Iraqi Journal of Science
ISSN: 0067-2904

Intelligent Age Estimation From Facial Images Using Machine Learning Techniques

Ayad R. Abbas*, Asaad R. Kareem
Computer Science Department, Technology University, Baghdad, Iraq.

Abstract

Lately, a growing interest has been emerging in age estimation from face images because of the wide range of potential implementations in law enforcement, security control, and human computer interactions. Nevertheless, in spite of the advances in age estimation, it is still a challenging issue. This is due to the fact that face aging process is not only set by distinct elements, such as genetic factors, but by extrinsic factors, such as lifestyle, expressions, and environment as well. This paper applied machine learning technique to intelligent age estimation from facial images using J48 classifier on FG_NET dataset. The proposed work consists of three phases; the first phase is image preprocessing which include five stages: gray scale image, noise removable, face detection, image size normalization and clipping process. The second phase is ~~a~~ data mining process which includes three stages: feature extraction, feature selection and classification using j48 classifier. The third phase includes two stages, estimation and evaluation. FG-NET dataset is used which is divided into three classes; first class represents (3-7), (26-30) ages and this class represents the ages from 3 to 7 years and from 26 to 30 years because this class have four attributes from any one of this images, second class represents (8-25) ages and this class represents the ages from 8 to 25 years because this class have five attributes from any one of this images, last class represents (31-50) ages and have nine attributes from any one of this images. The Experimental results illustrate that the proposed system can give results with high precision and low time complexity. The practical evaluation of the proposed system gives accuracy up to 89.13 % with time taken of 0.023.

Keywords: Age estimation, viola jones, linear discriminate analysis, machine learning, J48 classifier, age prediction.

تقييم العمر من صور الوجه بالاستخدام تقنية التعليم الالي

اسعد رحيم كريم، اياد روضان عباس*

قسم علوم الحاسبات، الجامعة التكنولوجية، بغداد، العراق

الخلاصة

في الآونة الأخيرة، ظهر اهتمام متزايد في تقدير العمر من الصور الوجه بسبب مجموعة واسعة من التطبيقات المحتملة في تنفيذ القانون، ومراقبة الأمن، والتفاعلات الإنسان و الكمبيوتر. مع ذلك، وعلى الرغم من التقدم المحرز في تقدير العمر، فإنه لا يزال مسألة صعبة. ويرجع ذلك إلى حقيقة أن عملية الشيخوخة الوجه ليس فقط التي وضعتها عناصر متميزة، مثل العوامل الوراثية، ولكن عن طريق عوامل خارجية، مثل نمط الحياة، والتعبيرات، وكذلك البيئة. طبق هذا البحث تقنية التعلم الآلي لتقدير العمر الذكي من صور الوجه باستخدام المصنف J48 على مجموعة بيانات FG_NET . يتكون العمل المقترح من ثلاث مراحل، المرحلة الأولى هي معالجة ما قبل التصوير تشمل خمس خطوات. الصورة الرمادية ، قابلية لإزالة الضوضاء، كشف

*Email: Ayad_cs@yahoo.com

الوجه، تطبيع حجم الصورة وعملية القص. المرحلة الثانية هي عملية استخراج الميزات و تشمل ثلاث خطوات، استخراج الميزة، واختيار الميزة وتصنيفها باستخدام المصنف j48. أما المرحلة الثالثة فهي تقدير العمر، ويشمل التقييم مرحلتين تقدير وتقييم . وتستخدم مجموعة البيانات FG_NET التي تنقسم إلى ثلاث فئات. تمثل الفئة الأولى (3−7)، (26−30) سنة ولها أربعة سمات، تمثل الفئة الثانية (8−25) سنة ولديها خمس سمات، آخر فئة تمثل (31−50) سنة ولها تسعة سمات. النتائج التجريبية توضح حقيقة أن النظام يمكن أن تعطي نتائج عالية الدقة مع وقت منخفض. التقييم العملي للنظام المقترح يعطي دقة 89.13٪ مع الوقت المستغرق هو 0.023.

