MEDICAL USEAGE OF AN EXPERT SYSTEM FOR RECOGNIZING CHAOS*

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ABSTRACT

It is shown that an expert system can detect chaos in medical applications. Chaos can be seen in fibrillation of the heart and in the brain during an epileptic fit. As an example for detection of fibrillation, considered as chaos, electrocardiograms recordings are analyzed with an expert system for the possible presence of chaotic behavior.

INTRODUCTION

Chaos is an ubiquitous nonlinear phenomenon that arises naturally in all fields of science [1]. Chaos has been reported in meteorology, engineering, biology, and pertinent to this paper, medicine. Chaos exhibits random behavior and is therefore difficult to predict [2]. In fact, unless a computer of infinite word length is used in simulation to obtain a response from initial conditions, no long-term prediction of the precise solution waveform is possible [3]. In this paper, the recognition of chaos is based on the physical appearance of the chaotic spectrum as opposed to a mathematical estimation.

Chaos permeates itself in fibrillation of the heart and during an epileptic fit of the brain [4]. The trajectories of a system in chaos, the heart, can be diagnosed from electrocardiogram (ECG) recordings. It is this application that the expert system will analyze. It takes a physician or trained expert to analyze ECG's, which record electrical impulses from the heart. In situations where the experts are not physically present an expert system could accomplish this task. Two separate types of fibrillation exist, atrial and ventricular. Atrial fibrillation occurs as a result of an uncoordinated contraction following the depolarization wave (electrical discharge) through the atria. The chaotic depolarization wavelets traverse a variable course from moment to moment. These wavelets traverse whatever fibers have recovered sufficiently to conduct, producing variable fibrillation waves on the ECG. The second type of fibrillation is known as ventricular fibrillation which describes the chaos when an irregular depolarization wave spreads through the ventricles. This disorganized state results when groups of cells are discharged without regard to their neighbors. At any one moment, different fibers are found in different states of electrical and mechanical activity. Effective circulation stops with the onset of ventricular fibrillation. It is the major cause of cardiac arrest [5]. Recognition of chaos is therefore of great significance.

Atrial and ventricular fibrillation each possess distinguishable characteristics. In order to recognize these features, the major waves of an ECG cycle are traditionally labeled P, QRS and T. Depolarization of the atria produces the P wave. Depolarization of the ventricles produces the QRS deflections, known as the QRS complex, and the T wave represents repolarization of the ventricles. Measurements of these major deflections in conjunction with analyzing peak values, zero crossings and shape irregularities in the contour of the waves yields a diagnosis of the specific arrhythmia. For example, the site of the arrhythmia can be determined by measuring the duration of the QRS complex. A narrow (0.01 sec. or less) QRS is always of supraventricular origin. A supraventricular arrhythmia is one which originates in the sinus node, atria, or A-V junctional apparatus. Conversely, a broad QRS generally suggests a ventricular arrhythmia originating in the ventricles. Consequently, the site of the fibrillation can be deter-

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mined. In addition, an irregular rhythm and rapid heart rate are of significant importance to uncovering the chaotic regime. Both atrial and ventricular fibrillation exhibit system nonlinearities that lead to nonperiodic continuous time domain solutions. The configuration of the waves vary from moment to moment in which the erratic undulations are of variable contour and amplitude. These types of parameters are prompted for from the user regarding the possible chaotic ECG recording.

The rule based expert system implements a backward chaining inference strategy to arrive upon conclusions. The prototype system was developed in Personal Consultant by Texas Instruments. The underlying language is SCHEME, a modern version of lisp. Arrhythmias such as tachycardia and flutter are also diagnosed as their specific characteristics are also being analyzed concurrently with fibrillation. It is interesting to note that ventricular flutter is similar to rapid ventricular tachycardia which often progresses to ventricular fibrillation; therefore, perhaps useful in the prediction of chaos (fibrillation).

The significance of utilizing expert systems technology for recognizing chaos is a lead to the idea of a portable chaos monitoring device that could be attached to the body. The device could continuously and in real time track variations in electrical impulses from the heart and give an immediate prognosis and an alarm warning a patient of the approach of a dangerous threshold.

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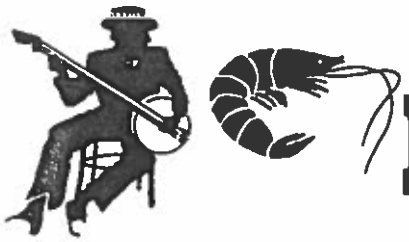

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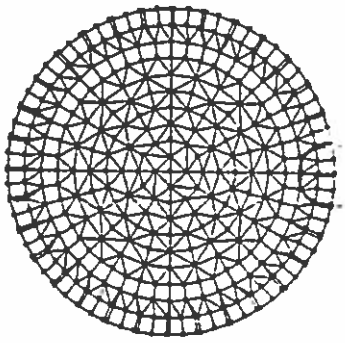

PART 3/4: COMPUTERS AND SIGNAL PROCESSING IN MEDICINE

THIS PART CONTAINS: