Multi-Modality PET-CT Imaging Visualization

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INTRODUCTION AND MOTIVATION

- Multi-modality positron emission tomography and computed tomography (PET-CT) imaging has introduced new clinical capabilities for staging cancer and assessing the response to treatment.
- PET-CT allows the visualization of biological and physiological functions from PET as region of interest (ROI), e.g. tumor, in the spatial context of anatomy from CT.
- Advent of efficient volume rendering algorithms and powerful graphical processing units (GPUs) has enabled the introduction of new 3D volume rendering to various visualization applications.
- Due to several limitations, e.g., 3D occlusions, the majority of medical imaging visualizations rely upon 2D based cross-sectional visualization.
- This research investigated several methods to address the limitations and intended to pave the way for the application of 3D volume rendering to PET-CT imaging visualization.

DIRECT VOLUME RENDERING (DVR)

- DVR enables a final image to depict a whole volume at once.
- Transfer function (TF) is used to manipulate opacity and color of the data values (intensity) in a volume.
- Optical contributions for every voxel in a volume are accumulated based on the optical definition from TF as following:

$$a_i = (1.0 - a(s(i))) * a_{i-1} + a(s(i))$$

$$c_i = \left(1.0 - a(s(i))\right) * c_{i-1} + c(s(i)) * a(s(i))$$

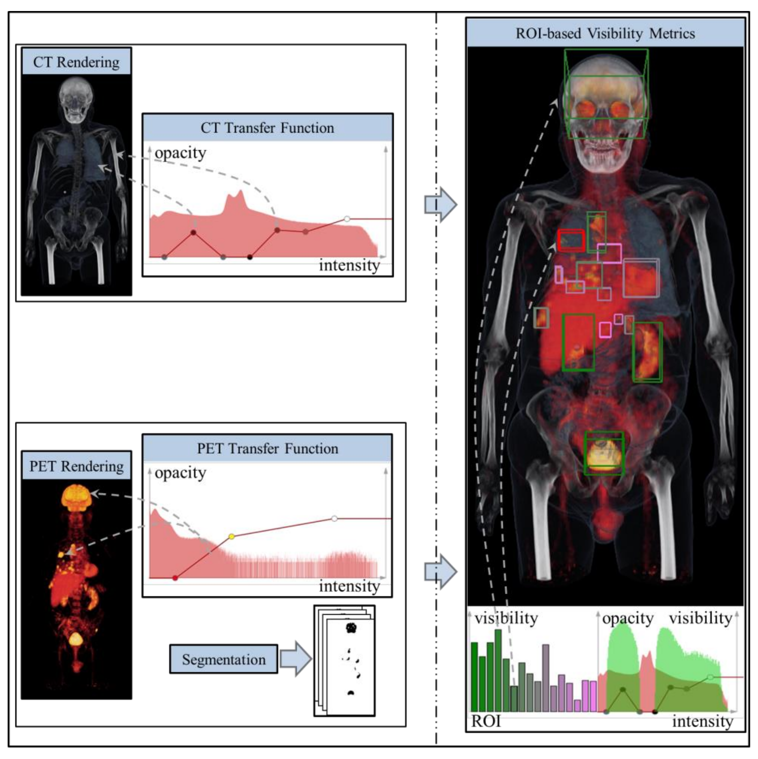
- Volume clipping is used to preserve the visibility of ROI by 'cutting away' parts of volumes that occlude the ROI.
- In typical PET-CT visualizations, TF are defined independently on the individual volumes with the resulting volumes being fused.

