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Dynamic Medical Visualization

3D heart modelling from biplane, rotational angiocardiographic X-ray sequences

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Abstract

The 3DHeartView project produced an advanced software application for time-variant 3D cardiac modelling based on back projection of rotational X-ray angiographic sequences. Due to standard DICOM 3.0 interface, the software can be used as an add-on to any modern digital angiographer. The system accuracy has been measured and the approach has been validated with static and dynamic phantom object studies. The prototype has been tested in a clinical routine environment as well. In this paper we present the main features of the system, the methodology of 3D angiographic modelling, and certain testing and operation results. We also describe the application of high-performance computing technology in the modelling process. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Back projection; 3D modelling; Cardiology

1. Introduction and motivation

Cardiac diseases are the most common reason for mortality in industrial countries. Statistically, about 50% of the population will suffer from cardiovascular diseases, followed by cancer in approximately 20%. Prevalence of clinical active coronary heart disease in industrialised countries is estimated to be 3.1–3.5% of the population, representing approximately 11 million persons in the European Union only; the figures for other industrialised countries are similar. Further, in the European Union a prevalence of congenital heart defects of 2 million persons and an incidence of congenital heart defects of 40,000 individuals per year have been estimated.

For the majority of patients (e.g. coronary stenosis, congenital heart defects), X-ray angiography is the diagnostic method of choice for a variety of reasons (accuracy, high-temporal acquisition, availability, relatively low equipment cost). Although angiocardiography is a standard diagnostic tool in adult and paediatric cardiology, valid volumetric data are not available for differently shaped hearts from functional impairment and/or congenital defects. Other problems are superimposition of cardiac structures, limitations resulting from the X-ray geometry.

Infants and children with heart defects require 20,000 cardiac catheterizations and costs of nearly 35 million Euro annually. Due to difficult decision making in young children or complex cardiac defects, many patients need more than one cardiac catheterization or several cine-angiocardiograms with injections of contrast agent.

The costs of an average treatment period for ca. 5 years after myocardial infraction are as high as 40,000 Euro per patient. In the European Union annual costs of chronic ischemic heart disease could be calculated as an amount of 50–100 billion Euro. From this background, a cost-saving potential of as low as 0.1% due to better imaging and treatment with new diagnostic tools, can result in

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