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A Machine Intelligence Based Approach for the Classification of Human Face with Mask and without Mask

Kalyan Kumar Jena[a,#], Krishna Prasad K[b]., Rajermani Thinakaran[c]

[a]Post-Doctoral Research Fellow, Institute of Computer Science and Information Science, Srinivas University, Mangaluru-575001, Karnataka, India.*

[a]Associate Professor, Institute of Computer Science and Information Science, Srinivas University, Pandeshwar, Mangaluru-575001, Karnataka,India

[c]Senior Lecturer, Faculty of Data Science and Information Technology (FDSIT), INTI International University, Nilai, Negeri Sembilan, Malaysia

Abstract

The importance of face mask (FM) is a major concern for the entire human society in the current circumstances. All people should wear FM in order to lower the chance of infection due to several diseases. It is very much essential to track the people who have not worn the FM in different crowded places, so that warning can be given to them to wear FM in order to lower the spread of infection of different diseases. So, the classification of human face images (HFIs) into human face with mask images (HFWMIs) and human face without mask images (HFWOMIs) types is an essential requirement in this situation. In this work, a machine intelligent (MI) based approach is proposed for the classification of HFIs into HFWMIs and HFWOMIs types. The proposed approach is focused on the stacking (hybridization) of Logistic Regression (LRG), Support Vector Machine (SVMN), Random Forest (RFS) and Neural Network (NNT) methods to carry out such classification. The proposed method is compared with other machine learning (ML) based methods such as LRG, SVMN, RFS, NNT, Decision Tree (DTR), AdaBoost (ADB), Naïve Bayes (NBY), K-Nearest Neighbor (KNNH) and Stochastic Gradient Descent (SGDC) for performance analysis. The proposed method and other ML based methods have been implemented using Python based Orange 3.26.0. In this work, 200 HFWMIs and 200 HFWOMIs are taken from the Kaggle source. The performance of all the methods is assessed using the performance parameters such as classification accuracy (CA), F1, Precision (PR) and Recall (RC). From the results, it is found that the proposed method is capable of providing better classification results in terms of CA, F1, PR and RC as compared to other ML based methods such as LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH and SGD.

Keywords: Deepfake, Forgery detection, Quantum Neural Networks.

E-mail address of authors: E-mail: kalyankumarjena1@gmail.com, krishnaprasadkcci@srinivasuniversity.edu.in, rajermani.thina@newinti.edu.my

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1. Introduction

In the current scenario, FM [1-23] is considered as an essential requirement for the entire human society. Wearing FM is an important concern to lower the chance of infection due to several diseases. The chance of spreading infection rapidly mainly comes in most crowded places. It is very much essential to classify the people who have not worn the FM in different crowded places from the people who have worn FM, so that warning can be given to people without FM to wear FM in order to lower the spread of infection due to different diseases. So, the classification of HFIs into HFWMIs and HFWOMIs types is a crucial requirement in this situation. ML [24-29] can be considered as a solution for the classification of HFIs into HFWMIs and HFWOMIs categories. The ML based methods can be broadly classified as supervised and unsupervised. The supervised ML [24, 25, 29] based methods such as LRG, SVMN, RFS, NNT, DTR, ADB, etc. play a significant role to accomplish the classification mechanism. However, each ML based method is not capable of providing better classification results in several situations. The performance of each ML based method varies from one scenario to another scenario. So, it is a very challenging task to perform the classification mechanism accurately in different scenarios. Therefore, there is a need for some enhanced methods to carry out the categorization mechanism in a better way.

In this work, the main focus is given to the classification of HFIs into HFWMIs and HFWOMIs categories [30] in a better way. Here, a MI [1-29] based approach is proposed to carry out the HFIs classification. This approach is focused on the stacking of LRG, SVMN, RFS and NNT methods to carry out such classification. The proposed method is able to perform better in terms of CA, F1, PR and RC than LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH and SGDC methods. Here, the proposed work tries to provide better classification results than other methods.

The contributions in this work are mentioned as follows.

(1) In this work, a MI based approach is proposed for the classification of HFIs into HFWMIs and HFWOMIs types.

(2) The proposed approach is focused on the stacking of LRG, SVMN, RFS and NNT methods to carry out suchclassification mechanisms.

(3) The proposed method is compared with other ML based methods such as LRG, SVMN, RFS, NNT, DTR, ADB,NBY, KNNH and SGDC in terms of CA, F1, PR and RC for performance analysis.