1. Introduction

Age estimation task is one of facial image classification tasks. It may be classified as determining the age of a person or their age group based on face images. Some of the potential implementations that use age estimation are: (i) Law enforcement: age estimation systems may be helpful in the determination of the suspects with a higher efficiency and accuracy via filtering the gallery data-base with the use of the estimated age. (ii) Security control: An automatic age estimation system may be utilized for preventing minors from purchasing alcohol or cigarettes from vending machines or the access to inappropriate websites. (iii) Human-computer interaction (HCI): The system is capable of adjusting the contents that are presented to users according to their ages. In this research, an estimation and classification to the age from facial face has been implemented using J48 classifier. The proposed method consists of three phase; image preprocessing phase, data mining process phase and age estimation and evaluation phase. The image preprocessing phase includes five stages; gray image, noise removal, faces detection and image normalization. Data mining process phase includes three stages; feature extraction, feature selection and classification, Finally; Age estimation and evaluation phase which includes two stages; estimation and evaluation stages. The contribution of age estimation to determining the age of immigrants or asylum seekers in situations where there are no documents proving the person's age, in law Enforcement to Suspect identification and Suspect tracking (investigation), for places on the Internet where entrance is permitted only to persons older than 18 years and The system can adjust the contents presented to a user based on his/her age. For example, a smart shopping cart can be designed to provide recommendations according to the age of the customer. In this proposed system, the problem of time spent on implementation was processed [1].

2. Literature Survey

Choobeh A. K.in 2012. Presented a framework for age estimation which is based on a group of individual estimators of age. Each of the mathematical and experimental proofs illustrate that, if the individual age estimators are varying in error, then for improving the outputs, has been made the group age estimator with the use of the optimal chosen individual age estimators. In this research of the automatic age estimating system utilized the FG-NET Aging Data-base, The results are performed via neural networks [2].

Kohail S. N. in 2012. Presents the application of NNs for the estimation of human age, the images have been collected from real people around the researchers (i.e. friends and family). Some of the images have been captured by a camera and the rest of them were provided by their owners. The results are performed by MLP network with accuracy 79.67[3].

Selim M., et, al, in 2012. In this research, the system is trained with the use of the FERET data-set. The training data is split to 5 basic age groups. This information is described with the use of the uniform Local Binary Pattern (LBP) and the age estimation is performed with the use of the K-Nearest Neighbour classifier with achieving a precision rate of 81% on the testing data [4].

Karthigayani P. and Sridhar S. in 2014. The presented system is made up of 4 steps. The first step is the extraction of the properties with the use of canny edge detection method, Secondly the face verification and recognition with the use of Elastic Matching Pattern and Maximum Likelihood Classifier. Third stage is using Back Propagation NN. Experiments are performed with the use of the ORL data-set. The results obtained from the system are 95% of accuracy [5].

Levi G.and Hassner T. in 2015. Presents the learning representations through using the deep-convolutional NNs (CNN), the idea is a simple convolutional net model that may be utilized even when the amount of learning data is not quite sufficient [6].Has been evaluating the method on

Adience benchmark for estimating age and gender. The results of age and Gender estimation are 86.8 accuracy ± 1.4.standard errors [6].

Table 1- illustrates the difference between the above works and the proposed work

No.	Name of author	Related works		
		Aim of work	Tools	dataset
1	Choobeh A. K.	Presented a framework for age estimation which is based on a group of individual estimators of age	neural networks (ANNs),Principal Component Analysis (PCA),	FG-NET
2	Kohail S. N.	Presents the application of NNs for the estimation of human age	Multi-layer perceptron neural networks (MLP)	Captured by a camera
3	Selim M.	Presents a work on age-group estimation from facial images using features that are not computationally expensive, and can be done in real-time.	K-Nearest Neighbor classifier	FERET dataset
4	Karthigayai P. and Sridhar S	deals about occlusion detection in face recognition and estimation of human age using image processing	Elastic Matching Pattern and maximum Likelihood Classifier	ORL dataset
5	Levi G.and Hassner T	a simple convolutional net model that utilized for age estimation even when the amount of earning data is not quite sufficient	deep-convolutional neural networks (CNN)	the recent Audience benchmark (mobile)
6	The proposed system	Presents the application of J48 classifier for the estimation of human age from facial images	Linear discriminant Analysis(LDA) and J48 classifier	FG-NET databases