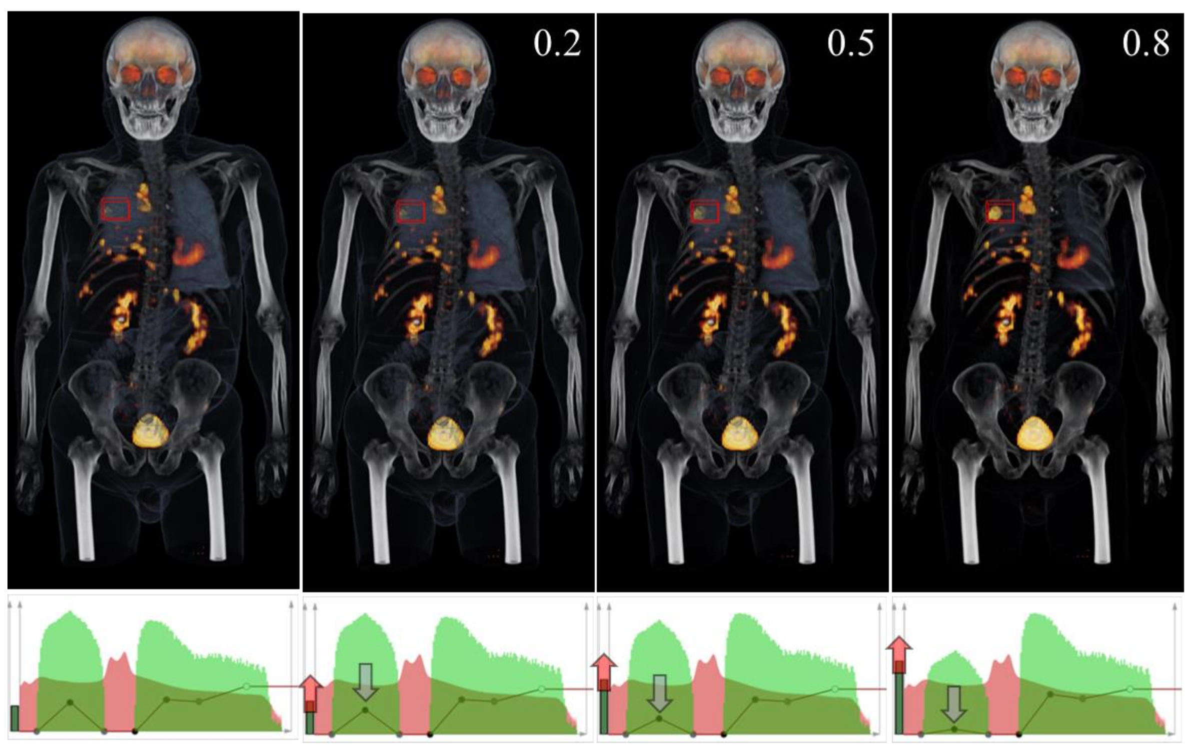
METHODOLOGIES AND OUTCOMES

1. Visibility-driven TF manipulation [1,2]

We introduce visibility histogram (VH) as a real-time visual feedback to guide TF.

- VH represents how much of ROIs are visible in resulting images.
- Automated generation of TFs in a way that an initial TF of CT volume can be optimized towards maximizing the visibility of ROI from its counterpart PET volume.
- Our visualization is able to maximally visualize relevant CT anatomy while preserving the visibility of PET ROI

