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Prediction of COVID'19 Through Multiple Organ Analysis Using IoT Devices and Machine Learning Techniques

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Abstract *- COVID-19 is a recently found coronavirus that tends to cause serious infections. It falls under the stage of mild to moderate does not require hospitalization. If the patient's immune system is strong, they can recover on their own with proper nutrition and treatment. This disease has an impact on the human hormone system. A computer-aided diagnosis is needed to predict COVID-19. The blood volume must be determined in order to predict the disease's severity level. The blood vessels or capillaries provide oxygen to the Red Blood Cells (RBCs), and the RBCs, in turn, provide oxygen to the internal organs. The wall and lining of the alveolus and capillaries are damaged and thickened by COVID-19. The oxygen transfer by RBCs becomes extremely difficult as the wall thickens. The body has trouble breathing as a result of this condition. This is the most common cause of respiratory problems in COVID-19 patients. Respiratory issues cause problems on the retina, triggering haemorrhages. It also has an impact on the human digestive tract and taste buds. This has been confirmed in medical studies. As a result, of diagnosis, the proposed IoT-based method needs microscopic blood smear images, CT images of the digestive tract, X-ray images of the chest, and fundus images of the eye. Hence, machine learning techniques have been used to process these images and yield more accurate results in diagnosis.*

Keywords: *Segmentation, classification, feature extraction, X-ray, retina, fundus, lungs, chest, tongue.*

I. INTRODUCTION

In China, Wuhan had suffered due to the new virus spread. This virus spread is identified initially through human saliva [1]. It is named Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2). Some people recover from the disease based on their immunity to the body. The following symptoms are identified as the reason for COVID-19. High fever, severe throat pain, cough, breathing difficulty, body pain, joint pain, vomiting, diarrhea, rash on the skin, discolored finger and toes, and headache. This viral spread occurred through cough, sneezing, droplet inhalation, or direct touch through human-to-human. The objects which are touched by COVID-19 positive person are warmed by anybody within three days, and there are chances for this viral spread [2]. The doctors who touch and treat the patients should be more careful and advised to wear safety measures. The person who cleans or handles the toilets and other things used by the COVID-19 patients is having the chance of this spread. Hence, the environment used by the COVID-19 patients should be sanitized. They are advised to cover with surgical masks, spectacles, or face shields [3]. The reason for the spread of COVID-19 is the Angiotensin-Converting Enzyme 2 (ACE2) that allows the SARS-CoV-2 inside the human blood cells. Hence, oropharyngeal and nasopharyngeal swabs are collected and tested. The health workers and technicians who handle this swab are having chances for this transmission.

Saliva fluid contains 94-99% of water with 0.5% organic molecules and 0.2% inorganic molecules. It helps with food digestion and prevents pathogenic growth. It also protects the respiratory tract and digestive tract from other microbial growth. There are 700 microbes growing in the saliva. These microbes are the reason for oral and other diseases. Hyposalivation causes respiratory infection and affects the lungs. Initially, the SARS-COV-2 virus is found in saliva before the lesions occur in the lungs. It affects the salivary glands and causes inflammation, pain, and discomfort. The saliva droplets are a combination of water and microorganism. The droplet's size is bigger than $60\mu m$ settle in the air, but less risk, when another human is closer to them. The droplets size less than $60\mu m$ spread among the people who are within one meter. These spreads occur while speaking, breathing, sneeze, cough, and vomit, etc. The transmission of these droplets varies from person to person based on the intensity of the cough; for each cough, 3000 droplets and when the person sneezes, where 40,000 droplets are produced [1]. This infected droplet may enter through eyes, noses, and lungs that are hosted by a COVID-19 positive person. COVID-19 will not spread through sexual contact. Even a pregnant

COVID-19 positive mother delivered a negative COVID-19 child. Because the newborn blood has immunoglobulin M(IgM) [4, 5], this antibody fights against the SARS virus. There is a possibility of transmission of SARS from animals such as ducks, dogs, cats, and chickens to humans. A German shepherded dog died after two days the owner was in quarantine [6]. Hence, the human must protect themselves from animals.