(4) The Simulation of this work is accomplished using python based Orange 3.26.0.

(5) From the results, it is found that the proposed method is capable of providing better classification results thanother ML based methods in this scenario.

The rest of this work is presented as follows. Section 2 to Section 5 describes the related works, methodology, results and discussion, and conclusion respectively.

2. Related Work

Many research works have been accomplished related to the HFIs processing and analysis [1-23]. Some of the works are mentioned as follows. Su et al. [1] concentrated on the deep transfer learning (TL) for the recognition and categorization of FM. Habib et al. [2] focused on the deep learning (DL) based model for the identification of FM.

Kumar et al. [3] concentrated on the Internet of Things (IoT) and DL for the identification of FM in public transportation in smart cities. Teboulbi et al. [4] focused on the DL framework for the categorization of FM. Chen et al. [5] emphasized on the Gaussian mixture model for the recognition of FM for fraud prevention. Ibrahim et al.[6] emphasized on the convolutional NTT for the identification of FM. Venkateswarlu et al. [7] concentrated on the mobilenet and global pooling block for the identification of FM. Militante et al. [8] focused on the DL for the recognition of FM with alarm system. Nagrath et al. [9] concentrated on the deep NNT based single shot multibox detector and MobileNetV2 for the identification of FM. Joshi et al. [10] focused on the DL framework for the identification of FM from video footage. Jignesh et al. [11] focused on the TL of inceptionv3 for the identification of FM. Suresh et al. [12] emphasized on optimistic convolutional NNT for the identification of FM. The review of some articles related to HFIs categorization is mentioned in Table 1.

S. No	Field of Research	Focus	Outcome	Reference
1	Image Processing	Deep TL	Recognition and categorizationof FM	Su et al. (2022). [1]
2	Image Processing	DL	Identification of FM	Habib et al.(2022). [2]
3	Image Processing	IoT and DL	Identification of FM	Kumar et al.(2022). [3]
4	Image Processing	DL	Categorization of FM	Teboulbi et al.(2022). [4]
5	Image Processing	Gaussian mixture model	Recognition of FM	Chen et al.(2018). [5]
6	Image Processing	Convolutional NTT	Identification of FM	Ibrahim et al.(2022). [6]
7	Image Processing	Mobilenet and globalpooling block	Identification of FM	Venkateswarlu et al. (2020). [7]
8	Image Processing	DL	Recognition of FM	Militante et al.(2020). [8]

From the literature survey, it is observed that a single method may not be efficient enough to accomplish the classification process of HFIs in all scenarios. A method which is working well in a scenario may not perform well in other scenarios. So, accurate classification of HFIs into several categories by applying different methods is a challenging task. So, there is a need for the development of enhanced methods to carry out the categorization mechanism in a better way to solve the mentioned issues.

3. Methodology

In this work, a MI [1-29] based approach is proposed for the classification of HFIs [30] into HFWMIs and HFWOMIs types. The proposed approach is focused on the stacking of LRG, SVMN, RFS and NNT methods to carry out such classification. The proposed method is compared with other ML based methods such as LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH and SGDC in terms of CA, F1, PR and RC for performance analysis. The methodology is described in Fig. 1.

At first, the HFIs are imported to Orange 3.26.0 [31] through the Import Images option. Afterwards, the image embedding (IED) process is accomplished on the HFIs to extract the essential features such as height, width, etc. For IED, several embedders such as SqueezeNet, Inception v3, DeepLoc, etc. can be used. In this work, SqueezeNet (local) embedder is considered for processing. After the completion of the IED process, test and score computation will be performed by considering the ML based methods such as LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and the proposed method to find out the CA, F1, PR and RC values in units. The test and score computation can be performed by considering cross validation (CRV) as well as random sampling mechanisms. In this work, the CRV process is focused. The CRV process can be carried out by recognizing the number of folds (NF) as 2, 3, 5, 10, 20, etc. But, in this work, the NF value is considered as 5 to accomplish the classification mechanism.

In this work, the parameter setup for each method is described as follows. For LRG, the regularization type can be considered as Lasso (L1) and Ridge (L2). İn this work, Ridge (L2) is considered for processing. The strength value (SV) for this work is considered as per equation (1).

$$SV=1 \tag{1}$$

For SVMN, the kernel can be considered as Linear, Polynomial, RBF and Sigmoid. In this work, the kernel is considered as a radial basis function and the iteration limit is taken as 100. Here, the numerical tolerance (NTL) value is taken for processing as per equation (2).

$$NTL=0.0010 \tag{2}$$

In this work, for RFS the number of trees (NBTR) considered for processing is mentioned in equation (3).

$$NBTR=50 \tag{3}$$

For NNT, the activation function can be considered as ReLu, Logistic, tanh, etc. The solver can be considered as Adam, SGDC, L-BFGS-B, etc. In this work, the activation function is considered as ReLu and the solver is considered as Adam with the maximal number of iterations as 100. The neurons (NR) in hidden layers and regularization (RE) value are considered in this work as per equation (4) and equation (5) respectively.

NR=200 (4)

RE=0.0001 (5)

For DTR, the maximum tree depth (MTDPT) is considered as per equation (6) with the minimum number of instances in leaves as 4.

MTDPT=100 (6)

For KNNH, the metric can be considered as Euclidean, Manhattan, Chebyshev and Mahalanobis and the weight(WT) can be considered as distance (ds) and uniform (u). In this work, for KNNH weight value is mentioned in equation (7) by considering the number of neighbors as 10 and the metric as Manhattan.

WT=ds (7)

At the test and score computation, the CA, F1, PR and RC values (in units) are computed. Then, the confusion matrix (CM) representation can be carried out. The CM can be represented by considering the number of instances, proportion of predicted and proportion of actual values. However, in this work, the number of instances is considered for processing. The methodology used in this work for the classification of HFIs into HFWMIs and HFWOMIs types is described in Algorithm 1.

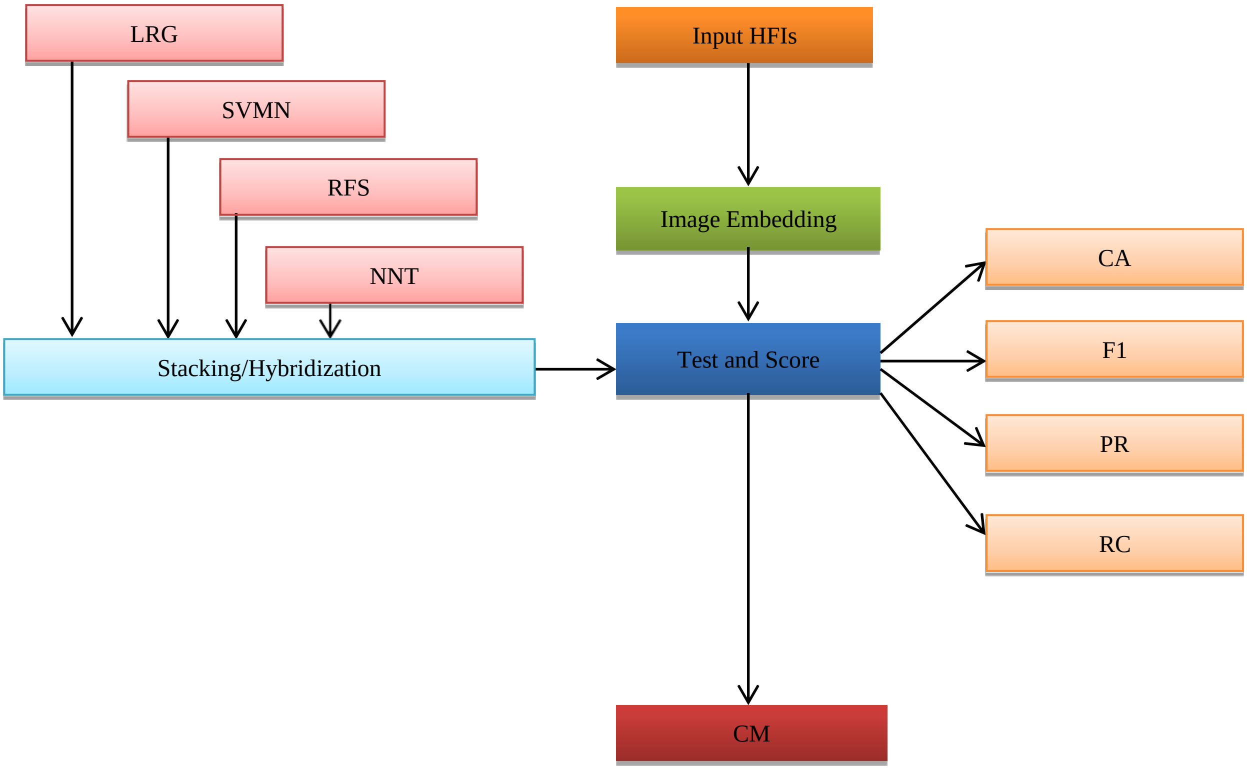

Fig. 1: Methodology

Algorithm 1:HFIs ClassificationInput: HFIs
Output: HFWMIs and HFWOMIs Type
Step 1: Start
Step 2: Input HFIs Step 3: IED (HFIs)
Step 4: Test and Score (LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC, Proposed Method)
Step 5: Compute CA, F1, PR and RC by applying LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and Proposed Method
Step 6: Create (CM) for each method to analyze the classification results
Step 7: Stop

4. Results and Discussion

The simulation of this work is accomplished using Python based Orange 3.26.0 [31]. In this work, 750 different sizes HFIs having 200 numbers of each type such as HFWMIs and HFWOMIs are taken from the source [30].The Orange workflow setup diagram is mentioned in Fig. 2. The sample representation of HFWMIs and HFWOMIs types are mentioned in Fig. 3 and Fig. 4 respectively. The HFIs are processed using several ML based methods such as LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and the proposed method when the NF value is recognized as 5. The performance of all the methods is accessed using performance parameters such as CA, F1, PR and RC which are described as follows.

- **CA:** It refers to the rate of correct classification. It is represented in equation (8) by considering the number ofcorrected predictions (CP) and the total number of input samples (IS).

CA= CP / IS (8)

- **F1:** It is the harmonic mean of PR and RC. It is mentioned in equation (9).

F1= 2* (PR * RC) / (PR + RC) (9)

- **PR:** It is represented in equation (10) by considering the true positives (TP) and false positives (FP).

PR= TP / (TP+FP) (10)

- **RC:** It is represented in equation (11) by considering the TP and false negatives (FN).

RC= TP / (TP+FN) (11)

The classification results are better when the CA, F1, PR and RC values are higher. Table 2 describes the CA, F1, PR and RC computed values (in units) of the proposed method and other methods. Fig. 5 to Fig. 8 represents the comparison results of all methods graphically in terms of CA, F1, PR and RC respectively. This work is also focused on CM representation. The CM represents the actual and predicted values by showing the number of instances for each of these methods. The CM representation for LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and the proposed method are mentioned in

Fig. 9 to Fig. 18 respectively. In CM, the actual values are represented using light blue color and the predicted values are represented using light pink color.

Table 2: Comparison of the proposed method with other MI based methods

Method	**CA**	**F1**	**PR**	**RC**
LRG	0.963	0.962	0.963	0.963
SVMN	0.963	0.962	0.963	0.963
RFS	0.935	0.935	0.937	0.935
NNT	0.963	0.962	0.963	0.963
DTR	0.885	0.885	0.886	0.885
ADB	0.833	0.832	0.833	0.833
NBY	0.885	0.885	0.889	0.885
KNNH	0.930	0.930	0.933	0.930
SGDC	0.960	0.960	0.960	0.960
ProposedMethod	0.970	0.970	0.970	0.970

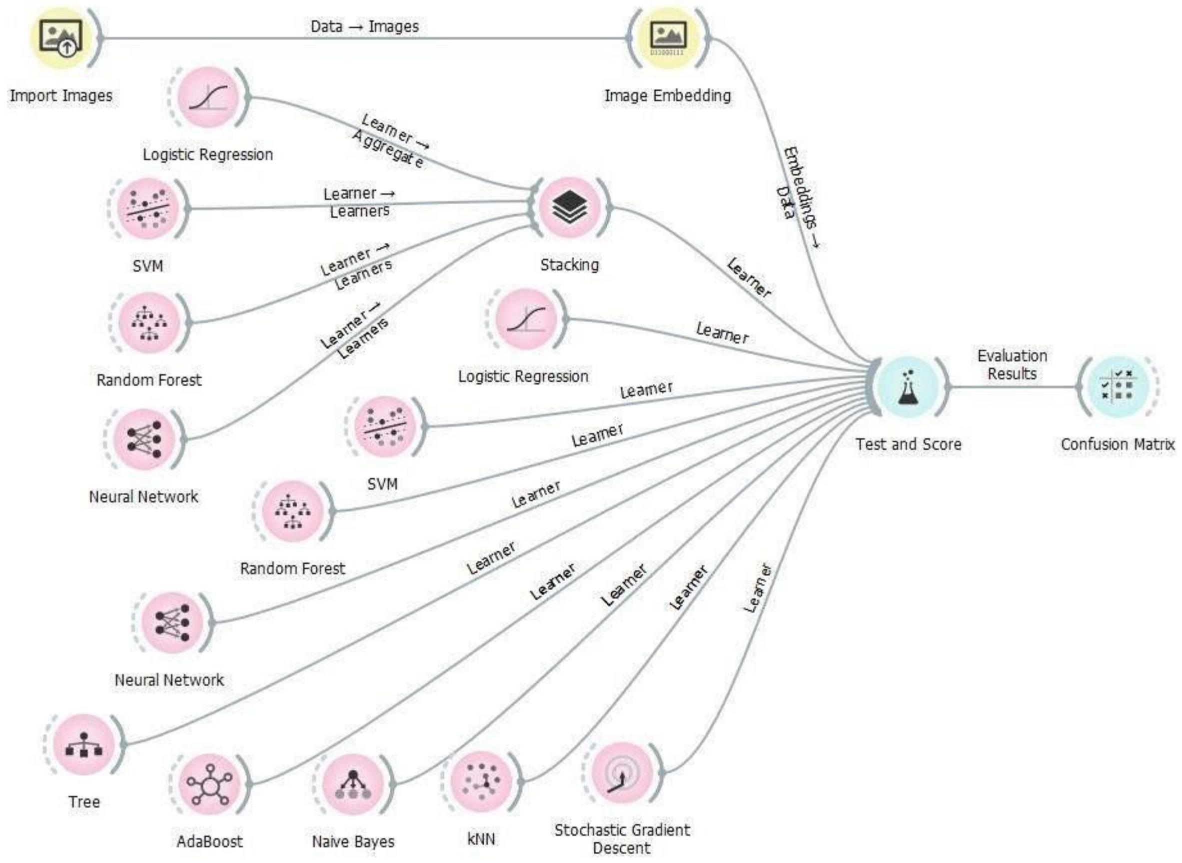

Fig. 2: Orange workflow setup diagram

Fig. 3: Sample depiction of HFWMIs

Fig. 4: Sample depiction of HFWOMIs

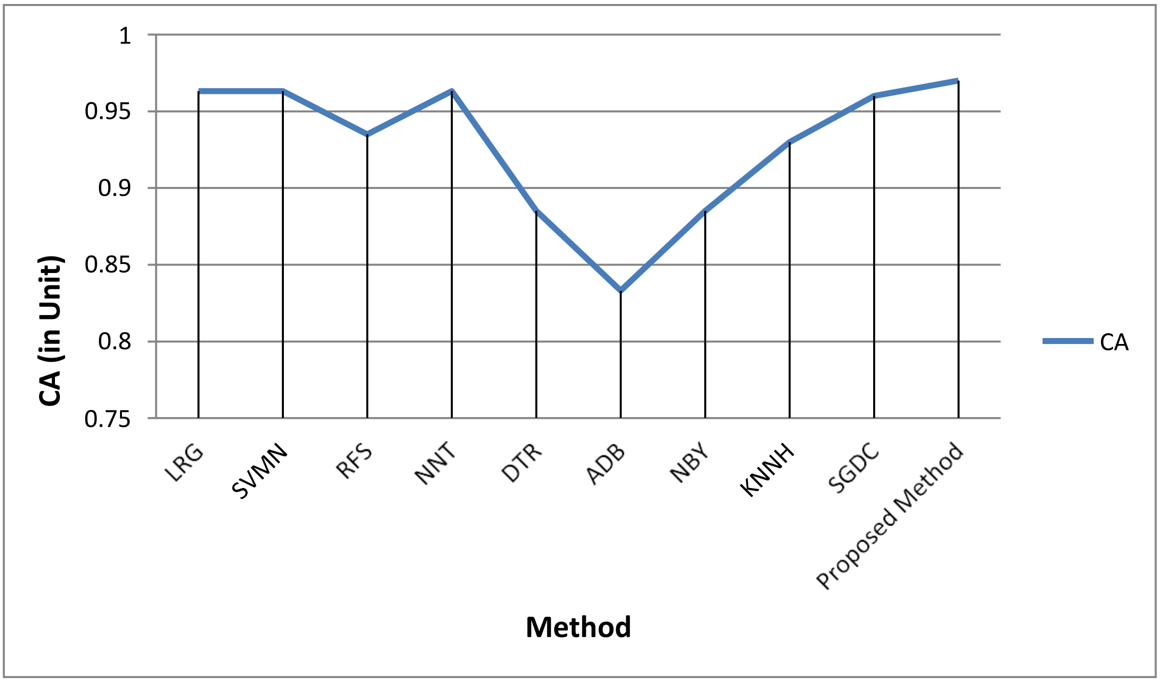

Fig. 5: Comparison results representation of all methods in terms of CA

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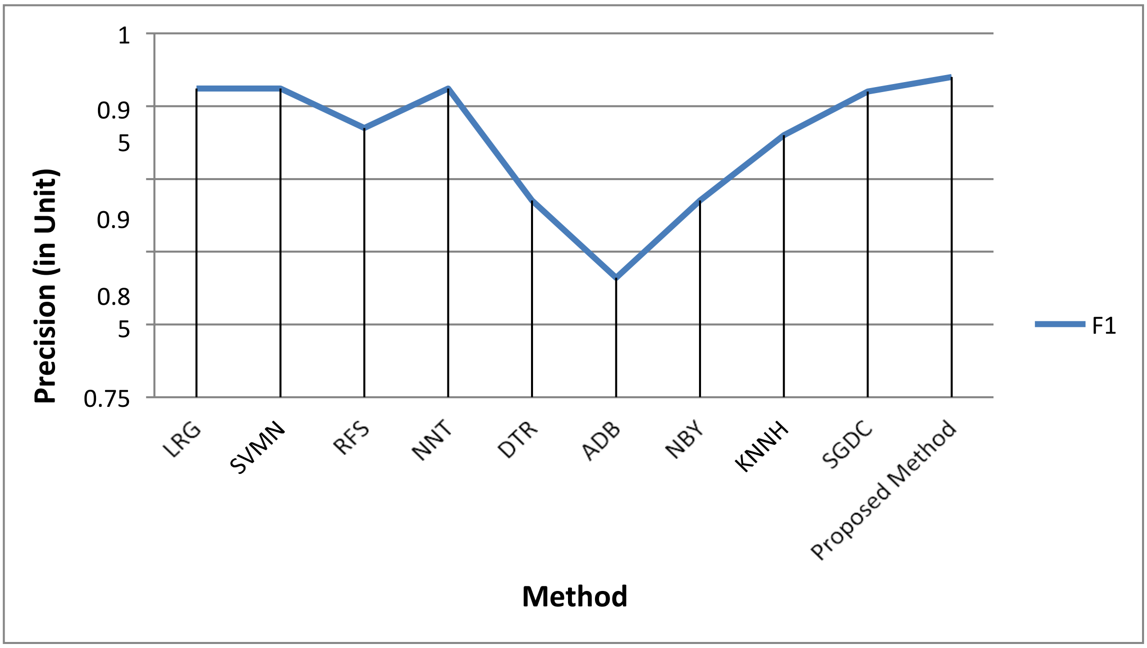


Fig. 6: Comparison results representation of all methods in terms of F1

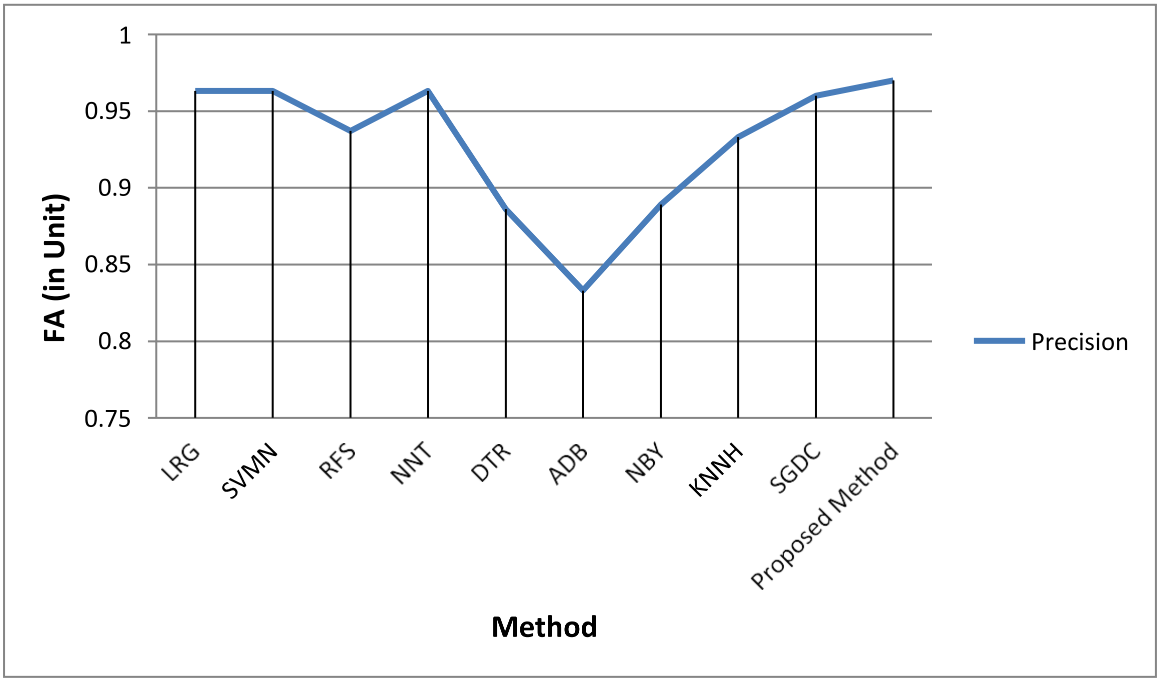


Fig. 7: Comparison results representation of all methods in terms of PR

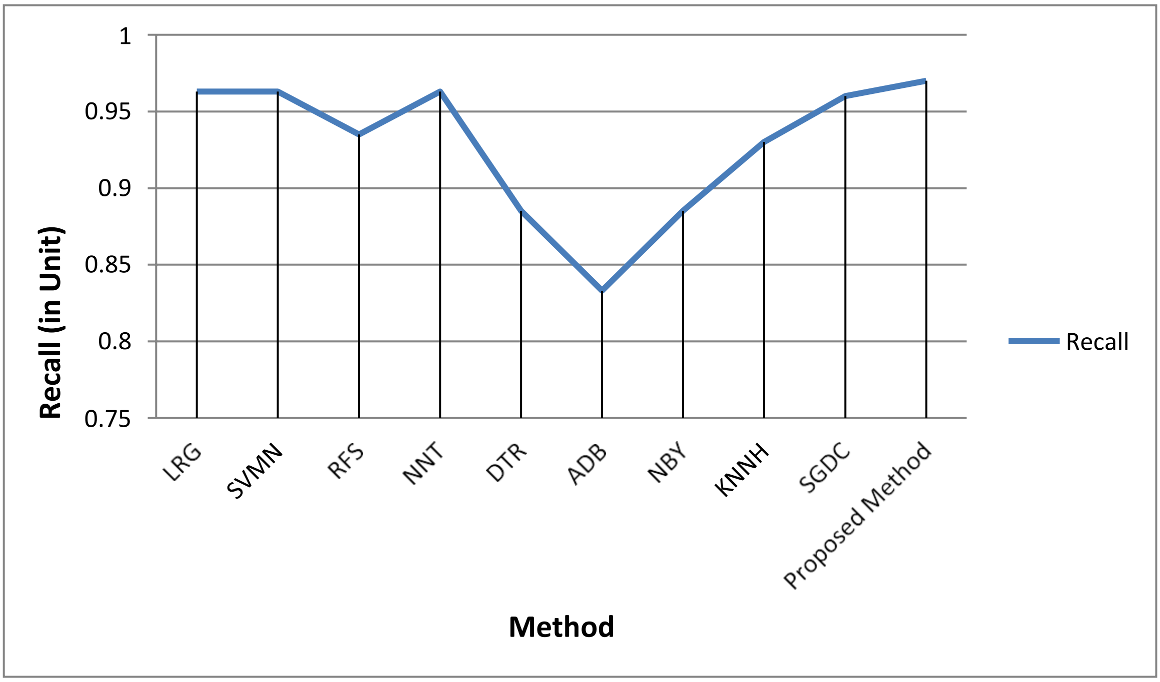
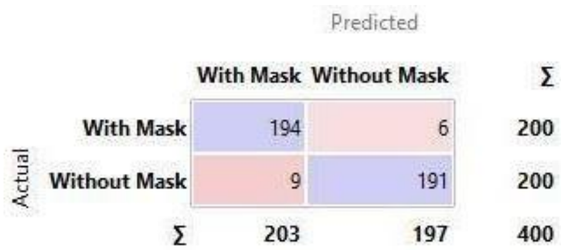
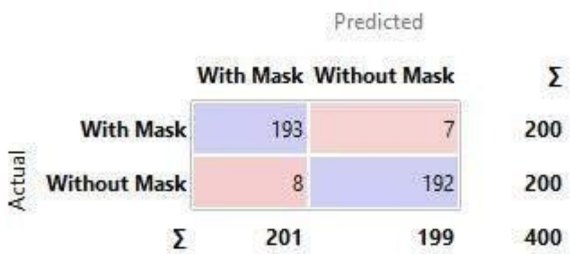


Fig. 8: Comparison results representation of all methods in terms of RC



Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	194	6	200
Without Mask	9	191	200
Σ	203	197	400

Fig. 9: CM of LRG



Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	193	7	200
Without Mask	8	192	200
Σ	201	199	400

Fig. 10: CM of SVMN

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	193	7	200
Without Mask	19	181	200
Σ	212	188	400

Fig. 11: CM of RFS

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	195	5	200
Without Mask	10	190	200
Σ	205	195	400

Fig. 12: CM of NNT

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	181	19	200
Without Mask	27	173	200
Σ	208	192	400

Fig. 13: CM of DTR

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	166	34	200
Without Mask	33	167	200
Σ	199	201	400

Fig. 14: CM of ADB

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	187	13	200
Without Mask	33	167	200
Σ	220	180	400

Fig. 15: CM of NBY

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	178	22	200
Without Mask	6	194	200
Σ	184	216	400

Fig. 16: CM of KNNH

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	193	7	200
Without Mask	9	191	200
Σ	202	198	400

Fig. 17: CM of SGDC

Actual \ Predicted	With Mask	Without Mask	Σ
With Mask	195	5	200
Without Mask	7	193	200
Σ	202	198	400

From Table 2 and Fig. 5 to Fig. 18, it is observed that LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and proposed method are able to provide 0.963, 0.963, 0.935, 0.963, 0.885, 0.833, 0.885, 0.930, 0.960 and 0.970 CA values (in unit) respectively. LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and proposed method are able to provide 0.962, 0.962, 0.935, 0.962, 0.885, 0.832, 0.885, 0.930, 0.960 and 0.970 F1 values (in unit) respectively. LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and proposed method are able to provide 0.963, 0.963, 0.937, 0.963, 0.886, 0.833, 0.889, 0.933, 0.960 and 0.970 PR values (in unit) respectively. LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC and proposed method are able to provide 0.963, 0.963, 0.935, 0.963, 0.885, 0.833, 0.885, 0.930, 0.960 and 0.970 RC values (in unit) respectively. So, the proposed method is capable of providing better classification results as compared to LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH, SGDC methods and it is having 0.970 CA, F1, PR and RC values in units. However, the ADB method is not capable of providing better categorization results than other methods and it is having 0.833, 0.832, 0.833 and 0.833 CA, F1, PR and RC values in units respectively. The decreasing order of performance of these methods is proposed method, NNT, LRG, SVMN, SGDC, RFS, KNNH, DTR, NBY and ADB.

5. Conclusion

This paper proposed a MI based approach for the classification of HFIs into HFWMIs and HFWOMIs types. The proposed approach is focused on the stacking of LRG, SVMN, RFS and NNT methods to carry out the classification of HFIs into such categories. From the results, it is found that the proposed method is capable of providing better classification results in terms of CA, F1, PR and RC as compared to other ML based methods such as LRG, SVMN, RFS, NNT, DTR, ADB, NBY, KNNH and SGDC. The CA, F1, PR and RC values in units using the proposed method are computed as 0.970 which is higher as compared to other methods. However, in this scenario, the ADB method is unable to perform better than other methods. The CA, F1, PR and RC values in units using the ADB method are computed as 0.833, 0.832, 0.833 and 0.833 respectively which are lower than other methods in this scenario. This approach can help the researchers to carry out the image classification mechanism in a better way for several applications.

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