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ALGORITHM DEVELOPMENT SIMULATOR FOR HUMAN HEART BEAT RATE

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ABSTRACT

Heart is one of the major organs in the body and it contributes a lot to the health status of humans. The heart rates measurement is varied in movement to the well beings of human. It is very difficult to determine the heart rates. This research work focuses on the determining series of human heart beat rate, using ages to determine the heart beat pattern and also to classify heart beat maximum, rest rate and reserve rate of human heart. A computer algorithm was developed called algorithm simulator to carry out the study. In accordance with this study, with the result generated using visual basic programming language, the human heart beat rate can be classified into different ways, which are maximum heart beat rate, rest rate, heart reserved rate. Human heart beat rate can be classified into different patterns and suggest the heart patient concern with any rigors We conclude that the software developed using visual basic can easily assist in checking human heart beat rate compared to the manual heart beat reading. It will serve as a way of checkmating the over work of the heart especially among the aged people.

Keywords: Heart Beat, Algorithm, Human, Heart Rest Rate, Heart Rate Maximum, Heart Reserve Rate, Stimulator.

1.0 INTRODUCTION

Heart rate can simply be described as the speed of the heartbeat measured by the number of contractions of the heart per minute (bpm). For this definition to be meaningful, an algorithm must be design to determine the human heart beat rate. Algorithm design can simply be describe as a way of using mathematical expression in solving problems. Algorithm design can be used for many solution theories such as dynamic programming and divide-and-conquer. Template method pattern and decorator pattern are the most common techniques used in algorithm design other include dynamic programming and divide-and-conquer.

Design can simply be described as the development of plan or convention for the construction of an object [15]. It can also be described as a purpose or motive [16]. Design is very useful in many areas such as Engineering, Computer science and Electronics.

The term algorithm design is very common in engineering and computer science for carrying out meaningful development especially in software engineering which is the back bone of software development. All this needs algorithm design to carry out it preplanning processes. Design of algorithm is very necessary before the task of programming can be carried out.

The essence of Algorithm design is to put the design into a meaningful scaling so that we can have a reasonable result. Divide and conquer algorithm was used in this study because is used to break down a complex problem into simpler form for efficient solution. It is used in sorting, multiplying large numbers, finding the closest pairs of points.

The term algorithm is a step by step procedure to solve a given problem. Which must be clearly represented, has beginning and must be terminated. In order To make this work more meaningful, the selected algorithm is to be applied into heartbeat functioning system since we know that heartbeat is working in a systematic format.
Heart is very important organs in human body system and it is located in the upper part of the abdominal cavity, it has the ability to circulate blood round the body, responsible for bringing in the oxygen into the body in order to make the cells alive, remove the carbon dioxide from the body, and also prevents the cardiac arrest which can lead to stroke and untimely death [13].

A computer simulation or model is a computer program that attempts to simulate an abstract model of a particular application. Computer simulations have become a useful part of mathematical modeling of many natural systems in physics, chemistry and biology; human systems in economics, psychology and social science and in the process of engineering new technology, to gain insight into the operation of those systems. Traditionally, the formal modeling of systems has been via a mathematical model, which attempts to find analytical solutions to problems which enable the prediction of the behaviour of the system from a set of parameters and initial conditions. Computer simulations are useful adjunct to purely mathematical models in science, technology and entertainment.

2.0 Literature Review

Heart rate is arguably a very easy cardiovascular measurement, especially in comparison to the invasive or noninvasive procedures used to estimate stroke volume and cardiac output. Consequently, measurement of heart rate is routinely used to assess the response of the heart to exercise, or the recovery from exercise, as well as to prescribe exercise intensities [1, 12].Given that the increase in heart rate during incremental exercise mirrors the increase in cardiac output, maximal heart rate is often interpreted as the upper ceiling for an increase in central cardiovascular function. The human heart beats is more than 3.5 billion times in an average of his lifetime. The heartbeat of a human embryo begins at approximately 21 days after conception, or five weeks after the last normal menstrual period (LMP), which is the date normally used to date pregnancy in the medical community. The electrical depolarizations that trigger cardiac myocytes to contract arise spontaneously within the myocyte itself. The heartbeat is initiated in the pacemaker regions and spreads to the rest of the heart through a conduction pathway [14]. Pacemaker cells develop in the primitive atrium and the sinus venosus to form the sinoatrial node and the atrioventricular node respectively. Conductive cells develop the bundle of His and carry the depolarization into the lower heart.

