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Psychological Interpretation of Drawings by Color Analysis for Mental Therapy

[1]Chieko Kato and [2]Tadahiko Kimoto
[1]*Department of Information Sciences and Arts, Toyo University, Kawagoe, Japan;*
[2] *Department of Science and Engineering, Toyo University, Kawagoe, Japan;*
[1]kato-c@toyo.jp; [2]kimoto@toyo.jp

ABSTRACT

In order to provide psychotherapists with an objective criterion for evaluating client's mental states, this paper proposes a method for analyzing a drawing that a client makes in drawing therapy for four psychological primary colors. The method consists of two steps: an image segmentation step and a color analysis step. In the first step, those areas which seem what the client intended to depict are extracted from the entire digitized image. The effective resolution in the extraction is made variable with the values of parameters in mathematically morphological processing. In the second step, the pixels of the extracted areas are classified into four categories, corresponding to the psychological primary colors, as determined by the dominant component of a pixel color.

A case study of employing the color analyses in drawing therapy was carried out with a series of drawings which were obtained in an actual clinical therapy. A comparison of the objective results of the analysis and subjective evaluations obtained in the process of cognitive behavioral therapy has demonstrated that the analyses are useful to describe a variation in a client's mental state in terms of psychological properties of colors. In conclusion, the color analysis method in drawing therapy works in cooperation with cognitive behavioral therapy.

Keywords: Drawing therapy; Cognitive behavioral therapy; Psychological primary colors; Mathematical morphology; Image segmentation; Color space division.

1 Introduction

Creative activities such as art making have therapeutic effects on mental clients. In drawing therapy, which is a practice of art therapy [1], a client is treated through the behavior of making drawings while they require no artistic talent or drawing skills. Deducing the client's mental state from the drawings enables a therapist to properly help them to improve in their therapeutic process. Thus, drawing therapy is currently recognized as an effective and proven way of treating clients for their mental problems [2].

Drawings that a client makes are supposed to contain psychological information about a wide variety of their emotions. Not only what is described in a drawing but also how it is made, for example, how it is composed on the drawing paper, how the drawing tools and materials are used to depict it, how it is made colored, and so on, can express different kinds of emotions. Observing the drawing, a therapist interprets it by describing the client's emotions in psychological terms and then, diagnoses their mental symptom.

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Different therapists often make different interpretations of the same drawing because pictures such as drawings are usually viewed from different viewpoints by different people. Besides, the personal experience of a therapist may affect their interpretation result. Thus, drawing therapy essentially involves subjective assessment by each therapist.

To reduce subjective views in the assessment of a drawing, employing its objective features is effective. A way to obtain such features is to analyze a drawing by techniques of image processing with a computer [3]. The analysis results are obtained in a numerical form and they can be used in further processing. For example, a change in client's feelings over a long period can be revealed by data sequence analysis. Consequently, computer-aided analysis of drawings is expected to help therapists to make treatments suitable for a client. It is also helpful for a therapist with a short-term experience. The effectiveness of such quantitative analysis has been recently reported in many researches for artistic paintings [4].

In the present study we consider a use of colors in drawing therapy. It is known in color psychology that some colors, which are called psychological primary colors, relate strongly to human mind. For each psychological primary color, those emotions which it generally symbolizes have been investigated [5]. Such psychological effects of colors indicate that which color is painted in a drawing expresses emotions, especially unconscious ones of a client who makes it. This paper proposes a method for analyzing a drawing for the psychological primary colors so that a therapist can assess the client's emotions from the analysis result.

The rest of this paper is organized as follows: Section 2 describes the significance of colors in drawing therapy. This section also includes an explanation of subjective assessment that is often performed in cognitive behavioral therapy, which will be used later for comparison. In Sect. 3, the method of color analysis for drawing images is explained in detail on the supposition of the image format same as that used in the next section. In Sect. 4, a case study of applying the color analysis method to drawing therapy is carried out with a series of drawings that a clinic patient made in their therapeutic process by one of the coauthors who is a qualified clinical psychotherapist. Section 5 concludes the paper.

2 Evaluation of Client's Emotions

2.1 Evaluation from colored drawings

In drawing therapy, a client is allowed to draw whatever comes into their mind in such a manner as they like with given drawing tools and materials. Then, various types of self-expression appear in such drawings while the client may have been unconscious of their own mental state in drawing. From visible features in the drawing, a therapist deduces the client's emotions with which the features are associated in psychology. Thus, the drawings can reveal the client's unconscious emotions and enable the transference between the therapist and the client.

As for color, a drawing is evaluated using the psychological properties of colors. The properties of a color are the emotions which it is usually associated with in psychology. A color has two mental aspects: a positive one and a negative one. In addition, a color provokes three kinds of mental responses. Combining these factors, each color has several psychological properties that affect human mental activities. In the psychological primary colors there are four foremost ones: red, green, blue and yellow. Main psychological properties of each of these colors are listed in Table 1.

In order to describe a drawing in terms of the psychological primary colors, it is necessary to analyze the drawing for the colors and then evaluate the amount of each color. For the implementation of such evaluation, in the method which will be described later, the entire drawing is to be divided into those

Table 1. Psychological properties of four primary colors [6].

Color	Positive properties	Negative properties
Red	Physical courage, strength, warmth, energy, basic survival, fight or flight, stimulation, masculinity, excitement.	Defiance, aggression, visual impact, strain.
Green	Harmony, balance, refreshment, universal love, rest, restoration, reassurance, environmental awareness, equilibrium, peace.	Boredom, stagnation, blandness, enervation.
Blue	Intelligence, communication, trust, efficiency, serenity, duty, logic, coolness, reflection, calm.	Coldness, aloofness, lack of emotion, unfriendliness.
Yellow	Optimism, confidence, self-esteem, extraversion, emotional strength, friendliness, creativity.	Irrationality, fear, emotional fragility, depression, anxiety, suicide.

areas which can each be made colored approximately in any of the primary colors. Then, the amount of each color included in the drawing, for example, the area ratio can be measured.

2.2 Subjective evaluation in cognitive behavioral therapy

Psychological problems are considered as the result of a defective way of thinking. Cognitive behavioral therapy helps a client to change their wrong way of thinking to a healthy one, and this allows them to change their behavior as a result. Because the brain deals with information which is gathered by the senses, human behavior is analyzed by having a client perform various mental tasks in cognitive psychology. Through such a therapeutic process, the client can understand their feelings better and turn their way of thinking into useful behavior accordingly.

A cognitive behavioral therapist evaluates mental states of a client by discussing their psychological problems with them. A way of how to give scores to the mental state is as follows: Suppose that a client first thinks in a negative way and may be angry after they have been scolded by their boss, for example. At this point in time, they are considered to be 100 percent angry in a terrible feeling. Let us suppose next that they can later afford to think in a more rational way and their feelings of anger decrease accordingly. For example, realizing that their boss was only trying to help them, they change their way of thinking. By talking with the client, the therapist estimates the degree to which their feelings of anger have dropped to be, say, 50 percent. This estimate indicates that the client has made a 50-point improvement in their way of thinking. We refer to the score as the degree of improvement, which will be used later in the case study in the present paper.

3 Color Analysis of Drawing Images

3.1 Method for analyzing drawings

Drawings to be dealt with in the present study are those which are depicted on a blank sheet of paper with chromatic materials such as pastels, crayons and pencils. It is supposed that there are no restrictions on the contents or the composition of a drawing. Arbitrary use of color is also allowed in drawing. Here, let a drawing area mean the entire area depicted intentionally so as to express objects.

A drawing area is situated within the sheet in various ways. Some cover all over the sheet; others are located inside the sheet with the surrounding area left blank, and the boundary can be arbitrarily shaped.

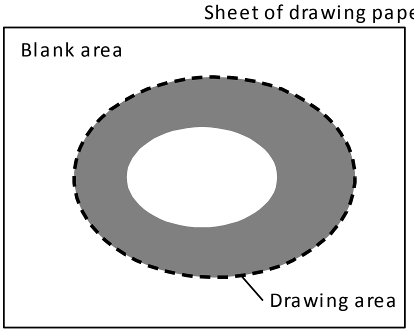


Figure 1. A drawing in a sheet of paper.

As shown in Fig. 1, the drawing area may also include that area looking like an internal hole inside which is either a part of sheet left blank or an area intentionally painted over in the same color as the ground color of the sheet.

A drawing area is painted and textured in various ways with painting materials and tools. Using lightly a crayon, for instance, perhaps also owing to the granularity of paper quality, can color in a mottled way. The mottled area which is depicted directly on the blank sheet in this way could include a lot of small unpainted holes.

The aim of analyzing a drawing with a computer is to investigate what colors are intentionally used there. To exclude the color of the blank area, first the drawing area is to be extracted from the entire digitized image of the drawing. Then, color analysis is carried out only in the drawing area. The details of each procedure are described below.

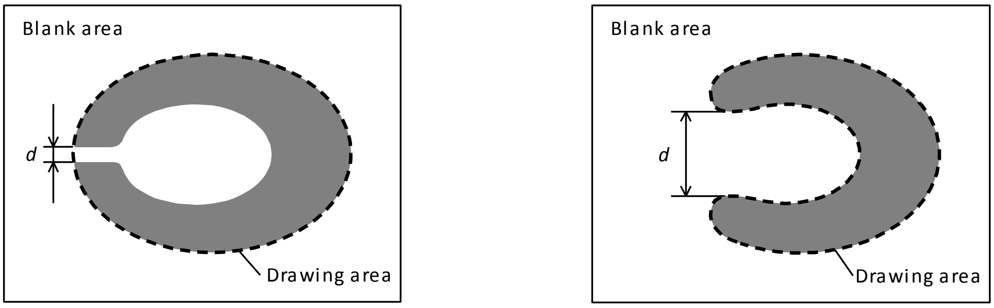
3.2 Extraction of a drawing area

A drawing area is defined in more detail in the following way. In the first place, it is reasonable to regard an area of different colors from the ground color of the sheet as a drawing area. As mentioned in 3.1, a blank area surrounded by the colored area is considered as a part of the object situated there, and hence, it should be included in the drawing area. As for an internal blank area connecting to the outside, if the connecting path is narrow as shown in Fig. 2(a) where d represents the path width, the internal area should be included in the drawing area. On the contrary, if the connecting path is wide and accordingly, the internal area looks like a "bay" rather than a hole as shown in Fig. 2(b) with a large value of d, it is reasonable that the blank area is no longer included in the object.

