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Deep Learning Based Mask Detector for Coronavirus

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Abstract Coronavirus (Covid-19), which appeared in December 2019, affected all countries in the world and was declared a pandemic by the World Health Organization (WHO). Covid-19 virus affects people through transmission. There are some guidelines to reduce the risk of contamination. The most important of these principles is the use of masks. As in all over the world, some restrictions have been imposed in our country to control the Covid-19 virus. Curfew restrictions were introduced firstly in order to minimize the risk of contamination and to control the patient density in the hospital. After a certain period of time, the restrictions were eased and "controlled life with mask" system was adopted. It has been made mandatory to use masks in the community in a controlled life order. It is forbidden for people without masks to be in an environment.

In this study, a deep learning project has been developed that detects whether there is a mask on a human face. A mask detector has been created with computer vision. We used OpenCV library for image processing, and Keras/Tensorflow API for deep learning model. The deep learning model is used as Convolutional Neural Network (CNN). The developed mask detector detects the human face from the computer camera and warns of "there is a mask" or "there is no mask". For the training and test of the proposed system, a data set has been created. Photographs of people whose permissions were obtained were used as the dataset. In the result of this study, it was observed that the masked and unmasked photographs were successfully detected in the trained dataset. It is thought that better results will be obtained by enriching the dataset in future studies.

Keywords: *Deep learning, Mask detection, Image processing, Machine learning, CNN.*

I. Introduction

The New Coronavirus Disease (Covid-19) is an infectious and deadly disease that first appeared in China in December 2019. It affected the whole world and declared a pandemic by the World Health Organization as a result of the rapid spread of the disease. Globally, as of 3:46pm Central European Summer Time (CEST), 16 April 2021, there have been 138.688.383 confirmed cases of Covid-19, including 2.978.935 deaths, reported to WHO. As of 14 April 2021, a total of 751.452.536 vaccine doses have been administered [1] . In Turkey, from 3 January 2020 to 3:46pm CEST, 16 April 2021, there have been 4.086.957 confirmed cases of Covid-19 with 35.031 deaths, reported to WHO. As of 14 April 2021, a total of 18.494.796 vaccine doses have been administered [1]. The virus is transmitted from person to person by inhalation of droplets scattered by the sick person's coughs and sneezes. There are some guidelines to reduce the risk of contamination and to prevent it. The main ones are: Hand

hygiene should be cared for, and contact with the mouth, nose, and eyes should be avoided until hands are cleaned. The distance that may be at risk of contamination with the sick individual should be maintained. People should not be found without masks in society [2].

Covid-19 virus is mostly caused by the sick person; it is known to be transmitted by coughing, sneezing, and droplets from the mouth and nose during speech. It has been proven that the risk of Covid-19 transmission is reduced by wearing a mask correctly. Wearing the mask, which is one of the most basic principles, has been made compulsory in some countries[1,2]. In our country, "controlled social life" has been adopted in the recent past and it has been forbidden to be in the society without wearing a mask. For example, you cannot enter a market, greengrocer, store, barber or shopping center without a mask. It is mandatory to wear a mask even on the street. With this prohibition, it has become very important in societies whether people wear their masks correctly or not [2].

The aim of this study is to determine whether people wear their masks correctly or incorrectly during the pandemic period. A data set that consisting of masked and unmasked photographs was created and they used in training and test of a deep learning model. In this study, firstly, the human face is detected and then, the mask information is displayed on the screen. It was tried to reduce the risk of contamination in crowded environments with this study. OpenCV[3] library for image processing and Tensorflow[4] / Keras[5] library for deep learning model were used in the study.

II. Materials and Methods

In this study, we utilized machine learning, computer vision, image processing and deep learning technique. The information about these methods is given below.

A. Image Processing and OpenCV

Image processing is a method developed to digitalize the image and perform some operations, to obtain specific images or to extract some useful information from it. The input of this method is an image such as a video or a photo. The output is the desired part of the image that needs attention. Generally, the image processing system handles images in two dimensions while applying predetermined Signal Processing methods.

The purpose of image processing can be briefly divided into five groups. This groups are "visualization" (observing hard-to-see objects), "image sharpening / restoration" (enhancing noisy images), "image acquisition" (interesting and high-resolution image search), "pattern recognition" (identifying various objects in an image) and "image recognition" (distinguishing objects in an image)[6–8].

