Instructions for the JPM and JPF phantoms

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Japan Atomic Energy Agency

1. Usage and citation of JPM and JPF phantoms

JPM and JPF can be downloaded and used free of charge. JPM and JPF are provided under the conditions of the MIT License. If you use JPM and JPF, you must cite the following paper [1].

[1] Sato K, Furuta T, Satoh D, Tsuda S. Construction of new polygon mesh-type phantoms based on adult Japanese voxel phantoms. PLOS ONE (https://doi.org/10.1371/journal.pone.0309753).

You are free to publish your research results obtained using JPM and JPF in papers, reports, articles, and conference presentations, if you cite the above-mentioned paper [1]. However, the developer shall not be liable for any damage caused by defects, malfunctions, or errors in the JPM and JPF phantom data itself, nor for any damage caused while using JPM and JPF.

2. License

Use of JPM and JPF is under the MIT License. Details of the MIT License are described in the "License.txt" file.

3. The JPM and JPF phantoms developed by JAEA

The adult Japanese Polygon mesh-type Male (JPM) and adult Japanese Polygon mesh-type Female (JPF) phantoms [1] were created through modification of adult Japanese Male voxel-type phantom 103 (JM-103) and adult Japanese Female voxel-type phantom 103 (JF-103) [2] previously developed at Japan Atomic Energy Agency (JAEA). Table 1 shows the physical characteristics of JPM and JPF. The body sizes (heights and body weights) and masses of organs, tissues, and organ contents in JPM and JPF were adjusted to the Japanese averages [3], except for those unimportant for radiation protection or risks. Therefore, JPM and JPF can be used for dose assessment considering the physical characteristics (e.g., height, body weight and organ mass) of the average adult Japanese.

Table 1. Physical characteristics of the JPM and JPF phantoms.

Property		JPM	JPF	Japanese average*	
Gender		male	female	male	female
Age		54	54	54	54
Height [cm]		170	155	170	155
Body weight [kg]		65	52	64	52
Number of total segmented region		198	198	-	-
Total data size of phantom [MB]	Polygon mesh	59	66	-	-
	Tetrahedral mesh	244	280-	-	-

*The averages of adult Japanese males and females were reported by Tanaka and Kawamura [3].

In addition, the identification regions of organs and tissues in JPM and JPF contain the sensitive regions of the respiratory tracts (ET1, ET2 and BB containing trachea and bronchi), the alimentary tracts (oral mucosa, esophagus, stomach, small intestine and colon), urinary bladder and lens of eye. Therefore, JPM and JPF are applicable to calculation of the exposure doses for adult Japanese according to the latest dose assessment methods [4] of the International Commission on Radiological Protection (ICRP). For more details on the above characteristics of JPM and JPF, please see to the paper by Sato et al [1].

4. Electronic data files of the JPM and JPF phantoms

To use JPM and JPF for dose calculations by radiation transport simulation code, the Particle and Heavy Ion Transport code System (PHITS) [5], the polygon mesh-type data of these Japanese phantoms were converted to the tetrahedral mesh-type data. Users can get both polygonal and tetrahedral mesh-type data of JPM and JPF from the "JPM-JPF-Phantom" repository(https://github.com/JapanesePolygonPhantom/JPM-JPF-Phantom). In addition, the "JPM-JPF-Phantom" repository also provides the information about electronical data files and license for the JPM and JPF phantoms. The "JPM-JPF-Phantom" repository is organized in two folders ("Phantom_data" and "PHITS_examples") and three files ("README-for-JPM-JPF-Phantom.pdf", "README.md" and "License"). A ZIP-format file of these electronical data for JPM and JPF can be downloaded on your PC by clicking "Download ZIP" at the bottom after selecting "Code" menu on the right side of the "JPM-JPF-Phantom" repository web page of the GitHub.

In addition, the ZIP-format package of the above electronical data files for the JPM and JPF phantoms can be also downloaded from the Release page of the "JPM-JPF-Phantom" repository. To

download the Zip-format package of electronical data files for the JPM and JPF phantoms, users need to click "Release" or "Latest version" menu on the right side of the "JPM-JPF-Phantom" repository web page of the GitHub. Then, users will then be able to obtain a ZIP-format file containing the latest electronic data for JPM and JPF after selecting “latest version” menu and by clicking "JPM-JPF-Phantom.zip" menu.

