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COMPARING THE FACIAL STRUCTURE OF THE SAME PERSON IN DIFFERENT AGE INTERVALS

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ABSTRACT

Facial structure comparison of the same person at different age intervals is a compelling area of research in image processing. The process involves acquiring a series of images of an individual at distinct age intervals and utilizing various algorithms, such as Scale-Invariant Feature Transform (SIFT) or Principal Component Analysis (PCA), to extract facial features. Machine learning algorithms, such as Support Vector Machines (SVM), can subsequently be employed to compare the extracted features across the different age intervals and visualize the outcomes. This research direction provides valuable insights into the aging process and contributes to the development of more accurate models of facial ageing. By investigating the effects of ageing on facial structure, including the emergence of wrinkles or alterations in facial symmetry, this approach can shed light on the complex dynamics of ageing.

The application of image processing techniques to compare facial structures holds immense potential in advancing our comprehension of the ageing process and assisting in the formulation of effective anti-ageing treatments. Through the utilization of sophisticated algorithms, this research endeavor enables the examination of facial transformations over time. By analyzing the changes in facial features and patterns, researchers can identify significant factors contributing to facial ageing and gain a comprehensive understanding of the underlying processes. Moreover, the visualization of the comparative ageing results obtained through machine learning algorithms facilitates the interpretation and communication of findings. This visual representation allows for a comprehensive analysis of facial changes, aiding in the identification of prominent ageing markers and potential strategies for intervention. Furthermore, this research provides a framework for assessing the efficacy of various anti-ageing treatments and interventions by quantitatively evaluating their impact on facial structure.

***Keywords*:** Face recognition; Face localization; Feature extraction; SVM; PCA ; Data Visualization.

INTRODUCTION

As human beings, we are captivated by the inexorable passage of time and its effects on our lives. Time leaves its indelible mark on every aspect of our being, including our physical appearance. One of the most striking and evident transformations occurs in our faces, where the subtle nuances of aging manifest themselves. The study of facial structure in different age intervals has long intrigued scientists, artists, and individuals alike, prompting a multitude of questions regarding the underlying mechanisms and variations that occur over time.

Understanding how our facial features change as we age holds significant scientific, social, and practical implications [1]. It provides insights into the complex interplay between genetics, environment, and individual lifestyles, shedding light on the factors that contribute to aging processes. Additionally, this knowledge can have far-reaching applications in diverse fields, including medicine, forensic science, and biometrics, as well as in areas such as facial recognition technology and age progression algorithms [2]. Nowadays, when life expectancy is increasing, age discrimination related to older people's appearance is also increasing [3].

This study aims to examine and compare the facial structure of the same person at different age intervals, employing an interdisciplinary approach that combines techniques from the fields of biology, anthropology, computer vision, and image processing [4]. In the older population, systemic diseases such as osteoporosis, sarcopenic dysphagia and malnutrition are influencing the pathological mechanisms, resulting in an increased risk of tooth loss [5, 6]. Other important factors are diseases such as amyotrophic lateral sclerosis, right-brain stroke and others, where maintaining good oral hygiene is challenging [7, 8]. Tooth loss and inadequate oral hygiene have a positive impact on frailty, which is a highly prevalent condition in the elderly and has been considered a crucial public-health issue [5, 9].

By analyzing facial images collected over time from individuals of various age groups, researchers can uncover the intricate patterns and changes that occur in different regions of the face, including the skin, muscles, and underlying bone structure [10,11].

To achieve this, advanced imaging technologies and computational algorithms are employed to capture and quantify the minute details and variations in facial features [12]. High- resolution photography, 3D scanning, and specialized software enable the extraction of precise measurements, texture analysis, and morphological comparisons, facilitating a comprehensive assessment of facial aging [13,14].

The findings from this research not only contribute to our fundamental understanding of the aging process but also have practical applications in diverse areas. In the medical field, for instance, this knowledge can aid in the development of more effective cosmetic procedures, dermatological treatments, and personalized care plans for individuals as they age. Furthermore, the identification and characterization of age-related facial changes can have implications in forensic investigations, helping to create accurate facial reconstructions and improving the reliability of age estimation techniques [15].

In conclusion, the exploration and comparison of facial structure in different age intervals provide a captivating glimpse into the profound effects of time on our appearance [16]. By unraveling the mysteries of facial aging, this study advances our understanding of the complex interplay between genetics, environment, and individual factors. Moreover, the practical applications derived from this research have the potential to revolutionize various fields, ushering in a new era of personalized healthcare, technological advancements, and forensic investigations [17].

