AIP Conference Proceedings

RESEARCH ARTICLE | JULY 25 2023

Low resolution images in face recognition using convolutional neural network FREE

Rulin Swastika; Didik Setiyadi; Saludin; Dian Ade Kurnia ✉; Rita Wahyuni Arifin

AIP Conference Proceedings 2798, 020011 (2023)
https://doi.org/10.1063/5.0164275

Low Resolution Images in Face Recognition Using Convolutional Neural Network

Rulin Swastika[1)], Didik Setiyadi[2)], Saludin[3)], Dian Ade Kurnia[4, a)]
Rita Wahyuni Arifin[3)]

[1]*Universitas Al-Khaeriyah, Banten, Indonesia*
[2]*Universitas Indonesia Mandiri, Bekasi, Indonesia*
[3]*Universitas Bina Insani, Bekasi, Indonesia*
[4]*Sekolah Tinggi Manajemen Informatika dan Komputer IKMI, Cirebon, Indonesia*

[a)] Corresponding author: dianade2014@gmail.com

Abstract. Research in image processing has remained in high demand to the present day. The subject of this research is computer vision, a subfield of computer science. The quality of an image object is affected by lighting, illumination, filtering, blurring, and noise. A computer cannot easily recognize a human face based on the camera's output. Numerous technical considerations must be made, the most critical of which is the processing of digital images. The purpose of this study is to develop a method for predicting facial recognition from individuals' low-resolution images. To address this, Convolutional Neural Networks are used. Convolutional Neural Networks are a subset of neural networks that make use of convolution (CNN). The dataset was constructed using publicly available data, specifically the Georgia Tech Face Database, which is accessible at the following URL: http://www.anefian.com/research/face reco.htm. The 128MB file contains images of 50 individuals at the Center for Signal and Image Processing at the Georgia Institute of Technology. Each individual in the database is represented by fifteen color JPEG images with a cluttered background measuring 640x480 pixels. According to the study's findings, the training data sample will be 85.69 percent accurate, while the validation data sample will be 80,81 percent accurate.

Keywords: image processing, computer vision, low-resolution, convolutional neural network, accuracy

INTRODUCTION

Research on image processing is still being done, especially in face recognition that has its own challenges [1]. These challenges include occlusion [2], variation in pose, illumination [3] and so on. Meanwhile, face recognition systems are built with good image quality, but sometimes there is in fact finding poor image quality as evidenced by low image resolution, which is caused when the camera takes the image is not in a state of focus, besides the process of taking the image position of the camera is at a distance. Of course, this will affect the sharpness in identifying an image object to get to know the human face.

For humans, knowing someone's face is certainly very easy to do, but for computers it is actually difficult to do.. Therefore, research in the field of computer vision is currently growing. Through artificial intelligence technology, of course, it is very helpful for computers to know object images, even if the image quality is not good [3]. Various algorithms that can prove the depth level of image objects can be recognized as evidenced by the results of performance accuracy obtained.

The dataset was constructed using publicly available data, specifically the Georgia Tech Face Database, which is accessible at the following URL: http://www.anefian.com/research/face reco.htm. The 128MB file contains images of 50 individuals at the Center for Signal and Image Processing at the Georgia Institute of Technology. Each individual in the database is represented by fifteen color JPEG images with a cluttered background measuring 640x480 pixels.

International Conference of SNIKOM 2021
AIP Conf. Proc. 2798, 020011-1–020011-7; https://doi.org/10.1063/5.0164275
Published by AIP Publishing. 978-0-7354-4598-7/$30.00

This study aims that the implementation of a neural network algorithm to recognize human facial image objects that have low-resolution image quality due to the blur of the camera lens, resulting in satisfactory accuracy. As a contribution of this study is as a contribution of science in the field of computer vision in the use of Convolutional Neural Network (CNN) algorithms to predict low-resolution image objects.

METHODS

Convolutional Neural Networks

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm that can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image, and be able to differentiate one from the other [4]. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets can learn these filters/characteristics[5] [6].

