Computer Aided Video Superimposition Device: A Novel Contribution to Skull Based Identification in Malaysia

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ABSTRACT: Skull-photo superimposition is a popular method for suggesting individual identification of unidentified human remains. From its beginning as a process of overlaying photographs, this technique has progressed to utilize video cameras and vision mixers rendering real time analysis of superimposed images. In spite of the popularity in many countries, this method is not in regular practice in Malaysia. Researches conducted earlier in Malaysia describe superimposition generated by the use of reflecting mirrors or Photoshop™. In Malaysia, some of the skulls preserved in Hospital Pulau Pinang and among the human remains buried or cremated in two hospitals in Kuala Lumpur are found to pertain to cases of equivocal death and/or possible homicide. As of now, DNA based identification has been attempted to in about 3% of the unidentified bodies buried or cremated in the hospitals in Kuala Lumpur and the rest of the dead continue to remain unidentified creating an impasse in the identification process and possible further investigation . In most the countries elsewhere, anthropological methods including skull-photo superimposition are being routinely used for the identification of the unidentified dead bodies. Hitherto, an appropriate device for superimposing the skulls and photographs or the required expertise had not been available in Malaysia and these had been the major factors impeding the identification of the unknown bodies. On a few occasions a Japanese professor had been engaged for dispensing skull-photo superimposition expertise in Malaysian courts. For the first time in Malaysia, a Computer Aided Video Superimposition Device has been fabricated in Universiti Sains Malaysia and manpower for utilizing the device has also been generated laying the foundation for practicing skull based identification indigenously. This article describes the Computer Aided Video Superimposition Device (CAVSID) fabricated and the manpower generated in the Health Campus, Universiti Sains Malaysia – research ventures that would place Malaysia among the countries elsewhere pioneering in human identification in forensic science.

Keywords: forensic science, forensic anthropology in Malaysia, video superimposition device, skull-photo superimposition, identifying the unidentified dead

Introduction

Skull-photo superimposition relies on the match between the image of an unidentified skull and the face image of a suspected dead individual and has been accepted as a scientific method for suggesting individual identification of unidentified human remains (Glaister, 1947; Sen, 1962; Krogman and İşcan, 1986; Iten, 1987; Chandra Sekharan, 1989; Gruner, 1993; İşcan, 1993; Jayaprakash et al. 2001; Taylor and Brown, 1998; Komar and Buikstra, 2008). Unidentified human remains encountered in criminal and civil circumstances include recovery of skeletonized remains, decomposed or dismembered bodies as found during homicide or unnatural death investigations, bodies subjected to shearing forces as in explosions, burnt or charred remains in mass disasters such as air crashes, tsunami etc. This method continues to be popular (Taylor and Brown, 1998; Kringsholm et al. 2001; Anderson et al. 2008; Hinkes, 2008; Anderson, 2008; Komar and Buikstra, 2008; Fenton et al. 2008; Cattaneo et al. 2010; Cavard et al. 2010) as it relies on the use of commonplace evidence, face photographs of missing individuals for comparing with the skulls recovered from human remains. After the premier acceptance of skull-photo superimposition based identification as evidence in the court of law in England, this method had gained legal acceptance in most of the countries (Glaister, 1947; Sen, 1962; Taylor and Brown, 1998; Hagemeier 1983; Quatrehomme and Iscan 2000; Nickerson et al. 1991; Brown et al. 1981; McKenna et al. 1984; Komar and Buikstra, 2008) including Malaysia (John Nyumbei v., P.P., 2007;

