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Age Group Estimation Model using K-Nearest Neighborhood

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Abstract: ***Age estimation labels exact real age or age group for a given face image. How to recognise the face of a human depends upon the age invariant features and patterns. After finding out the aging patterns, the researchers are in investigation to find out in what way we can characterise the aging of a face to get accurate performance. We can estimate the age through multi class classification or regression or a combination of both classification and regression. In our paper we are classifying, predicting and evaluating our proposed aging pattern algorithm to estimate the age. The brief process is first we split the data in to two subsets i.e. training data and test data by using stratified cross validation method. By using training data and test data we are classifying or predicting the age group using K-neighbourhood method and evaluation measures are considered by using confusion matrix. The Classification and Evaluation of Age estimation models results us to find out the best estimation model for different types of datasets which are used in different applications like biometric, law enforcement, and security control and human-computer interaction.***

Keywords: ***age estimation, K neighbourhood, multiclass confusion matrix, prediction, evaluation***

I. INTRODUCTION

Collecting large databases of images is also a challenging task for estimation of Age.There is many methods to extract the key features from each database. Among them one of the current main stream method is which extract the face feature vectors directly from human face is Local Binary Pattern model. After extracting the face features from facial image the labelling of the age can be done by a class or by a set of sequential values. If the labelling is done through a class then it is solved through classification otherwise it is solved through regression .Identification of the face and recognition of the features also improves the human interaction of computer.

By using the evaluation protocol we can determine the test set, and what are the conditions to select the data for testing and can evaluate the performance of given model. To evaluate the age estimation cross validation is one method. It divides the data into two subsets .One subset is used to train or learn age estimation model and another subset is used to validate or evaluate the model. A stratified cross validation is used to improve the accuracy.

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The age estimation can be done for our proposed algorithm by using classifier called KNN classifier and we are evaluating the performance of our algorithm by Accuracy, F1 score by calculating confusion matrix. The multi class classification considers the age value as a separate category. The rest of the paper is organized as follows: Section II describes some of the related works i.e. Literature Survey. Section III presents the proposed age estimation system. Experimental results and discussion are discussed in Section IV. Finally, concluding comments are provided in Section V.

II. LITERATURE SURVEY

A. Facial aging Different Databases

There are different types of facial aging databases. They are MORPH database, FG-NET aging database, Yamaha gender and age (YGA) database, WIT-DB database Burt's Caucasian face database, LHI face database, HOIP face database ,Iranian face database, Gallagher's web-collected database, Ni's web-collected database, Kyaw's web-collected database, BERC database, 3D morphable database. In our present research work we use some of the databases to implement our proposed algorithm.

B. Data Splitting methods

There are different data splitting methods. They are
a)Cross-Validation (CV) b) Bootstrap and Monte-Carlo Cross-Validation (MCCV)
c) Bootstrapped Latin Partition (BLP) d) Kennard-Stone algorithm (K-S) and Sample Set Partitioning Based on Joint *X–Y* Distances Algorithm (SPXY)

Our present research work uses Stratified cross validation is used to split train dataset and test dataset .Here we discuss some different types of Cross Validation.

1) Leave One Out Cross Validations(LOOCV) Among 100 data points records we are taking one data point as a dataset and the remaining all are as an training dataset. In this way we repeat the process 100 times by taking all different data points as an test set. The main drawback is this method having low bias and computationally expensive

2) k-fold cross-validation

In K-fold cross validation we have to assume k value preferable to select odd value. Suppose k=5 means we have to perform 5 experiments on our 100 dataset points. Now the no of data points in test data is 100/5=25 data points and the remaining data points are treated as training dataset .so this is repeated until all other 25 data points are selected as test data set .

This type of splitting may leads to imbalance dataset because all different types of categories may not include in k –fold test dataset.

3) **Stratified Cross Validation**

It is similar to K-fold cross validation .Only difference is select that 25 data points such that it covers all classes belong to our dataset points. Similarly we have to perform 5 experiments on our 100 dataset points by selecting different 25 dataset points which includes all different class type instances.

