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Fuzzification of Botulism.

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Abstract

Botulism is not age or gender restrictive. It has been seen over the years as a nerve toxin that is produced by the bacterium Clostridium botulinum and sometimes by strains of Clostridium butyricum and Clostridiumbaratii. It symptoms varies from double vision to muscle weakness. This research paper proposes a fuzzy model and fuzzy rule approach for recognizing botulismutilizing the decision variables pertaining to botulism, thereby enhancing or extending the traditional (conventional) method. The result obtained based on the fuzzy scale was subdivided into three: "Botulism Absent", "Modest Botulism "and "Botulism Diagnosed". The proposed expert system eliminates uncertainties and imprecision associated with the botulism diagnosis usually tied to an individual professional which usually might be affected by individual state of mind, level of experience and acquired head-knowledge.

Keywords: Botulism, De-fuzzification, Diagnosis, Fuzzy, Fuzzification.

1.0 Introduction

Botulism is a rare but serious paralytic illness caused by a nerve toxin that is produced by the bacterium Clostridium botulinum and sometimes by strains of Clostridium butyricum and Clostridiumbaratii [1]. There are five main kinds of botulism [1, 2].

a. Foodborne botulism is caused by eating foods that contain the botulinum toxin.
b. Wound botulism is caused by toxin produced from a wound infected with Clostridium botulinum.
c. Infant botulism is caused by consuming the spores of the botulinum bacteria, which then grow in the intestines and release toxin.
d. Adult intestinal toxemia (adult intestinal colonization) botulism is a very rare kind of botulism that occurs among adults by the same route as infant botulism.
e. Lastly, iatrogenic botulism can occur from accidental overdose of botulinum toxin. All forms of botulism can be fatal and are considered medical emergencies. Foodborne botulism is a public health emergency because many people can be poisoned by eating a contaminated food.

Clostridium botulinum is the name of a group of bacteria. They can be found in soil. These rod-shaped organisms grow best in low oxygen conditions. The bacteria form spores which allow them to survive in a dormant state until exposed to conditions that can support their growth. There are seven types of botulism toxin designated by the letters A through G; only types A, B, E and F cause illness in humans[1, 2, 3].

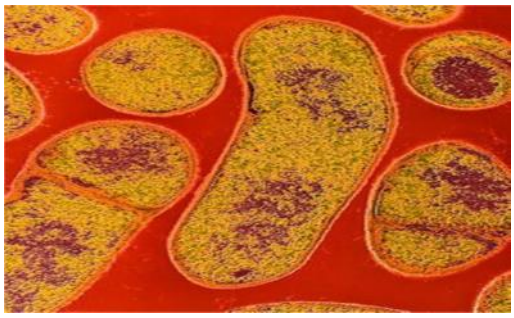

Figure 1: *Clostridium botulinum*

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The classic symptoms of botulism include double vision, blurred vision, drooping eyelids, slurred speech, difficulty swallowing, dry mouth, and muscle weakness. Infants with botulism appear lethargic, feed poorly, are constipated, and have a weak cry and poor muscle tone [1, 2]. These are all symptoms of the muscle paralysis caused by the bacterial toxin. If untreated, these symptoms may progress to cause paralysis of the respiratory muscles, arms, legs, and trunk. In food borne botulism, symptoms generally begin 18 to 36 hours after eating a contaminated food, but they can occur as early as 6 hours or as late as 10 days[4, 5].

Physicians may consider the diagnosis if the patient's history and physical examination suggest botulism. However, these clues are usually not enough to allow a diagnosis of botulism. Other diseases such as Guillain-Barré syndrome, stroke, and myasthenia gravis can appear similar to botulism, and special tests may be needed to exclude these other conditions. These tests may include a brain scan, spinal fluid examination, nerve conduction test (electromyography, or EMG), and a tensilon test for myasthenia gravis. Tests for botulinum toxin and for bacteria that cause botulism can be performed at some state health department laboratories and at CDC [5].

The respiratory failure and paralysis that occur with severe botulism may require a patient to be on a breathing machine (ventilator) for weeks or months, plus intensive medical and nursing care. The paralysis slowly improves. Botulism can be treated with an antitoxin which blocks the action of toxin circulating in the blood. Antitoxin for infants is available from the California Department of Public Health, and antitoxin for older children and adults is available through CDC.If given before paralysis is complete, antitoxin can prevent worsening and shorten recovery time. Physicians may try to remove contaminated food still in the gut by inducing vomiting or by using enemas. Wounds should be treated, usually surgically, to remove the source of the toxin-producing bacteria followed by administration of appropriate antibiotics. Good supportive care in a hospital is the mainstay of therapy for all forms of botulism [6].