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Hetty, 2009). Whenever blood relatives of the suspected dead individuals cannot be located due to lack of tentative identity and hence DNA based identification becomes impossible or DNA is not retrievable (Christensen and Crowder 2009; Gonza´lez-Andrade et al. 2006; Taylor and Glassman, 2000), skull-photo superimposition becomes the major alternate scientific method since face photographs are commonly available The problem of unidentified dead bodies has been well documented in forensic science (Kringsholm et al. 2001; Anderson et al. 2008; Hinkes, 2008; Anderson, 2008; Fenton et al . 2008; Slaus et al. 2007; Cavard et al. 2010; Rohan et al. 2009; Petju et al. 2007; Sribandimongkol et al. 2007; Tsokos et al. 2006) and skull-photo superimposition has been indicated as a possible solution by recent workers (Anderson et al. 2008; Hinkes, 2008; Anderson, 2008; Fenton et al . 2008). Although skull-photo video superimposition process has acquired popularity in most of the countries (Snow, 1976; Dorion, 1983; Iten, 1987; McKenna, 1988; Chandra Sekharan, 1989; Lan and Cai, 1993; Yoshino et al. 1995; Jayaprakash, 2001), yet, thus far, a device for the above purpose had not been available in Malaysia. Consequently, manpower for this expertise had not been available here impelling the utilization of an expert from abroad (John Nyumbei v., P.P., 2007; Hetty, 2009). It is seen that unidentified dead bodies, including those in which cause of death is equivocal, are not infrequent in Malaysia (Hetty, 2009) when compared to other countries (Kringsholm et al. 2001; Anderson et al. 2008; Hinkes, 2008; Anderson, 2008; Fenton et al . 2008; Slaus et al. 2007; Cavard et al. 2010). In the absence of facility for skull based identification, these dead bodies continue to remain unidentified and are being disposed off as such which may lead to dead end in the investigation process. Fabrication of Computer Aided Video Superimposition Device in Universiti Sains Malaysia and generating the required manpower has filled in the void that had existed hitherto paving the way for possible identification of such unidentified dead bodies and placing Malaysia on par with the countries in the world that lead in human identification.

Relevance of skull-photo superimposition as an identification technique

In forensic science practice, the need for popularizing a method depends on two prime grounds, first, that the method must have obtained acceptance among the scientific community at the international level and second, that, there should be a social need for the method to solve criminal cases. On both these grounds, skull-photo superimposition method amply qualifies for implementation. In the FBI, the popularity of identification of the dead using skull-photo superimposition recorded its peak during the nineties and this was found to reflect the availability of equipment and expertise as well as the awareness on the part of forensic science and law enforcement agencies (Ubelaker, 2000). There was a decline in this utility as molecular approaches became popular (Ubelaker, 2000). Indicating the above trend, recent workers have noted certain problems in relying on molecular approaches alone and have expressed optimism in expecting photographic superimposition to increase (Taylor and Glassman, 2000; Ubelaker, 2000). In tune with the above optimism, most of the European countries (Kringsholm et al. 2001; Anderson et al. 2008; Hinkes, 2008; Anderson, 2008; Fenton et al . 2008; Cattaneo et al. 2010; Cavard et al. 2010) and those in Asia and the east (Lan and Cai, 1993; Yoshino et al. 1995; Jayaprakash, 2001) have reported current utility of skull-photo superimposition method. Recent text books have also indicated the popular use of skull-photo superimposition evidence in the courts (Taylor and Brown, 1998; Komar and Buikstra, 2008). Molecular techniques based identification of human remains may appear befitting the western countries where dental records form the prime source for human identification. In countries like India where dental records are seldom available, skull-photo superimposition continues to be in regular practice from as early as during 1960. Similar to the earlier observation (Ubelaker, 2000), the first author found a trend in the utility of skull-photo superimposition that increased from 15 cases during the period from 1971-1975 to 412 cases during the period from 1996-2000 (Jayaprakash, 2001) to align with the availability of man power and appropriate equipments coupled with awareness on the part of the investigating officers. Lack of dental record is also a common problem in the south East Asian countries (Taylor and Brown, 1998; Komar and Buikstra, 2008; Sribandimongkol et al. 2007; Tsokos et al. 2006) including Malaysia. It is pertinent to cite that many workers have recognized the difficulties and the frequent circumstances that resulted in the inability to obtain DNA from the remains or as exemplar samples or other problems relating to utility of DNA (Sribandimongkol et al. 2007; Tsokos et al. 2006; Baraybar, 2008) and have stressed the need for conventional anthropological analysis. In view of the above facts, for Malaysia and other south East Asian countries, resorting to DNA technology for identifying human remains would not eliminate the need for applying conventional anthropological methods such as skull-photo superimposition.

