Modified CNN Model for Classifying Gender of Thermal Images Using Cloud Computing

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The utilization of thermal images has become widespread in various applications, particularly for thermal examination and night surveillance systems. Although many details associated with thermal imaging are virtually obscured or unclear, thermal imaging offers numerous benefits, including the ability to determine an individual's gender even in cases where human vision is impaired. Based on thermal faces, a convolutional neural network (CNN) has been developed to distinguish between people's genders. Since cloud computing offers a suitable setting and gained attraction, its concept has been adopted. Thermal databases were used for the experiments. The suggested model provides an overall accuracy of 99% and a gender categorization precision of 97.75%.

Povzetek:Razvit je sistem za prepoznavanje spola na termalnih slikah, ki dosega skoraj 100% točnost.

1 Introduction

Detecting the gender of people through images has many applications and systems that have proven effective in determining paths and decisions in monitoring systems. The human eye can easily distinguish this through many features through which a person can differentiate between male and female. Many methods and techniques were proposed that contribute to extracting facial features and entering them into discrimination systems to classify the data into two basic categories [1]. This basically requires overcoming all imaging problems as a primitive step for the purpose of focusing on the extracted characteristics, especially if there are emergency circumstances that require acceptance of any image quality or any angle of capture. Among these challenges is the issue of thermal images, which are basically low-resolution images, although they have many advantages, including detecting people who hide behind walls or among trees at night, which high-resolution color cameras are unable to do. The thermal grate records the distribution of heat in the human body and this distribution appears in the form of different colors [2][3]. In this work, a new gender classifier for facial thermal images is proposed using a convolutional neural network with a database consisting of 3366 thermal images for training and testing purposes according to the Cloud computing environment. The model was compared with our previous work on Resnet networks (18, 50, 101) on the MATLAB environment to record the difference between online and offline on the one hand, and between the network that was designed and the available networks on the other hand [4][5]. And because Cloud computing is an advanced field in the computer world because the computing environment provides integrated support for all tasks, and it is possible to access the available software at any time and from any device, we implemented a thermal image recognition system on it, and through the services it provides, we were able to obtain better results. This paper is orderly as follows: section 2 is related work that has been focused on gender classification in images, Section 3 describes CNN model that is used in the system, and Section 4 displayed our experiments conducted and compared the results. In the last, the conclusion and future suggestions are given in section 5.

2 Related work

One of the biggest challenges that researchers may encounter in dealing with thermal images is that most facial features are not clear because this type of camera does not depend on the outer layer of the face, but rather gives values that show the distribution of heat in the face, and as it is known, the parts of the face differ in thickness. Some areas contain muscles such as the cheeks, and others do not, such as the forehead, so the result differs in the given values. Recent studies focused on these challenges and suggested many techniques that can deal with these types of images [6][7]. Thermal imaging has been used in many medical applications as it is a non-destructive and rapid system at the same time, and one of the most important of these applications is the detection of breast

cancer, as it is considered a fatal disease for women, the emphasis has been placed on it because of its early detection benefit to save many lives. In addition, thermography is an advanced technique, as infection with this disease leads to an increase in body temperature in certain areas due to the secretion of nitric oxide by cancer cells, which impedes the nature of nervous control of blood vessel flow., leading to local vasodilatation in the early stages. The possibility of identifying areas that contain a high percentage of blood inside the breast, in addition to the asymmetry between the breasts, are among the most characteristic signs of breast cancer [7]. Automatic gender classification was based on face images with great interest in the world of biological measurements, where many experiments indicated that machine learning is much better than humans in classification, and many techniques are used to conclude the features such as SVM, LBP, LDA, PCA, MLP, GMM mixture model, Adaboost, Random Forest, ...etc. that is used even in low resolution [8]. Although these technologies have proven their great role in extracting the features of the images that were entered, the use of the convolution neural network (CNN) to extract the features from the images had a distinctive role in monitoring systems and people's gender identification systems. as well as we can based on other parts of the body rather than the face in adopting in classification mechanism is like the variations shown in the style of arrangement of hair, clothes, etc., whether in visual images or thermal images [9][10]. A group of researchers was also able to propose a simple set of features to distinguish gender, which was extracted from thermal infrared images. The first type depends on the average pixel value of certain locations on the face. The results of classification based on this feature are verified using traditional approaches, including the use of networks of simple nervous, and the second type takes advantage of the temperature distribution on people's ears and compares the differences between men and women [11]. Radial changes in thermal images can also be measured using the FLIR technique to determine if a person is ill with Covid-19, and the aim is to save time for disease prevention. Where the test is carried out on a group of people and submitted to CNN, which is derived from the Xception structure, to diagnose people with pneumonia caused by the Coronavirus. According to what is known, it enhances the early diagnosis of the disease and its treatment, and if it is necessary to isolate the disease in a special place (isolation), this saves time and helps in managing the crisis [12]. Table 1 gives an overview of the results from previous research on gender classification using facial thermal images. The table highlights the used techniques, and their respective classification accuracies.