4.1 Data files in "Phantom_data" folder

This folder contains three folders named "Phantom-image", "JPM" and "JPF". The "Phantom-image" folder contains JPG format image data files (JPM-JPF-whole-body.jpg), depicting the whole bodies of JPM and JPF phantom. "JPM" and "JPF" folders contain the data files of the tetrahedral mesh-type and polygon mesh-type versions of the JPM and JPF phantoms. The file names of the tetrahedral mesh-type version of JPM and JPF phantoms are as follows.

JPM.node

JPM.ele

JPF.node

JPF.ele

The data files consist of NODE- and ELE-format files. The NODE-format files contain a list of node coordinates composing the tetrahedral mesh-type phantom data of JPM and JPF, with the following format:

- First line: <# of nodes> <dimension (= 3)> <n/a (= 0)> <n/a (= 0)>
- Remaining lines list # of points: <node ID> <x> <y> <z>

The ELE-format files contain a list of tetrahedrons composing the tetrahedral mesh-type phantoms and each tetrahedron is represented as four node IDs listed in the corresponding NODE-format files and an organ ID number with respect to the tetrahedron, and the format is as follows:

- First line: <# of tetrahedrons> <dimension (= 3)> <# of attributes (= 1, for organ ID)>
- Remaining lines list # of tetrahedrons: <tetrahedron ID> <node 1> <node 2> <node 3> <node 4> <organ ID>

Data files for polygon mesh-type version of the JPM and JPF phantoms consists of the OBJ- and MTL- format files. The names of the OBJ-format files for polygon mesh-type version of JPM and JPF phantoms are as follows.

JPM.obj

JPF.obj

“JPM.obj” and “JPF.obj” files contain polygon mesh data related to the structures and shapes of organs and tissues. The MTL-format file contains data related to the colors to be displayed on each polygon mesh data of organ and tissue. The names of MTL- format file are as follows.

JPM.mtl

JPF.mtl

The OBJ- and MTL-format files must be stored together in the same folder. By storing them in the same folder, The polygon mesh-type version of the JPM and JPF can be imported in various three-dimensional commercial software and programs such as Metasequoia (Tetraface, Japan), 3D-DOCTOR 5.0 (Able Software Corp, USA), 3ds Max (Autodesk, USA), MAYA (Autodesk, USA) and Rhinoceros (Robert McNeel, USA). The organs, tissues, and organ contents of the imported polygon mesh-version JPM and JPF are represented according to the color information specified in the MTL-format files.

Lists of the media, elemental compositions and densities. The file names are as follows.

JPM-media.dat

JPF-media.dat

The elemental compositions and densities of JPM and JPF were based on the reference data given by ICRP Publication 89 [6] and ICRU Reports 44 [7] and 46 [8] for the most organs and tissues except bones, tooth, lymphatic tissue, prostate and eye tissues (lenses, eyeballs, etc.). The elemental compositions and densities by Veit et al. [9] and ICRU Report 44 [7] were used for dose calculation of hard bone, and active and inactive marrows in each anatomical bone region. The tooth density reported by Schlattl et al. [10] was adopted for JPM and JPF. The elemental compositions and densities of the lymphatic tissue and prostate were referred to ICRP Publication 110 [11]. The elemental compositions and densities reported by ICRP Publication 145 [12] were used for the eye tissues.

The mass fractions of active and inactive marrows, endosteum and hard bone in the twenty anatomical bone regions based on the divisions in ICRP Publications 70 [13] and 89 [6]. The file names are as follows.

JPM-bone.dat

JPF-bone.dat

The volumetric data (cm^3) of various organs, tissues and organ contents in the phantom. The file names are as follows.

