Assessment of the accuracy of radiotherapy by digital superposition of portal and reference images

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Teleradiotherapy imposes the requirement of **high accuracy** in reference to its medical as well as technical aspects. Close adherence to the geometrical parameters set up in therapy planning is vital. The current location of the irradiation field and anatomical structures can be recorded in the *portal image* acquired during the therapy course. Assessment of the treatment accuracy consists in registration (overlaying) of the reference and the portal image to compare the layout of anatomical structures and the irradiation field. Edges of the compared features are difficult to find in the portal image, which is inherently of low contrast. Hence, not all the edges present in the reference image can be found in the portal one, and the comparison of geometries in these images is difficult and time-consuming. There exists a need for a tool that could support and objectify this process.

At present the accuracy assessment is done manually by an experienced observer. As a rule, this tedious procedure is not performed routinely. The wide literature on image registration refers to portal images made with beams generated in accelerators rather than with the cobalt apparata. In Poland more than a half of patients are treated with cobalt. There are numerous references to image registration methods tailored for finding the fitting and non-fitting fragments of the compared edges. The majority of these methods lack generality. **The methodology to be presented** is general and requires little user intervention.

- **Features to be matched**: edges of selected anatomical structures, irradiation field and shields, as seen in scanned images.
- Edge detector: zero-second-derivative with scale fitted to noise and scale of edges, separately in portal and reference images.
- **Geometrical transformation**: affine (2 translations, rotation, 2 scalings – along two coordinate axes).
- **Measure of fitting accuracy**: modified Hausdorff distance measure – robust method based on voting. Parts of the contours that do not fit the general tendency are rejected. This is vital if portal images made with cobalt apparata are analysed.
- **Optimisation method** for finding the best transformation: maximum gradient (*chamfer matching*).
- **Final fit** can be calculated with the least squares method for only those pixels which were classified as fitting.
- **Speed-ups**: hierarchical method (pyramid of resolutions); in some cases: pre-calculated virtual transformations.
- **Automatic classification of edges** as belonging to anatomic structures, irradiation field or shields is possible.
- Experiments with enhancing the contrast of portal images using the optical system transfer function concept.

The software tool will be presented which makes it possible to correct the therapeutic system geometry or the location of the patient. Full control of the physician over the measurement process will be maintained, according to the requirement of human decision-making in the therapeutical process. The registration (overlaying) of a portal and a reference image is visualised for verification. Manual corrections of the result will be possible in the final version of the program.

Acknowledgement The work is supported by the Committee for Scientific Research within the grant no. KBN 4 P05B 064 18.

Reports of Practical Oncology and Radiotherapy, **6**(1):39-39, 2001. (Abstracts submitted for *Conf. on Advances in Radiation Oncology: Diagnosis - Treatment Planning - Clinical Outcome*, Poznań, Poland, Apr 19-21, 2001.)