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DETERMINING THE ECG 1 CYCLE WAVE USING DISCRETE DATA

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ABSTRACT

The objective of this article is to present the recording results of the ECG examination intended to obtain the wave of each cycle. A method to represent each cycle duration of the wave from the discrete data ECG record has been made. The duration from R-peak to R-peak is used as a period of each cycle. The retreat time shift of the half HR is the last wave from the previous cycle. The discrete data from the MIT-BIH and the results of the measurement itself are used as the data to obtain the number of the cycle in the ECG record, the R position of each cycle, the duration of each cycle and the heart rate value.
Keyword *: Cycle Duration ,Count Of Cycle, Discrete Data, ECG*

1. INTRODUCTION

The result of the Electrocardiograph examination of each patient is usually represented in the form of the wave in the monitor screen or is directly printed in a piece of paper special for Electrocardiogram (ECG). The background of the vertical and horizontal lines in the monitor or in the paper is used as an aid to count the wave using a mV unit for the amplitude and a ms unit for the duration [7,5]. A accurate examination of many cycles is needed in order to know the morphology and to determine the heart rate, while the examination of a cycle is required to understand the peak, the segment and the interval of the PQRST values. In a record of the ECG result, the duration of each period may be counted from the peak to peak distance [2,8,9], the beginning and the ending points of a cycle is difficult to obtain, however. A cycle is a time period needed to extend the impulses from the Sino Atrial node to the Purkinje fibre, and and returning to Sino Atrial node and so on [7]. It is on the basis of the information from each cycle that various heart diseases such as coronary, miocard infarct, hiperthropy, fibrillation, ischemia, arrhythmia, tachicardia, etc may be diagnosed [15].

Other researchers working on the discrete ECG data among others are Alfredo IM & Qinghua Z,(Proceedings of the 29^{th} annual International Conference of the IEEE EMBS, France, 2007) concluding that the QRS in a cycle may be detected using statistics. The difference with the present research is that it is intended to divide the results of the ECG examination in the discrete form into its cycles.

Remembering the importance of the information on waves in each cycle, it is necessary to know how to determine each of the cycle from the result of the ECG wave, where the wave of each cycle is required to obtain the accuracy of the values of the PQRST peak, heart rate or the wave trajectory length in each cycle. This may be reached if in each examination of the patient, the ECG wave represented is taken into account, and also the sampling process using a certain frequency is also made. The sampling process will produce discrete data which are the amplitudes as the time function [2, 12]. The stored discrete data enable the ECG data to be printed or represented either in the monitor or in a piece of paper. Moreover, the discrete data may be copied, sent to other concerned persons, or processed using another software.

On the basis of the description above, this article is intended to determine the ECG components such as the waves, the intervals and the segments.

2. ECG WAVES

Any periodic impulses emitted by Sino Atrial node (natural heart pacemaker) cause some systole/contractions and diastole/relaxations in the heart muscles which at last will result in beat waves as the mechanism of the heart pump [15]. In a

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cycle, impulses are emitted through the channel from the internodus atrium, AV node, bunder of HIS to the Purkinje fibre [15]. A heart functions as a pump to channel the blood from the heart to the lungs (pulmonal) or from the heart to all parts of the body (perifer) [15]. Figure 1 presents the heart electrical system. A normal heart shows 60-100 beats per minute called heart rate (HR). If the HR is under 60, it is called Bradicardia and above it, Tachicardia [15].

If a doctor examines a patient's heart using an Electrocardiograph, he will get an ECG wave represented in the monitor or at the paper special for the ECG. This wave is the representation of a part of the heart from the lateral, inferior, septal and anterior sides [15]. Figure 1 presents the heart electrical system, Figure 2, the side of a heart examined and Figure 3 shows the result of the heart examination using an electrocardiograph 12-lead.

