Scientific English Course Academic Year : 2019-2020

3rd year Licence Level Realised by: Dr.O Behadada

Academic Reading example text 2

Use the strategy of Reading Academic text on the following text

Heart activity simulation :

The study various arrhythmias development mechanisms, methods of diagnostics, and preventing ways is extremely important because in economically developed countries cardio-vascular diseases are the world'slargest killer. Among them the largest killer is so-called sudden cardiac death. Research of heart arrhythmia is performed by medicals, biologists, physicists and experts in mathematical simulation.

Heart is a dynamical system, and processes taking place can be described as an evolution of some state variables (electric membrane potential, ion channel conductivities, ion currents), so the mathematical model of heart can be obtained by analyzing the corresponding mathematical models. Cardiac tissues can be simplistically considered as a medium consisting of self-oscillatory and excitatory cells.

Then the mathematical model of heart is a system of a massive number (up to 10_{10}) of ordinary differential equations, describing the electric activity of a heart. Adequate analysis also requires account of mechanic movement of the cardiac tissue resulting in large number of additional equations. Therefore computer simulation of heart using specified models is only possible on cluster systems. The research of heart function is entering a new stage due to the two factors: sufficiently realistic cardiac tissue models based on the newest electrophysiology data and access to high performance systems capable of efficient simulation of complicated spatio-temporal cardiac processes.

There are several groups making research of heart function [8-16] and creating software for its simulation. In this paper we describe software Virtual Heart aimed at simulation of cardiac activity. This software can be used in research for large-scale simulation of spatio-temporal heart activity. It is capable of computing the current state of heart, its evolution, and integral characteristics such as virtual electrocardiogram. Another important aspect is a database containing virtual electrocardiograms, shots of spatio-temporal activity, temporal realizations of stresses at normal regime and various arrhythmias. This database can be used to help diagnostics of cardio-vascular conditions. We use multidomain heart model (Sachse F.B. et al. [17]) and highly realistic biological relevant models for heart segments (HodgkinHuxley [18], GrandiBers [9], FinkNoble [19], Courtemanche [20], Nygren [21], Stewart [22], Hoper [23]) and account for electromechanical interactions [16]. The input data is preprocessed MRT data. Based on that data we build grid and perform heart segmentation into ventricles, auricles, sinoatrial and atrioventricular nodes, bundle of His and Purkinje's fibers, fibroblasts, etc. Simulation consists of several consecutive stages, each using results of the previous one. We load the heart geometry as tetrahedral finite element mesh. After mesh normalization FEM assembler is initialized to assemble mass matrix and stiffness matrix represented in CSR sparse matrix format. Our software supports all models from open CellML storage [24] and has several preset models. The simulation can be done in sequential and parallel modes. Each iteration corresponds to ODE integration step using explicit Euler method with adaptive step size. Based on potential at mesh nodes we compute the Laplacian of the field, which is then used to compute external currents for cardiac hystiocytes at mesh nodes. The current values are used as right-hand side while solving the Poisson equation resulting in electric potential in intercellular space. Then we integrate differential equations describing electric physiology. These equations contain additional term accounting for intercellular interactions which depends on previously computed Laplacian and electric potential. The multi domain model allows for efficient research of dynamic processes control using global and localized external electric stimulation, thus enabling the development of new ways to handle arrhythmias. The

software allows to adjust models to fit specific personal parameters and test treatment methods.

From: High performance computing in biomedical applications S. Bastrakov et al. / Procedia Computer Science 18 (2013) 10 – 19