SEBHA UNIVERSITY JOURNAL OF PURE & APPLIED SCIENCES VOL.21 NO. 4 2022
DOI: 10.51984/JOPAS.V21I4.2120

مجلة جامعة سبها للعلوم البحتة والتطبيقية
Sebha University Journal of Pure & Applied Sciences

Journal homepage: www.sebhau.edu.ly/journal/index.php/jopas

Comparison of Two Face Recognition Machine Learning Models

*Safa Salem Dakhila[a], Nuredin Ali Salem Ahmed[b], Hala Shaari [c]

[a] College of Computer Technologies-Tripoli Ministry of Technical and Vocational Education, Libya
[b] Control Department, Technical Computer college Ministry of Technical and Vocational Education, Libya
[c] Department of Web Technologies. Faculty of Information Technology University of Tripoli, Libya

Keywords:
DeepFace
Face Recognition
Machine Learning
Model
OpenFace

ABSTRACT

Machine learning (ML) is one of the fastest-developing topics today, straddling the boundary between statistics and computer science, as well as data science. It is a type of artificial intelligence that allows software applications to become more accurate at predicting outcomes without being explicitly programmed. And It addresses the difficulty of the way to assemble gadgets that enhance themselves via experience, and make conclusions with minimum human assistance. For this purpose, there arises a need to use various statistical methods of face recognition' models, such as (DeepFace) and (OpenFace). DeepFace is the most lightweight face recognition and facial attribute analysis library for Python, and is currently on the verge of human-level precision. OpenFace on the other hand is an open source deep learning facial recognition model based on Google's Facenet model. In this paper, we will discuss the face recognition comparison between two models DeepFace and OpenFace on the calibrators of (Accuracy, Error Rate and Verification Time). DeepFace showed a higher accuracy rate by (3%) than that of OpenFace, and a lower error rate by (3%). Whereas OpenFace delivered with a minimum time shorter than that of DeepFace by (0.061323) second.

مقارنة بين نموذجين من نماذج التعلم الآلي للتعرف على الوجه

*صفاء سالم محمد دخيلة[1] و نور الدين على احمد[2] و هالة الشاعري[3]

[1]كلية تقنيات الحاسوب - طرابلس - وزارة التعليم التقني والمهني ، ليبيا
[2] إدارة الرقابة بالكلية التقنية للحاسوب .وزارة التعليم التقني والمهني .ليبيا
[3] قسم تقنيات الويب. كلية تكنولوجيا المعلومات جامعة طرابلس ليبيا

الكلمات المفتاحية:
DeepFace
Face Recognition
Machine Learning
Model
.OpenFace

الملخص

يعُد التعلم الآلي أحد أسرع الموضوعات تطورًا اليوم، حيث يعتبر الخط الفاصل بين الإحصاء وعلوم الكمبيوت، وكذلك علم البيانات. وهو نوع من الذكاء الاصطناعي حيث يسمح لتطبيقات البرامج بأن تصبح أكثر دقة في توقع النتائج دون أن تتم برمجتها بشكل صريح. ويتناول صعوبة طريقة تجميع الأدوات التي تعزز نفسها من خلال التجربة، والتوصل إلى استنتاجات بأقل قدر من المساعدة البشرية. لهذا الغرض، ستكون هناك حاجة لاستخدام الأساليب الإحصائية المختلفة لنماذج التعرف على الوجوه، مثل (DeepFace) و (OpenFace). الـ (DeepFace) هي مكتبة التعرف على الوجوه وتحليل سمات الوجه الأكثر وزنًا في لغة الـ (Python)، وهي حاليًا على وشك الوصول لمستوى دقة الإنسان. و من ناحية أخرى، تعُد (OpenFace) نموذجًا مفتوح المصدر للتعلم العميق للتعرف على الوجه، يعتمد على نموذج (Facenet) من (Google). في هذه الورقة، سنناقش مقارنة بين نموذجين (DeepFace) و(OpenFace) في التعرف على الوجوه من حيث معاير (الدقة و معدل الخطأ و وقت التحقق). حيث انه قد أظهرت (DeepFace) دقة أعلى بنسبة (3٪) من (OpenFace)، ومعدل خطأ أقل بنسبة (3٪). بينما تم سجلت (OpenFace) وقت التحقق أقل من (DeepFace) بمقدار (0.061323) ثانية.

