fast, low costs and real-time images (Lambers *et al.*, 2007; Patterson and Brescia, 2008; Nagai *et al.*, 2009). Thus they are effective in capturing images anywhere and anytime.

In order to have an effective crowd monitoring system, UAVs need to be equipped with GPS/IMU/Cameras (color or infrared) for capturing pictures and positioning data of overcrowding areas. This allows mapping the distribution of the crowd areas as well as estimating the density of the crowd. Once UAV sensory data are collected, they can be transmitted to the ground control station (GCS) through UAV communication infrastructure. These data can be processed and converted into meaningful information such as crowd density and the position of individuals. Then an alert is sent to the second responder (staff) of urgent situation. The second responder can accesses the information from any place and takes action within a short time (Witayangkurn et al, 2011).

Over 1970s, image analysis has been based on image processing tools which basically classify image objects based on the value of every pixel (Blaschke et al, 2014). This is particularly used for low resolution images. High resolution

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images (e.g., UAVs images) on the other hand, has been analyzed through a new procedures introduced by Blaschke and Strobl (2001). This method is known as object based image analysis (OBIA). The principle of this method depends on segmentation image objects based on a group of homogeneous regions. These regions consist of a bunch of pixels that have similar feature. Then the segments are further processed to classify image objects. Each image object is given a unique name to distinguish it from others (Burnett and Blaschke. 2003; Hay and Castilla. 2006; Blaschke et al, 2014).

In literature, crowd monitoring using UAVs images and video recordings has been well documented. Most of the research papers have been focused on designing a comprehensive system that makes crowd monitoring easier and faster. Thus, a platform which is fast, flexible, easy and autonomous has been used to achieve such task. This platform (UAVs) was deployed with sensors such as GPS, inertial sensors and vision sensors (Digital cameras, infrared cameras and laser scanner) to tracking motion objects and estimating crowd density. An instance of this is a study carried out by Talukder et al (2004). In this study optic flow and dense stereo were combined to estimate object background motion at every pixel. This is to increase the probability of detecting small objects or those with low texture where feature selection schemes might fail. Similarly; Rodriguez-Canosa et al (2012) Employed UAV to detect and track moving objects. The study used artificial and real optic flow in order to detect the motion objects.

Marana et al (1998) used texture analysis for estimating crowd density. The study has shown that high crowd density was effectively estimated. However, the accuracy was degraded in case of low crowd density. Similar procedures were conducted by Jiang et al (2014) to classify the density into crowd regions and extremely crowded regions. In this approach, a combination of pixel statistical method and texture analysis was performed. Then the number of people is calculated according to the corresponding fitting straight line which is based on linear regression method. The study however, has not provided sufficient results to prove the effectiveness of the proposed method.

Wang et al (2013) proposed a new approach for crowd density estimation through using a new texture feature called Tamura. In this approach crowd feature is extracted based on grey level co-occurrence matrix (GLCM). Then Principal Component Analysis (PCA) was employed to reduce the dimension of the feature vector before using support vector machine (SVM) for crowd density estimation. However, the approach was only implemented for close range images that include low crowd density.

Some studies (e.g., Hinz, 2009; Sirmacek and Reinartz, 2011; Perko et al, 2013) focused on estimating crowd density per square meter. Hinz (2009) detected background and foreground and estimated crowd density using Gaussian smoothing kernel with a fixed standard deviation / bandwidth. While Sirmacek and Reinartz (2011) employed Features from Accelerated Segment Test (*FAST*) feature detector technique and proposed an automated detection technique to detect blob-like and corner-like image structures. Perko et al (2013) presented a framework based on airborne video recordings for estimating crowd density and object motion. The volume of the crowd has also taken a considerable attention in other studies. A new framework has been proposed by Attya et al (2012) to estimate the volume of the crowd. This framework is based on building a 3D model for image geo-referencing. Helbing et al (2007) analyzed the reasons of the crowd disaster during Hajj (January 12, 2006; 1426H) through using video recordings.

In some places, crowd monitoring is necessary in order to provide safety and peaceful movements to minimize the risk in some incidents. This will enhance decision maker using accurate information to guide people in the field. This paper provides an approach for detecting and estimating crowd density through using UAV images. These images were taken from UAV sensors (Digital cameras) under different cases of camera position and orientation. This includes the altitude of UAV and the horizontal and vertical camera with different angles. By estimating the density of the crowd, accurate information and solution can be provided to the ground control station which in turn leads the crowd to alternative routes and ensure peaceful movements. The structure of the paper is as follows: UAV image analysis procedures including segmentation and classification is presented in the second section, the following section presents methodology of crowd density estimation. Then the experiments design and the results analysis is provided followed by the conclusion remarks in the last section.