COVID'19 affects the respiratory system of the human being [7, 8]. The spread of the disease is through different modes. At the later stage, it is expressed through the external symptom. But there is a way to predict it early before it appears externally. The COVID-19 virus first occurs in the human blood. Hence, there is a need to consider the blood volume analysis of the human being since it is the major consideration for diagnosis [9].

The blood volume of the human being contains three components, namely: WBC, RBC, and platelets [10]. These components are getting affected due to COVID-19. The proposed system considers the blood volume and other organs that impact the human body for early prediction and treatment. The purpose of the proposed system is to produce compact IoT-based devices for COVID-19 disease analysis through human blood volume [10], digestive tract [11], lungs, retina [12], the vibration of voice [13], and tongue [14].

The motivation of the research is to address the need of physicians and help the community by prediction and diagnosis through accurate analysis. The following are the objectives of the proposed research work.

i. Develop an android application for diagnosis of COVID-19 by multiple organ analysis.
ii. Obtain the input images such as the fundus images of the retina, the X-ray images of the lungs, CT images of the digestive tract, RBC, WBC, and Platelet images, culture test images of the throat, and taste buds nerves image of the tongue.
iii. Segment and classify the region of interest from the input images.
iv. Compare the extracted features of the segmented images with the expert's annotated parameters.
v. Analyze the resultant information and grade the severity of the disease.

II. COVID-19 DIAGNOSIS

People who have been exposed to COVID-19 have developed symptoms that must be tested in a clinic to assess the disease status using different tests. When a patient is diagnosed with a greater risk of infection, they must seek medical attention. SARS-CoV-2 spreads in two ways: direct contact: saliva droplet and human-to-human transmission; indirect contact: contaminated objects and airborne infirmity. The viruses are transmitted to humans via the mouth or nose, where the tiny particles are created by coughing, sneezing, speaking, singing, or inhaling profoundly. These droplets range in size from large to small. In the proposed system, the COVID-19 prediction is based on image processing techniques to analyze the following organs, as shown in Figure 1.

A. Tongue

The saliva is collected from the swabs, cough and spitting out, and duct from the salivary gland. Finally, the patients are classified as suspected or confirmed COVID-19. It is a respiratory infectious disease that affects the lungs of the patients, and it is expressed through the external symptoms of saliva in the tongue. The saliva settled in the tongue as a mild particle, and its color and features vary from the normal human being.

