Fuzzy Evaluation of Sore Throat Infection

Olusola Olajide Ajayi
Dept. of Computer Science
Adekunle Ajasin University
Akungba, Nigeria

Adedamola Emmanuella Adetimehin
Dept. of Computer Science
Adekunle Ajasin University
Akungba, Nigeria

Olugbenga Samuel Daso
Health Centre Unit
Adekunle Ajasin University
Akungba, Nigeria

Olufunmilayo Paulina Akinniyi
Health Centre Unit
Adekunle Ajasin University
Akungba, Nigeria

ABSTRACT
Sore throat has been viewed as a minor ailment, hence, less interest has been shown in its evaluation. Sore throats can either be acute or chronic. Various orthodox means exist for attending to sore throat infection. Medically, various means of diagnosis sore throat infection also avails. The predictability power of soft-computing techniques extends their tentacle to bioinformatics and medical computations. Literature search however shows no work on assessment of sore throat. This prompted this study which made use of Fuzzy Inference System approach to evaluate sore throat through the use of simulated data relating to the symptoms associated with Sore throat. The inputs (symptoms) and outputs (diseases) were fed into the MATLAB toolbox, and the fuzzy properties set. Twenty-one rules were formed to determine the end result of the diagnosed sore throat infection which can be a pointer to certain kind of sickness/disease. Fuzzy process on the simulated data shows that sore throat can infer a symptom to a kind of disease. The results proved that Fuzzy Inference System can successfully evaluate sore throat infection.

Keywords
Sore throat, evaluation, fuzzy, inference engine, diagnosis, rule base, simulated, soft-computing, bioinformatics, MATLAB, infection

1. INTRODUCTION
Sore throat is a layman term for Pharyngitis. The layman definition for sore throat is a wound in the throat. Medically, it is defined as an inflammation of the pharynx. Sore throat is a condition characterized by pain or discomfort on swallowing; it may be due to any variety of inflammations of the tonsils, pharynx, or larynx (Farlex Partner Medical Dictionary, 2012). Sore throat is any of various inflammations of the tonsils, pharynx, or larynx characterized by pain in swallowing (The American Heritage Medical Dictionary, 2007).

Almost everyone gets a sore throat at one time or another, although children in childcare or grade school have them more often than adolescents and adults. Sore throats are most common during the raining/harmattan/ season when upper respiratory infections (colds) are more frequent. Sore throats can be either acute or chronic. Acute sore throats are the more common. They appear suddenly and last from three to seven days. A chronic sore throat lasts much longer and is a symptom of an unresolved underlying condition or disease, such as a sinus infection.

Sore throat, also called Pharyngitis, is a painful inflammation of the mucous membrane lining the pharynx. Sore throat is also known as throat pain or irritation of the throat. It is a symptom often caused by an inflammatory process in the pharynx, tonsils or nasopharynx (ESCMID, 2012).

This section surveys past works on the subject of this study. It is systematically outlined thus:

    a.   Causes of Sore Throat

    b.   Symptoms of Sore Throat

    c.   Treatment of Sore Throat

    d.   Diagnosis of Sore Throat

    e.   Treatment of Sore Throat

    f.   Prevention of Sore Throat

    g.   Related works

A. Causes of sore throat
Sore throat has many different causes, and may or may not be accompanied by cold symptoms, fever, or swollen lymph glands. The causes of sore throat can be viral, bacterial, environmental factor, toxins, disease related and trauma/injury.

1) Viral Sore throat
Viruses cause 90-95% of all sore throats. Cold and flu are the main culprits. These viruses cause an inflammation in the throat and occasionally the tonsils. Cold symptoms usually accompany a viral sore throat. These can include a runny nose, cough, congestion, hoarseness and fever. The level of throat pain varies from uncomfortable to excruciating, when it is painful for the patient to eat, breathe, swallow or speak.

Another group of viruses that cause sore throat are the adenoviruses. These may also cause infections of the lungs and ears. In addition to a sore throat, symptoms that accompany an adenovirus infection include cough, runny nose, white bumps on the tonsils and throat, mild diarrhea, vomiting and a rash. It lasts about a week.

The other type of virus that can cause severe throat is the coxsackie virus. It can cause a disease called herpangina. Although, anyone can get herpangina, it is most common in children up to age 10 and is more prevalent during dry season. Herpangina is sometimes called "summer sore throat". Three to six days after being exposed to the virus, an infected person develops a sudden sore throat that is accompanied by a substantial fever usually between 102-104F (38.9-40^{0}C). Tiny graying-white blisters form on the throat and in the mouth. These blisters become small ulcers. It is often severe, interfering with swallowing. Children may become dehydrated if they are reluctant to eat or drink because of the pain. In addition, people with herpangina may vomit, have abdominal pain, and generally feel ill and miserable.

