The polyGeVerō® software for fast and easy computation of 3D radiotherapy dosimetry data

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Abstract. The polyGeVerō® software package was elaborated for calculations of 3D dosimetry data such as the polymer gel dosimetry. It comprises four workspaces designed for: i) calculating calibrations, ii) storing calibrations in a database, iii) calculating dose distribution 3D cubes, iv) comparing two datasets e.g. a measured one with a 3D dosimetry with a calculated one with the aid of a treatment planning system. To accomplish calculations the software was equipped with a number of tools such as the brachytherapy isotopes database, brachytherapy dose versus distance calculation based on the line approximation approach, automatic spatial alignment of two 3D dose cubes for comparison purposes, 3D gamma index, 3D gamma angle, 3D dose difference, Pearson’s coefficient, histograms calculations, isodoses superimposition for two datasets, and profiles calculations in any desired direction. This communication is to briefly present the main functions of the software and report on the speed of calculations performed by polyGeVerō®.

1. Introduction
Advanced radiotherapy techniques of tumors irradiation require corresponding 3D dosimetry [1]. As such, polymer gel dosimetry and radiochromic gel/plastic dosimetry attracted a great attention [2, 3]. The dosimetric systems after irradiation are measured with 3D scanning techniques such as magnetic resonance imaging, computed tomography, ultrasonography and optical computed tomography. Afterwards, the scanning results, in form of a set of 2D planes or a 3D cube, are processed usually with the aid of Matlab® software package (MathWorks, Inc.). This in turn requires the ability of writing codes for any new experiment that may be laborious, time consuming and discouraging both for 3D dosimetry false beginners and advanced users.

A solution to this problem can be a dedicated software package capable of processing 3D dosimetry data with ease and a high speed. A proposition of such one was described previously [4, 5]. This communication, however, is to briefly report on the new polyGeVerō® software package that was elaborated for the 3D dosimetry data calculations.

2. A brief review of the software’s functions
The polyGeVerō® software operates on DICOM (modality: MR, CT, US) and VFF type files; its structure can be expanded for other file formats and is to be further enriched in the new functionalities. All operations on the files obtained after scanning a 3D dosimeter are performed in four workspaces that were projected for the preparation of calibration equations, storing the calibration characteristics of the 3D dosimeters, calculating dose distribution cubes and comparing two datasets e.g. a measured dose distribution with the aid of a 3D dosimeter with the calculated dose distribution with the aid of a
treatment planning system. The calculations’ results can be exported as TXT and BMP files (1D and 2D graphs: signal and dose maps as well as profiles and other results). They can also be printed or saved as BMP images or in the form of ready-made reports.

In calibration workspace, linear, exponential and polynomial calibration equations are allowed for a few generally known calibration options that employs specific calibration phantoms (e.g. GeVero Co. phantoms): multi vials (a few phantoms are exposed to different doses such that each phantom comprises 2-3 irradiation bands), depth dose (a build-up and decrease of dose is observed for a depth dose phantom), cross beam (beams of radiation are crossed such that the crossing areas are taken for calculating calibration data points), and brachytherapy (a dosimeter is irradiated with an isotope usually at a single dwell position). These calibration methods give different number of calibration points that is the highest for the depth dose and brachytherapy and are characterised by different complexity which is the lowest for the cross beam calibration. Once the calibration equations are calculated they are stored in a calibration database with corresponding characteristics of a dosimeter.

In gel dosimetry dose distribution workspace the user calculates 3D dose cube (*.vec file) after application of calibration equation and selection of an isocentre point using dedicated tools. This cube, which corresponds to the measured dose distribution, is further used in gel dosimetry vs. treatment planning system (TPS) workspace for comparison with a TPS calculated dose distribution. In general, any two datasets can be compared in this workspace on 2D-2D or 3D-3D basis and calculations of gamma index, gamma angle, dose difference, Pearson’s correlation, histograms as well as isodoses superimposition and profiles analysis is allowed. The polyGeVero® is also equipped with tools for displaying a single 2D plane and multiple 2D planes of dose distribution in 3D. In figure 1 an example print screen of the polyGeVero® gel dosimetry vs. TPS workspace with two datasets uploaded and calculated is presented.

