Dynamics of Continuous, Discrete and Impulsive Systems
Series **A:** *Mathematical Analysis* **16 (2009)** 849-862
 http://www.watam.org

BIFURCATION ANALYSIS OF IZHIKEVICH NEURON MODEL

Akihisa Tamura[1], Tetsushi Ueta[2] and Shigeki Tsuji[3]

[1]Graduate School of Advanced Technology and Science
The University of Tokushima, Tokushima, Japan
[2]Center for Advanced Information Technology
The University of Tokushima, Tokushima, Japan
[3]EROTO Aihara Complexity Modeling Project
JST, Tokyo, Japan

Abstract. An autonomous differential equation with a jump has been proposed by Izhikevich for a demonstration of various spiking waves by changing its parameters. Some well-known firing patterns of this model are shown by numerical simulations, however, bifurcation analysis of the model has not been investigated in detail. In this paper, we apply our numerical computation algorithm to this model. Although it is a challenge to manage jumps with the Poincaré mapping and we obtain bifurcation parameter values by a shooting method. As a result, we conclude that some spiking modes are caused by local bifurcation of limit cycles.

Keywords. bifurcation, differential equation with jumps, Poincaré mapping.

AMS (MOS) subject classification: 34A36, 34A37

1 Introduction

There are two approaches in biological research recently. The first method consists in actual experimental analysis. The second method consists in developing mathematical models based on available data and knowledge of dynamical systems. As the experimental technique improves, a great number of data about genetics and models of biological organisms have been accumulated. According to this, the mathematical model's development is actively researched. In order to verify a model, the results of the simulation should match the experimental results. For the sake of biological science, the focus is put on the development of mathematical models.

Hodgkin-Huxley-type models and integrate-and-fire models are often refered as biological models. The former appears biologically valid, but it requires much calculations. The computational efficiency of the latter model is better, but it cannot express many different firing patterns seen in the brain. Then a simple model of spiking neurons is proposed by Izhikevich[1]. The biological plausibility of the model is as good as that of the Hodgkin-Huxley-type model. The firing pattern of all known types of neurons are