3. The proposed system

The proposed system can automatic estimate ages based on his/her face image. For achieving this aim, we present the following a research method which is made up of three phases as shown in the following Figure-1.

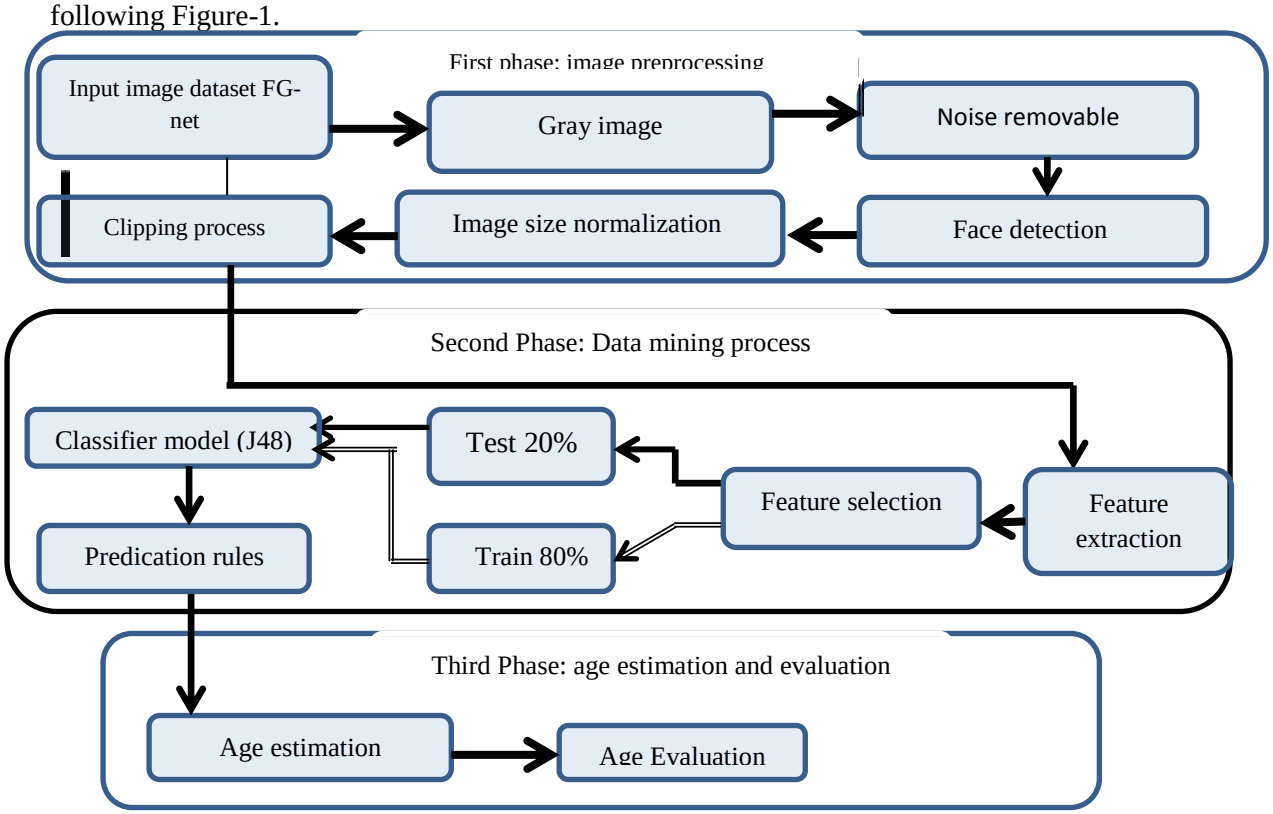

Figure 1-The Proposed System.