Corresponding author:
E-mail addresses: safa.salem23@gmail.com ,(N. A. Salem) nuredin.ahmed@cctt.edu.ly ,(H. Shaari) h.shaari@uot.edu.ly
Article History : Received 29 May 2022 - Received in revised form 29 June 2022 - Accepted 03 October 2022

Introduction

Face recognition is the process of identifying human face characteristics [1]. The face, a person's most recognizable biometric trait [2], is frequently employed in banking [3], biometric log-in, credit card verification, time attendance [4], video surveillance, public security [1], forensic identification [5], border surveillance [6], and military [7], etc. Today, it is considered one of the most important technologies that are in development [8]. Pose fluctuation, blurriness, low resolution, illumination, facial expression, viewing angle, and lighting circumstances are all obstacles in face recognition [9]. It is one of the most studied topics in biometrics because, unlike other biometrics such as iris, fingerprint, and palm print, it is a unique biometric [10,11].

It is used to identify a human being, but unlike them, the active co-operation of the person is necessary, but in facial recognition identification can happen without the person's intervention [11].

It includes these next steps:

- face detection.
- face alignment [12].
- Numerical representation [13].
- Recognition [14]

Face recognition can be two types:

1. **Face Verification:** (One to One), is consists in verifying whether or not two images face-to-face belong to the same person [15]. It is used most in airport systems, etc [3].
2. **Face Identification:** (One to many), which is a process of identifying someone by matching his or her face to those in the data base [16], it is used most in public security [1].

Most recent Face Recognition models are based on convolutional neural networks (CNN).

The (CNN): which are a kind of deep neuronal network. It has recently been successful in face recognition because of the use of deep learning architecture [17]. It is most commonly used in image classification, image recognition, face recognition, and object detection [18].

Because of the expanding use of face recognition, and in light of existing challenges. It is important to understand how advanced facial recognition systems currently make facial recognition possible. Ultimately, benchmarking is performed on existing state-of-the-art models to understand their level of performance and the challenges they face. We selected two models with extremely good facial recognition accuracy. Namely, DeepFace [19], and OpenFace [20]. We test them and compare them to each other against dataset we made for it especially.

DeepFace: Is a deep neural network model developed by researchers at Facebook [21] in 2014, by using 4 million face images to train a 9-layer model, on the LFW benchmark [22]. The most accurate outcome, which was then tested on real human beings in working and industry-like settings to establish the validity and necessary changes for a large-scale industrial implementation [23]. Approaching human performance on the unconstrained condition with (DeepFace: 97.35% vs. Human: 97.53%) [24].

OpenFace: Is a Google-created open-source tool [25], which Brandon Amos of Satya's research organization at Carnegie Mellon University developed [25,26]. It is built on the FaceNet algorithm for automatic face recognition [3]. The main advantages of OpenFace are that it does not require a lot of human resources [27], it performs well across the Labeled Faces in the Wild (LFW) benchmark.

Comparison:

1. **Related Work:** previous research was reviewed that employed Labeled Faces in The Wild "LFW": which is a database of face photos designed to study the problem of unrestricted face recognition [28]. And Image-Restricted Protocol: which stipulates that the similarity of two facial images should not be determined on the basis of an individual's name [29].

The relevant conclusions are as follows:

Each pair have four different outcomes based on the results of this thresholding process.

- True Positive (TP) whenever the pair is accurately classed as being similar.
- True Negative (TN) whenever the pair is accurately classed as dissimilar.
- False Positive (FP) whenever the pair is incorrectly classed as similar.
- False Negative (FN) whenever the pair is incorrectly classed as dissimilar.