METHODOLOGY

The study comprised 90 participants aged over 65 years (41 males and 49 females), along with 30 control individuals (15 young males and 15 young females). Inclusion criteria were established to exclude individuals with craniofacial anomalies, a history of significant facial trauma, plastic or orthognathic surgery, facial paresis, or tremors. Male participants with facial hair were not included to prevent potential distortions in the analysis [18].

The older adults were categorized into three subgroups. The first subgroup consisted of completely edentulous participants (15 males and 15 females). The second subgroup comprised partially edentulous participants (13 males and 17 females) who had lost five or more teeth. These individuals had unstable occlusion, non-repeatable intecuspal positions, and a lack of maintenance in the vertical dimension of the occlusion. Among the partially edentulous women, the average number of remaining teeth was 11±5, while in the partially edentulous men, it was 9±4. Two-thirds of the missing teeth were located in the intercanine region, while the remaining one-third were in the transcanine region [19, 20]. Although the missing teeth were not replaced with fixed prosthodontics, the participants had removable partial dentures, which were removed during the scanning process. The third subgroup consisted of toothed participants (13 males and 17 females) who had stable occlusion, repeatable intecuspal positions, and a maintained vertical dimension of the occlusion. All their teeth were present in the intercanine region, and they possessed three or more functional dental units of posterior teeth. In terms of occlusal units, a premolar in occlusal contact was counted as one unit, while the entire occlusal contact area of a molar crown was counted as two. The subjects in the control group had complete dentition with second molars. A flowchart with units [21] the composition of the groups is shown in Figure-1.