In this study, we used FG-NET [7] dataset which is consists of 1002 frontal face images of 82 diffeent individuals, 12 images per subject. Through experiments conducted, we noticed that division the dataset FG-NET into 80% training and 20% testing are becoming more accurate. The range of the

age from 3 year to 50 year, dataset divided into three classes; first Class represents (3-7), (26-30) ages and has four attributes and 215 instances, second class represents (8-25) ages and has five attributes and 409 instances, last class represents (31-50) ages and has nine attributes and 96 instances. Number of all instances is (720) images and number of all attributes is (21) attributes, the results are obtained using decision tree (j48) classifier .The proposed system implements three phases:

3. 1 Image processing

The proposed image processing phase includes five stages as follows:

3. 1. 1 gray image process [8]:

All gray-scale methods use the same main three-step operation: Get the RGB values of a pixel, implement mathematics for turning these numbers to one grey value, Replace the original RGB values with the new grey value by using following equation [8].

$$GY=0.56\ G + 0.33\ R + 0.11\ B \quad \textbf{(1)}$$

3. 1. 2 noise removal process:

Noise is an undesirable data can be produced from the image acquisition process. It is caused due to the low quality of optical scanner or paper types which affect the recognition rate. Therefore, it is very important for removing the noise before the image is fed into the next operations. Median filter is a best filter that can be used to remove the salt and pepper noise [9]**.**

3. 1. 3 face detection:

The face detection introduced by Viola and Jones to look for specific Haar properties of a human face [10]. When one of those properties is detected, the methods permits the candidate to move to the following step of detection. A facial candidate is a rectangular segment of the original image known as sub-window have a predefined size (usually 24×24 pixels). There are four key contributions as follow:

A. Integral Image:

This image is defined as the sum of all the pixel values of the initial image [11], The value at any index (x, y) of the integral image is the summation of the image pixels above and to the left of index (x, y). Figures-(2, 3) represents the generation of the integral image.

B. Haar Features:

Made up of either two or three rectangles. The weight and size of every one of the properties and the properties themselves are produced with the use of a machine learning approach from AdaBoost [12]. As seen in Figure-4 every one of the Haar features has a value computed via taking the area of every rectangle, multiplying every one of them by their respective weights, and after that adding up the results.

C. Haar Feature Classifier:

Utilizes the rectangle integral for calculating the value of a property and multiplies the weight of every rectangle by its area and the results are summed up together. Adds up all the Haar property classifier results in a step and compares this sum to a stage threshold. This threshold is also a constant value computed from the AdaBoost. According to the parameters of the training data individual steps may have a varying number of Haar properties [13].

D. Cascade:

This process performs an elimination of face candidates quickly via a collection of stages, which eliminates candidates via making stricter requirements in every step with later ones being much harder for a candidate to pass [14]. Candidates exit the cascade in the case where they pass all stages or fail any stage. A face is detected if a candidate passes all stages.

