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Fuzzy Matrix Theory and Infertility Management – Measures Follicle Fertilization Possibility

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Abstract. In this paper, we are exploring fuzzy logic in medical diagnosis of infertility where our aim is to predict the possibility of total fertility using fuzzy matrix theory by measuring the follicle fertilization possibility based on follicle size. Also developed a computer program to calculate fuzzy matrix based on MaxMin rule using JavaScript.

Keywords: Fuzzy matrix theory, maxmin rule, follicle size, total fertility and ultrasound.

AMS Mathematics Subject Classification (2010): 05C72

1. Introduction

The two most trendy application areas of fuzzy set theory are computer science and medicine. Fuzzy sets were introduced by Zadeh in 1965. Zadeh (1965) stated that fuzzy set is a class of objects with a continuum of grade of membership. Such a set is characterized by a membership function which assigns to each object a grade of membership ranging between zero and one. Sanchez (1976) worked on composite fuzzy relation equations and presents a method for resolution of some basic fuzzy relational equations, with grade of membership in sets and plans to explore medical aspects of fuzzy relations in future. Fuzzy sets have been used in many different and versatile disciplines. Holzmann *et al.* (1988) developed a fuzzy model for medical diagnosis, this model is a computerized expert system based on fuzzy theory, specified for six cardiopathies and find out patient's diseases on the basis of symptoms, objective of this model is to reduce physician's procedure for disease detection. Raich *et al.* (2011) diagnose diabetes and describe the occurrence relation Ro and conformability relation Rc to find the stages of diabetes. Raich *et al.* (2011) proposed a new approach for the multiplication of Interval Valued Fuzzy Matrices (IVFM) as <R/V> for diagnosis process of diarrhea. Samuel and Balamurugan (2012) suggested a new method for medical analysis on set of diseases and diseases associated set of symptoms using the notion of intuitionistic fuzzy sets (IFS) theory.

Smith *et al.* (2003) infertility, defined as 1 year of attempted conception without success, is one of the most common health disorders relating young adults. Clinical

evaluation of infertility specified that if a pregnancy has not occurred after 1 year of regular unprotected intercourse, because by that time 85% of couples attempting conception will have been successful. (http://www.who.int/ bulletin/volumes/88/12/10-011210/en/) According to bulletin of The World Health Organization (WHO), infertility affects up to 15% of reproductive-aged couples worldwide.

Few decades ago infertility was only a diagnosis with no or very little hope for treatment. But now this is the era of interdisciplinary techniques, which gives heights to infertility diagnosis and management techniques. Infertility is a concern affected both male and female. In this paper we discuss female infertility diagnosis aspects (follicular study). Typically infertility diagnosis has been done via follicular study, Hysterosalpingogram (HSG), Transvaginal ultrasonography (TVS), Ovarian Reserve Testing, Hormone Testing, Sonohysterography, Hysteroscopy, Laparoscopy, etc. Many gynecologists advise ovulation tracking or follicular study as an initial step of infertility treatment. For ovulation study patient have to go for ultrasound scans which help you time exactly when you ovulate, increases the possibility of conception.

Scheffer *et al.* (1999) study female reproductive status by the relation between age, number of follicle and size of follicle and find out that increasing age increase the probability of infertility. Hiremath and Tegnoor (2013) advise a fuzzy logic based methodology for follicle detection with the help of ultrasound images of ovary and follicle analysis based on follicle shape and size. Ovarian follicles are spherical fluid filled structures. They grow from 8 to 10 mm on an average. Only the dominant follicle can reach as much as 17–25 mm in diameter. The small follicles of 2–3 mm can also be perceived in the ultrasound images of ovaries. Hiremath and Tegnoor (2013) worked on ultrasound image of ovary and locate the follicles in such a noisy image of ovary and after that grade an ovary as normal, cystic and polycystic.