The human heart begins beating at a rate near the mother’s, about 75-80 beats per minute (BPM). The embryonic heart rate then accelerates linearly for the first month of beating, peaking at 165-185 BPM during the early 7th week, (early 9th week after the LMP). This acceleration is approximately 3.3 BPM per day, or about 10 BPM every three days, an increase of 100 BPM in the first month.

After peaking at about 9.2 weeks after the LMP, it decelerates to about 150 BPM (+/-25 BPM) during the 15th week after the LMP. After the 15th week the deceleration slows reaching an average rate of about 145 (+/-25 BPM) BPM at term. The regression formula which describes this acceleration before the embryo reaches 25 mm in crown-rump length or 9.2 LMP weeks is: There is no difference in male and female heart rates before birth [2]. Contrary to the view that under optimal conditions the heart beats sequence should remain the metronome, this is definitely not so. Due to the influence of Autonomic Nervous System, affecting the sinus node (nervous center, located in the heart, which activates each of the next cardiac cycle starting after a pause), pulse beats followed each other at different time intervals, and, as a result, the time span between two consecutive heart beats can vary over a wide range – from 400 to 1500 msec. Plotting these following time intervals graphically, we get a wavy line. It is called the Heart Rate Variability (HRV) line. It turned out that this curve is very informative. The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide. It is usually equal or close to the pulse measured at any peripheral point. Activities that can provoke change include physical exercise, sleep, anxiety, stress, illness, and ingestion of drugs [10].

The variations in heart rate may be evaluated by a number of methods. Perhaps the simplest to perform are the time domain measures. In these methods, either the heart rate at any point in time or the intervals between successive normal complexes are determined. In a continuous ECG record, each QRS complex is detected, and the so-called normal-to-normal (NN) intervals (that is, all intervals between adjacent QRS complexes resulting from sinus node depolarization) or the instantaneous heart rate is determined. The simplest variable to calculate is the standard deviation of the NN intervals (SDNN), that is, the square root of variance. Other commonly used statistical variables calculated from segments of the total monitoring period include SDANN, the standard deviation of the average NN intervals calculated over short periods, usually 5 minutes, which is an estimate of the changes in heart rate due to cycles longer than 5 minutes, and the SDNN index, the mean of the 5-minute standard deviations of NN intervals calculated over 24 hours, which measures the variability due to cycles shorter than 5 minutes. The most commonly used measures derived from interval differences include RMSSD, the square root of the mean squared differences of successive NN intervals, NN50, the number of interval differences of successive NN intervals greater than 50 ms, and pNN50, the proportion derived by dividing NN50 by the total number of NN intervals. All of these measurements of short-term variation estimate high frequency variations in heart rate and thus are highly correlated. Since many of the measures correlate closely with others, the following four measures are recommended for time domain HRV assessment

(1) SDNN (estimate of overall HRV),
(2) HRV triangular index (estimate of overall HRV),
(3)SDANN (estimate of long-term components of HRV), and
(4)RMSSD (estimate of short-term components of HRV).

2.1 Calculating the heart beat rate

In calculating the human heart beat rate, you subtract your age from 220 to get your maximum heart rate. Calculate your resting heart rate by counting your heart beats per minute when you are at rest, such as first thing in the morning. It's usually somewhere

between 60 and 100 beats per minute for the average adult.
Many texts cite the normal resting adult human heart rate range from 60–100 bpm. Tachycardia is a fast heart rate, defined as above 100 bpm at rest [3]. Bradycardia is a slow heart rate, defined as below 60 bpm at rest. Several studies, as well as expert consensus indicates that the normal resting adult heart rate is probably closer to a range between 50-90 bpm [4]. During sleep a slow heartbeat with rates around 40–50 bpm is common and is considered normal [5]. When the heart is not beating in a regular pattern, this is referred to as an arrhythmia. Abnormalities of heart rate sometimes indicate disease.