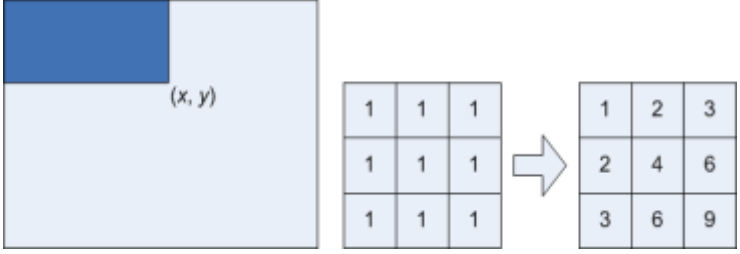

Figure 2- Integral image generation

Figure 3-Examples of Haar properties

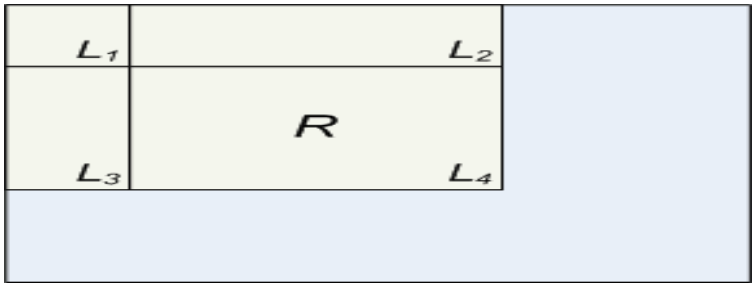

Figure 4-computing the area *R* is performed with the use of the corner of the rectangle locations of the integral image R= *L4-L3-L2+L1*

3. 1. 4 image size normalization:

It is a process which changes the range of pixel intensity values. Applications include photos with low contrast because of the glare. Sometimes, normalization is known as contrast or histogram stretching and converts an n-dimensional gray-scale image I:{X$\subseteq \boldsymbol{R^n}$}$\rightarrow$ {Min,..,Max} With intensity values in the range (Min,..Max), to a new image $\boldsymbol{I_N}$: {X$\subseteq \boldsymbol{R^n}$}$\rightarrow$ {newMin,., newMax}with Intensity values in the range (new Min, new Max). Normalization of a grayscale image is performed.

$\mathbf{I_N}$: (1-Min) $\frac{\textbf{new Max}-\textbf{new Min}}{\textbf{Max}-\textbf{Min}}$ + newMin **(2)**

3. 1.5 clipping process:

which delete unwanted white space around the face in the background image, the white space represented by (1) value can effect on the feature extraction result and make it dose non efficient, the removing white space process calculate the number of white pixels from all image directions (top, down, left, right).

3. 2 Data mining process:

The proposed data mining process consist of three stages as follows:

3. 2. 1 Feature extraction:

Process of the extraction of relevant data from a facial image, this data has to be valuable for the following stage of recognizing the item with a sufficient error rate. Linear Discriminant Analysis (LDA) [15] is typically utilized as dimensionality reduction approach for pattern-classification and machine learning applications. The aim is projecting a data-set onto a lower-dimensional space with an efficient class-reparability for avoiding over fitting and reducing computational costs as well.

In this first stage, calculation of the average vectors mi, (i=1, 2, 3) classes:

$$\text{mi}=\begin{bmatrix}\mu\omega i(\text{sepal length}))\\ \mu\omega i(\text{sepal width})\\ \mu\omega i(\text{sepal length})\\ \mu\omega i(\text{sepal width})\end{bmatrix}\text{,with i=1,2,3 vector}$$

$$\mathbf{mi} = \frac{\mathbf{1}}{\mathbf{ni}}\sum_{\mathbf{x\in Di}}^{\mathbf{n}}\mathbf{xk} \quad \textbf{(3)}$$

The next stage compute the scatter matrix includes within–class scatter matrix Eq. (.4), class-covariance matrices Eq. (.5), and between-class scatter matrix Eq. (6).

$$\text{SW}=\sum_{\mathbf{i=1}}^{\mathbf{c}}\ (\mathbf{N}-\mathbf{1})\ \frac{\mathbf{1}}{\mathbf{N-1}}\ \sum_{\mathbf{x\in Di}}^{\mathbf{n}}(\mathbf{x}-\mathbf{mi})(\mathbf{x}-\mathbf{mi})^{\mathbf{T}} \quad \textbf{(4)}$$

$$\sum \text{i}=\ \frac{\mathbf{1}}{\mathbf{N-1}}\ \sum_{\mathbf{x\in Di}}^{\mathbf{n}}(\mathbf{x}-\mathbf{mi})(\mathbf{x}-\mathbf{mi})^{\mathbf{T}} \quad \textbf{(5)}$$

$$\text{SB}=\sum_{\mathbf{i}}^{\mathbf{c}}\mathbf{Ni}(\mathbf{mi}-\mathbf{m})(\mathbf{mi}-\mathbf{m})^{\mathbf{T}} \quad (\mathbf{6})$$

where *m* is the total average, c no. of class, *mi* and *Ni* are the sample average and sizes of the

respective classes. Solving the generalized eigenvalue problem for the matrix $\mathbf{Sw^{-1}SB}$, then check that the eigenvector-eigenvalue calculation

