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# A Simulated Proposed Model for Black Fungus Detection by using Fuzzy Logic

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## ABSTRACT

Recently, some diseases and health problems have appeared that threaten human health. There is a global interest for knowing and preventing spread of pandemic diseases. At the top of importance after COVID-19 is now its different consequences such as Black Fungus that represents an unknown disease for the common. Black Fungus related to people who has low immunity. This research presents an overview of its characteristics, symptoms, and shape that will be manifested in the patient's body. Unfortunately, the shape of Black Fungus in body can be observed interiorly or exteriorly. The aim and scope of this research is to decompose the complexity of Black Fungus detection into five phases that covers all the forms of Black Fungus. Furthermore, a simulated fuzzy model of Black Fungus detection is presented, with the dependency on a proposed facial disease detection model. This model can be used to prove the relationship between post-Corona and Black Fungus patients. The proposed model can differentiate between the measure of Black Fungus infection risk and COVID-19 in an accurate way. Finally, this research helps in defeating the spread of side effects that may appear.

## General Terms

Black Fungus, Fuzzy Logic

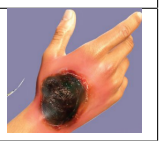
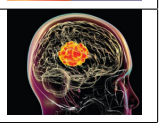
## Keywords

Mucormycosis, Black Fungus, COVID-19, Fuzzy Logic

## 1. INTRODUCTION

The world is afraid of the emergence of a health disaster like COVID-19, which has affected the economy and the death of many people. The learned lesson is that prevention is better than cure. Mucormycosis, previously known as Zygomycosis and publicly known as Black Fungus, is a rare disease caused by fungi [2]. Black Fungus is linked to COVID-19 as it is the most commonly-observed infection in post-COVID-19 stage in India especially in immunocompromised patients [3]. There are challenges in diagnosing and treating Black Fungus [4]. The spread of the possible affected body part based on the five forms poses many difficulties in diagnosis. Furthermore, clinical and radiological signs are not specific posing difficulties in diagnosis [5]. As shown in Table 1, there are 5 major forms of Black Fungus which include Rhino cerebral, cutaneous, disseminated, pulmonary, and gastrointestinal [6].

Table 1.
Forms

| Form | Ratio | Example |
|---|---|---|
| Rhino cerebral | 50% |  |
| Cutaneous | 16% |  |
| Disseminated | 12% |  |
| Pulmonary | 11% |  |
| Gastrointestinal | 11% |  |

The aim and scope of this research is to decompose the complexity of Black Fungus detection into five phases that covers all the forms of Black Fungus.
The phases are:

(1) face diagnosis
(2) skin color change
(3) chest CT scan
(4) brain MRI and
(5) abdominal symptoms and radiograph

The optimal regulation process between phases is unknown, and there is no research regulating it. Fuzzy logic is the science of measuring values concisely. Fuzzy logic can be used to determine the accurate optimal selection. According to what we see from the initial examinations of COVID-19, such as temperature, the Black Fungus examination is carried out in the same frame. But the stages can be divided into two stages. The first relates to what is apparent, such as the face and hands. The second concerns what is hidden, such as MRI and chest CT. This paper focuses on the first stage. Microbiological diagnosis of Black Fungus is out of scope of this paper.
The rest of the paper is organized of background and related work, proposed fuzzy model, conclusion, and future work.

## 2. RELATED WORKS

### 2.1 Mucormycosis

Mucormycosis, previously known as Zygomycosis and publicly known as Black Fungus, is a rare disease caused by a group of molds called mucormycetes [2]. Mucormycetes live in the environment mostly in decaying organic matter and soil [7]. There are 5 major forms of Black Fungus which include [6]: rhino cerebral, cutaneous, disseminated, pulmonary and gastrointestinal. These Black Fungus forms generally occur in immunocompromised people who lack ability to fight sickness and germs [8]. Dataset of the spread of Black Fungus in states of India is available [9], as shown in Figure 1.