4) Time Series cross validation

In this we are predicting day5 data by considering the data from day1 to day4.Similarly we are predicting day6 data by considering the data from day2 to day5.In this way we will find out the new values.

C. Classification methods

Classification is one of the most commonly used techniques to classify the large records or datasets. The classification of the data involves learning to analyse the trained data to build a model and also involves estimating the accuracy of the model using test data. The established rules from the given model is applied on new dataset. Several algorithms are developed based on multi-class classification. Those are neural networks, decision trees, k-nearest neighbours, naive bayes, support vector machines and extreme learning machines. In our proposed research work we use KNN to classify and predict Multiclass categories.

1) k-nearest neighbours

we can perform classification by using KNN classifier as it is based on feature similarity. It is one of the simplest supervised machine learning algorithms mostly used for classifying a data point.

It classifies the data based on the way of the neighbour's classification. It stores all available classes and new dataset points are classified based on similarity measure. k is a parameter that refers to the number of nearest neighbours we have consider .The k value should always be odd i.e..3, 5, 7....Use formula k=Sqrt(n) where n is the total no of data points. Here we have to calculate the Euclidean distance from unknown data point to

all known data points. Next we select k entries in our database which are closest to the unknown sample. Among them the most common classification gives us the solution

D. The Confusion matrix for multiple classes

The confusion matrix is a matrix where columns represent the predicted classes and rows represent the actual classes. The diagonal values are True Positive values for their respective class. The confusion matrix is used to measure the model performance.

We are using Accuracy, Precision, Recall, F1 score are the performance measures based on confusion matrix. To select one of the models we have to use one of the performance measure based on the dataset points. To calculate those performance methods we have to know about the following terms

1) True Positive: True Positive (TP) are the values which are correctly identified for each class i.e. When both actual class of the data point and the predicted was true.

2) True Negatives: True Negatives (TN) are correctly rejected for a given class i.e. when both actual class of the data point and the predicted was false.

3) False Positives: False Positives (FP) are incorrectly identified for certain class i.e. when the actual class of the data point is false and predicted as true

4) False Negatives: False Negatives (FN) are incorrectly rejected for certain class i.e. when actual class of the data point was true and predicted as false.

The performance measures based on confusion matrix are

a. Accuracy: It is calculated as total no of correct predictions divided by total number of data points

Accuracy=$TP_A+TP_B+.....TP_N$/(total no of data points).

b. Precision: The output of the precision is it returns only relevant instances of a given model. The formula of the precision for a given class A is

Precision P (A) =$TP_A/(TP_A+FP_A)$

So Average Precision=P(A) +P(B) +.....+P(N)/N

c. Recall or Sensitivity: The output of the sensitivity is to identify all relevant instances. The formula of the sensitivity for a given class A is

Recall R (A) =$TP_A/(TP_A+FN_A)$

So Average Recall=R(A)+R(B)+...+R(N)/N

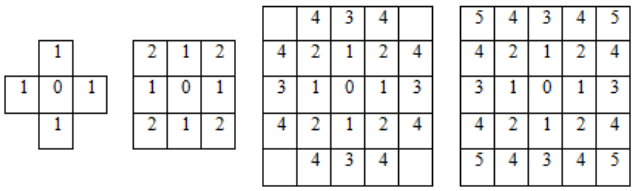
d. F1 score: The output of the F1 score is the harmonic mean of recall and precision. Single metric that combines recall and precision using the harmonic mean

F1 Score = Harmonic Mean(Precision, Recall)

F1 Score = 2 * Precision * Recall / (Precision + Recall)

.

E. N^{th} order Neighbourhood



Fig(1) a)1st Order (b) 2ndorder (c)3rd order (d) nthorder Neighbourhood pattern

The fig(1) illustrates different orders of neighbourhood for a central pixel. Most of the research involved in image processing is mostly revolved around second order neighbourhood only.

