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Technique to Obtain Peak Amplitude Electrocardiogram Based on Discrete R-R Duration

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Abstract: This study aims to obtain amplitude values using discrete electrocardiogram data based on R-R duration. The novelty in this research is to produce peak amplitude values in each electrocardiogram cycle. Discrete electrocardiogram data from cardiac examination results are filtered to obtain the peak R-value in each cycle along with the integer position. R-R duration is the duration between peak R and the next peak R, which can get an integer starting point position and an integer endpoint position in each cycle. The minimum value between the starting point integer and peak R integer will be obtained by peak Q and the integer. In contrast, the maximum value between the starting point integer and peak Q integer will obtain the peak P-value. The integer peak value, while the maximum value between integer peak S and integer endpoint will be peak value T. Obtaining peak amplitude values in each cycle, cardiologists no longer need to calculate manually using small boxes on ECG paper. Besides the examination time can be faster with better results than the manual method, the examination process will also be faster, which impacts the correct diagnosis results for patients with heart disease.

Keywords: peak amplitude, R-R duration, discrete electrocardiogram.

基於離散电阻時長的峰值幅度心電圖獲取技術

摘要：本研究旨在使用基於电阻持續時間的離散心電圖數據獲得振幅值。這項研究的新穎之處在於在每個心電圖週期中產生峰值振幅值。對來自心臟檢查結果的離散心電圖數據進行過濾，以獲得每個週期的峰值电阻值以及整數位置。电阻持續時間是峰值电阻和下一個峰值R之間的持續時間，可以得到每個週期的整數起點位置和整數終點位置。起點整數和峰值电阻整數之間的最小值將由峰值问和整數獲得。相反，起點整數和峰值问整數之間的最大值將獲得峰值磷值。整數峰值，而整數峰值S和整數端點之間的最大值將是峰值吨。獲得每個週期的峰值幅度值，心髒病專家不再需要使用心電圖紙上的小方框手動計算。除了檢查時間可以比手動方法更快，結果更好，檢查過程也會更快，這影響了心髒病患者的正確診斷結果。

关键词：峰值幅度、电阻持续时间、离散心电图.

1. Introduction

Important information on heart examination results using an electrocardiograph, both on the monitor screen and presentation on ECG paper, should contain the peak amplitude value, namely the peak P-value, peak Q value, peak R-value, peak S value, and peak T value in each lead. The P wave corresponds to atrial depolarization, the QRS wave corresponds to ventricular depolarization, and the T wave corresponds to ventricular repolarization [1], [2]. Concerning medical interpretation and diagnosis, the peak P-value is correlated with the presence of blockage or thickening of the atrial wall (atrial hypertrophy), the peak R-value is correlated with the presence of blockage or thickening of the ventricular wall (ventricular hypertrophy), and the peak T value is correlated with the presence of ischemia, injury or Myocard Infarct [3-4].

The limited information on the peak amplitude value of the results of this examination forces the doctor to perform manual calculations using small boxes on ECG paper or a ruler to get the peak

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amplitude values. This manual calculation takes a long time in observing wave morphology and is less accurate in its results, leading to errors in the interpretation and diagnosis of heart disease [5]. Based on research that has been done by researchers [6-19]. The author concludes that the determination of the peak amplitude values in each cycle has not been carried out.

This study aims to obtain amplitude values using discrete electrocardiogram data based on R-R duration. The novelty in this research is to produce peak amplitude values in each cycle. R-R duration is the duration between one R peak (Rn) and the next R peak (Rn+1) [20-22].

2. Material and Method

2.1. Material

In this study, 20 samples of discrete electrocardiogram data were used for 10 seconds, obtained from the Physionet (Massachusetts Institute Technology, MIT) as many as 10 samples of sinus rhythm [23], and 10 samples from the cardiovascular care unit (CVCU) Saiful Anwar Hospital (SAH) Malang. Each Physionet sample consists of 2 leads (lead II and lead V2), while each SAH sample consists of 12 leads (I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6) [24], [25]. The step data integer (n) represents 8 ms for the Physionet sample and 4 ms for the SAH sample. Table 1 shows the sample data for Physionet record 16265, and Fig. 1 shows the electrocardiogram for lead II. Table 2 shows the sample SAH record 1825001, while Fig. 2 shows the electrocardiogram for lead II.