$Av=\lambda v$ **(7)**

Where $A= \mathbf{Sw^{-1}SB}$, v=Eigenvector, λ=Eigenvalue. the last stage, has been used the 4×2D matrix W, which just calculated for transforming the samples to the new sub-space using the formula.

$Y = X * W$ **(8)**

Algorithm LDA –Fisher Faces Feature [16]
Input: clipped face image Output: fisher face feature vectors(average from 4 to 9)
Step 1:read transform face images Step 2: store transform face image in matrix. Step 3: compute the d-dimensional mean vectors by using Equation (.3) Step 4: compute the scatter matrices. a) Compute within –class scatter matrix (SW) by using Equation (.4). b) Compute the class-covariance. by using Equation (.5) c) Compute between –class scatter matrix (SB) by using Equation (.6). Step 5: Solving the generalized eigenvalue problem for matrix by Equation (.7). Step 6: Choosing linear discriminates for the new property sub-space. a) Sorting the eigen-vectors via decreasing eigen-values. b) Selecting *k* eigen-vectors with the biggest eigen-values. Step 7: transforming the samples to the new sub-space by using Equation (.8). Step 8: return feature vectors.

3. 2. 2 Classifications [17]:

Is a simple C4.5 decision tree for classification, it creates a binary tree. The decision tree method is most beneficial in the classification problem. With this method, a tree is constructed for modeling the classification procedure. As soon as the tree is constructed, it is applied to every tuple in the data-base and results in the classification for that tuple. While building a tree, J48 discards the missing values; the main concept is dividing the data to range according to the attribute values for that item found in the training sample. J48 permits classification via either decision trees or rules generated from them [18].

Algorithm J48 classifier (*D*) [17]
Input: data set Output: Decision tree (Decision rule)
Step1: read features face image Step 2: Checking if algorithm satisfies the criteria of termination. Step 3: Computer information-theoretical criteria for each attribute. Step 4: Select the optimal attribute according to the information-theoretical criteria. Step 5: Creating a decision node according to the optimal attribute in step4. Step 6: Inducing the data-set according to the newly produced decision node in step5. Step 7: For every sub-dataset in step6, call J48 algorithm to obtain a sub-tree. Step 8: Attaching the tree produced from step7 to the decision node in step5. Step 9: return tree.

4. Experimental results and evaluation

Experiments are performed on age estimation system by applying J48 classifier with 10 fold cross validation [18]. To evaluate the machine learning techniques (J48 classifier), confusion matrix [19] Table-2 and root mean square errors are used as follows:

Table 2-confusion matrix

Actual Class	*predicted Class*		
		Positive (a)	Negative (b)
	Positive (c)	True positive (TP)	False Negative (FN)
	Negative (d)	False positive (FP)	True Negative (TN)

- True positive rate = diagonal element/ summation of relevant row **(9)**
- False positive rate = non-diagonal element/ summation of relevant row **(10)**
- Precision = TP/ (TP + FP) **(11)**
- Recall = TP / (TP + FN) **(12)**
- F-measure =2*$\frac{\text{prscision}*\text{recall}}{\text{precision}+\text{recall}}$ **(13)**
- Accuracy (Acc) = (TP+TN) / (TP+FP+TN+FN) **(14)**
- Error rate (*Err)* =(FP+FN) / (TP+FP+TN+FN), Err = 1- Accuracy **(15)**
- Mean absolute error (MAE) = $\frac{1}{N}\sum_{i=1}^{n}\left|\overline{\theta}i-\theta i\right|$ **(16)**
- Root mean squared error(RMSE) = $\sqrt{\frac{1}{N}\sum_{i=1}^{n}(\overline{\theta}\,i-\theta i)^2}$ **(17)**
- Relative absolute error(RAE) = $\frac{\sum_{i=1}^{n}|\overline{\theta}i-\theta i|}{\sum_{i=1}^{n}|\overline{\theta}-\theta i|}$ **(18)**
- Root relative squared error (RRSE) = $\sqrt{\frac{\sum_{i=1}^{n}(\overline{\theta}i-\theta i)^2}{\sum_{i=1}^{n}(\overline{\theta}-\theta i)^2}}$ **(19)**