Unidentified dead: its relevance for popularizing skull-photo superimposition

In Milan, Italy, during the 14-year period from 1995 to 2008, a total of 454 cadavers were received as unidentified out of which positive identification

could be achieved for 62%. The mean unidentified dead per year was 32. The authors list the most frequently methods used in decreasing order as follow: visual, fingerprints, soft tissue personal descriptions, information from respective consulates, forensic anthropology, forensic odontology and DNA (Cattaneo et al. 2010). Identification of the unidentified dead is reported from other countries like Denmark (Kringsholm et al. 2001) and France (Cavard et al. 2010). In Malaysia the second author had preserved 20 unidentified skeleton remains with skulls in appropriately dealt facilities anticipating the future identification since the cause of death was either equivocal or indicating possible homicide. During the 10 years period, between 1999 and 2008, in two hospitals in Kuala Lumpur (HKL and UMMC) a total number of 441 unidentified dead bodies have been buried or criminated and in about 116 of them cause of death was either indeterminable or indicating possible homicide (Hetty, 2009). Among the 411 instances, DNA based identification had been attempted in 12 instances (about 3%). Records relating to subsequent identifications, if any, among the above 411 cases are not available (Hetty, 2009). The unidentified dead continuing to be so or being disposed off as such is seen to be a fair ground for popularizing conventional anthropological methods such as skull-photo superimposition for purposes of establishing identity. A comparison of the unidentified dead in the above countries is provided in **TABLE 1**. The data on the missing individuals available in PDRM, Malaysia (Hetty, 2009) indicates that about thousand missing individuals continue to remain untraced every year (**TABLE 2**).

TABLE 1: Comparison of the annual mean among the unidentified dead and rate of identification

Country	Period of study	Unidentified bodies (annual mean)	Per cent identified
Milan, Italy[*]	14-year period from 1995 to 2008	32	62%
Denmark[×]	5-year period 1992-1996	18	88.76%
France[α]	6-year period from 2003 to 2009	22	89.8%
Malaysia[β]	10-year period from 1999-2008	41	---

Note: [*]Cattaneo et al., 2010; [×]Kringsholm et al., 2001; [α]Cavard et al., 2010; [β] Hetty, 2009

TABLE 2: Data on missing individuals; traced and remaining untraced [PDRM, Malaysia] (Hetty, 2009)

Years (5)	Total number of persons reported as missing		Total number persons traced alive		Total number of persons that remained missing	
	Male	Female	Male	Female	Male	Female
2004-2008	4,622	10,528	2,633	6,645	1,989	3,883
	15,150		9,278		5,873	

Studies on the reliability in skull-photo superimposition

There have been controversies on the reliability of skull-photo superimposition based identification. Aulsebrook et al. (1995) recognized the credibility of superimposition system shown on human remains collected by the Smithsonian Institute by Ubelaker et al (1992). Among the other researches (Koelmeyer, 1982; Dorion, 1983; Seta and Yoshino, 1993; Austin-Smith and Maples, 1994; Yoshino et al. 1995), Austin-Smith and Maples (1994) verified superimposition using one skull with multiple photographs of living individuals and reported about nine per cent chance of wrong match. However, these authors (Austin-Smith and Maples, 1994) did not evaluate fitness of superimposing images in 'life size'. Furthermore, they did not apply anthropological measurements from the skull for bringing out the life size of the face photographs but instead used average tissue thickness. Cranio-facial morphanalysis, an additional procedure for conjoint application with skull-photo superimposition, has been shown to eliminate wrong matches (Jayaprakash et al, 2001). Preliminary studies (unpublished) in Universiti Sains Malaysia that included the application of cranio-facial morphanalysis indicate an enhanced reliability in skull photo superimposition. Recent authors have endorsed superimposition method as reliable provided adequate caution is exercised (Taylor and Brown, 1998; Komar and Buikstra, 2008). As had been stressed by many authors, this method cannot generate 'definite' identity (Glaister, 1947; Sen, 1962; Krogman and İşcan, 1986; Iten, 1987; Chandra Sekharan, 1989; Gruner, 1993; İşcan, 1993; Jayaprakash et al. 2001; Taylor and Brown, 1998; Komar and Buikstra, 2008). It is well to remember the instructive guideline of Thomas Dwight that 'absolute certainty' is not the objective in anthropological identification (Stewart, 1979). Rather, the expert is required to assist in establishing the identity and it would be for the judge to confirm it. In forensic science practice, the best measure of a success of a method would be to assess its acceptance by the courts where the ultimate utility of the method for the purpose of justice administration is tested.