Face recognition is one of the most used image processing branches in our country and in the world. In the face recognition process, the specific features of human faces are taught to the machine by following the deep learning methodology [8–12]. The metric features for forming the face shape can be defined as the distance between the two eyes and the shape of the average human face. After the criteria specific to human faces are taught to the machine, the machine accepts all objects similar to the same shape in the image as a face.

The mask detection is performed in this work with object recognition, which is one of the purposes of image processing. In order to detect the mask, it is necessary to determine the human

face and to check whether the mask on the face is present or not. The control process is done instantly from the computer camera. OpenCV [3] library was used for this purpose.

OpenCV [3] is successfully used in detecting and identifying faces and objects, tracking and detecting moving objects in the camera. In this study, it was preferred because the mask on the face will be detected. The region of the face has been framed thanks to OpenCV [3]. At the same time, the OpenCV [3] library supports TensorFlow[4] deep learning technology.

B. Deep Learning

It is an artificial intelligence method that uses multi-layered artificial neural networks in areas such as deep learning, object recognition, speech recognition, natural language processing, and is one of the types of machine learning[8,10,13–15]. Instead of learning with rules coded unlike traditional machine learning methods; it can be learned automatically from the data symbols of pictures, videos, sounds and texts.

Deep learning structures enable them to design, train and verify artificial neural networks using advanced programmed interfaces. In this work, Keras[5] and Tensoflow[4] were used as deep learning libraries. MobileNet [9,16,17] deep learning model is provided ready-made by Keras[5]. TensorFlow[4] which is an interface for expressing machine learning algorithms, is used in sentiment analysis, voice recognition, text summarization, information retrieval etc. used in many computer science. It is a mathematical calculation library used to train and build the model. Keras[5] is a neural network interface and is a software library with Python[18]. It works with TensorFlow[4], which facilitates deep learning. MobileNetV2 [9,16,17] architecture was used to continue training the trained model and to fine-tune the model.

C. Machine Learning

Machine learning, which is a sub-branch of artificial intelligence, is a discipline that provides the ability of systems to learn and develop automatically from data or experiences. Machine learning focuses on the development of computer programs that can access data and use it to learn.

The machine that learns the data in the training data with certain algorithms can then make its own decision. Machine learning is closely related to computational statistics that focus on making predictions using computers. Mathematical optimization study offers methods, theory and application areas in the field of machine learning. There are multiple ways you can teach data to the machine depending on your purpose in machine learning. These can be classified as "supervised learning", "unsupervised learning" and "reinforcement learning"[10,12]. In this study, supervised learning was utilized to train the deep learning model.

D. Computer Vision

Computer vision seeks to understand and automate the tasks of the human visual system. Computer vision tasks include methods for obtaining, processing, analyzing and understanding digital images, for example to generate numerical or symbolic information in decision forms, and extracting high-dimensional data from the real world. It shares other topics such as artificial intelligence and computer vision, image recognition and learning techniques. As a result, computer vision is sometimes seen as a part of the field of artificial intelligence or computer science in general [11].

III. SOFTWARE METHODS

In this study, Jupyter Notebook [19] was used as a machine learning implemented in Python[18]. OpenCV [3] was used as an image processing library. Tensorflow[4] and Keras [5] were used as deep learning techniques.

A. Jupyter Notebook

Jupyter Notebook [19] is a machine learning project and implemented in Python language [18]. It is an open source program that provides an interactive environment for various programming languages.

B. TensorFlow

TensorFlow [20] is deep learning software that uses data flow charts. It has an open source software library for numerical calculations. Mathematical operations are represented by their nodes in the graphs, while multi-dimensional data arrays are shown with graphical edges in TensorFlow. Since it has a flexible architecture, the codes written can run on desktop, server or mobile devices[14,15,21].

C. Keras

Keras [5] is a deep learning library for Python [18] that allows you to easily create and train a deep learning model thanks to the many functional functions it contains. It has been developed to enable fast and easy application of deep learning models for research and development. It is compatible with Tensorflow [20], Theano [22] and CNTK [23] libraries.

IV. RESULTS AND DISCUSSION

In this work, the Covid-19 mask detector was implemented with computer vision and deep learning. Deep learning based mask detector was tested on real-time video and image images. Fig. 1 shows the project structure on Jupyter Notebook folder. The Jupyter Notebook folder structure is explained below:

- Dataset: The data set of the project consists of images masked and without mask.
- Example: There are pictures used in the mask detection tests from the image.
- Train Mask: The model is trained with the training process with the visuals in the data set.
- Video Mask Detection: The trained model is tested with the video project.
- Image Mask Detection: The trained model is tested for mask detection over the image.

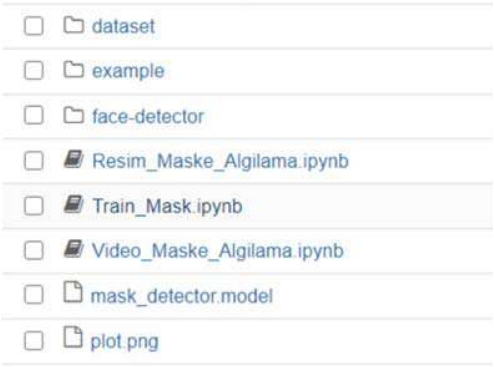


Fig.1. Jupyter Notebook folder, project structure

A. Creating a Dataset

Deep learning model used in this study was trained by supervised learning method, which is a machine learning type. A dataset consisting of masked and unmasked images was created for the training and testing phase. Fig. 2 shows some examples of dataset of people wearing masks. In Fig. 3, some examples of dataset consisting of people who do not wear masks are shown.

Fig. 2. Dataset of people wearing masks

Fig. 3. Dataset of people who do not wear masks

B. Training of the deep learning model (CNN)

The second phase is the training part of the dataset. After the necessary libraries are imported in the Train_Mask project folder, images are taken from the dataset and transferred to a list and arranged. After the data is prepared and edited, it is loaded into the CNN model and the model is ready to train. CNN model is trained with the train dataset and its weight parameters are optimized. As can be seen from Fig. 4, after the training was completed, 99% accuracy was determined. Fig. 5 shows the accuracy and loss curves of the CNN model during training process. It was observed that the loss of education was lower and the accuracy rate was higher as can be seen from the graph of the training process.

```
[INFO] evaluating network...
              precision    recall  f1-score   support

     maskeli       1.00      0.97      0.99        34
    maskesiz       0.97      1.00      0.99        38

    accuracy                           0.99        72
   macro avg       0.99      0.99      0.99        72
weighted avg       0.99      0.99      0.99        72

[INFO] saving mask detector model...
```

Fig. 4. Training result of CNN model

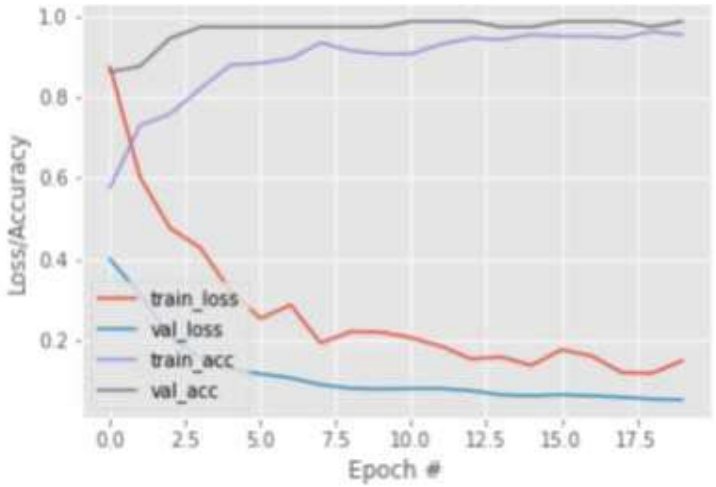


Fig. 5. Accuracy and loss curves of CNN model

C. Mask detection on the image

The trained CNN model has been tested to perform mask detection on human faces in test images. First, the face region was estimated from the image, and then the mask was estimated

thanks to the proposed deep learning model. As a result, the borders of the face region were drawn using OpenCV on the screen. The mask detector displays a green frame if the mask is worn, and displays "there is a mask" ("maske var" in Turkish), if the mask is not worn, it displays a red frame and shows "no mask" ("maske yok" in Turkish) on the screen. Fig. 6 shows the results of the mask detection based on CNN model for images with people wearing masks. In Fig. 7, test results for images with people without a mask are shown. As can be seen from the results in both figures, the proposed mask detector successfully detected the mask on the images.

