ON A VISUALIZATION OF LOW FREQUENCY MAGNETIC FIELDS BY USING PARAVIEW PACKAGE

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Abstract

In this work we describe a process of visualization of low-frequency magnetic field generated by several coils. The technic was applied to visualize the magnetic field occurring in a special magnetotherapy device — magneto bed. The obtained image shows a patient position, coils, and the magnetic field distribution in the area of coils action. To do this we use Paraview tools, body model and the special scenario – Python language script.

1. INTRODUCTION

It is well known that the calculation and visualization of the low-frequency or constant magnetic field is both a time-and memory consuming. The computation depends on the environment geometry, field influence and the visualization method.

But in the case when we consider the magnetic field generated by a coil (that is the most frequent element in magnetotherapy devices) we can use a mathematical model where the superposition principle is applied: in this case due to constant current value the induction and self-induction are supposed to be negligible quantities and the common magnetic field is the sum of the fields generated by the contours of a coil. For several coils the magnetic field is the sum over all the coils.

In [1] this problem was solved for 3D case – the magnetic field was calculated in the points of 3D grid. In [2-4] some method for interpolation of magnetic field have been implemented. The visualization algorithms of obtained values of magnetic field were discussed in [5,6] and implemented by using Paraview package [7]. The result of the visualization showed the lines of magnetic fields in different ways depending on a selection of Paraview parameters. But such images did not show the patient position.

In this work we consider a method of visualization that shows a patient position, coils, and the magnetic field distribution in the area of effect on the patient body. To do this we use Paraview tools, body model and the special scenario – Python language [8] script. Such a scheme allows us to select a pair of coils and corresponding data file (results of calculation or interpolation) and perform the visualization. We also may to watch all the pairs step by step. Such a visualization is a practical tool and may considerably help a physician in the estimation of magnetotherapy effects.

2. VISUALIZATION OF MAGNETIC FIELD FOR MAGNETIC BED

We used a system for magneto-therapy called “magnetic bed” (Fig. 1). In every moment only one pair of coils is active. In the process of the system functioning every pair of coils is active by turns and a movement of magnetic field occurs. The order of the choice of pairs of coils is defined by a data table. The number of every coil and the coordinate system XYZ are shown on the Fig. 1.

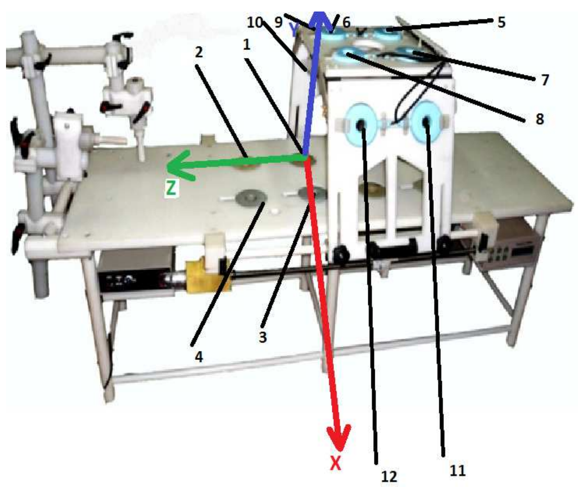

Fig. 1. Magnetic bed and the disposition of coils

In previous works we calculated magnetic field generated by a given pair of coils both by mathematical model and the interpolation using experimental data. To visualize the obtained results we use Paraviev package that allows us to show the lines of magnetic field in various regimes.

It should be noted that in the package there are tools to interpolate data for better visualization, in other words Paraview performs an interpolation automatically if necessary.

There is a possibility to show a patient position schematically. For this purpose we use a template from [9] (the file has extension .stl) and Blender package to edit 3D images [10]. To repeat similar actions for different pairs of coils it is convenient to write scenarios (scripts), i.e macros which you may run with given parameter values. Scenario files are written in Python language and have extension .py. One can write script for a pair of coils or for several ones. We may use a list of coils (where all the pairs and their parameters are given in a definite order) to obtain a script to visualize step by step all the given combinations.

In this work we used results of calculation for the following pairs of coils: (1-5),(1-7),(1-9),(3-11),(1-3),(1-11),(3-7)

The obtained data files are numbered in accordance the order in the list of coil pairs. The order of the selection of a result file is given by the user in the script. In our experiments we follow the list of coil pairs, but ot may be changed easily.

3. MAIN STEPS FOR VISUALIZATION

3.1. File loading

To visualize in Paraview the results of calculation (or interpolation by using experimental data) of magnetic field we have to load the data file: *File – Open.* Select the file required and click the button *Apply.* Data files have extension *.vtk*.

