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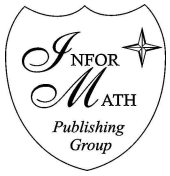

Estimating the Bounds for the General 4-D Continuous-Time Autonomous System

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Abstract: In the present paper, the general 4-D continuous-time system is considered and the estimate of the upper bound of such a system is investigated, using the multivariable functions analysis. Especially, sufficient conditions for this system to be contained in a four-dimensional ellipsoidal surface are obtained. The results obtained in this investigation generalize all the existing results in the relevant literature concerning the finding of an upper bound for the fourth order dynamical system.

Keywords: *4-D continuous-time system; upper bounds.*

Mathematics Subject Classification (2010): 65P20, 65P30, 65P40.

1 Introduction

Since Lorenz discovered chaos in a simple system of three autonomous ordinary differential equations in order to describe the simplified Rayleigh–Benard problem in 1963 [12], the analysis of dynamics of 3-D chaotic and 4-D hyperchaotic systems has been a focal point of renewed interest for many researchers [2, 3, 5, 6, 8, 13, 15, 17, 19, 21, 22, 26, 27]. Hyperchaos is characterized as a chaotic system with more than one positive exponent, this implies that its dynamics are expended in several different directions simultaneously. Thus, hyperchaotic systems have more complex dynamical behaviors than ordinary chaotic systems. As we know, there are many hyperchaotic systems discovered in the four-dimensional social and economical systems. Typical examples are 4-D hyperchaotic Chua's circuit [1], 4-D hyperchaotic Rôsslor system [18] and 4-D hyperchaotic Lorenz-Haken system [14]. Since hyperchaotic system has the theoretical and practical applications in technological fields, such as secure communications, lasers, nonlinear

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