THE EFFICIENCY OF ANTHROPOLOGICAL EXAMINATIONS IN FORENSIC FACIAL ANALYSIS

Adli Yüz Analizinde Antropolojik İncelemelerin Etkinliği

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Özet

Bu çalışma, morfolojik ve antropometrik metotları içeren yüz analizinin güvenlik kamera görüntülerindeki limitasyonlarını tartışmak ve adli yüz inceleme uzmanını etkileyen olumsuz faktörleri de dikkate alarak güvenlik kamera görüntülerinin etkinlik düzeyini analiz etmeyi amaçlamaktadır. Farklı üniversite ve adli bilim laboratuarlarından katılan on adli uzman bu araştırma içinde yer almıştır. Uzmanlardan, değişik kalitedeki tetkik konusu güvenlik kamera görüntüleri ile mukayese fotoğraflar arasında karşılaştırma yapmaları istenilmiştir. Sonuçlar, düşük kalitedeki görüntülerde hata oranı yüksek ve genel itibari ile düşük seviyede bir kanaat beyan edilirken, ortalama kalitedeki görüntüler üzerinde ise morfolojik ve antropometrik analizlerin daha kesin ve yüksek seviyedeki bir kanaat ile doğru bir şekilde uygulandığını göstermektedir. Morfolojik ve antropometrik yöntemlerin etkin bir şekilde kullanılabilmesi ve adli kimliklendirme çalışmalarında güvenlik kamera görüntülerinden maksimum seviyede faydalanılması için yüksek kalitede kayıt yapabilecek güvenlik kamera kayıt standardının oluşturulması önerilmektedir.

Anahtar Kelimeler: Antropoloji, Yüzden kimliklendirme, Yüz analizi, Antropometri, Güvenlik kamerası.

Abstract

This study aims to discuss the limitations in the facial analysis of closed-circuit television (CCTV) images, including the use of morphological and anthropometric methods, and to analyze the level of effectiveness of CCTV images, taking into account any

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negative factors that may affect the forensic anthropologist/forensic facial examination expert's conclusion. Ten forensic experts from different forensic laboratories and universities participated in this research. The experts were asked to compare the query CCTV images, which were of varied quality, with the target images. The results suggest that a high error rate and low-level assessment are provided by low quality CCTV images, whereas morphological and anthropometric analysis can be performed more accurately and correctly with the high level of assessment provided by moderate/reasonable quality CCTV images. To use morphological and anthropometric methods efficiently and take maximum advantage of the use of security cameras in forensic facial identification, it is suggested to set a CCTV recording standard for high quality recordings.

Key Words: Anthropology, Facial identification, Facial analysis, Anthropometry, Security camera.

Introduction

The human face is an important part of the body that reflects not only details of a person's biological profile, such as age, sex, and ethnicity, but also the person's health and emotional state (Taylor, 2001; Wilkinson, 2004). Thus, the features and morphological characteristics of the face play an important role in forensic identification.

Facial images from closed-circuit television (CCTV) are accepted as visual evidence. Therefore, CCTV has been instrumental in identifying and apprehending those involved in all aspects of criminality. Facial identification through a comparison of the CCTV images of an offender, obtained from the scene of a crime, with photographic images of suspects taken in custody is known as forensic facial analysis (Gerrard et al., 2007; Lee et al., 2009).

However, the images captured on CCTV are often small, of low resolution and contrast, or show faces in poor and improper lighting and from odd angles (Lee et al., 2009). Considering the issues with facial identification from CCTV images, this study aims to discuss various facial analysis methods and examine how negative factors influencing poor quality CCTV images affect a forensic expert's conclusion.

Gill and Spriggs (2005) state that CCTV has become an important tool in the areas of monitoring and crime prevention. Cameras collect images that are stored in analog or digital media sources and are available for

viewing and reviewing. With the substantial increase in the use of imagery obtained from CCTV to support crime investigations, one needs to question the image and video recordings as well as the forensic facial comparison.