This is because all the 8- neighbouring pixels are well connected with central pixels and the methods based on second order neighbourhood are given extraordinary results in various issues. The present approach considering the difficulties and complexities involved in the third order neighbourhood and derived a new, simple and efficient model for image analysis based on transitions. The considered third order neighbourhood is formed in 5×5 by window. The Third order Neighbourhood (TN) has thirteen pixels of twenty five pixels of 5×5 neighbourhood as shown in Figure 5. .

F. Local Binary Patterns

Local Binary Patterns technique. This method detects different kinds of patterns like spot, edges, lines flat areas which are on the skin. The LBP patterns of spot, edges, lines, and flat areas can be identified

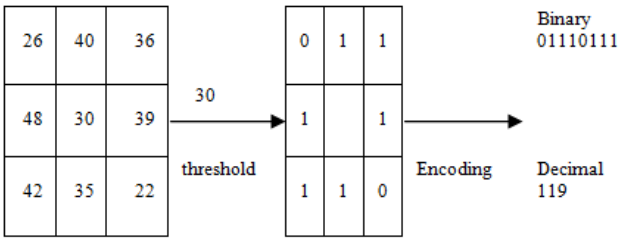
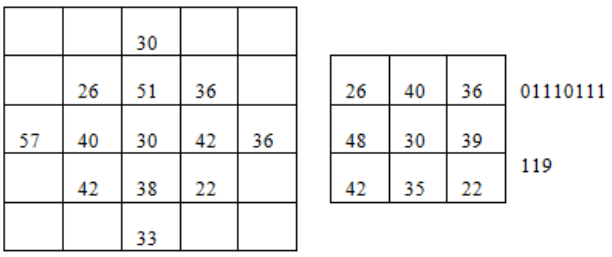


Fig 2. Example of LBP operation LBP techniques are used to describe textures

like gender classification, age estimation, and facial component tracking. The process of LBP is shown in Fig2 .The centre pixel value is treated as Threshold value. If the values are greater than the threshold value, then that value is converted as 1otherwise it is converted as 0.Then the summation of all the values gives us a binary number. While summing the binary number with highest value gives us rotation invariant feature. The LBP operator is used to find out the features for different types of neighbourhood with different radii. The LBP codes are categorized as uniform and non-uniform patterns. Uniform patterns represent structures like line, spot, edge and flat area. The 2 bit wise transitions i.e. from 0to 1 or 1 to0 are categorized as uniform pattern. We say the pattern is a uniform pattern if the transitions count from 1to 0 and 0 to 1 is equal. For example, 00010000 is uniform pattern because the transition from 0->1 or 1->0 has same count. Similarly 00000000 and11011111 patterns are uniform .In the same way 01010000 is non uniform pattern because the transition count is not equal and similarly 11100101 and 10101001 are non-uniform patterns. To calculate the number of uniform patterns the formula is n (n − 1) + 2 uniform patterns for n binary bits. The LBP code is circularly rotated until its min value is obtained so that the LBP code can extract rotational invariant features.

G. Conversion of 5X5 neighbourhood into 3X3 neighbourhood and then to LBP code

We are converting 5X5 neighbourhood into 3X3neighborhood by finding out the mean of all the 4 middle values as shown in Fig(3). From the above figure we can say the top value is changed as 40 by finding mean of (30, 51).The bottom value is changed as 35 by finding out the mean of (38, 33).



Fig(3) a) 5X5 neighbourhood b) 3x3 neighbourhood c) Binary form of LBP and its code

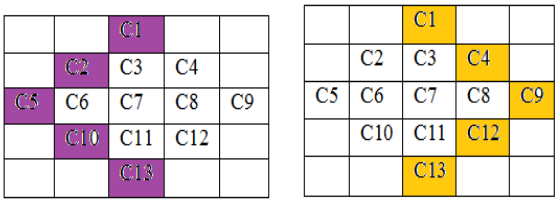
The right value is changed as 39 by finding mean of (42, 6).The Left value is changed as 48 by finding out the mean of (57, 40).we can easily find out the LBP binary value ad LBP decimal value from third order neighbourhood

III. PROPOSED METHOD

A. Counting the zero, two, four transitions for Left Angle Pattern Count and Right Angle Pattern Count

1) First the image is converted into their corresponding pixel value .Each and every pixel in the image is then converted into LBP code as shown in the fig(5). Here we are using some of the facial database images as input.

