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Augmented reality 3D navigation system for evaluation of dose plan distribution in radiation therapy

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Purpose/Objective:

In recent years, the growth of computer vision, depth cameras, and computer graphics has enabled a new range of devices for virtual (VR) and augmented reality (AR) applications. Unlike VR, which fully immerses the user into a new environment, AR overlays computer-generated objects over the real-world view. Both VR and AR have been used in radiation therapy (RT) setting, such as for patients' education and staff training. Evaluation of treatment plans in RT involves careful assessment of the doses received by the target volumes, as well as by the critical organs at risk (OARs). Conventionally, the evaluation is performed through dosimetric indexes and careful visual inspection of the dose distribution in the treatment planning system (TPS).

Aim of this study is to develop and test the effectiveness of an AR system for plan dose distribution assessment. The project is part of a collaboration between the xxxxx and the xxxxx.

Material/Methods:

One patient with diagnosis of nasopharyngeal carcinoma and treated at IEO with SBRT has been considered. The study was approved by Ethics Committee of the IEO and Centro Cardiologico Monzino of Milan and the patient signed a dedicated informed consent. Simulation computed tomography (CT) and the planned dose distribution were exported in DICOM files from RayStation TPS.

Patient anatomy visualization in the AR environment was based on the Volume Rendering technique, which enables three-dimensional visualization from CT. The treatment plan was discretized into two-dimensional images along the axial plane, which were subsequently remapped and aligned with the patient's anatomy.

The DICOM file of the dose distribution plan was analyzed using the pydicom library for Python to generate colored images of the frames in PNG format, mirroring the characteristics of the original plan. In particular, the pixel data was scaled by the dose grid scaling parameter expressed in the DICOM file, resulting in dose values in Grays for each pixel. The dose values range was then divided into six levels, and a color gradient from green (low dose values) to red (high dose values) was assigned to each level.

The generated images were imported into the Unity3D environment with a pixel spacing parameter matching the one specified in the DICOM file. The CT scan and models of the patient's organs were also loaded into the same environment using the UnityVolumeRendering plugin for Unity.

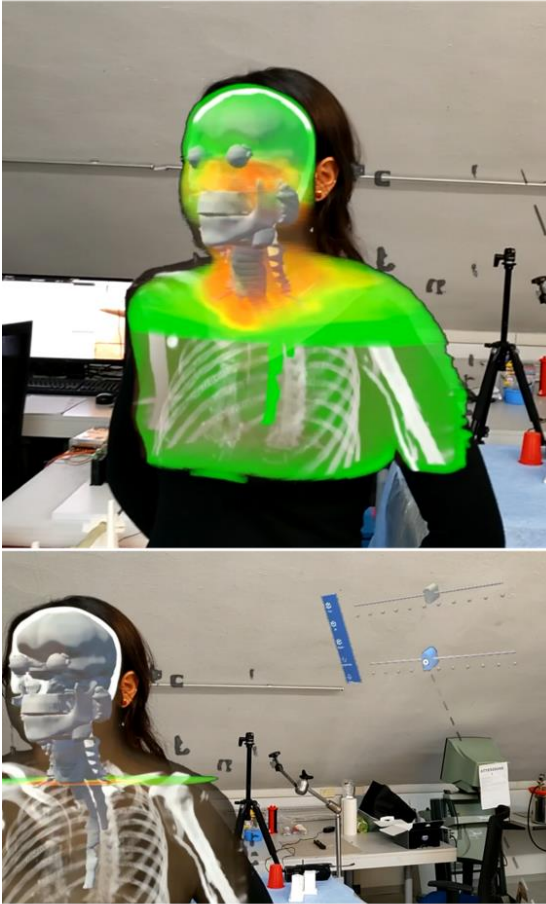
Subsequently, an AR interface was developed with the Mixed Reality Toolkit (MRTK) for Unity and visualized through the HoloLens2 head-mounted display.

Results:

Simultaneous integration and visualization of patient CT simulation, contours (targets and OARs) and plan dose distribution was successfully developed. The interface offered 3D data visualization, with the ability to activate or deactivate elements via three graphical user interface (GUI) buttons. Additionally, two buttons controlled the functionality of the sliders, allowing users to adjust the transparency of the dose plan for better visualization of underlying structures and to visualize individual frames of the therapeutic plan

For a more detailed analysis of isodose levels, another panel enabled the visualization of dose levels based on the dose values in Grays. The user could visualize each individual level reconstructed in 3D overlaid on preoperative images. Screenshots of the obtained AR environment are shown in **Figure 1**.

Figure 1. Screenshots of the obtained AR environment visualized through the HoloLens2 head-mounted display.



Conclusion:

Simultaneous integration and visualization of patient simulation CT and corresponding dose distribution was found to be feasible. A future survey will be conducted among the physicists in the department to understand the possible usefulness of the developed system compared to the traditional 2D visualization in the TPS. Future prospects include evaluating the effectiveness of the environment in comparing rival photon-proton plans.

Keywords: augmented reality, plan evaluation, radiotherapy

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Patients' perspectives on AI and decision making in cancer care

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