Imagery forms a very important source of evidence, since it is a recording of the actual happenings during an event. A camera records what it sees. Therefore, such imagery is highly useful if properly recorded and correctly examined.

This study discusses the practical methods of facial comparison and image/video analysis used in support of the judicial system. First, a literature review is designed to provide a framework for the research. In order to understand forensic facial identification from image recordings, the history and importance of CCTV are examined in detail, followed by the examination of forensic facial identification and other methods of facial comparisons. Different types of CCTV footage and personal photographs are utilized in this study. The participation of forensic experts and trained students from different institutions and universities in this research is advantageous in the addressing of a comprehensive perspective for this study.

Several studies have been conducted to determine the capability of persons in correctly identifying subjects in video recordings. However, none of the studies have been able to analyze and produce reliable statistics on the percentage of a conclusion rate. The aim of this study is also to discuss the limitations with the anthropological facial analysis of CCTV images and to analyze the level of effectiveness of some of the primary negative factors (i.e., low resolution, incorrect lighting, and blur) on the experts' conclusions on CCTV images.

1. Closed Circuit Television (CCTV)

Closed Circuit Television, commonly known as CCTV, is a video system used in surveillance systems to visually monitor a specific location for security or industrial purposes (Damjanovski, 2005). There are many different types of CCTV systems which have various capabilities, features and prices.

Basically, CCTV uses video cameras to transmit the images almost simultaneously to the central point. However, CCTV may use different technologies for transmission, including wireless connections. CCTV

may operate continuously, but it can also operate in a designated period of time or any time determined by the motion sensors.

1.1. History and Importance of CCTV

The CCTV industry appeared in the 1960s. CCTV was used first in 1961 in a London underground train station (Keval and Sasse, 2006). Newburn and Hayman (2002), in their work, emphasize that CCTV was also used for apprehending and deterring shoplifters in the 1960s. It experienced a rapid growth throughout the 1970s because of the improvements in technology of mass video surveillance. In the 1980s, the growth continued with further improvements in functions and other hardwares required to enhance the television security system. During the 1980s, the introduction of the solid-state CCTV camera was the most significant advance. By the early 1990s, most of the tube cameras used over the past 30 years were replaced with the new ones (Kruegle, 2004).

Over the past ten years, CCTV cameras have become increasingly widespread in many developed countries. Video surveillance technology is accepted, by the authorities, as having a key role in the struggle against crime and criminal (Goold, 2002). It has been estimated that over four million CCTV cameras are operating currently in the UK (Lee et al, 2009; Norris and Armstrong, 1999). CCTV cameras are operating in streets, town squares, shopping centres, leisure centres, large complexes (universities, hospitals, and airports), car parks and stores (Goold, 2003).

Today, video surveillance is used for a variety of purposes and many users have different goals for their systems. CCTV is typically used for identification, capturing evidence for criminal investigations and presenting CCTV evidence to court for prosecution purposes (Keval and Sasse, 2006).

In terms of protecting the public, CCTV plays a significant role in assisting the police in the investigation of crime. In her research on the effective of CCTV, Keval (2008) states that there are many evident benefits to using CCTV, e.g. faster response to incidents. This makes it possible for the police and other law enforcement units to respond to incidents when alerted, and to have information about what to look for when they arrive (Gill and Spriggs, 2005).

2. Forensic Facial Analysis

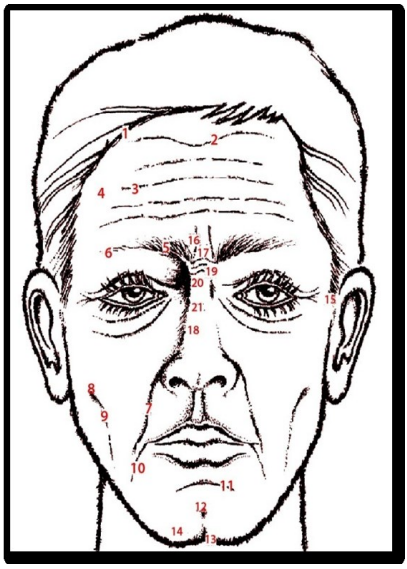
Scientists, anthropologists, artists and philosophers have been studying the human face for a long time utilizing both aesthetic and anthropologic tools (Bulut, 2010; Özdemir et al., 2008). The shape of the human face depends on both the structure of the hard tissue (bone) and the soft tissues such as cranial cavity, two ears, two orbits, two nasal cavities and an oral cavity (Özdemir et al., 2008; Drake et al., 2005).