Suppose that concave parts of an object are expressed in the ground color while convex parts are depicted in the material colors. Then, small concave parts along the edge of the object are to be included in the drawing area as illustrated in Fig. 3(a). In other words, the ground color is assumed to be intentionally used there. On the contrary, on the assumption that relatively large concave parts are represented by the curvature of the object's contour, they are excluded from the drawing area as shown in Fig. 3(b).

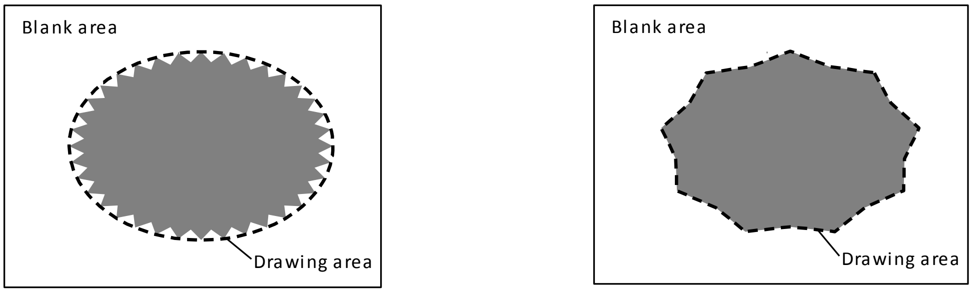
So as to achieve the above definition, the procedure for extracting drawing areas from a drawing image is composed of the following steps:

(1) Digitization: A digitized image of a drawing is obtained using an optical scanner. Let D denote the



(a) (b)

Figure 2. A drawing area with an internal blank area connecting to the outside.



(a) (b)

Figure 3. A drawing area with surrounding concave parts.

scanning resolution in both horizontal and vertical directions in units of dots per inch (dpi). Each pixel of the digitized image has three quantized values of the primary color components, red (R), green (G) and blue (B). Let IO represent the digitized image and a description of an image followed by (x, y), such as IO(x, y), denote a pixel of the image at spatial coordinates (x, y). The image IO will be also used in the later color analysis.

(2) Reduction: According to actual roughness of drawing, the image IO can be reduced to a coarse one. By replacing a square block of pixels with a pixel, the resultant resolution is equal to D/u. Let JO represent the resulting reduced image. Each pixel of JO still has three color components.

(3) Binarization: Pixels of the ground color of the sheet are distinguished in the image JO in the following way: Suppose that each color component has 8-bit levels in the range [0, 255], and that white is given by ; black is given by . Let us refer to a color composed of these three 8-bit color components as a 24-bit RGB color. Given the ground color of the sheet, for example, white, the color of each pixel is classified to two categories to produce a binary image, denoted by JB, by thresholding as follows:

$$J_B(x,y)=\begin{cases}0 & \text{if } j_R(x,y)>L_{\max}-a,\ j_G(x,y)>L_{\max}-a, \text{and } j_B(x,y)>L_{\max}-a\\ 1 & \text{otherwise,}\end{cases} \quad (1)$$

where jR(x, y), jG(x, y) and jB(x, y) are the red component, the green one and the blue one of a pixel JO(x, y), respectively, and a performs an allowable margin of level variation that is likely to occur in the digitization. Thus, pixels labeled 1 in the image JB correspond to objects, whereas pixels labeled 0 correspond to either the unpainted background or internal holes.

(4) Smoothing: Objects in the image JB are smoothed in the following two steps: First, gaps in the object are closed by morphological closing [7]. By using a square block of pixels whose origin is located at the center as a structuring element in the processing of closing, gaps of a width of less than or equal to 2p pixels are closed.

Next, the objects are smoothed by morphological opening. By using a square block of pixels whose origin is located at the center as a structuring element in the processing of opening, projections of a width of less than or equal to 2q pixels along the edge of the object are planed off. Also, being considered as noises, tiny isolated spots are removed. Let JS represent the resulting image of this step.

(5) Segmentation: To extract a drawing area with the internal holes included, a blank area that surrounds the drawing area is distinguished in the image JS as follows: Suppose that pixels labeled 1 have 8-connectivity in the image JS, whereas pixels labeled 0 have 4-connectivity. Then, a blank area is defined as a set of pixels that are 4-connected to the outside of the image. By labeling pixels of the blank area as 0 from the outside of the image to the inside according to the definition of 4-connectivity, the remaining pixels are labeled as 1 and regarded as the drawing area. Let us refer to the resulting binary image as a map image JM.

Through the above procedure, a map image JM produced from the original image IO of the resolution D is a function of the above parameters u, a, p, and q. Consequently, the drawing is to be effectively resolved with the spatial resolution of in mm. Parts smaller than a square block with one side w pixels are considered to be painted solid. Also, minimal parts of the drawing area are assumed to be in mm wide.

Figure 4 demonstrates the above segmentation. Figure 4(a) shows an example of a drawing image of 3294 2668 pixels with a 24-bit RGB color that was produced by digitizing a client's drawing with an optical scanner at D=300 dpi. Figures 4(b) and 4(c) show the results of segmentation with different values of the parameter p, where the drawing area is shown in black and the blank area in white. The evaluated w of Fig. 4(b) is 2 mm, and that of Fig. 4(c) is 3.4 mm. We observe that according to the spatial resolution, the white area on the right of "flower" is connected to the surrounding blank area in Fig. 4(b), whereas it is included in the drawing area in Fig. 4(c). Thus, values of the parameters can be determined so that desired parts can be included in the resultant area.

On the other hand, an extracted drawing area may include those parts which seem to result from something like stains on a sheet, that is, which seem unrelated to the intended contents, such as the fractions seen at the top and left sides of the images in Figs. 4(b) and 4(c). Such parts can be removed from the map image by manual operation with a kind of graphics application software.

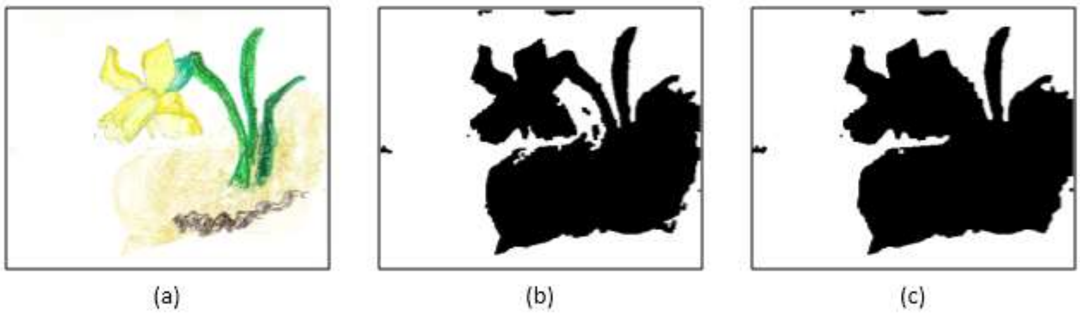


Figure 4. Example of segmentation: (a) an original image of *D*=300 dpi; (b) a map image obtained with *u*=8, *a*=8, *p*=1, *q*=1; (c) a map image obtained with *u*=8, *a*=8, *p*=2, *q*=1. Here (b) and (c) are shown by magnifying to the same size as (a).

original image I_O in the segmentation process, first, J_M is extended to the same size as I_O. A simple method for the extension is to replace each pixel with a value, t, which is either 1 or 0 in J_M, with $u \times u$ pixels with the same value of t. Let I_M represent the extended map image.

Consider classifying colors by dominant color components. The dominant component of a color is defined as that which has the largest or the smallest value among the three color components. We refer to a color whose dominant component is α as a α-class color. Let a color that has three color components r, g and b be represented by a point (r, g, b) in the three-dimensional RGB-coordinate space. Then, the set of red-class colors, denoted by P_R, is defined as

$$P_R = \left\{ (r, g, b) \,\middle|\, r > g \text{ and } r > b \right\}. \tag{1}$$

Similarly to P_R, the set P_G of green-class colors and the set P_B of blue-class colors are defined as

$$P_G = \left\{ (r, g, b) \,\middle|\, g > r \text{ and } g > b \right\} \tag{2}$$

and

$$P_B = \left\{ (r, g, b) \,\middle|\, b > r \text{ and } b > g \right\}, \tag{3}$$

respectively. The cubic space that represents all the 24-bit RGB colors is divided into three subspaces corresponding to P_R, P_G and P_B as shown in Fig. 5(a), where they are illustrated apart from each other for easiness to see. Note that the sets exclude the boundaries between the subspaces. Also, as for the CMY-color system using three color components cyan (C), magenta (M) and yellow (Y), the set of yellow-class colors, P_Y, is defined by using RGB-components as

$$P_Y = \left\{ (r, g, b) \,\middle|\, b < r \text{ and } b < g \right\}. \tag{4}$$

Figure 5(b) illustrates the subspace corresponding to P_Y located in the RGB-coordinate space together with the other two subspaces corresponding to cyan-class colors and magenta-class colors.