2. UAVs Image Analysis

Numerous methods have been developed to analyze images taken from moving platforms. The diversity of the methods is due to the fact that the images are taken from different platforms (e.g., MAVs, UAVs and Satellites) and also different types of cameras which range from digital cameras, multi channel or several layers of data from a lot of spectral channels. Thus, image analysis technique is based on the application in hand as well as the type of the images (high or low resolution). Generally, any image analysis process includes two main steps: segmentation and classifications.

2.1 Image segmentation

Image segmentation is to change/ divide the image into meaningful segments (objects) which are homogeneous in their color, shape and texture. In other words, Image segmentation includes classifies a bunch of pixels into objects which may not correspond to the real world objects. However, these objects are further analyzed through another step called image classifications (Marpu, 2009). Until today, all image segmentation algorithms have been developed to achieve a specific task. Generally speaking, most of these algorithms follow either pixel based or object based image segmentation. This could be attributed to the different type of platforms and sensors that provide remotely sensed data. Furthermore, several image segmentation methods have been evolved from computer vision point of view. These methods primarily based only on tone or color which is represented as a digital number such as the brightness value in each pixel of the digital image (Blaschke et al, 2014). In the last decade, pixel based image analysis has been diminished by a new method known as Object-Based-Image-Analysis (OBIA) (Hay and Castilla. 2006; Burnett and Blaschke 2003; Blaschke and Strobl (2001); Blaschke, 2010). This technique based on analyzing a group of pixels and get information about an object instead of single pixel information. More specifically, image objects are a group of pixels that are similar to one another based on a measure of spectral properties such as color, size, shape, and texture, as well as context from neighborhood pixels.

2.2 Image Classification

Classification step is to assign a unique name for each image segment. This can be achieved through employing one of the classification methods such as artificial neural networks, fuzzy logic/fuzzy-sets, and expert systems. These classification techniques are based on per pixel classifications. On the other hand, OBIA also called Per-field classification approach (Weng, 2009) has been used recently for high-resolution images. In this approach a unique name is assigned for each segment (object). Unlike Low resolution images classification technique which based on pixel by pixel, OBIA classification suits high resolution images particularly UAV imagery (Blaschke et al, 2004). This is due to the fact that an accurate, faster and easier interpretation can be performed by OBIA classification comparing with those achieved by single pixel classification. Therefore, OBIA classification meets the development of remote sensing technology in sensors and platforms (Blaschke et al, 2014).

2.3 Detecting crowd from UAV imagery

Similar to any object (e.g., vegetation, buildings and streets) in digital images, crowd has been considered as an object that needs to be detected and estimated. Therefore, digital image is analyzed through segmentation and classifications of image objects. As the scope herein is to deal with crowd, other objects are normally neglected. As mentioned in the previous section, various methods have been used for image analysis. For crowd density estimation using UAV images, images need to be processed and segmented. This is to distinguish crowd object among other image objects. Then further image processing tools including statistics are required to extract the density and the coordinate of the crowd. This allows mapping the levels of crowd density.

3. Methods

In order to detect and estimate crowd density, UAVs images need to be analyzed. In any image processing method, image segmentation and classification are two consecutive steps that normally performed based on image properties (e.g., color, shape and size). In this paper, color-based segmentation method is used for image segmentation and hence detecting crowd in the image. Figure 1 shows UAVs image analysis procedures used in this paper.

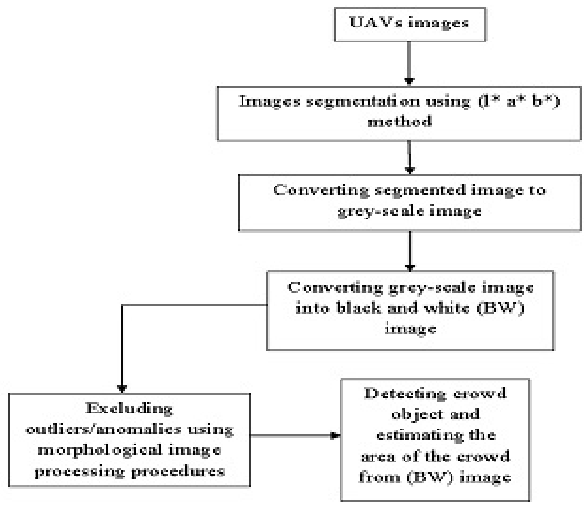

Figure 1 flow chart of crowd detection and estimation procedures

3.1 Color-based segmentation

In this paper, L*a*b* color-based segmentation method has been used in order to delineate UAV image objects. In this approach, RGB images are converted into L*a*b* color space. This means a color is assigned for each image feature classes to distinguish between classes in the image and hence between objects. Therefore, the content of the image is classified into readable features. Basically, this method consists of three main color channels L*a*b*. Where L* indicates the luminosity and a*b* indicate the chromaticity. Thus image classes belongs to either 'a*' (red-green axis) space or 'b*' (blue-yellow axis) space (Rathore et al, 2012).