- **Accuracy of analysis methods:**

  Accuracy is measured by dividing the total pairings by the sum of True Positive (TP) and True Negative (TN) on (total pairs) [30].

  So Accuracy = $\frac{TP+TN}{Total\ Pairs}$

- **Error Rate of analysis methods:**

  Error Rate is measured by dividing the total pairings by the sum of False positive (FP) and False negative (FN) on (total pairs) [31].

  So Error rate = $\frac{FP+FN}{Total\ Pairs}$

2. **Related Comparison:** the following are some results of past comparisons between DeepFace and OpenFace.

Table 1: Related Comparison Accuracy

Since	DeepFace	OpenFace
In 2016	0:9735 ± 0:0025 [3]	0:9292 ± 0:0134 [3]
In 2018	0.975 ± 0.003 [30]	0.955 ± 0.007 [30]

Comparative analysis: in this section we create code for face recognition verification and facial attribute analysis. We will test DeepFace and OpenFace, on their face recognition capacity based on their accuracy and error rate and Verification time.

Methodology: using a framework for python, and installing a DeepFace library powered by TensorFlow and Keras. Keras is a compact, easy-to-learn, high-level Python library for profound learning that can work on TensorFlow [32,33]. And installing matplotlib.pyplot libaray gives an implied way, like MATLAB, to plotting, it also opens the figures on screen, and acts as a graphics handler [34].

Dataset: We have collected a number of photos of people; they are split into pairs; half of the pairs consist of two different photos of the same person. While the other half of the pairs are two pictures of different people including famous people. These serve as input for the code.

Table 2: Sample data

Images	120
Identities	112
Pairs	60

Fig. 1: Example image pairs

Code works:
In this section we will show how the code works.

- First select two images.
- Then the function performs its verification; drawing two images to compare (image_1, image_2, model_name, and metrics) [35]. Model_name here refers to the model being used to assess the two images. Substituting it with DeepFace or OpenFace. The metric being used is cosine.
- After that the function result is assessed based on distance value.
- In the case the value of (distance) is less than a predefined threshold value, the result response is (They are same).
- In the case the value of (distance) is larger than a predefined threshold value, the result response is (They are not same).

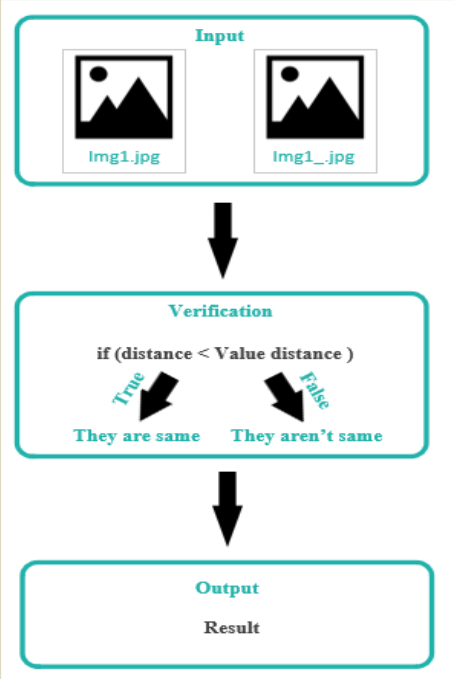

Fig. 2: Cycle Code

Analysis results based on outputs:
In this section we will display the code output results, and make a calculation, and show the comparison result.