One other common cause of a viral sore throat is mononucleosis. Mononucleosis occurs when the Epstein-Barr infects one specific type of lymphocyte. The infection spreads to the lymphatic system, respiratory system, liver, spleen, and throat. Symptoms appear 30-50 days after exposure.

Mononucleosis, sometimes called the kissing disease, is extremely common. Symptoms are often mild, especially in young children, and are diagnosed as a cold. Since symptoms are more severe in adolescents and adults, more cases are diagnosed as mononucleosis in this age group. One of the main symptoms of mononucleosis is a severe sore throat.

Viral Sore throats are contagious and are passed directly from person to person by coughing and sneezing.

2) Bacterial sore throat
From 5-10% of Sore throats are caused by bacteria. The most common bacterial sore throat results from an infection by group A Streptococcus. This type of infection is commonly called "strep throat". Anyone can get strep throat, but it is most common in school age children.

Pharyngeal gonorrhea, a sexually transmitted bacterial disease, causes a severe sore throat. Gonorrhea in the throat is transmitted by having oral sex with an infected person.

3) Environmental factors and Toxins
Not all sore throats are caused by infection. Post nasal drip can irritate the throat and make it sore. It can be caused by hay fever and other allergies that irritate the sinuses. Environmental and other conditions, such as heavy smoking or breathing second-hand smoke, heavy alcohol consumption, breathing polluted air or chemical fumes, or swallowing substances that burn or scratch the throat can also cause pharyngitis (Sore throat). Dry air, like that in airplanes or from forced hot air furnaces can make the throat sore. People who breathe through their mouths at night because of nasal congestion often get sore throats that improve as the day progresses. Sore throats caused by environmental conditions are not contagious.

4) Trauma/Injury
Any direct injury to the throat or neck area can lead to sore throat. Sometimes, a foreign body (for example, a bone or piece of food) can cause a sore throat. Excessive yelling or screaming can irritate the throat and larynx, also leading to sore throat.

5) Gastroesophageal reflux disease (GERD)
This disease may also cause a sore throat. It is a digestive condition that occurs when stomach acid flows back into the esophagus. This condition caused an array of symptoms of which sore throat is included.

6) Muscle strain
It is possible to have sore throat when the muscles in the throat is strained, such as; at a sporting event, talking loudly or talking for long periods without rest.

7) HIV Infection
A Sore throat and other flu-like symptoms sometimes appear early after someone is infected with HIV. In addition, someone who is HIV positive might have a chronic or recurring sore throat due to a secondary infection, such as a fungal infection called oral thrush and cytomegalovirus (CMV) infection, a common viral infection that can be serious in people with compromised immune system. Both oral thrush and CMV can occur in anyone, but they are more likely to cause a sore throat and any other symptoms in people with weakened immune systems.

8) Tumors
Cancerous tumors of the throat, tongue or voice box (larynx) can cause a sore throat.

B. Symptoms of sore throat
From the consultations made with a health consultant at the Health center of Adekunle Ajasin University, the following were said to be symptoms of sore throat.

- Fever (increase in temperature above 37.5 ^{0}C)
- Pain in the throat (mostly during swallowing)
- Chills and rigor
- Headache
- Tonsils become red and big
- Pus on the tonsils (this occurs only when the sore throat has advanced)

C. Diagnosis of sore throat
It is easy for people to tell if they have a sore throat, but difficult to know what has caused it without laboratory tests. Most sore throats are minor and heal without any complications. A small number of bacterial sore throats do develop into serious diseases. Because of this, it is advisable to see a doctor if a sore throat lasts more than a few days or is accompanied by fever, nausea, or abdominal pain. Diagnosis of a sore throat by a doctor begins with a physical examination of the throat and chest. The doctor will also look for signs of other illness, such as a sinus infection or bronchitis. Since both bacterial and viral sore throats are contagious, the doctor will seek information about whether the patient has been around other people with flu, sore throat, colds, or strep throat. If it appears that the patient may have strep throat, the doctor will do laboratory tests.

If mononucleosis is suspected, the doctor may do a mono spot test to look for antibodies indicating the presence of Epstein-Barr virus. The test is inexpensive, takes only a few minutes, and can be done in a physician's office. An inexpensive blood test can also determine the presence of antibodies to the mononucleosis virus.

1) Differential diagnosis
These are diseases that may have sore throat as one of its symptoms.

