Automatic tuning of liver tissue model using simulated annealing and genetic algorithm heuristic approaches

Abstract

Mass Spring Model (MSM) is a highly efficient model in terms of calculations and easy implementation. Mass, spring stiffness coefficient and damping constant are three major components of MSM. This paper focuses on identifying the coefficients of spring stiffness and damping constant using automated tuning method by optimization in generating human liver model capable of responding quickly. To achieve the objective two heuristic approaches are used, namely Simulated Annealing (SA) and Genetic Algorithm (GA) on the human liver model data set. The properties of the mechanical heart, which are taken into consideration, are anisotropy and viscoelasticity. Optimization results from SA and GA are then implemented into the MSM to model two human hearts, each with its SA or GA construction parameters. These techniques are implemented while making FEM construction parameters as benchmark. Step size response of both models are obtained after MSMs were solved using Fourth Order Runge-Kutta (RK4) to compare the elasticity response of both models. Remodelled time using manual calculation methods was compared against heuristic optimization methods of SA and GA in showing that model with automatic construction is more realistic in terms of realtime interaction response time. Liver models generated using SA and GA optimization techniques are compared with liver model from manual calculation. It shows that the reconstruction time required for 1000 repetitions of SA and GA is faster than the manual method. Meanwhile comparison between construction time of SA and GA model indicates that model SA is faster than GA with varying rates of time 0.110635 seconds/1000 repetitions. Real-time interaction of mechanical properties is dependent on rate of time and speed of remodelling process. Thus, the SA and GA have proven to be suitable in enhancing realism of simulated real-time interaction in liver remodelling.