Glasnik Antropološkog društva Srbije / Journal of the Anthropological Society of Serbia
Niš, vol. 53, str. 29–37, 2018, UDK 572(05), ISSN 1820-7936

Stručni članak
Professional Paper

UDK 343.892.3/.9
doi:10.5937/gads53-16924

SUPERIMPOSITION - SP: 304 / 04 G.Z.

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Summary. Skull/image superimposition is the most prevalent method by which unknown skulls are being identified, since a photograph of the suspected dead person may be easily obtained from the victim's family. The sculls were photographed under the same angle as the head of the subjects during their lives. The most delicate part of the work was the correct positioning of the scull on the stand, and proportional magnification of the scull image. The Adobe® Photoshop® 6.0. (PWW600R724387 - 473) computer program was used during the experiments. After being incorporated in the computer memory, digitalized images of the scull and face were put one over the other and showed on the monitor in order to determine their possible congruence or differences. A special attention was paid to the congruence of the same anthropometrical spots of the scull with the face, as well as to following their contours. The process of fitting the skull into the image usually begins by positioning the eyes in correct relation to the orbits. The skull must not be broader or longer than the soft tissue on the image, and the chin, mouth, nose, ears and so on, should be in their correct positions. All difficulties, associated with the superpositioning process were recorded, with the special attention to the critical evaluation of negative and positive superimposition. The social justification of this method for identification, on both state and international level (Interpol) was noted. The paper has been fully illustrated with images showing all stages of the work by chronological and logical order. This is the one of the first papers trying to complete superimposition in our country.

Key words: Forensic Science, Forensic Anthropology; Face; Image processing, Computer-assisted; Scull.

Case Report

Saponificated corpse of an unknown female person was found in the Tisa River, near Zrenjanin (Serbia) in 2004. According to the type of drowning (submersio) the autopsy established that the cause of death was mechanical asfiction. The personal document found in the corpse's clothes (Levi's company pass) proved that she was a citizen from the neighbouring Hungary, 40 years old (born in 1964) whose corpse floated down the river to our country. The skull and the photograph of her face were used for making the superposition.

Methods

Assembling the skull into a whole – After the autopsy, all saponificated tissues were mechanically removed from the skull (Figs. 1 and 2). Following this, the skull was boiled and faded with 33-36% of hydrogen-peroxide (H_2O_2). The arch of the skull and the lower jaw were joined with thin, 1mm-thick, rust protected wires with the remaining parts of the skull. The lower jaw was placed in so called *physiological state of rest.*

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Primljeno u redakciju 22. 3. 2018, rad prihvaćen za publikovanje 11. 6. 2018.

Skull positioning and photographing – The assembled skull was placed on a wooden stand (29x21x4, 5 cm) with a support (27x3 cm) which was inserted into the big hole of the back of the head. By a digital camera (SONY DSC S85 4.1 Mega pixels) the skull was photographed on the tripod stand, first frontally in the so called *Frankfurt horizontal level.* This image served for subsequent control of the correct skull positioning. Then the skull was positioned according to the head position like from the photograph taken during life, and a few images were taken. These images were mutually analyzed by computer with the position on the photograph. If necessary, the skull position was adjusted until it reached its correct positioning. In the work Computer (Intel – Pentium(R) IV CPU, 2.0 GHz, 512 Mb RAM) was used, System (Microsoft Windows XP Professional, Version 2002), Computer program (Adobe® Photoshop® 6,0 – (PWW600R724387 – 473), as well as scanner (Canon CanoScan D 1250 U2).

Proportional enlargement of the skull image according to the face image. – There are several modes (Iscan & Helmer, 1993; Iten, 1987; Bajnoczky, 1994; Takač, 2007a, Takač i Budakov, 2007; Delfino et al., 1993; Hunger & Leopold, 1978; Krogman, 1973; Eckert & Teixeira, 1985; Gatliff, 1984; George 1987; Gerasimov, 1955):