- Malaria
- Tonsillitis
- Pharyngeal gonorrhea
- HIV
- Scarlet fever
- Peritonsillar abscess

There are 5 common parameters for differentials:
i. Neutrophils-60%
ii. Lymphocytes- 25-30%
iii. Basophils
iv. Eosinophil
v. Monocyte

Each of the differentials has a value. If the sore throat is caused by virus, the lymphocytes will increase to 70% or more, if it is a bacterial cause, neutrophils will be up to 80% or more. Increase in Basophils and Monocytes may be as a result of allergy. Increase in Eosinophil occurs as a result of the presence of parasites.

2) **Chest Xray**: This is done if it has spread to the lungs

3) **Electrocardiogram (ECG)**: This is to check if it has affected the heart and abnormality in the ECG
4) **Malaria parasite**: This is to check if malaria parasite is present in the blood.
5) **Kidney function**: The test done to check the kidney functions are urinalysis, electrolyte, urea and creatinine test.

D. Treatment of sore throat

Efforts should be made to make an accurate diagnosis before considering treatment. Effective treatment varies depending on the cause of the sore throat. As frustrating as it may be to the patient, viral sore throat is best left to run its cause without any drug treatment. Antibiotics have no effect on a viral sore throat. They do not shorten the length of the illness, nor do they lessen the symptoms.

Sore throat caused by a streptococci or another bacteria must be treated with antibiotics. Penicillin is the preferred medication. Oral penicillin must be taken for 10 days. Patients need to take the entire amount of antibiotic prescribed, even after symptoms of the sore throat improve. Stopping the antibiotic early can lead to a return of the sore throat. Occasionally, a single injection of long-acting penicillin-G is given instead of 10days of oral treatment. These medications generally are not expensive.

Because mononucleosis is caused by virus, there is no specific drug treatment available. Rest, a healthy diet, plenty of fluids, limiting heavy exercise and competitive sports, and treatment of aches with acetaminophen (Datril, Tylenol, Panadol) or ibuprofen (Advil, Nupren, Motrin, Medipren) will help the illness pass. Nearly 90% of mononucleosis infections are mild. The infected person does not normally get the disease again.

In the case of chronic sore throat, it is necessary to treat the underlying disease to heal the sore throat. If a sore throat caused by environmental factors, the aggravating stimulus should be eliminated from the sufferer's environment. Alternative treatment can also be used to cure sore throat. This focuses on easing the symptoms of sore throat using herbs and botanical medicines.

- Aroma-therapists recommend inhaling the fragrances of essential oils and lavender (Lavandula officinalis), thyme (Thymus vulgaris), eucalyptus (Eycalyptus globulus), sage (Salvia officinalis), and sandalwood.

- Ayurvedic practitioners suggest gargling with a mixture of water, salt, and turmeric (Curcuma longa) powder or astringents such as alum, sumac, sage and bayberry (Myrica spp.)

- Herbalists recommend taking osha root (Ligusticum porteri) internally for infection or drinking ginger (Zingiber officanale) or slippery elm (Ulmus fulva) tea for pain.

- Homeopaths may treat sore throats with superdilute solutions Lachesis, Belladoa, Phytolacca, yellow jasmine (Gelsemium), or mercury.

- Nutritional recommendations include zinc lozenges every two hours along with vitamin c with bioflavonoids, vitamin A, and beta-carotene supplements.

E. Prevention of sore throat

There is no way to prevent a sore throat; however, the risk of getting one or passing one on to another person can be minimized by:

- washing hands well and frequently

- avoiding close contact with someone who has a sore throat

- not sharing food and eating utensils with anyone

- not smoking

- staying out of polluted air

2. BACKGROUND TO THE STUDY

Disease Diagnosis is one of the most complicated processes and requires sophisticated techniques to overcome complexities. It is often challenging, because many signs and symptoms are nonspecific. For example, sore throat, by itself, is a sign of many disorders and thus does not tell the healthcare professional what is wrong. Thus differential diagnosis, in which several possible explanations are compared and contrasted, must be performed. This involves the correlation of various pieces of information followed by the recognition and differentiation of patterns. Occasionally the process is made easy by a sign or symptom (or a group of several) that is pathognomonic. Over the years before the advent of Soft computing techniques, disease diagnosis has been done using different methods.