Anthropologists are called to express their expert opinions in specific fields of anthropology, such as facial comparison, in forensic cases to identify criminals (İşcan, 1993). Evidence is central to a forensic investigation. It can provide leads or sufficient cause for an indictment (Houck, 2007). As containing visual information, an image can be accepted as evidence. According to Klasen (2002) visual evidence is a primary evidence type e.g. CCTV, facial images, crime scene imaging and 3D imaging.

Forensic facial analysis is the technique of comparing photographs of an offender with images of a suspect (Bromby, 2003**)**. It is considered one of the most common activities in forensic laboratories. Facial identification is one of the major fields of study in forensic image analysis. It is the process of analysing visual information and comparing the images of a criminal with target images based on the methods of morphological analyses and anthropometric measurements of the facial landmarks (Portar and Doran, 2000; Wilkinson and Evans, 2009).

Every face has several morphological characteristic features with significant details that make each face different from others (Bulut, 2010). Morphological analysis of facial structures is defined as the comparison of stable, identifiable features of the face. In forensic cases, the forensic facial imaging expert or forensic anthropologist may explain their opinions through scientific findings by using the anthropological nomenclature (**Fig. 1**) (Rosing, 2000).

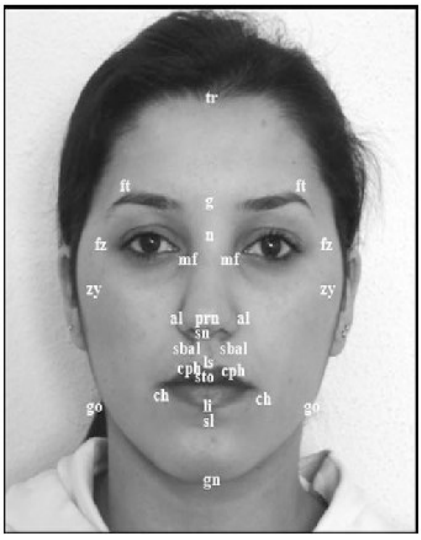
Fig.1: Facial Surface Anatomical Terms



1 Hairline; **2** Upper forehead crease; **3** Forehead creases; **4** Forehead; **5** Eyebrow; **6** Supra-orbital margin; **7** Naso-labial crease; **8** Buccal pit; **9** Bunco mandibular Groove; **10** Marionette line; **11** Mental crease; **12** Mental pit; **13** Median chin crease; **14** Chin; **15** Sideburn; **16** Vertical glabellar lines; **17** Glabella; **18** External nose; **19** Transverse nasal grooves; **20** Nasal root; **21** Nasal bridge (Modified from Dunn & Harrison, 1997).

Anthropometrical measurements are used to analyse the anthropometric landmarks (**Fig. 2**), dimensions and angles to quantify facial characteristics and proportions from a photograph (İşcan, 1993).

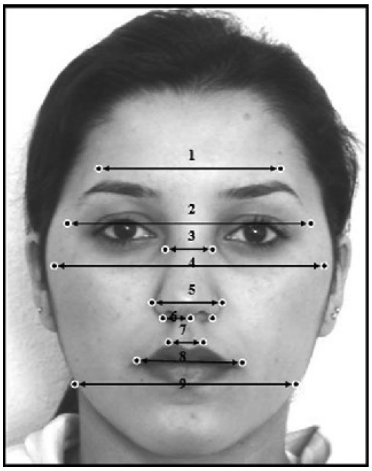
Fig. 2: Facial Landmarks Located on the Frontal Photographs



tr-trichion; **g**-glabella; **n**-nasion; **mf**-maxillofrontale; **pr**-pronasale; **al**-alare; **sbal**-subalare; **sn**-subnasale; **cph**-crista philtre; **ls**-labiale superius; **ch**-cheilion; **sto**-stomion; **li**-labiale inferius; **sl**-sublabiale; **gn**-gnathion; **zy**-zygion; **go**-gonion; **ft**-frontotemporale; **fz**-frontozygomaticus (Ozdemir et al, 2008).