Table 1 Sample Physionet record 16265

n	lead II (mV)	lead V2 (mV)
1	-0.145	-0.015
2	-0.125	0.005
3	-0.145	-0.005
4	-0.155	-0.005
5	-0.165	-0.005
6	-0.145	-0.015
7	-0.185	-0.005
8	-0.155	-0.005
9	-0.135	0.025
…..	…..	…..
1280	-0.115	0.005

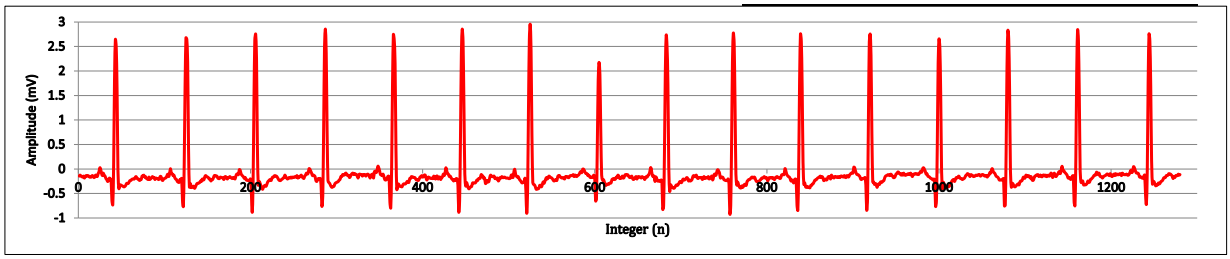

Fig. 1 Electrocardiogram lead II sample Physionet record 16265

Table 2 Sample SAH record 1825001

n	I	II	III	aVL	aVR	aVF	V1	V2	V3	V4	V5	V6
1	-0.1149	-0.1301	-0.0152	0.1225	-0.0499	-0.0727	-0.1083	-0.0873	-0.0552	-0.1432	-0.165	-0.1171
2	-0.1121	-0.1253	-0.0132	0.1187	-0.0495	-0.0693	-0.1066	-0.0863	-0.0541	-0.1444	-0.1672	-0.1178
3	-0.1078	-0.1216	-0.0138	0.1147	-0.047	-0.0677	-0.1072	-0.0876	-0.0563	-0.149	-0.1707	-0.1197
4	-0.097	-0.1188	-0.0218	0.1079	-0.0376	-0.0703	-0.1116	-0.0921	-0.062	-0.1568	-0.1761	-0.1238
5	-0.0841	-0.1145	-0.0304	0.0993	-0.0269	-0.0725	-0.116	-0.0957	-0.0668	-0.1621	-0.1791	-0.1265
6	-0.078	-0.1116	-0.0336	0.0948	-0.0222	-0.0726	-0.1169	-0.0957	-0.0676	-0.1619	-0.1773	-0.1259
7	-0.0813	-0.1101	-0.0288	0.0957	-0.0263	-0.0695	-0.1168	-0.0959	-0.0671	-0.1603	-0.1739	-0.1236
8	-0.0904	-0.1089	-0.0185	0.0996	-0.036	-0.0637	-0.1183	-0.0983	-0.0683	-0.1607	-0.173	-0.1217
9	-0.1006	-0.1081	-0.0075	0.1043	-0.0466	-0.0578	-0.1217	-0.1028	-0.0715	-0.1639	-0.1755	-0.1212
……	……	……	……	……	……	……	……	……	……	……	……	……
2500	0.1555	0.3287	0.1732	-0.2421	-0.0088	0.251	-0.053	0.3012	0.2862	0.1318	-0.0294	0.0665

