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Coexisting periodic orbits in a 3-dimensional neuronal firing rate model

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Investigation of a deterministic population based firing rate model of neurons is presented. The system describes the dynamical behavior of an excitatory and an inhibitory population and as a negative feedback of excitatory cells, adaptation current is also added. The non-linearity of the model is given by a shifted rectified linear unit function which is applied as activation function. The investigation of the model is focused on the effect of the adaptation current and the strength of connections between the two populations. Bifurcation theory is applied to study the dynamical behavior of the model. Our goal is to detect different kind of oscillations which are observed in neurobiological experiments. The piece-wise linear activation function allows us to give explicit formulas for the curves of local bifurcations. Hopf bifurcation is determined which results in birth of periodic orbits and unstable limit cycle is detected in the three-dimensional phase space via Poincaré map. The behavior of the model in the different parameter regions created by the bifurcation curves are described and a few examples for the most interesting phase portraits are shown including coexisting periodic solutions and bistability.