- **DeepFace:** The test results are as follows

Table 3: DeepFace Results

DeepFace		Actual	
		Positive	Negative
Predicted	Positive	(TP) = 28	(FP) = 2
	Negative	(FN) = 1	(TN) = 29

From the accuracy law we know that:

$$\text{Accuracy} = \frac{28+29}{60} = 0.95$$
$$0.95 * 100 = 95\%$$

$$\text{Error rate} = \frac{2+1}{60} = 0.05$$
$$0.05 * 100 = 5\%$$

Time taken for one pair of faces verification:
Minimum time = 0.192245 sec
Maximum time = 1.174499 sec

- **OpenFace:** The test results are as follows

Table 4: OpenFace Results

DeepFace		Actual	
		Positive	Negative
Predicted	Positive	(TP) = 27	(FP) = 3
	Negative	(FN) = 2	(TN) = 28

$$\text{Accuracy} = \frac{27+28}{60} = 0.92$$
$$0.92 * 100 = 92\%$$
$$\text{Error rate} = \frac{3+2}{60} = 0.08$$
$$0.08 * 100 = 8\%$$

Time taken for one pair of faces verification:
Minimum time = 0.130922 sec
Maximum time = 0.973826 sec

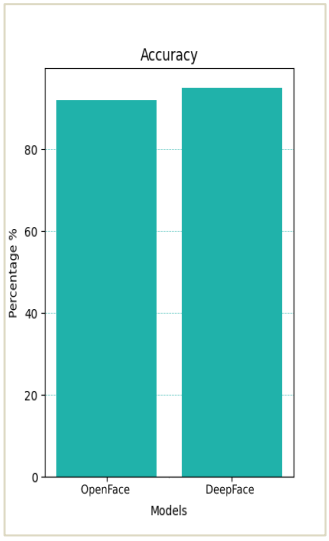

Fig. 3: Accuracy of models

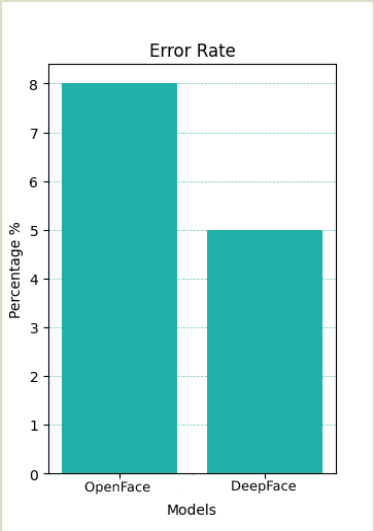

Fig. 4: Error rate of models

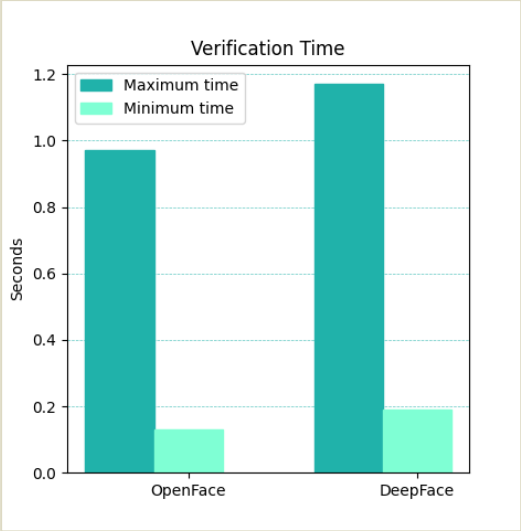

Fig. 5: Verification time of models

As such, we see that DeepFace scored a higher accuracy rate than OpenFace, while DeepFace has a smaller error rate compared to OpenFace. It should be taken into consideration that the verification time is affected by several factors such as speed (central processing unit (CPU) – Random Access Memory (RAM) …) which leads to varying readings in more than one test.
It is important to point out here, that due the small sample size tested, compared to the very large ones used in previous standard tests; these result naturally don't reflect as accurately as their predecessors and may not match them closely.

