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PROGNOSTIC DIAGNOSIS OF PELVIC INFLAMMATORY DISEASE UTILIZING LOGICAL FUZZY CLASSIFIER EXPERT STRUCTURE

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ABSTRACT
In this paper, the traditional procedure of the medical diagnosis of PID employed by physicians is expressed using Fuzzy classifier. The proposed expert system eliminates uncertainty and imprecision associated with the diagnosis of PID.

Key Words: *PID, Fuzzy Set, Fuzzy Logic, Fuzzy Classifier, Diagnosis*

INTRODUCTION
Pelvic inflammatory disease (PID) is an infectious and inflammatory disorder of the upper female reproductive tract, including the uterus, fallopian tubes, and adjacent pelvic structures, MedicineNet (2011) and MedScape (2011).

Pelvic inflammatory disease (PID) is initiated by infection that ascends from the vagina and cervix. *Chlamydia trachomatis* is the predominant sexually transmitted organism causing PID. However, newer studies using more sensitive and specific laparoscopic cultures have found acute PID to be polymicrobial (multiple bacteria causes) in up to 30-40% of cases, *N. gonorrhoeae* and *C. trachomatis* may be instrumental in the initial infection of the upper tract, with anaerobes, facultative anaerobes, and other bacteria increasingly isolated as inflammation increases and abscesses form. Organisms involved in PID Infections include the following, Healthline (2011) and MedScape (2011) *Gardnerella vaginalis, Mycoplasma hominis, Mycoplasma genitalium—Ureaplasma urealyticum,* Herpes simplex virus–2 (HSV-2), *Trichomonas vaginalis,* Cytomegalovirus, *Haemophilus influenza, Streptococcus* agalactiae, Enteric gram-negative rods (*Escherichia coli*), *Peptococcus* species, Anaerobes

In addition, cytomegalovirus (CMV) has been found in the upper genital tracts of women with PID, suggesting a potential role of CMV in PID. In iatrogenically (Induced in a patient by a physician's activity, manner, or therapy) induced infections; the endogenous microfloras of the vagina predominate. *Bacteroides fragilis* can cause tubal and epithelial destruction. *N gonorrhoeae* and *C trachomatis* may be instrumental in the initial infection of the upper tract, with anaerobes, facultative anaerobes, and other bacteria increasingly isolated as inflammation increases and abscesses form, MedScape (2011).

The classic high-risk patient of PID is a menstruating woman younger than 25 years who has multiple sex partners, does not use contraception (condoms), and lives in an area with a high prevalence of sexually transmitted disease, a history of prior STIs, and a history of sexual abuse. Patient experiencing frequent vaginal douching, who recently had an IUD

(intrauterine device) inserted, had an abortion and had PID before are also high risk patients, MedScape (2011) and Wedmd (2011).

The differential diagnosis includes appendicitis, cervicitis, urinary tract infection, endometriosis, and adnexal tumors. PID is the most common incorrect diagnosis in cases of ectopic pregnancy. A pregnancy test is required in all women of childbearing age. A delay in diagnosis or treatment of PID can result in long-term sequelae, Healthline (2011), such as chronic pelvic pain and tubal infertility.

Most cases of pelvic inflammatory disease (PID) are presumed to occur in 2 stages. The first stage is acquisition of a vaginal or cervical infection; this infection is often sexually transmitted and may be asymptomatic. The second stage is direct ascent of microorganisms from the vagina or cervix to the upper genital tract, with infection and inflammation of these structures.

Clinical symptoms of PID includes; fever, pelvic cramping, abdominal pain, pain with intercourse, abnormal vaginal discharge, pains in bowel movements, pain during urination and headache.

Fuzzy logic provides a means of representing and manipulating data that are not precise, but rather fuzzy. The theory of fuzzy logic utilizes mathematical strength to capture the uncertainties associated with human cognitive process. Existing method of analyzing pelvic inflammatory disease uses approaches that are unable to handle uncertain or vague data. In this paper, the rich facilities of fuzzy classifier are used for dealing with such uncertainties.