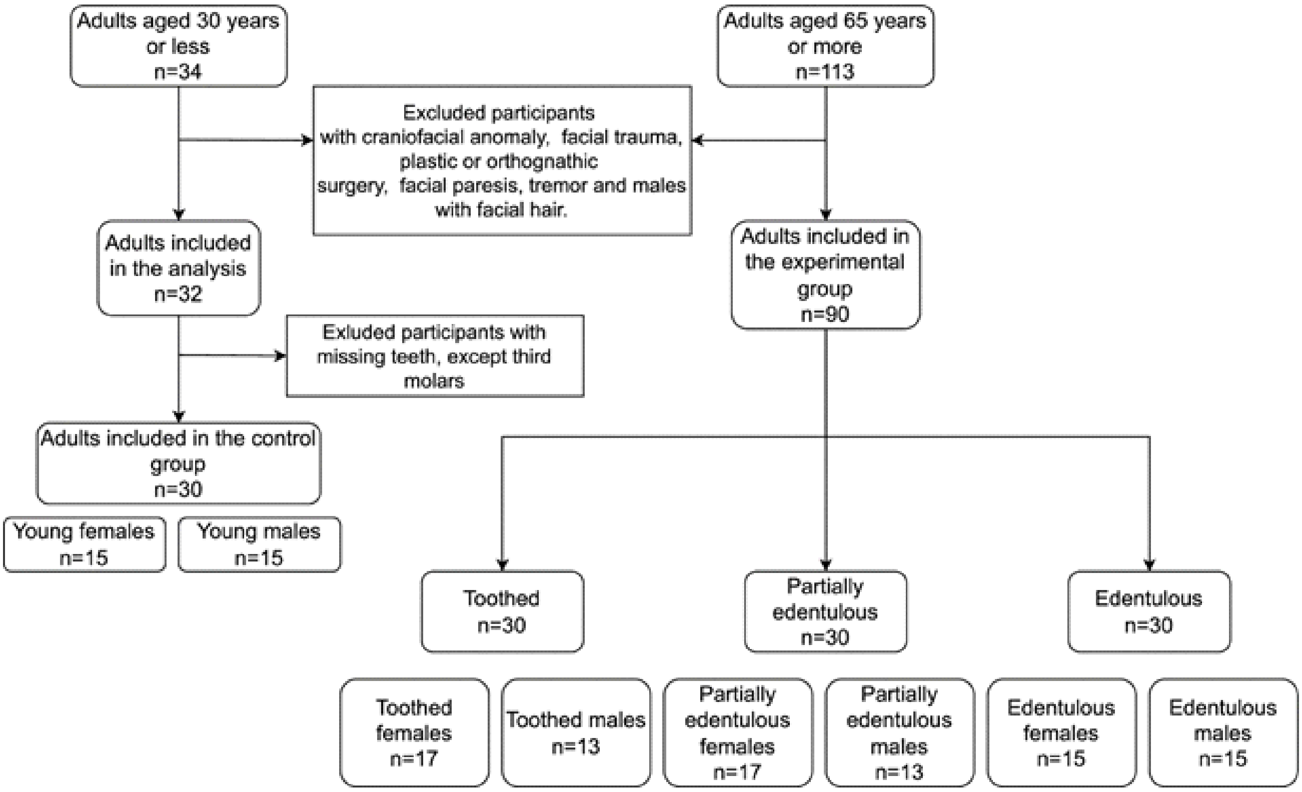

Figure-1: Structure of different people of different age groups

During the image acquisition, special attention was given to positioning the participant and relaxing the facial musculature. The participants sat in a relaxed posture with a natural head position, looking to the front with a relaxed mouth-closed position (without contractions of the mouth muscles). The instructions were to not to swallow and keep both eyes open during the acquisition of the image, which took less than 10 seconds. The natural position of the head was achieved by moving it up and down a few times and then stopping the movement and looking into the distance. The relaxed mouth-closed position was achieved with repeated wide opening and closing of the mouth until light contact with the lips was achieved. All dentures were removed from the mouth. Here in figure-2, you can easily see the facial structure and its different parts for age estimation.

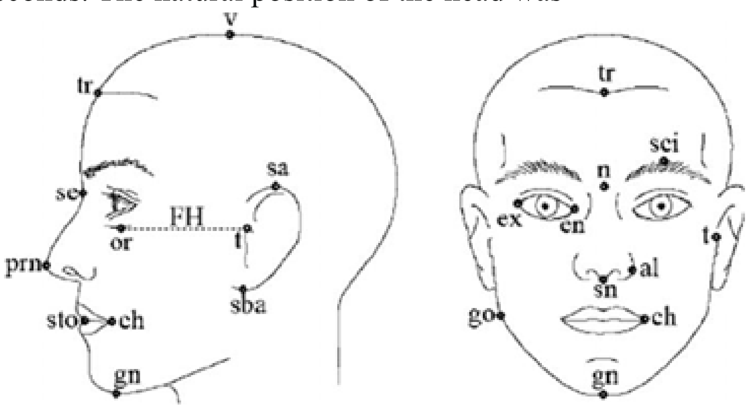

Figure-2: Age estimation using the facial structure

Taken together, the findings to date consistently suggest that older compared to young adults are worse at identifying facial expressions. Furthermore, several studies suggest that young and older adults differ in their attention and memory biases, with older but not young adults showing an attention preference toward positive and away from negative faces and better memory for positive than negative faces. Nevertheless, evidence regarding memory for emotional faces is more mixed. Inconsistencies across studies may result from differences in tasks used and, perhaps more important, from age-group differences in facial expression identification which are likely to have an impact on which faces are remembered. That is, age- group differences in memory for emotional faces should be examined in relation to participants' own categorizations of facial expressions, as done in the present study. In the figure-3, the points on the human face are defined.

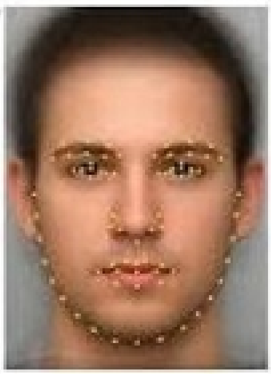

Figure-3: Facial points for the extraction of facial features

RESULT

The facial width of the older adults was found to be greater than that of the control group in both males and females. In the male group, this difference was statistically significant (p = 0.001), while in the female group, it was close to reaching statistical significance (p = 0.071). Additionally, the older adults exhibited longer faces compared to the control group, and this difference was statistically significant in the male group (p = 0.000). Moreover, the older adults had a longer middle facial height compared to the control group, which reached statistical significance only in the male group (p = 0.010). They also had a larger lower facial height than the controls. In terms of facial and lower facial height, both measurements were significantly smaller in the completely edentulous subgroup than in the toothed subgroup for both males and females.

Furthermore, the completely edentulous participants, regardless of sex, had significantly narrower mouths compared to those with teeth. The upper-lip height was longer in the group of older adults, and it was close to statistical significance in the male group (p = 0.072). Both upper-lip and lower-lip rednesses were significantly narrower in the group of older adults for both males and females, with the completely edentulous subgroup exhibiting the narrowest rednesses. Older men had statistically significantly longer noses than young adults, although no statistical significance was found in the female group (p = 0.084).