Conclusion: In this experience, we identified how to test models and analyze their results using python. After which, we perform a comparison between the results of the different models; in regards to performance and in terms of Accuracy and Error Rate. The comparison was performed on the DeepFace and OpenFace models. We used a dataset specifically assembled for this purpose, containing different faces, to test face recognition capacity. DeepFace was shown to be the better of the two with an Accuracy equal to (95%), an error rate of just (5%), and registered minimum time of (0.192245) second, and maximum time of (1.174499) second. Whilst OpenFace recorded an Accuracy Rate equal to (92%), an error rate up to nearly (8%), and registered minimum time of (0.130922) second, and maximum time of (0.973826) second. Showing smaller verification time than DeepFace. It may be concluded that these models perform well, showing high quality. We can also conclude that more accurate comparison results can be obtained from the test by an increased sample size.

Reference:

[1]- Wang, S. (2022, January). The Application of Face Recognition System. In 2021 International Conference on Social Development and Media Communication (SDMC 2021) (pp. 242-247). Atlantis Press.
[2]- Wang, M., & Deng, W. (2021). Deep face recognition: A survey. Neurocomputing, 429, 215-244.
[3]- Amos, B., Ludwiczuk, B., & Satyanarayanan, M. (2016). Openface: A general-purpose face recognition library with mobile applications. CMU School of Computer Science, 6(2), 20.
[4]- Srisuk, S., & Ongkittikul, S. (2017, March). Robust face recognition based on weighted deepface. In 2017 International Electrical Engineering Congress (iEECON) (pp. 1-4). IEEE.
[5]- Chethana, H. T., & Nagavi, T. C. (2022). A Review of Face Analysis Techniques for Conventional and Forensic Applications. Cyber Security and Digital Forensics, 223-240.
[6]- del Rio, J. S., Moctezuma, D., Conde, C., de Diego, I. M., & Cabello, E. (2016). Automated border control e-gates and facial recognition systems. computers & security, 62, 49-72.
[7]- Kusuma, M. (2022). Civil War Twin: Exploring Ethical Challenges in Designing an Educational Face Recognition Application (Doctoral dissertation, Virginia Tech).
[8]- Husain, A., & Vishvakarma, V. P. (2022, March). Face Recognition Method Based on Residual Convolution Neural Network. In IOP Conference Series: Materials Science and Engineering (Vol. 1228, No. 1, p. 012005). IOP Publishing.
[9]- Chethana, H. T., & Nagavi, T. C. (2022). A Review of Face Analysis Techniques for Conventional and Forensic Applications. Cyber Security and Digital Forensics, 223-240.
[10]- Trabelsi, S., Samai, D., Dornaika, F., Benlamoudi, A., Bensid, K., & Taleb-Ahmed, A. (2022). Efficient palmprint biometric identification systems using deep learning and feature selection methods. Neural Computing and Applications, 1-23.
[11]- Zeng, D., Veldhuis, R., & Spreeuwers, L. (2021). A survey of face recognition techniques under occlusion. IET biometrics, 10(6), 581-606.
[12]- Taigman, Y., Yang, M., Ranzato, M. A., & Wolf, L. (2014). Deepface: Closing the gap to human-level performance in face verification. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 1701-1708).
[13]- Amos, B., Ludwiczuk, B., & Satyanarayanan, M. (2016). Openface: A general-purpose face recognition library with mobile applications. CMU School of Computer Science, 6(2), 20.
[14]- Deng, J., Guo, J., Xue, N., & Zafeiriou, S. (2019). Arcface: Additive angular margin loss for deep face recognition. In Proceedings of the IEEE/CVF conference on computer vision and pattern recognition (pp. 4690-4699).
[15]- Crosswhite, N., Byrne, J., Stauffer, C., Parkhi, O., Cao, Q., & Zisserman, A. (2018). Template adaptation for face verification and identification. Image and Vision Computing, 79, 35-48.
[16]- Schroff, F., Kalenichenko, D., & Philbin, J. (2015). Facenet: A unified embedding for face recognition and clustering. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 815-823).
[17]- Hu, G., Yang, Y., Yi, D., Kittler, J., Christmas, W., Li, S. Z., & Hospedales, T. (2015). When face recognition meets with deep learning: an evaluation of convolutional neural networks for face recognition. In Proceedings of the IEEE international conference on computer vision workshops (pp. 142-150).
[18]- Sun, Z., Guo, X., Xu, Y., Zhang, S., Cheng, X., Hu, Q., ... & Xue, X. (2022). Image Recognition of Male Oilseed Rape (Brassica napus) Plants Based on Convolutional Neural Network for UAAS Navigation Applications on Supplementary Pollination and Aerial Spraying. Agriculture, 12(1), 62.
[19]- Oinar, C., Le, B. M., & Woo, S. S. (2022). KappaFace: Adaptive Additive Angular Margin Loss for Deep Face Recognition. arXiv preprint arXiv:2201.07394.