Classification of the content of an image into 'a*' and 'b*’ space requires a reference which is based on a sample color classes/regions. Each color class/region is generalized through calculating the average of each sample’s region in 'a* and ’b*' space. Then each image pixel is classified using nearest neighbor rule. This is to identify each color marker in either 'a*' and a 'b*' value. Note that the smallest distance tells that the pixel most closely matches that color marker. For further information about L*a*b* method, interested readers are directed to Bora et al (2015).

3.2 Detecting and estimating crowd density

After segmentation, the image is divided into regions which are defined based on color classes. The density of crowd is calculated through converting the segmented image into a black and white image (binary image). Thus crowd object appears as white regions while other objects remain in black regions. In binary image, the properties such as (area) can be calculated through further image processing. Thus, white regions/areas which show the crowd object are measured. Once the area of the crowd is measured, crowd density per meter square can be calculated by taking the ratio between the white and black regions. Based on this method, the number of people in the scene is ambiguous while crowd density is simply classified into low, moderate and high.

Then the levels of crowd density need to be shown in a thematic map. This needs to find the object coordinate/positioning. Note that each region is considered as an object and then it is geo-referenced directly and indirectly. For direct geo-referencing, integration of GPS and IMU is required without need of ground control points

(GCPs). For indirect geo-referencing, a triangulation can be performed through matching the image coordinate (xyz) with object coordinate (XYZ) in real world. Once the object coordinate is known, the levels of crowd density are spatially shown. In this paper however; due to the lack of UAV sensory data and ground-based measurements (GCPs), only image segmentation and classification have been performed.

3.3 Outliers/anomalies detection

In any image segmentation procedures, anomalies/outliers may contaminate the results of segmented images. In this method used herein, classification might be influenced due to the similarity of colors between features classes. As an example of the anomalies that might contaminate the classification of crowd object is the shadow in the image. This can be reduced through taking into account the differences between the brightness values of pixels. In other words, shadow takes a unique color class. Another anomalies type occurs when a number of different features classes are classified in one feature class due the color similarity between those features. In order to deal with this problem, other parameters such as size, shape and the position (morphological procedures) are used to distinguish between features classes. In this case, classifications of crowd is conditioned based on assigning constrain for each object classification. An instance of this is the position of the crowd in the image which is normally in flat areas (e.g., streets), thus surrounding environments such as buildings, trees and vehicles are eliminated from image segmentation process.

3.4 Dataset

The soup of this paper is to process and analyse UAV images for detecting and estimating crowd density among other image objects (e.g., built up areas, streets and vegetative environment). In order to achieve the goal of this paper, several dataset (UAV images) were used. The sources of these dataset were as follows:

- UAV Dataset/images that show the crowd: these data was downloaded from online videos. This is to process and analyze the images for detecting and estimating crowd density. A video was paused at specific time to generate vertical and horizontal images with different camera angels (45° and 90°). The size of the vertical and horizontal images is 768×1366×3 unit8.
- Close range image was downloaded from Google/images. The size of this image is 497×1283×3 unit8.
- Dataset from Hajj: an image was downloaded from Google/images. The size of this image is 621×982×3 unit8. this image was processed to show the effectiveness of the method for estimating the crowd density under different situations.

4. Results Analysis

In this section, three examples for crowd monitoring were presented. Each example is representing a camera case in terms of vertical images (camera facing the ground), horizontal images from long distance and close range case. In each case, the images have been analyzed through segmentation and classification of crowd object among other image objects such as buildings, streets and vegetation.

4.1Vertical camera (camera face down) case

In this example, UAV images were taken from vertical camera as can be seen from figure 2. One can note that the original image was segmented and converted into gray-scale and then to black and white image. The purpose of this step is to eliminate all image objects excepts the crowd object and then estimate crowd density. It is obvious that the crowd appears as a strip following the direction of the street. This can clearly been seen in figure 3 which illustrates the overlay image on the origonal image. The overlay image detect the crowd and show it in green color. This is to domenstrate the capability of L*a*b* color-based segmentation method for accuratly detecting and estimating crowd object among other image objects.

