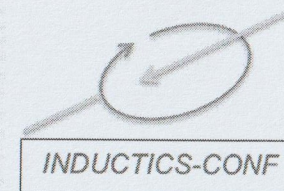


الجمهورية الجزائرية الديمقراطية الشعبية
الملتقى الوطني الثامن حول كهرومغناطيسية

**8th National Colloquium on Inductics:
University-Industry**

November 17-18, 2024, M'Sila-Algeria



Ref : Id-024

Certificate of participation

This is to certify that: **Mr Tawfiq BEGHRICHE**

Has participated in the **National Conference (8th National Colloquium on Inductics: University-Industry)**
held on November 17-18, 2024, M'Sila-Algeria and presented a paper (**Poster session**) entitled:

An innovative CNN-SVM hybrid model for enhanced diabetic retinopathy detection

Author(s): **Tawfiq BEGHRICHE, Mohamed DJERIOUI, Youcef BRIK**



The General Chairs
Dr. Hemza MEKKI

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***Proceeding du
The 8th Conference on Inductivce Techniques
University - Industry***

November 17-18, 2024, M'sila

Topics

1. Computation of the electromagnetic field (analytical, semi-analytical and numerical)	7. Sensors and actuators
2. Design and optimization of electromagnetic devices	8. Modelling and characterization of materials (conductor, magnetic, composite)
3. Evaluation & Non-destructive testing (E-NDT) by electromagnetic methods	9. Various applications: Biomedical, Contactless battery charging, Geophysics
4. Multi-scale and meshing problems	10. Industrial communications
5. Artificial intelligence tools and inverse problems	11. Educational communications
6. Multi-physical problems (Electromagnetic, Thermal, Mechanical)	12. Students projects
	13. Electrical engineering (power supply, machines, control, ...)

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Programme

8^{ème} Colloque sur L'inductique (Inductics-Conf-2024)

17-18 Novembre 2024, M'Sila, Algérie



1 ^{ère} journée, dimanche 17 novembre 2024				
Enregistrement	08h00-08h30			
ouverture	08h30-09h00	Mouloud FELIACHI, Ali DJERIOUI, Abdelhalim ZAOUI		
Plénières PL1 et PL2		Présidents : Ibkhaldoun LEFKIER, Abdelhalim TAIEB BRAHIM		
	09h00-09h35	PL1 : Integral and Integro-Differential Approaches for Calculating Interactions between Electrical System Elements Prof Hicham ALLAG Mohamed Seddik Benyahia University, Jijel, L2EI Laboratory, Algeria		
	09h35-10h10	PL2 : The Finite Volume Method an Alternative Method for Electromagnetic Problems Prof Ahmed CHERIET, LGEB Laboratory, Electrical Engineering Department, Biskra University, Algeria		
Pause café	10h10-10h30			
		Salle 1 : Session orale A1 Présidents : Abdelhalim ZAOUI, Rabia MEHASNI	Salle 2 : Session orale A2 Présidents : Hicham ALLAG, Mehdi OUILI	Session Poster 1 10h10-11h50 Prof MEKKI Hamza; Prof RAHALI Hilal
Sessions orales A1 et A2	10h30-10h50 10h50-11h10 11h10-11h30 11h30-11h50	A1-1 : D.R. TOUIL A1-2 : A. ABBASSI A1-3 : F. OUBBATI A1-4 : F. BARRARAT	A2-1 : M.T. BOUZAHAR A2-2 : M.T. BOUZAHAR A2-3 : A.C. LAHRECH A2-4 : M.T. BOUZAHAR	
déjeuner	12h00-14h00			
		Salle 1 : Session orale A3 Présidents : Bachir HELIFA, Mohamed KHEBBAB	Salle 2 : Session orale A4 Présidents : Hamza MEKKI, Brahim Ladghem CHIKOUCHE	Session Poster 2 15h20-17h40 Prof RAHALI Hilal, Prof DJERIOU Ali
Sessions orales A3 et A4	14h00-14h20 14h20-14h40 14h40-15h00 15h00-15h20	A3-1 : A. TAIEBBRAHIM A3-2 : Z. OUDNI A3-3 : M. BENSALEM A3-4 : A. TAIEBBRAHIM	A4-1 : O. SAFER A4-2 : F. LAIB A4-3 : M. SARI A4-4 : A. ZEGHLACHE	
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		Salle 1 : Session orale A5 Présidents : Ahmed CHERIET, Abderraouf BOULOUDENINE	Salle 2 : Session orale A6 Présidents : Abdelmadjid NOUICER, Bachir HELIFA	Session Poster 2 15h20-17h40 Prof RAHALI Hilal, Prof DJERIOU Ali
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2 ^{ème} journée, Lundi 18 novembre 2024				
Plénières PL3, PL4 et PL5	Présidents : Abdelhalim TAIEB BRAHIM, Hicham ALLAG			
	08h20-08h55	PL3 : Magnetic separation: Principle, applications and study framework Prof Rabia MEHASNI Electrical Laboratory of Constantine(LEC), University of Constantine 1, Mentouri brothers, Algeria		
	08h55-09h30	PL4 : Implementation of Artificial Intelligence Techniques on Reconfigurable Circuits for Monitoring and Control of Electrical Drives Prof Djalal Eddine KHODJA Faculty of technology, University of Mohamed Boudiaf, Msila, Algeria		
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An innovative CNN-SVM hybrid model for enhanced diabetic retinopathy detection