For an original image I_O of a drawing and the extended version I_M of a map image produced from I_O, pixels in the extracted drawing area, that is, those which satisfy $I_M(x, y)$=1 are classified according to the color classes. Let S_R be a set of those pixels in the drawing area of I_O whose colors belong to the red-class P_R, that is, expressed in the relation

$$S_R = \left\{ I_O(x, y) \,\middle|\, I_M(x, y) = 1, \left(i_R(x, y), i_G(x, y), i_B(x, y) \right) \in P_R \right\}, \tag{5}$$

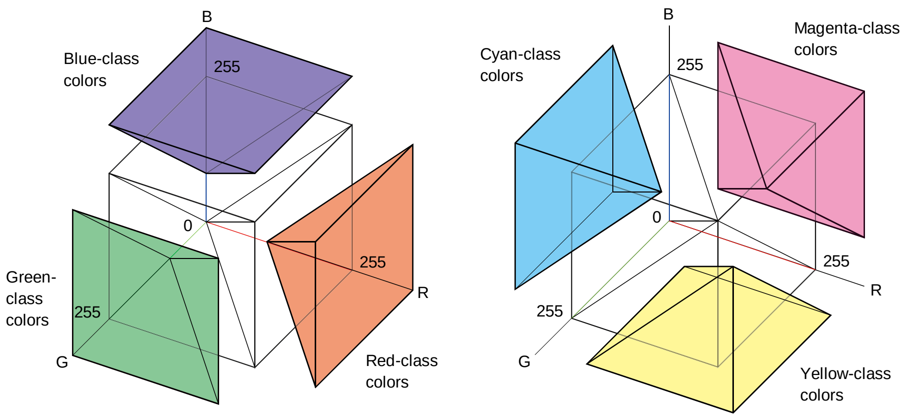
where $i_R(x, y)$, $i_G(x, y)$ and $i_B(x, y)$ denote the respective components of red, green and blue of a pixel $I_O(x, y)$. We refer to S_R as the red-class area. Similarly to S_R, the green-class area S_G, the blue-class area S_B and the yellow-class area S_Y are defined and obtained from I_O for P_G, P_B and P_Y, respectively.

Figure 6 demonstrates the results of color analysis: Figure 6(a) shows an original image I_O, and the map image I_M in Fig. 6(b) was produced from I_O to represent the extracted drawing area. Figures 6(c), 6(d), 6(e) and 6(f) show the resulting red-, green-, blue- and yellow-class areas on a white ground, respectively. Figures 6(c)-(e) are three sets of pixels which are mathematically exclusive, in other words, disjoint to each other. We observe from them that the drawing area is divided into three differently colored areas which look like the objects of respective colors, such as trees, the sky and the pond.

4 Case Study

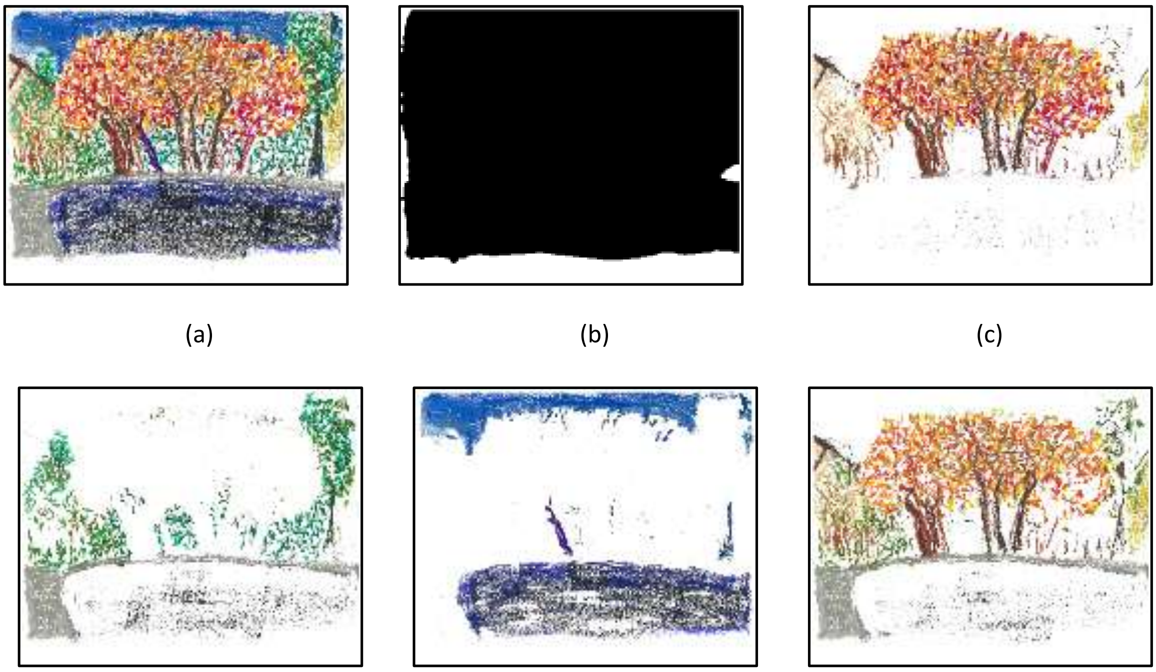
4.1 Method of a case study

A case study of using the proposed color analysis method in drawing therapy is carried out in this section. Drawings, together with scores of the degree of improvement, which were obtained previously in the actual clinical therapy for a certain client are used as the experimental data. From the viewpoint of a qualified clinical psychotherapist, we examine how useful the objective analyses can be for assessing the client's mental state.



(a) (b)

Figure 5. Division of the 3-d color space.



(a) (b) (c)

(d) (e) (f)

Figure 6. Example of color analysis: (a) an original image; (b) the map image; (c) the red-class area; (d) the green-class area; (e) the blue-class area; (f) the yellow-class area.

The client and the therapy are described in brief below. The client was a male in his 50's. He was experiencing some difficulties at work, and was feeling pretty depressed. He had held a will to live and more importantly, he wanted to be cured of his mental problems. In general, cognitive behavioral therapy works well with intelligent and serious clients, because they are required to write in their diaries and also to work on correcting their negative behavior. The client concerned in the case study was well-educated and serious-minded, so he had well adapted to this kind of therapy. He also liked the fine arts, so he had selected art therapy as a form of treatment included in cognitive behavioral therapy. He had been treated once a month between 2007 and 2011 at a mental health clinic.

The drawings were obtained in the following way: The client made a drawing as he pleased in every month during his therapeutic process. He came for counseling once a month with not only his diary but also the drawing. Thus, a sequence of the monthly drawings by the same client were obtained.

Each drawing was analyzed by the method described in Sect. 3. Here we use the same notation as in Sect. 3. Before analysis, each drawing was scanned at a resolution of 300 dpi (i.e. D=300) and quantized to a 24-bit RGB color image, denoted by I_O. The images previously shown in Figs. 4(a) and 6(a) are samples of these digitized drawings. The drawing area was extracted from I_O by the method stated in Sect. 3.2, and also the map image J_M was generated so as to specify the drawing area. In the segmentation procedure, values of the parameters u, a, p and q were determined for each drawing so that the resultant area could look like what the client wanted to depict.

For each I_O, the color analysis was carried out to obtain the red-class area S_R, the green-class area S_G, the blue-class area S_B and the yellow-class area S_Y by the method described in Sect. 3.3. Now we are ready to evaluate the amount of each psychological primary color in each drawing. Let N be the number of pixels in the segmented drawing area; that is, N is defined in the relation

$$N = \left| \left\{ I_M(x,y) \,\middle|\, I_M(x,y) = 1 \right\} \right|, \tag{6}$$

where $|s|$ denotes the number of elements in a set s. In addition, let N_R, N_G, N_B and N_Y be the respective numbers of pixels in S_R, S_G, S_B and S_Y; that is,

$$N_R = |S_R|, \quad N_G = |S_G|, \quad N_B = |S_B| \quad \text{and} \quad N_Y = |S_Y|. \tag{7}$$

Then, we define the respective area ratios of S_R, S_G, S_B and S_Y by

$$\rho_R = \frac{N_R}{N}, \quad \rho_G = \frac{N_G}{N}, \quad \rho_B = \frac{N_B}{N} \quad \text{and} \quad \rho_Y = \frac{N_Y}{N}. \tag{8}$$

Thus, the respective sequences of the area ratios have been obtained from the sequence of the drawings.

On the other hand, the scores of the degree of improvement were obtained in the following way: In the cognitive behavioral therapy, the client had written down his feelings in his diary at any time, when he felt stress or got upset about something, for instance. From the monthly records of his feelings, his therapist assessed how his mental state had changed in that period and estimated the degree of improvement. Thus, a sequence of the degrees of improvement of the client has been obtained, each of which accompanies his monthly drawing.

4.2 Result and discussion

Figure 7 shows the degrees of improvement in the order of the sequence, or equivalently, with time in months by taking a moving average of three consecutive values. From this figure it is observed that soon after the client started his therapy, the degree of improvement dropped somewhat and then remained low until around 14th month; after that, he improved to some extent, but he got worse again. The change in the degrees of improvement after the 37th month indicates that he was gradually getting better.

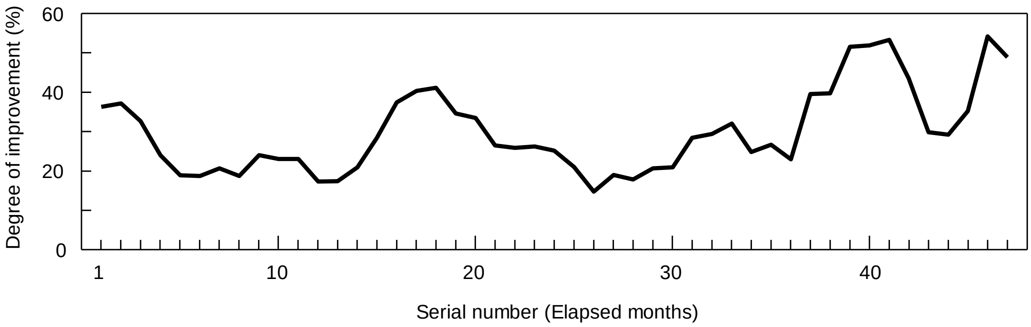


Figure 7. Degrees of improvement in the therapy period.

Figure 8 shows the respective sequences of the area ratio ρ_R, ρ_G, ρ_B and ρ_Y by taking a moving average of three consecutive values. From this figure, together with Fig. 7, the client's mental state is assessed in terms of the four colors as below.

The variation of ρ_R looks roughly coincident with that of ρ_Y in Fig. 8, and also, both the variations look roughly coincident with the variation of the degree of improvement in Fig. 7 while changes seem occurring in the degrees of improvement somewhat later than in the two area ratios. This observation indicates a probability that a diagnosis that the client is getting better can be made in drawing therapy before an improvement in his feelings is recognized in cognitive behavioral therapy.

