XSPECT vers 3.5c [a]

Michael Flynn

Summary:

XSPECT is a collection of programs for modeling x-ray production, attenuation, and detection for radiographic imaging systems. The spectral distribution of the source can be generated using XSPECT's semi-empirical model for electron target tubes or can be input from previously stored tabular data. Attenuation is computed from libraries having data on material composition, _materials, and data on interaction coefficients, _database. New materials can be easily added to the material library. Utility programs allow the spectra to be integrated or determination of the exposure (i.e. air ionization). From precomputed tables of signal and noise detection efficiency, the response of a particular detector system can be computed.

Documentation for each program is in the _doc directory along with supplemental documentation regarding the use of the tcl for running XSPECT programs and the use of gnuplot for plotting results. A standard file format is used to describe the spectral distribution of x-rays at various positions in the model. This format, explained in spect.tmp.txt, allows the spectral distribution to be expressed in different units.

The XSPECT version 3.5c programs have evolved from software developments begun in 1983 in the X-ray Imaging Research Laboratory at Henry Ford Health System. Contributions to this effort have come from Michael Flynn, Scott Wilderman, Zhiheng Ge, James Pipe, Sean Hames, Chip Dodge and numerous users who have contributed useful suggestions. Particular recognition must be given to the efforts of Scott Wilderman who wrote the majority of the original Fortran code and assembled the database of interaction cross sections.

Platform:

XSPECT was originally developed using a Unix Platform. The Radiation Imaging Computational Lab was originally offered on Unix systems using the c-shell script language (csh). The use of tcl/tk on Unix system was subsequently introduced. In 2004, students were offered the option of using either Windows or Unix. Beginning in 2005, support for Unix systems was dropped. Support for Linux and Mac OS is currently being developed.

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[a] Revision History:

02/18/96 03/02/03 01/17/05 01/09/11 01/11/13
01/08/16 01/07/18

Usage:

To use the XSPECT programs the appropriate links to the libraries and the executable programs must be established. The introductory modules for a computational laboratory course which uses XSPECT contain specific information on setting up these links. The subsequent course modules on sources, image formation, and image detection contain a multitude of examples that may be useful in learning how to effectively use these programs.

Models:

A model for a particular problem will usually be developed by writing a Tcl script to invoke the particular XSPECT programs to be used. Within the _templates directories are files with the Tcl commands recommended for execution of each XSPECT program. Within the _tcl directory are Tcl procedures that can be used to execute each of the XSPECT programs using a single line command. When starting a model for a new problem, it is recommended that a new working directory be established first. Within that directory, a script for the model can then be created by either combining the short script templates or by using the Tcl procedure calls as necessary.

A simulation model for an x-ray imaging process sequentially calls XSPECT routine to compute the energy spectrum emitted by the x-ray tube, modify the x-ray spectrum to account for attenuation by filters and by the object being imaged, and to compute the detected signal and noise for a particular x-ray imaging detector. The radiation exposure at various positions will typically be of interest. At typical model starts with specific Tcl commands that define directories and programs in the XSPECT installation. These commands are in the link.tcl file. Then sequential calls are made to XSPECT procedures. For example;

- link.tcl Initializes the XSPECT computing environment
- spectgen generate the x-ray spectral distribution.
- atten account for tube filtration.
- sr2cm change units for the object distance.
- mR compute the input exposure to the object.
- atten account for object filtration.
- cm2cm change distance to the detector.
- mR.txt compute the input exposure to the detector.
- detect compute the detector signal and noise.

The modules of the Radiation Imaging Computational Lab systematically explain what the available procedures do and how the arguments are specified.

Distribution:

The standard distribution for XSPECT 3.5c will have the following directories;

- _database interaction data files
- _detectors detector response files
- _doseTables Tables to compute mean mGy dose
- _materials material definition files
- _xspect3.5
  - _bin executable files
  - _doc documentation files
  - _Examples laboratory solution examples
  - _Models model files from projects
  - _tcl Tcl/Tk procedures
  - _templates short tcl script templates

Academic use:

The XSPECT environment for the simulation of x-ray imaging has been used by numerous investigator. This includes application for Computed Tomography (CT) applications as well as radiography and mammography. A bibliography of scientific articles referencing the use of XSPECT is attached to the end of this document.

Whats next?

Considerable work has been done on a major upgrade to version 4.0. This includes all new radiation interaction data and new models for x-ray spectral estimation. The new software will be more suitable for optimization problems with several variables. This release is expected to be finished by end of 2018.

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Appendix 1.

Bibliographjy of articles referencing use of XSPECT.

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