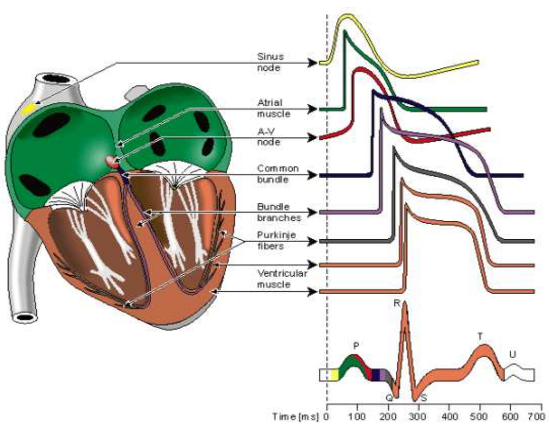

Figure 1. The Heart Electrical System

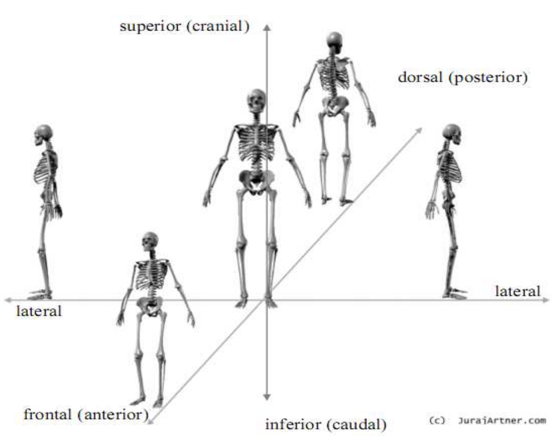

Figure 2. The Heart Sides Examined Using ECG

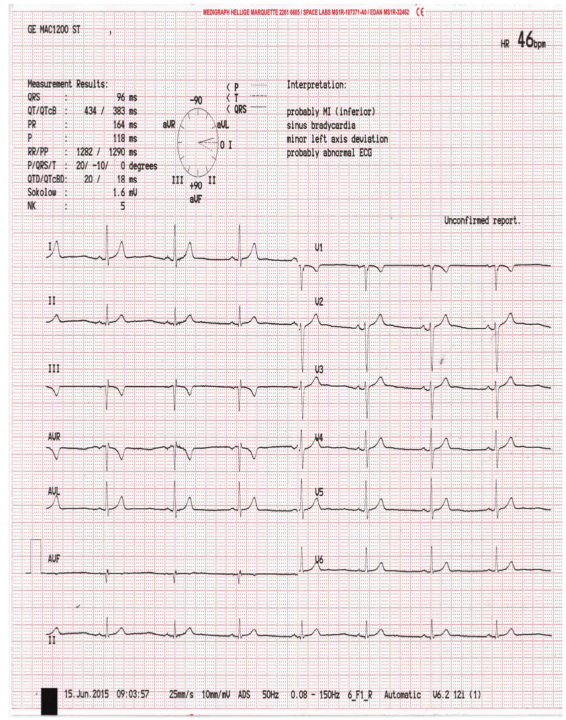

Figure 3. The Results of the Heart Examination Using the ECG 12-lead

On the base of the wave presentation in Figure 1, the examiners (cardiologist or the ECG expert) will be able to diagnose the patient's heart condition. The examination starts from the whole wave presentation to the peak amplitude of a cycle. The number of cycles in general will be determined by counting the number of the peak amplitude of the R wave at the lead II and I [1, 3, 5].

3. DISCRETE DATA

All the natural condition in the world in general is a continuous, analogue signal, a phenomenon or symptom as a time function [4, 7,9]. A discrete signal is the result of sampling from the analogue signal with a certain sample frequency [4]. If a cycle of a signal in the sampling has a frequency of 250 Hz, for example, it means that in one second there are 250 sampling data. Discrete data may mean as a process of digitalization of a time function from the analogue signal, while Quantizing may mean as the process of the digitalization of the amplitudes from the analogue signal [4]. If the two processes are employed in the analogue signal, a digital signal will result in [4]. Figure 4 shows an analogue, discrete and digital signals.

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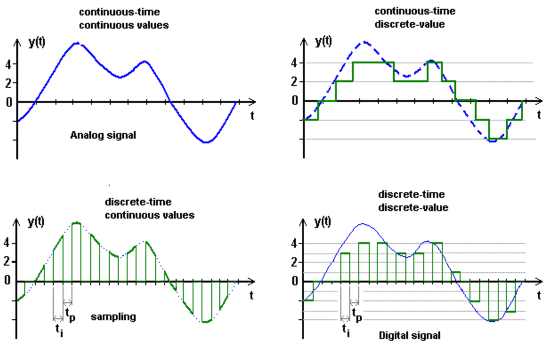

Figure 4. Analog, discrete and digital signals

4. METHOD

In this paper, a method to determine the number of cycles in an ECG record and the duration of a wave in a cycle is proposed. In this research, a quantitative approach was employed.