The relationship between variations in the usage of the above two colors and improvements in cognitive behavior is explained from the viewpoint of consciousness and unconsciousness in mind as follows: Yellow in drawing therapy represents positive mental states such as optimism, extraversion and so on in an unconscious mind. If these feelings are getting strong and appear in the client's conscious mind, he improves accordingly. As for red, it represents stimulation, excitement, aggression

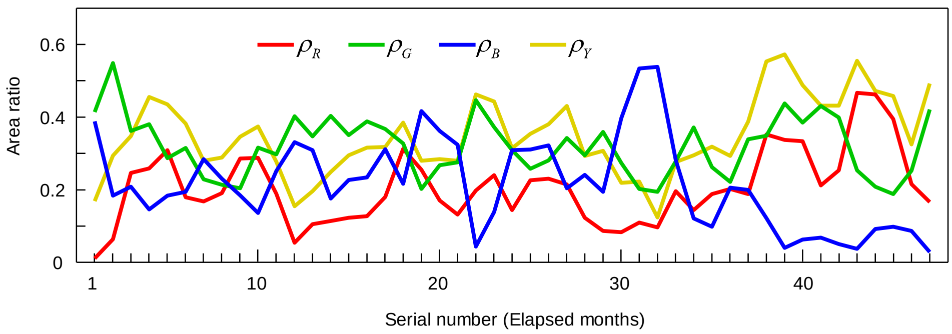


Figure 8. Area ratios of psychological primary colors in the therapy period.

and so on. It is observed from Figs. 7 and 8 that at first, the client got a sharp increase in these feelings, and later, as an improvement occurred in his unconscious mind, the feelings were subsiding accordingly. Generally, in drawing therapy a client improves unconsciously; on the contrary in cognitive behavioral therapy a client is aware of their improvement. Because colors are easy to observe, a therapist can find changes in a client's mental state immediately although the client may be unaware of their improvement in drawing therapy.

On the other hand, a variation in the blue-area ratio ⍰B indicates a time when there was a reversal in the client's improvement. It is observed that the curve of ⍰B was trailing away while an improvement was occurring in his mental state, and his behavior such as unfriendly one seems to have been mitigated accordingly.

5 Conclusions

Because each color expresses both positive emotions and negative ones, it is difficult to judge if a client's mental state is getting better or worse from a variation in the usage of a single color. Hence, it is necessary to combine analysis results for several colors.

In the above case study by comparing the amounts of the primary colors and the degree of improvement, we have investigated which colors can be associated with the client's improvement and also how they can be associated. The result indicates that the colors can describe how a client is improving, more specifically speaking, which sort of emotions the client is improving in. Hence, if this type of therapy goes smoothly, a therapist can realize a client's mental condition without missing important signs or details regarding a client's behavior and feelings, by using objective and quantitative analyses.

In the present paper, we have concentrated on the four psychological primary colors. The study will be extended to the eleven psychological basic colors including these four colors. The main subjects are not only the analysis of drawing images for those colors but also the application of the analyses to cognitive behavioral therapy.

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[1]Sultan Almazroui, [2]William Wang and [3]Guangfu Zhang
[1,2]School of Engineering and informatics, University of Sussex, Brighton, UK;
[3]National University of Defense Technology (NUDT), Changsha, China;
taud8@sussex.ac.uk; w.j.wang@sussex.ac.uk; guangfuz818@hotmail.com

ABSTRACT

Imaging technologies have been an essential part of security screening especially in aviation security. Aviation security uses different kinds of scanning systems including X-rays, millimeter waves. New development has been researched in both imaging technologies in the past years all over the world. Recently microwave imaging systems for security applications has been researched in the University of Sussex with new finding in the imaging results. This paper will discuss the integration, factors and other management issues when it comes to deploy new imaging technology to serve the environment of aviation security.

Keywords: Aviation Security; X-ray Scanners; Millimeter wave Scanners; Imaging Technology; Microwave imaging; Privacy; Integration.

1 Introduction

Aviation security is constructed around the defenses established in the 1970s to fight hijackers and on approvals completed by the Commission on Aviation Security and Terrorism, which were considered in the wake of Pan Am 103 explosion over Lockerbie, Scotland. Developments in aviation security have been complex for the reason that government administrations and industry frequently found themselves at odds, not capable of resolving arguments over funding, efficiency, technology, and possible influences on processes and passengers [1]. Throughout history, terrorists, criminals and smugglers have always found aviation an easy target to access and exercise their illegal actions. Aviation is considered a strong arm for countries' economies, and if aviation is not run very well because of terrorism or other factors, people will use different technologies in order not to travel, such as video conferencing and other telecommunication technologies. If business people find alternative ways to travelling by air, airline companies could raise their ticket prices, which will deter frequent travelers from travelling. In addition, other industries will be affected such as hotels, tourism, rentals and export or import industries. Aviation includes airline operations and airports. Airports consist of commercial, general, private and military aviation services. Anyone who has the responsibility of securing aviation should be the most updated in strategies and new technologies to tackle new threats: screening officers should always be well trained in new screening technology. Strategies such as passenger profiling should be updated, and intelligence agencies should try to infiltrate terrorist groups to understand their intentions and plans for their next target. Airplanes and airports have always been high priority targets for terrorists. Aviation security is costly, tragic and lasts. It is one of the targets where terrorists can affect such enormous numbers of a country's population. Aviation security is required to be cooperative work between different organizations, which include international and national organizations, airport ground staff operators, airline staff and government teams such as police and intelligence agencies. All have one goal, of providing safe and secure services

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for travelers to travel without any difficulties to strengthen the economy of the country. In airports the airline staff are obliged to check in the passengers' baggage and screen them; some airlines hire private screening companies to do this job. The airport ground staff is responsible for the airport's general policy for internal and external security. The screening officers are sometimes hired by the government or by the airport itself: this depends on each country's policies. For example, Dubai airport only hires locals for the screening. Governments control the security covering who comes in and who goes out through immigration and other police departments. Also they provide intelligence information to the airport to block or catch terrorists or criminals. Governments correspondingly support the research of new policies to be implemented, and technology research to enhance security such as security screening. Since the start of civil aviation security, its programme has always been designed around detecting, preventing, or mitigating terrorist threats in relation to trivial amounts of explosives and personal weapons. Also it has been based on a number of principles, as argued in[2]. The key aspects of these principles are divided into:

1. Terrorist intrusion of civil aviation premises should be completely prevented, and that is the role of intelligence including police and government intelligence;
2. A strict policy or procedure combined with technological detection systems to prevent any terrorist from breaching the front line of security at the aviation premises;
3. Damage control procedure: if the terrorist succeeded in breaching step two of the security line, then the aircraft system and structure must be robust enough to minimize the damage.

From the illustrated security breached history of aviation security, it was important to invest in scanning equipment research and development. Following the 11 September attack the US Committee of Commerce, later Transportation, and USA Senate has formed to discuss: 1) computer aided systems used for aviation security; 2) access control of airports; 3) screening of passengers and their baggage, and how US systems are different from other countries. In 2000, the committee identified that the key aspect of the problem is the weakness of the screeners. This is because of the huge, unbearable amount of work to check every bag by the screeners. There is a high turnover in screening staff, mainly because of limited benefits, low salaries and a boring repetitive style of work. This concludes that there will always be a problem with human factors when screening passengers, and, in the USA, the Federal Aviation Authority (FAA) proposed the use of threat projection software deployed in the X-ray screening machine to keep the screener on alert if illegal objects were detected. Moreover this software monitors the screener's performance and actually certifies the screener for employment in the screening employment. All the previous discussion confirms that screening is a vital issue to enhance security against terrorism and smuggling. The recent terrorist attacks have strengthened the research in finding new technologies to image inside human bodies and to detect illegal materials carried with passengers. This paper will discuss the new imaging technology discussed in [] and its general integration management for airport security control.

2 Importance of airport security

Airports are vibrant parts of the 21st century framework, demonstrating current growth and the existing procedures of globalization. In 2013, the aviation industry opens up the UK to the worldwide tourism market, with incoming tourists putting almost £19bn into the UK economy [3]. The airline industry is a major industry that employs around 8.3 million people, and supports 15.1 million jobs worldwide[4]. Airports are an essential infrastructure of the transportation industry, where passengers use them daily. In Geneva, as an example of the growth in passenger numbers, the International Air Transport Association (IATA) has released a report showing a strong growth of 6% year on year growth. With the growing number of travellers throughout the world, airports are critical targets for terrorist groups. Therefore technologies in the field of security imaging are racing to overcome such attacks to manage the terrorist events before they happen; this is called critical security management. Passengers are using airports on a daily basis, which makes it a critical source of wealth to the country and improving the economy by increasing employment for people. Passengers take the luxury, benefit and easy operations of these substantial and progressively complicated facilities for granted. However, modern passengers would also like to see no queues or delays in airports. Both security and delays in airports could have an impact on the country economically and politically. Following the 9/11 terrorist acts, all security regulations and laws and technologies in airports have been changed. These changes include 100% of passenger's baggage being screened through explosive detection systems[4]. Sophisticated safety and security programmes have to be constructed to meet the highest level of security.

3 Summary of current airport security worldwide

Most airports currently have several layers of security screening. It starts when the traveler comes to the check-in area where identification is required. They then answer some security questions from the check-in desks, such as the contents of their bags and if someone else has touched their bags. Once the passenger leaves his luggage at the check-in area he is allowed to take a certain weight of any hand luggage, including not more than 50ml of liquids. After this he goes through a checkpoint where, in some domestic European airports such as the UK and Ireland, a photograph is taken of the passenger before they reach the metal detection gate. There are several lanes containing metal detection gates and X-ray scanners to view the passengers' carry-on baggage. Liquids and laptops are taken from the carry-on baggage and screened separately for better visualization by the X-ray scanners. These X-ray scanners view a 2D image and, if the screener has suspicions about the carry-on baggage, then this baggage only will be checked manually by another officer. After this the traveler goes through the metal detector; if there is an alarm then he will be further checked by a pat-down search. If the traveler is suspected of carrying anything dangerous he goes through another human X-ray scanner to view the location of the detected alarm and further investigation. If not, then the passenger takes his screened carry-on baggage to the duty free and then to the plane. Recently millimeter wave gates have been implemented in some UK airports, such as Gatwick. These are behind the walk through metal detector and are used for external checks, These new millimeter wave systems require an extra person to check the screen of the system to see if there is contraband material held by the traveler: this is an extra cost for the airports.The baggage left by the passenger at the check-in area after weight allowance control then goes through an Explosive Detection System (EDS), which uses computed axial tomography (CAT). The image resulting from the scanned baggage is then sent to a human screener for final review and analysis before loading in the aeroplane. If there is something suspicious in the baggage then another security officer has to search the bag or deal with the baggage depending on the analysis of the images.