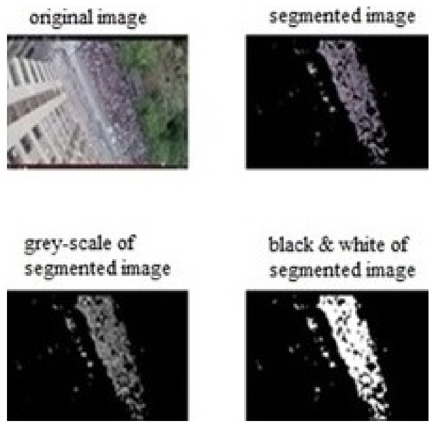

Figure 2. Original image, segmented image, grey-scale image and B &W image of the crowd

As can be seen in figure 3, the overlay of the segmented image on the original image show the capablility of the method for identifying individuals along with anomalies/outliers. The green color illustrates the people in the image with some anomalies. These anomalies appear due to the similarity between the color selected for the crowd and the color of other image objects. However, one can note that the anomalies are rarely occur in surrounding objects. This means that the segmentation method used herein proviede an acceptable range of crowd detection.

For mapping purposes, the distribution of the crowd after eliminating the anomalies is shown in figure 4. It is clear that the crowd was formed in one connected object with some holes. These holes could be either misdetected people or real gaps between people. Due to the lack of ground control points and positioning sensors (GPS and INS), this image could not be georeferenced to the real world coordinate systems XYZ and hence the crowd density could not be shown in real map.

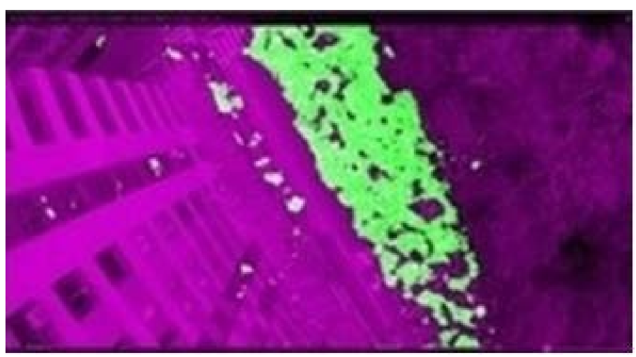

Figure 3. Image overlay that show people/crowd in original image with green color.

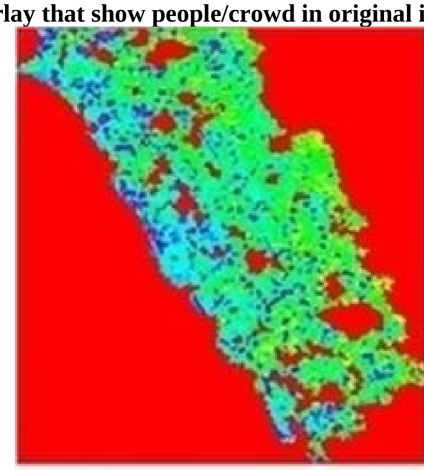

Figure 4. Overall distribution of the crowd in the image

Other image objects appear in the image were also segmented. These objects are built up areas, vegetation and streets. The purpose of analyzing these objects is to show the capability of segmented method for truly segmentation and classification the whole image features. As can be seen in figure 5 which shows the original image and the segmented, grey-sacle and the binary images of the built up areas, the method can segment and classify the built up areas (buldings) and eliminate other surronding objects. One can note that, the method falsely classified other features as built up areas due to the color similarity. This situation is clearly domenstarted in figure 6. As can be seen, some features in flat areas such as street were wrongly classified as buildings objects. As mentioned above, these are nomalies that need further image processing for elimenation.

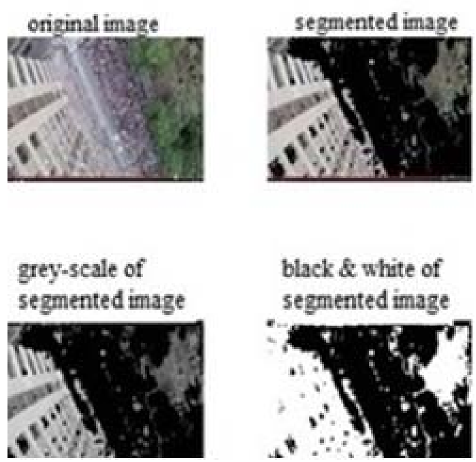

Figure 5. Original image, segmented image, grey-scale image and B&W image of buildings

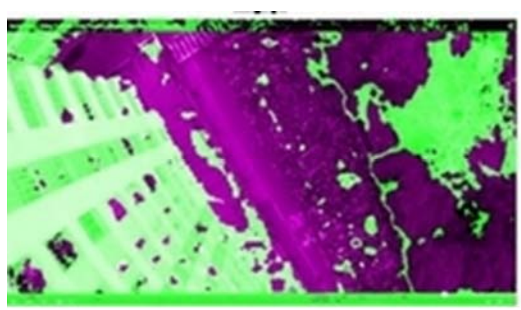

Figure 6. Original image and image overlay that show buildings in green color.

