APPLICATION OF FUZZY CLASSIFIER TO OBSESSIVE COMPULSIVE DISORDER (OCD) IDENTIFICATION AND PROGNOSIS

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ABSTRACT

Many of us occasionally have to go back and double-check that an iron is unplugged or the car door is locked. However for sufferers of obsessive-compulsive disorder (OCD), obsessive thoughts and compulsive behaviors become so excessive that they interfere with their daily lives. The persistent thought associated with OCD often lingers unnecessarily. Family history, chemical imbalances in the brain, specific chromosome/gene variation and some life stressors; like being the victim of sexual abuse as a child are thought to contribute to the development of the disorder. Symptoms of OCD are characterized by ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thoughts, frequent thoughts of violence, fear of causing harm, unwelcome sexual thoughts and fantasies. In this paper, the traditional procedure of the medical diagnosis and prognosis of OCD employed by physicians is expressed using Fuzzy classifier. The proposed expert system eliminates uncertainty and imprecise diagnosis of OCD.

Keywords: Fuzzy classifier, fuzzy logic, fuzzy set, diagnosis, OCD

INTRODUCTION

Obsessive Compulsive Disorder (OCD) is a disorder of the brain and behavior (OCDF, 2011). It is an anxiety disorder in which people have unwanted and repeated thoughts, feelings, ideas, sensations (obsessions), or behaviors that make them feel driven to do something (compulsions).Often the person carries out the behaviors to get rid of the obsessive thoughts, but this only provides temporary relief. Meanwhile not performing the obsessive rituals can cause great anxiety (Healthline, 2011; Pub Med Health, 2011).This disorder interferes with ability to function socially, occupationally, or educationally, either as a result of the amount of time that is consumed by the symptoms or the marked fear or other distress suffered by the person. An Obsession is a thought, impulse, or image that either recurs or persists and causes severe anxiety. These thoughts are irresistible to the OCD sufferer despite the person's realizing that these thoughts are irrational (unreasonable, foolish, crazy or absurd). Examples of obsessions include worries about germs/cleanliness or about safety or order. A compulsion is a ritual/ behavior that the individual with OCD engages in repeatedly, either because of their obsessions or according to a rigid set of rules. The aforementioned obsessions may result in compulsions like excessive hand washing, skin picking, and lock checking, or repeatedly arranging items. Compulsions habits are behaviors that occur in order to neutralize the obsessive thought which occurs routinely, which are particularly time-consuming, and cause stress. Examples of such habits include cracking knuckles or storing car keys in a coat pocket (Healthline, 2011; MedicineNet, 2011; PUB Med Health, 2011; RightDiagnosis, 2011).

There are different forms of OCD which includes (Helpguide, 2011; Medicine-

Net, 2011):

a. Washers are afraid of contamination. They usually have cleaning or hand-washing compulsion.
b. Checkers repeatedly check things (oven turned off, door locked and so on) that they associate with harm or danger.
c. Doubters and sinners are afraid that if everything isnot perfect or done just right something terrible will happen or they will be punished.
d. Counters and arrangers are obsessed with order and symmetry. They may have superstitions about certain numbers, colors, or arrangements.

   Hoarders fear that something bad will happen if they throw anything away. They compulsively hoard things that they do not need or use.

Individuals with OCD are more likely to also develop chronic hair pulling (trichotillomania), muscle or vocal tics (Tourette's disorder), or an eating disorder like anorexia or bulimia. OCD sufferers are also predisposed to developing other mood problems, like depression, generalized anxiety disorder, and panic disorder. OCD puts its sufferers at a higher risk of having excessive concerns about their bodies (somatoform disorders) like hypochondriasis, which is excessive worry about having a serious illness. People with OCD are more vulnerable to having bipolar disorder, also called manic depression (MedicineNet, 2011).

Although sometimes confused with OCD, obsessive compulsive personality disorder (OCPD) is defined by perfectionism and an unbending expectation that the individual and others will keep a specific set of rules. OCPD sufferers do not tend to engage in ritualized behaviors (compulsions). However, OCPD tends to occur more often in people with OCD than in those without and therefore can be considered another risk factor for the development of obsessive compulsive disorder (MedicineNet, 2011).