1. **Determining the number of the ECG cycle**

The number of cycles in general is determined by counting the number of R-peaks [3,14]. In the file of the ECG discrete data, a series of the amplitude number as a time function is shown. The amplitude shows the spread of impulses in the muscles (mV), while the time function is a sampling period (ms) [4, 6, 8]. One period is one cycle, namely the time needed to complete one wave cycle. One period may be obtained by measuring the time needed to pass from one R-peak to another R-peak [5,9]. The Algorithm to determine the number of cycle is as follows:

1. The number of R-peaks at the lead II or lead I discrete data is determined by choosing the R >1mV amplitude
2. If there is a group of numbers > 1mV, in each group the maximal value is chosen.
3. In each group, there is one value, the peak R value.
4. The maximal values and also the proper n position is ordered, where n is the sampling order. The number of the maximal values is the number of cycles in the file.

2. **Determining 1 cycle**

One cycle is determined based on the n number or the duration between one R peak to another. If Dx is the duration between the Rn peak to the Rn + 1 peak, the end cycle (ec) is the ending cycle, and the start cycle is the starting cycle, ec=Peak Rn – 0.5Dx and sc=ec-Dx

The determination of the start cycle and the end cycle is presented at Figure 5.

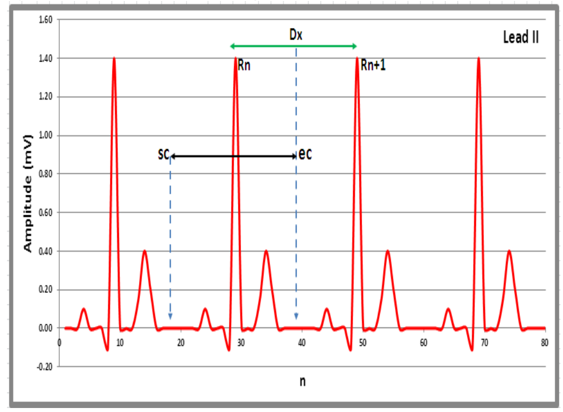

Figure 5. Determination Of The Start And End Of A Cycle

Figure 6 shows a flowchart of a patient's data recording and monitoring using discrete data. If the recording is chosen, the result of the examination will be represented and stored in the discrete file, but if the ECG monitoring is preferred, the result will be merely represented without being stored.

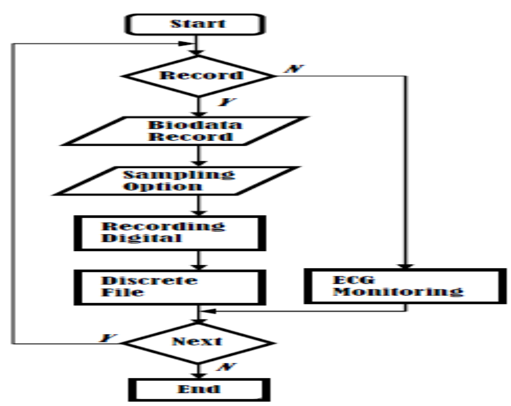

Figure 6. A Flowchart Of A Patient's Discrete Data Recording

5. RESULT

The finding of this research showed the duration of the wave in each cycle and the value of peak R in each cycle. The duration of the wave in each cycle (dx) results in the beginning and the ending positions from each cycle wave.

The discrete data used in this present research is either the Physionet MIT-BIH or the results of the researcher's measurement himself. The Data from Physionet is St Petersburg Incart 12-lead Arrhythmia database record 102 with the sampling of 250 Hz dan MIT-BIH normal sinus rhythm database record 16265 using the sampling of 125

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Hz. The results of running the program Electrocardiogram discrete (ECGd) to determine the number of cycle ECG for 6 seconds for lead II from the data record 16265 are shown at Figure 6 and the order of the cycle is shown at Table 1. For the data record 102, it is shown at Figure 7 and the order of the cycle at Table 2. The data from the researcher's measurement is Masda-01 with the sampling of 250 Hz. The result of running for the data lead II from the Masda-01 data record is shown at Figure 8 and the order of the cycle at Table 3.

