The dynamics of a complex system can be modelled from a single measurable quantity of the system using the recently developed methods in deterministic chaos (Schuster, 'Deterministic chaos', Physik Verlag, Heidelberg 1984). In the case of experimental signals, the existing techniques using qualitative measures like Fourier transform, autocorrelation function, etc., do not enable one to classify between low-dimensional deterministic chaos and broad band stochastic noise. But recent studies have shown that time series analysis can reveal the underlying characteristics of nonlinear dynamical systems. Moreover, such analyses give quantitative measures which are the invariants of the system (Grassberger P and Procaccia I, Phys. Rev. Lett. 50A 1983, GP algorithm). One of the interesting properties of the GP technique is that, it can give significant insight into the nature of the given system, whose basic equations are unknown.

In the analysis based on GP algorithm, equally spaced, digitized temporal or spatial variation of any measurable quantity of the system can be used as time series and finite data set is enough to give valuable information about the long-term behaviour of the system. GP algorithm is mainly used for the characterization of nonlinear dissipative systems, the basic assumption being that, time series contains all the information about the system (Packard N.H, Crutchfield J.P, Farmer J.D and Shaw R.S, Phys. Rev. Lett. 45 1980).
Time series analysis is successful in many complex systems like, for example, biological systems, climatic systems, Astronomical systems, Laser - matter interactions, chemical reactions etc. The complexity of the system is mainly due to the existence of nonlinear interactions and this leads to unpredictability in the framework of conventional methods of dynamics.

In the case of nonlinear dissipative systems, which can be represented by n ordinary differential equations, evolution of state function constitutes a flow in phase space, and in time. The flow converges towards a finite dimensional subset of the phase space known as the attractor, which is invariant under the action of flow. The geometric structure and dimension of the attractor varies with systems. In the case of a periodic system, the behaviour of the system is predictable and the attractor is independent of the set of initial conditions and such attractors are called regular attractors. But, for chaotic systems, two initially close trajectories will diverge exponentially, resulting in loss of resemblance. The attractor is said to be sensitive to initial conditions and this subset has a complicated structure and is known as strange attractor. We can model the dynamics of a nonlinear system by estimating different characteristic properties of attractors, like generalized entropies \( K_q \), generalized dimensions \( D_q \), Lyapunov exponents \( \lambda \), \( f(\alpha) \) spectrum etc.

In the present thesis, we give prime importance for the Second order dimension \( D_2 \) and Second order Kolmogorov entropy \( K_2 \). \( D_2 \) and \( K_2 \) are significant among \( D_q 's \) and \( K_q 's \) (Caputo J.G and Atten P : Phys. Rev. 35A, No.3, 1987). \( D_2 \) and \( K_2 \) are reported to be sensitive parameters to characterize dynamical systems.

\( D_2 \) and \( K_2 \) are helpful in understanding whether a system exhibits regular \( (D=\text{integer}, K=0) \), chaotic \( (D=\text{noninteger}, K>0) \) or completely stochastic \( (D=\text{undefined}, K=\infty) \) behaviour. More than that, these parameters quantify the degree of chaos in a nonlinear system.
The present thesis deals with the following studies we have carried out on neural system and certain astronomical systems in terms of D and K.

i) Human brain under clinically normal condition and under various pathological conditions like Epilepsy, Migraine, Tumour, Head ache and Psychotic, based on the analysis of Electroencephalogram (EEG), which is the electrical activity of brain.

ii) Particle distribution in Asteroidal system.

iii) Matter distribution in Saturn ring structure.

The thesis contains eight chapters. The first chapter gives a general idea about different types of dynamical systems and their phase space behaviour.

The different signal processing techniques like, fast fourier transform (FFT), autocorrelation function (ACF), Poincare method and their limitations are described in chapter II. The chapter also includes certain new concepts in nonlinear analysis, like generalized dimensions, generalized entropies, correlation dimension and Kolmogorov entropy. Detailed discussion on GP algorithm and its advantages are also given.

Usually experimental signals include noise. Hence such signals should be filtered to eliminate noise before any nonlinear analysis are done. Chapter III describes a mathematical technique to filter out noise from a time series.

A major portion of the thesis is devoted to the classification of Neural system under various pathological conditions. Studies on the relation between mental and neural activities are also attempted. Hence a general idea about the Neural system is unavoidable, and this is the subject matter of
the fourth chapter.

The evaluation of $D_2$ and $K_2$ from EEG pattern is explained in chapter V. $D_2$ is a static parameter and $K_2$ is a dynamic parameter, so that $K_2$ is more sensitive than $D_2$. Kolmogorov entropy $K_2$, which is a measure of information content, is used to characterize the dynamics of brain during mental activity and the results obtained are described in this chapter. The generalized dimensions as well as $f(\alpha)$ spectrum of a clinically normal person during rest and mental activity are compared.

Sixth chapter introduces the idea that $K_2$ can be used to classify different pathological conditions of the brain. The variation of $K_2$ at different points of the brain during an epileptic seizure is studied. The capacity of the brain to regain its original state is investigated through the analysis of EEG of a person having headache. The variation of $K_2$, in the case of psychotic, tumour and epilepsy (with demylination) are also studied.

In the case of Astronomical system, the spatial variation of particle density is used as "time series" to characterize the system. We study in chapter VII the dynamics of two astronomical systems - the matter distribution in asteroidal belt and Saturn ring structure.

In the last chapter, we discuss the results and general conclusions obtained from the present studies. Future scope of this work is also included.

In the Appendix, we discuss the algorithm (modified from GP algorithm to develop Fortran code) used in the evaluation of $D_2$ and $K_2$. This appears to be an efficient computer program which therefore enabled us to carrying out the work successfully.
Part of the investigations described in the thesis has provided materials for the following publications.

List of Research papers published

a) Standard refereed journals


b) Symposia


Papers communicated / under preparation


5. Lalaja V, Nampoori V.P.N and Pratap R, "Imaging of Brain using Kolmogorov entropy" (under preparation).