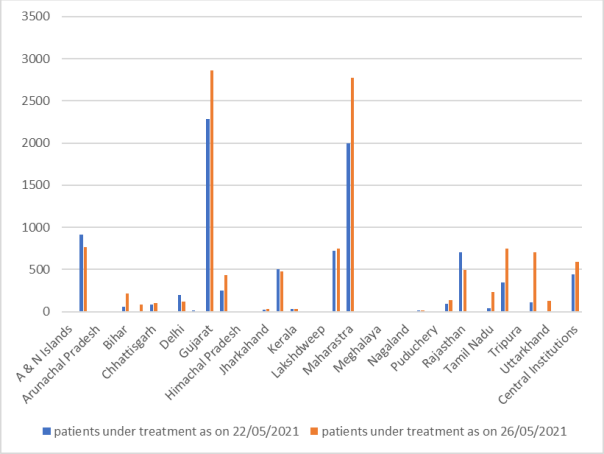



Fig. 1. Dataset of Black fungus spread in India

### 2.2 From Face Recognition to Facial Diagnosis

Face detection and recognition in real-time has been advanced [10]. Quick face detection using a boosted cascade of simple features is a seminal work [11]. A face detection survey categorizes face detection algorithms into 3 schemes [12]:

(1) templates gained by boosting,
(2) deep neural networks, and
(3) face description by its parts.

Table 2 summarizes state-of-the-art in facial diagnosis.
A pipeline of Ada-Boost, Local Binary Pattern (LBP), Haar features and Principal Component Analysis (PCA) is proposed with 99.2% recognition true-positive rate [10]. Introducing deep learning such as Convolutional Neural Network (CNN) let the speed and accuracy of face recognition to make great leaps [21]. Detecting faces observable symptoms using a hybridization of computer vision and semi-supervised anomaly detection is proposed [22]. Recently, deep transfer learning is employed to transfer knowledge gained from pre-trained face recognition deep neural network to achieve diagnosis of facial diseases [23].

Table 2.
Diagnosis

| Authors | Disease | Dataset size |
|---|---|---|
| [13] | Down syndrome | 48 |
| [14] | Down syndrome | 130 |
| [15] | Acromegaly | 117 |
| [16] | Acromegaly | 1123 |
| [17] | Diabetes Mellitus | 515 |
| [18] | X-linked hypohidrotic ectodermal dysplasia | 1000 |
| [19] | 10 syndromes | 147 |
| [20] | 216 syndromes | 26692 |

### 2.3 Fuzzy Logic

Fuzzy logic is invented by Lotfi Zadeh [24]. Max-Min method also known as Mamdani method. It obtains an output by going through steps of: fuzzy sets formation, applying membership functions, rules composition, and defuzzification [25]. Fuzzy logic can be used in medical diagnosis systems [26]. There is a Matlab toolbox dedicated for fuzzy logic that can be used in medical diagnosis [27].

## 3. PROPOSED METHODOLOGY

The proposed model is to decompose the complexity of Black Fungus detection into five phases that covers all the forms of Black Fungus, as shown in Figure 2. As shown in Figure 3, the phases are: face diagnosis, skin color change, chest CT scan, brain MRI, and abdominal radiograph.

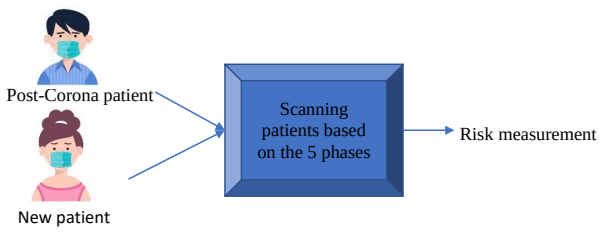



Fig. 2. Proposed Framework

This paper shall focus on the first stage, as shown in Figure 4. First, face image is acquired. Then, it is converted to gray-scale and LAB color space. If face is not detected loop until face is detected. Contrast enhancement is performed. Face diagnosis is performed using SVM classifier.
The first step in building the Fuzzy Inference System (FIS), is to define inputs and output as shown in Figure 5. Inputs are Black fungus signs (BFSigns) and Corona signs (CoronaSigns). Output is Black fungus risk (BFRisk). Second step is to define membership functions (MF). BFSigns input has Gaussian MF, as shown in Figure 6. BFSigns parameters are standard deviation and the mean. Rare has $[0.125, 0]$, Average has $[0.125, 0.5]$, and Obvious

