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A FRACTAL APPROACH TO THE DIAGNOSING PROCESS OF EPIDEMIC COVID-19 CARDIAC DISEASES

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Abstract: Covid-19 is the biggest identified group of tremendous RNA viruses with an extensive kind of herbal hosts and an international danger to public health and is caused by SARS-CoV-2. It reaches the cells via the angiotensin-converting receptors of enzyme 2. The modern-day results confirmed that the fatality danger for patients with heart illnesses (10.5 %) was higher than patients with different chronic health situations (7.3 % for diabetes, 6.3 % for chronic breathing disorders, and 5.6 % for cancer). In this paper, to scrutinize the impact of covid-19 in cardiac patients, fractal elements are used. Based on Higuchi's dimension ($\boldsymbol{HD}$) and Rescaled range method ($\boldsymbol{R/S}$), very minor ECG modifications are described. Through this, we examined the cardiac state of Covid-19 patients.

Index Terms **- Electrocardiography signals (ECG), Fractal dimension, Heart rate time series, Cardiac disease.**

I. INTRODUCTION

Due to the currently discovered SARS-CoV-2, Coronavirus contamination is a unique infectious ailment. The epidemic of Covid-19 turned into the maximum urgent check of countrywide capacity to respond to a health emergency. Covid-19 cases have been said for the primary time in China, but in a count number of days, after the epidemic began to spread, it was confirmed as a public health emergency of global significance. Here after it expanded exponentially and spreading across the globe. The range of deaths accompanied, as reported instances rose. It was defined as a virulent disease [1] after only a few weeks. Globally more than 300 international locations, areas, or territories and $>$ 1,12,649,371 confirmed instances of Covid-19, consisting of $>$ 25,01,300 deaths were stated to WHO [2].

Contemporary studies has propounded that older people and those with acute health issues, which include cardiovascular disorder (CVD) were at more threat for mortality [3].Congestive heart failure was the second most frequent baseline comorbidity 42.9% [4] in a series of 21 sufferers with Covid-19. Latest work suggested that Covid-19 can fabricate coronary heart harm, even to people with no earlier coronary heart troubles [3]. However, even though the clinical shows of Covid-19 are tormented by respiratory symptoms, [5] might also transpire via specific pathways of cardiovascular involvement.

Acute cardiac damage is the maximum extensively recorded cardiovascular abnormality 8-12 in Covid-19 patients [6]. In a sample of 187 Covid-19, 35% of CVD and 28% of acute myocardial harm had identified. Another study manifested that 23% of 191 sufferers had acute heart failure [7].

Consistent with fitness scientists, the extent of irritation is attributed to a cytokine typhoon wherein the immune system creates too much opposition to the Covid-19 virus. In preference to destroying the virus, immune cells are damaging healthy cells. A large inflammatory reaction can create a lot of anxiety at the heart, making it tough for the coronary to pump blood across the body, at the same time as the body fights off the contamination, which may lead to heart failure or cardiovascular disorder.

Fractal dimension (FracDim) is a proportion that gives a mathematical index of trouble comparing. It describes the complexity of the pattern changes with the size at which it is measured. Fractal estimations are too calculated with the help of different strategies.

The ECG signals play an important part within the cardiovascular system, as well as a fast, dependable, drawn-out and cost-effective strategy to analyze cardiac disarranges. More center has also been paid to the ECG signal examination which driving to the headway in cardiac treatment practices.

Since ECG signals have the same morphological characteristics, they are more important than other biosignals. The majority of cardiac conditions may well be remotely distinguished by considering these morphological changes. The ECG measures electrical activities actuated by depolarization of the heart muscle, which expands to the skin by throbbing electrical waves. The waves P, Q, R, S, T are delivered as a result of depolarization. The RR interim was characterized as the interim between two progressive R waves.

The ECG signals are self-similar in such a way that a fractal examination can be done for the right utilize of the data assembled so that interesting cardiac obsessive issues can be analyzed utilizing such mathematical models.

In this work, Higuchi's dimension (HD) and the Rescaled Range System (R/S) are proposed for the identification of Covid-19 cardiac defects.

II. TYPE STYLE AND FONTS

FracDim is a valuable way of quantifying basic changes in signal characteristics. ECG signals are exceedingly complex and self-similar, as a consequence FracDim is utilized to analyze cardiac illnesses. This work centers on two distinct strategies for quantifying the FracDim values of the ECG time series (RR intervals) Fig. 1.

