BLACK FACE-BASED AGE ESTIMATION SYSTEM USING GENETIC ALGORITHM-ARTIFICIAL NEURAL NETWORK

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D) IN COMPUTER SCIENCE IN THE DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE, COLLEGE OF SCIENCE AND TECHNOLOGY, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

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ACCEPTANCE

This is to attest that this thesis is accepted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Computer Science in the Department of Computer and Information Sciences, College of Science and Technology, Covenant University, Ota, Nigeria.

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(Dean, School of Postgraduate Studies) Signature and Date

DECLARATION

I, **OLADIPO OLUWASEGUN (15PCG01032)**, declare that this research work was carried out by me under the supervision of Prof. Elijah O. Omidiora of the Department of Computer Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso and Prof. Victor C. Osamor of the Department of Computer and Information Sciences, Covenant University, Ota, Nigeria. I attest that this thesis has not been presented either wholly or partly for the award of any degree elsewhere. All the sources of data and scholarly information used in this thesis are duly acknowledged.

OLADIPO, OLUWASEGUN  **27/06/2022**

Signature & Date

CERTIFICATION

We certify that the thesis titled, "**Black Face-Based Age Estimation System Using Genetic Algorithm-Artificial Neural Network.**" is an original research work carried out by **OLADIPO, OLUWASEGUN (15PCG01032)** in the Department of Computer and Information Sciences, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria under the supervision of Prof. Elijah O. Omidiora and Prof. Victor C. Osamor. We have examined and found this work acceptable as part of the requirement for the award of a degree of Doctor of Philosophy in Computer Science.

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DEDICATION

This thesis is dedicated to my late mother, Mrs. Elizabeth Usen Oladipo, who inspired the pursuit of purpose. I also appreciate my dad, Mr. Oladipo James. Thank you for being a pillar of support, morally and financially.

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LIST OF ABBREVIATIONS

2-D: Two-Dimensional

2DLDA: Two-Dimensional Linear Discriminant Analysis

2DPCA: Two-Dimensional Principal Component Analysis

3-D: Three-Dimensional

AAM: Active Appearance Model

AES: Age Estimation System

AFM: Appearance Feature Model

AGES: Aging Pattern Subspace

AM: Anthropometric Model

AMM: Age Manifold Model

ANN: Artificial Neural Network

ART: Average Recognition Time

BIF: Bio-inspired features

BP: Back Propagation

BPNN: Back Propagation Neural Network

CCR: Correct Classification Rate

CEA: Conformal Embedding Analysis

Cp: Cross over probability (Genetic algorithm parameter)

CS: Cumulative Score

DNA: Deoxyribonucleic Acid

EBGM: Elastic Bunch Graph Matching

EEG: Electroencephalogram

GA: Genetic Algorithm

GA-ANN: hybrid of Genetic Algorithm and Artificial Neural Network (Genetic-Artificial Neural Network)

GANN: Gabor Wavelet Artificial Neural Network-based Age Estimation System

GGANN: Gabor Wavelet Genetic- Artificial Neural Network-based Age Estimation System

GGANN-220: Gabor Wavelet Genetic- Artificial Neural Network-based Age Estimation System trained with 220 black faces

GGANN-855: Gabor Wavelet Genetic- Artificial Neural Network- based Age Estimation System trained with 855 black faces

GW: Gabor Wavelet

HCI: Human-Computer Interaction

HOG: Histograms Oriented Gradients technique

ICA: Independent Component Analysis

IT: Information Technology

LARR: Locally Adjusted Robust Regressor

LBANN: Local Binary Pattern Artificial Neural Network- based Age Estimation System

LBGANN: Local Binary Pattern Genetic- Artificial Neural Network- based Age Estimation System

LBGANN-220: Local Binary Pattern Genetic- Artificial Neural Network- based Age Estimation System trained with 220 black faces

LBGANN-855: Local Binary Pattern Genetic- Artificial Neural Network- based Age Estimation System trained with 855 black faces

LBP: Local Binary Pattern

LDA: Linear Discriminant Analysis

MAE: Mean Absolute Error

MATLAB: Matrix Laboratory Software

Mp: Mutation Probability (Genetic algorithm parameter)

MU: Momentum update

MU_dec: Momentum update decreasing factor

Ngen: Number of Generation (Genetic algorithm parameter)

NN: Neural Networks

OCR: Optical Character Recognition

PCA: Principal Component Analysis

PLS: Partial Least Square Approach

Ps: Population Size (Genetic algorithm parameter)

PubFig: Public Figures benchmark

rKCCA: Reduced Canonical Correlation Analysis

RT: Recognition Time

SOM: Self-Organizing map

SURF: Speeded-Up Robust Features

SVM: Support Vector Machine

SVR: Support Vector Regression

TSP: Traveling salesman problem

TT: Training Time

ABSTRACT

Age estimation is the determination of a person's age based on its biometric features. Its application can be seen in areas such as forensic analysis. E-Government, security and surveillance. Face biometric being non-intrusive is a preferred biometric for age estimation. Research focus in face-based age estimation system is to increase the number of correctly classified images, reduce the recognition time, and make appropriate choice of feature extraction technique to use, especially in an uncontrolled environment. Some of the computational approaches that have been used for face-based age estimation include machine learning techniques such as support vector machines, neural network and Bio-inspired Features (BIF). However, optimization techniques can be integrated into the classification module of age estimation systems to improve the overall performance. The back-propagation algorithm is the most popularly used algorithm for training a multilayer Artificial Neural Network (ANN). It is an efficient technique applied to classification problems, but still suffers drawback with complex problem space, as it has the tendency to converge at a local minimal point. This study is aimed at developing a face-based Age Estimation System (AES) using Genetic Algorithm - Back Propagation Artificial Neural Network (GA-ANN) for improved age estimation. The combination is motivated by the fact that Genetic Algorithm (GA) has the potential to traverse the entire search space while remaining time efficient. Hence, offsetting the aforementioned problem. The study implemented two feature extraction techniques namely Local Binary Pattern (LBP) and Gabor Wavelet (GW) separately, to deduce which is most suitable for black faces. Principal Component Analysis (PCA) was further applied to the feature vector generated for the second level feature extraction in order to remove redundant features. The system was trained and tested with a newly developed database containing 855 black faces taken in an uncontrolled environment using a mobile app and 500 faces from the FG-NET database. The system was trained 80% and tested with 20% of the database. The developed systems LBP GA-ANN (LBGANN) and GW GA-ANN (GGANN) were implemented in MATLAB programming environment. The study showed that the developed GA-ANN based AES (LBGANN and GGANN) performed better than standard back propagation Artificial Neural Network (ANN) based systems (LBANN and GANN) in terms of Correct Classification Rate (CCR) and recognition time, as it showed a correct classification rate of 94.97% and 92.11% respectively as against the standard ANN-based system that had 89.69% and 88.72% respectively. The developed system incurred more training time as it iterates through several GA generations. The study also showed that LBP feature extraction technique is more suitable for faces as it better encodes face texture information and morphological changes during growth than Gabor wavelet.

Keywords: Age estimation, face-based, artificial neural network, genetic algorithm, black face