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Estimation of Menstrual Cycle Period (Days) From Phoenetic Features

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Abstract

In this paper we discuss a new non- invasive, user friendly approach to estimate the menstrual cycle period (days) using phonetic features of users voice. The wavelet transform has been used for analyzing phoneme properties.
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Keywords: Female harmonal cycle, phonetic study, mathematical model, wavelet transform.

1. INTRODUCTION

In this paper we are going to discuss an approach to estimate the total days of menstrual cycle of females from the analysis of phonetic features with the utterance of International Phonetic Alphabets (IPA table). The previous studies have shown that the physiological state of females change with their hormonal changes especially during their menstrual period, in the both fertile and non- fertile phases. In 2017 Grazyna [4] highlighted the change in voice parameters during different phases of menstrual cycle.

1.1 THE MENSTRUAL CYCLE

A period of menstruation cycle marks the beginning of the process by which the uterus or womb prepares itself for pregnancy, whilst it's convenient to think of the menstruation cycle as a monthly event, indeed we get the word "menstruation" from the 28 day cycle of the Moon. Only about 12% of women actually have a period every 28 days, most women with regular periods have a cycle lasting 21 to 35 days, see Creinin[1].

The process of menstruation is regulated by hormones. According to health line survey (www.healthline.com) hormones are natural substances produced in the body. Hormones help to relay message between cells and organs and affects many body functions. There are different male or female sex hormones present in the humans but we are interested in female sex hormones only. There are four key hormones, estrogen and progesterone which comes from the ovaries while luteinizing hormones (LH) and follicle stimulating hormones (FSH) are released by pituitary gland in the brain. Estrogen plays a big role in reproduction and sexual development including puberty menstruation, pregnancy and menopause. On the other hand the second main female sex hormone, Progesterone prepares the lining of uterus, support pregnancy and suppress the estrogen produced on after ovulation. According to Johnson[7], in the menstruation cycle period the FSH increases and release the follicle to produce estrogen. The rising estrogen levels inhabiting the output of LH. Oestrogen levels continuously rise to the threshold level at which point the negative feedback is reversed and LH Surges. At this stage ovulation occurs and results in a decline of estrogen. After all this process LH is secreted and the menstrual cycle begins again.

We know that these hormones regulates the functioning of various gynecological phases. Therefore regularity of menstrual cycle plays a key role in order to estimate hormone level. The most important aspect of the female cycle is the periodic nature in which it occurs. From the time a young female begins to menstruate until the time that women reaches menopause, hormonal pulses and secretions occur regularly, varying little from month to month. This periodicity is described by Johnson[7] using difference equation, which are the functions of LH, estrogen and progesterone. This all indicates the importance of estimation of menstruation cycle period.

1.2 IMPORTANCE OF SPEECH AND MATHEMATICAL MODEL

Research shows that hormonal changes in a female across the menstrual cycle affects vocal production. Our present result supports the hypothesis that sex hormones have an

effect on voice function. Vocal changes in relation to hormonal level changes are subtle. The basic parameters of speech are intensity, pitch and formants which are needed to recognize and synthesize speech. Out of these paramaeters we choose one frequency parameter formant F_1. According to Harald[6] formants are the concentration of acoustic energy around a particular frequency. There are different formants around each 1000Hz frequency band i.e. formant-F_0 is concentration of acoustic energy around 0th Hz frequency band, formant- F_1 around 1000Hz, formant-F_2 around 2000Hz, formant-F_3 around 3000Hz and so on. In the approach presented here, we have modeled maximum value of formant-F_1 only.

Mathematical model is a system that uses mathematical concepts and languages for developing the solution for a problem. According to Kapur[8] mathematical modelling means, we catch hold of the real world problem in our teeth, dive into the mathematical ocean, swim there for some time and we come out on the surface with the solution of the real world problem with us.

1.3 BACKGROUND

The menstruation cycle is the periodic change that occur in the female reproductive system that make pregnancy possible. Considerable attention has been paid to the development of methods to predict the day of ovulation and the day of onset of menstruation. The method available for the estimation of menstrual cycle are self reported menstrual history, calendar based counting Wideman et.al[12], basal body temperature method by Fukaya et.al[3], Urinary measurement method, Donna[2] and plasma hormone analysis method. In 2004 Creinin et. al[1] performed a retrospective analysis to ascertain how accurately woman who believes that they have regular menstrual cycle to estimate the length of their actual cycles. Also in 2006 Guo [5] modelled the menstrual cycle length using a mixture distribution. The periodicity of menstrual cycle is modelled mathematically by Johnson[7], Guo et.al [5] and Rinecke and Deuflhard[10]. Also effects of speech on menstrual cycle is modelled mathematically by Thakur et.al[11] and Pipitone and Gallup[9].

There are two results which model utterance of vowels with menstrual cycle period, see Thakur et.al[11] and Grazyna[4]. Thus in view of the discussion above we can conclude that there is a need for a method or system to estimate menstrual cycle period which is easy, user friendly and non-invasive. All the results obtained yet to estimate menstrual cycle period are invasive while ours is non-invasive and user friendly.

1.4 MATERIALS AND METHODOLOGY

Voice samples of around 80 females lying in the age group of 20 to 25 years were recorded. Each female had to utter all the 48 alphabets of Hindi character set of IPA table for a period of 30-35 days and in later cases 40-45 days.

Initially Logitech HD webcam CS10 was used with Microsoft windows 10 home single language for recording voice data. And in later phase the recording was done using a software made for recording of alphabets by Speech Markers Pvt. Lmt. Pune. PRAAT software was used for separating the utterance of alphabets and extracting different speech parameters from the samples.

First we recorded all the alphabets of hindi script from अ to ज्ञ and then speech parameters specially formant F_1 is extracted using a software "PRAAT". After analyzing all the speech parameters we developed a mathematical model to estimate menstrual cycle period in days.

2. MAIN FINDINGS

2.1 Analysis using Formula for Menstrual Cycle Period

After the recording samples of all alphabets in our analysis we established correlation between maximum value of formant- F_1 of four consonants and menstrual cycle period. The following equation represents the correlation :

$$Menstrual\ cycle\ period = \left(\frac{Average\ of\ F_1 - max.\ of\ the\ phonims}{100}\right) + (Average\ of\ ratios\ of\ F_1 - max.\ of\ phonims) * 20$$

Here we use four consonants, one semi vowel and three nasal phonems. Let-

F_1- max of first Nasal phonem $= c_1$,

F_1- max of first semi vowel $= c_2$,

F_1- max of second Nasal phonem $= c_3$,

F_1- max of third Nasal phonem $= c_4$.

then

$$Menstrual\ cycle\ period = \frac{c_1 + c_2 + c_3 + c_4}{400} + \frac{(c_1 : c_2) + (c_2 : c_3) + (c_3 : c_4)}{3} * 20$$

The values of F_1-max from the recorded samples and the values of estimated menstrual cycle period out of it are listed below in the following Table 1

Table 1: Observation Table

S. No.	Case No.	Day from mensuration	F1- max frequency				Estimated time
			C1	C2	C3	C4	
1	5	7	1008.629	901.279	1052.24	1038.2	29.92
2	8	24	1223.113	837.2507	767.7654	756.8457	32.72
3	15	25	893.0525	888.7741	922.034	1176.714	31.7
4	18	29	901.3782	772.4654	887.7731	798.2624	31.19
5	20	8	1333.197	1533.478	1090.958	837.1035	30.612
6	21	6	1052.743	1380.274	1318.007	886.4395	27.513
7	22	10	961.2411	844.6058	941.1618	890.4078	29.706
8	23	5	881.2484	1157.742	1026.791	959.756	29.776
9	28	16	1841.043	858.8273	910.1301	901.9332	27.273
10	51	15	863.3	1310.5	1054.2	1374.4	29.298
11	52	2	738.23	1503.7	1375.7	1734.3	29.228
12	53	1	842.85	866.69	771.82	753.53	28.885
13	55	25	830.09	655.89	1193	1511	27.841
14	58	6	1716.2	1102.3	836.93	906.24	36.721
15	59	1	833.15	1174.6	1699.6	762.04	35.379
16	60	29	924.6042	732.58	1332.2	10359	30.717
17	62	30	779.132	1174.474	975.868	774.967	30.093
18	64	1	927.364	1029.971	1195.969	987.011	30.173
19	67	8	797.582	700.635	1067.127	808.92	29.197
20	68	5	1004.39	697.41	948.11	1255.76	29.303
21	75	1	812.173	1132.31	1385.23	1086.92	29.769