For vegetation object analysis, it is clear that the method was succesfuly detected and classified the trees in the image as vegetative environment. As can be seen in figures 7 and 8, anomalies were rarely occur in this segmentation case. This could be attributed to the green color which is rearly appear in other feature classes. For streets classification however, one can notice that the classification of streets were contaminated by some outliers. This situation is clearly seen in figure 9 and 10.

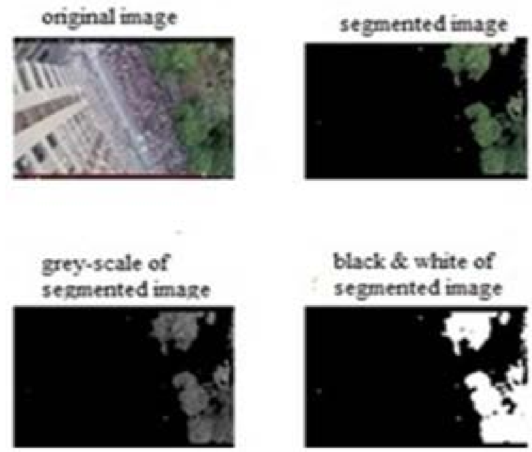

Figure 7. Original image, segmented image, grey-scale image and B&W image of vegetation

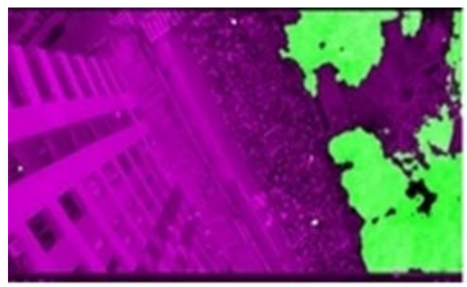

Figure 8. Original image and image overlay that show vegetation in green color

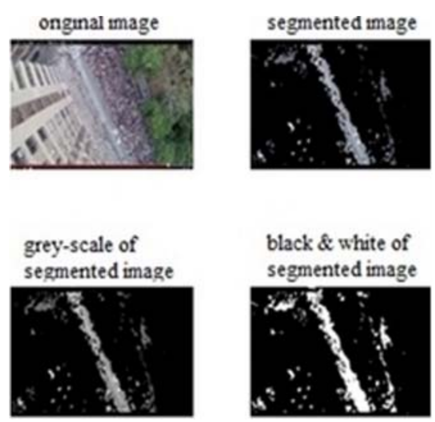

Figure 9. Original image, segmented image, grey-scale image and B&W image of streets

Figure 10. Original image and image overlay that show streets in green color

The size of each image object has been illustrated in table 1. It is obvious that the built up area has taken a huge part of the image. The number of pixels is approximatly 165744 with percentage of around 50 %. While the crowd involved in 128630 pixels (12.5 %). Other image objects such as street and vegetation were taken approximately 10 % and 16% from the total image pixels.

Table 1. the size of each image object

	Streets	Vegetation	Buildings	Crowd	mixed
Area/pixels	103133	165744	505207	128630	118630
Percentage	10.09	16.21	49.43	12.58	11.69

For visulization purposes, the bar in figure 11 represnts the perecentage of each image object comparing with the crowd object. Note that mixed objects involoved around 10% of the total image pixels.

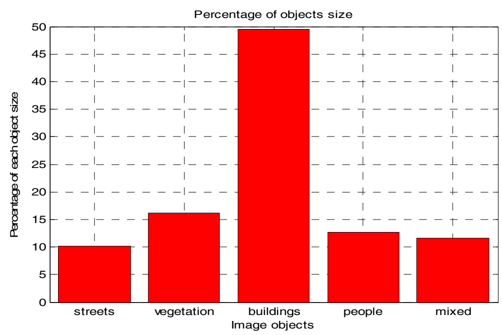

Figure 11. The percentage of image objects sizes under vertical camera

4.2 Horizontal camera case

The orientation of the camera in this example has been changed to horizontal. This means that the area of the crowd is larger than thoes in the previous section. Thus, different cases of camera may influence the detection and estimation the crowd among other image objects.

Crowd analysis presented in figure 12 shows clearly the distribution of people along with the street. As can be seen in figure 13, the segmented image filtered all other image objects out and remains the features that belong to the crowd. As normal situation, similar color of the crowd features may occur in the surrounding environment. This contaminate the results and lead to misleading information. In this example, one can notice that the segmentation method has falsely identified other features as crowd features. Once again, this is due to color similarity between feature classes. In this case, several procedures for anomalies elimination must be considered. One of these procudres is using position constrains.This would remove the surrounding environments (e.g., buildings, trees) from the crowd area. When removing the features which are falsely belong to the crowd, actual crowd density can be achieved. This situation is clear in figure 13 which illustrates overall distribution of the crowd when removing the surrounding environment.