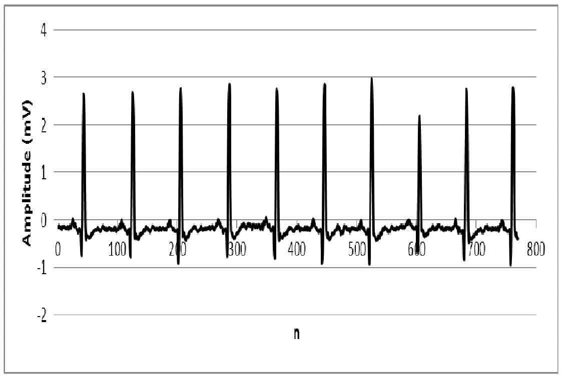

Figure 6. The Presentation Of The Lead II For Data 16265 For 6 Seconds

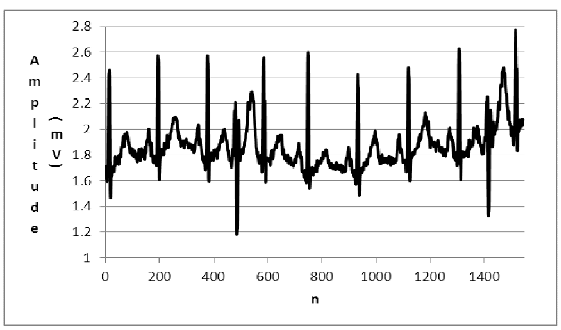

Figure 7. The Presentation Of The Lead II Data 102 For 6 Seconds

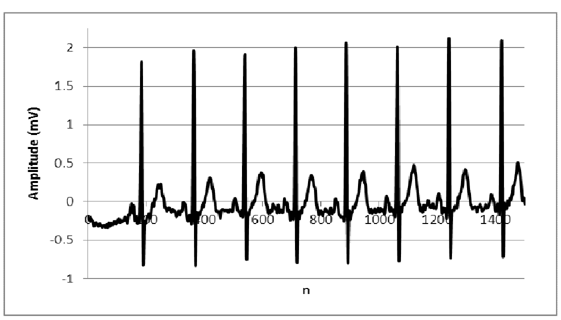

Figure 8. The Presentation Of The Lead II Data Masda-01 For 6 Seconds

Table 1. The Position Of The Peak R And N In Each Cycle Data 16265

Peak R (mV)	N position	Cycle
2.635	43	1
2.675	125	2
2.755	206	3
2.855	287	4
2.735	366	5
2.855	446	6
2.955	525	7
2.175	605	8
2.725	683	9
2.775	761	10

Table 2. Position Of The Peak R And N In Each Cycle For Data 102

Peak R (mV)	n position	Cycle
2.438	13	1
2.575	194	2
2.575	377	3
2.513	585	4
2.598	749	5
2.428	933	6
2.418	1119	7
2.627	1308	8
2.775	1516	9

Table 3. Position Of The Peak R And N In Each Cycle For Data Masda-01

Peak R (mV)	n position	Cycle
1.7927	183	1
1.9602	363	2
1.8893	538	3
1.9982	712	4
2.0593	887	5
2.0153	1062	6
2.1195	1240	7
2,0798	1420	8

From Table 1, it is known that for six-second duration there is 10-peak R, from Table 2, 9-peak R and Table 3, 8-peak R. Heart Rate (HR) is the number of the heart beat per time unit normally represented as beat per minute (bpm), based on the number of the ventricle contraction or peak R [16, 17, 18]. The normal HR in adult is 60-100 bpm. In this article, HR may be counted from (60 seconds/6 seconds) x the number of the cycle in 6 seconds [ ]. Therefore, the data 16265, 102 and data masda-01 possess HR 100 bpm, 90 bpm and 80 bpm respectively. The result of the running program to extract or to determine one cycle lead II from the data record 16265 is presented at Table 4 and its wave at Figure 8. An the result of the running program to determine one cycle lead II from the data record 102 is presented at Table 5 and its wave at Figure 9. Moreover, the result of the running program to determine one cycle lead II from data record Masda-01 is presented at Table 6 and its waves at Figure 10.