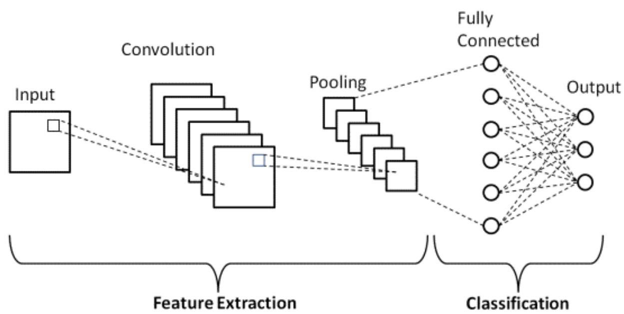

FIGURE 1. Convolutional Neural Network (CNN) Architecture

1. Convolutional Layer
   This layer is the first layer that is used to extract the various features from the input images. In this layer, the mathematical operation of convolution is performed between the input image and a filter of a particular size MxM. By sliding the filter over the input image, the dot product is taken between the filter and the parts of the input image concerning the size of the filter (MxM).
   The output is termed as the Feature map which gives us information about the image such as the corners and edges. Later, this feature map is fed to other layers to learn several other features of the input image.
2. Pooling Layer
   In most cases, a Convolutional Layer is followed by a Pooling Layer. The primary aim of this layer is to decrease the size of the convolved feature map to reduce computational costs. This is performed by decreasing the connections between layers and independently operates on each feature map. Depending upon the method used, there are several types of Pooling operations.
3. Fully Connected
   The Fully Connected (FC) layer consists of the weights and biases along with the neurons and is used to connect the neurons between two different layers. These layers are usually placed before the output layer and form the last few layers of a CNN Architecture. In this, the input image from the previous layers is flattened and fed to the FC layer. The flattened vector then undergoes few more FC layers where the operations of the mathematical function usually take place. In this stage, the classification process begins to take place.
4. Dropout
   Usually, when all the features are connected to the FC layer, it can cause overfitting in the training dataset. Overfitting occurs when a particular model works so well on the training data hurting the model's performance when used on new data.
5. Activation Function
   Finally, one of the most important parameters of the CNN model is the activation function. They are used to learn and approximate any kind of continuous and complex relationship between variables of the network. In simple words, it decides which information of the model should fire in the forward direction and which ones should not at the end of the network.

It adds non-linearity to the network. There are several commonly used activation functions such as the ReLU, Softmax, tan H, and the Sigmoid functions. Each of these functions has a specific usage. For a binary classification CNN model, sigmoid and softmax functions are preferred and for a multi-class classification, generally softmax is used.

Stages of Method

The method used in this study refers to the business methodology that is a cross-industry standard process for data mining (CRISP-DM) such as business understanding, analytic approach, data requirements, data understanding, data pre-processing, data modeling, data evaluation [7] [8].

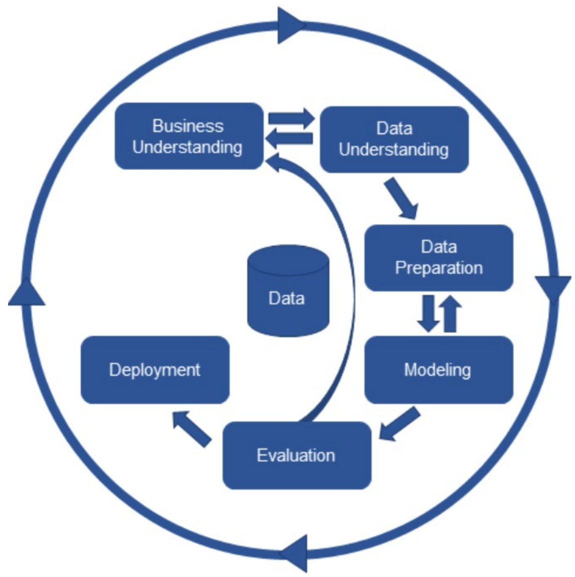

FIGURE 2. Stage of Methods Data Science

Business Understanding

The step of developing system intelligence from data begins with the determination of the problem to be solved. The business problems to be solved must be clear and measurable. This means that the problem is understandable to all involved and the status of its achievements can be measured.