Fuzzy logic, a multivalued (as opposed to binary) logic developed to deal with imprecise or vague data. Classical logic holds that everything can be expressed in binary terms: 0 or 1, black or white, yes or no; in terms of Boolean algebra, everything is in one set or another but not in both. Fuzzy logic allows for partial membership in a set, values between 0 and 1, shades of gray, and maybe-it introduces the concept of the "fuzzy set." When the approximate reasoning of fuzzy logic is used with an expert system, logical inferences can be drawn from imprecise relationships.

Expert systems are knowledge-based systems that contain expert knowledge. An expert system is a program that can provide expertise for solving problems in a defined application area in the way the experts do. Fuzzy systems are rule-based expert systems based on fuzzy rules and fuzzy inference (PCAI, 2002; NIJ, 2011; Steffen 2011).

Fuzzy sets were introduced by (Zadeh, 1965) to represent/manipulate data and information possessing non statistical uncertainties. Fuzzy sets provide a means of representing and manipulating data that are not precise, but rather fuzzy. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false"(Kasabov, 1998; Robert, 2000; Christos and Dimitros, 2008). The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. A fuzzy set A is called trapezoidal fuzzy number (Figure 1) with tolerance interval [a, b], left width α and right width β if its membership function has the following form

$$A(t) = \begin{cases} 1-(a-t)/\alpha & \text{if } a-\alpha \le t \le a \\ 1 & \text{if } a \le t \le b \\ 1-(t-b)/\beta & \text{if } a \le t \le b+\beta \\ 0 & \text{otherwise} \end{cases}$$

and we use the notation A = (a, b, α, β). It can easily be shown that

$$[A]^{\gamma} = [a-(1-\gamma)\alpha,\ b+(1-\gamma)\beta],\ \forall \gamma \varepsilon [0, 1].$$

The support of A is (a −α, b + β).

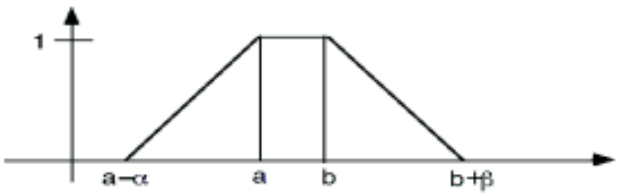

Figure 1: *Trapezoidal fuzzy number*

Fuzzy systems often learn their rules from experts. When no expert gives the rules, adaptive fuzzy systems learns by observing how people regulate real systems (Leondes, 2010) The difference between classical and fuzzy logic is something called "the law of excluded middle" (Bart and Satoru, 1993 and Ahmad, 2011). In standard set theory, an object does or does not belong to a set. There is no middle ground. In such bivalent systems, an object cannot belong to both its set and its compliment set or to neither of them. This principle preserves the structure of the logic and avoids the contradiction of object that both is and is not a thing at the same time (Zadeh, 1965). However, fuzzy logic is highly abstract and employs heuristic (experiment) requiring human experts to discover rules about data relationship (Angel and Rocio, 2011).

Fuzzy classification assumes the boundary between two neighboring classes as a continuous, overlapping area within which an object has partial membership in each class (Kuang *et al.,* 2011**)**. It not only reflects the reality of many applications in which categories have fuzzy boundaries, but also provides a simple representation of the potentially complex partition of the feature space. (Sun and Jang**,** 1993 and Ahmad, 2011) propose an adaptive-network-based fuzzy classifier to solve fuzzy classification problems. Conventional approaches of pattern classification involve clustering training samples and associating clusters to given categories. The complexity and limitations of previous mechanisms are largely due to the lacking of an effective way of defining the boundaries among clusters. This problem becomes more intractable when the number of features used for classification increases (Robert, 2000; Kasabov, 1998; Rudolf, 2008); Christos and Dimitros, 2008). The symptoms of OCD is vague, therefore the adoption of fuzzy logic as a means of handling fuzzified OCD data. The main focus of this work is to develop fuzzy classifier system for the identification and prognosis of OCD.