2. Method

On the basis of follicle size we had broadly classified fertility diagnosis into three categories No Fertility, Partial Fertility and Total Fertility as D1, D2 and D3 respectively. No Fertility means there is no chance to get conceives, Partial Fertility means there is possibility to conceive after medical assistance and Total Fertility means there is maximum possibility to conceive. Generally follicle grows from 8 to 10 mm on an average, only the dominant follicle can reach as much as 17–25 mm in diameter and the small follicles of 2–3 mm can also be identified in the ultrasound images of ovaries. In our study ultrasound done at 12^{th} day and for continuity of membership function we consider 0-5, 5-15 and 15-25 mm range in place of 2-3, 8-10 and 17-25 respectively.

We use,
S = Crisp set of follicle size, S1, S2 and S3.
D = Set of all diagnosis, D1, D2 and D3.
P = Set of all patients, P1, P2 and P3.

In medical diagnosis an Occurrence relation Ro provides knowledge about the tendency or frequency of appearance of symptoms when the specific diagnosis is present i.e. how often does the symptoms occur with diagnosis. A conformability relation Rc describes the discriminating power of the symptoms to confirm the presence of the diagnosis i.e. how; strongly does the symptom confirm diagnosis. Fuzzy relations Rs specify the degree of presence of symptoms for patients.

Matrix Ro is occurrence relation, relation between set of symptoms and set of diagnosis, shows the frequency of occurrence of symptoms with diagnosis. i.e. Ro = S X D. Matrix Rc is conformability relation, relation between set of symptoms and set of diagnosis shows the degree to which symptoms confirms the presence of diagnosis i.e. Rc = S X D. Matrix Rs is occurrence relation, relation between patient and set of symptoms, shows the degree to which the symptoms is present in patient i.e. Rs = P X S.

We can calculate another four relations R1, R2, R3, R4 using relation Ro, Rc, Rs.

1. R1 is the occurrence indication relation, calculated by R1 = Rs * Ro.
2. R2 is the conformability indication relation, calculated by R2 = Rs * Rc.
3. R3 is the non occurrence indication relation, calculated by R3= Rs*(1- Ro).
4. R4 is the non-symptom indication relation, calculated by R4=(1- Rs) * Ro.

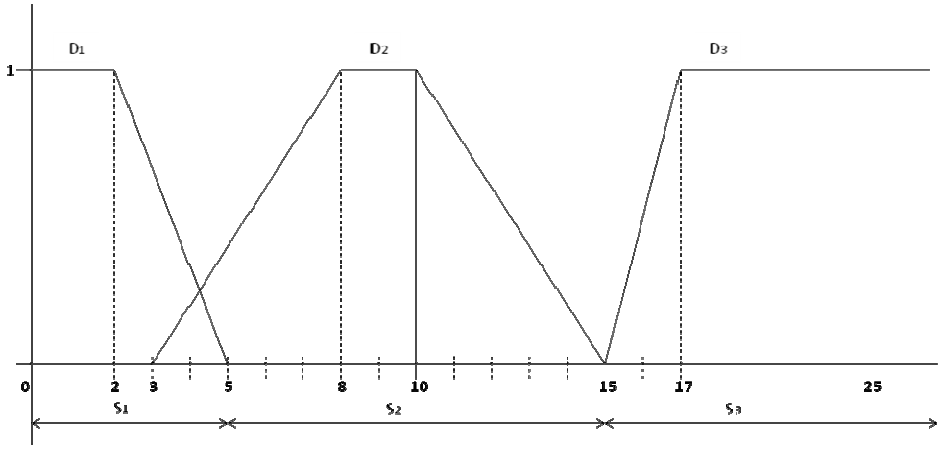

Figure 1: As follicle size increased the possibility of follicle fertilization increases.

where

$$D1 = \begin{cases} 1, if\ x < 2 \\ \dfrac{5-x}{3}, 2 \le x \le 5 \\ 0, x \ge 5 \end{cases} \quad (1)$$

$$D2 = \begin{cases} 0, if\ x < 3 \\ \dfrac{x-3}{5}, 3 \le x \le 8 \\ \dfrac{17-x}{7}, 10 \le x \le 17 \\ 1, 8 \le x \le 10 \end{cases} \quad (2)$$

$$D3=\begin{cases}0, if\ x<15\\ \dfrac{x-15}{2}, 15\le x\le 17\\ 1, x\le 17\end{cases} \quad (3)$$