Anthropometric landmarks are used for facial feature localization and anthropometric measurements (**Fig. 3**) can be obtained from the face with using the reference points of landmarks (Ozdemir et al., 2008).

Fig.3: Linear Horizontal Distances Measured From the Frontal Photographs



1 minimum frontal breadth, **2** supraorbital breadth, **3** nasal root width, **4** maximum facial breadth, **5** nose width, **6** nostril floor width, **7** philtrum width, **8** labial fissure width, **9** bigonial breadth (Ozdemir et al., 2008).

Before using these methods, it will be very appropriate to enhance the image before facial comparison. Image enhancement is any process intended to improve the visual appearance of an image (SWDIG, 2006). Brightness and contrast adjustment, color balancing, cropping, linear filtering, nonlinear contrast adjustments, pattern noise reduction, and random noise reduction are some of the enhancement techniques.

Fig 4: An Example of an Original CCTV Image and Enhanced Image

Image A (Original image)

Image B (Enhanced image)

Forensic Experts in this field of work have been providing expert reports in identification evidence, principally in criminal cases. Bromby (2003) has asserted that the CCTV images of the offender's face can be identifiable if the quality of the recording is sufficient to see the details of the face.

However, a CCTV image may often be difficult and almost impossible to interpret due to some factors affecting it negatively. Basically, these are; effects of camera and video quality, perspective, incorrect lighting levels and motion (Wilkinson and Evans, 2008).

According to Keval and Sasse (2008) video which is recorded at a low resolution will show less detail than video recorded at a high resolution. As can be seen in **Figure 5**, the face of the person cannot be identified exactly due to the low resolution of the CCTV image. Kovesi (2009) states in his research that low quality images are almost impossible for facial identification.

Fig 5: An example of a low resolution CCTV image

Image A (Original image) **Image B** (Enhanced image)

One of the other most common factors which degrade the quality of CCTV images is poor lighting (SWGIT, 2004). Adequate, balanced lighting should be provided in areas viewed by the cameras. It is recommended that sufficient lighting is given to the CCTV camera capture area, so that the observer can capture as much facial detail as

possible from the CCTV image. Gill and Sprigs (2005) state that too strong lighting considerably reduces the quality of CCTV footage (**Fig 6**).

Figure 6: An Example of an Inappropriate Lighting Level of a CCTV Image

Image A(Original image) **Image B** (Enhanced image)

Proximity is another important factor affecting identification from CCTV images. A large distance between the CCTV camera and the target does not allow for personal identification. **Fig. 7** is an example of long range CCTV recording. It is not likely to be suitable for personal identification.

Figure 7: An example of a long range CCTV image

Image A(Original image) **Image B** (Enhanced image)

Keval (2008) indicated other variable factors (**Table 1**) which affect the CCTV video quality and expert/observer's performance.

Table 1: Factors Affecting CCTV Video Quality and Expert/Observer Performance

Target	Technical	Environmental	Owner
Gender Race Ethnicity Gait Posture Clothing & accessories Skin tone Hair style Hair colour Facial features (scars, moles, birth marks)	Camera height Camera resolution Camera position Age of equipment Camera connections Type of CCD chip Type of recorder Recorder (storage) capacity Network capability Network reliability Video CODEC Compression level VHS tape quality	Physical obstructions Weather conditions Lighting capture area Accidental damage Vandalism Business of scene Special events	Lack of knowledge about technology Technophobic user Equipment not maintained regularly Low budget for system/network Poor advice from installers and sales **User** Training Experience in task Level of skill Motivation Familiarity with system

The forensic expert analyzes the footage based upon the standard operation procedure (SOP) including video-image enhancement, editing and facial comparison applications. The details of the face obtained from the CCTV footage have an important role on the expert's conclusion. However, Home Office National CCTV Strategy (2007) reported that 80% of CCTV footages in the UK were far from ideal and not useful for as evidence because of low quality recording.