![Figure 1. An example view of one of four workspaces of polyGeVero®: gel dosimetry vs. TPS, with a polymer gel and TPS data compared. A window with a 3D view of dose distribution is shown as well.](image)

3. How fast does it calculate dosimetry data

It is believed that the easiness of calculations in polyGeVero® does not require thorough discussion. Due to its structure the software allows for most important for routine clinical dosimetry calculations without the need for writing new codes as in case of e.g. Matlab® calculations. For the routine
dosimetry purposes those calculations should also be quick. Therefore in this section we present the results of a test of calculations speed. This test included the following operations: i) calculations of the calibrations equations based on four calibration approaches: the multi vials, cross beam, brachytherapy and depth dose, ii) storage of the calibration characteristic in a calibration database, iii) calculations of four dose distributions 3D cubes after application of four calibration equations, iv) comparison of each 3D dose cube measured with a TPS calculated one. The test was performed on a computer of the following parameters: processor AMD Phenom™ II X4 965 3.4 GHz, RAM: 4 GB, operating system: 64 bit Win 7. The results are presented in table 1. It should be noted that the total time of calculations is equal to less than thirty minutes. The calculations, even complex ones such as the 3D gamma index, take just seconds for a parameter. The most time consuming during the test were the other operations such as indication of a folder with raw data or typing additional information for the data being uploaded.

**Table 1.** Results of the test of calculations speed for the polyGeVero® software.

| Workspace/Operations                                    | Time of operation [min] |
|---------------------------------------------------------|-------------------------|
| Calibration                                             | Brachytherapy calibration| 2.8                     |
| 1. Searching for DICOMs                                 |                          |                         |
| 2. Building images series                               |                          |                         |
| 3. Recognising layers                                   |                          |                         |
| 4. Calculating R2                                       |                          |                         |
| 5. Preparation of complete R2 vs. dose curve, linear calibration equation and export of calibration characteristics to the calibration database | Brachytherapy calibration | 2.8                     |
|                                                        | Depth dose calibration   | 7.6                     |
|                                                        | Cross beam calibration   | 12.0                    |
|                                                        | Multi vials calibration  | 19.8                    |
| Gel dosimetry dose distribution                         | *.vec file for cross beam calibration | 23.2                    |
| 1. Searching for DICOMs                                 | *.vec file for depth dose calibration | 24.0                    |
| 2. Building images series                               | *.vec file for brachytherapy calibration | 25.0                    |
| 3. Recognising layers                                   | *.vec file for multi vial calibration | 25.8                    |
| 4. Calculating R2                                       | *.vec file for cross beam calibration | 23.2                    |
| 5. Calculating dose distribution for brachytherapy, depth dose, cross beam and multi vial calibration equations | *.vec file for depth dose calibration | 24.0                    |
| 6. Calculating 3D dose cube (*.vec file) for the dose distributions mentioned above | *.vec file for brachytherapy calibration | 25.0                    |
|                                                        | *.vec file for multi vial calibration | 25.8                    |
| Gel dosimetry vs. TPS                                   | Gamma index for TPS vs. gel dosimetry 3D cube (brachytherapy calibration) | 27.4                    |
| 1. Import TPS generated plan of irradiation (head size phantom: number of pixels of 1 layer: 5460; 100 layers) | Gamma index for TPS vs. gel dosimetry 3D cube (cross beam calibration) | 28.2                    |
| 2. Import gel dosimetry 3D dose cubes as calculated in gel dosimetry dose distribution workspace (head size phantom: number of pixels of 1 layer: 16384; 62 layers) | Gamma index for TPS vs. gel dosimetry 3D cube (depth dose calibration) | 29.0                    |
| 3. Calculation gamma index in 3D mode for all planes for each set of data: TPS vs. a dose distribution 3D cube of gel dosimetry | Gamma index for TPS vs. gel dosimetry 3D cube (multi vial calibration) | 29.8                    |
| Total time of calculations                              | 29.8                    |
4. Conclusions
In this communication the polyGeVer® software package, which was prepared for 3D dosimetry data calculations, was briefly presented. The software calculates data with a high speed. It is also easy to perform calculations typical for routine dosimetry with the software since, inter alia, it is not necessary to write separate protocols for any new experiment performed. This software package is subject to further development. For instance, presently DICOM (modality MR, CT, US) and VFF files (of VISTA optical scanner, Modus Medical Devices, Canada) can be processed, however, the software’s structure is ready for expansion to comply with the other file formats as well.

More information on polyGeVer® including short movies presenting its main options can be viewed on the GeVer Co. web site: http://polygevero.com as well as elsewhere [6].

5. References
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