From results provided in table 2, we find that the whole distance covered in 5 seconds by the car according to the actual speed values (135.4 m) is significantly higher than the calculated distance (91.7 m), assuming that the car moved at a constant collision speed for a period of 5 seconds. Such a large difference between the real distance and the distance traveled at a constant collision speed in later stages of the investigation may affect the reliability of the conclusions regarding the technical possibility of a driver to avoid collision. Thus, this example shows how important it is to have reliable data about the movement of the vehicle before the accident.

Besides the vehicle speed data, the automobile EDR report contains data on the time of the event the angle of the steering wheel, the position of the brake pedal, the fluid pressure in the brake system, the value of longitudinal and lateral delta-V speeds, acceleration values during collision, data on the SRS air bags deployments and many other parameters useful for research.

It is important to know that this data recorded during a traffic accident, when vehicle systems are overloaded and vehicle equipment breaks. The data collected at the place of the traffic accident can be used to compare with the report data in order to interpret it correctly and avoid errors. Sometimes an EDR device contains data from several events, therefore it is important to be able to identify the correct data of a specific event and use it properly.

In the future this practice of retrieving and using data in traffic accident investigations will undoubtedly expand, EDR devices will be found not only in cars, but also in trucks, buses and motorcycles, so it is very useful for experts to learn how to work with equipment that can read data from vehicle EDR devices and use them properly in accident investigations. The reliability of this data is confirmed by tests and guaranteed by automobile manufacturers who install the corresponding equipment in their vehicles.

Sex and age estimation from 2D and 3D images of bones using deep learning techniques

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Deep neural networks to accurately estimate sex from photographs of the ilium (children) and the humerus (adults), and age from 3D models of the pubic symphysis.

Keywords: forensic anthropology; biological profile estimation; age estimation; sex estimation; artificial intelligence; deep learning.

Оцінка статі та віку за двовимірними та тривимірними зображеннями кісток із застосуванням методів глибинного навчання

Пабло Масаджоу, Алехандро Манцанаріс, Хав'єр Венема, Хав'єр Ірурíта

Представлено глибокі нейронні мережі для точної оцінки статі за фотографіями крила клубової кістки (дітей) і плечової кістки (дорослих), а також віку за 3D-моделями лобкового симфізу.

Ключові слова: судова антропологія; оцінка біологічного профілю; вікова оцінка; оцінка статі; штучний інтелект; глибинне навчання.

Traditionally, sex estimation is performed by means of numerical/tabular data obtained from manual measurement of the bones of interest. However, the success of a set of Artificial Intelligence techniques, known as Deep Learning (DL) [1], in image analysis problems (mainly through convolutional networks) invites the use of such techniques in the estimation of the biological profile (BP). These techniques allow fully automatic estimation from the images themselves, decreasing times and

increasing the objectivity and reproducibility of the identification processes, matching, or even improving the performance of human experts in certain tasks and generating new knowledge.

If we focus on sex estimation, the research done to date by Panacea Cooperative Research, in collaboration with the University of Granada (UGR), has focused on two main problems:

Sex estimation in children from photographs of the ilium bone (Figure 1.a) [2].

Sex estimation in adults from photographs of the humerus bone (Figure 1.b) [3].

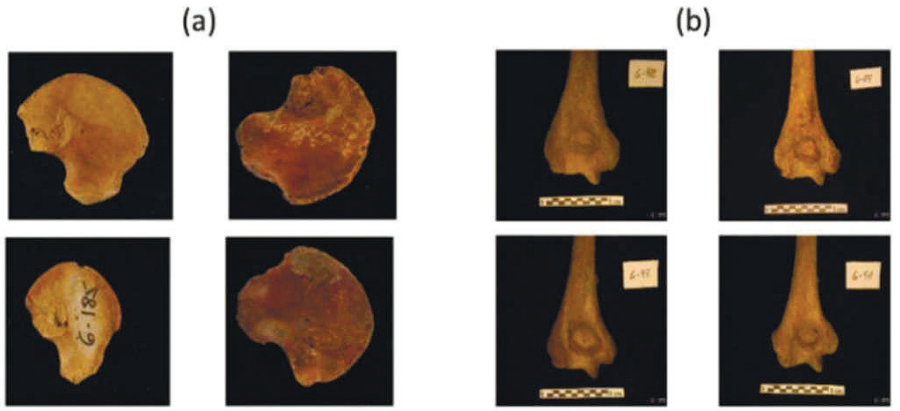

Fig. 1. Examples of ilium photographs used in sex estimation in children (a). The left column shows bones from male infants, while the right column shows bones from female infants. Examples of photographs of the humerus used in sex estimation in adults can be seen in b. The left column shows examples of photographs of the humerus used in sex estimation in adult males, while the right column shows bones from adult females

In both problems, a similar strategy was followed (which can be seen in Figure 2). In the first case, a set of 135 photographs taken from the collection of the Physical Anthropology Laboratory of the UGR was used: 83 boys and 52 girls, with mean ages (± standard deviation) of 240 ± 491 and 292 ± 499 days for male and female infants, respectively. The results showed, on the one hand, the great difficulty of the problem in question, given that even an expert anthropologist did not exceed 61 % success rate. This is logical given that the dimorphic characteristics that differentiate females and males do not appear until puberty. On the other hand, the DL techniques obtained a 59 % success classification rate, very close to that of the expert. In this specific application, classical DL techniques were able to come very close to the performance of the human expert.