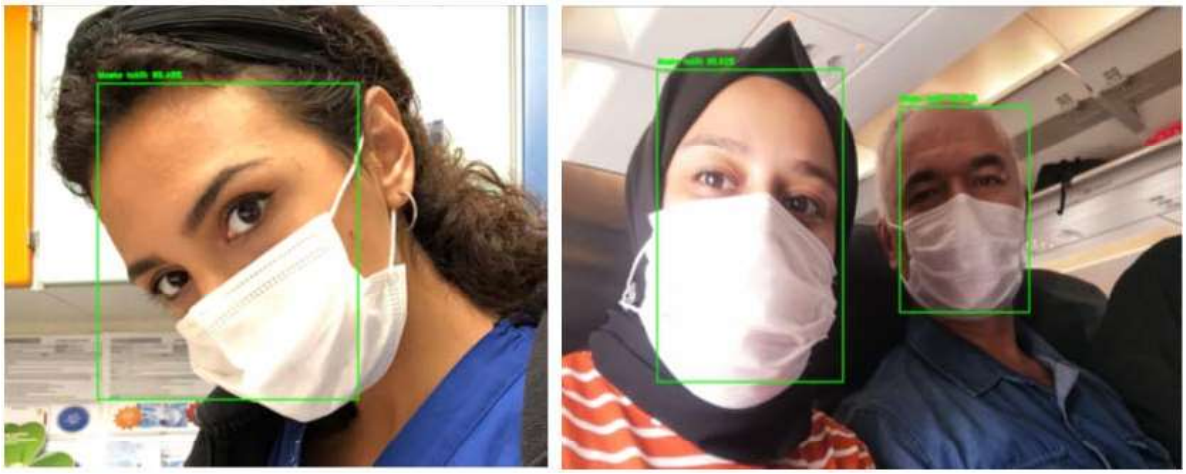


Fig. 6. Mask detection on the images (mask on)

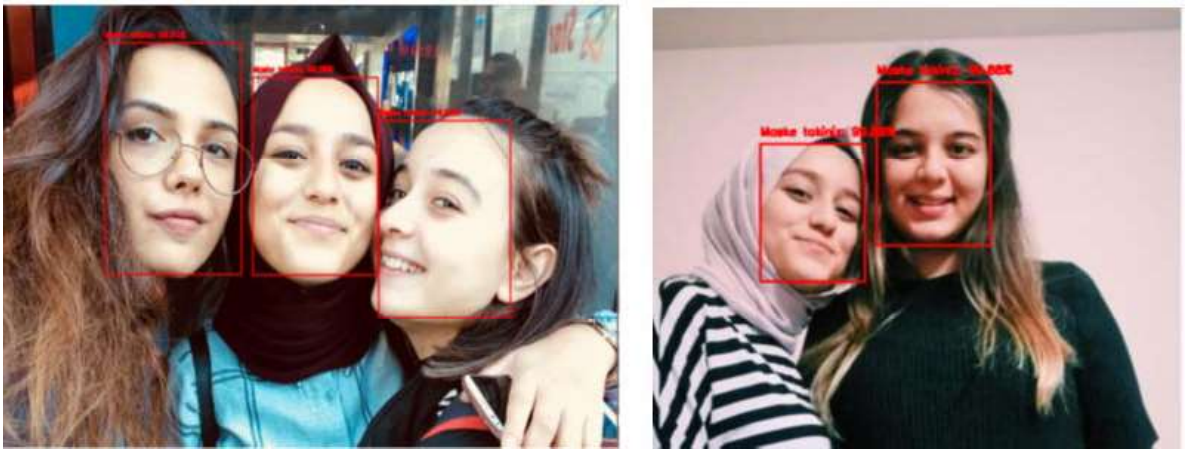
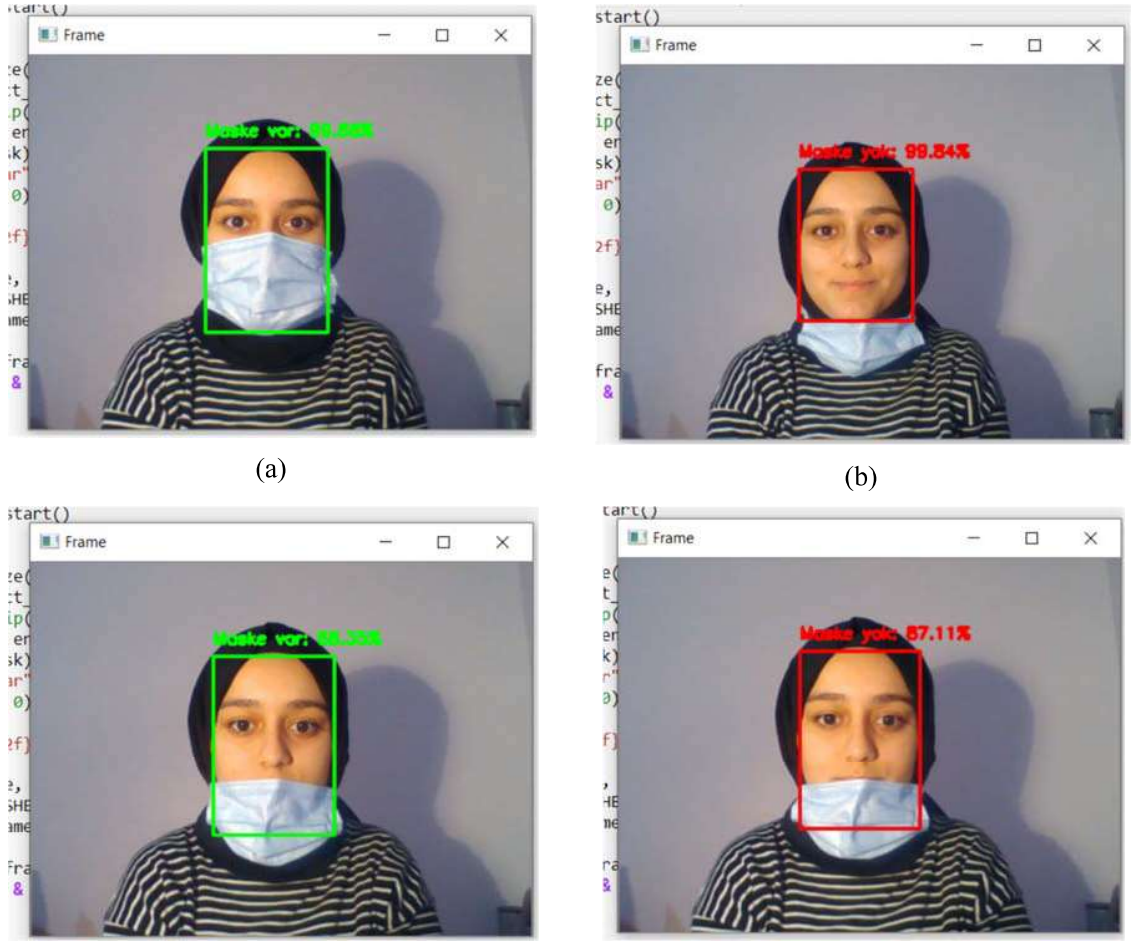


