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Using computing models from particle physics to investigate dose-toxicity correlations in cancer radiotherapy

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Radiotherapy is planned with the aim of delivering a lethal dose of radiation to a tumour, while keeping doses to nearby healthy organs at an acceptable level. Organ movements and shape changes, over a course of treatment typically lasting four to eight weeks, can result in actual doses being different from planned. The UK-based VoxTox project aims to compute actual doses, at the level of millimetre-scale volume elements (voxels), and to correlate with short- and long-term side effects (toxicity). The initial focuses are prostate cancer, and cancers of the head and neck. Results may suggest improved treatment strategies, personalised to individual patients.

The VoxTox studies require analysis of anonymised patient data. Production tasks include: calculations of actual dose, based on material distributions shown in computed-tomography (CT) scans recorded at treatment time to guide patient positioning; pattern recognition to locate organs of interest in these scans; mapping of toxicity data to standard scoring systems. User tasks include: understanding differences between planned and actual dose; evaluating the pattern recognition; searching for correlations between actual dose and toxicity scores. To provide for the range of production and user tasks, an analysis system has been developed that uses computing models and software tools from particle physics.

The VoxTox software framework is implemented in Python, but is inspired by the Gaudi C++ software framework of ATLAS and LHCb. Like Gaudi, it maintains a distinction between data objects, which are processed, and algorithm objects, which perform processing. It also provides services to simplify common operations. Applications are built as ordered sets of algorithm objects, which may be passed configuration parameters at run time. Analysis algorithms make use of ROOT. An application using Geant4 to simulate CT guidance scans is under development.

Drawing again from ATLAS and LHCb, VoxTox computing jobs are created and managed within Ganga. This allows transparent switching between different processing platforms, provides cross-platform job monitoring, performs job splitting and output merging, and maintains a record of job definitions. For VoxTox, Ganga has been extended through the addition of components with built-in knowledge of the software framework and of patient data. Jobs can be split based on either patients or guidance scans per sub-job.

This presentation details use of computing models and software tools from particle physics to develop the data-analysis system for the VoxTox project, investigating dose-toxicity correlations in cancer radiotherapy. Experience of performing large-scale data processing on an HTCondor cluster is summarised, and example results are shown.

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