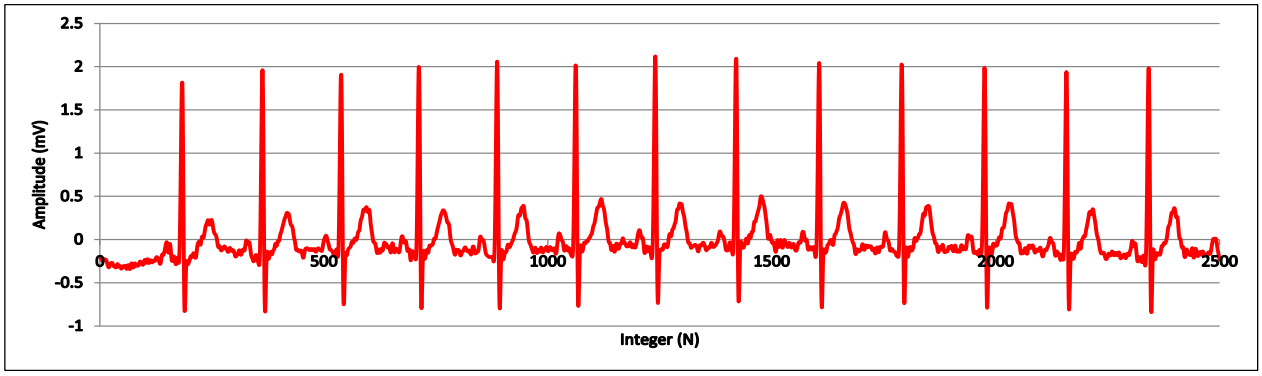

Fig. 2 Electrocardiogram lead II sample SAH record 1825001

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2.2. Method

In this research, the steps taken are to follow the flowchart of the R-R algorithm as shown in the picture, and the explanation is illustrated in Fig. 4 [20].

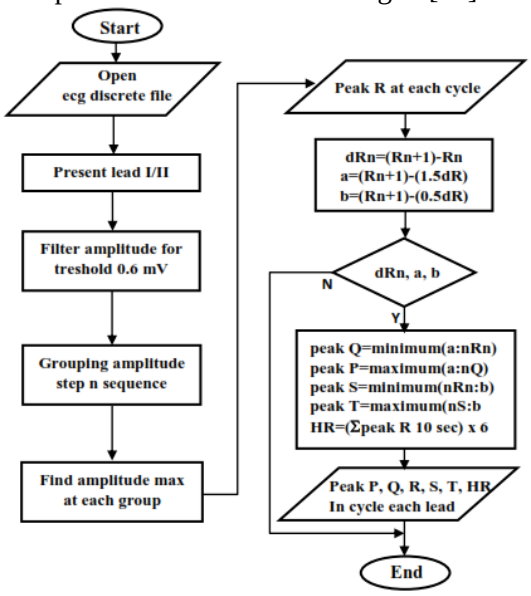

Fig. 3 Flowchart of finding peak amplitude values in each cycle

Considering Fig. 3, select the sample file to be processed, then choose Lead I or Lead II to represent the morphology electrocardiogram. (Selection of lead I or lead II data depends on the clarity of the electrocardiogram display).

Determination of peak R in each cycle: Filter the amplitude values at a threshold of 0.6 mV, and group the amplitude values with consecutive integer steps. (This 0.6 is the minimum limit for the peak R amplitude and the maximum value for the amplitude peak P and the peak amplitude T) [26]. Find one maximum value from each group (peak R) and its integer position (nRn).