1. **Net of thin vertical and horizontal lines (raster)** over both images on the screen. By comparing parts of both images, or contours of the skull and face within the same raster, it is possible to do exact enlargement of the skull and its correct positioning.
2. **Rubber markers for the tissues,** glued to the anthropometric skull points, show thickness of the face's soft tissues on these spots. The skull image is enlarged until the peaks of the tissue markers reach the edge of the soft tissues of the face in profile and an face (Goyne, 1982; Kiszely, 1976; Jordanov, 1981; Balneva et al., 1988; Takač, 1990, 2005, 2006a, 2006b).
3. **Inserting a marker into the anterior acoustic pore of the skull.** The anterior acoustic pores are not visible from the frontal skull position. Aiming better show, a marker is inserted into them (a thin stick of 5-6 cm length) and then they are photographed (Fig. 3). It is important for placing the skull in so called *Frankfurt horizontal level*, and later for correct enlargement of its image on the screen (Iscan & Helmer, 1993; Bajnoczky, 1994).
4. **Rectilinear section of the face image (Vertical, Horizontal and Diagonal Sweeps)** serve for the control of the correct face image enlargement, as well as for correct positioning of the face organs at the skull (Figs. 7, 8). The horizontal double section of one face segment over the skull is a special type (Box Sweep) which is used for a clearer show of the superposition of a certain face segment (only the position of eyes, nose or lips, in relation to the skull) (Figs. 9, 10) (Iscan & Helmer, 1993; Bajnoczky, 1994; Takač, 2007a, Kiszely, 1976).
5. **Fading/blending of the skull over the face image (Blending or Fading)** It may be done by decreasing or increasing the transparency level of the skull over the face (Fig. 11). By parallel rapid fading and blending of the skull image over the face, a clearer projection of eyes, ears, nose, lips and contours of the chin may be obtained related to the bone structure and holes. Errors are corrected by skull repositioning and by proportional enlargement of the skull image (Iscan & Helmer, 1993; Taylor, 2001).
6. **Accessory lines with rectilinear** connection of the same anthropometric points on the skull and face (at least eight lines). Both images are placed next to each other on the screen, (they are connected with horizontal lines) by which the length of the enlargement level of the skull image is controlled (Figs. 3, 4) (Iscan & Helmer, 1993; Taylor, 2001, Bajnoczky, 1994; Takač, 2007a).

7. **Distance measuring** between related anthropometric points of the skull and face. Anthropometric points on the digital image of the skull and face are marked. The computer automatically measures the distance between two anthropometric points on the skull image. Both measured points and their mutual distance are transferred to the face image at the same place. The other measured pairs are transferred likewise. If there is a significant difference between their position and distance in both images, it is necessary to do a new enlargement of the skull image or to perform repositioning of the skull. By their mutual comparison, both the enlargement and positioning are checked in relation to the position of the head on the photograph (Bajnoczky, 1994; Takač, 2007a).
8. **Measuring of the overlap angle** among three related anthropometric points. By connecting one anthropometric point with the other two, it is possible to do correct enlargement of the skull image, as well as to perform additional repositioning of the skull (Bajnoczky, 1994).

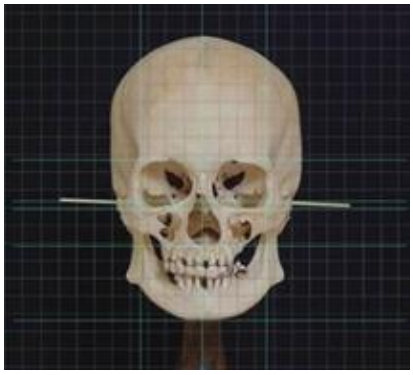
Correct superimposition of the skull and face image. By superimposition, adaptation of all contours, thickness of the soft tissues and overlap of the identical anthropometric points is checked. Eyes, nose, lips and ear conchae are positioned at their definite places on the digital skull image (Jordanov, 1981; Balneva et al., 1988; Takač, 1990, 2005; 2006a, 2006b, 2007b, 2007c; Taka; i sar., 2008). The most important points in digital images of the skull and face are marked by small circles, a small dot and square or connected by a line (Fig. 5). The superimposition is acceptable if the related anthropometric points correspond with each other, including the soft tissue thickness of the face (Figs, 5, 6).

Results

Chronological and logical sequence of all work stages is presented on the photographs..

Slika 1. Izgled lobanje saponifikovanog leša.
Figure 1*. Look of the skull of a saponificated corpse.*

Slika 2. Ceo izgled saponifikovanog leša.
Figure 2*. The open display of the saponificated corpse.*



Slika 3. Oznaka antropometrijskih tačaka lobanje pomoću linija.
***Figure 3**. Anthropometrical skull's points are marked by lines.*

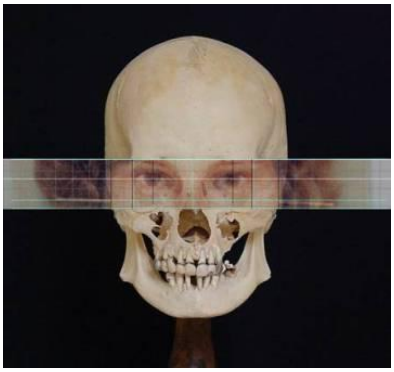
Slika 4. Oznaka antopometrijskih tačaka lica pomoću linija.
***Figure 4**. Anthropometrical face's points are marked by lines.*