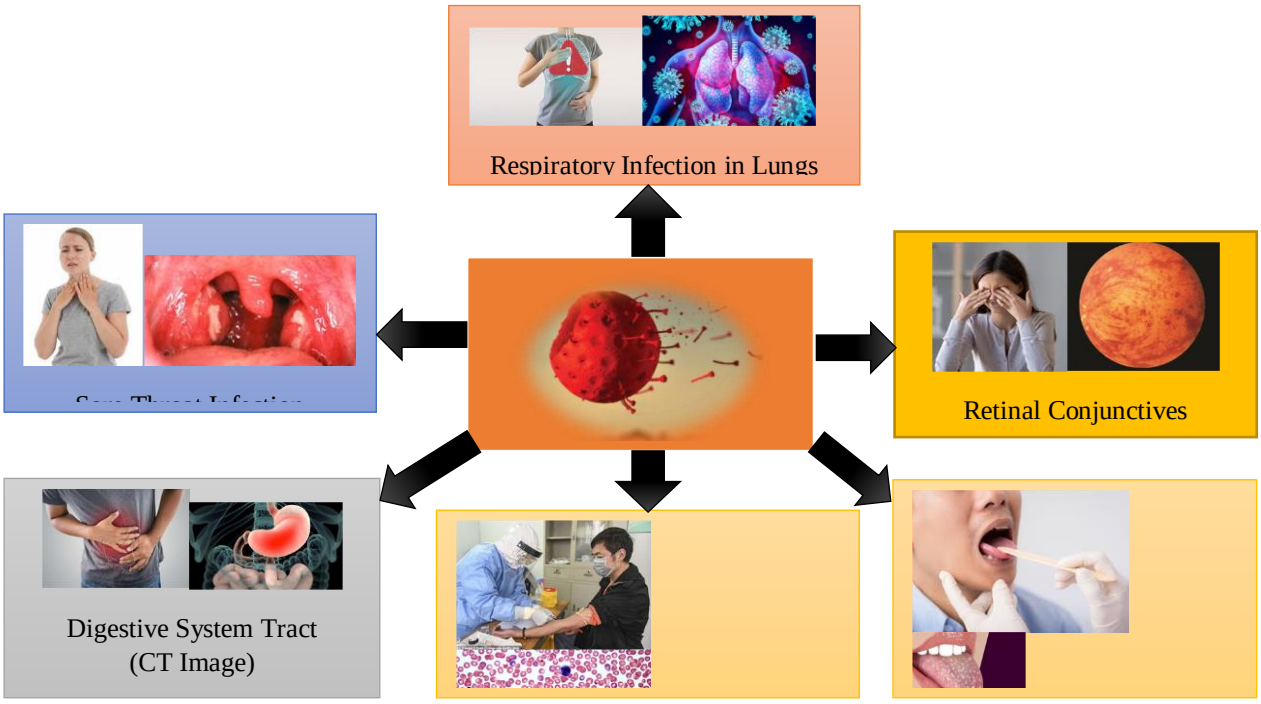

Figure 1 COVID-19 Prediction based on image processing system.

The SARS CoV-2 virus has been related to bleeding and inflammation in oral soft tissues of a widespread increase in secretion associated with elevated levels of cytokines and interleukins. For a number of reasons, COVID-19 has been closely connected to dry mouth. The most normal case is when a person wears a mask and inhales through their mouth. Mouth breathing can dehydrate the oral tissue, specifically if people don't drink enough water. Another genetic variant proposed by the research is the viral entry into the salivary glands, which are widespread in the ACE2 receptors. COVID-19 has been linked to vascularity abnormalities caused by viral blood vessel destruction. The virus uses the ACE2 receptor to gain access into the endothelial cells that line blood vessels, weakening them and inducing oxygen deprivation. As shown in Figure 2, damage to vessels can cause tissue necrosis and oral ulcerations. Steadily increasing inflammation and tissue impairment cause ulceration and tissue damage.

Figure 2 (a) Ulceration tongue of COVID-19 patient, (b) Segmented tongue image for diagnosis.

B. Retina

The ophthalmologist, Dr. Li Wenliang in Wuhan, China, was one of the first people to recognize the outbreak of COVID-19 in late 2019. In a case, it causes conjunctive and itchiness in the eye. The same person was tested by a swap with negative, had SRS-COV-2 viral spread in his eye [2]. Hence, the infection spread through tears and conjunctiva secretion. Doctors estimated that 1 percent to 3 percent of people with COVID-19 could experience conjunctivitis, also identified as pinkeye, based on the most recent research. The virus attacks the conjunctiva, a tissue that guards the white portion of the eye against the inside of the eyelids. Pinkeye is also known as conjunctivitis, and that has been considered a significant symptom of COVID-19 inflammation.

While COVID-19 has been associated with conjunctivitis, a chronic condition and persistent vision loss from COVID-19 are yet to be reported. Poor respiration and respiratory failure cause serious damage to metabolically active tissues such as the optic nerve or retina if an individual has respiratory distress for a long period of time, but this case is yet to be recorded. The possibility of infection spreading by contaminated ocular tissue or fluid has been reviewed. In a limited minority of cases, a novel coronavirus was discovered in tear samples. COVID-19 is transmitted due to the existence of viral particles, but the risk is minimal. However, the risk of transmission and the clinical relevance is unknown at the moment, yet further investigation is warranted. The incidence of COVID-19 relates specifically to the diameter of retinal veins. Thus assessing retinal veins might have been a component of the diagnosis of the disease.

C. Blood Components

In the bloodstream of the patients, there are 27 proteins, the volume of which differs based on the intensity of the disease.