Fig. 7. Mask detection on the images (mask off)

D. Mask Detection on Video

The second test of the trained CNN model was carried out on the video. You can access a test video from the https://www.youtube.com/watch?v=hbhWHSAmnCA&ab_channel=BetülYılmaz link. In Fig. 8, the results of the mask detection on video are shown.



(a) (b)

(c) (d)

Fig. 8. Mask detection results on video

Looking at the results, it is understood that the proposed system detected the mask with 99.88% accuracy when the person wears the mask properly in the video as seen in Fig. 8a. When the person does not wear the mask properly, it can be seen from Fig. 8b that the proposed system detects that there is no mask with an accuracy of 99.84%. As in Fig. 8c, it is seen that the rate of wearing a mask by the system is 68.35% when the mask is not fully worn. As can be seen in Fig.8d, the mask is only in the mouth area and the rate of mask absence is 87.11%.

V. CONCLUSION

In this study, a mask detector based on deep learning model has been proposed to detect whether people are wearing the mask correctly. The mask was detected by taking video from the

computer camera and using the existing photo images. We used Jupyter Notebook, OpenCV, Tensorflow, and Keras libraries/methods. The proposed system detects the mask in the face images on the picture or video and gives a warning to the screen as "there is a mask" or "there is no mask" together with the classification accuracy rates.

The project is open to development and can be used by integrating with other systems. In the next step of this work, a camera placed at the entrance of any indoor environment can be used to develop a system that allows access to people with a mask at the entrance and does not allow access to those who do not have a mask. In addition, it can be integrated with security cameras, it can be instantly checked whether there is a mask on people's faces in a closed environment, and if the mask is removed, it can be detected and warned. In addition, it can be designed and used as an application on Android / iOS platforms.

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