Slika 5. Superpozicija oba digitalna snimka.
***Figure 5**. Both digital snapshots superimposition.*

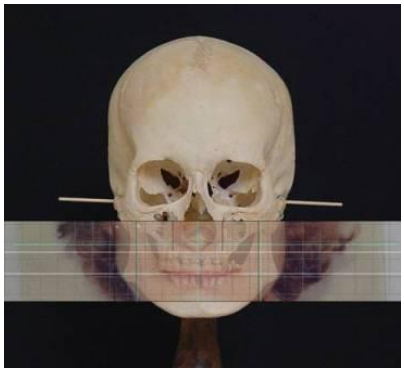
Slika 6. Konačna superpozicija.
***Figure 6**. Final superimposition.*

Slika 7. Vertikalni i horizontalni preseci.
***Figure 7**. Vertical and Horizontal Sweeps.*

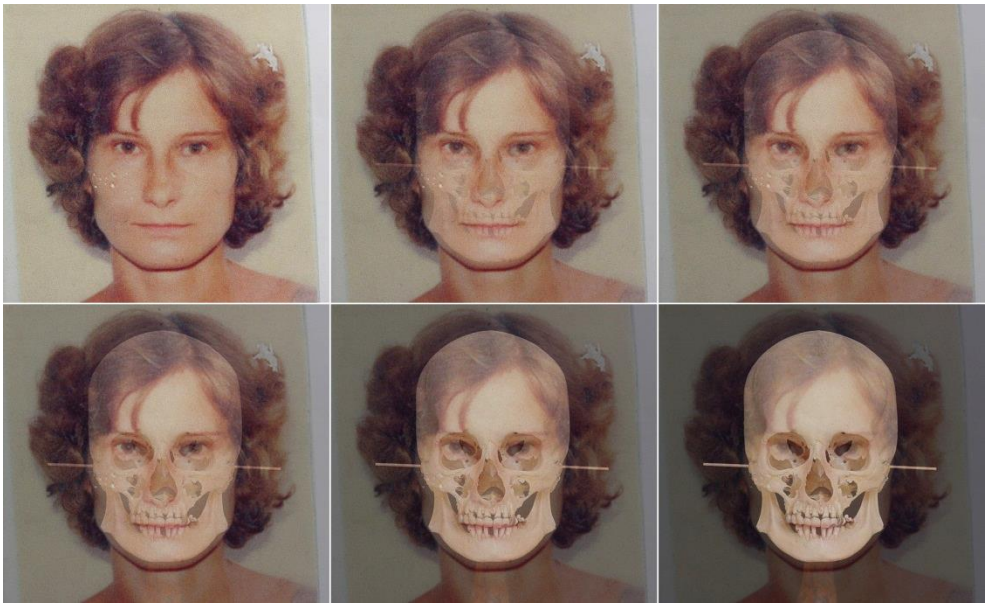
Slika 8. Kosi preseci.
***Figure 8**. Diagonal Sweeps.*



Slika 9. Presek preko jednog segmenta lica.
Figure 9*. Box Sweep.*



Slika 10. Presek preko donjeg sprata lica.
Figure 10*. Box Sweep.*



Slika 11. Postepeno izbleđivanje i tamnjenje slike.
Figure 11*. Blending progression.*

Discussion

The parameters for determining the face organs:

A – Position of the eyes – The first step of a good face superimposition is a good eye position in the orbital holes of the skull image. The eye position in the bone orbit is determined in the following way (Delfino et al., 1993; Hunger & Leopold, 1978; Krogman, 1973; Eckert & Teixeira, 1985; Gatliff, 1984; George 1987; Gerasimov, 1955; Goyne 1982):

a) – In profile – the most extended point of the cornea (Polus anterior oculi s. Vertex corneae) is on the tangent line, pulled from the upper to the lower edge of the orbit.

b) – Frontal – the peak of the coroneae is at the place where two lines cross:
- One is pulled from the point of Maxillofrontale to Ectoconchiona,
- The other is pulled from the middle of Margo supraorbitalis, to the middle of Margo infraorbitalis.

Position of the eyelids. – The internal angle of the eyelids is projected around the middle of the lacrimal hole (Fossa sacci lacrimalis) while the exterior corner corresponds with a small bone protrusion – bridge of the Processus frontalis ossis zygomatici, named after Gerasimov (1955) as Tuberculum orbitale (Whitnall's tubercle after Ernest Whitnall, Oxford, 1911) (Krogman, 1973). Its development shows the development of the muscles Pars palpebralis m. orbicularis oculi.