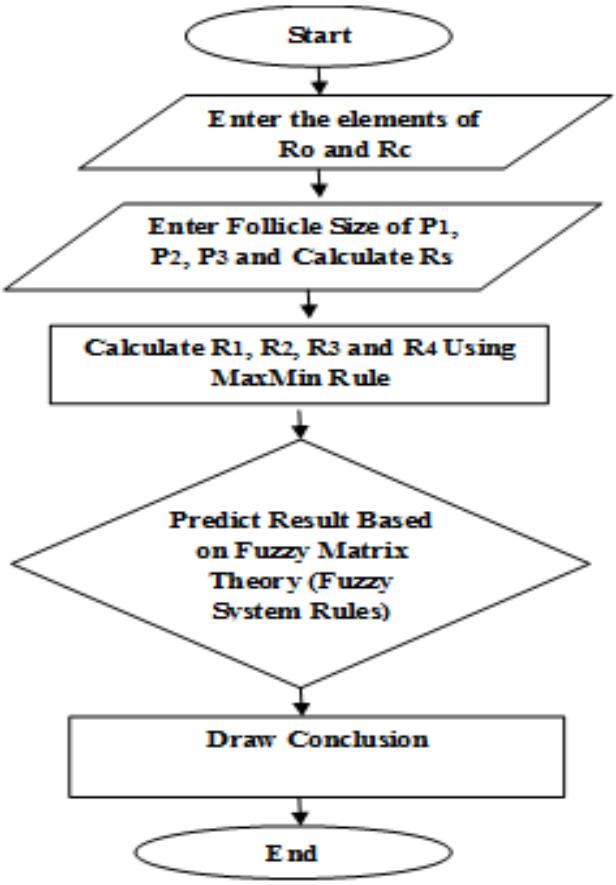

Figure 2: Flowchart of the proposed method

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MATRIX SOLUTIONS

Select Option	○ Min Max ◉ Max Min
Enter element of Rs & write Rs in Name box	Name Rs Rows 3 Represented by Cols 3 Represented by
Enter element of Ro & write Ro in Name box	Name Ro Rows 3 Represented by Cols 3 Represented by
Enter element of Rc & write Rc in Name box	Name Rc Rows 3 Represented by Cols 3 Represented by
	Form Matrix Get Output

Enter Elements of Rs

	1	2	3
1	.33	.9	0
2	0	1	.5
3	0	0	1

Enter Elements of Ro

	1	2	3
1	.95	.3	0
2	.5	.9	.4
3	0	.7	.9

Enter Elements of Rc

	1	2	3
1	1	.4	0
2	.4	1	.5
3	0	.8	1

The occurrence indication relation R1 calculated by R1=Rs * Ro

	1	2	3
1	0.5	0.9	0.4
2	0.5	0.9	0.5
3	0	0.7	0.9

The conformability indication relation R2 calculated by R2=Rs * Rc

	1	2	3
1	0.4	0.9	0.5
2	0.4	1	0.5
3	0	0.8	1

The nonoccurrence indication relation R3 calculated by R3=Rs * (1- Ro)

	1	2	3
1	0.5	0.33	0.6
2	0.5	0.30	0.6
3	1	0.30	0.09

The non-symptom indication relation R4 calculated by R4=(1-Rs) * Ro

	1	2	3
1	0.66	0.7	0.9
2	0.95	0.5	0.5
3	0.95	0.9	0.4

3. Conclusion

In this paper we proposed a new technique to measure follicle fertilization possibility based on follicle size using fuzzy matrix theory. This technique is the mathematical form of linguistic predictions of gynecologists and physicians' regarding possibility of follicle fertilization (initial step for infertility management or ratio of fertility) which ease their efforts.

In our case study R2 is the conformability relation indicates patient P1 suggest itself in the category of No Fertility and having 90% possibility to be in Partial Fertility. Patient P2 occur in Partial Fertility with 100% fertility rate and having 50% chance to be in Total Fertility. And patient P3 predicts itself in Total Fertility with 100% fertilization possibility. This study calculates similar results like an expert. In the present study we considered only follicle size but in future we will try to include multiple symptoms or set of symptoms to produce more accurate results because as we know that infertility caused by one or more than one reason.

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