METHODOLOGY

The diagnosis of OCD begins when a person consult a trained therapist (doctor or physician) in order to diagnose the disorder. The therapists will look for three things (Healthline, 2011; MedicineNet, 2011):

a. Is the person having obsessions?
b. Is the person exhibiting compulsive behaviors?
c. Does the obsessions and compulsions take a lot of time and get in the way of important activities the person values, such as working, going to school, or spending time with friends?

Fuzzy classifier is applied to the diagnosis of OCD using the model prescribed in Figure 2.

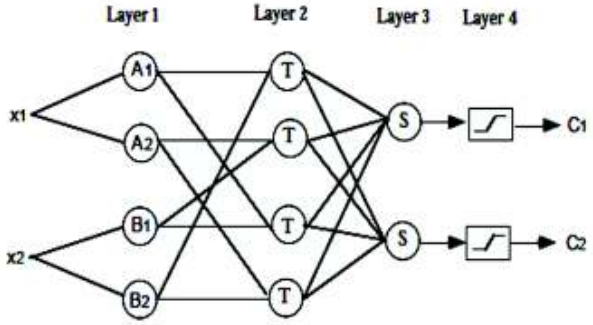

Figure 2*: Fuzzy Classifier System for the Prognosis (Both Diagnosis and Severity) of Obsessive Compulsive Disorder*

The system parades two input variables X_1 and X_2 which are symptoms of OCD. The training data are categorized by two classes $C_1$and C_2. Each input is represented by the two linguistic terms, thus we have four rules.

Layer 1: The output of the node is the degree to which the given input satisfies the linguistic label associated to this node. This is governed by the bell-shaped membership.

Functions which represent the linguistic terms.

$$A_i(u) = \exp\left[-\frac{1}{2}\left(\frac{u - a_{i1}}{b_{i1}}\right)^2\right],$$

$$B_i(v) = \exp\left[-\frac{1}{2}\left(\frac{v - a_{i2}}{b_{i2}}\right)^2\right],$$

Where $\{a_{i1}, a_{i2}, b_{i1}, b_{i2}\}$ is the parameter set where **u** and **v** is the total parameter set. As the values of these parameters change, the bell-shaped functions vary accordingly, thus exhibiting various forms of membership functions on linguistic labels A_i and B_i. In fact, any continuous, such as trapezoidal and triangular-shaped membership functions are also quantified candidates for node functions in this layer. The initial values of the parameters are set in such a way that the membership functions along each axis satisfy:- completeness, normality and convexity. The parameters are then tuned with a descent-type method.

Layer 2: Each node generates the signal corresponding to the conjunctive combination of individual degrees of match of OCD symptoms. The output signal is the firing strength of the fuzzy rule with respect to OCD.

We take the linear combination of the firing strengths of the rules at Layer 3 and apply sigmoidal function at Layer 4 to calculate the degree of belonging to a certain class. Given training set $\{(x^k, y^k), k = 1 \ldots K\}$ where x^k refers to the k^{th} input pattern then

$$y^k = \begin{cases} (1,0)^T & \text{if } x^k \text{ belongs to Class 1} \\ (0,1)^T & \text{if } x^k \text{ belongs to Class 2} \end{cases}$$

The error function for pattern k can be defined by

$$E_k = \frac{1}{2}[(o_1^k - y_1^k)^2 + (o_2^k - y_2^k)^2]$$

Where y^k is the desired output and o^k is the computed output.

Using fuzzy IF-THEN rules to describe a classifier**,** assume that K patterns $x_p = (x_{p1}, x_{pn})$, p = 1 . . . K are given from two classes, where $x_p$is an n-dimensional crisp vector. Typical fuzzy classification rules for n = 2 are like

IF $x_{p1}$is small and $x_{p2}$is very large THEN $x_p = (x_{p1}, x_{p2})$ belongs to Class C_1

IF $x_{p1}$is large and $x_{p2}$is very small THEN $x_p = (x_{p1}, x_{p2})$ belongs to Class C_2

where$x_{p1}$and $x_{p2}$are the features of pattern (or object) p, small and very large are linguistic terms characterized by appropriate membership functions.

The task of fuzzy classification of OCD is to generate an appropriate fuzzy partition of the feature space. In this context the word appropriate means that the number of misclassified patterns is very small or zero. Then the rule base should be optimized by deleting rules which are not used.