Analytic Approach

From the problem that has been defined and the size of his business success has been determined then the problem is changed to Task Analytic. Several analytic tasks can be selected according to the problems faced, namely regression, classification, clustering, association, anomaly detection, or recommendations.

Data Requirements

Furthermore, after the analytic task is done that must be fulfilled is to determine what data is needed, and where the data is obtained. There are 3 (three) that need to be considered in terms of data structure, amount of data, and data source.

Data Understanding

Data understanding is an activity to understand data more deeply. There are three main activities in data understanding, namely data collection, data analysis, data validation.

Data Pre-Processing

Data pre-processing (data preparation) uses the results of the analysis that has been done to change the data so that the quality of the data is improved and can improve the modeling process. Any changes made to the data need to be documented as a trial audit. There are four main steps in pre-processing data including selection features, data cleaning, data reconstruction, data integration.

Data Modeling

The following stage is the utilization of Machine Learning (ML) algorithms to form a model of data that has been improved/prepared. The target of modeling is to find the best model that can be found using processed data. The problem is which algorithmic techniques will be used and what combination of parameters from the algorithm will give the best results even if the experiment is done as little as possible. For that, several steps are taken at this stage of modeling.

Data Evaluation

In this step, measurement of the performance of the model has been obtained and analysis of whether the model is good enough from a technical angle and business angle (domain) to be used. Because the number of models developed is not just one, a way to choose which model is best. This analysis is done technically or business.

RESULTS AND DISCUSSION

Load Data

Datasets are retrieved from public datasets through: http://www.anefian.com/research/face reco.htm, then stored in their own computer folders. Directories are separated between high-resolution images and low-resolution images.

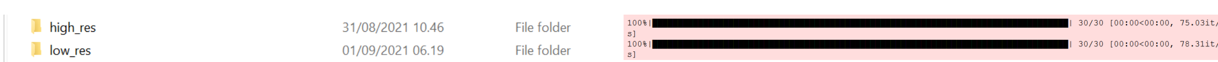

Figure 3 Load Data of Public Datasets

Data Visualization

Next display high-resolution, low-resolution images of datasets that have been stored in the computer folder.

FIGURE 4. Data Visualization High and Low Resolution Images

Image Pre-Processing with Feature Slicing and Reshaping Images

In the pre-processing stage in this section, there are two techniques, namely slicing and reshaping techniques. Slicing is a technique of selecting data from datasets in the form of arrays. The reshaping technique is used to modify the dimensions of the originally generated matrix to the desired dimension. Below are two techniques used against data training images, test images and validation images.

```
Shape of training images: (20, 256, 256, 3)
Shape of test images: (5, 256, 256, 3)
Shape of validation images: (5, 256, 256, 3)
```

FIGURE 5. Image Pre-Processing

Data Modeling

The algorithm used in this data modeling is the Convolutional Neural Network (CNN). The stages in building the CNN model are Convolution, Pooling, Flatenning and Fully Connection.