Tawfiq Beghriche¹, Mohamed Djerioui¹, Youcef Brik¹

¹University of M'sila, M'sila, Algeria, LASS Laboratory

Abstract

Diabetic retinopathy (DR) presents a significant threat to global visual health. This study introduces a method leveraging deep learning and machine learning to enhance DR detection accuracy. By combining pre-trained CNNs (MobileNetV2, ResNet50, and Xception) with high performance classifiers like SVM and KNN, our method significantly improves diagnostic performance. The combination of ResNet50 and SVM achieved a 95.90% accuracy in detecting retinal abnormalities for the APTOS 2019 Blindness Detection dataset, demonstrating its superiority over current diagnostic techniques.

Keywords Diabetic retinopathy, Convolutional neural networks (CNNs), Machine learning algorithms, Classification, APTOS 2019

1. Introduction

Diabetic retinopathy (DR) is a leading cause of vision loss in adults with diabetes, affecting millions globally [1]. Early detection is crucial for effective treatment, yet conventional diagnostic methods are time-consuming and limited by the availability of trained professionals [2]. Deep learning, particularly Convolutional Neural Networks (CNNs), has shown promise in automating and improving the accuracy of medical diagnoses [3]. This study aims to develop a hybrid method combining CNNs and machine learning classifiers to enhance DR detection. Our approach integrates pre-trained CNNs with SVM and KNN classifiers, evaluated on the APTOS 2019 dataset, to improve diagnostic accuracy and efficiency.

Recent studies have explored deep learning for DR detection, achieving notable accuracies with CNN-based models. Xu et al. [4] achieved 94.5% accuracy using deep CNNs, while Gargeya and Leng [5] reported an AUC of 0.97 with high sensitivity and specificity. Krause et al. [6] addressed grader variability, achieving an AUC of 0.986. This study builds on these advancements by integrating CNNs with SVM and KNN to further enhance diagnostic accuracy.

2. Proposed System

The proposed system involves several steps: (1) using the APTOS 2019 Blindness Detection dataset, (2) extracting features with three CNN architectures (ResNet50, MobileNetV2, Xception), and (3) classifying the extracted features using SVM and KNN. Our method aims for high accuracy and efficiency in DR image classification. Figure 2.1 illustrates the workflow.

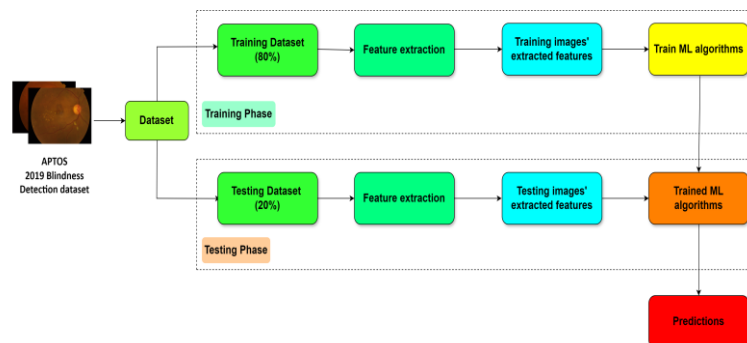


Figure 2.1.Proposed method's flowchart.

2.1Dataset Description

The APTOS 2019 dataset [7] contains 3662 images classified into five DR severity levels. Table 2.1 summarizes the dataset.

Dataset	N. of images	N. of classes	N. of images per class	
APTOS 2019	3662	5	No_DR	1805
			Mild	370
			Moderate	999
			Severe	193
			Proliferate_DR	295

Table 2.1. The APTOS 2019 Blindness Detection dataset description.

2.2 CNN models

ResNet50, MobileNetV2, and Xception are employed for extract the most relevant features of the APTOS 2019 dataset.

2.3 Machine learning classifiers

SVM and KNN are used for classification. SVM is effective in high-dimensional spaces, while KNN is simple and effective for smaller datasets.

3. Results and discussion

This section briefly discusses the evaluation metrics and highlights the superior performance of our method.

3.1 Evaluation Metrics

Accuracy, sensitivity, specificity, precision, and F1-score are calculated from the confusion matrix (Figure 3.1).

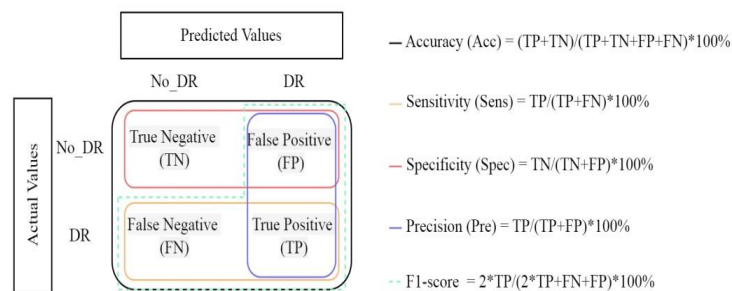


Figure 3.1. Confusion matrix for binary classification tasks.