2.0 Review of Related Literature

Several research works have been done online pertaining to Botulism diagnosis, treatment and monitoring [7, 8].

A **Fuzzy *classifier*** is an algorithm that assigns a class label to an object, based on the object description. It is also said that the classifier *predicts* the class label [9, 10]. The object description comes in the form of a vector containing values of the features (attributes) deemed to be relevant for the classification task [11, 12, 13]. Typically, the classifier learns to predict class labels using a training algorithm and a training data set. When a training data set is not available, a classifier can be designed from prior knowledge and expertise. Once trained, the classifier is ready for operation on unseen objects [14, 15].

Classification belongs to the general area of pattern recognition and machine learning [16] which includes:

a. *Soft labelling.* The standard assumption in pattern recognition is that the classes are mutually exclusive. A standard classifier will assign a single *crisp* label. A fuzzy classifier can assign degrees of membership (*soft* labels). A fuzzy classifier, D ,producing soft labels can be perceived as a function approximator $D:F\rightarrow[0,1]c$, where F is the feature space where the object descriptions live, and c is the number of classes. While tuning such a function approximator outside the classification scenario would be very difficult, fuzzy classifiers may provide a solution that is both intuitive and useful [17, 18, 19].
b. *Interpretability.* Automatic classification in most challenging applications such as medical diagnosis has been sidelined due to ethical, political or legal reasons, and mostly due to the *black box* philosophy underpinning classical pattern recognition. Fuzzy classifiers are often designed to be *transparent*, i.e., steps and logic statements leading to the class prediction are traceable and comprehensible [20].
c. *Limited available data and expert expertise.* Examples include predicting and classification of rare diseases, oil depositions, terrorist activities, natural disasters. Fuzzy classifiers can be built using expert opinion, data or both.

2.1 Fuzzy Rule-Based Classifier System (FRBCS)

The simplest fuzzy rule-based classifier is a fuzzy if-then system, similar to that used in fuzzy control. Consider a 2D example with 3 classes. A fuzzy classifier can be constructed by specifying classification rules, e.g.

IF X1 is medium and X2 is small Then Class is 1
IF X1 is Medium and X2 is large Then Class is 2
IF X1 is large and X2 is small Then Class is 2
IF X1 is Large and X2 is small Then class is 3
If X1 is small and X2 is large Then Class is 3

The two features x1 and x2 are numerical but the rules use *linguistic values*. If there are M possible linguistic values for each feature, and n features in the problem, the number of possible different if-then rules of this conjunction type (AND) is Mn. If the fuzzy classifier comprises of all such rules, then it turns into a simple look-up table. Unlike look-up tables, however, fuzzy classifiers can provide outputs for combinations of linguistic values that are not included as one of the rules. Each linguistic value is represented by a membership function.

3.0 Methodology

The model of the methodology is presented on Figure 1.

