



Face Recognition Using Machine Learning: Techniques, Methods and Future Challenges

JAWAD HUSSAIN AWAN^{1*}, SYED RAZA HUSSAIN SHAH², KHALIL-UR-REHMAN KHOUMBATI², KHALID NOORUDDIN CHARAN³, UBaidULLAH ALIAS KASHIF⁴ SHABREENA²

¹Faculty of Engineering, Science & Technology, Iqra University, Karachi, Pakistan

²Faculty of Engineering & Technology, University of Sindh, Jamshoro, Pakistan

³Department of Computing, Faculty of Engineering, Science & Technology, Hamdard University, Karachi, Pakistan

⁴Department of Computer Science, The Shaikh Ayaz University Shikarpur, Sindh, Pakistan.

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Corresponding author

Raza.shah@usindh.edu.pk

ABSTRACT

Privacy and security becomes the global challenge and security of authentication is most prior for users, technologists, and researchers. So, facial recognition is the problem of authentication systems, and breaching cases are reported. Thus, Facial recognition attracted the researcher's attention and grew as an interesting and challenging theme in various domains such as computer vision, machine learning, and digital image processing. Moreover, it covers a huge number of applications such as personnel sign systems, search engines, and prisoner detecting systems. In this paper, the discrete quantity of Biharmonic Equation (PDE) is proposed for a 3D image in which a gray level matrix represents the image and compares the origin face image with a constructed image. In this regard, some functions are also defined and designed by the Biharmonic Equation; these functions represent the parametric curve equations in space and divide the surface.

Keywords: Face Recognition, Machine Learning, ML, Partial Differential Equation, PDE and Biharmonic Equation

INTRODUCTION

Nowadays, human face recognition is key application and playing important for security purpose in cyber and digital world. Therefore, face recognition has gained much attention due to the deployment of technology in the security applications and law enforcement sector. Thus, facial geometry parameterization becomes one of most crucial role-playing fields. The 21st century is digital world, most of modern developing and developed countries invested and allocated a huge amount for security projects to combat frauds, human crimes, because of rapid increasing ratio of security beaches, threats and growing criminal activities via cyber warfare and various activities (Despotović et al., 2023). From the surveys, research and literature, it is noticed that Partial differential equation not only performs its functions in the field of physical and Engineering Science but also applicable in other fields such as biological and computational sciences.



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Moreover, it illustrates a relationship among unknown functions and partial derivatives. In fact, PDE is applicable in an interaction research area where various independent variables are carried out for research. So, Partial Differential Equations are rush in the field of science and technology (Wang et al., 2024) Therefore, Partial Differential Equations (PDE) is used efficiently in the modeling of human face along with facial features, where multipart geometry is produced and generated as an algebraic edge boundary-value problem. Modeling of faces is a plausible idea due to use of the efficiency via complex geometry in parameter (Lattas et al., 2023). This paper (Bellamy & Kröger, 2024) expands the utilization of the PDE technique to head perception with processed tomography information and show how these two essential restorative representations implies. The surface reproduction and volume rendering can be coordinated into one single structure through PDEs. In the paper, proposed plan initially performs head division from CT (Computed Tomography), and then cuts utilizing approach, the yield can be utilized for extraction of a little arrangement of PDE limit conditions. With the separated limit conditions, head surface recreation is then executed. Few couple of cuts is utilized to perform head surface recreation all in both computational time and capacity cost of the calculation of broadly utilized walking shapes. In the third parameter with the PDE technique, a strong head can be made; the head volume is rendered with 3D surface mapping. This paper relates the alpha estimation of texels of the 3D surface with the PDE parameter through a direct change rather than planning an exchange work. This affiliation empowers the generation of an outwardly translucent head volume. The test comes about exhibit the possibility of the created head representation strategy. Therefore, the theme of this research is to develop and generate human face by comprising generated act entities using PDE based numerical formulation. The proposed technique is adopted to produce FACS (Facial Action Coding System) by mapping the edge curves with main aspects of the face and includes the cohort of smooth PDE exterior view in dynamic time and efficient storage space of facial information. The paper is ordered as follows. Section II defines biometric technologies, section III describes face recognition techniques, section IV discusses data acquisitions and filtration of face regions, section V discusses face recognition method, section VI concludes and section VII recommends and suggests future work.