JPM.volume

JPF.volume

4.2 Data files in "PHITS_examples" folder

This folder contains a file named "README-Input example for PHITS.pdf" and two folders named "JPM_PHITS" and "JPF_PHITS". The file “README-Input example for PHITS.pdf” has instructions on how to implement and use JPM and JPF for dose calculations. Each folder contain example input files for implementation of the tetrahedral mesh-type version of JPM and JPF into the PHITS. Example input files are prepared for organ dose calculations due to external and internal exposures. Example input files for external and internal dose assessments stored in "External" and

"Internal" folders, respectively. These files are also useful in confirming the availability of JPM and JPF in the user's computer platform. In the example input files, the source is defined as a homogeneous liver source (for internal exposure) and a surface source located in front of the phantom (for external exposure), respectively, both emitting 1 MeV photons.

In additions, "JPM_PHITS" and "JPF_PHITS" folders also contain "Phantom" folder. ELE- and NODE- format files describing the 3D structure and shape of JPM and JPF organs, tissues and organ contents, CELL-format file describing organ identification numbers, material identification numbers and densities, and MATERIAL-format file describing material identification numbers and elemental composition are stored in the folder "Phantom". As described in Section 4.1, the NODE-format files contain a list of node coordinates composing the tetrahedral mesh-type phantom data of JPM and JPF. In addition, the ELE-format files contain a list of tetrahedrons composing the tetrahedral mesh-type phantoms and each tetrahedron is represented as four node IDs listed in the corresponding NODE-format files and an organ ID number with respect to the tetrahedron. The list of files stored in the "Phantom" folder is shown below.

JPM.cell
JPF.cell
JPM.ele
JPF.ele
JPM.material
JPF.material
JPM.node
JPF.node

Detailed information on the implementation is described in the "README-Input example for PHITS.pdf" file included in compressed file. Please note that the phantom developers shall not be liable for any result produced by any of the example input files.

5. Reference

[1] Sato K, Furuta T, Satoh D, Tsuda S. Construction of new polygon mesh-type phantoms based on adult Japanese voxel phantoms. PLOS ONE. (https://doi.org/10.1371/journal.pone.0309753).

[2] Sato K, Takahashi F, Satoh D, Endo A. Construction of average adult Japanese voxel phantoms for dose assessment. JAEA-Data/Code 2011–013. Japan Atomic Energy Agency, 2010.

[3] Tanaka G, Kawamura H. Anatomical and physiological characteristics for asian reference man. Male and female of different ages. NIRS-M-115. National Institute of Radiological Sciences, 1996.

[4] International Commission on Radiological Protection. The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann ICRP. 2007; 37 (2–4).

[5] Sato T, Iwamoto Y, Hashimoto S, Ogawa T, Furuta T, Abe S, et al. Recent improvements of the particle and heavy ion transport code system - PHITS version 3.33. J Nucl Sci Technol. 2024; 61: 127-135.

[6] International Commission on Radiological Protection. Basic anatomical and physiological data for use in radiological protection reference values. ICRP Publication 89. Ann ICRP. 2002; 32(3/4).

[7] International Commission on Radiation Units and Measurements. Tissue substitutes in radiation dosimetry and measurement. International Commission on Radiation Units and Measurements, ICRU Report 44. Bethesda, MD, USA. 1989.

[8] International Commission on Radiation Units and Measurements. Photon, electron, proton and neutron interaction data for body tissues. ICRU Report 46. International Commission on Radiation Units and Measurements, Bethesda, MD, USA. 1992.

[9] Veit R, Zankl M, Petoussi N, Mannweiler E, Williams G, Drexler G. Tomographic anthropomorphic models. Part I: Construction technique and description of models of an 8-week-old baby and a 7-year-old child. GSF-Bericht 3/89. Gesellschaft für Strahlen- und Umweltforschung, 1989.

[10] Schlattl H, Zankl M, Petoussi-Henss N. Organ dose conversion coefficients for voxel models of the reference male and female from idealized photon exposures. Phys Med Biol. 2007; 52: 2123-2145.

[11] International Commission on Radiological Protection. Adult reference computational phantoms. ICRP Publication 110. Ann ICRP. 2009; 39(2).

[12] International Commission on Radiological Protection. Adult mesh-type reference computational phantoms. ICRP Publication 145. Ann ICRP. 2020; 49(3).

[13] International Commission on Radiological Protection. Basic anatomical and physiological data for use in radiological protection: the skeleton. ICRP Publication 70, Ann ICRP. 1995; 25 (2).