Layer (type)	Output Shape	Param #	Connected to
input_8 (InputLayer)	[(None, 256, 256, 3)	0	
sequential_70 (Sequential)	(None, 128, 128, 128	3584	input_8[0][0]
sequential_71 (Sequential)	(None, 64, 64, 128)	147584	sequential_70[0][0]
sequential_72 (Sequential)	(None, 32, 32, 256)	296192	sequential_71[0][0]
sequential_73 (Sequential)	(None, 16, 16, 512)	1182208	sequential_72[0][0]
sequential_74 (Sequential)	(None, 8, 8, 512)	2361856	sequential_73[0][0]
sequential_75 (Sequential)	(None, 16, 16, 512)	2359808	sequential_74[0][0]
concatenate_35 (Concatenate)	(None, 16, 16, 1024)	0	sequential_75[0][0] sequential_73[0][0]
sequential_76 (Sequential)	(None, 32, 32, 256)	2359552	concatenate_35[0][0]
concatenate_36 (Concatenate)	(None, 32, 32, 512)	0	sequential_76[0][0] sequential_72[0][0]
sequential_77 (Sequential)	(None, 64, 64, 128)	589952	concatenate_36[0][0]
concatenate_37 (Concatenate)	(None, 64, 64, 256)	0	sequential_77[0][0] sequential_71[0][0]
sequential_78 (Sequential)	(None, 128, 128, 128	295040	concatenate_37[0][0]
concatenate_38 (Concatenate)	(None, 128, 128, 256	0	sequential_78[0][0] sequential_70[0][0]
sequential_79 (Sequential)	(None, 256, 256, 3)	6915	concatenate_38[0][0]
concatenate_39 (Concatenate)	(None, 256, 256, 6)	0	sequential_79[0][0] input_8[0][0]
conv2d_47 (Conv2D)	(None, 256, 256, 3)	75	concatenate_39[0][0]

Total params: 9,602,766
Trainable params: 9,600,206
Non-trainable params: 2,560

FIGURE 6. The Convolutional Neural Network (CNN) Model

The model type that we will be using is Sequential. Sequential is the easiest way to build a model in Keras. It allows you to build a model layer by layer.

Model Evaluation

The evaluation model is important in developing a good machine learning model. The model evaluation process can be done after the model training is completed. Evaluation data testing produces the true accuracy value of a model that has been trained. In this study, the model validated the low image and high image variables with experiments 7 times (epoch). The results of the last experiment showed an accuracy rate of 85.69%, loss validation of 02.54%, and validation of the accuracy of 80.81% with a loss value of 02.20%. The results are shown in the graph below.

```
Epoch 1/7
20/20 [==============================] - 7s 364ms/step - loss: 0.1060 - acc: 0.6683 - val_loss: 0.0806 - val_acc: 0.7744
Epoch 2/7
20/20 [==============================] - 7s 339ms/step - loss: 0.0481 - acc: 0.7474 - val_loss: 0.0527 - val_acc: 0.7566
Epoch 3/7
20/20 [==============================] - 7s 340ms/step - loss: 0.0364 - acc: 0.7853 - val_loss: 0.0412 - val_acc: 0.7721
Epoch 4/7
20/20 [==============================] - 7s 342ms/step - loss: 0.0307 - acc: 0.8083 - val_loss: 0.0368 - val_acc: 0.7738
Epoch 5/7
20/20 [==============================] - 7s 338ms/step - loss: 0.0273 - acc: 0.8322 - val_loss: 0.0309 - val_acc: 0.7758
Epoch 6/7
20/20 [==============================] - 7s 339ms/step - loss: 0.0239 - acc: 0.8452 - val_loss: 0.0278 - val_acc: 0.7678
Epoch 7/7
20/20 [==============================] - 7s 338ms/step - loss: 0.0220 - acc: 0.8569 - val_loss: 0.0254 - val_acc: 0.8081
```

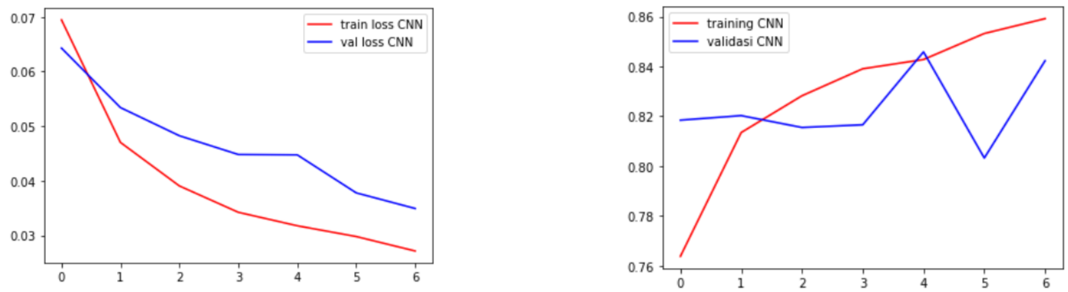

FIGURE 7. Model Evaluation

Prediction Visualization

In this section will be displayed predictions in the form of visualizations by comparing high- resolution, low and prediction images 4 times..