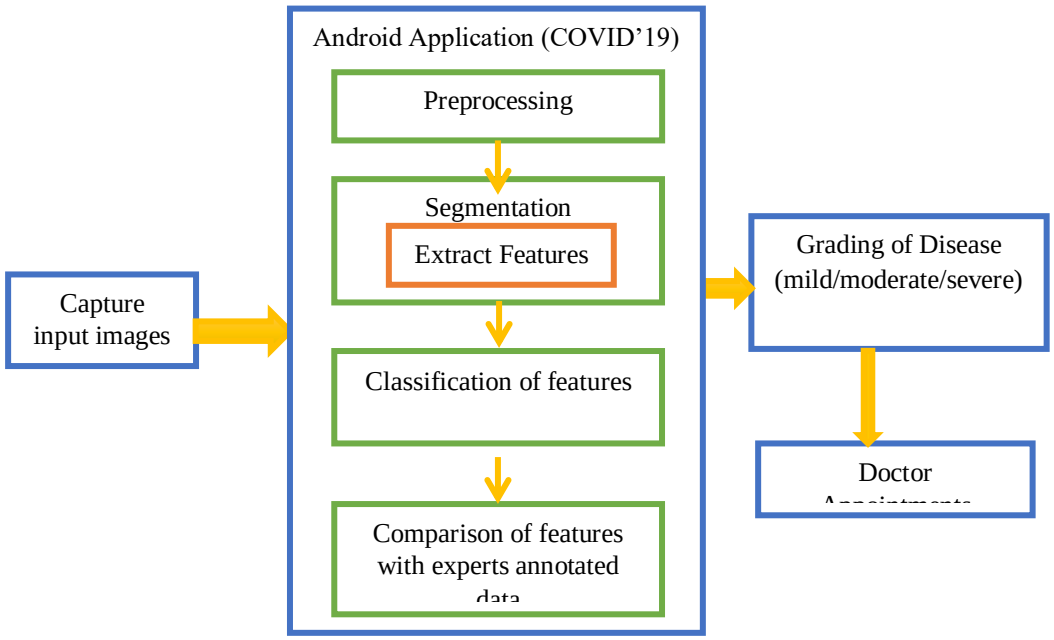

Figure 3 The proposed architecture for prediction of COVID'19 diagnosis.

Erythrocytes are red blood cells that carry the iron-rich protein hemoglobin, which transports oxygen across the body. Due to a shortage of oxygen, the loss of erythrocytes may cause serious damage to brain neurons, blood vessels, and vital organs. Artificial ventilation is ineffective in such cases since no one is transporting the oxygen inside the human body. As per the report, administering erythrocyte mass and vitamin B12 is an effective treatment for such patients. According to the report, the body's natural response to the SARS-COV-2 virus is the destruction of red blood cells, which advances gradually. An increase in WBC and decrease in hemoglobin, lymphocyte, eosinophil, albumin count are the symptoms of COVID'19 [3].

By consuming iron, the patient learns more about the pathology. This arises because the saliva contains hemoglobin that has been released from erythrocytes in the bloodstream. The virus enters into the epithelium and increases exponentially. Then it is absorbed into the bloodstream and affects the internal epithelial cells such as the gastrointestinal system, lungs, and respiratory system, as well as erythrocytes.

D. Cardiovascular System

The ground-glass opacity in the lungs is the symptom of COVID-19. It is triggered by SARS-CoV-2. The COVID-19 patients with pre-existing cardiovascular disease are related to worse outcomes and a higher mortality rate.

Coronaviruses are composed of structural proteins that form an enveloped spherical particle. Finally, the structural proteins and genomic RNA are transformed into different infected cells.

III. MATERIALS

The sample images required to conduct the experimental analysis among different age group populations are given in Table 1. The table gives the input images and their dimensions for image registration. These test images are collected from the hospitals, which are uploaded through android device interfaces for diagnosis.

Table 1 Image details considered for experimental analysis.

#	Type of Images	Device Input	No. of Samples
1	Fundus Image	Fundus Camera	50
2	Lung	CT Scanner	10
3	Tong	Camera	50
4	Throat	X-ray	25
5	Digestive Tract	CT Scanner	10
6	Blood volume	Blood Test	30

The above said samples are considered as the basic requirement to successfully implement the project. The cost of the test is greatly reduced through the proposed technique compared with the PCR test. For the successful implementation of the proposed system, initially, 7 to 15 positive COVID'19 cases are considered. This reduces false positive and false negative cases of errors. The same experimental setups are used for clinical purposes to test more COVID'19 positive cases. Hence it is economically best, and rural people also get benefited from utilizing the project.