3.2 Performance assessment

ResNet50 combined with SVM outperformed other combinations, achieving the highest accuracy of 95.90% on the APTOS 2019 dataset (Table 3.1).

CNN Models	Performance (%)									
	CNN + SVM					CNN + KNN				
	Accuracy	Precision	Sensitivity	Specificity	F1-score	Accuracy	Precision	Sensitivity	Specificity	F1-score
MobileNetV2	89.63	87.75	92.47	86.70	90.05	74.62	82.06	63.97	85.59	71.90
Xception	94.54	96.11	93.01	96.12	94.53	80.35	92.22	66.93	94.18	77.57
Resnet50	95.90	96.97	94.89	96.95	95.92	93.45	97.09	89.78	97.22	93.29

Table 3.1. Classification performance of different CNNs and ML algorithms.

4. Comparison with the state of the art

Our method's performance is compared with existing studies (Table 4.1). The combination ResNet50+SVM surpassed other state-of-the-art methods, achieving the highest accuracy of 95.90%, demonstrating its effectiveness in DR detection.

Authors	Year	Method	Dataset	Task	Accuracy (%)
[8] V. Vives-Boix et al.	2021	InceptionV3	APTOS 2019	Binary	95.56
[9] W. L. Alyoubi et al.	2021	CNN512		Multi-classes	84.1
[10] A. K. Gangwar et al.	2021	Inception-ResNet-v2		Multi-classes	82.18
[11] B. K. Anoop	2022	CNN architecture		Binary	91.2
Ours	2024	Resnet50+SVM	APTOS 2019	Binary	95.90

Table 4.1. Comparison of the proposed method with the state-of-the-art methods.

5. Conclusion

In this study, we introduced a hybrid method for accurate and effective diagnosis of diabetic retinopathy (DR), combining pre-trained CNNs—MobileNetV2, ResNet50, and Xception—with robust machine learning classifiers such as SVM and KNN to overcome the limitations of manual diagnostic methods. ResNet50 combined with SVM achieved the highest accuracy of 95.90% in detecting retinal abnormalities, outperforming other combinations and state-of-the-art methods. The proposed method represents a significant advancement in automated DR detection.

5. References

- 1.O. Dekhil, A. Naglah, M. Shaban, M. Ghazal, F. Taher, and A. Elbaz, “Deep learning based method for computer aided diagnosis of diabetic retinopathy, ” in 2019 IEEE International Conference on Imaging Systems and Techniques (IST), 2019, pp. 1-4.

- 2.D. J. Browning, M. D. McOwen, R. M. Bowen, and P. V. O'Malley, "Comparison of the clinical diagnosis of diabetic macular edema with diagnosis by optical coherence tomography, " *Ophthalmology*, vol. 111, no. 4, pp. 712-715, 2004.
- 3.C. De Vente, L. H. Boulogne, K. V. Venkadesh, C. Sital, N. Lessmann, C. Jacobs and B. Van Ginneken, "Automated COVID-19 grading with convolutional neural networks in computed tomography scans: A systematic comparison, " *IEEE Trans. Artif. Intell.*, vol. 3, no. 2, pp. 129-138, 2021.
- 4.K. Xu, D. Feng, and H. Mi, "Deep convolutional neural network-based early automated detection of diabetic retinopathy using fundus image, " *Molecules*, vol. 22, no. 12, p. 2054, 2017.
- 5.R. Gargeya and T. Leng, "Automated identification of diabetic retinopathy using deep learning, " *Ophthalmology*, vol. 124, no. 7, pp. 962-969, 2017.
- 6.J. Krause, V. Gulshan, E. Rahimy, P. Karth, K. Widner, S. Silpa-Anan, ... and L. Peng, "Grader variability and the importance of reference standards for evaluating machine learning models for diabetic retinopathy, " *Nature Digit. Med.*, vol. 1, no. 1, p. 10, 2018.
- 7.APTOS 2019 Blindness Detection dataset, [Online]. Available: <https://www.kaggle.com/c/aptos2019-blindness-detection/data>. [Accessed: Mars. 1, 2023].
- 8.V. Vives-Boix and D. Ruiz-Fernández, "Diabetic retinopathy detection through convolutional neural networks with synaptic metaplasticity, " *Computer Methods and Programs in Biomedicine*, vol. 206, 2021, Art. no. 106094.
- 9.W. L. Alyoubi, M. F. Abulkhair, and W. M. Shalash, "Diabetic retinopathy fundus image classification and lesions localization system using deep learning, " *Sensors*, vol. 21, no. 11, 2021.
- 10.A. K. Gangwar and V. Ravi, "Diabetic retinopathy detection using transfer learning and deep learning, " in *Evolution in Computational Intelligence*, vol. 1176, 2021.
- 11.B. K. Anoop, "Binary classification of DR-Diabetic Retinopathy using CNN with fundus colour images," *Mater. Today: Proc.*, vol. 58, pp. 212-216, 2022.