3. Materials and Methods

3.1. Materials

Materials obtained from different types of CCTV footages and personal photographs. Materials were split into two main parts;

3.1.1. Query Images

There are five query sets of CCTV images which are of different quality. Every query set has five CCTV images.

- First query Set of CCTV ımages; It consists of one moderate quality image (**image no 4**) and three poor quality images affected by different factors (**image no 1:** blurry effect, **image no 2:** low resolution, **image no 3**: incorrect lighting effect) created in laboratory work **(Table 2)**.

Table 2: First Query Set of CCTV Images

IMAGE NO:1	IMAGE NO:2	IMAGE NO:3	IMAGE NO:4
Properties Resolution:72 dpi Lighting: 0% (Normal) **Blurry effect added**	**Properties** **Resolution:25 dpi** Lighting: 0% (Normal)	**Properties** Resolution:72 dpi **Lighting: 60% (-)**	**Properties** Resolution:72 dpi Lighting: 0% (Normal)

- Second query Set of CCTV Images; It consists of one moderate quality image (**image no**

4) and three poor quality images affected by different factors (**image no 1:** blurry effect, **image no 2:** low resolution, **image no 3**: incorrect lighting effect) created in laboratory work (**Table 3)**.

Table 3: Second Query Set of CCTV Images

IMAGE NO:1	IMAGE NO:2	IMAGE NO:3	IMAGE NO:4
Properties Resolution:72 dpi Lighting: 0% Normal) **Blurry effect added**	**Properties** **Resolution:25 dpi** Lighting: 0% (Normal)	**Properties** Resolution:72 dpi **Lighting: 40% (-)**	**Properties** Resolution:72 dpi Lighting: 0% (Normal)

- Third Query Set of CCTV Images; It consists of one moderate quality image (**image no 4**) and three poor quality images affected by different factors (**image no 1:** incorrect lighting effect, **image no 2:** blurry effect, **image no 3:** low resolution) created in laboratory work (**Table 4)**.

Table 4: Third Query Set of CCTV Images

IMAGE NO:1	IMAGE NO:2	IMAGE NO:3	IMAGE NO:4
Properties Resolution:72 dpi **Lighting: 60% (-)**	**Properties** Resolution:72 dpi Lighting: 0% Normal) **Blurry effect added**	**Properties** **Resolution:25 dpi** Lighting: 0% (Normal)	**Properties** Resolution:72 dpi Lighting: 0% (Normal)

- Fourth Query Set of CCTV Images; It consists of one moderate quality image (**image no 4**) and three poor quality images affected by different factors (**image no 1:** incorrect lighting effect, **image no 2:** low resolution, **image no 3:** blurry effect) created in laboratory work (**Table 5)**.

Table 5: Fourth Query Set of CCTV Images

IMAGE NO:1	IMAGE NO:2	IMAGE NO:3	IMAGE NO:4
Properties Resolution:72 dpi **Lighting: 40% (-)**	**Properties** **Resolution:25 dpi** Lighting: 0% (Normal)	**Properties** Resolution:72 dpi Lighting: 0% (Normal) **Blurry effect added**	**Properties** Resolution:72 dpi Lighting: 0% (Normal)

- Fifth Query Set of CCTV Images; It consists of one moderate quality image (**image no 4**) and three poor quality images affected by different factors (**image no 1:** incorrect lighting effect, **image no 2:** low resolution, **image no 3:** blurry effect) created in laboratory work (**Table 6)**.