Verification

1. **For Serial Number 4:-Estimated Time**

$$= \left(\frac{901.3782 + 772.4654 + 887.7731 + 798.2624}{400}\right) + \left(\frac{1.166 + 1.112 + 1.149}{3}\right) * 20$$

$$= 8.39 + (1.14) * 20$$

$$= 8.39 + 22.84$$

$$= 31.19$$

2. **For Serial Number 7:-Estimated Time**

$$= \left(\frac{961.2411 + 844.6058 + 941.1618 + 890.4078}{400}\right) + \left(\frac{1.138 + 0.897 + 10.57}{3}\right) * 20$$
$$= 9.093 + (1.03) * 20$$
$$= 9.093 + 20.613$$
$$= 29.706$$

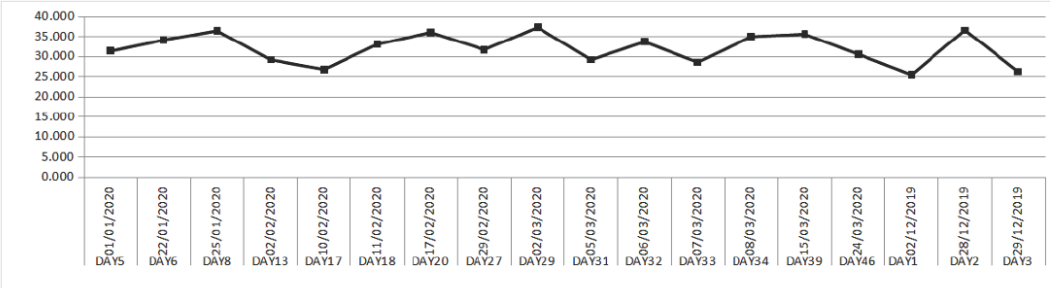
3. **For Serial Number 17:-Estimated Time**

$$= \left(\frac{779.132 + 1174.474 + 975.868 + 774.967}{400}\right) + \left(\frac{0.663 + 1.203 + 1.259}{3}\right) * 20$$
$$= 9.261 + (1.041) * 20$$
$$= 9.261 + 20.83$$
$$= 30.093$$

2.2 Analysis using graphs

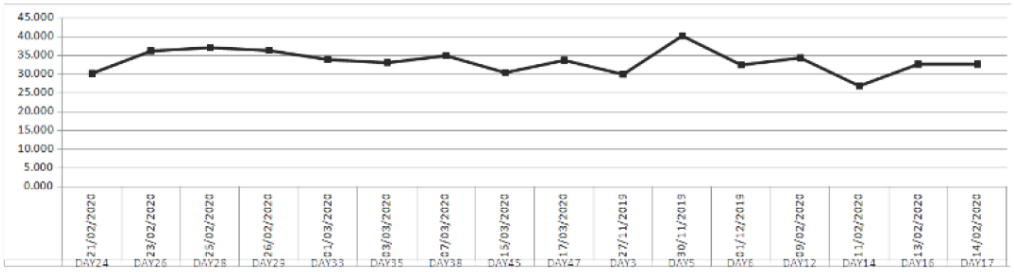
We prepared the graphs and observations whose details are as follows:

1. We use the filter for the 30-40 days recorded values of max f_1, as it had some noise and errors at the time of recording.
2. These filtered values are entered in the formula for estimation of menstrual cycle time.
3. Graphs are drawn with days as x-axis and estimated values on y-axis.
4. We observe that our model gives better results in first 5 to 6 days of menstrual cycle as compared to other days.