Fuzzy classifier is a subset of fuzzy system since there full application is only utilized using fuzzy system. While the fuzzy system on one hand operate an object into class (enabling them to work together), fuzzy classifier provide the fuzzy self-learning rule (conditional statement) which enable the system to be fully optimal. Fuzzy systems are fundamental methodologies to represent and process linguistic information, with mechanisms to deal with uncertainty and imprecision (Reza and Ali, 2011).

The system is developed in an environment characterized by Microsoft Windows XP Professional operating system and Microsoft Access Database Management System, Visual Basic Application Language and Microsoft Excel.

RESULTS AND DISCUSSION

The fuzzy partition for each input feature consists of the clinical symptoms of Obsessive Compulsive Disorder; which is usually a combination of both Compulsive symptoms (Rituals feelings, Repeated hand washing, Repeated touching, repeated counting, Repeated checking, Rearranging things) and Obsessive symptoms (Anxious thoughts, Frequent thoughts of violence, Fear of causing harm, Unwelcome sexual thoughts, Fantasies, Inappropriate thoughts (Suicidal thought), Fear of becoming contaminated, Fear of being poisoned, Feelings of doubt). Combining both clinical symptoms we derive OCDs clinical

symptoms which includes; Ritual feelings, Repeated hand washing, Repeated touching, Repeated counting, Repeated checking, Rearranging things, Anxious thoughts, Frequent thoughts of violence, Fear of causing harm, Unwelcome sexual thoughts, Fantasies, Inappropriate thought (suicidal thought), Fear of becoming contaminated, Fear of being poisoned, Feelings of doubt. However, it can occur that if the fuzzy partition of OCD is not set up correctly, orif the number of linguistic terms for the input features is not large enough, then some patterns will be misclassified. The rules that can be generated from the initial fuzzy partitions of the classification of OCD is thus

a. Experiencing OCD (C1)

b. Might be experiencing OCD (C2)

c. Not experiencing OCD (C3)

If the patient have at least five or more symptoms (C1), having at least four symptoms (C2) and if the patient have less than four symptoms (C3).

Typical Fuzzy IF-THEN Rules for OCD is thus:

R1: IF the patient is experiencing ritual feelings THEN he/she is in C3.

R2: IF the patient is experiencing ritual feelings and repeated hand washing THEN he/she is in C3.

R3: IF the patient is experiencing ritual feelings, repeated hand washing and repeated touching THEN he/she is in C3.

R4: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching and repeated counting THEN he/she is in C2.

R5: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, counting and repeated checking THEN he/she is in C1.

R6: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking and rearranging things THEN he/she is in C1.

R7: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things and anxious thoughts THEN he/she is in C1.

R8: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought and frequent thoughts of violence THEN he/she is in C1.

R9: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought, frequent thought of violence and fear of causing harm THEN he/she is in C1.

R10: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought, frequent thoughts of violence, fear of causing harm and unwelcome sexual thoughts THEN he/she is in C1.

R11: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought, frequent thoughts of violence, fear of causing harm, unwelcome sexual thoughts and fantasies THEN is in C1.

R12: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought, frequent thoughts of violence, fear of causing harm, unwelcome sexual thoughts, fantasies and inappropriate thought (Suicidal thought), THEN he/she is in C1.

R13: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought, frequent thoughts of violence, fear of causing harm, unwelcome sexual thoughtsfantasies, inappropriate thought (Suicidal thought) and fear of becoming contaminated THEN he/she is in C1.

R14: IF the patient is experiencingritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, re-

arranging things, anxious thought, frequent thought of violence, fear of causing harm, unwelcome sexual thoughtsfantasies, inappropriate thoughts (Suicidal thought), fear of becoming contaminated and fear of being poisoned THEN he/she is in C1.

R15: IF the patient is experiencing ritual feelings, repeated hand washing, repeated touching, repeated counting, repeated checking, rearranging things, anxious thought, frequent thoughts of violence, fear of causing harm, unwelcome sexual thoughtsfantasies, impropriate thought (Suicidal thought), fear of becoming contaminated, Fear of being poisoned and feelings of doubt THEN he/she is in C1.