3.1 Screening of baggage

The European Parliament and council regulations for civil aviation security require all travelers and their luggage to be screened using available security screening machines [5].Almost all European airports operate dual-energy X-ray systems to screen baggage that is held by passengers or left at the check-in area. The operator is able to visualize the images by these X-ray systems using a pseudo color technique to differentiate between different material colors. Computed tomography (CT) machines are also implemented in some parts of European airports; these show the baggage in 3-D and can be rotated through 360 degrees. The hand luggage is screened using dual-view or multi-view. All existing dual-view and multi-view X-ray systems, and CT show the cutting edge of such technology. These systems are equipped with very useful software such as an Image Enhancement Function (IEFs), image storage and Threat Image Protection (TIP). All this state-of-the-art software can be turned on or off while screening. IEFs are used to recognize and analyze the image more carefully, such as edge-enhancement, color inversion, organic only and metal only, etc. Nevertheless, some researchers question the effectiveness of such software because the best recognition of the image is the original image[6],[7]. Image storing functions are used for the benefit of data storage and are to be used when necessary. Every nation has their own national law for data storage; therefore the operation of such software differs from nation to nation. TIP has been seen to be the best function to help operators in their decisions on selecting bags with threats. TIP depends on using stored threat images to cross-check passengers' baggage, both cabin and hold bags. Fictional Threat Images (FTIs) are selected by computer to be immersed in the passenger's cabin bag image. For the hold bags, the computer selects Combined Threat Images (CTIs) and Combined Non-Threat Images (CNTIs); these are also immersed in the real images of the hold bags. TIP can increase the prevalence to decrease the miss rate done by the screeners. In signal detection expressions, the prevalence can be described as a measure of alteration and not an adjustment in sensitivity. A system of short-term retraining times with high prevalence and full evaluation grants the screeners the ability to embrace a good measure during times of low prevalence with no evaluation[8]. Where low prevalence in the case of cabin bags is limited because screeners can correct their mistakes and catch it, in the case of hold bags it is not possible for the screener to catch their mistakes [9]. It is also known that vigilance is described as observance, physical readiness to respond or react during visual searches decreases over time[10],[11]. TIP also shows messages of how efficient all screeners are in the screening process. Even though X-ray imaging technology has been established for more than 41 years, it still has its limitations in penetrating high density machines. Modern passengers travel these days with their mobile phones, mp3 players, or iPad, and all these come with their cables and chargers that show more complex images to the operator. Research shows that if a laptop remains in a passenger's bag it could prevent other items from being clear to the security officer and it showed that laptops being screened separately provided screening officers the greatest screening practice[12]. All these electronic devices and their batteries could be similar to an improvised explosive device, therefore the operator at this point has to open the baggage manually to make sure it is not a contraband device or material. At the moment X-ray machines were invented for the purpose of speeding up the security check process. However, the speed of any security check also depends on these machines' belt movements and the time taken by the security officers to analyze the image. Therefore the issue here with current X-ray machines depends on human interaction with such a technology or any other new developed technology.

3.2 Passenger screening

There are two types of human body imaging scanners: ionizing radiation such as X-ray systems or non-ionizing radiation systems such as terahertz and millimeter waves. They are active and passive systems. An active system emits radiation to screen the passengers and a passive system receives radiation from the passengers to visualize their bodies. However, there are privacy and health concerns from using these body scanners on human bodies. In America it is routine to use these scanners, but in Europe the law is still strict on using these scanners on passengers. Ionizing scanners have been proven to use a very low radiation dosage, which is less than 1% of the dose a passenger will get from a flight in high altitude. Therefore there is no risk of radiation from the screening according to[13]. Consequently there is no risk at all from a non-ionizing system, similar to millimeter waves, or my developed system in the [14].The process in human body screening using ionizing technology such as X-rays is to view an image of the screened person by the screener who actually interprets it to see if that person is carrying something illegal. This is thought to be revoking people's right to privacy as stated by the European Union and other privacy protection groups. Recently new European Union regulations have been amended to allow non-ionizing body scanners to be used in European airports[15]. Millimeter wave scanners using non-ionizing technologies have solved the privacy problem by developing ATR (Automated Target Recognition) such as millimeter waves. The body of the passenger does not appear, only a dummy photo with the location of targets, if there are any. On the screen of the imaging of mmw, if the passenger has no suspicious material concealed within his body the screen shows OK with no image. However, if there is anything it will be highlighted in the pictogram and a pat-down search will be carried out by the security officer. However, using non-ionizing technology with ATR alone will not solve privacy concerns unless there is some kind of policy implementation within both technological and operational procedures. As seen from the above discussion, one of the main concerns to people is privacy; the second concern is the radiation. However non-ionizing systems are no risk to passengers; in addition, the ionizing X-ray body scanners used for people in airports are also safe, but extra care has to be taken when children and pregnant women are scanned [16], [13]. Privacy concerns have been initiated and argued by the public and European Union since the first generation of X-ray systems, which show the full image of the person being scanned and interpreted by the screener. The image of a scanned person viewed by the screener in detail to look for contraband material in the image formed faced a complete rejection by the European Union. Research has been undertaken to see the balance between security and privacy invasion to people. Air travellers would like to travel safe from any terrorism; at the same time their privacy and health should be considered. Some religions have to be taken into account regarding the privacy issue. Studies show that security officials, such as Transport Security Administration (TSA), should provide air travellers with an educational campaign about the privacy and health issues with new scanning machines [17], [18]. The balance of security and other issues could be discussed and agreed depending on the time and the circumstance for using ionized scanners. As explained above, millimetre wave scanners have solved the issue of privacy, however, they do not store the images scanned [19]. In general, all of the above discussed scanners have their own advantages and disadvantages. The advantage of ionizing scanners is that they can provide a better resolution than non-ionizing scanners. The disadvantages of the ionizing scanner are privacy concerns, health concerns from radiation emitted, and the comprehensive training required for the security officers to interpret the images formed. The advantage of non-ionizing scanners is that they are safe for health, there is no privacy intrusion as discussed, and less training is needed for the screeners. On the other hand, the disadvantage is lower resolution, which could miss contraband material that could be implanted in the human body. Finally security scanners have a substantial effect on humans (air travellers and screeners), security, throughput, process (policy and pat-down) and cost.

4 Factors affecting security imaging technologies

No matter how the technology has been developed, there are factors that can affect the process of security control. State-of-the-art technology can always help in the detection of contraband objects carried within people, and minimize the effect of other factors such as external factors and internal factors. External factors can always affect the security control, such as seasonal variety for airport security. For example, passengers will travel with heavier clothes in winter and carry more baggage with them; this results in more security checks or poor image quality of screened objects and will be more challenging for security operators to analyse. Internal factors that affect the security control will be the human factors both as a security operator or passenger's interaction with new technologies.

To shed light on the human factors in security control, there is the story of the TSA undercover bomber who succeeded in going through two security check points at Newark Airport USA, even though the undercover bomber carried an improvised explosive device stuffed down his pants: he also went through a pat-down search [41]. In addition, privacy and health issues were one of the main issues to be considered as factors to new security technologies. From the above history and reviews of airport security systems, the problem still exists if any terrorist is hiding contraband materials inside his body. Moreover, although changes in security regulations and technologies have been accomplished and enhanced to be effective in detecting any terrorist act, even the consequences of this are complicated, such as delays and spending more time inspecting passengers in the airports [30]. One of the main problems that aviation security faces over a long period is detecting dangerous objects planted within a human body with clear images. Technology alone cannot do this, without security screening personnel who received the blame for poor performance. This is because of poor training and low salaries for the screeners [31]. Technologies in security could be anything from cyber security, biometric and screening technology. Our main focus in this thesis is screening technology, which has the following issues;

1. health issues;
2. privacy issues;
3. space issues due to machine size;
4. human interaction with new technologies;
5. traffic issues caused by delays in screening;
6. New technologies integration with existing technologies.

4.1 Human issues on image screening technologies

Human factors should be included and considered in the design of scanning machines. For instance, there is a problem with detection by some screeners and this is due to image based factor view difficulty as illustrated in [20]. Viewing luggage and its contents, as well as the X-ray machines are the main factors for these difficulties. This could be solved with more computer-based training. In addition, the new X-ray machines or any other systems with a multi-view function could reduce the detection problem. A dark alarm system has been implemented in X-ray machines to warn the screener if a dense area in the bag has exceeded limits, and a manual search has to be done at that point. The visual ability of the person is one of the factors that can affect the detection problem, but this could be solved by better training on computer-based object recognition[21]. Knowledge of the contraband materials and how they could look is also a factor. Visual ability is stable but knowledge ability is built up with time. Therefore more training is needed to keep the screeners more efficient and updated [20]–[22]. However, assessing the screener's visual ability is required before employment, and some research has demonstrated that it is important for the manager to asses screeners before they employ them using an object recognition test tool (ORT) in X-ray systems [23]. After assessing the screener, there is also a national standard test that has to be taken, as well as computer-based training as identified in [24]. Moreover, some European countries carry out a competency assessment test annually to certify the screeners, to make sure that they are capable of interpreting images from X-ray machines[25]. Although this cutting edge technology has been extensively developed and innovated, research today has moved towards whole system performance, management and leadership, operational factors and motivation of the screeners. The human factor with security was always the weakest link in today's security process; therefore training is needed in leadership awareness and team work for any security control process. There are already studies focused on the training and competency aspects[26]. Also covert testing in security control is shown to be effective in enhancing security measures in the field of airport security. Covert testing is part of the training to the security personnel to deal with dangerous situations and give them the ultimate preparation if there are real threats[27].