Table 1: Overview of thermal images classification

Ref	Techniques	Result
[13]	Haar wavelet Transform, Local Binary Pattern, PCA	Recognition rate:95.09%
[14]	CNN	Head Rotation:98% Expression :99.40% Illumination:100%
[15]	CNN	Accuracy:0.8367, Recall:0.7876, Precision:0.8476
[16]	CNN	Accuracy:99.6%

From what was presented in the previous table, the need emerged to support low-quality thermal images for the purpose of gender classification, and to design a convolutional neural network suitable for this type of data. Taking into account, to investigate new design approaches, and not to just rely on existing networks such as Resnet, and VGG.

3 Deep learning methodology

In the recent period, accurate solutions have been found to the problems of machine learning and artificial intelligence, such as classification, recognition, and pattern analysis, through deep networks. The more the network varies in depth, it leads to a change in accuracy commensurate with the size of the data entered [4][17], and as it is known, attempts to improve and develop. In networks, it was not simple or easy, but it was necessary in the case of big data, and as a result, it takes more time for a machine to train and reach the network learning stage. In our previous work [18], we dealt with the mechanism of gender recognition using thermal images with three types of networks, and they differed in depth and gave good results. For competition and comparison, we designed a neural network based on the concept of convolutional neural networks and applied it to the Cloud computing environment. We have shown that relying on cloud computing has additional advantages in the stages of classification and giving differences, due to the ability of its updated weights to speed up training and reach better results, as well as providing storage and updating libraries capable of processing noisy data and the possibility of designing a network that suits the input data, whether by increasing the number of layers or by reducing them. As we noticed the network’s ability to adapt and get closer to reaching the desired goal in a faster way.

3.1 Proposed network

We have noticed the architecture of the convolutional neural network (Resnet 50) and we have seen the number of its layers and connections. And we have previously explained that increasing the number of data (input images) will cause an increase in processing time in addition to an increase in time. So, it was necessary to design a neural network that takes the approach of convolutional neural networks, but with fewer layers, and so the fewer parameters used, the lower the execution time. We proposed the design of a neural network based on the principle of convolutional neural networks and it gave good results for training thermal images that networks (ResNet50, ResNet101) were previously used for gender recognition. We compare the two networks. Below is a table showing the difference between the two architectures (Resnet50, Cloud_Res), Table 2.

Table 2: The comparison between Resnet 50 and the designed networks

Subject	Cloud_Res	Resnet50
No. batch_normalization	30	53
No. Convolution	29	50
No. Relu	29	49
No. Add	14	16
No. pooling	1	2
Trainable params	15,618,824	23,600,130
Non-trainable params	12,422	53,120
Total params	15,631,246	23,653,250

We notice in Table 2 that the difference between the number of variables in the two networks is reduced by approximately half (convolution, Relu, total parameters), and this certainly causes a difference in processing time and storage space. It also prevents the network from falling into local minima (the network does not learn due to its fixation on a specific point and the inability to climb it easily), which makes the network need more cycles to reach the desired goal. The figure below shows the final design of the network, Figure 1.