3.2. Primitive adding

If we tend to show the position of coils and the bed schematically in accordance with their sizes, we should use so called primitives or primitive objects (cylinder, line, plane, sphere, etc) by performing the following actions:

Find in menu item *Sources*, select the necessary object and then on the inlay *Properties* set up its parameters and click button *Apply*.

3.3. Object transformation

To set the primitive in the right position, which in our case is defined from the bed size and the position of the coils in the space we have perform a transformation. To do it we should select it in Pipeline Browser, then select *Filters – Alphabetica*l – *Transform*. On the inlay *Properties* set up the parameters and click the button *Apply*

3.4. Resampling

To add a model in the image (to show a patient body position) we should use a template. After the definition of parameters for primitive objects and the template we can form a final image. It is performed as follows: Select a model (file with extension .stl) in *Pipeline browser*, then select *Filters – Alphabetical – Resample with Datase*t. The file with numerical data should be taken as *Input*, file of the model as *Source*. When clicking *Apply* we apply the obtained magnetic field to the model. To set up color scale we use the inlay *Properties* (item *Colors*).

We see that it is very time consuming to repeat the same actions many times. Hence we should write macros (scenario) that describes all necessary steps.

4. HOW TO RUN A SCENARIO

When working we select *Tools – Start Scenario-name.* Then we define the required parameters, perform actions and select *Tools – Stop Scenario-name.*

An example of the scenario written in Python language may be the following.

In the text the primitive objects (that will show the coils) are created. The parameters of the objects are set up in accordance with their sizes in the magneto bed construction.

```
from paraview.simple import *

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import time

#### disable automatic camera reset on

'Show'

paraview.simple._DisableFirstRenderCameraReset()

# get active view

renderView1 = GetActiveViewOrCreate('RenderView')

# uncomment following to set a specific view size
```

```
# renderView1.ViewSize = [808, 783]
# reset view to fit data
renderView1.ResetCamera()
# create a new 'Cylinder'
cylinder1 = Cylinder()
# Properties modified on cylinder1
cylinder1.Height = 34.0
cylinder1.Radius = 58.0
cylinder1.Center = [184.0, 500.0, 116.0]
cylinder1.Capping = 0
# show data in view
cylinder1Display = Show(cylinder1, renderView1)
# trace defaults for the display properties.
cylinder1Display.ColorArrayName = [None, '']
# create a new 'Cylinder'
cylinder2 = Cylinder()
# Properties modified on cylinder2
cylinder2.Height = 34.0
cylinder2.Radius = 58.0
cylinder2.Center = [416.0, 500.0, 116.0]
cylinder2.Capping = 0
# show data in view
cylinder2Display = Show(cylinder2, renderView1)
# trace defaults for the display properties.
cylinder2Display.ColorArrayName = [None, '']
# create a new 'Cylinder'
cylinder3 = Cylinder()
# Properties modified on cylinder3
cylinder3.Height = 34.0
cylinder3.Radius = 58.0
cylinder3.Capping = 0
# create a new 'Transform'
transform2 = Transform(Input=cylinder3)
transform2.Transform = 'Transform'
# Properties modified on transform2.Transform
transform2.Transform.Translate = [550.0, 250.0, 116.0]
transform2.Transform.Rotate = [0.0, 0.0, 100.0]
# show data in view
transform2Display = Show(transform2, renderView1)
# trace defaults for the display properties.
transform2Display.ColorArrayName = [None, '']
# create a new 'Cylinder'
…
```

5. VISUALIZATION ALGORITHMS

Hence the visualization algorithm may be the following:

- Calculate magnetic field induction for given pairs of coils. Number the obtained files in accordance with the list of coil pairs.
- Put in a working directory obtained data files, file containing 3D model of a body (template) and script file. In the script file the path to the working directory is given.
- Load script in Paraview and run it. When script running we see the picture of magnetic field distribution.
- Save screenshots by using Paraview tools
- Stop script running.

The block scheme of the algorithm is the following.