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Table 4. The Determination Of The Limit Of 1 Cycle Lead II For Data 16265

Cycle	Rn	Rn1	Dx	sc	Ec
1	43	125	82	2	84
2	125	206	81	85	166
3	206	287	81	166	247
4	287	366	79	248	327
5	366	446	80	326	406
6	446	525	79	407	486
7	525	605	80	485	565
8	605	683	78	566	644
9	683	761	78	644	722

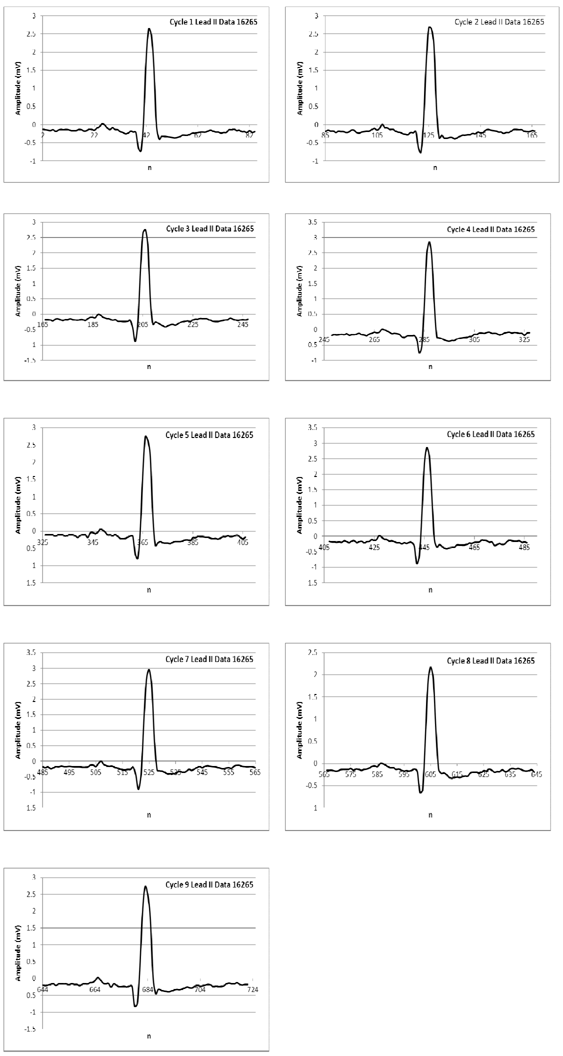

Figure 8. Extraction Of The Wave Of 1 Cycle Lead II Data 16265 In Duration For 6 Seconds

Table 5. Determination Of The Limit Of 1 Cycle Lead II For Data 102

cycle	Rn	Rn1	Dx	sc	ec
1	13	194	181	78	104
2	194	377	183	103	286
3	377	585	208	273	481
4	585	749	164	503	667
5	749	933	184	657	841
6	933	119	186	840	1026
7	119	1308	189	1025	1214
8	1308	1516	208	1204	1412

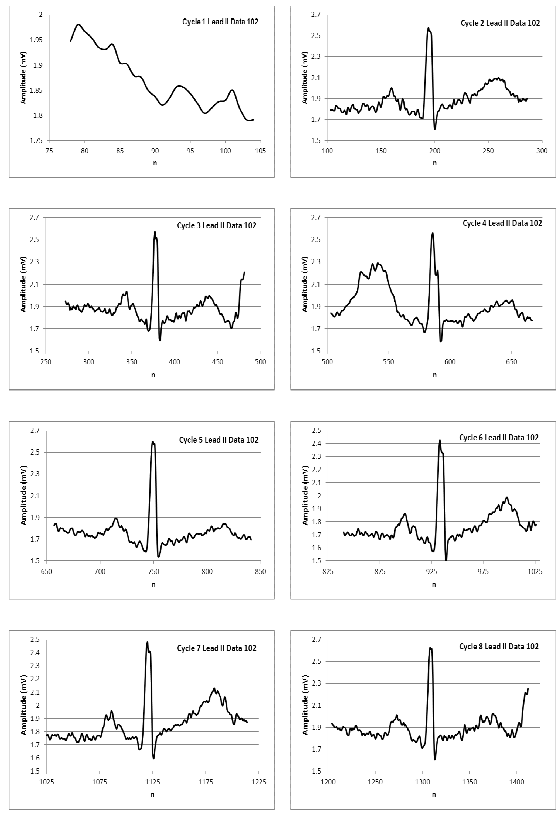

Figure 9. Extraction Of The Wave Of 1 Cycle Lead II Data 102 In Duration For 6 Seconds