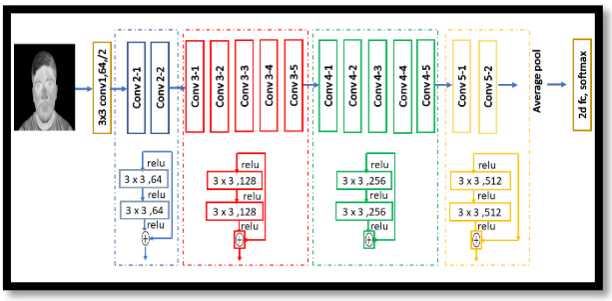

Figure 1: The cloud_res design

This designed network proved efficiency for data thermal images that were previously implemented using convolutional neural networks. We noticed the difference in parameters and layers that affected the implementation time, which is a key factor, especially in areas where the Internet is slow or irregular due to the momentum of places.

3.2 Gender detection

Trying to classify gender in thermal images is considered a major challenge due to the disappearance of most of the facial features that help distinguish a man from a woman. There are also factors that can make matters more difficult, such as (shaving the mustache and beard, wearing earrings, and long hair for men, as well as shortening the hair for women). Therefore, the convolutional neural network depends on finding other differences by selecting many features, and this is what distinguishes it from the rest of the techniques. It does not depend on the user to choose or define the features as in the figure 2.

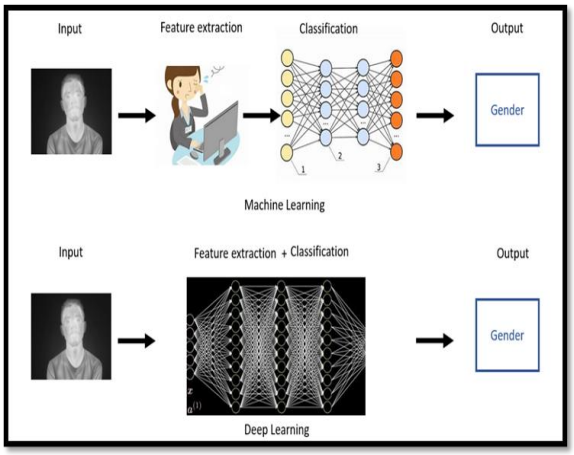

Figure 2: The different between machine learning and deep learning

Therefore, we enter the data into the convolutional neural network shown in Figure 1 after completing the image processing stages, as we explained in our previous work [18], in order to calculate the classifiers and prediction stages, leading to the recognition stages shown in Figure 3. Then, after two layers, a skip connection is added. Furthermore, we added the maximum clustering in the first layer and the average clustering in the last layer. However, a fully connected network is applied at the end of the layers.

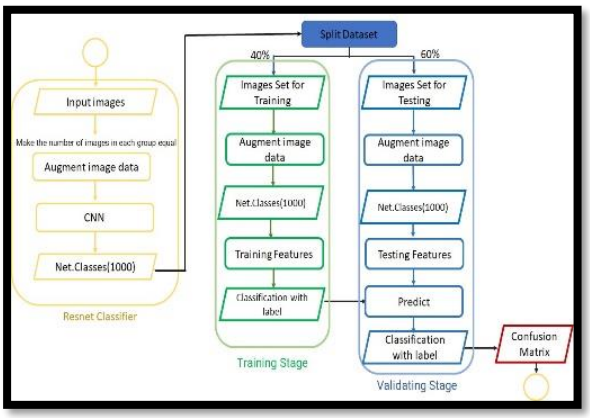

Figure 3: Recognition stages

4 Experimental results

To train and test the proposed network classifier for thermal images, we used the same data used in the previous research (Table 2), but the difference was that the thermal images were transferred to Google Drive and using the Python version. We also labeled the data for males and females, and we used discrimination measures, which are precision, recall, overall accuracy, and f-score as in second research. The confusion matrix for the model above is shown in Figure 4.