B – Projection and the nose width - According to Gerasimov (1955) the nose profile is determined by two-line projection:

a) – direction of the lower third of nose bones

b) – direction of the front nose spine (Spina nosalis anterior)

The papers of J. Jordanov and Lebedinskaja supplement Gerasimov's finding proposing to take the basic direction of the total length of nose bones and not only the direction of the lower third, and at the same time also basic direction of the front nose spine (Gerasimov, 1955; Jorfanov, 1981; Balneva et al., 1988). The point where two lines cross determines the tip of the nose, which has a spherical shape. According to Krogman (1973) the width of a pear like opening (Apertura piriformis) in europoid race is about 3/5 of the whole soft tissues width of the nose, measured over nose wings. The tip of the nose is located on the triple length of the front nose spine (measured by Subnasale to Pronasale) (Krogman, 1973).

According to Bulgarian authors (Bojanov, 1965: Jordanov, 1972) the nose width corresponds with the distance between the peaks of upper eye teeth on both sides (Jordanov, 1981). According to Robert M. George (1987) the horizontal surface of the nose is projected on the lower part of the front nose spine curve and its length (protrusion) is 60% of vertical nose length in males, and 55% in females. Russian authors (Lebedinskaja and Surnina, 1988) pointed out that the nose profile could be obtained as follows: a parallel is drawn on the line that connects Nasion-Prosthion points from Rhinion downwards and then the distances from the Aperture piriformis to this line are transferred to the opposite side. The points are connected and the profile of the cartilaginous part of the nose is obtained on which the thicknesses of the soft tissues of the nose are added (Balneva et al., 1988). **The height of the nose wings** is determined on the basis of the height of Cristae conchalis ossis palatine, which is connected to the rear part of Conchae nasalis inferior (Delfino et al., 1993; Gatliff, 1984).

C – Width and shape of the lips - The look of the lips depends on the appearance of the alveolar extensions of the jaws, the width of the teeth range, teeth size and shape, teeth occlusion, senile changes on the jaws, teeth abrasion and race characteristics. According to Gerasimov (1955) the width of the lips is identical with the distance between lateral sides of the other premolars maxillae on both sides, while the height of the lips is determined by the height of teeth enamel (Enamelum) of the upper medial incisors. According to Krogman (1973) the lips width approximately corresponds with the distance between irises of both eyes (interpupilar distance), as well as with the distance of the lines located between the eyetooth and the first premolar maxillae on both sides. Recent researches of Irido-Oral (I-Ch) proportions indicate that the width of the lips corresponds with the distance between medial edges of both irises (Iscan & Helmer, 1993). According to Betty Pat Gatliff, closed lips cover six frontal teeth, while in smiling 8-10 front teeth are seen. The width of relaxed lips corresponds with the distance between the eye teeth and the first premolar on each side, and the height of the lips is determined by jaw lines on the teeth (Gatliff, 1984). According to

Robert M. George the edge of the upper lip (Labrale superior) reaches to the upper fourth of the maxillary incisor at both sexes. In Black people it is higher than the Prosthion point. In the middle part of Rima oris, it is projected in the height of the lower third of the central maxillary incisor in females, and in the height of the lower fourth in males. The lower lip's edge (Labrale inferior) in most people corresponds with the size of the lower ¾ of the central mandibular incisor (George, 1987).

Position and depth of the furrow of Sulcus nasolabialis - If the Fossa canina is deep, and the face bones are of significant relief, then the furrow is also deep and vise versa. The upper part of the skull furrow is projected from the lateral side of the pear-like opening in the level of Cristae conchalis. From that spot it is divergently descending passing over Foosae caninae and ends above the second molar, near the angles of the lips on both sides. By aging it is getting deeper (Taylor, 2001; Delfino et al, 1993; Hunger & Leopold, 1978; Krogman, 1973; Eckert & Teixeira, 1985; Gatliff, 1984; George 1987; Gerasimov, 1955; Goyne, 1982).

D – The influence of the chin bone on the look of the face – The lower jaw participates in shaping the lower oval of the face. The chin is huge and convex, if the lower jaw's angle is straight or is close to straight angle. If the angle is obtuse, the chin is less expressive, placed lower, and not forward (Taylor, 2001; Krogman, 1973; Gatliff, 1984; George, 1987; Goyne, 1982). If the body of the mandible is of relief shape, the chin is huge and rough, and the soft tissues are thicker. Huge chins can be found in the people with a strong physical power and in gigantism (Krogman, 1973; Gatliff, 1984; George, 1987).