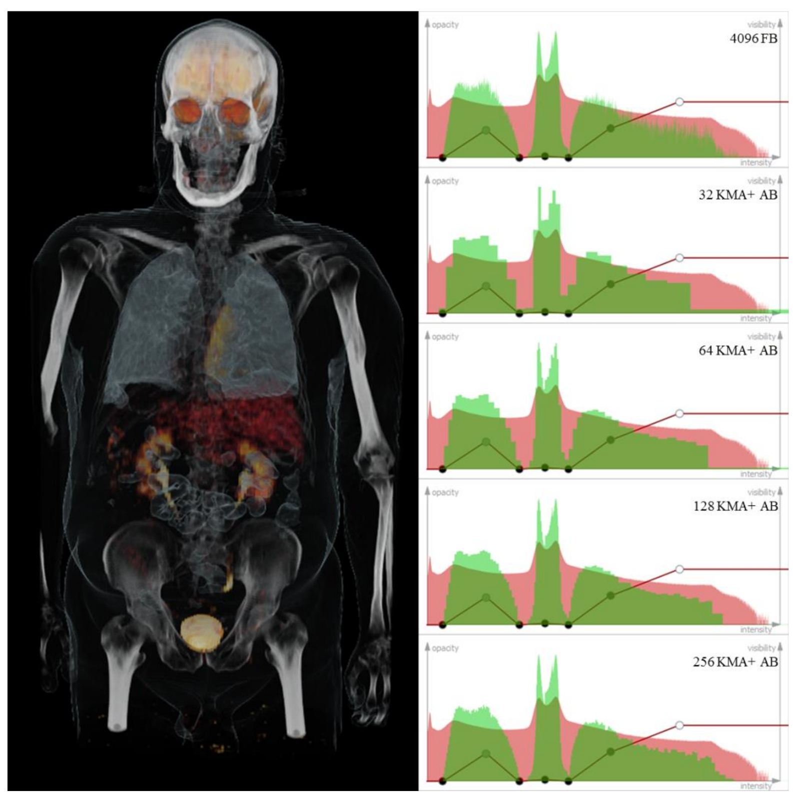


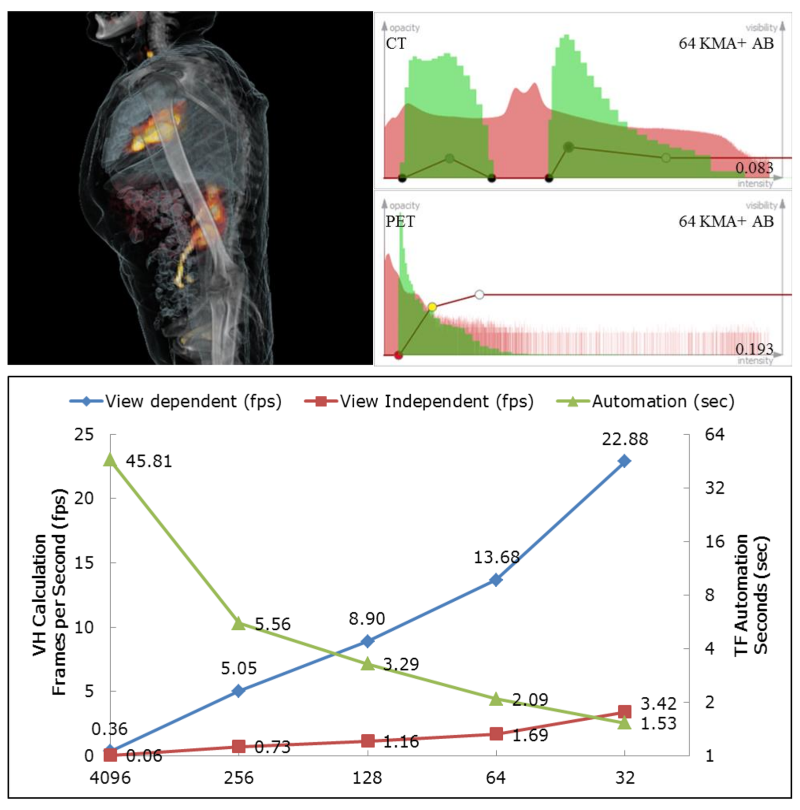


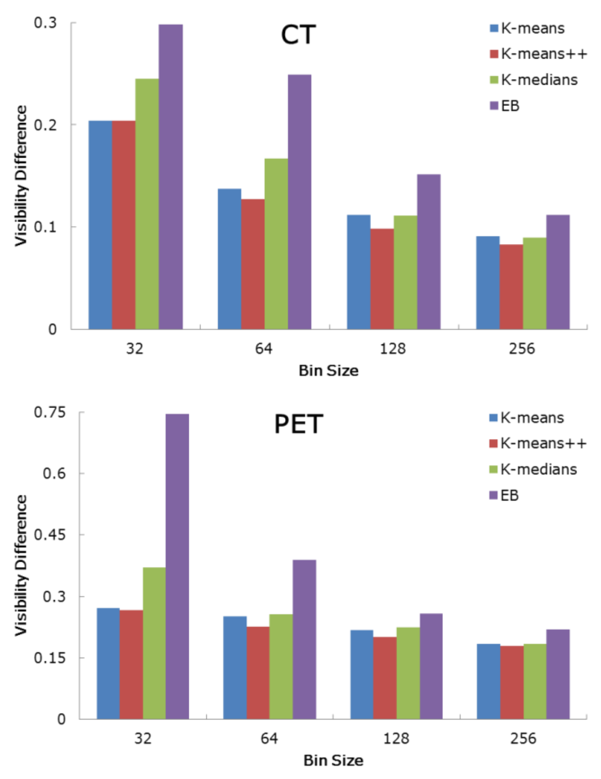
2. Adaptive binning of VH [3]

We introduce an efficient construction of VH by *K*-means clustering based adaptive binning.

- A smaller number of adaptive bins are used to represent the visibility distribution of the full bin equivalent.
- Significant computational efficiency for the histogram construction in volume rendering manipulations, without noticeable degradation of the quality of the VH.