[20]- Baltrušaitis, T., Robinson, P., & Morency, L. P. (2016, March). Openface: an open source facial behavior analysis toolkit. In 2016 IEEE Winter Conference on Applications of Computer Vision (WACV) (pp. 1-10). IEEE.
[21]- Cole, M. R. Edge Computing for Facial Recognition & Emotion Detection.
[22]- Hemathilaka, S., & Aponso, A. (2022). A Comprehensive Study on Occlusion Invariant Face Recognition under Face Mask Occlusion. arXiv preprint arXiv:2201.09089.
[23]- Chiurco, A., Frangella, J., Longo, F., Nicoletti, L., Padovano, A., Solina, V., ... & Citraro, C. (2022). Real-time Detection of Worker's Emotions for Advanced Human-Robot Interaction during Collaborative Tasks in Smart Factories. Procedia Computer Science, 200, 1875-1884.
[24]- Yamada, S., Rizk, H., & Yamaguchi, H. (2022). An accurate point cloud-based human identification using micro-size lidar. In International Conference on Pervasive Computing and Communications Workshops and other Affiliated Events (PerCom Workshops). IEEE.
[25]- Stüber, J., Junctorius, L., & Hohenberger, A. (2022). Investigating Non-Visual Eye Movements Non-Intrusively: Comparing Manual and Automatic Annotation Styles. Journal of Eye Movement Research, 15(2).
[26]- Al-Amoudi, I., Samad, R., Abdullah, N. R. H., Mustafa, M., & Pebrianti, D. (2022). Automatic Attendance System Using Face Recognition with Deep Learning Algorithm. In Proceedings of the 12th National Technical Seminar on Unmanned System Technology 2020 (pp. 573-588). Springer, Singapore.
[27]- Fydanaki, A., & Geradts, Z. (2018). Evaluating OpenFace: an open-source automatic facial comparison algorithm for forensics. Forensic sciences research, 3(3), 202-209.
[28]- Learned-Miller, E., Huang, G. B., RoyChowdhury, A., Li, H., & Hua, G. (2016). Labeled faces in the wild: A survey. In Advances in face detection and facial image analysis (pp. 189-248). Springer, Cham.
[29]- Kan, M., Shan, S., Xu, D., & Chen, X. (2011, September). Side-Information based Linear Discriminant Analysis for Face Recognition. In BMVC (Vol. 11, pp. 1-12).
[30]- Santoso, K., & Kusuma, G. P. (2018). Face recognition using modified OpenFace. Procedia Computer Science, 135, 510-517.
[31]- Grother, P., Grother, P., Ngan, M., & Hanaoka, K. (2019). Face recognition vendor test (frvt) part 2: Identification.
[32]- Manaswi, N. K. (2018). Understanding and working with Keras. In Deep Learning with Applications Using Python (pp. 31-43). Apress, Berkeley, CA.
[33]- Ismael, K. D., & Irina, S. (2020). Face recognition using Viola-Jones depending on Python. Indonesian Journal of Electrical Engineering and Computer Science, 20(3), 1513-1521.
[34]- https://matplotlib.org/3.5.0/api/_as_gen/matplotlib.pyplot.html.
[35]- https://github.com/serengil/deepface.