Table 6: Fifth Query Set of CCTV Images

IMAGE NO:1	IMAGE NO:2	IMAGE NO:3	IMAGE NO:4
Properties Resolution:72 dpi **Lighting: 50% (+)**	**Properties** **Resolution:25 dpi** Lighting: 0% (Normal)	**Properties** Resolution:72 dpi Lighting: 0% (Normal) **Blurry effect added**	**Properties** Resolution:72 dpi Lighting: 0% (Normal)

3.1.2. Target Images

Five target images for each query set are all in similar quality. The images have been scaled to the similar size.

The experts used the same conclusion scale developed by ENFSI/ DIWG (European Network of Forensic Science Institute / Digital Imaging Working Group). It is used by most of the of European Forensic Laboratories (ENFSI/ DIWG, 2009) with the following expressions for the confidence of answers was used (**Table 7**);

- "No evidence to support it is/ is not the same person",
- "Some/limited evidence to support it is/ is not the same person",
- "Reasonable/moderate evidence to support it is/ is not the same person",
- "Strong evidence to support it is/ is not the same person"
- "Very strong evidence to support it is/ is not the same person"

Table 7: The Table of Conclusion Scale

C O N C L U S I O N S C A L E								
SAME PERSON				**NO CONCLUSION**	**NOT the SAME PERSON**			
VS	**S**	**R/M**	**S/L**	**NO EVIDENCE** to support it is/ is not the same person	**S/L**	**R/M**	**S**	**VS**

	CONCLUSION FOR SAME PERSON
	NO CONCLUSION
	CONCLUSION FOR NOT THE SAME PERSON

(**VS**:Very Strong, **S:**Strong, **R/M:** Reasonable/Moderate, **S/L**: Some/Limited)

3.2. Methods

Seven forensic facial imaging experts from three different forensic institutes and three students from Forensic Anthropology departments of two different universities took part in the research. These seven are; six forensic facial imaging experts from Turkish Forensic Police Laboratory [*www.kpl.gov.tr*], one forensic facial imaging expert from Netherland Forensic Institute [*http://www.forensicinstitute*.nl], one PhD student from Anthropology Department, University of Ankara[*www.ankara.edu.tr*] and two M.Sc. and one PhD student from The Centre for Anatomy and Human Identification, University of Dundee[*www.dundee.ac.uk*]. The forensic experts have been working more than seven years in accordance with the standards of ISO 17025. They have experience in at least 1000 forensic cases in the field of forensic facial comparison. The students are being taught on anatomy and forensic facial analysis under the training of Forensic Anthropology, Forensic Art and Forensic Human Identification courses.

The subjects (five male) in query CCTV images were between the ages of 25 and 63 years. The subjects in target images were in similar or the same ages with the subjects in the query images. Every query CCTV

image was examined separately. The Forensic analysts (experts and students) viewed the query and target sets in digital format. They were asked to analyse and compare query CCTV images with the relevant target images separately. They were also set free to use any image processing software and benefit from any kind of scientific sources that they could.

4. Results

In total, 200 forensic facial comparisons (20 comparisons by 10 analysts) were performed in this study. Within this research, 50 forensic facial comparisons were performed on moderate quality images, 150 forensic facial comparisons were performed on poor quality images affected by different factors (50 poor quality images/low resolution, 50 poor quality images/incorrect lighting condition, 50 poor quality images/blurry effect).

4.1. Comparison Results of Moderate Quality Images

92% of the comparisons on 50 moderate quality images were brought to a correct conclusion. 4% of the comparisons were brought to a wrong conclusion. 4% of the comparisons were not brought to any conclusion (**Fig. 8**).

91% of the correct conclusions (either “the same person” or “not the same person”) were performed at a “strong” or “very strong” level (**Fig. 9**).