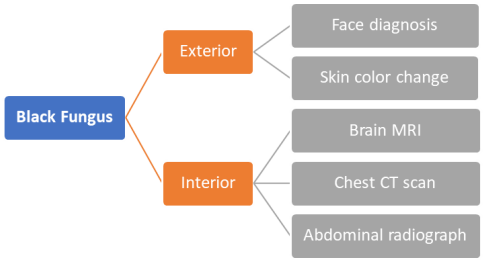



Fig. 3. Black Fungus detection phases

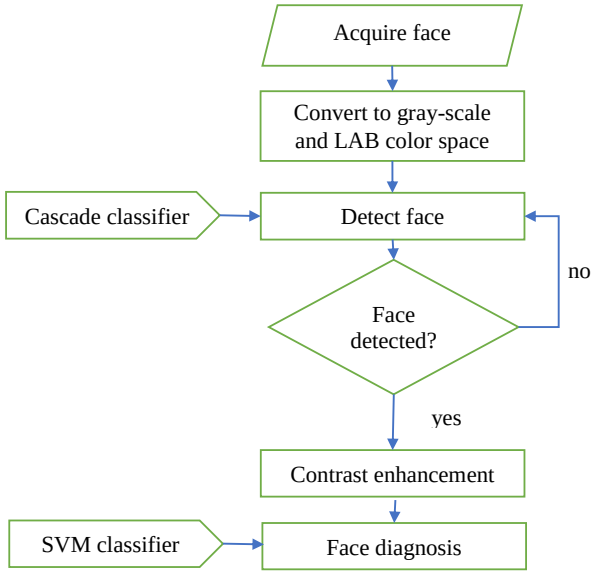



Fig. 4. Flowchart of Phase 1 (Face diagnosis)

has $[0.125, 1]$. CoronaSigns input has trapezoidal MF, as shown in Figure 7. CoronaSigns parameters are: Rare $[-0.9, -0.1, 0.1, 0.3]$, Obvious $[0.6971, 0.9, 1.1, 1.9]$. BFRisk output has triangle MF, as shown in Figure 8. BFRisk parameters are: Low $[0, 0.15, 0.3]$, Average $[0.3, 0.5, 0.7]$, High $[0.7, 0.85, 1]$.

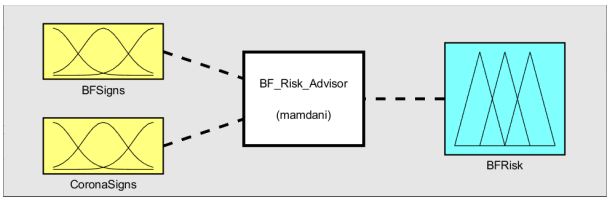



Fig. 5. Fuzzy Inference System (FIS)

Third step is to define rules for FIS:

1.IF BF-Signs are rare
OR Corona-Signs are rare
THEN BF-Risk is low

2.IF BF-Signs are average
THEN BF-Risk is average

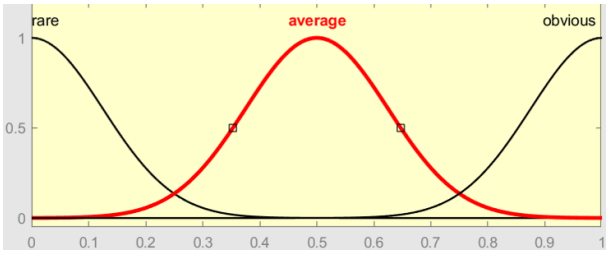



Fig. 6. BFSigns Gaussian MF

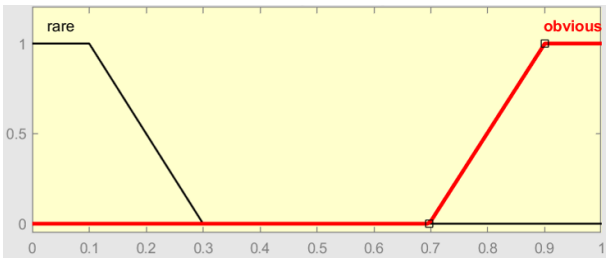



Fig. 7. CoronaSigns Trapezoidal MF

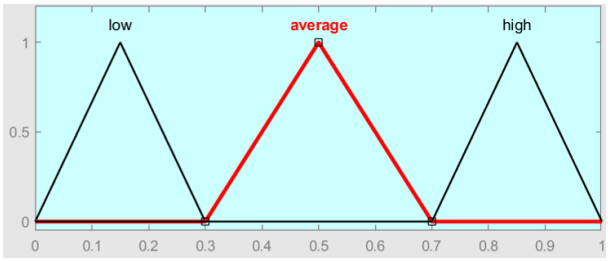



Fig. 8. BFRisk triangle MF

3.IF BF-Signs are obvious
OR Corona-Signs are obvious
THEN BF-Risk is high

It's time to simulate and analyze FIS. As shown in Figure 9, each row corresponds to a rule. The bottom right plot depicts how the output of each rule are combined to make an aggregate output in defuzzified value. The thick red line defines a defuzzified value that corresponds to the output. Now we can slide the red line indexes to change input values to be combined into a new output, as shown in Figure 10. It shows the output at BFSigns =0.243 and CoronaSigns=0.789. Finally, let us show the 3D surface that maps the inputs to the output, as shown in Figure 11.

## 4. CONCLUSION AND FUTURE DIRECTIONS

Objective of proposed model is to measure the risk of Black Fungus infection within its relation to COVID-19. A facial diagnosis is proposed based on the first phase of Black Fungus characteristics. Considering other phases is a possible future direction. Microbiological diagnosis of Black Fungus is another possible future direction.

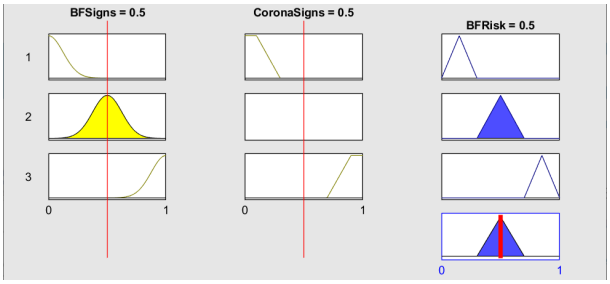



Fig. 9. Simulating the FIS at BFSigns =0.5 and CoronaSigns=0.5

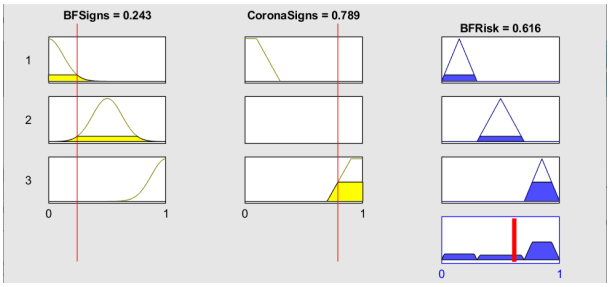



Fig. 10. Simulating the FIS at BFSigns =0.243 and CoronaSigns=0.789

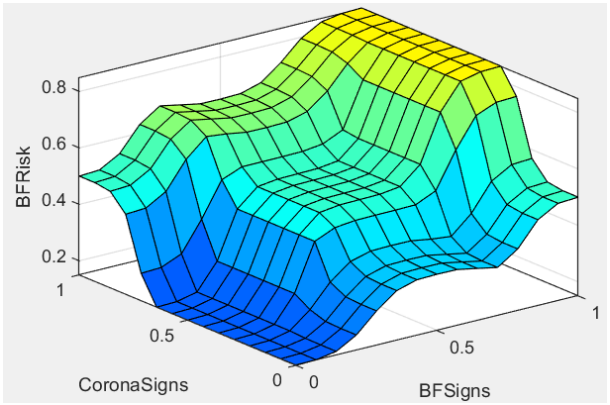



Fig. 11. 3D Surface mapping inputs to output

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