Court acceptance of superimposition evidence

Internationally, identification of human remains using skull-photo superimposition method has gained acceptance as evidence in the courts in England (Glaister, 1947), Australia (Brown et al. 1981), Hong Kong (McKenna et al. 1984), Japan and Malta (Taylor and Brown, 1998); Germany (Hagemeier 1983), France (Cavard, 2010), Switzerland (Taylor and Brown, 1998) and India (Sen, 1962; Jayaprakash et al. 2001; Komar and Buikstra, 2008). The first author had testified on skull-photo superimposition in the courts of Tamil Nadu, India in 211 instances during the ten year period from 1994 to 2004. In Malaysia, courts have accepted identification of human remains using superimposition method in three instances (John Nyumbei v., P.P., 2007; Hetty, 2009) wherein the superimposition is indicated to have been carried out by Prof. Dr. Masatsugu Hashimoto, University of Tokyo, Japan. The ample evidence on the acceptance of this method by the courts, abroad as well as in Malaysia is a fair endorsement on the reliability of this method for application in the context of identifying the dead.

Skull-photo superimposition: state of the art of research in Malaysia

Pertaining to skull-photo superimposition method in Malaysia, identification of a charred skull based mainly on the recovery of part of a 'Chanel' ear ring has been reported and skull-photo superimposition has been mentioned although the methodology has not been described or the results illustrated (Noorazman and Shahrom, 2007). An article on superimposition indicates the use of Furue's method as the choice for the study as it was inexpensive (Scully and Nambiar, 2002). A case report (Noorazman and Shahrom, 2006) describes the application of Photoshop™ for the purpose of dental model superimposition. It has to be mentioned here that, elsewhere, the experts who had been researching on or applying superimposition for application purposes of justice in the court law from early seventies till recent times (Snow, 1976; Koelmeyer, 1982; Dorion, 1983; Iten, 1987; McKenna, 1988; Chandra Sekharan, 1989; Lan and Cai, 1993; Aulsebrook et al. 1995; Yoshino et al. 1995; Jayaprakash, 2001; Komar and Buikstra, 2008; Fenton et al . 2008) had been employing the validated method of producing the superimposition effect using the video-vision mixer and mirror based image mixing would not serve such purposes. Yet another research on craniofacial analysis in Malaysia related to developing craniofacial database for Malaysian population (Rajion et al. 2005) which has no relevance to individual identification in forensics. The descriptions of the methodology in the researches described above indicate that there is a paucity of state of the art equipments for conducting skull-photo superimposition. It is also seen that the institutions involved superimposition in Malaysia are those that are other than forensic science laboratories while many countries such as the USA, Japan, China and India, superimposition based identification is dispensed as a regular service by the forensic science laboratories. As such, skull-photo superimposition is yet to form part of the scientific methods in the forensic science laboratory for providing service to the investigation officers in Malaysia.

Skull-photo superimposition: contributions from USM, Kubang Kerian

Forensic Science being a course offered in Universiti Sains Malaysia, the necessity for contributing to fabricating validated and state of the art equipments and generating man power for popularizing skull-photo superimposition was duly recognized and a research initiated in this regard was supported by RU grant 1001/ppsk/843011. The major objectives set forth included fabricating a Computer Aided Video Superimposition Device (CAVSID) and generating man power for performing skull-photo superimposition in Malaysia.

Fabrication of Computer Aided Video Superimposition Device (CAVSID)

The Computer Aided Video Superimposition Device (CAVSID) (**FIG. 1**) fabricated in Universiti Sains Malaysia is the first of its kind in Malaysia (Ridzuan et al. 2009). The device consists of the following components:

Two high resolution (600 pixel) CCD video cameras (Bosch) with Fuginon TV Zoom lens (Manual: 1.2/12.5-7.5) enabling zooming the images in focus locked state for capturing high resolution images of the skull (**FIG. 2**) and face photograph (**FIG. 3**). These cameras are mounted on high quality tripod (Manfrtto™) camera stands for providing stability during fine adjustments while enlarging the face photograph or positioning the skull. A digital video vision mixer (Panasonic-G-MX70E) that enables real time capture of the images in analogue form is connected to the cameras. The vision mixer is the prime component that enables mixing the two images independently captured by the two CCD cameras. The mixing effects include a range of the two major types, one fade effect (**FIG. 4**) and the other wipe