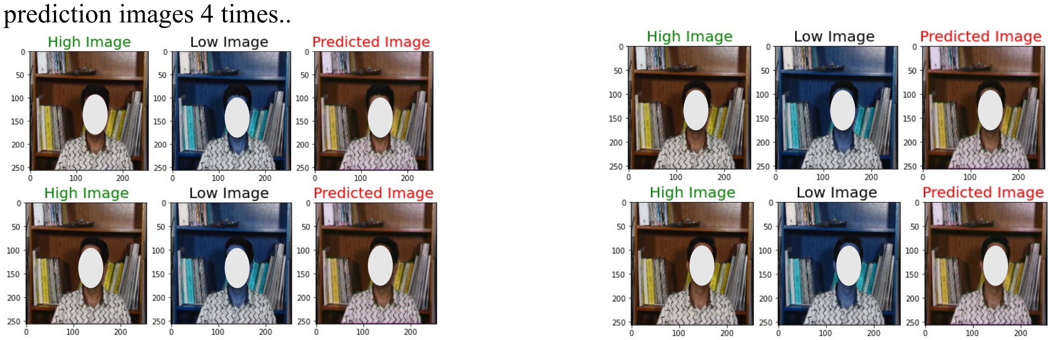

FIGURE 8. Visualization of Image Prediction

CONCLUSIONS

This study has been implemented a convolution-based neural network algorithm (CNN) to recognize images of human faces that are low resolution resulting from poor camera results or blur. CNN was able to predict images of human faces from low resolution to high resolution with an accuracy prediction rate of 85.69 percent.

ACKNOWLEDGMENTS

Thank you to Al-Khaeriyah University, University of Indonesia Mandiri, Bina Insani University and STMIK IKMI Cirebon who have supported the publication of this research.

REFERENCES

1. E. Zangeneh, M. Rahmati, and Y. Mohsenzadeh, "Low resolution face recognition using a two-branch deep convolutional neural network architecture," *Expert Syst. Appl.*, vol. 139, p. 112854, 2020.
2. H. Jia and A. M. Martinez, "Support vector machines in face recognition with occlusions," *2009 IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. Work. CVPR Work. 2009*, vol. 2009 IEEE, pp. 136–141, 2009.
3. A. M. Martínez, "Recognizing imprecisely localized, partially occluded, and expression variant faces from a single sample per class," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 24, no. 6, pp. 748–763, 2002.
4. D. A. Kurnia, A. Setiawan, D. R. Amalia, R. W. Arifin, and D. Setiyadi, "Image Processing Identifacation for Indonesian Cake Cuisine using CNN Classification Technique," *J. Phys. Conf. Ser.*, vol. 1783, no. 1, 2021.
5. I. Neforawati, N. S. Herman, and O. Mohd, "Precision agriculture classification using convolutional neural networks for paddy growth level," *J. Phys. Conf. Ser.*, vol. 1193, no. 1, 2019.

6. O. Nurdiawan, D. A. Kurnia, D. Solihudin, T. Hartati, and T. Suprapti, "Comparison of the K-Nearest Neighbor algorithm and the decision tree on moisture classification," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1088, no. 1, p. 012031, 2021.
7. D. A. Kurnia, D. Sudrajat, N. Rahaningsih, A. R. Rinaldi, and F. A. Pratama, "The selection of candidate of call center operator 112 using analytical hierarchy process method," *J. Phys. Conf. Ser.*, vol. 1360, no. 1, pp. 0–6, 2019.
8. P. C. Ncr, J. C. Spss, T. K. Spss, T. R. Daimlerchrysler, and R. W. Daimlerchrysler, "The CRISP-DM Process Model," no. C, 1999.