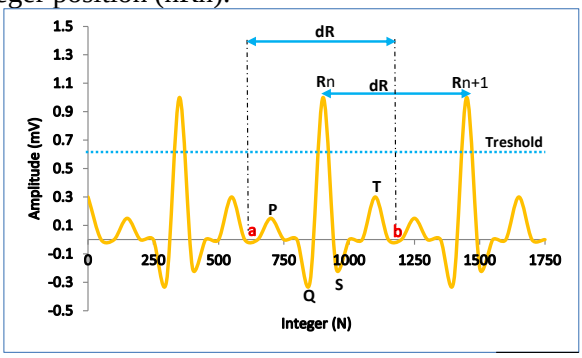

Fig. 4 Illustration of finding the peak amplitude value in each cycle

Determination of the position of the starting point (a) and the endpoint (b) of each cycle (Fig. 4): Calculate duration dR = (position Rn+1) – position Rn. The position of the cycle starting point *a*:

a = (position Rn+1) – (1.5× (position Rn))

The position of the cycle end point *b*:

b = (position Rn+1) – (0.5× (position Rn))

Determination of peak Q value (Fig. 4): Minimum a:nRn, nQ (peak Q position).

Determination of peak P-value (Fig. 4): Maximum a:nQ.

Determination of peak S value (Fig. 4): Minimum nRn:b, nS (peak S position).

Determination of peak T value (Fig. 4): Maximum nS:b.

3. Result and Discussion

Table 3 shows the peak R and its integer position in each cycle for the sample Physionet record 16265. The 16 peak R also represents the number of cycles, where the duration of dN, position *a*, and position *b* in the 16th cycle do not match. This discrepancy is caused because the value of N in the 17th cycle does not exist (considered zero), which also affects the determination of the position of point *a* and the position of point *b*.

Table 3 Peak R each cycle and duration lead for sample 16265

Cycle	N	Peak R (mV)	dN (ms)	a	b
1	43	2.635	82	2	84
2	125	2.675	81	85	166
3	206	2.755	81	166	247
4	287	2.855	79	248	327
5	366	2.735	80	326	406
6	446	2.855	79	407	486
7	525	2.955	80	485	565
8	605	2.175	78	566	644
9	683	2.725	78	644	722
10	761	2.775	78	722	800
11	839	2.745	81	799	880
12	920	2.755	80	880	960
13	1000	2.655	80	960	1040
14	1080	2.825	81	1040	1121
15	1161	2.835	83	1120	1203
16	1244	2.745	-124	1866	622

Table 4 shows the peak R and its integer position in each cycle for the 1825001 sample. The 13 peak R also represents the number of cycles, where the duration dN, position *a*, and position *b* in the 13th cycle do not match. This discrepancy is caused because the value of N in the 14th cycle does not exist (considered zero), which also affects the determination of the position of point *a* and the position of point *b* in each cycle.

Table 4 Peak R each cycle and duration lead II for sample 1825001

Cycle	N	Peak R (mV)	dN (ms)	a	b
1	183	1.793	180	93	273
2	363	1.960	175	276	451
3	538	1.889	174	451	625
4	712	1.998	174	625	799
5	886	1.902	176	798	974
6	1062	2.015	178	973	1151
7	1240	2.120	180	1150	1330
8	1420	2.080	186	1327	1513
9	1606	2.043	184	1514	1698
10	1790	2.026	185	1698	1883
11	1975	1.987	183	1884	2067
12	2158	1.939	184	2066	2250
13	2342	1.983	-2342	3513	1171

Table 5 Peak PQRST value lead II record 16265

Cycle	P (mV)	Q (mV)	R (mV)	S (mV)	T (mV)
1	0.025	-0.725	2.635	-0.395	-0.125
2	0.005	-0.755	2.675	-0.395	-0.135

Continuation of Table 5

3	-0.015	-0.885	2.755	-0.415	-0.125
4	0.005	-0.765	2.855	-0.375	-0.085
5	0.055	-0.785	2.735	-0.415	-0.125
6	0.025	-0.885	2.855	-0.405	-0.115
7	-0.005	-0.905	2.955	-0.415	-0.135
8	-0.005	-0.655	2.175	-0.335	-0.115
9	0.025	-0.825	2.725	-0.445	-0.125
10	-0.015	-0.925	2.775	-0.385	-0.155
11	0.005	-0.835	2.745	-0.385	-0.125
12	0.035	-0.945	2.755	-0.375	-0.065
13	0.025	-0.765	2.655	-0.405	-0.095
14	0.005	-0.755	2.825	-0.365	-0.115
15	0.055	-0.745	2.835	-0.325	-0.065
16	2.745	-0.705	2.745	-0.925	-0.065

Table 5 shows the peak values of P. Q, R, S, and T for 10 seconds in each cycle sample of 16265 lead II, while Table 6 shows the peak values of P. Q, R, S, and T in each cycle sample of 1825001 lead II.