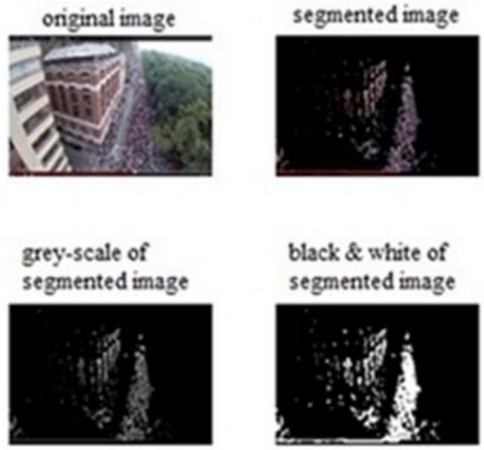

Figure 12. Original image, segmented image, grey-scale image and B&W image for crowd detection

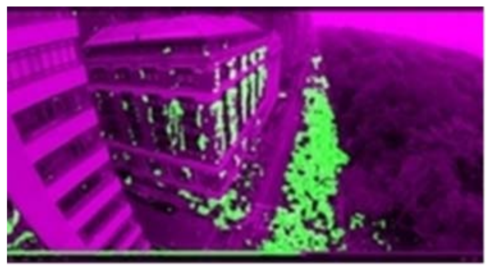

Figure 13. Original image and image overlay that show crowd in green color

The size of each image objects has been depicted in table 2. As can be seen, the size of the crowd object is only 10 % comparing with other feature classes. While buildings and vegetation take approixmately 38% and 25% respectively. This also can been in figure 15.

Figure.14 Overall distribution of the crowd in the image

Table 2. the size of each image object

	Streets	Vegetation	Buildings	Crowd	mixed
Area/pixels	158710	255577	387635	100909	127720
Percentage	15.43	24.84	37.68	9.81	12.24

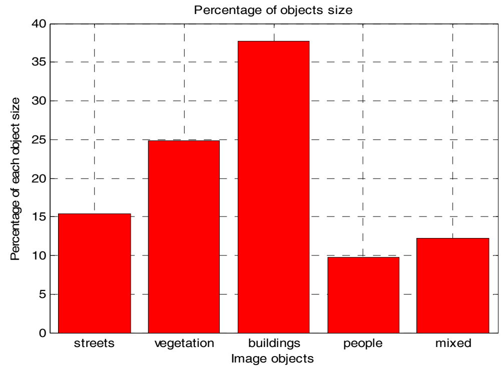

Figure 15. The percentage of image objects sizes under horizontal camera

4.3 Close range case

This example demonstrates similar results which were presented in the previous sections. The only difference is the distance which is relatively short between the camera and the crowd. As can be seen in figures 16 and 17, the crowd was distinguished from other feature classes. the overall ditribution of the crowd is presented in figure 18. It can be noted that the total area of the crowd is less than thoes presented in figure 17. This is due to two reasons. Firstly: the surrounding environment were removed from the scene and hence all the features which were falsey identified as people were neglected. Secondly: some crowd features were misdetected which means that the segmentation method was not able to detect them as crowd object.

It can be seen from table 3 and figure 17 that the area of crowd takes around 40% from the total image pixels. However, some features (e.g., red flags surronding the crowd) were identified as people. Following the same positioning constrains procedures, these features can easily be removed.

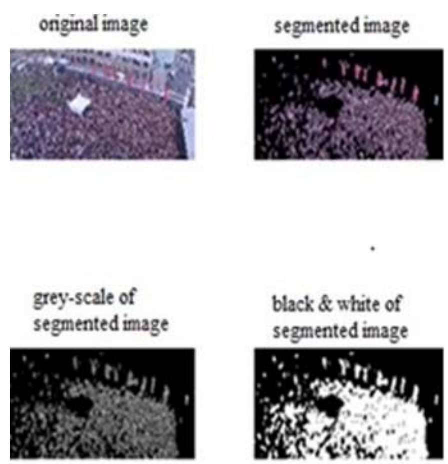

Figure 16. Original image, segmented image, grey-scale image and B&W image for crowd detection