BIOMETRIC TECHNOLOGIES

In this emerging world, Biometrics technologies are offering an appropriate solution for identification and personal verification security purposes. While these technologies provide some unique advantages when compared to previous identification and verification techniques, which relying on personal identification numbers (PINs). In addition, simple password is easily guessed by a hypocrite while difficult password is difficult to remember by an authentic user (Bellamy & Kröger, 2024) . First, when password or authentication is stolen or missed then may be used by someone else but biometrics is individualized traits. However, you have not to remember anything because a biometric is very convenient. Nowadays, biometric technologies offer reliable and accurate authentication. Thus, rapid deployment of biometric technology is increased because of its accuracy and inexpensive. Whenever, all biometrics are compared then we find a face biometric unique from others because face belongs to physiological and behavioral category and it is a natural, non-intrusive biometric (Prakash et al., 2023). Biometrics is an automated technique that offers automatic recognition of those relying on their behavioral traits or physiological traits shown in Figure 1.

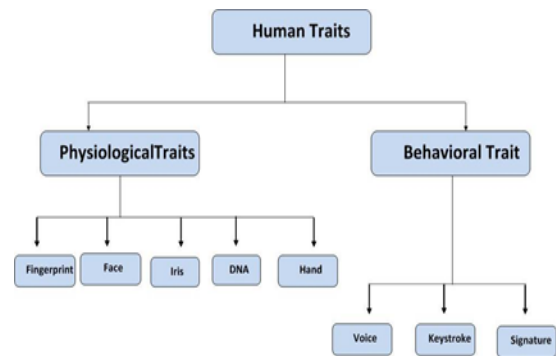


Figure 1: Human Physiological and behavioral traits (Memon et al., 2011)

Recently, the research notified that the users are commonly using passwords but validating someone's identity is offered via biometric identification in a suitable and interactive manner. With the help of biometrics, it is possible to authenticate a user's identity relying on "who he or she is", instead of "what she or he possesses" (Such as Identity card) or "what he or she memorizes" (Such as Passwords) . This biometric technology contains recording and

recognition of individual's biological and behavioral traits. More, it is noticed from different experiments that each individual has unique biometric characteristics which neither be transferred nor their information be lost, stolen or forgotten. Biometric is a high standard solution which ensures security measures in different security applications. Furthermore, a biometric system provides tremendous expediency along with high level of security. When the security level breaches which increases number of transaction fraud and demands a highly secured technology for protection and security (Khan et al., 2023). Biometric-dependent access has capability to offer the security services in different contexts (Ayeswarya & Singh, 2024). Biometric technologies are deployed in either uni-modal or multimodal. Uni-model biometric system is appropriate for lower as well as moderate security purposes. Because of security threats and requirements, cyber terrorists are applying different high-level technical approaches in biometrics security technologies for the breaching of the security level. In this purpose, uni-modal systems are not satisfactory. While multi-modal biometric security systems install several sensors for data acquisition and allows capturing numerous samples of a single or various biometric feature or characteristics (Memon et al., 2011). Multi-biometric technologies are gathering the required information from different uni-modal biometric technologies to offer a higher level of security Multi biometric technologies enhance the capability of recognition from their accuracy, efficiency and performance of an authentication technique by combining the facts which can be obtained from different sources of information. Therefore, a multi-modal biometric technology system is most applicable and efficient as compared to uni-modal system.

FACE RECOGNITION TECHNIQUES

From the literature, it is witnessed that human face recognition became a crucial and challenging research area in past and multiple techniques proposed, adopted and deployed in developed system but now it become an interesting area in various domains such as computer vision, machine learning, and digital image processing. Moreover, this section comprises of two sub-sections such as feature based matching and template matching. These are two face recognition techniques and discussed below and getting a one-to-one correspondence between the stimuli (means human face of authenticated person),

which has to be recognized and then forwarded for storage in the database (Dash et al., 2024)

Feature-Based Matching

Feature based matching is geometric face recognition technique in which information of individual features is used for face recognition. Unfortunately, these features are not clearly determined but a face can be recognized through other enduring information and this information is available in an intelligence sense. More, this technique is purely geometrical and represents missing data at a rude resolution of distinct features which are extracted after wards (Huang et al., 2023). Further, equation (1) is shown below is mostly used in feature-based matching (Zhang et al., 2023).

$$\int \left(\left(\frac{\partial u}{\partial s} \right)^2 + \left(\frac{\partial u}{\partial t} \right)^2 \right) ds + \beta \int (\bar{u} \cdot \bar{n} - u^t)^2 ds \quad (1)$$

Template Matching

Template matching is modern technique to find smart and tiny parts of image. Hence, plays an important role in daily life and machine learning, digital image processing. The projected tiny edges of image are matched with existing sampled images available in storage media, and then detect the similar edges of images. The template matching is a simplest technique or approach to commonly used for image edge detection. This is also represented as bi-dimensional array comprises of intensity values, which are compared with existing template of human face, available in storage media or cloud via Euclidean distance metric. Some methods of template matching discussed in (Prakash et al., 2023).