The FG_NET dataset was divided into 80% training and 20% testing to increase accuracy.

Table 3- instance, attribute, correctly, incorrectly classified and class age range

class-age range	instance	attribute	correctly classified instances	correctly percentage	incorrectly classified instances	incorrectly percentage
(0-7) (26-30)	215	5	201	93.4884	14	6.5116
(8-13) (14-9) (20-25)	409	6	390	95.3545	19	4.6455
(31-40)(41-50)	96	10	71	73.9583	25	26.0417
Average	720	21	662	87.6004	58	12.3996

Table 4-Accuracy and Time taken

class-age range	true positive rate	true negative rate	precision	recall	f-measure	time taken
(0-7)(26-30)	93.4884	98.9060	93.9389	93.4884	93.1367	0.02
(8-13)(14-19)(20-25)	95.3545	99.6734	95.5211	95.3545	95.3500	0.03
(31-40)(41-50)	73.9583	98.9436	78.4739	73.9583	74.7255	0.02
average	87.6004	99.1744	89.3113	87.6004	87.7374	0.0233

Table 5-Mean Absolute Error

class-age range	Mean absolute error	root mean squared error	relative absolute error	root relative squared error
(0-7)(26-30)	1.3838	11.4240	7.8819	38.5745
(8-13)(14-19)(20-25)	0.5967	7.1809	5.7246	31.4562
(31-40)(41-50)	2.4878	15.1529	26.3438	69.6451
average	1.4894	11.2526	13.3168	46.5586

The results of J48 classifier (precision, recall, f-measure, time taken) are compared with other classifier such as (multilayer perceptron, hoeffding tree, smo) as mentioned in Tables- 2,3,4 and 5.

Table 6- details of the results for four classifiers

algorithms / Accuracy and error	j48	SMO	multilayer perceptron	hoeffding tree
true positive rate	87.6004	78.0000	90.9000	92.8333
true negative rate	99.1744	97.2000	99.2333	99.7000
precision	89.3113	73.9333	91.0000	92.8667
recall	87.6004	78.0000	90.9000	92.8333
f-measure	87.7374	73.1667	90.2333	92.4333
mean absolute error	1.4894	11.7100	2.1867	0.8133
root mean squared error	11.2526	23.4733	8.8167	8.1200
relative absolute error	13.3168	94.5575	19.3268	7.6425
root relative squared error	46.5586	95.2148	36.5495	34.1935
time taken	0.0233	0.9067	1.7800	0.0533

To illustrates the application of the J48 classifier Show Figure-5.

Figure 5: Example of age estimation using the proposed system

The J48 classifier was selected on the basis of time and precision, but we note from

Table-4 that multilayer perceptron and hoeffding tree have higher accuracy and more time for execution. So J48 classifier is the best way to implement.

5. Conclusion

Age estimation is one of the facial image classification tasks; it may be defined as the determination of the age of the person or his age group from facial images. In this research has been concluded that using decision tree J48 classifier having high precision rate with low time taken by

using the FG_NET dataset. J48 classifier gives **accuracy** is 89.13 % and **time taken** is 0.023. (Ages difference), we observed from Tables- (4 and 2) that the greater the number of instance in the class the greater the precision and the time taken for implementation. In additional to, the dataset type utilized for the estimation of the age, images quality and their number, to ensure that the estimate of age is correct.

