INTRODUCTION

Hyperthermia treatment planning (HTP) is software used to predict the 3D electromagnetic and/or temperature distributions inside the treated volume using patient specific models [1]. At the Erasmus MC, HTP is being used for pre-treatment optimizations and to guide the hyperthermia treatment in real time [2]. The objective of this paper is to provide an overview of required hardware and software stability verification procedures as performed at our institute to ensure reliable of the HTP results, at first time use and after each upgrade of the package.

MATERIALS AND METHODS

For electromagnetic and temperature simulations, we apply the finite difference time domain simulation package SEMCAD X (version 14.8.6., Speag, Zürich, Switzerland) [3, 4]. In 2009, we developed our verification procedure based on dedicated bench-mark simulations which ensures the stability of HTP after changes, e.g. installation of a novel software version. Figure 1 shows an interface of this tool for benchmark setup two, i.e. the Lucite cone applicator (LCA) (434MHz), water bolus and homogenous muscle phantom. In this setup we verify the consistency of the specific absorption rate (SAR) distribution in the region under the LCA aperture.

Using this tool, every new version of SEMCAD X is compared and verified to the results of version 13.4. from 2008. Note that fundamental changes in the simulation software must lead to the creation of a new benchmark that is validated using measurements.

SEMCAD X allows usage of Nvidia GTX series graphical processor units (GPU). These provide a very cost effective means for computational power but, compared to TESLA series cards, do not possess memory error protection and thus could be more sensitive in terms of the stability required for clinical computations [5]. Therefore, every new PC configuration at our unit for HTP purposes is tested for reliability by a standard computer stress tool [6]. In addition, to test GPU computation stability we developed a tool (Figure 2) in which the computation domain is automatically scaled such that the entire memory of the GPU card
is used. Calculation time (one hour by default) is adjusted according to calculation speed of the GPU card by changing the amount of periods of 434MHz harmonic signal. Next the SAR distribution predictions of multiple runs (24 by default) are compared as a 24 hours stress-test of the GPU.

RESULTS

In total, we have used our verification tool for eleven SEMCAD X releases and all were accepted for clinical use. Between 2008 - 2015, the maximum SAR_{1g,IEEE-1529} difference in the area under the LCA model for all SEMCAD X versions was under 0.196%. This difference could be allocated to adjustments in the SEMCAD X gridding engine as it was detected by verification tool.

For GPU computation stability, we always obtained identical SAR results when testing the stability of the Nvidia GTX 970 card.

CONCLUSIONS

Software and hardware verification of HTP systems is important in clinical practice to ensure correct prediction of SAR/temperature distributions inside the treated region. In upcoming work we plan to extend our verification procedure for temperature simulations.

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REFERENCES