Data Acquisition

A face recognition technique which is based on 3D face recognition possess multiple proprieties of the original form within an absolute reference frame such as robustness, rotation, position and scaling. But, 3D face recognition technique is not reliable to achieve above mentioned goals [5]. In this paper, two methods are discussed in which a human face is generated a 3D facial model. In first method, the face is acquired in chronological steps. First of all, 3D information is associated consistent with camera's

reference system by setting the z -axis as well as optical axis. Secondly, gathering 3D information which is coming from different positions of views and then forwarded to a blending process. Then, 3D information is enhanced in proportion to predefine given criteria. Finally, mesh generation algorithm (Abdi et al., 2023) is used to design the 3D polygonal mesh. In other method, a morph able model is exploited to acquire 3D face model (Suchde et al., 2023)

FILTRATION AND DATA ACQUISITION OF FACE REGIONS

The edge filter is used to filter each gray scale version of the potential face region. While a simple global thresholding is used in binarized method, and then labeled as to extracts the feature. The potential face region blocks are evaluated in the labeled image for determining which feature block is either a potential face or not. Furthermore, Eyes, Eyebrows, Nose and Mouth structure is searched for filtering face regions purpose and discussed in (Hildreth et al., 2023)

Development of feature sets

In face recognition techniques, the geometrical feature of human face is helpful in the face recognition task, which consumes small amount of time and memory because of their low aspect. For this purpose, unique facial features are detected, which relies on the Fuzzy representation. In this section, a geometrical facial feature set is purposed and containing 26 features; in which face detector obtain 12 facial features and finds out 14 projected features such as eyebrows, eyes, ears, nose and mouth. Calculate the distance ratio features and area is calculated from following figure (Islam et al., 2023)

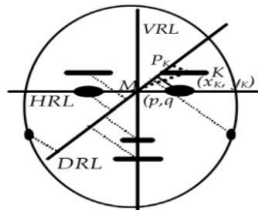


Figure 2: Diagonal Reference Line for Features Projection (Khan et al., 2023)

FACE RECOGNITION METHOD

This section covers two methods for discussion. Both methods are necessary for face recognition. The first method is analytical equation and other one is numerical of Biharmonic equation for face recognition purpose. The purpose of Partial Differential Equation is to generate composite geometric shape which relies on a boundary condition. Biharmonic Equation is also known as Elliptic Equation and the function of Elliptic Equation is to generate the elliptic surface, which contains information related to the face. The Laplace operator which generates and also grants the smooth transition among the boundaries. Here Equation (2) is written below which measures the efficiency for face recognition purpose (Duan & Wang, 2023).

$$(v^2)^2 = \frac{\partial^4 U}{\partial x^4} + 2 \frac{\partial^4 U}{\partial x^2 \partial y^2} + \frac{\partial^4 U}{\partial y^4} = 0 \quad (2)$$

In this section, here discrete finite difference approximation is simplified for data points of a given neighborhood in equation (2) shown below.

$$(v^2)^2 = \frac{\partial^2 U}{\partial x^2} + 2 \frac{\partial^2 U}{\partial y^2} + \frac{\partial^2 U}{\partial z^2} = 0 \quad (2)$$

Here an equation is given for the Laplace operator, in which the integers j , with mesh spacing h so that the coordinates $u=ih$ and $v=jh$, let $k=h=1$ are denoted and given in Equation 3.

$$\frac{\partial^2 U}{\partial x^2} = U(x_{i+h}, y_j) - 2U(x_i, y_j) + U(x_{i-h}, y_j) \quad (3)$$

CONCLUSION

This paper discussed facial recognition process and model using Partial Differential Equation. The paper used two methods for face recognition by using Biharmonic equation. Partial Differential Equation is also applied and used to evaluate the performance by representing 3D information for human face recognition. In Equation for face recognition method section, numerically equation and finite difference methods are discussed and applied to divide the surface to get intensity values, which represents the gray level of image for face recognition. Furthermore, representation of the face recognition process is defined, in which Biharmonic equation extracts the gray level of the image. In this paper,

both discussed methods are used to measure and compare for human face recognition purpose.

FUTURE WORK

Face recognition is a crucial problem of recent days and attracted the attention of researchers and professional to propose and develop such a protected system for security purpose. Face recognition techniques are experimented and surveyed to measure its reliability and accuracy as make it possible to deploy in security applications for authentication purpose. Nowadays, face recognition is emerged in face book applications Such as tagging a person photo in timeline. Secrecy and Information Protection, Processing of Real-Time information and its Scalability, Confrontational Attacks and Robustness, Integration of Biometric Modalities in a centralized system and ensuring the trust amongst end users are the future challenges, where researchers need to work and improve the recognition systems.

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