2.2 Heart Rate measure for healthy people

For healthy people, the Target Heart Rate or Training Heart Rate (THR) is a desired range of heart rate reached during aerobic exercise which enables one's heart and lungs to receive the most benefit from a workout. This theoretical range varies based mostly on age; however, a person's physical condition, sex, and previous training also are used in the calculation. Below are two ways to calculate one's THR. In each of these methods, there is an element called "intensity" which is expressed as a percentage. The THR can be calculated as a range of 65–85% intensity. However, it is crucial to derive an accurate HR_{max} to ensure these calculations are meaningful. Example for someone with a HR_{max} of 180 (age 50, estimating HR_{max} As 220 □age):

65% Intensity: (220 □(age = 50)) × 0.65 □ 110.5 bpm
85% Intensity: (220 □(age = 50)) × 0.85 □ 144.5 bpm

The maximum heart rate (HR_{max}) is the highest heart rate an individual can achieve without severe problems through exercise stress [1, 12] and generally decreases with age. Since HR_{max} varies by individual, the most accurate way of measuring any single person's HR_{max} is via a cardiac stress test. In this test, a person is subjected to controlled physiologic stress (generally by treadmill) while being monitored by an ECG. The intensity of exercise is periodically increased until certain changes in heart function are detected on the ECG monitor, at which point the subject is directed to stop. Typical duration of the test ranges ten to twenty minutes.

Adults who are beginning a new exercise regimen are often advised to perform this test only in the presence of medical staff due to risks associated with high heart rates [8]. For general purposes, a formula is often employed to estimate a person's maximum heart rate. However, these predictive formulas have been criticized as inaccurate because they generalized population-averages and usually focus on a person's age. It is well-established that there is a "poor relationship between maximal heart rate and age" and large standard deviations relative to predicted heart rates [6, 7].

The interest in improving the accuracy of maximal heart rate estimation was based on the original formula for heartbeat rate calculation HRmax=220-age. As far as we could determine from books and research, the first equation to predict maximal heart rate was developed by Robinson. His data produced the equation HRmax=212-0.77(age), which obviously differs from the widely accepted formula of HRmax=220-age. Interestingly, [7, 13 and 14] developed a multivariate equation using the variables age, age2, age4/1000, ethnicity, mode of exercise, activity levels, and type of protocol used to assess HR. However, no statistical results pertaining to significant increases in the explanation of variance in HRmax using a mutivariate model was provided by the authors. The same criticism applies to the study of [8, 9] showed that endurance training lowers HRmax, and others have shown the exercise mode specificity of HRmax an original study of HRmax using multiple independent variables is long overdue.

2.3 Methods of Measuring Heart Beat Rate

Manual measurement: Heart rate is measured by finding the pulse of the heart. This pulse rate can be found at any point on the body where the artery's pulsation is transmitted to the surface by pressuring it with the index and middle fingers; often it is compressed against an underlying structure like bone. (A good area is on the neck, under the corner of the jaw.) The thumb should not be used for measuring another person's heart rate, as its strong pulse may interfere with the correct perception of the target pulse.

The radial artery is the easiest to use to check the heart rate. However, in emergency situations the most reliable arteries to measure heart rate are carotid arteries. This is important mainly in patients with a trial fibrillation, in whom heart beats are irregular and stroke volume is largely different from one beat to another. In those beats following a shorter diastolic interval left ventricle doesn't fill properly, stroke volume is lower and pulse wave is not strong enough to be detected by palpation on a distal artery like the radial artery [14].

Electronic measurement: A more precise method of determining heart rate involves the use of an electrocardiograph, or ECG (also abbreviated EKG). An ECG generates a pattern based on electrical activity of the heart, which closely follows heart function. Continuous ECG monitoring is routinely done in many clinical settings, especially in critical care medicine. On the ECG, instantaneous heart rate is calculated using the R wave-to-R wave (RR) interval and multiplying/dividing in order to derive heart rate in heartbeats/min. Multiple methods exist:

- HR = 1,500/(RR interval in millimeters)
- HR = 60/(RR interval in seconds)
- HR = 300/number of "large" squares between successive R waves.

Heart rate monitors allow measurements to be taken continuously and can be used during exercise when manual measurement would be difficult or impossible (such as when the hands are being used). Various commercial heart rate monitors are also available. Some monitors, used during sport, consist of a chest strap with electrodes. The signal is transmitted to a wrist receiver for display.

All the measurement of heartbeat rate mentioned above can be described as a medical monitoring device. Medical monitoring devices can be found in the area of engineering, computer and electronics [9]. With the help of medical monitoring devices, physicians can get up to date information of a patient. In modern society, physicians can use this monitoring to monitor patient at critical condition. It can be used to diagonize patient with chronic infections which may affect the earth. with the review of the past methods, it is clearly shown that the device is not suitable for anybody that is not a physician. And also, the patient also find it difficult to diagonize themselves or with the assistant of the other who are a physician. Even the manual method is not easy to be used by the patient. In this study, we focus on the design of new method by which the patient can monitor their own heartbeat with the uses of computer program by translating the simple equation into computer program through the uses of algorithm. This simple program that will be developed will also assist to classify the heart beat rate into normal and abnormal through a simple calculation and this will greatly help the patient to monitor their heat beat rate in order to prevent diseases such as hypertension and stroke.