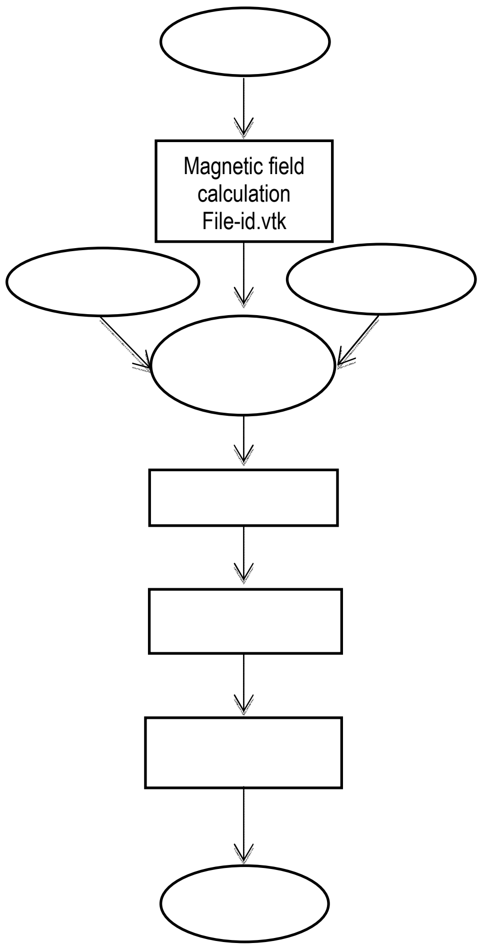

Fig. 2. Algorithm for the configuration of magnetic bed coils

Examples of visualization

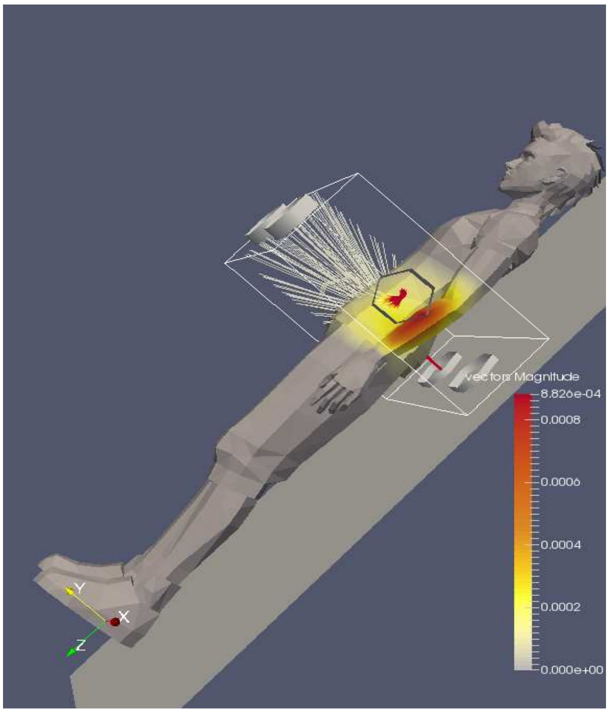

Fig. 3. Visualization results for the pair of our-of-line coils

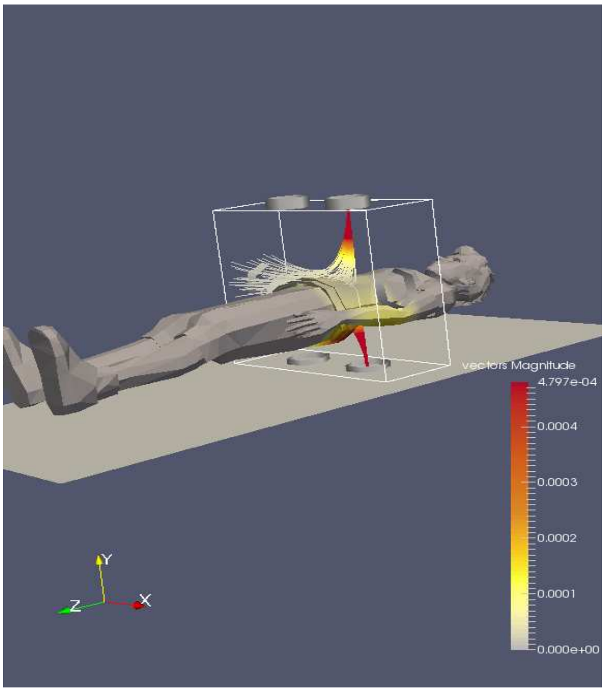

Fig. 4. Visualization results for the pair of coaxial coils

6. CONCLUSION

The implemented technic allows us to visualize the numerical data obtained by the calculation or interpolation of low-frequency magnetic field such that the position of a patient and the coils are shown. We use freeware packages Paraview and Blender, and templates for 3D images. To optimize the process of showing we use the Python language script. All the calculation may be performed before the visualization. The described method may be used for any magnetotherapy device.

7. ACKNOWLEDGMENTS

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[7] ParaView Tutorial: http://paraview.org/Wiki/images/d/d5/ParaViewTutorial398.pdf

[8] Python programming language: http://www.docs.python.org

[9] http://tf3dm.com/3d-model/boy-10833.html

[10] https://www.blender.org/