2) Each image is divided in to blocks of size N*N. Our present research derives the algorithm for '<' pattern and '>' pattern in 5X5 window consists of 5 pixels. The 5x5 window is moved to overall image of size NxN such that 5x5 window covers each and every pixel. In the fig(4) '<' pattern pixels are indicated with one colour and '>' pixels are indicated with another colour. The positions c1, c2, c5, c10, c13 form '<' pattern and the positions c1, c4, c9, c12, c13form'>'pattern

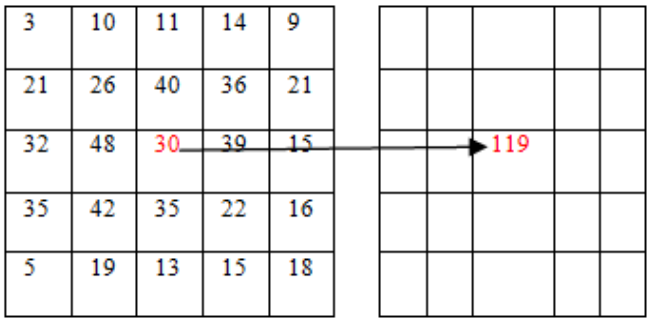


Fig(4) a)'<' pattern b)'>'pattern

3) In each '<' and '>' patterns count the number of 0,2,4 transition in the pattern. The transition means value is changed either from one-to-zero or zero-to-one in pattern. The present paper considers the transitions in circularly. While considering the pattern circularly, three types of transitions are occurred i.e. 0, 2, and 4 transitions.

For example, the considered pattern‘00000’or‘11111’ has 0 transitions, while patterns 00001, 00010, and so on have two 1->0 or 0->1 transitions. The binary patterns like 00101, 01001, 01011 and other circularly pivoted bitwise turned renditions have 4 one-to-zero or zero-to-one transitions.

The present approach uses 5 bits to from ‘<’ and inverted ‘>’ patterns of TNP. So, totally forms 32 distinct patterns with one of the 3 transitions i.e. zero, two and four transitions. The present approach evaluated the frequency occurrences of transitions
on ‘<’ and ‘>’ of TNP on the facial images for estimating the age groups. Each ‘<’ or ‘>’ pattern consists of 5 bit pattern. The different combinations for 5 bit pattern are 2^5 i.e. 32 bit patterns. There are two 0 transitions for decimal values 0 and 31. The decimal values 5,9,10,11,13,18,20,21,22,26 results for 0 to 1 or 1 to 0 four transitions.
The rest of the binary equivalent decimal values1,2,3,4,6,7,8,12,14,15,16,17,19,23,24,25,27,28,29, 30 results two transitions. For each image we can count how many number of zero, two, four no of transitions occurred for a given database easily from the above explained information.



Fig(5) Input image **Output image**

4) The Total no of 0 transitions, 2 transitions,4 transitions for left angular pattern and the total no of 0transitions,2 transitions,4 transitions for right angular pattern for each and every image for child hood database ,young database, Middle age database, senior age database and senior citizen database. For example the Table 1 shows us the total no of 0 transitions, 2 transitions, 4 transitions for left angular pattern and right angular pattern for child hood databases. Similarly we can construct table for Young age databases, Middle age databases, senior age databases and Senior citizen databases

5)From the construction of tables for child ,young ,Middle age , senior age and senior citizens database .we can observe what is the count for 0 transition ,2 transition , 4 transition for each and every database.

6)From the observations of the above database we derived our proposed algorithm to estimate the age The algorithm is shown below

S. NO	Image Name	Left <pattern Count (LAC)							Right> pattern Count (RAC)						
		0	2	4	0+2	0+4	2+4	0+2+4	0	2	4	0+2	0+4	2+4	0+2+4
1	001A02	340	1501	500	1841	840	2001	2341	893	1195	253	2088	1146	1448	2341
2	001A05	373	1010	958	1383	1331	1968	2341	963	1192	186	2155	1149	1378	2341
3	001A08	421	1020	900	1441	1321	1920	2341	959	1178	204	2137	1163	1382	2341
4	001A10	461	1280	600	1741	1061	1880	2341	955	1149	237	2104	1192	1386	2341
5	002A03	530	1241	570	1771	1100	1811	2341	1023	1147	171	2170	1194	1318	2341
6	002A04	521	1510	310	2042	842	1820	2341	972	1144	225	2116	1197	1369	2341
7	002A07	535	990	816	1525	1351	1806	2341	1022	1144	175	2166	1197	1319	2341
8	008A06	538	1500	303	2038	841	1803	2341	1045	1141	155	2186	1200	1296	2341
9	009A00	538	1500	303	2038	841	1803	2341	823	1133	385	1956	1208	1518	2341
10	010A01	557	1080	704	1637	1261	1784	2341	851	1132	358	1983	1209	1490	2341
11	gi008	566	1200	575	1766	1141	1775	2341	843	1131	367	1974	1210	1498	2341
12	gi003	576	865	900	1441	1476	1765	2341	870	1130	341	2000	1211	1471	2341
13	gi002	571	1100	670	1859	1391	1952	2341	1062	1123	156	2185	1218	1279	2341
14	gi009	594	1550	197	2144	791	1747	2341	1059	1120	162	2179	1221	1282	2341
15	gi007	631	1370	340	2001	971	1710	2341	992	1116	233	2108	1225	1349	2341
16	gi005	636	1509	196	2145	832	1705	2341	992	1113	236	2105	1228	1349	2341
17	si001	670	1131	540	1801	1210	1671	2341	1027	1107	207	2134	1234	1314	2341
18	si003	685	1434	222	2353	2119	1656	2341	1124	1087	130	2211	1254	1217	2341
19	si005	700	1460	181	2160	881	1641	2341	1011	1078	252	2089	1263	1330	2341
20	si009	730	1430	181	2160	911	1611	2341	1030	1075	236	2105	1266	1311	2341

Example Table1.Frequency occurrences of transition’<’and ’>’ patterns of TNP for childhood images

B) Derived Algorithm to estimate the Age

From the data in FV tables, define a user defined algorithm for estimating the age group of the input facial test image. The algorithm classify the facial test input image into one of the pre- Input Image Output Image defined class group such as Childhood (0-12 years), Young Adults (13-25 years), Middle-aged Adults26-40 years), Senior Adults (40-60 years) and Senior Citizens (more than 60 years). The derived user defined algorithm is defined in algorithm1.

Algorithm 1: Age group estimation (image)
Input: facial test image for Age group estimation
Output: Age group
Start
Step 1: Extract the skin region of the face using HIS model
Step 2: Crop the Skin region of the facial image.
Step 3: Convert the Crop color image into grey level image by using HIS color model
Step 4:Convert each 5×5 sub image of TNP into two valued matrix
Step 5: find transition trends of ‘<’ and ‘>’ patterns in each 5×5 sub image of TNP.
Step 6: Based on the transition count, estimate the age group of the test image. Let LAC be ‘<’ pattern count, RAC be the

'>' pattern count, 0 be the zero transition count, 2 be the two transition count, 4 be the four transition count.

If ((LAC (0) <= 734) and (RAC(0+4>1143)&& (RAC (0+4 < 1269))
Print ("Facial image is considered as Childhood aged group");
Else if ((LAC (0) < 837) and (RAC (0+4 >1269) && (RAC (0+4 <1494))
Print ("facial image is considered as Young adult aged group");
Else if ((LAC (0) <909) and (RAC (0+4 >1049) && (RAC (0+4 <1086))
Print ("Facial image is considered as middle aged group");
Else if ((LAC (0) <1013) and (RAC (0+4 < 1049))
Print ("Facial image is considered as Senor aged Group ");
Else if ((LAC (0) <1193) and (RAC (0+4 >1085) && (RAC (0+4 <1143))
Print ("Facial image is considered as Senior Citizen aged Group ");
Else
Print ("Unknown age group");
End

7) Now we have to test the performance of algorithm by using KNN classifier and we use performance measures like Accuracy and F1 score to determine how best our model is

a. The KNN classifier must have one training data set and one test dataset to classify the data and to predict the data.
b. In our research work to divide the data into training dataset and test dataset we are using stratified cross validation method
c. Stratified Cross Validation: It is similar to K-fold cross validation .In this method we select the test set such that it includes all types of instances so that we can get more accuracy rate for our derived model. This method splits the data into Train dataset and Test dataset which is taken from 5 different databases as shown in results and experiments.
d. Now the KNN classifier classifies new data or predicts the data by finding out the 3 nearer values for each and every training dataset using Euclidean distance. Among the 3 values we consider the age group category in which two values represents the more or max values representation.
e. At last we find the performance of our algorithm with Accuracy and F1score using confusion matrix.

IV. RESULTS AND EXPERIMENTS

Table2.shows us the Euclidean distance for each and every test data set

Lac(0)	Rac(0+4)	Age group	ED1	ED2	ED3	ED4	ED5	ED6	ED7	ED8	ED9	ED10
557	**1209**	**1**	97.493 (I)	182.14	187.87	314.54	324.99	364.47	486.78	478.7	484.14	638.52
566	**1210**	**1**	106.53 -2	173.29 -3	179.07 -3	306.47 -3	317.65	356.39	480.93	470.62	475.71	629.68
781	**1330**	**2**	349.68 -3	81.835 (I)	74.652 (I)	64.031 -2	285.37	273.73	471.84	364.68	345.77	451.95
796	**1333**	**2**	363.46	94.047 -2	86.977 -2	53.235 -1	285.56	270.38	470.77	358.05	337.55	439.65
870	**1075**	**3**	425.4	236.81	239.38	308.91	37.643 -1	30.083 -2	202.61	139.71	155.32	328.89
872	**1077**	**3**	426.78	236.4	238.89	307.26	40.459 -2	27.658 -1	204.15 -3	138.24 -3	153.2	326.53
945	**998**	**4**	521.43	343.58	345.82	401.62	116.72 -3	96.648	125.15 -1	75.802 -2	118.19	285.91
952	**1009**	**4**	523.99	339.6	341.6	393.44	118.68	91.021 -3	137.64 -2	63.812 -1	105.38 -2	274.38 -3
1092	**1115**	**5**	635.68	392.23	390.91	379.03	259.03	195.63	297.8	138.84	73.409 -1	103.58 -2
1124	**1122**	**5**	666.58	419.14	417.49	397.31	292.01	228.52	324.09	142.56	105.68	70.88

											-3	-1

Table 3 The Training dataset which is taken from 5 different databases is shown in the below

LAC(0)	RAC(0+4)	AGE GROUP
557	1209	childhood
566	1210	childhood
781	1330	young
796	1333	young
870	1075	middle
872	1077	middle
945	998	senior age
952	1009	senior age
1092	1115	Senior citizens
1124	1122	Senior citizens

Training Dataset

Table 4 The Test dataset which is taken from 5 different databases is shown in the below

LAC(0)	RAC(0+4)	Age Group
461	1192	child
730	1266	child
734	1272	young
821	1380	young
841	1051	Middle
899	1083	Middle
913	877	Senior
1006	1043	Senior
1025	1085	Senior Citizen
1192	1142	Senior Citizen

Test dataset

Step1.The Table3 and Table4 are Training data set and test dataset which are formed due to stratified cross validation.

Step2.The Table 2 results are obtained after using KNN classifier with k=3 and distance measure is taken as Euclidean distance.