Table 6. Determination Of The Limit Of 1 Cycle Lead II For Data Masda-01

cycle	Rn	Rn1	Dx	sc	Ec
1	183	363	180	93	273
2	363	538	175	276	451
3	538	712	174	451	625
4	712	887	175	625	799
5	887	1062	175	799	974
6	1062	1240	178	973	1151
7	1240	1420	180	1150	1330

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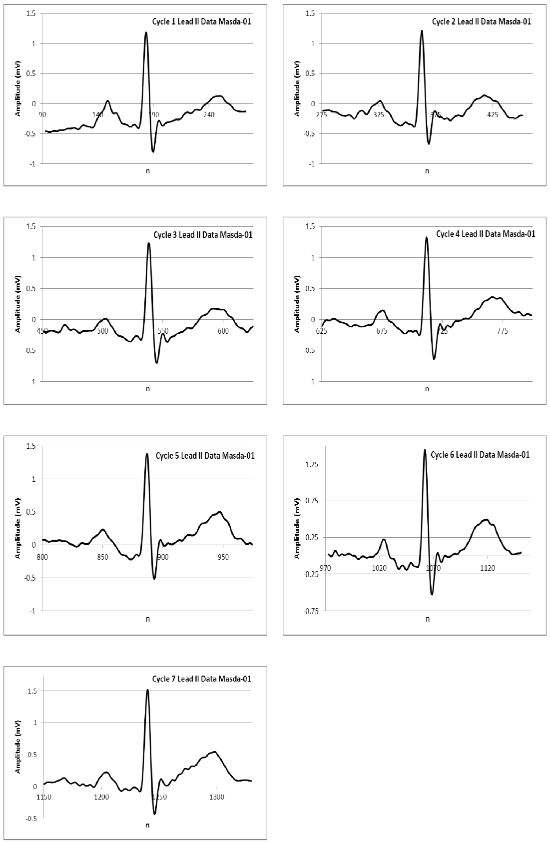

Figure 10. Extraction Of Wave Of 1 Cycle Lead II For Data Masda-01 In Duration For 6 Seconds

The sampling process with the frequency of 125Hz will possess step n with the duration of 8 ms, while the sampling with the frequency of 250 Hz will have step n with the duration of 4 ms [4, 13, 15]. Therefore, the duration of 1 cycle for the data 16265, 102 and masda-01 is shown at Table 7, Table 8, and Table 9, respectively.

Table 7. Duration Of Each Cycle For Data 16265

Cycle	Dx	Duration (second)
1	164	0.656
2	162	0.648
3	162	0.648
4	158	0.632
5	160	0.640
6	158	0.632
7	160	0.640
8	156	0.624
9	156	0.624
Average duration		0.638

Table 8. Duration Of Each Cycle Of The Data 102

Cycle	Dx	Duration (second)
1	181	0.724
2	183	0.732
3	208	0.832
4	164	0.656
5	184	0.736
6	186	0.744
7	189	0.756
8	208	0.832
Average duration		0.751

Table 9. Duration Of Each Cycle O For Data Masda-01

Cycle	Dx	Duration (second)
1	180	0.720
2	175	0.700
3	174	0.696
4	175	0.700
5	175	0.700
6	178	0.712
7	180	0.720
Average duration		0.707

On the basis of the average duration at Table 7, Table 8 and Table 9, the numbers of cycle for one minute for data 16265, 102 and data masda-01 for one minute are 94.01 bpm, 79.84 bpm dan 84.88 bpm, respectively. The numbers are the heart rate based on the number of cycles.

6. CONCLUSION

On the basis of the description above, it can be concluded that the inter-cycle duration (dx) and the peak value among the R are not always the same. The determination of the number of cycles may be easily counted based on the number of the R peak. The final determination of the cycle may be counted by shifting a half duration from one R peak to another. The examination using any hardware and software of Electrocardiogram discrete (ECGd) may store a patient's data digitally. The file of such digital data may be used as a patient's medical

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record that may be presented or printed any time. The Software designed in this present research may easily know each R peak and the number of cycles in the results of the ECG record, extract the duration for each cycle, or understand the heart rate. In this research, there are some differences in the values of the heart rate between the basis of the number of the R peak and of the cycles.