This can also serve as a training tutor for those that want to know more about the mode of heartbeat rate in order to prevent heart disease in future.

Alternative methods of measurement include pulse oximetry and seismocardiography.

2.3.1 Tachycardia

Tachycardia is a resting heart rate more than 100 beats per minute. This number can vary as smaller people and children have faster heart rates than average adults.

Physiological conditions where tachycardia occurs:

1. Exercise
2. Pregnancy
3. Emotional conditions such as anxiety or stress.

2.3.2 Bradycardia

Main articles: Bradycardia and Athletic heart syndrome

Bradycardia was defined as a heart rate less than 60 beats per minute when textbooks asserted that the normal range for heart rates was 60–100 BPM. The normal range has since been revised in textbooks to 50–90 BPM for a human at total rest. Setting a lower threshold for bradycardia prevents misclassification of fit individuals as having a pathologic heart rate. The normal heart rate number can vary as children and adolescents tend to have faster heart rates than average adults. Bradycardia may be associated with medical conditions such as hypothyroidism.

Trained athletes tend to have slow resting heart rates, and resting bradycardia in athletes should not be considered abnormal if the individual has no symptoms associated with it. For example, Miguel Indurain, a Spanish cyclist and five times Tour de France winner, had a resting heart rate of 28 beats per minute, [11] one of the lowest ever recorded in a healthy human.

3.0 Methodology

Algorithm to calculate accurate maximum heart beat rate in human, you have to:

Determine the heart rate rest

Determine the heart rate reserve

Determine the heart rate maximum

The Heart Rate Rest can be determined by using your pulse with your stop watch in ten second.

E.g. if your count is 13 in 10seconds then your rest rate = 13 * 6 = 78 beats per minutes.

The Heart Rate Maximum is determined by subtracting age from a constant number of 220.

E.g. if your age if 50. Then your Heart Rate Max = 220 – 50 which gives you 170bmp. Which shows that the difference in age have effect on the average range of Heart beat.

Heart rate reserve = Heart rate max – Heart rate rest

The heart rate reserve will be 170 – 78 = 92

Heart rate Max = Heart rate reserve – Heart rate rest

Heart rate Rest= Heart rate Max – Heart rate reserve

3.1 Algorithm used

1. Start
2. Enter your age, pulse rate and time
3. Calculate Heart rate rest
4. Calculate Heart rate maximum
5. Calculate Heart rate reserve
6. Compute the 65% Intensity rate
7. Compute the 85% Intensity rate
8. Display all the computed values
9. Stop

4.0 Discussion of Results

The following are the output generated from the algorithm above.

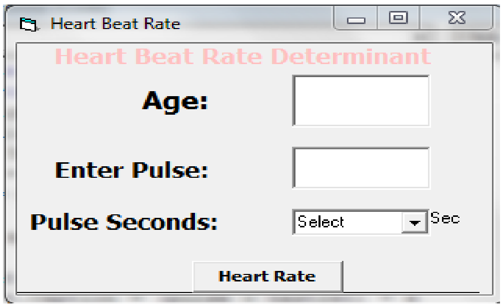

Figure 1: Heart Beat Rate Interface.

Figure 1 displays the form where the individual will be asked to enter his age, pulse and select the time in seconds so as to calculate his heart rate rest, heart rate maximum, heart rate reserve and also the heart intensity.

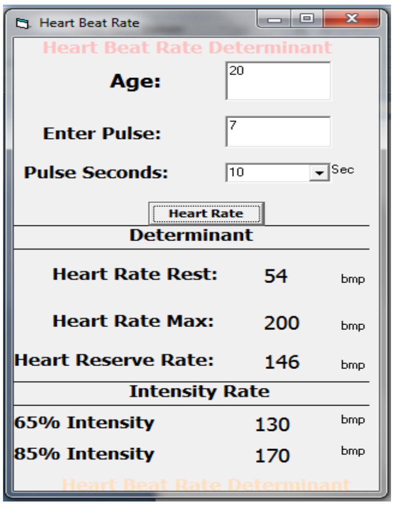

Figure 2: Heart Beat Determinant with age range 20years.