effect (**FIG. 5**). The independent images of the skull and face photograph are cast on a 32 inch LCD TV monitor in 'life size'. The 2-D images of the skull and face photograph are measured for affirming their relative size to that of the skull in 3-D form. The flat screen in the LCD monitor permits measurements with least error. During the process of superimposition, the match between the skull and face images is visually assessed based on the correspondence between the skeletal organs of the skull mage and the organs in the face image utilizing the fade and wipe facilities of which the wipe mode offers better assessment. A remote-controlled pan and tilt device (CS Lilin™, PIH-303 Model) to which the universal skull clamp is fabricated to be held on stand is used for manipulating the various movements of the skull for achieving the desirable positioning in correspondence with the posture of the face seen in the face photograph. A control unit for the pan and tilt device (PIH-301-C (24VAC/240VAC) that enables finer movements of the skull is positioned in a location of favorable ergonomics from where the various movements can be effected and observed with ease. A VCR (Sony™-SLV-C317PS) for recording the real time analogue images generated during the superimposition process is connected to the video vision mixer. In spite of the facilities to store the superimposed images in digital form, recording the analogue images is considered essential to counter the suggestion that is often put forth during the trials that the digital images are prone for manipulation (Du Chesne et al. 1999). Alongside the connection to the TV monitor from the vision mixer, there is another cable connection to a computer system with video capture software (Compro™) and a 22 inch LCD monitor (Samsung) and this system is used for capturing the superimposed images both frame by frame or as video strip. The captured images are printed in black and white using a laser printer (1200 pixels resolution). Two improvised vertical stands are used, one for affixing the enlarged face photograph and, the other for fixing the servo assisted pan and tilt device supporting the skull. These stands are provided with soft dark blue velvet cloth background for avoiding shadow and scattering of light.