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REFERENCES

[1] Ali Zifan, et.all, 2005. *Automated ECG segmentation using Pecewise derivative dynamic time warping*, International Journal of Biological and life Science 1:3 2005.

[2] Alfredo IM, Qinghua Z, 2007. *An Algorthm for QRS onset and offset detection in single lead electrocardiogram records*. Proceeding of the 29th annual International Conference of the IEEE EMBS, Lyon-France.

[3] Andreas S, et.all, 1998. *Analysis of beat to beat variability of frequency contents in the Electrocardiogram using two-dimensional Fourier Transforms*. IEEE transactions on Biomedical Engineering, vol.45, No.2, February 1998

[4] Ashish Birle, Suyog Malviya, Deepak Mittal, 2015. *A novel technique of R-peak detection for ECG signal analysis : variable threshold method*. International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), vol.4, issue 5, May 2015

[5] David Prutchi, Michael Norris. 2005. *Design and Development of Medical Electronic Instrument*. A John Wiley & Sons, Inc., Publication

[6] Deboleena S and Madhuchhanda M, 2012. *R-peak detection algorithm for ECG using double difference and RR interval processing*. SciVerse ScienceDirect Elsevier, Procedia Technology 4 (2012) 873-877

[7] FU Huwez, PW Macfarlane, 2003. *Assesment of selected ECG voltage criteria for abnormality in Eccentric and Concentric left ventricular hypertrophy*. IEEE Computer in Cardiology, 2003;30:57-59

[8] Guyton. Arthur & Hall.E , 2008, *Textbook of Medical Physiology*, 11th edition, Elsevier, Singapore

[9] Hussain A Jaber AL, Ziarjawey and Cankaya, 2015. *Heart rate monitoring and PQRST detection based on graphical user interface with Matlab*. International Journal of Information and Electronics Engineering, vol.5, No.4, July 2015

[10] Jiapu Pan and Willis J.Tompkins, 1985. *A real-time QRS detection Algorithm*. IEEE Transactions on Biomedical Engineering, vol.BME-32, No.3, Marc 1985

[11] Kamalapriya M and Renulakshmi R, 2012. *Electrrocardiogram signal analysis using zoom FFT*. IEEE Biosignal and biorobotics conference (BRC), 2012

[12] Mohammad Rakibul Islam, et.all, 2015. *Arrhythmia detection technique using basic ECG parameters*. International journal of Computer Applications (0975-8887) vol.119, No.10,June 2015

[13] PA Otubu, *For the Realisation of the design of Electrocardiogram for the Monitoring of the Physiology of Human Heart*, Journal of Engineering and Applied Sciences 3(11):856-860, 2008. ISSN:1816-949X,@Medwell Journals, 2008

[14] Rashid GA, Mohammad AT, 2015. *ECG based detection of left ventricular hypertrophy using higher order statistics*. IEEE 2015 23rd Iranian Conference on Electrical Engineering (ICEE)

[15] Ramesh Kumar S, *The Deterministic Chaos in Heart Rate Variability signal and analysis Techniques*, International Journal of Computer Applications (0975-8887), vol.35, no.7, December 2011

[16] Sabar S, Rasjad I, Djanggan S, Setyawan S, *Using Discrete data of ECG in the Numerical and Spectral forms*, International Journal of Electrical & Computer Sciences, IJECS-IJENS, vol.15, No.03, June 2015

[17] Sachin Singh, Netaji Gandhi, *Pattern analysis of different ECG signal using Pan-Tompkin's algorithm*, International Journal on Computer Science and Engineering (IJCSE), vol.02, no.07, 2010, 2502-2505

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[18] Thulasi Prasad S & Varadarajan S, 2015. *Analysis of ST-Segment abnormalitiesin ECG using signal block averaging Technique*. International Journal of Advanced Research in Computer and Communication Engineering, vol.4, Issue 2, February 2015

[19] Vivek SC, Durgesh KM, PB Patil, 2011. *Assessment of selected Electrocardiogram voltage criteria for left ventricular hypertrophy by using SPSS*. IEEE First International Conference on Informatics and Computational Intelligence, 978-0-7695-4618-6/11. DOI 10.1109/ ICI. 2011.69