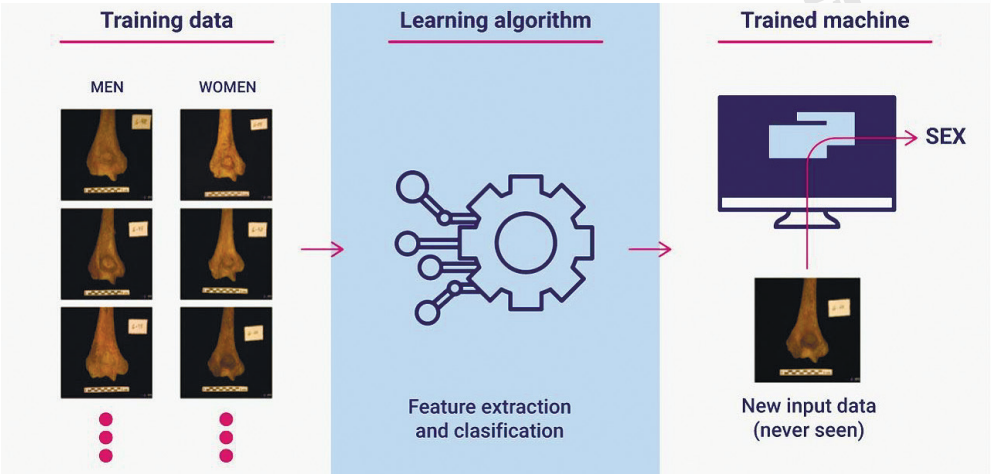

Fig. 2. Approach followed in estimating sex from bone images. A set of labeled examples, belonging to females or males, is available from which to learn. The learning algorithm corresponds to a DL technique that performs relevant feature extraction and binary classification (male vs. female). Finally, once the machine is trained, it can classify new images not seen in the training phase. In this figure, the estimation of sex in adults from photographs of the humerus is used as an example

In the second case, we used a collection of 401 photographs of the posterior view of the right humerus taken from the collection of the Physical Anthropology Laboratory of the UGR: 188 females and 213 males. The results showed, on the one hand, the lower difficulty of this problem in relation to age estimation in children, given that the accuracy percentages are much higher (both for the anthropologist and for the state-of-the-art techniques in an anthropological level (in this case, geometric morphometric techniques [4]), as well as for the DL techniques). Specifically, the expert achieved a hit rate of 83 %, while the geometric morphometric technique obtained 75 %, and the proposed DL technique reached 91 %. In this particular application, not only has the performance of a physical anthropologist and the best pre-existing techniques been greatly exceeded but also, thanks to the application of certain explainability techniques, it has been possible to identify the most relevant regions of the bone for sex estimation. The areas of the bone containing these dimorphisms have been identified by the model as containing the most relevant information for sex estimation. However, in addition to the already known dimorphisms (trochlea and olecranon fossa), it has also been observed that the convolutional network used considers an area of the bone superior to the distal epiphysis, which had not been evaluated in the field of forensic anthropology. Thus, the neural network is even capable of generating new knowledge and proposing a new anatomical region of possible anthropological interest (see Figure 3).

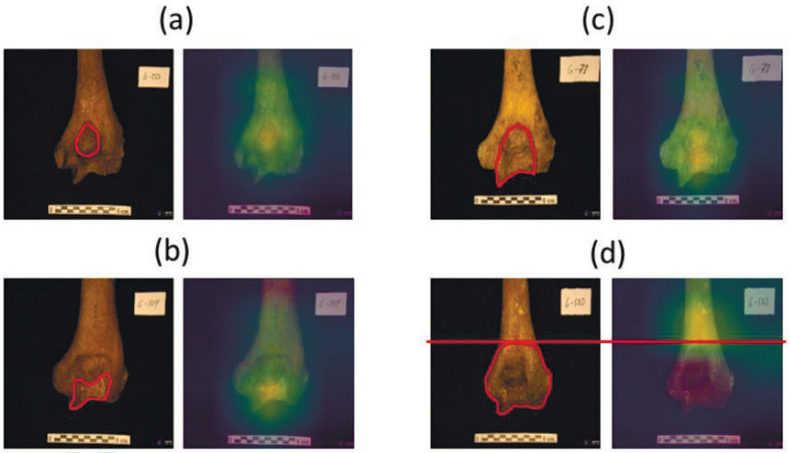

Fig. 3. The higher the intensity of the yellow color, the more weight that area has in the network estimation. The estimates of the deep neural network are based on information from the olecranon fossa (a), the trochlea (b), or both (c). In the image in the lower right corner (d), a new region identified by the network and located over the distal epiphysis (in red, in d) can be seen. Previous scientific literature had not paid attention to this region, which the network has considered relevant for sex estimation