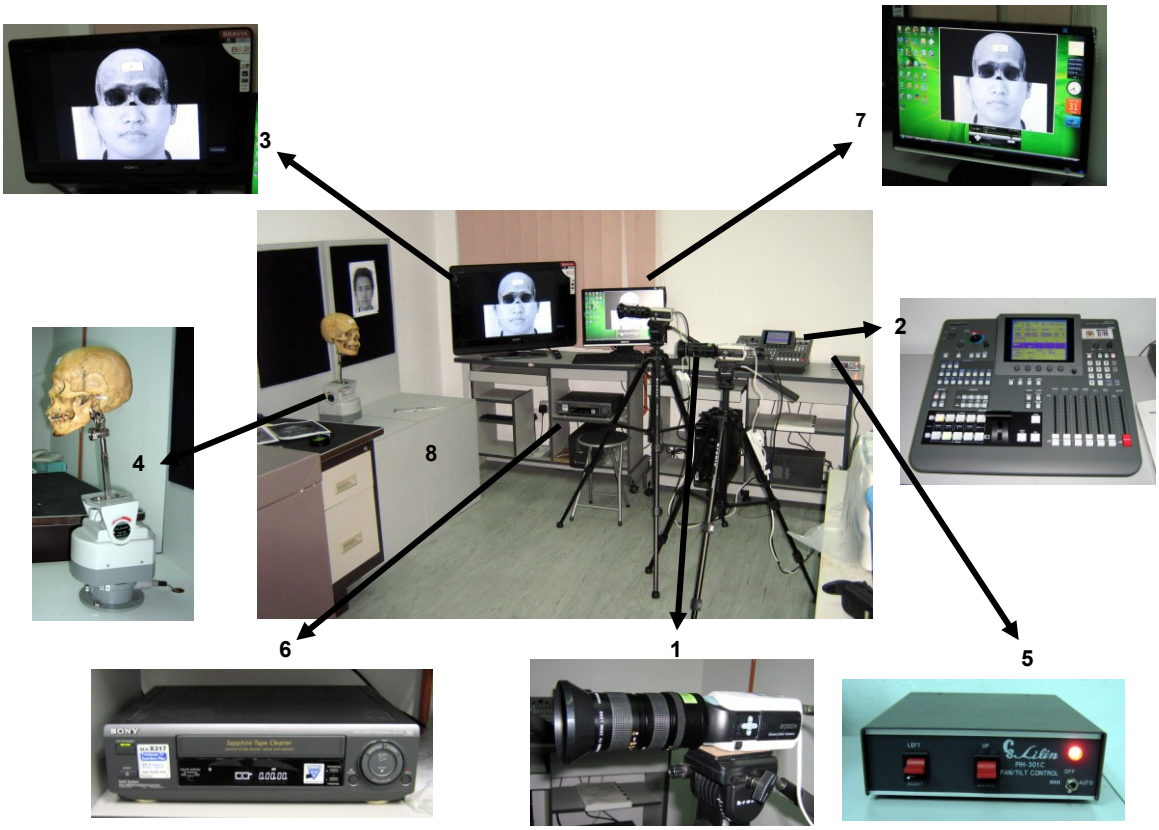

FIG. 1- Components of the Computer Aided Video Superimposition Device (CAVSID) fabricated in Universiti Sains Malaysia, the first of its kind in Malaysia.
(1- CCD video camera (Bosch) with Fuginon TV Zoom lens (Manual: 1.2/12.5-7.5); 2- Digital video vision mixer (Panasonic-G-MX70E); 3- 32 inch LCD TV Monitor; 4- Pan and tilt device (CS Lilin™, PIH-303 Model) with skull clamp; 5- Control unit for the pan and tilt device (PIH-301-C (24VAC/240VAC); 6- VCR (Sony™-SLV-C317PS); 7- Computer system with video software (Compro™) and 22 inch LCD monitor; 8- Improvised vertical stands for affixing skull and face photograph)

FIG. 2- Skull image

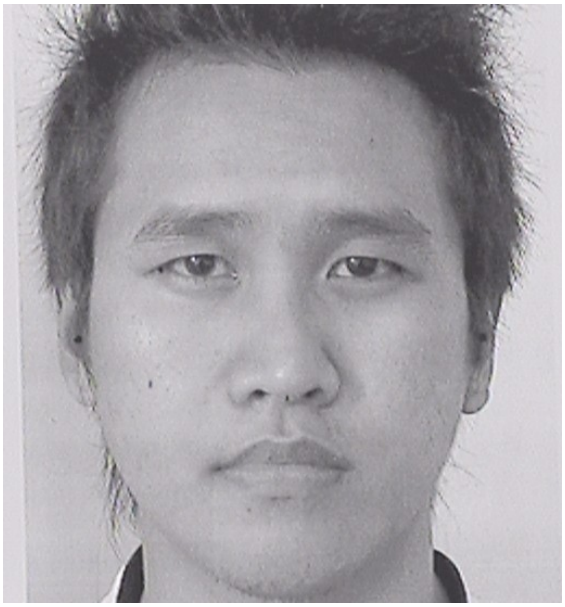

FIG. 3- Face image

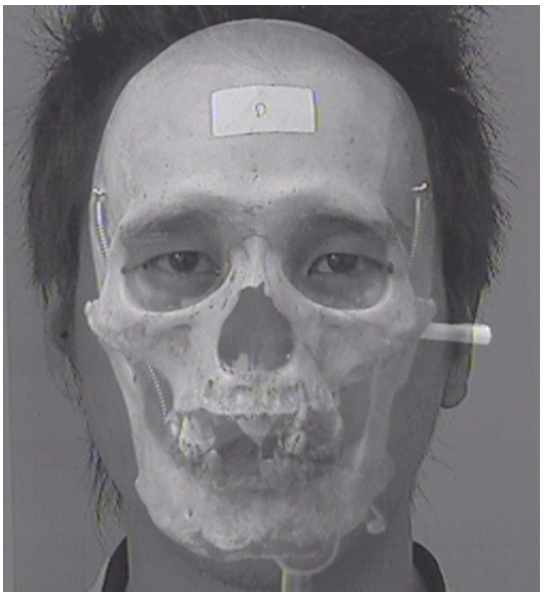

FIG. 4- Superimposed image (fade mode)

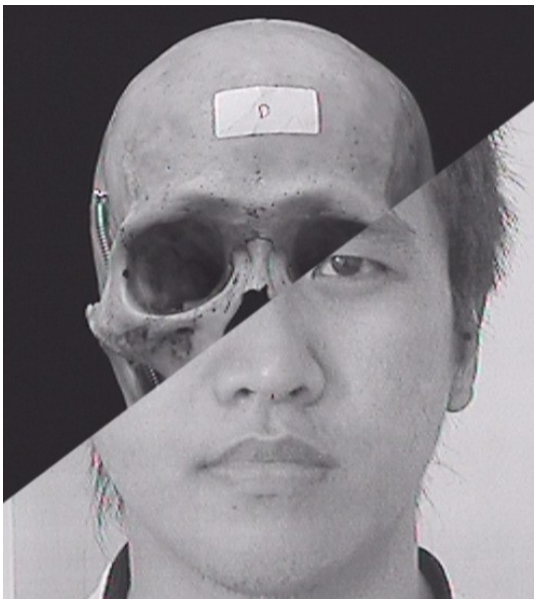

FIG. 5- Superimposed image (wipe mode)

The minimum distance between the skull and the video camera is 1.2 m, and a similar distance is maintained between the "life size" face photograph and the other video camera. A distance of more than 1 m has been shown to reduce distortion in the skull to a minimum level permitting superimposition of its 2-D image. Diffuse fluorescent light from two 40 w tube lamps positioned 2.3 m in front of the skull at a height of 0.75 m above the level of the skull is used for illumination for the skull as well as the face photograph.