DISCUSSION

The face is one of the most diverse parts of the human body. The various races, ethnic origins, sexes and ages are reflected in the faces of everybody. In today's society, which puts an emphasis on general social acceptance and the associated aesthetics, the appearance of the face has an important role. On the other hand, the influence of tooth loss on facial appearance is still very poorly explained. Recognizing the characteristics of an older adult's face and being able to differentiate between the changes as a result of an ageing face or as a result of tooth loss have a large impact on treatment planning. 3D facial analysis is not involved in the standard diagnostic procedures for dental treatment. However, diagnostics of the whole face is possible with a 3D scan of the facial surface. The cephalometric analysis of a 3D scan is now a well-established and proven method in many fields of head and neck medicine; it was used in a study evaluating facial characteristics after two different types of prosthodontic rehabilitation.

Different studies have shown that the face becomes wider with age. In our case, the facial width was greater in both sexes compared to the control group. Wider faces of older adults could also be a consequence of the higher BMI in this group because the influence of the transverse facial dimensions has been proven. We assumed that the loss of teeth had no great impact on the facial width, but surprisingly our study indicated narrower faces for the completely edentulous participants.

The facial height and the lower facial height were smaller in the completely edentulous subgroup. Barlett et al. [22] have studied skull differences in the toothed and edentulous older adults and discovered a shortening of the facial height, because of a shortening of the lower facial height as a result of teeth loosening and atrophy in both jaws. When comparing the different subgroups of older adults, we observed a trend of reducing the size of the middlefacial height with the loss of teeth, which is statistically significant among the female subgroups and close to statistical significance among the male subgroups.

Apart from the eyes, the most recognizable part of every face is the mouth. Ageing has no impact on the width of the mouth, but tooth loss does. The completely edentulous participants had narrower mouths than the toothed. Sex dimorphism is observed for this parameter, with men having wider mouths than women. The upper-lip height was longer in the group of older adults and some studies have already proven it to be a result of gravity, rather than a decrease in soft-tissue volume. The height was the longest for the toothed, and the shortest in the completely edentulous subgroup. The teeth in the intercanine sector are preventing the lip from curling inwards.

Upper- and lower-lip rednesses become narrower with age, as has been already described. The completely edentulous subgroup had the narrowest rednesses, which has not yet been described.

The nose is a very significant part of the face and has its own characteristics. In our study, we identified nose prolongation with age, no matter the shape and the size of the nose. Older men had longer noses than young adults. The prolongation of the nose is a consequence of the intrinsic loosening of the lower lateral alar cartilages and the supporting ligaments. We discovered longer noses in the toothed than the completely edentulous adults. No such study comparing edentulism and nose length has been conducted before.

CONCLUSION

The comparative analysis of facial structure in different age intervals has provided valuable insights into the complex nature of aging and its impact on our physical appearance. Through interdisciplinary approaches encompassing biology, anthropology, computer vision, and image processing, researchers have unraveled the intricate patterns and transformations that occur in facial features over time.

This comprehensive study has shed light on the underlying mechanisms of facial aging, highlighting the interplay between genetic factors, environmental influences, and individual lifestyles. By examining facial images collected from individuals across various age groups, precise measurements, texture analyses, and morphological comparisons have allowed for a deeper understanding of the aging process.

The findings from this research hold significant implications for numerous fields. In the realm of medicine, this knowledge can contribute to the development of more effective cosmetic procedures, dermatological treatments, and personalized care plans tailored to individuals as they age. Additionally, in forensic investigations, accurate facial reconstructions and improved age estimation techniques can be achieved by understanding and characterizing age-related facial changes.

Furthermore, the practical applications derived from this research extend to areas such as biometrics and facial recognition technology. By comprehending the variations in facial structure over time, age progression algorithms can be refined, enhancing their accuracy and reliability. This has profound implications for law enforcement, security systems, and other domains where facial recognition plays a crucial role.

The exploration and comparison of facial structure in different age intervals have not only deepened our understanding of the aging process but also paved the way for future advancements. Continued research in this field holds promise for further uncovering the intricacies of facial aging, refining existing techniques, and developing novel approaches to mitigate the effects of aging on our appearance.

Ultimately, by unraveling the mysteries of facial structure and its evolution over time, this research contributes to the broader understanding of human biology, identity, and the impact of time on our physical selves. It opens up avenues for targeted interventions, personalized healthcare, and technological advancements, heralding a new era of advancements in aging- related research and applications.

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