Table 6 Peak value PQRST lead II record 1825001

Cycle	P (mV)	Q (mV)	R (mV)	S (mV)	T (mV)
1	-0.029	-0.828	1.816	-0.828	0.229
2	-0.009	-0.835	1.960	-0.835	0.311
3	0.046	-0.747	1.907	-0.747	0.377
4	0.040	-0.795	1.998	-0.795	0.339
5	0.037	-0.799	2.059	-0.799	0.391
6	0.073	-0.769	2.015	-0.769	0.470
7	0.110	-0.735	2.120	-0.735	0.420
8	0.095	-0.682	2.092	-0.682	0.502
9	0.092	-0.787	2.043	-0.787	0.428
10	0.085	-0.738	2.026	-0.738	0.391
11	0.053	-0.791	1.987	-0.791	0.420
12	0.020	-0.811	1.939	-0.811	0.353
13	-0.013	-0.825	1.983	-0.825	0.365

Table 7 shows the number of cycles and peak R max and peak R min for the SAH sample, while Table 8 shows the number of cycles and peak R max and peak R min for the Physionet sample. Refers to the heart rate (HR), which is between 60 to 100 beats per minute (bpm), bradycardia >60, and tachycardia <100 bpm [27], then all SAH samples are in normal condition. At the same time, one record (record 16273) from the Physionet sample is in tachycardia condition.

Table 7 Peak R max and number of cycle samples SAH

No	Record	Cycle	Peak R	
			Min (mV)	Max (mV)
1	1825001	13	2.175	2.955
2	1825002	13	1.784	2.119
3	1825003	11	0.750	1.021
4	1825004	11	0.723	1.344
5	1825005	14	0.713	1.354
6	1825006	11	0.870	1.185
7	1825007	13	1.716	2.072
8	1825008	10	1.829	2.888
9	1825009	14	1.393	2.196
10	1825010	16	0.321	1.158

Table 8 Peak R max and number of cycle samples Physionet

No	Record	Cycle	Peak R	
			Min (mV)	Max (mV)
1	16265	16	2.175	2.955
2	16272	10	1.055	1.615
3	16273	17	2.925	3.555
4	16420	16	1.365	2.155
5	16483	16	1.255	1.615
6	16539	13	1.315	1.775
7	16773	13	2.715	3.145
8	16786	12	2.525	2.945
9	16795	11	0.655	0.985
10	17052	11	1.185	1.465

4. Conclusion

The novelty in this research is to produce information on the peak amplitude values in each cycle of the electrocardiogram. Obtaining peak amplitude values, then manual calculations using boxes in ECG paper or rulers are no longer needed. Manual calculations that require time to observe waves are no longer needed so that inspection and diagnosis times will be faster. A fast diagnosis time will help patients with heart disease make a diagnosis so that an increase in the stage of the disease can be avoided, including preventing patient death. The proposed method presented the peak amplitude value in each cycle, namely 10 Physionet samples and 10 SAH samples.

Determination of the peak R amplitude value in each cycle lead I and lead II can be done by using a threshold of 0.6 mV and a maximum amplitude filter. The cycle duration R-R (dR) can be used to determine the boundary position of the starting point of the cycle and the position of the end of the cycle for each cycle.

5. Limitations and Further Study

This study is still limited to using discrete ECG data under normal conditions; therefore, further research needs to be done using discrete ECG data for abnormal conditions such as hypertrophy, myocardial infarction, ischemia, coronary, arrhythmia, and injury. The information presented is still limited for amplitude values in each cycle, it is necessary to develop methods that can be used to obtain segment duration and interval duration values, for example, artificial intelligence or expert systems.

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