For Example:If Lac(0)=461 and Rac (0+4)=1192 then predict the Age Group?.

Sol:- From the above table by using KNN with k=3 ,we find the Euclidean distance (ED1)for all the training dataset ,the first three shortest distance values will gives you the result. Among them two shortest distance value results to Age Group category -1 i.e. Child and one shortest distance results to Age Group category-2.Young. At last we

Decide the result as CHILD AGE GROUP. In this way we predict the Age group of all Test Data set.

Step3.By using the KNN we build the above table2 and using that table we construct confusion Matrix table5 and find the performance metrics like Accuracy, F1 score to identify the performance of our Algorithm. This is a Multi class Confusion Matrix i.e... the matrix which is having more than 2 classes. In this confusion matrix there are 5 different classes. The diagonal values of each and every class is treated True positive value (**TP**).Above the diagonal values and below the diagonal values are treated as False Positive values(**FP**).Similarly The right and left of the diagonal values are treated as False Negative Values(**FN**).Similarly all the four corners of diagonal values are treated as True Negative Values(**TN**).By using **TP,FP,FN,TN**

TN	FP	TN
FN	TP	FN
TN	FP	TN

we can find out the Accuracy and F1 score algorithm for our proposed algorithm

From the above figure we have to understood the Terms TP, TN, FP, FN. Mainly we have to consider the TP cell .The vertical values of **TP** represents **False Positive** values. The horizontal values of **TP** represent **False Negative** values. All the four corner values represent **True Negative** values

Multi Class Confusion Matrix

FN(1)=1; FN(2)=0;FN(3)=0 ; FN(4)=0; FN(5)=0

	Chiid	Young	Mid Age	Senior	Senior Citizen	Total
Child	1	1	0	0	0	2
Young	0	2	0	0	0	2
Mid Age	0	0	2	0	0	2
Senior	0	0	0	2	0	2
Senior Citizen	0	0	0	0	2	2
Total	1	3	2	2	2	10

TP=1; TP=2; TP=2; TP=2; TP=2

FP=0 ; FP=1; FP=0; FP=0; FP=0

P (1) =1; P(2)=0.666;P(3)=1;P(4)=1;P(5)=1

Step4. Different Performance Measures

1) ACCURACY: For balanced data accuracy gives good results. If accuracy is high our model is good. But finding out the accuracy for imbalanced data misleads performance. The TP gives us correct classifications.

Accuracy =TP1+TP2+TP3+TP4+TP5/(Total no of Classifications)

=1+2+2+2+2/10=9/10=0.9

2) PRECISION:

precision (Class 1)=P(1) =TP1/(TP1+FP1)

P (1) = 1/1+0 =1; p(2)=2/2+1=2/3=0.666;

P(3)=2/2+0 =1 ; P(4)=2/2=1 ;

P (5)=2/2=1;

So Average Precision=(1+0.666+1+1+1)/5 =0.9332

3)RECALL:

Recall(Class1)=R(1)=TP1/(TP1+FN1)

R(1)=1/1+1 =0.5; R(2)=2/2+0 = 1;R(3)=2/2=1;

R(4)=2/2=1;R(5)=2/2=1;SoAverageRecall=(0.5+1+1+1+1)/5 =4.5/5=0.9

4) F1 SCORE:

F1 score= 2 * Precision * Recall / (Precision + Recall

=2*0.9332*0.9/(0.932+0.9);

=1.67976/1.832

=0.916899.

V. CONCLUSION

The present paper evaluates the performance of our derived algorithm from Left angular pattern count and Right angular pattern count .The K-nearest neighbour classifier classifies the data and predicts the dataset. The accuracy of our proposed derived algorithm is 0.9. The F1 score value for our proposed algorithm is 0.916899.The accuracy value for our model is good when the dataset in confusion matrix is balanced data. For imbalanced data the F1 score is the perfect measure. In Future for our derived model we can use some other classifiers like naive bayes, neural networks. In the same way we can use other metrics to measure the performance.

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