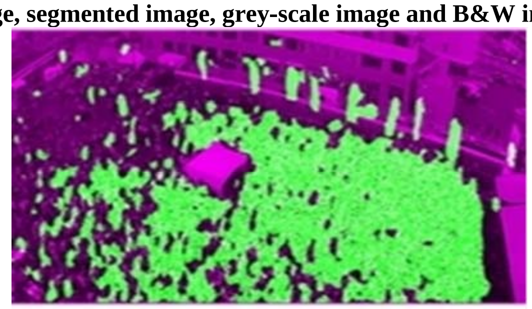

Figure 17. Original image and image overlay that show crowd in green color

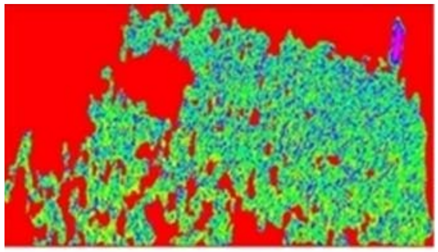

Figure.18 Overall distribution of the crowd in the image

Table 3. the size of each image object

	Streets	Vegetation	Buildings	Crowd	mixed
Area/pixels	76258	38791	163523	246596	103122
Percentage	11.91	6.06	25.54	38.52	17.7

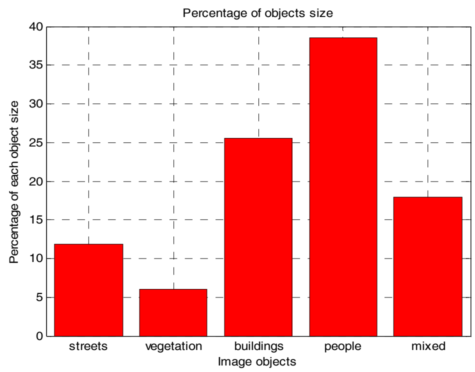

Figure 19 The percentage of image objects sizes Close range camera

4.4 Crowd monitoring in Hajj season

Crowd monitoring in Hajj seasons is very essential operation to avoid overcrowding proplems. Every year, many souls are taken due to the highly crowded area (Makkah/Mena) and lack of management and action. This could be attributed to the misleading information, lack of sensors and platforms that survey and manage the area. This serious problem needs an effective system for sensing, alerting and action (SAA). In SAA system, three nodes need to be cooprated in order to provide safety moving of the crowd. In sensing, dataset such as the images and poistioning of the crowd can be transmitted to the ground control station. This can be performed through using UAV sensores such as GPS/IMU/Camera and wireless devices. The ground control station can process the data and converting them into information. Processing including estimating and mapping crowd density per metre square and then alerting the second responder (staff) for action. The second responder can take an action based on the information received. This aids the staff to experience crowding conditions at first hand. It also enables them to observe people's faces, identify signs of distress and sense atmospheres or tension. Staff may discourage dangerous behaviour by their presence in the crowd.

The information also enable staff finding an alternative routes to reduce the number of people in a specific area, providing real time maps for pilgrims to avoid overcrowding proplem. Furthermore, estimating the flow of the crowd in terms of time and directions.

In order to assess the risk of overcrowding in Hajj area/seasons, image from close range camera was analyzed in this paper. As can be seen in figuer 20 the the segmentation method is obviously distinguishes the crowd with relatively higher accuracy comparing with thoes presented in the previous sections. This is due to the fact that the number of image objects are limited. Consequently, the main colors are white, black. This made segmentation method to be more accurate in detecting and estimating crowd density. This is clearly appears in figure 21 which shows an overlay image. One can also noticed that the number of anomalies is less than thoes occur in the previous sections.

Thus, using positioning constrain procedures will easily remove the anomalies in the segmented image.

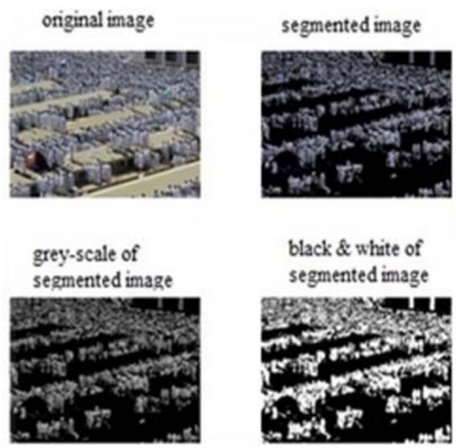

Figure 20. Original image, segmented image, grey-scale image and B&W image for crowd monitoring using close range camera

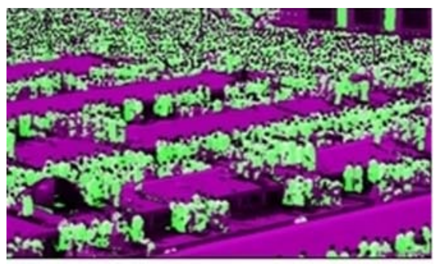

Figure 21. image Overlay (green color) on the original image

4.5 Quality assessment

As mentioned above, UAV images were analyzed based on color-based segmentation and classification method. As can be seen in the previous sections, the performance of color-based segmentation method is acceptable in delineating UAV image objects including crowd object. In some cases however, the method was unable to distinguish between feature classes due to the color similarity. The performance of color-based method for detecting and estimating crowd object among other image objects can be evaluated through two main ways. These are:

- **Misdetection**. This occurs when the method could not detect and idntify some people in the image. This is due to the fact that the color of undetected people is far away from the average color of the crowd. When misdetection rate is high, estimation of crowd density becomes unrealistic.
- **False detection**: this situation appears when the method wrongly classifies some features classes as people when they are actually belong to other feature classes. This would produce high crowd density when it is actually low.