IV. METHODOLOGIES

The proposed computer-aided remote access system increases the opportunity for a huge number of beneficiaries all around the world. The following are the steps involved in the proposed diagnosis system and are depicted in Figure 3. The physicians access the COVID'19 diagnosis system through android application interfaces. It comprises the following internal processes.

A. Preprocessing

There are variations in the image captured from different devices due to lighting from the camera. The light may change the color of the captured images. Hence there is a need for pre-processing to improve the intensity of the captured images and remove the noise present in the image.

B. Segmentation

The deep neural network algorithms increase the possibility of marking all the pixels that are infected by its more hidden layers characteristics. The following test cases are considered for diagnosis.

CASE 1: In the COVID-19 patient, the taste bud nerves of the tongue are getting damaged [15]. These nerves are present on the upper side of the tongue. COVID-19 causes lymph and leaking of blood from these nerves. Due to this issue, the dimensions of the nerves are changed. Hence, the structures of these nerves are considered for diagnosis.

CASE 2: Due to COVID-19, the liver tissue gets damaged. This affects the gastrointestinal tract, and it is reflected through the elevated liver enzymes. The thickness of the jejunum and the ileum was probably infectious due to COVID-19 [16].

CASE 3: COVID-19 damages the blood vessels of the retina and settles the particle as hemorrhages inside the eye [19]. Hence, the patient's eyes will be filled with red color clots and other depigmentation. Also, it leads to macular neovascularization and settlement of exudates in the eye [18].

CASE 4: The lungs get congested, and the lesion appears as mixed ground-glass opacities and consolidations or pure ground-glass opacities in the positive cases of chest X-ray images [17, 24, 25].

CASE 5: The tonsillitis gland gets enlarged and infected through COVID'19 [20, 21]. The enlargement of the gland is needed to be analyzed with the annotated data.

CASE 6: COVID'19 virus occurs in the blood and affects the count of blood components [22]. The blood components of WBC, RBC, and platelets are identified by their color and dimension.

All the above six features of humans are considered for COVID-19 diagnosis. Thus there is a need for segmentation of the above features for the classification of the disease.

C. Classification

The extracted infected region pixels are clustered together on their similarity with the neighborhood pixels. Based on the number of clusters present in the image, and dimensions of each cluster are measured and considered for the identification of the severity level of the disease. The disease will be graded as mild, moderate, or severe. Based on the severity, the patients are advised to get an appointment with a nearby hospital for treatment. The stepwise implementation of the proposed system is given in Table 2.

V. DISCUSSIONS

The application is trained through the publically available data also set through the direct interactions of the physicians. The following are the benefits of the proposed system.

i. Deploy and the android application to diagnose COVID-19 from remote places.
ii. Enable the application usage to reach the rural population and others without any training.
iii. Diagnose COVID-19 within 30 minutes.
iv. Reduce a load of physicians in examining the patients during critical times and reduce the risk of contamination.
v. Reduce the cost of exporting experimental kits and other instruments from neighboring countries.

The state of the art of the proposed research work is as follows:

i. The aim of the research is to analyze the symptoms of COVID-19 at an early stage through different modes of external examination.
ii. IoT based device helps the physicians who have involved in conducting the COVID-19 preliminary test for different people across the world.
iii. Predict the COVID-19 positive or negative cases accurately by testing multiple organs within a short period of time.

At present, private hospitals are not allowed to conduct COVID-19 medical tests on their own. These hospitals are not equipped with sufficient devices to do the test. Hence, these private hospitals are considering only the parameters such as body temperature, blood pressure, breathing difficulty, fever, cold, cough, and joint pain symptoms that are occurred altogether to identify the patients. In tool booths and security tunnels in government or private organizations, only a temperature sensor is used to identify the symptom of COVID-19 patients.