CRSIP VALUE

LINGUISTIC TRANSFORMATION

LINGUISTIC VARIABLES RESULT GENERATED

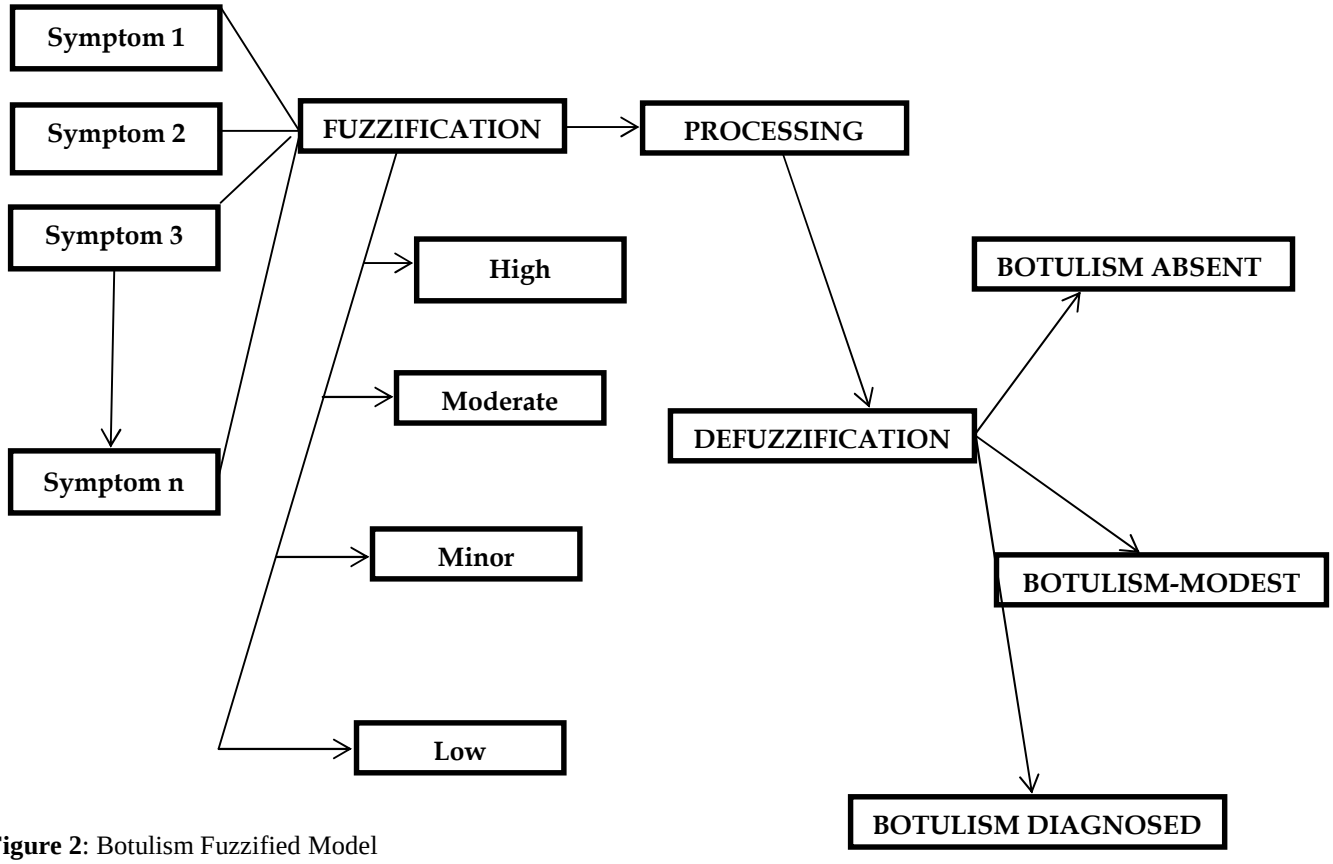

Figure 2: Botulism Fuzzified Model

The methodology is geared toward specifying fuzzy rules utilizing fuzzy set theory application which has been exemplified in the model above. We utilize several symptoms (Linguistic variables) of botulism(double vision, blurred vision, drooping eyelids, slurred speech, difficulty swallowing, dry mouth, and muscle weakness) and several linguistic values/labels (High, Moderate, Minor and Low). Each of these symptoms fall into rule (R1, R2… R8) and Label. The fuzzy rules Specifies

a. IF a patient exhibit $S \leq 3$ THEN Botulism Absent
b. IF a patient exhibits $S = 4$ THEN Modest Botulism
c. If a Patient exhibits $S \geq 5$ THEN Botulism Diagnosed.

In set theory, the union (denoted by ∪) of a collection of sets is the set of all distinct elements in the collection. It is one of the fundamental operations through which sets can be combined and related to each other. The initial ∪ is initialized as $R \cup \emptyset = R$, for the set R. Therefore the fuzzy set rules are thus:

R0: R∪∅
R1: {∅∪double vision} = Botulism Absent.
R2: {∅∪double vision} ∪blurred vision= Botulism Absent.
R3: {∅∪double vision∪blurred vision}∪drooping eyelids= Botulism Absent.
R4: {∅∪double vision∪blurred vision∪drooping eyelids} ∪slurred speech= Modest Botulism.
R5: {∅∪double vision∪blurred vision∪drooping eyelids∪slurred speech}∪difficulty swallowing = Diagnosed Botulism.
R6: {∅∪double vision∪blurred vision∪drooping eyelids∪slurred speech∪difficulty swallowing}∪dry mouths Diagnosed Botulism.
R7: {∅∪double vision∪blurred vision∪drooping eyelids∪slurred speech∪difficulty swallowing∪dry mouths} ∪muscle weakness = Diagnosed Botulism.

4.0 Discussion

The main focus of our approach is geared toward designing a model-based approach for the diagnosing of Botulism disease utilizing the rich facilities of fuzzy set theory application which is more objective and robust in fusing certain linguistic values to certain linguistic variables. This approach extends the conventional (traditional or manual based approach). Previous approach obtain recognition solely on symptoms [2] recognition neglecting, the linguistic value, which invariably tied the level of occurrence. Previous approaches [2, 3] are also times consuming and quite expensive because of repeated unnecessary test, the current approach propagated is a simple fuzzy based approach in handling imprecision.

5.0 Conclusion

An objective approach has been attained utilizing the fuzzy linguistic variables and linguistic values for the diagnosis of Botulism Disease.

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