The first recorded examples of medical diagnosis are found in the writings of Imhotep (2630-2611 BC) in ancient Egypt (the Edwin Smith Papyrus). A Babylonian medical textbook, the Diagnostic Handbook written by Esagil-kin-apli (1069-1046 BC), introduced the use of empiricism, logic and rationality in the diagnosis of an illness or disease (Horstmanshoff et al, 2004). Hippocrates was known to make diagnoses by tasting his patients' urine and smelling their sweat. Traditional Chinese Medicine, as described in the Yellow Emperor's Inner Canon or Huangdi Neijing, specified four diagnostic methods: observation, auscultation-olfaction, interrogation, and palpation (Jingfeng, C., 2008).

i. **Observation:** It indicates that doctors directly watch the outward appearance to know a patient's condition. As the exterior and interior corresponds immediately, when the inner organs run wrongly, it will be reflected through skin pallor, tongue, the facial sensory organs and some excrement.
ii. **Auscultation and olfaction:** This is a way for doctors to collect messages through hearing the sound and smelling the odor. This is another reference for diagnosis.
iii. **Interrogation:** This suggests that doctors question the patient and his relatives, to know the symptoms, evolution of the disease and previous treatments.
iv. **Pulse taking and palpation:** refer that doctors noting the pulse condition of patients on the radial artery, and then to know the inner change of symptom. Doctors believe that when the organic function is normal, the pulse, frequency, and intension of pulse will be relatively stable, and when not, variant.

As traditional or orthodox approach use of medical diagnosis consisted of non-specific presentation of the disease, improper management system as well as unavailability of trained and skilled medical experts, it has gone obsolete as it resulted in

considerable errors affecting the patients and often wrong diagnosis leaded to unnatural death. Improper disease diagnosis also possesses a continuous threat to human life due to inaccurate and untimely diagnosis procedures employed by the medical system. In recent years, the ratio of the patients to the doctor number is increasing day to day, so manual diagnosis can no longer be efficient. This is where technology comes into play. Diagnosis through computer-aided design can serve large number of patients in less time and being affordable. Due to inadequate healthcare facilities and scarcity of medical experts, the use of Soft Computing has become popular in disease diagnosis techniques.

Soft computing techniques came into existence to deal effectively with the emerging problems related to medical diagnosis (Bishnupriya Mukherjee, 2016). As medical diagnosis which is totally based on human abilities, uncertain factors, ambiguous symptoms, high accuracy and bulk of medical records, soft computing techniques prove to be a more effective solution.

There are various Soft Computing techniques, which have been proposed for disease diagnosis, some of which are Artificial Neural Network (ANN), Fuzzy Expert System (FES), Particle Swarm Optimization (PSO), Genetic Algorithm etc. These techniques help one to have an idea about the recent trends in disease diagnosis. ANN has the ability to solve complex and non-linearity problems related to diagnosis. Fuzzy Expert System is used to tackle imprecision and uncertainty, while Genetic Algorithm is used to optimize the extracted features and PSO is used for decision-making system to recognize the diseases from the selected features.

3. MOTIVATION FOR THE STUDY
It is inferred from various literature surveys that fuzzy logic has been successfully applied in medical field for diagnosing and monitoring of various diseases but it is rather sad to see that no work has been done on Sore throat. Considering the fact that Sore throat is a symptom of underlying diseases like myocarditis, rheumatic fever, scarlet fever, peritonsillar abscess etc. If not taken care of at its earliest stage can lead to cardiac attack, kidney damage or even death, this work will assist in the correct diagnosis of sore throat and also its evaluation using Fuzzy logic.

4. STATEMENT OF THE PROBLEM
Several soft computing techniques are used for system evaluation and prediction, among which are fuzzy logic, artificial neural network, neuro-fuzzy approach, genetic algorithm and so on. While existing literature proved the use of some of these techniques in disease diagnosis (Adeli et al, 2010– Heart Disease; Djam et al., 2011– Malaria; Bhatla et al, 2012 – Heart disease; Ephzibah et al., 2012- Heart disease; Kumar et al, 2012- Heart disease; Singh et al, 2012- Arthritis disease; Sharma et al, 2013- Malaria and Dengue; Niranjana et al, 2014- Coronary artery disease; Chandra et al, 2014- Hypertension; Akinyokun and Iwasokun, 2015- Heart failure disease; Walia, et al, 2015-Tuberculosis), searches show that none have been applied in the evaluation of sore throat

Several attributes like systolic blood pressure, diastolic blood pressure, age, body mass are taken as inputs. The data was based on M.G.M Hospital, Jamshedpur. Also in 2014, Chandra and Singh diagnosed Arthritis disease using Fuzzy logic controller (FLC), a successful application of fuzzy set theory. As three-fourth of the patients recently suffering from Osteoarthritis and Rheumatoid arthritis so the main focus of

disease. Considering the prowess of fuzzy logic technique however, this study deploys fuzzy inference system (FIS) in the assessment of sore throat infections.

5. METHODOLOGY
Fuzzy logic based approach shall be adopted as methodology for this study. For successful execution of this study, the following procedures shall be followed:

i. **Data Collection:** Data relating to parameters that determine sore throats were collected from the Adekunle Ajasin University Health Centre after due permission.
ii. **Data Representation:** The collected data shall then be represented in the appropriate form and fed into the MATLAB Toolbox.
iii. **Data Analysis:** The Fuzzy logic computation will be carried out and results analyzed accordingly.