1. Higuchi's fractal dimension (HD)
2. Rescaled Range Method (R/S)

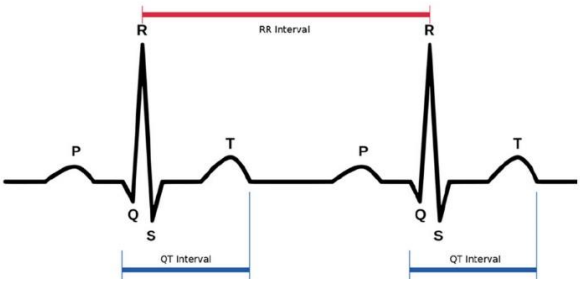

Fig.1: RR interval

2.1. Higuchi's dimension (HD)

In this method to evaluate the HD of the given n-sample data sequence s(1), s(2), ..., s(n), they are reconstructed into new sub-data set as,

$$s_t^{t_0} = s(t_0), s(t_0 + t), s(t_0 + 2t), \ldots, s\left(t_0 + \left|\frac{n - t_0}{t}\right| . k\right), \qquad t_0 = 1,2,\ldots,t$$

Where t lagged time series starting from t_0 position with gap of scale t and $L_t^{t_0}$ of each curve is obtained from the equation

$$L_t^{t_0} = \frac{1}{t}\left[\sum_{i=1}^{\left|\frac{n-t_0}{t}\right|} |s(t_0 + i.t) - s(t_0 + (i-1).t|\right] \times \frac{n-1}{\left|\frac{n-t_0}{t}\right| . t}$$

It represents the normalized sum of absolute values of difference in ordinates of pair of points distant t (with initial point t_0). The length of the curve for the time interval t is calculated as follows.

$$L(t) = \frac{\sum_{t_0=1}^{t} L_t^{t_0}}{t}$$

Then HD can be computed from the relation

$$L(t) \sim t^D$$

Here, $L(t)$ is the length of the curve that indicate the time series. HD can be obtained by plotting the logarithm of $L(t)$ vs the logarithm of $1/t$.

2.2. Rescaled Range Method (R/S)

The R/S is a statistical measure of the unevenness of the given time series and is determined by differing the range of its mean adjusted cumulative deviate series by the standard deviation. The rescaled range can change by adjusting the number of observations.

The change of R/S range can be defined by making a plot of the $log(R/S)$ vs. $log(Number\ of\ samples)$. The slope of this line gives the Hurst exponent (H). It is obtained from the equation

$$\frac{R(\tau)}{S(\tau)} = \left(\frac{\tau}{2}\right) H$$

Whereas, $R(\tau) = max\ s(t,\tau) - min\ s(t,\tau),\ 1 \le t \le \tau$;

$s(t,\tau) =$ cumulative sum ;

$S(\tau) =$ standard deviation.

The relation between *FracDim* and H can be expressed as $FracDim = 2 - H$.

III. PROCEDURE

3.1. Data Collection

Initially, databases of ECG signal were convened from variety of origins, via MIT-BIH, ESC and UCI. This may comprise of various files of ECG such as wave shapes,.mat,.csv,.xml,.dat or.txt. and it have been executed by the database banks, ECG machines, ECG amplifier and ECG simulators.

3.2. Extracting signals

This process has been conveniently achieved by a multipurpose instrument i.e., MATLAB. Initially, base and gain from raw signals had extracted by using the underneath calculation:

$$s_{new} = \frac{s_{old} - Base}{Gain}$$

Where $s =$ ECG Sample,

$B =$ Baseline Value,

$G =$ Gain Factor.

Some signals had plotted straightforwardly based on their formats (.mat). The few required transformation from one format to another format (.csv, .xml, .dat, or .txt) to .mat by the significant frequency and threshold along with re-dimensioning of the variable matrix.

3.3. Prior-Processing

The noise is expelled at the pre-processing stage or conquered by the application of special filters. This can be achieved by amplitude normalization, in which each sample of signal is separated by maximum of the absolute value of the signal and is used to restrict the dynamic spectrum of signals from-1 to 1. i.e., $\frac{s_i}{\max|s|}$ where, s_i is a sample of ECG at a particular point.

3.4. FracDim Calculation

The ECG of 50 individuals was analyzed among which 29 individuals had been affected by Covid-19 and some of them had previous heart issues. Using MATLAB, and HD and R/S were estimated. Sample figures of this study are seen in Fig. 2 and Fig. 3.

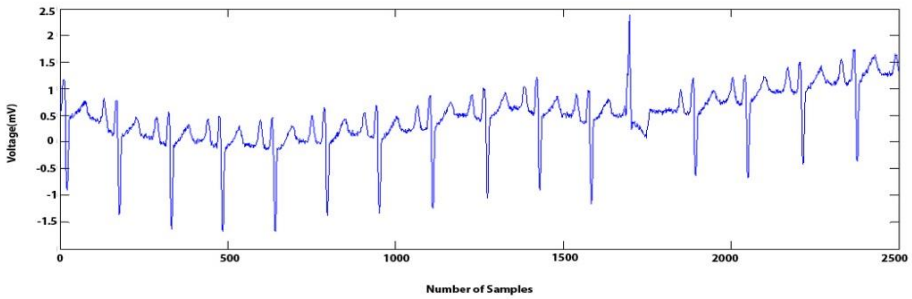

Figure. 2: ECG sample

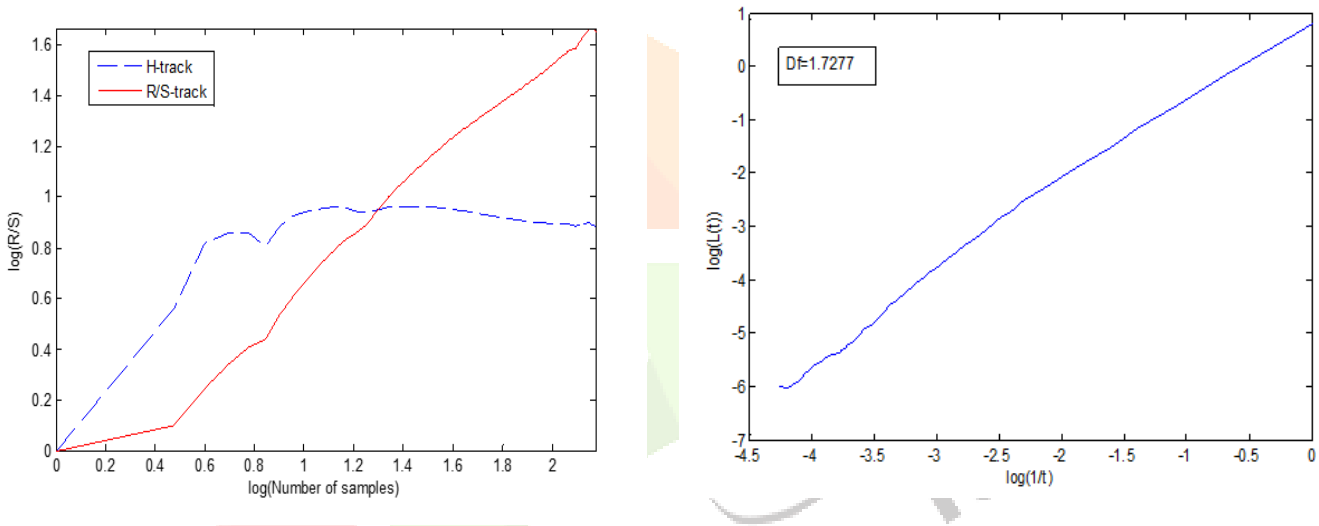

Fig. 3: Graph Outcomes of HD(Left) and R/S(Right) analysis

IV. RESULTS

This work offers the fractal measurement of both Covid-19 patients and typical people ECG. Table 2 legitimizes the reality that Covid-19 can cause enduring heart impairments. Whether Covid-19 patients are heart patients or not, the Covid-19 will make a few heart troubles for the patients. Assume, in case the persistent has any cardiac therapeutic history at that point we ought to deliver more consideration to watch their heart state something else the heart may confront gigantic problems.

More contrasts between ordinary and unusual fractal measurements will allow more accuracy in the diagnosis process. From Table 2 and Fig.4 R/S analysis provides the more difference between normal and abnormal data are compared with other methods. As a consequence R/S analysis has better accuracy to calculate fractal dimension compare with other method.

FracDim	Normal	Critical
HD	$1.6-1.8$	<1.5
R/S	$1.2-1.4$	<1.1

Table 1: Range of FracDim

	HD	R/S
Normal	1.7906	1.3847
Abnormal	1.5228	1.0955
Difference	0.2678	0.2892

Table 2: Differences between averages *FracDim*

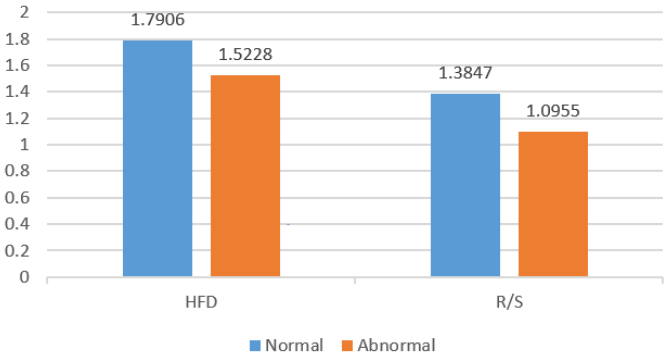

Fig. 4: Bar diagram of FracDim

V. Conclusion and Future Works

This work outfits a fractal approach to the epidemic of Covid-19 cardiac malady. Moreover utilizing fractal highlights, ECG signals are analyzed and different scale behaviors are found for individuals with a solid and undesirable heart.

Finding the *FracDim* of ECG is an easy and accurate way to diagnose heart diseases and also an inexpensive method. In the future, standardizing *FracDim* finding procedure will make a really enormous effect on the diagnosis process. We can do the same *FracDim* analysis by using the entropy method, Power spectral density method.

VI. Acknowledgment

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