The degree of intensity of OCD symptoms order in the following classes for a typical scenario is presented in Table 1.

Table 1: Degree of Intensity of OCD symptoms

SYMPTOMS OF OCD (Parameters)	CODES	DEGREE OF MEMBERSHIP OF OCD		
		CLUSTER (C_1)	CLUSTER (C_2)	CLUSTER (C_3)
Ritual feelings	P01	0.50	0.40	0.10
Repeated hand washing	P02	0.50	0.10	0.40
Repeated touching	P03	0.40	0.55	0.05
Repeated counting	P04	0.10	0.60	0.30
Repeated checking	P05	0.62	0.28	0.10
Rearranging things	P06	0.05	0.80	0.15
Anxious thoughts	P07	0.10	0.13	0.77
Frequent thoughts of violence	P08	0.80	0.10	0.10
Fear of causing Harm	P09	0.20	0.69	0.11
Unwelcome sexual thoughts	P10	0.51	0.39	0.10
Fantasies	P11	0.66	0.10	0.24
Inappropriate thought (suicidal thought)	P12	0.79	0.11	0.10
Fear of becoming Contaminated	P13	0.66	0.10	0.24
Fear of being poisoned	P14	0.60	0.40	0.00
Feelings of doubt	P15	0.75	0.15	0.10
RESULTS		**Experiencing OCD**	**Might be Experiencing OCD**	**Not Experiencing OCD**

Scale (0.00 -1.00)

Cluster 1, represents possible situation of Experiencing OCD because at least five of the symptoms are pronounced. In cluster 2, "Might be experiencing OCD" since only four of the symptoms are pronounced. Cluster 3, Not experiencing OCD but possibly some other disorder since only one of the symptoms of OCD is pronounced.

The OCD ***prognosis*** is very severe if any patience is diagnosed with Cluster 1(C1). In that case, he /she should consult a physician immediately or could experience untimely death.

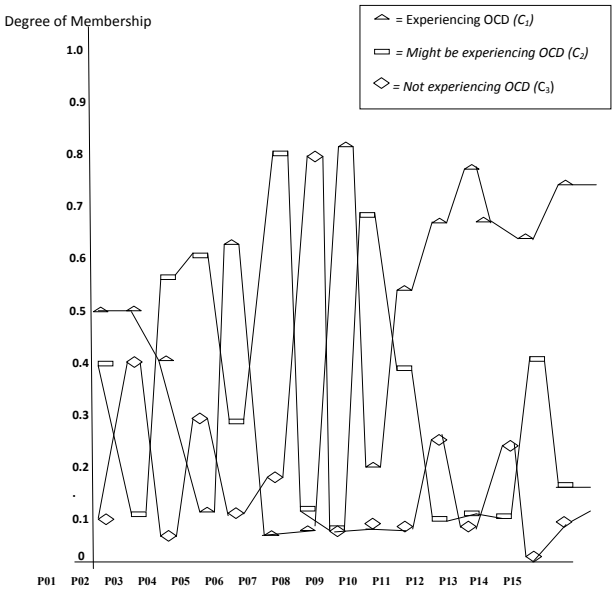

Figure 3: *Graphical representation of Membership Grades of OCD clinical symptoms*

The graphical representation in **Figure 3,** is a representation of Table 1 and clearly show ten clinical symptoms with high degree of "Experiencing OCD" in Cluster 1, four clinical symptoms with high degree of "Might be experiencing OCD" in Cluster 2 and a symptom with high degree of "Not experiencing OCD" in Cluster 3.

CONCLUSION

This work demonstrates the application of soft computing in the domain of prognostic assessment diagnosis of OCD using fuzzy classifier method when given a set of symptoms. Using fuzzy classifier methodology, differential diagnosis of OCD into three major classes "Experiencing OCD""Might be experiencing OCD" and "Not experiencing OCD" was presented. The system is designed for the prognostic diagnosis of OCD and not to prescribe drugs but can be expanded to do so after some more research have been carried out. Soon there would be a fully computerized system to handle diagnosis of diseases and mental disorder in general. A system of this nature that has the ability to diagnose a person suffering from OCD should be introduced in the health sector to assist doctors in making diagnosis most especially in cases of severe illnesses.

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