6. RELATED WORKS
Here, we present related research works in the assessment of sore throat infection.

In 2010, Adeli et al. designed a fuzzy expert system for the diagnosis of the heart disease. In this design, Mamdani Inference method was used. 13 attributes were taken as input variables and a single output variable was referred to the presence of the heart disease in the patient. The result obtained was correct to 94% when compared to Cleveland Foundation database.

Djam et al. (2011) proposed fuzzy expert system for the management of Malaria. Malaria which has been identified as a predominant environmental health problem in several parts of the world, this system provided a suitable platform for the researchers to diagnose the disease accurately. The results showed that FES performed better.

In 2012, Bhatla et al. performed heart disease diagnosis by reducing the number of attributes and the number of tests undertaken by the patients. Decision tree and Naive-Bayes using fuzzy logic was used. Also in 2012, Ephzibah et al. framed Neuro-Fuzzy expert system for heart diagnosis with only 6 attributes. They analysed that using Neuro-Fuzzy classifier is much more efficient and effective in detecting cardiovascular disease than any other classifier used earlier.

Sharma et al (2013) presented a decision support system for diagnosis of malaria and dengue. This system used fuzzy logic for the uncertainty and imprecision information involved in the symptoms of the diseases.

Niranjana et al (2014) presented an evolutionary Fuzzy expert system for the diagnosis and therapy of the Coronary Artery Disease (CAD).The proposed system used fuzzy rules constituting fuzzy rule base and to optimize the membership functions Genetic Algorithm was used. Also in 2014, Vishal Chandra et al. used methodology for the development of a web based fuzzy expert system for the management of the hypertension using fuzzy logic approach.

the paper was to detect the symptoms of the arthritis at early stage without delay.

Akinyokun and Iwasokun (2015) proposed a fuzzy logic driven expert system for the diagnosis of heart failure disease. Also in 2015, Walia et al. proposed a decision support system for tuberculosis bacterium class identification. Using this framework, the authors suggested use of fuzzy diagnosability

approach for diagnosis of mycobacterium tuberculosis and

formalize reasoning.

7. RESEARCH DESIGN

A. *System Model*

In the proposed model, Fuzzy is developed, tested using MATLAB toolbox. The steps involved is depicted in Figure 1.
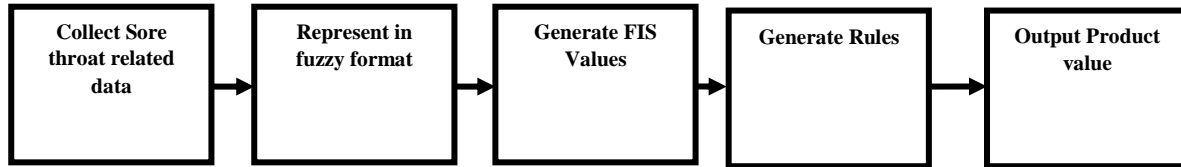
Collect Sore throat related data	→	Represent in fuzzy format	→	Generate FIS Values	→	Generate Rules	→	Output Product value