The advantages of the present device

The often cited work on the reliability of identification using the skull-photo superimposition method is the one reported by Austin-Smith and Maples in 1994. These authors compared three skulls of known identity with 98 face photographs of living individuals and found that there could be chance of 9% wrong match when only one photograph was used. The video monitor they used was Panasonic model WV-5410. This monitor being a 14 inch CRT type, would produce low resolution images which would be far smaller than the 'life size' as the CRT's diagonal measurement was only 14 inches. In the device described here, high resolution images are cast in 'life size' on a flat LCD screen, a prime advantage for comparative study of the skull and face morphology. Computerized superimposition was found to be useful only for lateral view photographs and for computerizing the entire process of superimposition one may have to wait for the researches on neural networking to advance to equal the output of the human brain (Jayaprakash et al. 2001). Capturing the images from the TV screen for presentation as evidence, a process that was formerly accomplished by direct photography, is now performed by using commercially available video capture software installed in the computer system.

Man power generation: pioneering contribution from USM

Forensic anthropology is a relatively new branch both in institutions teaching physical anthropology as well as in forensic science laboratories. Even before forensic anthropology was recognized as branch in American Academy of Forensic Sciences i.e. during 1972 (Stewart, 1979), skull-photo superimposition had been practiced in the forensic science laboratories since early sixties and the qualification of the expert performing had remained largely ill defined. In the context of Daubert criteria, the qualification of the expert has acquired importance and the American Board of Forensic Anthropologists (ABFA), the body that is often cited for quality criteria for experts and procedures, has indicated degree in physical anthropology as the qualification for the forensic science staff engaged in human identification. However, insisting physical anthropology as the qualification may not suit Asian countries where physical anthropology is seldom offered as course in popular universities. When the first author, a zoologist, was posted to work in the Anthropology Division in the Tamil Nadu Forensic Science Laboratory, Chennai, India, training in physical anthropology in one of the pioneering universities in India was arranged. During the training, it was found that the anthropology department of that university had neither the equipments nor expertise to teach anything relating to skull based individual identification in general and superimposition technique in particular. This was not surprising since physical anthropologists are normally concerned with general traits applicable to populations rather than individual identification. In the context of forensic science practice, the requirements from the investigation and judicial officers categorically relates to individual identification and suggestion on general traits will be of little applied value. Under these circumstances, in Asian countries, adherence to the prescription of physical anthropology as the qualification for developing forensic anthropology may defeat the very purpose of introducing this branch of forensic science. Instead, graduates in forensic science can be encouraged to do masters in the specific area of skull based identification and can be employed in the forensic science laboratories where Forensic Anthropology can be started as separate division devoted for identifying the unidentified dead. From this point of view, Universiti Sains Malaysia has made a pioneering contribution to this country by initiating the production of Master candidate in the skull identification.

Conclusion

Unidentified dead bodies are posing a challenge that has been well reckoned internationally. In the context of lack of dental records or DNA samples from siblings, the only other option would be resort to the conventional anthropological methods like skull-photo superimposition. Thus far, facilities for skull-photo superimposition has been lacking in Malaysia proving a void in applying the above conventional method for the identification process. In the absence of a method for skull based identification, unidentifiable human remains would continue to remain without identification leading to dead end in the investigation process. Since skull-photo superimposition method has potential use in utilizing the photographs of missing individuals for suggesting possible identity using the skulls recovered from unidentified dead bodies and since a unit has been fabricated in Malaysia, there is no reason why this method should not be used on routine basis. Such use would be similar to victim identification ventures in FBI that can be extended to mass disaster victim identification also. Describing the Computer Aided Video Superimposition Device fabricated for the first time in Malaysia in Universiti Sains Malaysia, it is proposed that skull-photo superimposition be introduced and popularized in Malaysia contributing to reducing the problem of the unidentified dead in Malaysia.

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