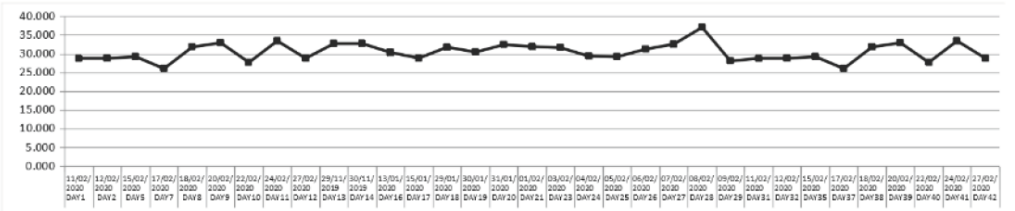
DAYS	5	6	8	13	17	18	20	27	29	31	32	33	34	39	46	1	2	3
((C1+C2+C3+C4)/400) + (((C1/C2+C2/C3+C3/C4)/3)*20)	31.369	34.195	36.530	29.197	26.793	33.134	36.104	31.739	37.382	29.224	33.735	28.569	35.040	35.675	30.598	25.452	36.671	26.241

Figure 1: Case number 67



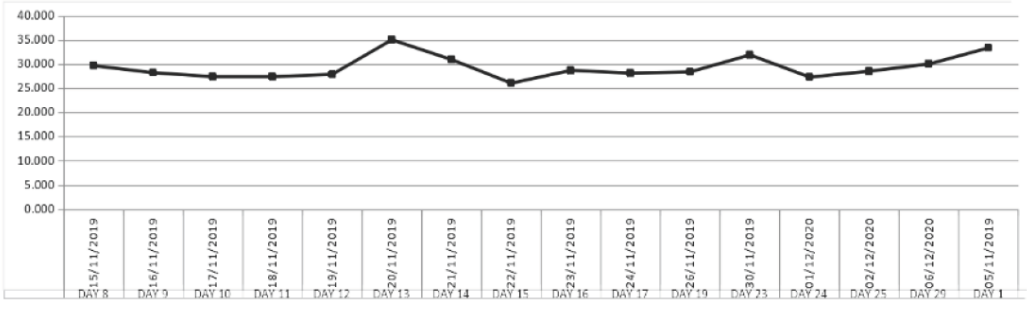
DAYS	24	26	28	29	33	35	38	45	47	3	5	6	12	14	16	17
((C1+C2+C3+C4)/400) + (((C1/C2+C2/C3+C3/C4)/3)*20)	30.173	36.154	37.053	36.269	33.852	33.024	34.880	30.372	33.672	29.921	40.172	32.416	34.316	26.824	32.614	32.695

Figure 2: Case number 64



DAY	1	2	5	7	8	9	10	11	12	13	14	16	17	18	19	20	21	23	24	25	26	27	28	29	31	32	35	37	38	39	40	41	42
((C1+C2+C3+C4)/400) + (((C1/C2+C2/C3+C3/C4)/3)*20)	28.764	28.966	29.303	26.127	31.894	33.016	27.774	33.513	28.865	32.805	32.835	30.426	28.908	31.858	30.520	32.510	32.004	31.681	29.446	29.284	31.294	32.656	37.114	28.145	28.764	28.966	29.303	26.127	31.894	33.016	27.774	33.513	28.865

Figure 3: Case number 68



DAY	8	9	10	11	12	13	14	15	16	17	19	23	24	25	29	1
((C1+C2+C3+C4)/400) + (((C1/C2+C2/C3+C3/C4)/3)*20)	29.769	28.302	27.489	27.471	27.953	35.108	31.022	26.153	28.792	28.230	28.477	31.990	27.395	28.621	30.104	33.452

Figure 4: Case number 75

3. CONCLUSION

At this stage we are capable of estimating menstrual cycle period in days by the use of maximum frequency formant F_1, which is a very important aspect to know gynecological status of a female. This model can be improved and software can be made so that it will be easier to know the gynecological status of a female. Our method is non-invasive and user friendly than all other known methods for estimation of menstrual cycle, which makes it more effective.

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