Figure 1: Fuzzy logic modelling for Sore throat evaluation

B. *Architectural Design*

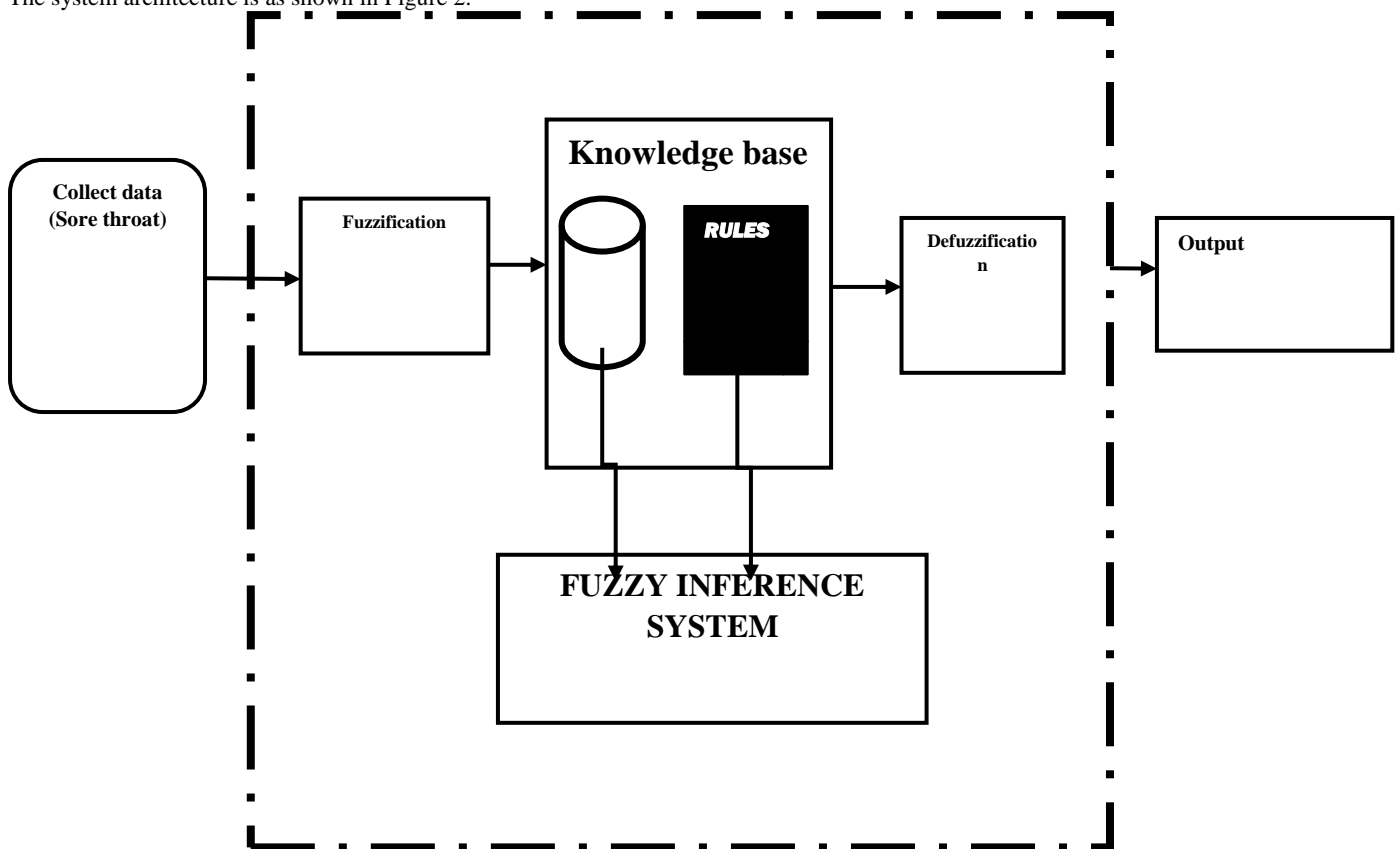The system architecture is as shown in Figure 2.

Figure 2: The proposed Fuzzy logic based model for Sore throat evaluation

C. *Rule Base*

The twenty-one (21) rules formed were constructed to control the output variable, using the simple IF-THEN rule with a condition/antecedence and a conclusion/consequence. Some of the rules are as shown below and also in Figure 3:

1) If (temp1 is low) And (mparasite is absent) And (throatpain is absent) Then (malaria is no_malaria)

2) If (temp1 is high) And (mparasite is present) And (throatpain is present) Then (malaria is malaria_presence)

3) If (HIV is absent) And (oralthrush is absent) And (CMV is absent) And (throatpain is absent) Then (HIV is no_HIV)

4) If (HIV is present) And (oralthrush is present) And (CMV is present) And (throatpain is present) Then (HIV is HIV_presence)

5) If (temp2 is low) And (throatspot is absent) And (swelling is absent) And (throatpain is absent) Then (Tonsillitis is no_tonsillitis)

6) If (temp2 is high) And (throatspot is present) And (swelling is present) And (throatpain is present) Then (Tonsillitis is tonsillitis_presence)

7) If (temp3 is low) And (redrash is absent) And (streptococcus is absent) And (throatpain is absent And (paleskinlips is absent) And (redottedtongue is absent) Then (scarlet fever is no_scarletfever)

8) If (temp3 is high) And (redrash is present) And (streptococcus is present) And (throatpain is present And (paleskinlips is present) And (redottedtongue is present) Then (scarlet fever is scarletfever_presence)
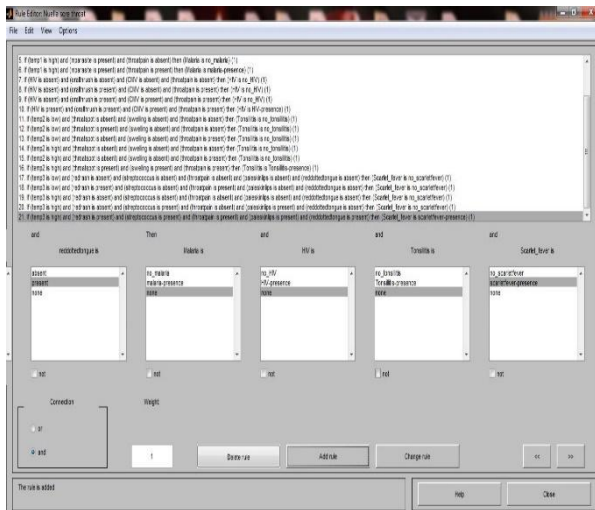