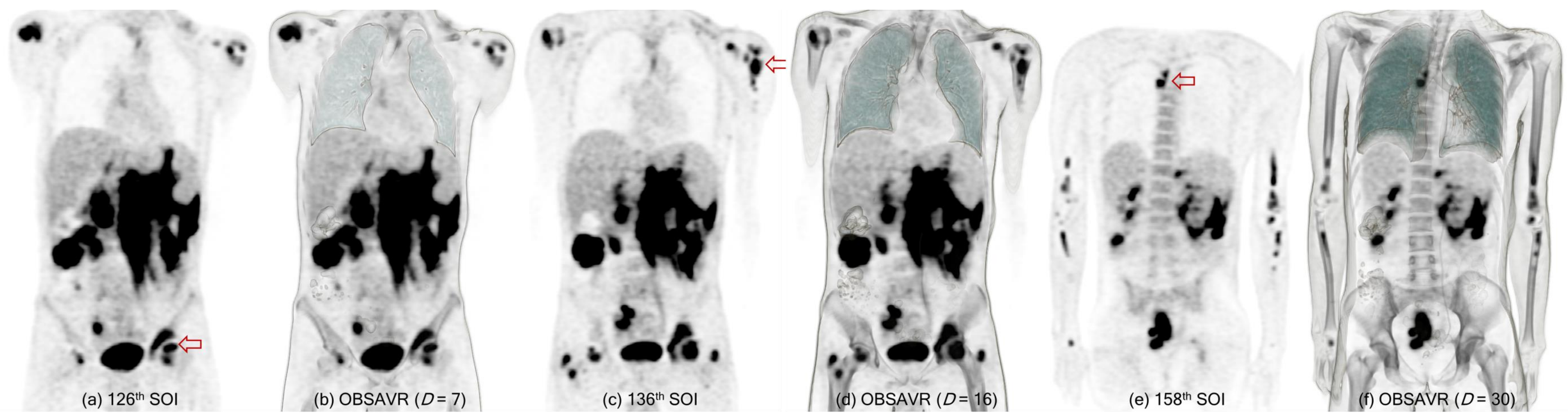


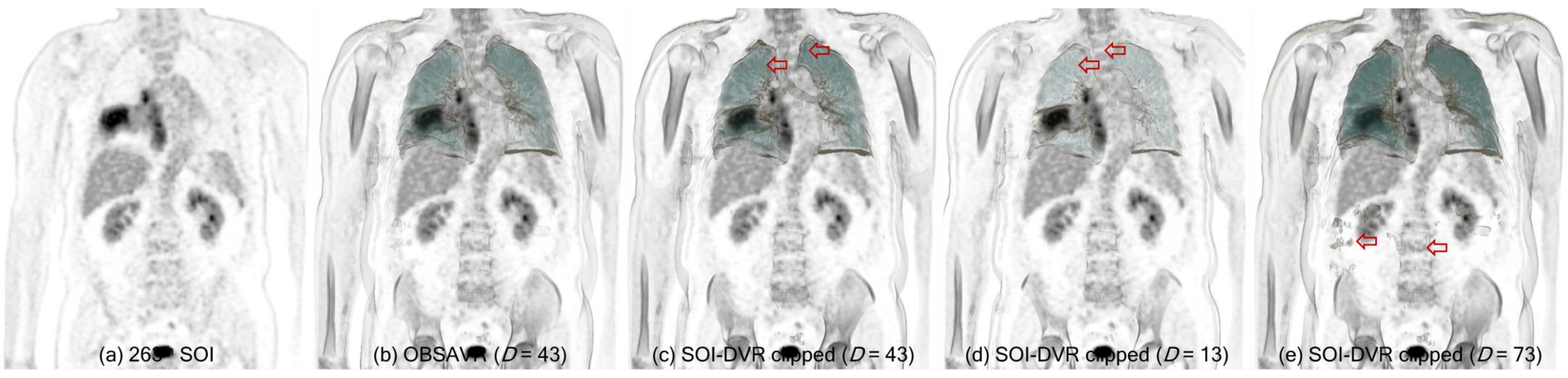


3. Occlusion-based slices augmented by volume rendering (OBSAVR)

We propose a new method where 2D slice of interest (SOI) from PET volume is augmented by volumetric contextual information from DVR of the counterpart CT volume, while minimizing the obtrusiveness on the SOI.

- An automated computation of an 'augmentation depth' to control the amount of visual information from CT DVR
- Improvements in PET-CT visualization when compared to a conventional 2D visualization and different SOI-DVR visualizations.





CONCLUSIONS and FUTURE WORKS

- We proposed the methods above for effective visualization of multi-modality PET-CT image volumes
- Positive feedbacks from a clinical expert in terms of usefulness and feasibility of our methods.
- Achieved real-time interactivity by using the massive parallelism and programmability of the modern GPU.
- We will investigate the applications of our methods to other co-aligned medical imaging modalities.

PUBLICATIONS

[1] Y. Jung et al., "Dual-modal visibility metrics for interactive PET-CT visualization," *Proc IEEE EMBC*, 2696-9, 2012.

[2] Y. Jung et al., "Visibility-driven PET-CT visualisation with region of interest (ROI) segmentation," *The Visual Computer* , 29(6-8), 805-15, 2013.

[3] Y. Jung et al., "Visibility-driven transfer function for dual-modal PET-CT visualization using adaptive binning," Poster, *In IEEE Symp. Pacific Visualization*, 2013.

We are preparing publications of the works, (2) and (3), to journal materials.