On the other hand, the estimation of the biological profile of an individual is a fundamental task within the field of forensic anthropology. In particular, the estimation of the age-at-death of an individual is crucial to reduce the range of possible coincidences during the identity process. Although several approaches address it, it remains a hot topic. This is due not only to the search for an approach that shows better performance than the existing ones, but also to the fact that most approaches depend on the subjective judgment of an expert. In this research, we propose two deep learning-based methods (see Figure 4) that overcome this by automatically extracting characteristics from three panoramic views of a 3D model of the pubic symphysis. These three views correspond to the three principal coordinate axes and consist of 3-channel images generated from the Spatial Distribution Map, Normals' Deviation Map, and Gradient Normals' Deviation Map projections. The use of a multi-view approach favors the integration of the existing information in a 3D model from different points of view and, consequently, obtaining more discriminating learning models. The dataset consists of 552 pairs of 3D models representing the pubic symphysis of an individual. Each pair consists of two 3D models: the first represents the right side, and the second represents the left side of the pubic symphysis. In total, 1,104 models of labeled individuals between 15 and 82 years of age are available. Our approach not only detects high-level characteristics of the pubic symphysis undetectable by the human eye but reduces the age estimation error to a mean absolute error of 8.33, improving 30—50% the accuracy of the state of the art.

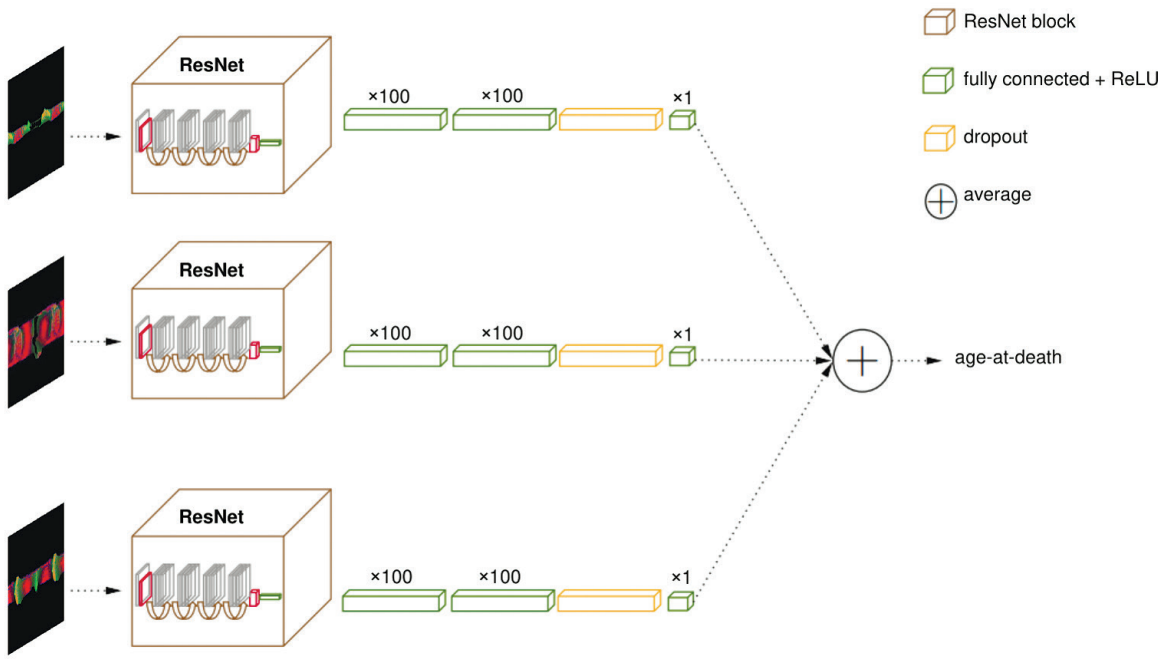

Fig. 4. Multi-view ResNet-CNN architecture with three convolutional modules. Each module is associated with a ResNet- CNN network, whose input is an RGB image and whose output value is aggregated to predict an individual's final age

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Prerequisites for Solving Identification Tasks when Studying Signatures Made by Elderly and Old Persons During Physiological Aging and Certain Types of Diseases

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Issues related to the problem of solving diagnostic (non-identification) problems are considered, and the task of forensic handwriting examination and the selection of persistent signs and symptomatic effects of specific unusual conditions and diseases on handwriting are defined.

Keywords: "confounding" factors, the process of writing a manuscript, selective variability of handwriting, elderly and senile persons, impaired cerebral circulation, myocardial infarction.