Figure 3: Rules Viewer

8. IMPLEMENTATION

Matlab R2012a software was used for the simulated implementation of this study. In the study, all inputs were scaled into the MATLAB fuzzy sets as Low (-04, 0, 0.49) and High (0.5 0.75, 1), while the outputs were also captured as Absent (-0.4, 0 0.49) and Present (0.5, 0.75, 1). Figures 4 and 5 present the FIS properties pages.
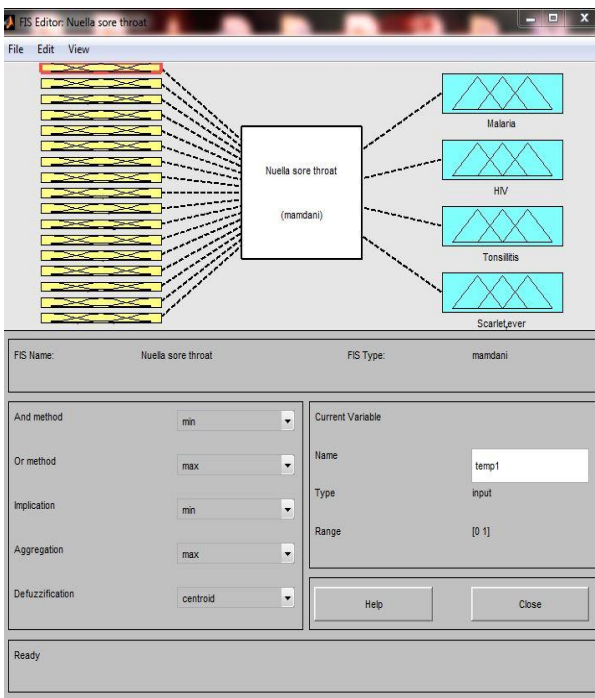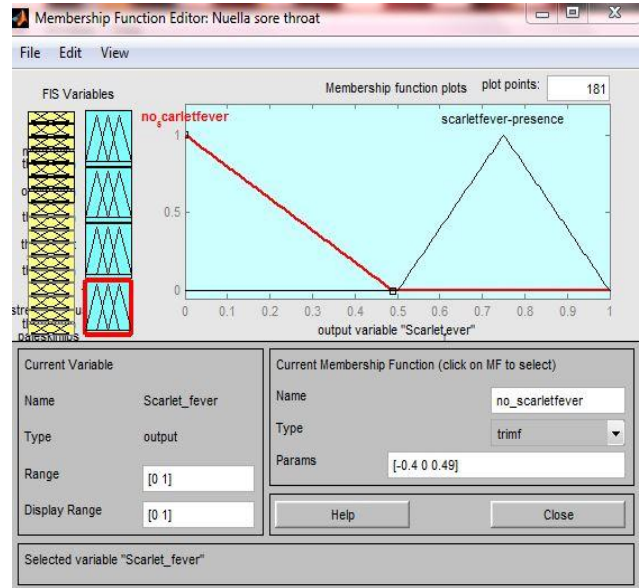

Figure 4: FIS properties for Sore Throat Evaluation

Figure 5: Membership Function for Output Variable

9. RESULT OF FINDINGS

Figures 6 and 7 show some of the simulated results achieved in the study.

SYMPTOMS	VALUES	RESULTS	REMARKS
TEMP3	0.40		
RED RASH	0.27	0.24	NO SCARLET FEVER
STREPTOCOCCUS	0.43		
THROAT PAIN	0.32		
PALE SKIN LIPS	0.38		
RED-DOTTED TONGUE	0.43		
	0.82		
	0.85		
	0.80	0.75	SCARLET FEVER PRESENT
	0.88		
	0.64		
	0.90		

Figure 6: Results on Scarlet Fever based on Simulated Data

SYMPTOMS	VALUES	RESULTS	REMARKS
TEMP1	0.21		
MPARASITE	0.26	0.189	NO MALARIA
THROAT PAIN	0.19		
	0.55		
	0.73	0.75	MALARIA PRESENT
	0.77		

Figure 7: Results on Malaria Fever based on Simulated Data

The results as shown proved that FIS can adequately evaluate sore throat infections.

10. CONCLUSION

Sore throat is one of the most common ailment people experience at one time or the other. Although, children in childcare or grade school have them more often than adolescents and adults. Sore throats are most common during the raining/harmattan season when upper respiratory infections (colds) are more frequent. Sore throats can be either acute or chronic. Acute sore throats are the more common. They appear suddenly and last from three to seven days. A

chronic sore throat lasts much longer and is a symptom of an unresolved underlying condition or disease, such as malaria, tonsillitis, scarlet fever etc. These, this work has been able to unravel and justify the applicability of Fuzzy Inference System in its evaluation.

11. SUGGESTIONS FOR FURTHER STUDY

In this present study, data used was simulated and four diseases were considered. Real life sore throat data and other diseases can be used for further study to produce better results and accuracy. Aside Fuzzy Inference System, which this study has proved to be important in the evaluation of Sore throat, other soft-computing techniques like Neuro Fuzzy (ANFIS), genetic algorithm, genetic-fuzzy (GFS), genetic adaptive neuro-fuzzy inference system (GANFIS), etc. can be deployed in assessing the evaluation of sore throat.

12. REFERENCES

[1] Akinyokun O.C, Iwasokun G.B: Fuzzy logic driven expert system for the diagnosis of heart failure disease. Artificial Intelligence research 2015, Volume 4, No 1.

[2] Ali Adeli, Mehdi Neshat," A fuzzy Expert System for Heart Disease Diagnosis" Proceedings of the International MultiConference of Engineers and Computer Scientists 2010, Volume-1, IMECS, 2010

[3] Cohen JF, Bertille N, Cohen R.: Rapid antigen detection test for group A streptococcus in children with pharyngitis. Cochrane Database Syst Rev. 2016 Jul 4 7:CD010502. doi: 10.1002/14651858.CD010502.pub2

[4] E. P. Ephzibah, Dr. Sundarapandipan: A Neuro-Fuzzy Expert System for Heart disease diagnosis, CSEIJ, Volume 2, No.1.February 2012.

[5] Farlex Medical Dictionary, 2012

[6] McNally D, Shephard A, Field E: Randomised, double-blind, placebo-controlled study of a single dose of an amylmetacresol/2,4-dichlorobenzyl alcohol plus lidocaine lozenge or a hexylresorcinol lozenge for the treatment of acute sore throat due to upper respiratory tract infection. J Pharm Sci. 2012 15(2):281-94.

[7] Nidhi Bhatla, KiranJyoti: A novel Approach for Heart disease diagnosis using Data Mining and Fuzzy logic, International Journal of Computer Application, 0975-8887, Volume 54, No.17, September 2012.

[8] Oxford JS, Leuwer M: Acute sore throat revisited: clinical and experimental evidence for the efficacy of over-the-counter AMC/DCBA throat lozenges. Int. J. Clin. Pract. 2011 May 65(5):524-30. doi: 10.1111/j.1742-1241.2011.02644.x.

[9] Pelucchi C, Grigoryan L, Galeone C.: Guideline for the management of acute sore throat. Clin Microbiol Infect. 2012 Apr 18 Suppl. 1:1-28. doi: 10.1111/j.1469-0691.2012.03766.x.

[10] Phuong, Nguyen Hoang and Kreinovich, Vladik: Fuzzy Logic and its Applications in Medicine (2000). *Departmental Technical Reports (CS).* Paper 498.

[11] Priyanka Sharma, DBV Singh, M.K.Bandil, Nidhi Mishra: Decision Support System for Malaria and Dengue Disease Diagnosis, (IJICT), ISSN: 0974-2239, Volume-3, Number 7, 2013, pp-633-640

[12] Purling GK, Del Mar CB, Dooley L.: Delayed antibiotics for respiratory infections. Cochrane Database Syst Rev. 2013 Apr 30 (4):CD004417. doi: 10.1002/14651858.CD004417.pub4.

[13] Spinks A, Glasziou PP, Del Mar CB: Antibiotics for sore throat. Cochrane Database Syst Rev. 2013 Nov 5 11:CD000023.

[14] Spurling G.K, Del Mar C.B, Dooley L: Delayed antibiotics for respiratory infections. Cochrane Database Syst Rev, 2013

[15] The American Heritage Medical Dictionary, 2007

[16] Vishal Chandra, Pinki Singh: Fuzzy Based High Blood pressure Diagnosis, IJARCST, Volume 2, Issue 2, April-June 2014, ISSN: 2347-9817.

[17] X. Y. Djam, G. M. Wajiga, Y. H. Kimbi: A fuzzy Expert System for the Management of Malaria" International Journal of Pure and Applied Sciences and Technology. 5(2), 2011, pp-84-108

[18] Y. Niranjana Devi, S. Anto: An Evolutionary Fuzzy Expert System for the Diagnosis of Coronary Heart Disease" IJARCET, Volume-3, Issue4, April 2014