DOSIS: a patient-specific MC based dosimetry toolkit for nuclear medicine procedures

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The need for a patient-specific calculation

**MOTIVATIONS**

- The increasing number of nuclear medicine techniques
- The high delivered doses involved in techniques devoted to treatments
- The growth of nuclear medicine uses in therapeutic procedures

**REQUIREMENTS**

- More accurate dosimetric assessment both in tumor tissues and organs at risk
- Millimetric resolution at voxel level
- Radiobiological effects
DOSIS calculation approaches

DPK CONVOLUTION

- Mean energy/dose radial distribution computed by analytical and numerical methods
- Capacity for voxel level assessment
- Models for non homogeneous media (in progress)

MONTE CARLO SIMULATIONS

- Radiation transport and delivered energy calculation through MC method
- Organ, sub-organ and voxel level
- Capacity for using different MC general-purpose codes physics packages (PENELOPE for now, next step FLUKA)
How to obtain patient properties?

ANATOMY

- Actual patient mass/media/tissues distribution from morphological images
- CT, MRI
- ~1-3 mm side voxel size resolution

ACTIVITY

- Actual source/radionuclides biodistribution and activity from functional images at different times
- SPECT, PET
- ~1-3 mm side voxel size resolution

Dual images techniques are recommended
3D calculation framework

**RADIOPHARMACEUTICAL CUMULATED ACTIVITY**
- Integration of patient-specific activity within ROIs along time from functional images (SPECT, PET)
- Potentiality for 2D planar dosimetry (i.e. from scintigraphic images)
  - Module dedicated to 2D dosimetry
  - Possibility of including urine and blood information for 2D dosimetry assessment

**DEPOSITED ENERGY CALCULATION**
- $\gamma$ and $\beta$ kernels obtained through analytical methods (infinite media approximation)
- $\gamma$ and $\beta$ kernels calculated through MC simulation
- DPK convolution in a water medium assuming each voxel as a potential source
- MC transport simulation and energy delivery considering patient-specific mass distribution (anatomy)
DOSIS Workflow

2D

DOSIS

MC method

3D

DPK method

MC simulation

Visualization

3D dosimetry assessment

Patient specific information

- isotope

- kernel set up

CT

mass

sources

SPECT

Transmise & planar images

Blood & urine data

ROIs selection

- Urine excretion
- WB Activity

(cnts./px) vs. t at each ROI

- segmentation - tissues

- MC parameters (eabs, # prim, etc.)
Graphical user interface

3D MONTE CARLO

PLANAR DOSIMETRY
Preliminary validation (example)

DPK


Next steps...

- To move to free languages (Python)
- To improve GUI and segmentation modules
- Free available web app
- To develop FLUKA subsroutines aimed at alpha emitters and extending to more radionuclides
- To reextend comparisons between the DOSIS toolkit and other independent calculation softwares
- To include machine learning and deep learning techniques for supporting in segmentation and visualization modules
- To complete analytic model for DPK calculation on non-homogeneous media

Run DOSIS for applications!
Thanks!

And visit us!

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