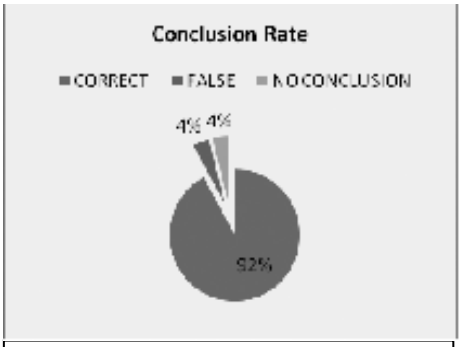


Figure 8: Conclusion rate of comparisons on moderate quality images

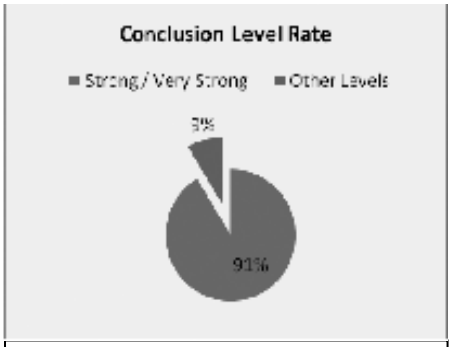


Figure 9: The level rate of correct conclusions on moderate quality images

4.2. Comparison Results of Poor Quality Images

53% of the comparisons on 150 poor quality images didn't come to any conclusion ("no conclusion"). 20% of the comparisons brought a wrong conclusion. 27% of the comparisons brought a correct conclusion (**Fig 10**).

85% of the correct conclusions (either "the same person" or "not the same person") were performed at a "limited" level. 15% of the correct conclusions (either "the same person" or "not the same person") were performed at a "moderate" level. There was no correct conclusion at a "strong" or "very strong" level (**Fig 11**).

Figure 10: Conclusion rate of comparisons on poor quality images

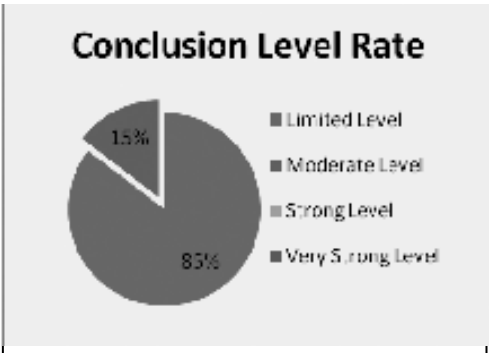


Figure 11: The level rate of correct conclusions on poor quality images

Discussion and Conclusion

This study examined how negative factors in CCTV images affect analysts' examinations and conclusions. The most important finding is that theaccurate facial analysis performance declined with poor quality images. Since the negative factors deteriorated the quality of the CCTV images, facial features were less clear for anthropological analysis (morphological and anthropometrical comparison) and identification.

More than half of the identification of poor quality images (53%) was inconclusive. In addition, one of every five comparisons (20%) was a wrong conclusion. Therefore, the results reveal that a forensic facial analysis can hardly be performed on poor quality CCTV images.

The results also suggest that forensic facial comparison/analysis methods such as morphological and anthropometrical techniques can be performed more accurately with a high level assessment of good/moderate quality CCTV images.

Conclusions were drawn from almost all the moderate quality images (96%). Only two of the moderate quality images (4%) were inconclusive. Contrary to the poor quality images, 46 of the comparisons (92%) on 50 moderate quality images were correctly concluded. Therefore, the results show that forensic facial analysis can successfully be performed on moderate quality CCTV images. The results also show that the analysts who come from different institutes and universities had drawn similar conclusions with a similar level of assessment.

The CCTV system is a very important tool for monitoring and crime prevention. However, seldom will a forensic expert be able to provide a positive identification from poor quality images that stand in their own right as proof in court. There are several best practices, recommendations, and guidelines for facial identification and forensic image analysis published by professional associations and scientific working groups such as the British Association for Human Identification (BAHID), Council for the Registration of Forensic Practitioners (CRFP), and Scientific Working Group on Imaging Technology (SWGIT/FBI). Even so, there is no regulation on the standardization of the image quality of CCTV systems.

In conclusion, we suggest the provision of consistency and high quality standards for image and video recordings. Setting a standard on CCTV systems on the basis of these documents and the results of the studies mentioned above will eliminate the handicaps and failures of

facial identification and forensic image analysis in practice, specifically in forensic cases. The implementation of such a standard in CCTV systems enables the efficient use of morphological and anthropometric techniques for identification purposes.

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