E – Position of the auricle – Although it is not considered as a part of the face, ear contributes to its look. There are very few skeleton data which determine the shape and size of the auricle. There is a significant correlation between the auricle and the length of the nose. As a rule, the thumb, ear and nose are approximately of the same length as from the metacarpophalangeal joint to the top of the thumb. The distance between Glabele-Subnasale is identical with the distance between Superaurale-Subaurale. (On the skull bone it is the distance between Glabele-Nasospinale). The width of the auricle is half of the thumb's length (Taylor, 2001; Goyne, 1982, Takač, 1990). The top of the ear corresponds with the eyebrow's height. Ramus mandibulae determines the direction of the auricle (Delfino et al., 1993, Krogman, 1973). The top of the tragus is at the outer acoustic pore (Jordanov, 1981).

A signaletic photograph or the photograph of the head from the ID card in norma frontalis, taken in Frankfurt horizontal level is considered to be a positive control. Positioning of eleven measuring points of the skull are checked (Iscan & Helmer, 1993; Taylor, 2001; Takač, 2007a). For the correct superimposition, the images of the head are suitable, in profile ante – and retroflexion, and also when the head is bent on the left-right in the frontal image. In these positions distances of the anthropometric points are not changed from the level of photo-film camera. Half profile images of the head in ante- and retroflexion are less convenient. On the photographs of males with a diffuse beard, mustaches and long hair, the contours of the top of the head, forehead, face and the top of the chin can be covered and invisible, making thus superimposition difficult. The eyes, nose, and lips are visible and they need to be superimposed correctly (Iscan & Helmer, 1993; Taylor, 2001). Vertical, horizontal and diagonal sections of the face (Sweeping) over skull (Figs. 7, 8) are used for controlling the proportional enlargement of the image of the skull, as well as for the correct projection of the face organs. The other way is by gradual fading and blending of the image of the skull over the image of the face (Blending or Fading) – (Fig. 11).

Conclusion

Superimposition has a greater **negative evidence value** (identification exclusion) than a positive one (possible identification). It is easy to reach a 100% negative superimposition, but almost never a 100% positive one (Takač, 2007a). Positive superimposition in the frontal position of the head does not mean a priori positive superimposition in the profile image of the head. Their mutual opposition excludes the possibile identification of a person (Iscan & Helmer, 1993; Bajnoczky, 1994; Takač, 2007a).

International significance – By final elaboration of the superimposition, the overall work aiming to identify an unknown person by this method is ended. It is also possible to get additional information for determining the identity of an unknown person through public media (*TV, Press, and Internet).* It is desirable to supplement the result of superimposition by some other identification methods. If there are no appropriate results at the beginning, publicity could be extended on republic, state or international levels by sending digital images of the final superimposition to the international investigation organization *(Interpol)* or the investigation offices of other countries (*FBI, Scotland Yard*).

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SUPERPOZICIJA - SP: 304 / 04 G.Z.

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Sažetak. Superimpozicija lobanje i fotografije lica je najčešći metod kojim se nepoznate lobanje identifikuju, obzirom da se fotografija pokojnika lako može nabaviti od njegove porodice. Lobanje su slikane pod istim uglom kao što su i glave na zaživotnoj fotografiji. Korektno pozicioniranje lobanje na stalku i proporcionalno uvećanje slike lobanje sa fotografijom lica predstavlja najdelikatniji deo rada. U radu je korišćen kompjuterski program Adobe®Photoshop® 7.0. Digitalizovane fotografije lobanje i lica su nakon unošenja u kompjuter superponirane jedna na drugu i prikazane na monitoru u cilju utvrđivanja njihove moguće podudarnosti ili isključivosti. Posebna pažnja je data podudaranju istih antropometrijskih tačaka lobanje i lica kao i praćenju njihovih kontura. Proces preklapanja lobanje i fotografije obično započinje postavljanjem očiju u pravilan položaj u odnosu na koštane orbite. Lobanja ne sme biti šira niti duža od mekih tkiva na fotografiji, a brada, usta, nos, uši itd., moraju biti na svom određenom položaju. Evidentirane su sve poteškoće koje prate izradu superpozicije sa posebnim osvrtom na kritički aspekt i vrednovanje rezultata rada kod pozitivne i negativne superpozicije. Ukazano je i na društvenu opravdanost ove metode identifikacije kako na državnom tako i na međudržavnom nivou (Interpol). Rad je bogato ilustrovan slikama koje prikazuju sve etape rada hronološkim i logičkim redom. Rad predstavlja jedan od prvih prikaza superpozicije u našoj zemlji.

Ključne reči: forenzična antropologija, superpozicija lica, skeletizacija.