The proposed system allows physicians to conduct an image-based examination through the IoT-based android mobile device. In this system, the fundus images of the retina, the X-ray images of the lungs, CT images of the digestive tract, images of RBC, WBC, platelet, and culture test images of the throat are considered as input. These images must be uploaded through an android application from a mobile device. All the input images are preprocessed through the Contrast Limited Adaptive Histogram Equalization algorithm (CLAHE), and it removes the noise present in the images. The resolutions of the input images are enhanced through the step-by-step process. The background images are removed by applying the mask. The region of interest is identified and segmented through the deep learning algorithm. The clustering techniques are used to cluster similar features. The segmented portions of the malignant particle are analyzed and compared with the expert's annotated data. Based on the percentage of deviations in the resultant image from the normal image, the severity level of the virus attack is graded. COVID-19 is graded finally as mild, moderate, or severe based on considering the abnormality observed by the algorithm. The proposed system considers the multiple organs of the human being. The other existing systems considered the single external symptoms for diagnosis.

Table 2 Stepwise implementation of the proposed system.

Steps	Phases of Work	Descriptions
1	Image Registration & preprocessing	➢ Collect the input images such as the fundus images of the retina, X-ray images of the lung, CT images of the digestive tract, images of RBC, WBC, Platelet, and the culture test images of the throat. ➢ Develop the preprocessing algorithms to remove the noise and enhance the images captured under the different fields of view. ➢ Store the images in the cloud.
2	Android application	➢ Create a GUI for diagnosing COVID-19. ➢ Android application is used to classify the malignant regions based on the expert's annotated data.
3	Classification algorithm	➢ Classify the lesions present in the image using the image classification algorithm.
4	Segmentation algorithm	➢ Segment the region of interest using a machine learning algorithm for disease classification and grading.

VI. SOCIAL RELEVANCE AND USEFULNESS OF THE PROPOSED SYSTEM TO THE STATE AND COUNTRY

COVID-19 affects all age group populations across the world. This pandemic effect created fear in the community. It has been confirmed as of 19th June 2021, and there are 178,118,597 confirmed cases across the countries and 3,864,180 deaths [26]. In congested places, there are more chances for viral spread, and it is increasing day by day. Everywhere, most people need to come out from their homes to public places to meet their daily needs. The crowd is regulated by the volunteers and police personals through social distancing. All are advised to wear masks and sanitize very often. With these precautionary measures, the body temperature of the crowd is monitor through temperature sensors. If there is a symptom of more than body temperature with cold and cough, those people are isolated and advised to go for a COVID-19 PCR test. This system is improved by incorporating additional features of examining multiple organs of the patients through an IoT-enabled device. The facility provides the advanced mechanism for the early prediction of COVID-19 patients with the help of an IoT-based system. Hence, the infected person is identified and isolated early for treatment. While considering the cost of the PCR test, the proposed system is cost-efficient and accurate enough to identify COVID-19 within few minutes.

VII. Conclusion

The Covid-19 disease is anticipated to transmit mainly through close contact from human to human. Reports say that this virus transmits easily as influenza and not as efficiently as measles, which means it spreads from human to human without ease. Scientists and several companies around the globe are working vibrantly on potential treatments and vaccines. Although none has turned up with a solution for this pandemic, some supportive measures are recommended to improve the outcome. Educational awareness and intensive care on people definitely improve the disease outcomes. Therefore a precise knowledge of transmission, and the best possible ways to manage along with preventive measures, is essential. Moreover, clear-cut surveillance and diligence remain a principal necessity to physicians and public health authorities as well. In the present article, a multi-organ diagnosis system is a unique method of finding out the pathological conditions that occur among the patients to discriminate COVID-19. Extracting the reliable features of the multiple organs assists the physicians in the diagnosis of patients with COVID-19. Diagnosis may be delayed due to various problems in accessing the COVID-19 kits and other examinations. The proposed system enables every user to test their health conditions that they are infected with COVID-19 and know the status as positive or negative. The sign and symptoms of the multiple organ diagnosis through the android application help the person to get early treatment. Hence, a lot of people's life will be saved, and the death rate can be minimized through the proposed system.

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