Reference

1. Han, H., Otto, C. and Jain, A. K. **2013**. Age Estimation from Face Images: Human vs. Machine Performance, Spain. *International Conference on Biometrics (ICB)*,IEEE Xplore Digital library 978-1-4799-0310-8.doi: 10.1109/ICB.2013.6613022
2. Choobeh, A. K. **2012** Improving Automatic Age Estimation Algorithms using an Efficient Ensemble Technique, *International Journal of Machine Learning and Computing*, **2**(2)**.**
3. Kohail, S. N**. 2012.** Using Artificial Neural Network for Human Age Estimation Based on Facial Images, *International Conference on Innovations in Information Technology*, 978-1-4673-1101-4/12.
4. Selim, M., Raheja, S. and Stricker, D. **2013**. Real-time Human Age Estimation based on Facial images using uniform Local Binary Patterns, German. *German Research Center for Artificial Intelligence*, DFKI, Kaiserslautern.
5. Karthigayani, P. and Sridhar, S. **2014.** Detection Tree Based Occlusion Detection IN Face Recognition and Estimation of Human Age Using Back Propagation Neural Network, *Journal of Computer Science*. **10**(1): 115-127.
6. Levi, G. and Hassner, T. **2015**. Age and Gender Classification using Convolutional Neural Networks, Boston, MA, USA**,** *IEEE xplore digital library, Computer Vision and Pattern Recognition Workshops (CVPRW), IEEE* , **66**: 34-42.dio:10.1109/CVPRW.2015.7301352
7. The FG-NET Aging Database **2009**. [Online]. Available: http://www. fgnet.rsunit.com/, accessed Jul. 24, 2009.
8. Chandran, S. **2010**. Color image to grayscale image conversion, *International Conference on Computer Engineering and Application*, **12**: 96-199. doi**:**10.1109/ICCEA.2010.192
9. Pitas I. **2000**. *Digital Image Processing Algorithms and Applications*, New York, E-Book.
10. Gupta, A., and Tiwari, R. **2015**. Face Detection Using Modified Viola Jones Algorithm, *International Journal of Recent Research in Mathematics Computer Science and Information Technology***, 1**(2): 59-66.
11. VIOLA, P. and Jones, M. 2004. Robust real time face detection, *international journal of computer vision*, **57**(2): 137–154.
12. Wang, Y. **2014**. An Analysis of the Viola-Jones Face Detection Algorithm, *Image Processing On Line on (IPOL)*, pp. 128-148.
13. Talele, T., Kadam, S. and Tikare, A. **2012**. Efficient Face Detection using Adaboost, *Processing on International Conference in Computational Intelligence (ICCIA)*, 10 (ISBN: 978-93-80866-68-7)
14. Phillip, I.W. and Fernandez, J. **2006**. FACIAL FEATURE DETECTION USING HAAR CLASSIFIERS, *Journal of Computing Sciences in Colleges (JCSC)*, **21**: 127-133.
15. Jie, Y., Hua, Y. and Kunz, W. **2002.** An Efficient LDA Algorithm for Face Recognition, *School of Computer Science Interactive Systems Laboratories*. Carnegie Mellon University Pittsburgh.
16. Raschka**,** S. and Mirjalili, V. **2017**. *Python Machine Learning*. 2nd Edition Paperback**,** Michigan, Michigan State University
17. Kumar, V. and WU, X. **2009**. *The Top Ten Algorithms in Data Mining***,** new york, chapman &hall/CRC Data Mining and Knowledge Discovery Series ,series editor. Taylor & Francis Group, LLC
18. Witten, H. and Frank, E. **2005**. *Data Mining –Practical Machine Learning Tools and Techniques*, second Edition, New York.
19. Goyal, A. and Mehta, R**.2012.** Performance Comparison of Naïve Bayes and J48 Classification Algorithms, Published in *International Journal of Applied Engineering Research*, ISSN: **7**(11):0973-4562.