Cluster analysis or clustering is the assignment of a set of observations into subsets (called clusters) so that observations in the same cluster are similar in some sense. Clustering is a method of unsupervised learning, and a common technique for statistical data analysis used in many fields, including machine learning, data mining, pattern recognition, image analysis and bioinformatics. A cluster is therefore a collection of objects which are “similar” between them and are “dissimilar” to the objects belonging to other clusters, Osama, (2008). The goal of clustering is to determine the intrinsic grouping in a set of unlabeled data.

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. They use human knowledge to solve problems that normally would require human intelligence. These expert systems represent the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve problems, PCAI (2002).

Fuzzy systems are rule-based expert systems based on fuzzy rules and fuzzy inference.

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", Christos and Dimitros (2008); Kasabov, (1998) and Robert (2000). The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning.

Fuzzy systems often learn their rules from experts; where expert are not present they observe how real system are regulated. 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). In standard set theory, an object does or does not belong to a set. There is no

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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.

Fuzzy classification assumes the boundary between two neighboring classes as a continuous, overlapping area within which an object has partial membership in each class. 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) 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, Christos and Dimitros, (2008); Kasabov (1998); Robert (2000) and Rudolf (2008).

MATERIAL AND METHODS

Fuzzy classifier is applied to the diagnosis of PID using the model prescribed in Figure 1. The system is developed in an environment characterized by Microsoft Windows XP Professional Operating System, Microsoft Access Database Management system, Visual Basic Application Language and Microsoft Excel.

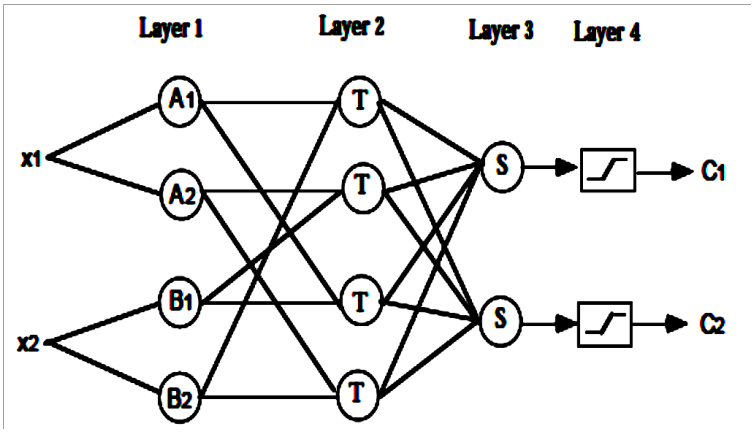

Figure 1: *Fuzzy Classifier System for the Diagnosis of PID*

The system parades two input variables X_1 and X_2 which are symptoms of PID. 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

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

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

which represent the linguistic terms, where $\{a_{i1}, a_{i2}, b_{i1}, b_{i2}\}$ is the 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 continuum, 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 (symptoms) 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 PID symptoms. The output signal is the firing strength of the fuzzy rule with respect to PID.

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

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

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:

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 PID 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. The scheme is extensible to any number of input and classes.

RESULTS

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

The fuzzy partition for each input feature consists of PID symptoms (fever, pelvic cramping, abdominal pain, pain with intercourse, abnormal vaginal discharge, pains in bowel movements, pain during urination and headache). However, it can occur that if the fuzzy partition of PID is not set up correctly, or if 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 PID is thus

a. Have PID (C1)

b. Might have PID (C2)

c. Not PID (C3)

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

The Fuzzy IF-THEN Rules (Ri) for PID is

R1: IF the patient is experiencing fever THEN he/she has class C3.

R2: IF the patient is experiencing Fever and pelvic cramping THEN he/she has class C3.

R3: IF the patient is experiencing fever, pelvic cramping and abdominal pains THEN he/she has class C3.

R4: IF the patient is experiencing fever, pelvic cramping, abdominal pains, and pain during intercourse THEN he/she has class C2.

R5: IF the patient is experiencing fever, pelvic cramping, abdominal pain and abnormal vaginal discharge THEN he/she has class C1.

R6: IF the patient is experiencing fever, pelvic cramping, abdominal pain, abnormal vaginal discharge and pain during bowel movement THEN he/she has class C1.

R7: IF the patient is experiencing fever, pelvic cramping, abdominal pain, abnormal vaginal discharge, pain during bowel movement and pain during urination THEN he/she has class C1.