4.2 Privacy

Privacy is seen as a vital human right. There is no specific definition of privacy, but it normally includes the right of an individual to keep his private sphere, such as body, home, property, and identity. A person has the right to be left alone[28]. The protection of privacy is seen as how far outsiders, such as the government or any other society body, can interfere in someone's private property. In airports, security scanners can reveal sensitive information about the scanned passengers. This could be medical details or any other private areas within the body that could cause embarrassment to the scanned person. Researchers still argue whether a physical pat-down search or 3D full body image is violating the privacy of the person. It seems that a full body image that could be transferred or saved on the web invades the person's privacy more than physical touching during a search[29] [153]. New screening technologies used in security applications ensure safety for passengers and increase security. However, questions are always being raised about their clear images that violate the privacy of human bodies. Full naked body images produced by these technologies invade the privacy and the physical integrity of our bodies, which results in an invasion of our human rights and dignity. Body scanners, such as millimeter waves and backscatter X-rays, use the most advanced and least invasive technology, and seem to be quicker for passenger inspections. However, they have always been criticized, and concerns have been raised by privacy advocates, data protection authorities and different parliaments. The approach detailed in[14]in imaging the human body using microwave technology would be similar to the approach using millimeter wave technologies, but with a different frequency range. Therefore it is worth illuminating the issues arising from these advanced technologies and look at the possible solutions to minimize the threat to individual privacy. The security of the aviation industry is set by an agency called the International Civil Aviation Organization (ICAO), but they do not give any guidance about body scanning imaging technology. They are aware of privacy and other issues that conflict with society's interests when using body scanners. From the legal side, by using these scanners an image has already been captured, processed and stored, which breaches both data protection rights and the human rights convention, such as the Universal Declaration of Human Right 1948 (UDHR). If a passenger chooses not to go through these body scanners then he has to face the consequences such as not flying, further questioning or a different method of passenger search such as a pat-down, which controls the freedom of the passengers. In Article 13 of the UDHR, Everyone has the right to leave any country, including his or her own, and to return to his or her country, every person has the right to freedom of movement and residence within the borders of each state. [30]. In Dubai airports authorities did not agree to the deployment of these scanners and they are against these advanced body scanners. This is because, according to Arab culture and tradition, these advanced scanners show the whole body, which is a violation of human rights and sanctity. In addition the effect of these body scanners on human health is not yet known, although they say the scanners use very low dosage radiation, a person has the right to fear unknown effects on his health. In the end, no matter how these technologies can save lives of passengers and crews, a person has to consider whether his right to life and freedom will not conflict with his right to dignity and privacy. One example occurred in Nigerian airports on 21 September 2010 when security officers who were trained on the 3D body scanner abused the use of the scanners to see female images[31]. A person has the right not to be exposed to these scanners, but if that happened in the USA the passenger would be searched through a pat-down search and metal detection walk through gate. In the UK, passengers have the right to opt out from these scanners, but they have to agree to a manual search or they will not be able to fly [32]. In the UK, ministers are facing pressure to legislate that children under the age of 18 do not have to be scanned as scanning is against child pornography laws. However, at the same time consequences might lead to terrorists recruiting children for their operations. In Europe there is no alternative search method if a passenger refuses to go through body scanners installed at that airport.

Passengers are also questioning why 3D body scanners are not deployed in all ICAO member states but only some of them. Also the effectiveness of these scanners was questioned since Hassan Ali Al-siri planted in himself half a kilo of explosive, which he then detonated while sitting negotiating with Prince Nayef of Saudi Arabia. Also the underwear bomber, Umar Abdualmutallab, flew from Amsterdam to Detroit with a hidden plastic bomb in his underwear: Schiphol airport had 15 body scanners at that time. The following paragraph will discuss how to overcome the privacy issue. Some companies such as TSA have used Advanced Imaging Technologies (AIT) to search passengers at an airport; some of these AITs are backscattering X-rays and millimeter wave systems. Millimeter waves are currently equipped with privacy software called automated target recognition based on the types of the target concealed under clothing of humans. Backscatter systems are not equipped with this software; this is why backscatter X-ray systems have been removed from most American airports until privacy software has been developed. Microwave body scanners in[14] could follow the same steps by integrating filter software to avoid privacy concerns. Millimeter wave technology has ATR (Automated Target Recognition): the body of the passenger does not appear, only a dummy photo with the location of targets if there are any. In the screen of the mmw image, if the passenger has no suspicious material concealed within his body the screen shows OK with no image. However, using AIT systems with ATR alone will not solve privacy concerns, unless there is some kind of policy implemented in both technologies and operational procedures. Policies on the AIT systems could be such as disabling the data storage on the same screening units, remote imaging location so the screener cannot see the image of the passengers. TSA also prevents its screening personnel from taking any recording devices with them. A clever privacy filter installed in the AIT units blurs facial features or provides a less detailed image of the human body; this will help to reduce privacy concerns. Despite taking all the above cautions, still there were complaints that some passengers had been screened repeatedly, and TSA replied in its policy not to screen any passenger twice. Above all 100% security cannot be achieved, even if the machines neglect the role of privacy. Body imaging scanners can do the job of security, but future developments of screening systems should include an intelligent system to study the behavior of the passengers as soon as they enter the airport, and make a probability calculation to detect and screen people who might be a terrorist. At the same time, this intelligent behavior system could be used to alert security officers and train staff to easily target only suspicious passengers for further screening. Another way of reducing mass screening of all passengers is to profile check passengers, but this will raise concerns of fewer people being searched. From 4 December 2013, TSA created a pre-check program to passengers in most American airports. Pre-approved passengers or low risk travelers will be allowed to move through faster lanes where they do not need to take off their shoes or belts, or any laptops or gels from their bags[33] . Most passengers around the world will see this as a good approach to avoid strict screening or waiting for long periods in queues. There is still no good answer about whether these technologies can really ensure the safety of passengers against losing their right to privacy and dignity. Therefore it is also very difficult for privacy advocates to win this argument in favor of security standards. Until now governments have failed to create a body scanner policy that takes care of the privacy law. Future policies for body scanner technology should include legal policy and technical measures to regulate scanning, and control the scanners. The expectation of the new technologies should take into account privacy issues and data protection, or develop alternative solutions to tackle the privacy problems. Passengers should be fully notified with the information about scanning machine technology so that they can determine their right to privacy. Before deploying new scanning machines in airports a review from authorized companies, government bodies and individuals should be made available for the public to read and be informed. The manufacturer or the creator of scanning machines should be aware of the legal issues associated with privacy that could be raised by law. These legal measures include image capture, storage, copyright, system encryption, password and complex identification/authentication mechanisms. Furthermore, the ICAOs could take body scanning measures seriously and start to link them with a human's right to privacy.

4.3 Traffic management on imaging screening technologies

More security developments in airports have created long queues. Tight security has also caused increases in the cost and time wasted on screening non-threatening passengers, and passengers get frustrated from longer screening times. To manage such complex queues a trade-off and balance between maximum security and screening times has to be achieved. There are a number of strategies to achieve effective security and timing, such as selection of technologies or combination of technologies when it comes to screening technologies selection[34]. Moreover there are strategies developed where passengers will be screened depending on a passenger pre-screening process[35]. A multiple level of screening has been examined and proposed according to passengers' risk levels [35]–[39]. The literature provided an overview of queueing models that have focused on minimizing the number of passengers, and minimizing the time a customer spends on each security system [40]–[45]. A reasonable approach to tackle this issue could be a study by Harrison and Wein where they separate passengers as type A to go through one station alone, while other passengers, type B, goes through two stations. They classify passengers as they arrive to be chosen to be screened differently according to their dynamic policy: this minimizes the number of customers per system[46]. Moreover, research by Schwartz shows that a freedom lane selection by passengers could work better than any conventional way. That led them to develop a static model to calculate the number of passengers and length of time at each lane depending on the class of passenger [47]. Recent research has developed a static simulation framework that makes use of the selected passenger lane depending on the neighborhood search procedure, which succeeded in the selection of 4% probability of true alarm than the usual passenger selection lane programme [48]. The key problem when it comes to aviation security is time and security efficiency; therefore Lee and Jacobson have solved such a problem by modelling a number of policies and programmes. These are:

1. Queuing program for multilevel check point security systems in the airport made from specialized screening devices;
2. Obtaining a steady state policy to minimize the time passengers spent on security systems;
3. Developing a dynamic policy that analyses the balance between true alarm probability and the amount of time spent on security systems;
4. The classification of security systems into two classes, instead of the conventional primary and secondary level of screening. The two class system has proved a high throughput of passengers screened with less time for each passenger in the security system[49].

Future queueing strategy has to take into consideration the special processes to tackle time length and queueing length depending on the security levels of screened passengers. For instance, a true alarm passenger has to go through a different security class for strict screening and investigation, while lower risk passengers can go through a different security class, then it will take less time for all overall passenger security screening.

4.4 Hazard of microwave used in imaging scanner technology

The above research has investigated whole body scanner imaging technology, which they operate in a type of frequency such that their energy per photons is not sufficient to ionize molecules or atoms: this is non-ionized radiation. This scanner technology can image inside the human body and clothing for any hidden contraband materials. In general, whole body scanners would be X-ray backscatters and millimeter wave scanners. The microwave technology research in [14] has investigated lower frequencies than millimeter wave scanners, where millimeter wave uses frequencies from 30-100GHz. Millimeter waves are so called because their wavelengths are 3-10mm in air and they take 2-5 seconds to complete a multi-directional scan. To educate ourselves more on such allowable effects on human bodies, a good reference of this statement is available on the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[50] and IEEE standards[51]. It is known in radio frequency that the absorption of RF measured as (SAR) Specific Absorption Rate within a specified tissue mass. Therefore SAR is a quantity to measure the dose of RF in human bodies. The radiation quantity of SAR exceeding 4W/Kg is required to harm human tissues in the range between 1MHz and 10GHz. The microwave scanners are a pulsed operated mode, which will generate a low level of power density. For example the power densities for millimeter wave scanners are 1kW per meter square, which is almost one-tenth of the acclaimed guidelines for the general public. To conclude the above subject, to date there are no known health effects from pulsed microwave scanners or millimeter wave scanners according to the Food and Drug Administration in the USA.