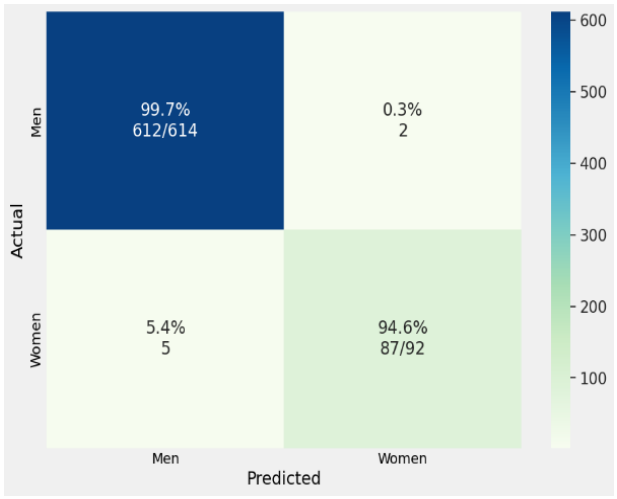

Figure 4: Confusion matrix of the Cloud_Res

We made two comparisons, the first comparing our network with the previous research networks (18, 50, 101) in Table 3, and the second comparing with the rest of the researchers' results, in Table 4.

Table 3: Performance measures of proposed Network with our previous work

Research	Net name	Metrics	All Data Ratio
[18] On MATLAB 2020	IRT_ResNet 18	Precision	96.6%
		Recall	93.8%
		F-Score	95.2%
		Overall accuracy	95.2%
	IRT_ResNet 50	Precision	94.5%
		Recall	96%
		F-Score	95.3%
		Overall accuracy	95.2%
	IRT_ResNet 101	Precision	97.3%
		Recall	97%
		F-Score	97.2%
		Overall accuracy	97.2%
Our work Cloud Computing	Cloud_Res	Precision	97.75%
		Recall	94.5%
		F-Score	96.1%
		Overall accuracy	99%

Our previous work was limited to distinguishing gender in thermal images using three convolutional networks, as shown in the previous table, using the Matlab 2020 program (offline training). Thus, we aimed to design a different network that was suitable for the size and type of data on Python (online) and calculate the difference. In terms of metrics, whichever produces better results, and as shown, the new network showed good results given that online training is subject to continuous updates and overcomes obstacles that may occur as a result of poor data quality. Nevertheless, cloud management systems overcome the limitations of scalability, privacy and reliability.

Table 4: Comparing with the rest of the researchers' results

Research	Net name	Metrics	All data ratio
[10]	CNN	Accuracy	90.61%
[12]	Xception	Precision	93%
		Recall	93.3%
		F-Score	93.1%
		Overall accuracy	92%
[19]	CNN	F-Score	80%
[20]	VGG	Precision	91%
		Recall	90%
		Accuracy	93%
[21]	Temperature Features + BN	Accuracy	73.5 %
		Kappa	0.391
		F-Score	0.584
	LBP+ BN	Accuracy	82.9 %
		Kappa	0.608
		F-Score	0.733
[22]	Machine Learning	Precision	93%
		F-Score	98%

For expanding on the potential application of proposed model in surveillance systems, we work on developing our own Cloud-based surveillance system targeting people entering public organizations and investigate how it could enhance gender classification. Currently, we succeed in employing deep learning to help in identifying invaders and infected people. We also delve into the limitations of implementing our approach in real-world applications and how to work on images having variant accuracy or lost information due to unexposed regions of the face [23].

5 Conclusion

In this paper, a thermal face analysis system has been proposed to classify gender in Cloud computing. we design a convolution neural network that has been implemented using Cloud. We used two databases that are announced below [24][25]. This model has shown the best gender classification recognition (100%), for the dataset of size 3366. and it accomplishes precision rate (97.75%), recall rate (94.5%), F1-score (96.1%), and overall accuracy (99%). There are improvements in the performance metrics of CNN on Cloud computing compared with the

Matlab environment. These improvements are good compared with the time needed to train and validate, but it is necessary to use more layers when the data is huge. The system performance promotes its adaptation for person identification, in the future, to be employed in security and surveillance applications.

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