Figure 2 display the determinant of human Heart Rest Rate, Maximum Rate and Reserved Rate to be 54bmp, 200bmp and 146bmp respectively from the supplied value age, pulse and time of 20years, 7 and 10seconds respectively.

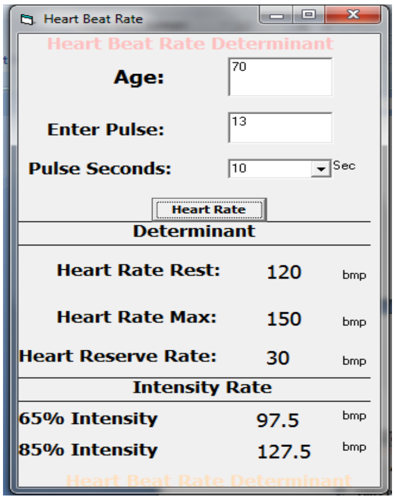

Figure 3: Heart Beat Rate of age 40.

This figure displays the Heart Beat Rate of age 40years and calculates the Rest rate, Maximum Rate and Reserve rate which gives 102bmp, 180bmp and 78bmp respectively with the intensity rate to be 117bmp and 153bmp respectively.

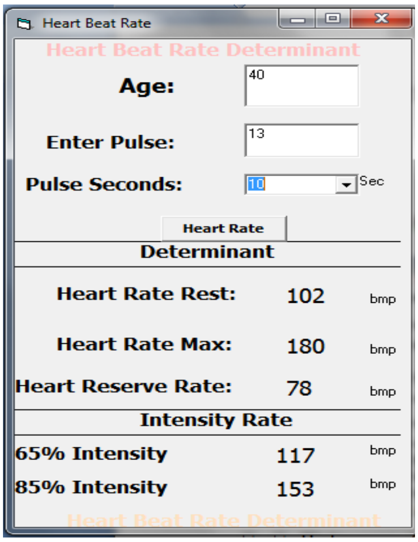

Figure 4: Heart beat rate of age 55.

Figure 4 display the determinant of human Heart Rest Rate, Maximum Rate and Reserved Rate to be 108bmp, 165bmp and 57bmp respectively from the supplied value age, pulse and time of 55years, 13 and 10seconds respectively.

This figure displays the Heart Beat Rate of age 70years and calculates the Rest rate, Maximum Rate and Reserve rate which gives 120bmp, 150bmp and 30bmp respectively with the intensity rate to be 97.5bmp and 127.5bmp respectively.

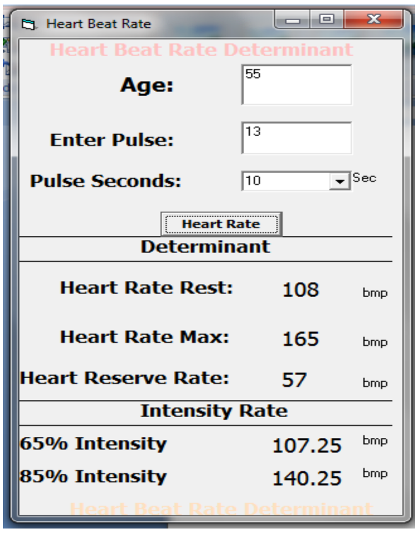

Figure 5: Heart beat rate of age 70.

Table 1: Generated Result from the application.

Age	Pulse	Time	Heart Rate Rest	Heart Rate Maximum	Heart Reserve Rate	65% Intensity Rate	85% Intensity Rate
20	7	10	54	200	146	130	170
40	13	10	102	180	78	117	153
55	13	10	108	165	57	107.25	140.25
70	13	10	120	150	30	97.5	127.5

The table 1 shows the generated results from different age. From the table it can be deduced that as the age increases the rate rest of the heart beat increases while the maximum and reserve rate of the heart beat reduces also the intensity of the heart beat reduces.

5.0 CONCLUSION AND RECOMMENDATION

The whole process of this paper concludes that the algorithm developed stimulator used in the application is reliable and will always give reliable results and an unbiased judgement in calculating the heart beat rate.

The research also draw up a conclusion that for a reliable result to be gotten the user must implement all the processes with the right tools (age, pulse and time) and equipment so has to come up with the desired results. It can also be concluded that the heart functions most at the tender rate and reduce its functionality at adult stage.

It is therefore recommended that the application should be implemented with the right tools specified by the research so as to obtain the desired results.

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