5 Imaging Security systems and efficiency enhancement in airports

Firm security in scanning systems means an image of forbidden materials carried out with passengers from boarding to an aircraft or even allowed to travel. Effective efficiency means imaging the baggage of passengers using imaging systems without using a manual search method for faster operation. In order to do this, a cutting edge technology should be developed to achieve firm security and effective efficiency. X-ray systems at the moment are developed to view baggage without human interaction unless necessary. However, even with these technologies available there are still challenges to meet high security and high efficiency. The demonstrated microwave imaging system in[14] could enhance both aspects. These technologies are in the hands of security officers who image passengers to ensure that the security is fast, not missed and producing fewer false alarms. Also there is stress caused by passengers needing to catch their flights. To achieve security and efficiency in airports, the scanning imaging technology needs to be accurate and fast in order to achieve a smooth operation and achieve passenger satisfaction. A study proposed that screeners should work on a single goal or dual goals such as speed and accurate security. It seems that when screeners work on one goal, they achieve it in favor of the other factor. For instance, if they focus on speed scanning there are errors in the scan. But if they focus on dual goals such as speed scanning and security accuracy, that slowed down the scanning operation and made the security more robust. Therefore both goals have to be managed together, as long as both goals do not affect their mental or emotional levels[52]. This means that there is a balance between speed and security accuracy that should be taken into account to reach both goals. Accordingly, the legal constructions of an airport should consider the balance of security, safety, costs, operation and privacy to manage a complicated operation overall. It has become a nationwide priority that measuring productivity of an organization should come before improving it. Therefore, to measure the balance of an airport's complex operations, a system called Productivity Measurement and Enhancement System (ProMES) could be implemented [53],[54]. ProMES can be an excellent method of setting up system performance management and security control enhancement. Managers of airports should rely on a holistic approach to decide on investing in new security scanning imaging technology. This approach carries out a laboratory test, field test and stress test as demonstrated in[55]. The earlier proposed microwave research in [14] should refer to this approach for future development

6 Imaging Security systems integrations in airports

Airport security systems have been integrated in different ways internationally depending on the size of the airport and the country those airports are. The airports in the USA were equipped with high end technologies because of the threats received after 9/11. The regulations and rules have been changed since then, and much research has been carried out to develop airports in a smarter and more cost efficient way. An example of exact data has been taken from the website of TSA (Transportation Security Administration). This states that they operate and manage more than 781 check points across US airports, with more than 43,000 transportation security officers [56]. This means a high cost for the TSA of approximately US$3 billion a year. Although this is a high cost of security spending at the checkpoints, an undercover test made by TSA officers at Chicago O'Hare International Airport and Los Angeles international airport, showed failure to detect contraband materials of between 60% and 75% [57]. From the above facts, the outstanding problem is still how to integrate all security screening technologies and methods with the existing airport systems to deliver better control of security with reduced current operational cost. Therefore screening in airports should be integrated with other security systems to have an effective tool for the better detection of suspected terrorists or smugglers. Pre-screening checks should be integrated with the screening systems to decide on who to screen and which baggage to concentrate screening on. Screening results should be integrated with the main security control officers for analysis and be integrated with other security systems such as facial recognition, CCTV in airports, and behaviour analysis systems.

7 Future Imaging Security systems in airports and Conclusion

Future imaging security such as X-rays and CT scanning machines could be developed to have higher resolution, be reliably fast and cost effective. Automation research is gradually increasing in imaging scan technology. It is already executed in the hold baggage scan, and soon possibly it will be implemented in the scanning of cabin baggage. CSIRO and Nuctech Company Limited developed automated systems to detect the shape of contraband materials such as chemical materials, explosives, narcotics and other organic threat materials smuggled through cargos. They looked for future development on the system to be faster in scanning for larger volumes of cargo and improved image resolution[58]. Automated detection is a useful function in the system, but the detection should always executed by a human. Machines could always give a false alarm and therefore screeners will not trust the machine; on the other hand, sometimes screeners will think real threats are false alarms and that could have tragic consequences. New European laws urge researchers to find ways to detect gels or liquids. X-rays and CT scanners can visualize this easily without the need for automation, but it is a helpful function to differentiate different types of materials from each other, such as contraband materials. Deploying new scanning imaging technologies will change the job requirement of the screeners, or sometimes new technologies will not need screeners to sit beside the device itself. This is called remote screening where one officer can control all the images passed through scanning devices in one control room somewhere in the airport. This has been already deployed for hold baggage and in the future it could be executed for cabin baggage. This remote image control can save time, is cost effective, and has an advantage of focus for the screeners to have a quiet and pleasant environment to focus in their image analysis. The only disadvantage of this innovative method that is the screeners will be far away from the passengers and the baggage to be scanned, which will make it hard for the screeners to call the passengers if there is a real threat or even have access to the baggage.The development of new microwave imaging in the field of the security systems[14] had breakthrough technologies to image contraband materials hidden or implanted within human bodies. To this end it was proven that microwaves can image inside a human body using a state-of-the-art imaging algorithm called Time Reversal Multistatic Signal Classifications. It was important to carry out research on a technology and its management that is less harmful and human friendly to be used in scanning people in airports, or securing VIP sites from any terrorist acts or smuggling. As technology proved to be successful in imaging, particularly in scanning systems, the above therefore discussed the scanning security system management used in airports and how new technologies could be managed by airport management and operators. Most current scanning systems suffer from privacy and health concerns for passengers. All these aspects have been discussed to give the reader experience on how security is handled in airports, and how to manage security from any terrorist act or risk that could cause countries to have a major economic crisis. Finally, this technology in [14] proved that microwaves could be used to image inside the human body, and that this technology could be developed in a real system in the future to be used for security applications. This technology has been discussed to be suitable for a scanning system to replace X-ray systems used in airports. Microwave systems are non-ionized, safe, protect passenger's privacy, and provide clear images of objects inside human bodies.

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Video Object Classification System with Shadow Removal using Gaussian Mixture Model

[1]Adekunle A.O., [2]Omidiora E.O., [3]Olabiyisi S.O. and [4]Ojo J.A.
[1]*Computer Science Dept. Adeyemi Federal University of Education,Ondo Nigeria*
[2, 3,4]*Computer Science and Engineering Dept, Ladoke Akintola University,Ogbomoso Nigeria*
gaacademics@gmail.com/adekunleao@aceondo.edu.ng; eoomidiora@lautech.edu.ng;
soolabiyisi@lautech.edu.ng; jaojo@lautech.edu.ng

ABSTRACT

Classification is the process of assigning a class to a group of objects. Moving objects classification can be difficult a task in the presence of dynamic factors like occlusion clutters and shadows. This paper developed a classifier for moving images (video stream) by using a modified adaptive background mixture model method. This system removes shadows and correctly classifies moving objects as human, human group and vehicles.

Background Mixture Model is common technique used in Computer Vision, Video object classification is not an exception, many background models have been designed to address different problems ranging from slow start and shadow removal; this paper presents a method which models each pixel as a mixture of Gaussians and using a Maximum A Posteriori approximation to update the model, this paper also introduces a two level shadow removal technique which suppressed shadows in colour and texture consistencies in the classified objects so that the system will not mis- classify moving shadows as objects. This work overcome the problem of slow learning in busy environment and can classify more than one object in view of the camera

Keywords-Classification, Gaussian Mixture Model, background subtraction, Maximum A Posteriori and Shadow detection

1 Introduction

It is easy for human beings to identify moving objects in a video clip; it is also not difficult for human beings to categorize such objects as a vehicle, a human being, a bike or a helicopter. However, it is rather a difficult task for a computer system to do the same (Dedeoglu, 2004), and due to this reason, computer vision has become an important field of study. In computer vision images are acquired, processed and analyzed to produce information. Such images can be taken from video sequences and multiple camera; the applications of computer vision in real life includes medical and automation industry. This work proposes a system that is able to distinguish transitory and stopped foreground objects from static ground objects in dynamic scene and classify detected objects into different groups such as human, human group and vehicle. The system will also detect shadows and suppress it; generate trajectory information even in multi-occlusion cases in video imagery.

2 Design

A reference background is initialized at the start of the system with the first few frames of video and updated to adapt to short and long term dynamic scene changes during the operational period. At

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each new frame, foreground pixels are detected by subtracting the intensity values from the background and filtering the absolute value of the differences with a dynamic threshold per pixel.The Gaussian distribution for each pixel is maintained and updated by using the Maximum *A Posteriori estimate* .The individual pixels are now grouped and labelled by using the component libelling algorithm to create connected moving regions. These regions are further processed to group disconnected blobs and to eliminate relatively small sized regions.After grouping, each detected foreground object is represented by its bounding box, area, center of mass and colour histogram. Moving pixels from the static background of the scene, connected regions are classified into predetermined object categories human, human group and vehicle. The classification algorithm depends on thresholds that are set based on the distance of the camera to the objects, shadows are now removed using the HSV and Phong's illumination Model.

2.1 Current State Estimation

While Kaew Trakulpong and Bowden (2001) employed the L-recent windows update equations to determine the current state because it allows fast convergence on a stable background model, this work will estimate the current state of the model by classifying each pixel to know how it looks when the pixel is part of a different class. Maximum a Posteriori (MAP) will learn how a Mixture of Gaussian (MOG) will view such a pixel. Like Expectation and Maximization, MAP is also a two-step estimation process: the first step is used to compute the estimate of sufficient statistics of the training data for each mixture in the prior model. The second step handles the "new" sufficient statistics estimates and then combine with the "old" sufficient statistics from the prior mixture parameters. The parameters are collectively represented by the notation

$$\Theta = \{w_i , \mu_i , \Sigma_i \} \tag{1}$$

w , μ , Σ represents the Gaussian weight, mean and covariance matrix respectively.