R8: IF the patient is experiencing fever, pelvic cramping, abdominal pain, abnormal vaginal discharge, pain during bowel movement, pain during urination and headache THEN he/she has class C1.

Table 1: Degree of Intensity of PID Symptoms; Scale (0.00 -1.00)

PID Symptoms (Parameters)	**PID Symptom Codes**	**Degree of Membership of PID**		
		Cluster 1 (C_1)	**Cluster 2 (C_2)**	**Cluster 3 (C_3)**
Fever	P01	0.50	0.00	0.50
Pelvic cramping	P02	0.27	0.53	0.20
Abdominal Pin	P03	0.30	0.65	0.05
Pain during Intercourse	P04	0.10	0.80	0.10
Abnormal vaginal discharge	P05	0.50	0.50	0.00
Pains during bowel movement	P06	0.80	0.15	0.05
Pain during urination	P07	0.50	0.37	0.13
Headache	P08	0.75	0.15	0.10
RESULTS		**Having PID**	**Might be PID**	**Not PID**

From Table 1, Cluster 1 represent possible situation of "Having PID" since only five of the symptoms are pronounced. In cluster 2, there "Might be PID" because only four of the symptoms are pronounced. Cluster 3, "Not PID" since only symptoms of PID is pronounced.

The PID prognosis is very severe if any patient is diagnosed with Cluster 1 (C1), the patient should consult a physician immediately to prevent total deterioration.

DISCUSSIONS

This work demonstrates the application of soft computing in the domain of differential diagnosis of PID (Pelvic inflammatory disease) utilizing fuzzy classifier method when given a set of symptoms. Using fuzzy classifier methodology, differential diagnosis of PID into three major classes "Having PID, Might be PID and Not PID" were presented. The system is designed to diagnose PID and not to prescribe drugs but can be expanded to do so in future research. Soon there would be a fully computerized system to handle diagnosis of diseases in general. A system of this nature that has the ability to diagnose a person suffering from PID should be introduced in the health sector to assist doctors in making diagnosis most especially in cases of severe illnesses.

REFERENCES

Bart K. and Satoru I. (1993), "Fuzzy Logic", retrieved from http//:Fortunecity .com/emachines/e11/86/fuzzylog.html.

Christos S. And Dimitros S. (2008) "Neural Network", retrieved from http://www.docstoc.com/docs/15050/neural-networks.

Healthline, (2011), "PID, symptoms and causes", retrieved from http://healthline.com

Kasabov N. K. (1998), "Foundations of neural networks, fuzzy systems, and knowledge engineering", A Bradford Book, The MIT Press Cambridge, Massachusetts London, England

Leondes C. (2010), "The Technology of Fuzzy Logic Algorithm retrieved from Suite101.com/examples-of-expert-System-application-in-artificial Intelligence.

MedicineNet (2011), "PID: Symptoms, causes and treatment", retrieved from http:// medicineNet.com.

MedScape (2011), "Pelvic Inflammatory disease", retrieved from medscape.com

Osama A. A. (2008), "Comparison between Data Clustering Algorithm", http://www.ccis2k.org/iajit/PDF/vol.5,no.3/15-191.pdf

PCAI (2002), "Expert Systems", retrieved http://www.pcai.com/web/ai_info/expert_systems.html.

Robert F. (2000), "Introduction to Neuro-Fuzzy Systems, Advances in Soft Computing Series", Springer-Verlag, Berlin/Heildelberg, 289 pages

Rudolf K. (2008), Neuro-fuzzy systems, retrieved from http://ask.com

Sun C.T. and Jang J.S. (1993) "A neuro-fuzzy classifier and its applications", in: Proc. IEEE Int. Conference on Neural Networks, San Francisco, pp.94–98.

WebMd, (2011), "PID test", retrieved from http://www.webmd.com/sexual-conditions/PID-test

RightDiagnosis, (2011), "Introduction; Causes, diagnosis, types and treatment of PID" retrieved from http:// wrongdiagnosis.com.

Zadeh L.A. (1965): "Fuzzy sets and systems". In: Fox J, editor, System Theory: Polytechnic Press, Brooklyn, NY