As mentioned earlier in this paper, anomalies elemination is required. This can be achived through using some constrains such as positioning of the individuals in the image. In addition, other axuilry image processing parameters such morphological parameters can be used to enahnce segmentation process.

It is necessay to mention that estimation of crowd density does not require to count each person in the image. It deals with a group of people in a specific area. As normal situation, people are spread in flat areas (e.g., streets, pedestrains path), thus other surrounding environment such as vegeation and building areas need to be excluded. Therefore, the real crowd density is a ratio between the size of the flat area and the area which includes the crowd object.

5. Conclusions

Detecting and estimating crowd density using UAV images has been investigated in this paper. These images have been taken under different cases of camera position and orientation including vertical, horizontal, and close range cameras. L*a*b* color based segmentation method was employed to segment and classify UAV images. This method basically depends on per pixel analysis. In order to estimate the density of crowd, the segmented image was converted into black and white image.

The results show that color based segmentation method performed well in all camera cases. It has been found that, the results were improved when removing the surrounding environment through using positioning constraints. This is because of removing the anomalis/ distortion in segmented image. These anomalies/ distortion was originate from either false detection or misdetection of crowd features. When using some morphological parametrers such shape, context and size in image processing, more accurate results can be achived. In addition, It has been shown that when the image includes a few feature classes, more accurate results can be achived. This is due to the fact that less color similarity between feature classes. this situation was clearly shown in images from Hjj areas. In these images, the colors are mostly white, black. Thus distinguishing crowd object in this image type is relatively easier comparing with other image situation.

A realistic estimation of crowd density can be achived when removing all surrounding enivrnment and remain the flat areas which includes crowd. In future research more UAV image analysis procedures for crowd density estimation are required in order to find the bset way for high resolution segmentation and classification.

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استخلاص وتقدير مستويات كثافة الحشود باستخدام الصور الملتقطة بواسطة الطائرة بدون طيار

*علي المقبل**

ملخص

في الآونة الأخيرة استخدمت الطائرة بدون طيار بشكل مضطرد في المجالات المدنية من مثل: السيطرة على البيئة والمسح الجوي للمحاصيل الزراعية والسيطرة على الطرق والحرائق بالإضافة إلى تعداد الحياة البرية. وتعد السيطرة وإدارة المناطق المكتظة خاصة في الأماكن التي تكتظ بالتجمعات البشرية مثل الإحداث الرياضية وفترات الحج احد هذه التطبيقات. تناولت هذه الدراسة استخلاص وتقدير لمستويات كثافة التجمعات البشرية حيث اعتمدت طريقة الألوان في استخلاص الحشود من خلال تحليل الصور الملتقطة بواسطة الطائرة بدون طيار. لقد تمت الدراسة تحت عدة حالات للكاميرا من حيث موقع الكاميرا واتجاهها. قسمت هذه الحالات إلى ثلاثة أقسام شملت الصور الملتقطة بواسطة الكاميرا العمودية، والكاميرا الأفقية، والكاميرا القريبة من الحشود. بينت نتائج الدراسة إن الطريقة المستخدمة في الدراسة استطاعت أن تستخلص وتميز الحشود عن باقي مكونات الصور الأخرى (مثل الطرق والمباني والمناطق الخضراء). كما بينت الدراسة أن الطريقة أعطت نتائج أفضل نسبيا عند استخدام الصور الملتقطة بواسطة الكاميرا العمودية مقارنة بالأفقية والقريبة. ويعود السبب في ذلك إلى أن الكاميرا تعطي تركيزا على المنطقة المكتظة أكثر من المناطق المحيطة. كما أن تقدير كثافة الحشود في أثناء الحج يعد أكثر فعالية مقارنة بالحالات الأخرى. لعل السبب في ذلك يعود إلى انخفاض طبقات الألوان في مثل هذا النوع من الصور، الذي يقتصر على اللون الأبيض والأسود. تم تحسين نتائج الدراسة عندما استثنيت التشوهات المرافقة لعملية تحليل الصور من خلال استخدام وسائل إضافية في معالجة الصور.

الكلمات الدالة: طائرة بدون طيار، إدارة الحشود، طريقة الألوان، تحليل الصور الجوية.

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