A Gaussian Mixture Model of M component Gaussian density is given by

$$P(x \setminus \Theta) = \sum_{i=1}^{M} \omega_i g(x \setminus \mu_i \sum_i) \tag{2}$$

X is a D- dimensional continous valued data vector ω_i is the mixture weight,i=1,…M

$g(x \setminus \mu_i \sum_i) =$ Component Gaussian density

i=1…M

D -Variate Gaussian function

$$g(x \setminus \mu_i \sum_i) = \frac{1}{(2\pi)^{D/2} |\Sigma|^{1/2}} \exp\{\frac{-1}{2}(x-\mu_i)^T \Sigma_i^{-1}(x-\mu_i)\} \tag{3}$$

Where

μ_i is the mean vector

Σ_i is the covariance matrix and

$\sum_{i=1}^{M} \omega_i = 1$ (must be satisfied)

$\Theta = \{\omega_i, \mu_i, \Sigma_i\}$ i=1,…,M

The Posteriori probability for component ἰ is given by:

$$\Pr(i \setminus x_t, \Theta) = \frac{w_i\, g(x_t \setminus \mu_i, \Sigma_i)}{\sum_{i=1}^{M} w_k\, g(x_t \setminus \mu_k, \Sigma_k)} \tag{4}$$

Given a prior model and training vectors from a class

$$x = \{x_1, \ldots, x_T\} \tag{5}$$

The M distributions are ordered based on the fitness value w_i / σ_i and the first B distributions are used as model of the background of the scene where B is estimated as

$$B = \arg_b \min\left[\sum_{i=1}^{b} w_i > T\right] \tag{6}$$

The threshold T is the minimum fraction of the background model, it is the minimum prior probability that the background is in the scene. Background subtraction is performed by marking a pixel foreground if it is more than 2.5 standard deviation away from any of the B distributions.

The above new sufficient statistics from the training data are used to update the priors sufficient statistics for mixture *i* to create adapted parameters for mixture *i* having the following equations will update the Gaussian

$$w_i = \{\alpha_i^w N_i / \hat{T} + (1 - \alpha_i^w)\}\omega_i\}\gamma \tag{7}$$

$$\hat{\mu}_i = \{\alpha_i^m \mu_i + (1 - \alpha_i^m)\mu_i\} \tag{8}$$

$$\hat{\sigma}_i^2 = \alpha_i^v \sigma_i^2 + (1 - \alpha_i^v)(\sigma_i^2 + \mu_i^2) - \mu_i^2 \tag{9}$$

Where

α_i^w is for the mixture weights

α_i^m is for the mixture means

α_i^v is for the mixture variances

γ is the scale factor, which is ensured sum to unity for all adapted mixture weight.

2.2 Shadow Removal Technique

The technique employed is a two level approach that removed shadows optimally in outdoor situations; this research work used the HSV suppression and the Phong reflection model, since each of the approaches suffers its own weaknesses. Phong reflection model, an illumination model widely used in 3D computer graphics would be employed to remove shadows from video streams, Phong reflection model helps to prove the local coherence(over a pixel neighborhood) of intensity reduction ratio used in texture verification. Phong model exploited the chromaticity, texture and intensity reduction. According to Phong illumination model, a surface point is lit by three types of lights: ambient light i_a, diffuse light i_d, and specular light i_s. The point of luminance in the image is described by:

Our relevance is the RGB colour space that becomes

$$I^j = k^j (i_a^j + (\mathrm{L.N})\mathrm{i}_a^j) \quad (10)$$

where index j corresponds to red, green and blue.

A shadow occurs when light power from the light source to a surface is partially or completely blocked by an object. Then the point of luminance becomes:

$$I_{shadow}^j = k^j (i_a^j + \beta(\mathrm{L.N})\mathrm{i}_d^j) \quad (11)$$

where β ε [0,1] indicating how much diffused light has been blocked.

After that HSV suppression will be applied since the phong reflection model works well in indoor environments.

3 Implementation

Several video recording were made at different times of the day to monitor designated campus sites where students' moves freely except for the human actions simulated.

SETUP

This paper worked on the setup parameters below based on set objectives:

- Uniform background, uniform illumination
- Non- uniform background, uniform illumination

3.1 Test Cases

The test cases involved the set objectives of this research work, i.e. to detect moving regions in a video frame, classify these regions as human, human group and to optimally remove shadowed regions using a combination of HSV suppression and Phong's Model.

3.2 Moving Object Classification Detection Results

Figure 1: Correctly classified Human Group (people on a moving bike and people moving inside the building)

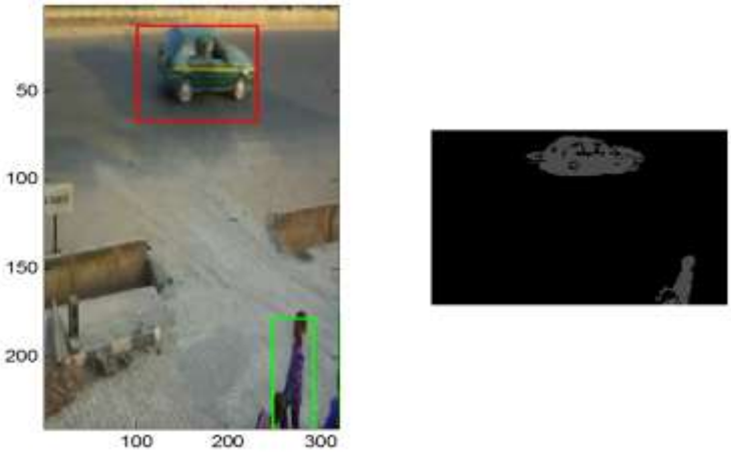


Figure 2: Correctly classified car and human group on the view of the camera

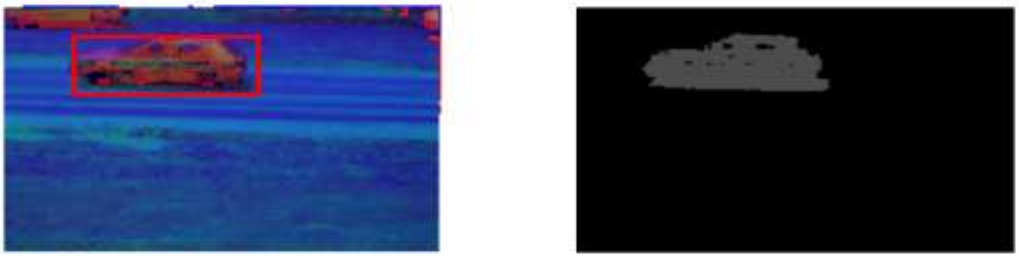


Figure 3: Correct vehicle classification with partial shadow removal(HSV suppression only)

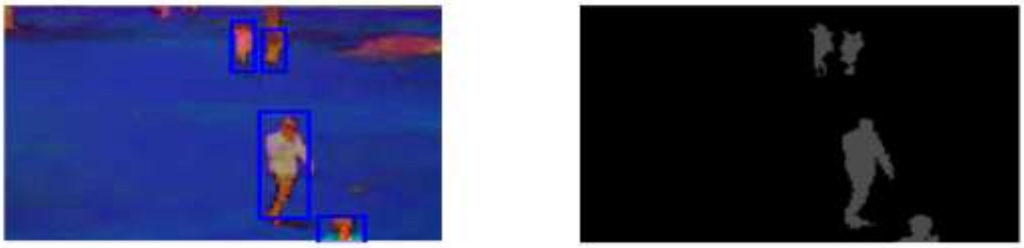


Figure 4: Correct Human Classification and shadows completely removed

3.3 Classification Experimental Results

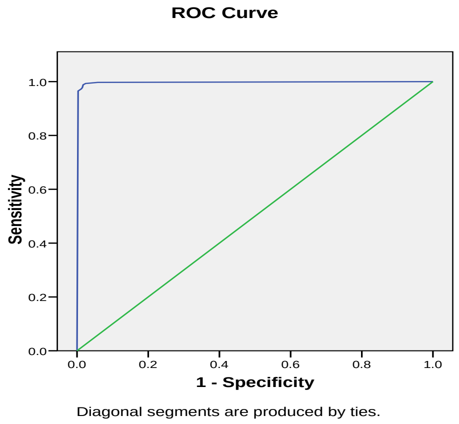
As seen in Figures 1,2,3 and 4.The algorithm classifies human(H)(4), human group(HG)(1 and 2) and vehicle(V)(3) correctly and generates a 3x3 confusion matrix in Table 4.3, it is observed that the algorithm has a high mis-classification(high false negative) in human group using this algorithm for some instance, this is due to the variance of the said group of people being equal to that of cars or trucks.; it can however be improved if the camera distance from the object is altered. The True positives 32, 23, and 45 obtained for Human, Human Group and Vehicles respectively.

4 Evaluation

This paper measured the sensitivity of the model to detect moving targets with low contrast against the background and how this sensitivity is affected by the target presence in the scene using the Percentage Correct Classification (PCC) and the Area Under the Curve (AUC) of Receiver Operating Characteristics (ROC).

Table 1: The Confusion Matrix of the Moving Object Classification.

	H	HG	V	%
H	**32**	**0**	**0**	**100**
HG	**0**	**23**	**2**	**91**
V	**0**	**0**	**45**	**100**



Percentage Correct Classification =98%; Area Under Curve=0.9

Figure 5: The ROC of the Moving Object Classification

4.1 Shadow Removal Technique

The performance of any shadow detection and removal technique can be tested using two metrics proposed by Prati *et al*, namely shadow detection rate (η) and shadow discrimination rate (ξ):

$$\eta = \frac{TP_S}{TP_S + FN_S} \quad (12)$$

$$\xi = \frac{TP_F}{TP_F + FN_F} \quad (13)$$

Where TP and FN stand for true positive and false negative pixels with respectively to either Shadows(S) or foreground objects (F). The shadow detection rate is concerned with labeling the maximum number of cast shadow pixels as shadows. The shadow discrimination rate is concerned with maintaining the pixels that belong to the moving object as foreground.

Table 2: Table showing the discrimination rate and detection rate at each stage of the shadow removal

	Shadow Detection Rate	Shadow Discrimination Rate
HSV	0.482	0.786
HSV&PHONG	0.695	0.895

5 Conclusion

This paper employed the modified adaptive background mixture model method in detecting human and vehicular motions in video images, the Maximum A posteriori (MAP) was used to update the Gaussian to , classify the moving region as Human, Human Group or Vehicles and remove shadowed regions in the video scene optimally using the combination of HSV suppression and the Phong's illumination Model(Chromaticity and Texture constraints only).

The system performed well in detection of moving images(Human, Human Group or vehicles), the system also classifies moving objects in its view to Human ,Human Group and Vehicles, but fails in classification when a group of people are walking or running at the same speed in the same direction; this type of motion confuses the system giving this set of people the variance of a car or a truck, The system performs well in classification creating a bounding boxes on the target objects correctly even when more that one object is in its view , for example ,Figure 4.9 where a moving Taxi cab(Red Box) and a woman with her child(Green Box) were correctly classified.

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