Developments In DeepTuning: Translational Invariance of Trade-Off Feature Extraction In Real-Time Tunable Dose Prediction Framework

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ABSTRACT

Background: DeepTuning is a multi-criteria dose prediction framework that uses real-time tuning to generate multiple trade-off doses.

Objective: This study evaluates and enhances the shift equivariance of trade-off feature extraction within the DeepTuning framework.

Methods: DeepTuning utilizes a U-Net architecture featuring dual encoders and a shared decoder design. A posterior encoder extracts a trade-off encoding vector (ΔZ) from historical plans, while a prior encoder captures patient-specific geometry to generate a prior latent representation (Z_{prior}).

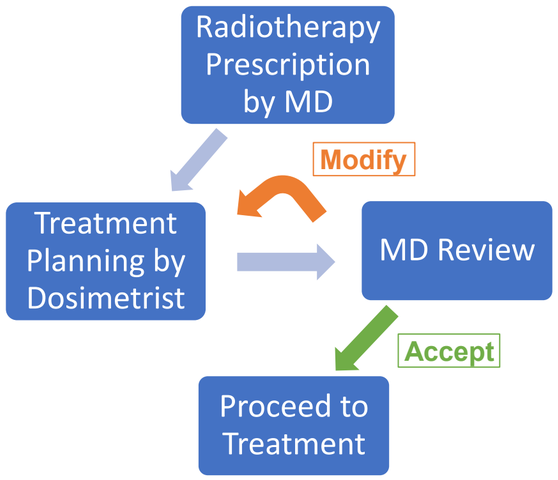
Results: By shifting input images across spatial increments while modulating the trade-off vector, we evaluated the model's performance and confirmed its ability to generate real-time, tunable doses without spatial aliasing.

Conclusion: DeepTuning allows physicians to adjust dose distributions in real-time, streamlining treatment planning by minimizing iterative communication. Our results demonstrate that incorporating anti-aliasing down-sampling is essential to achieve shift equivariance in this framework.

1. INTRODUCTION

Radiotherapy planning requires a time-consuming feedback loop between radiation oncologists and dosimetrists

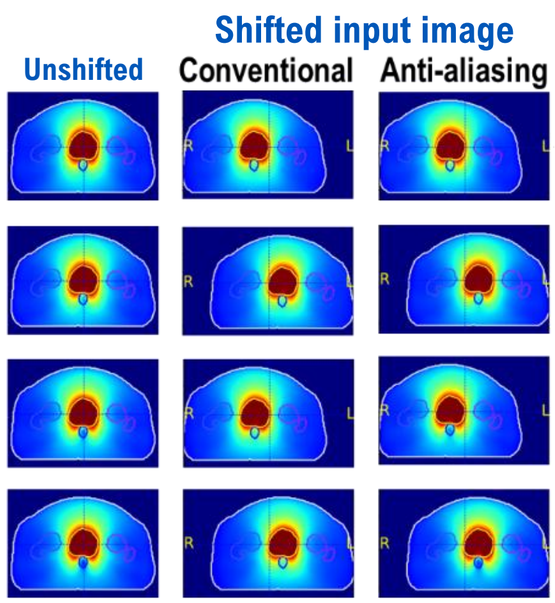
To accelerate this workflow and boost efficiency, we developed DeepTuning, a deep learning framework that generates real-time tunable dose distributions



3(A). RESULTS I

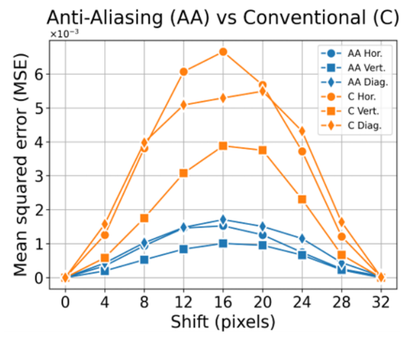
PROBLEM: Aliasing due to image shifts inside the field of view

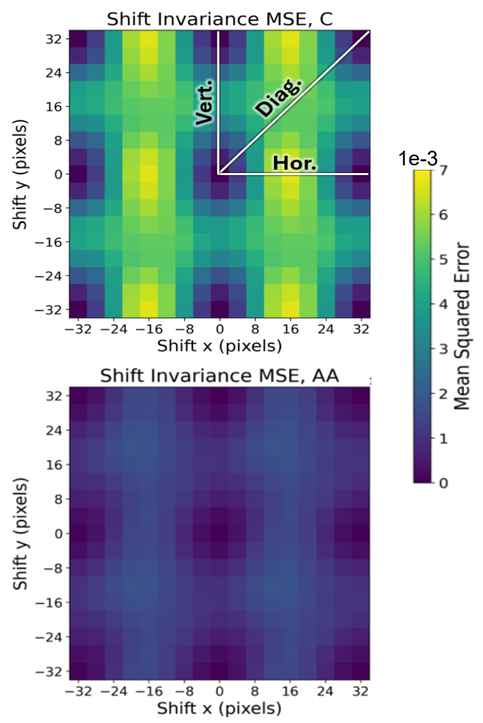
SOLUTION: Add anti-aliasing step during downsampling before striding



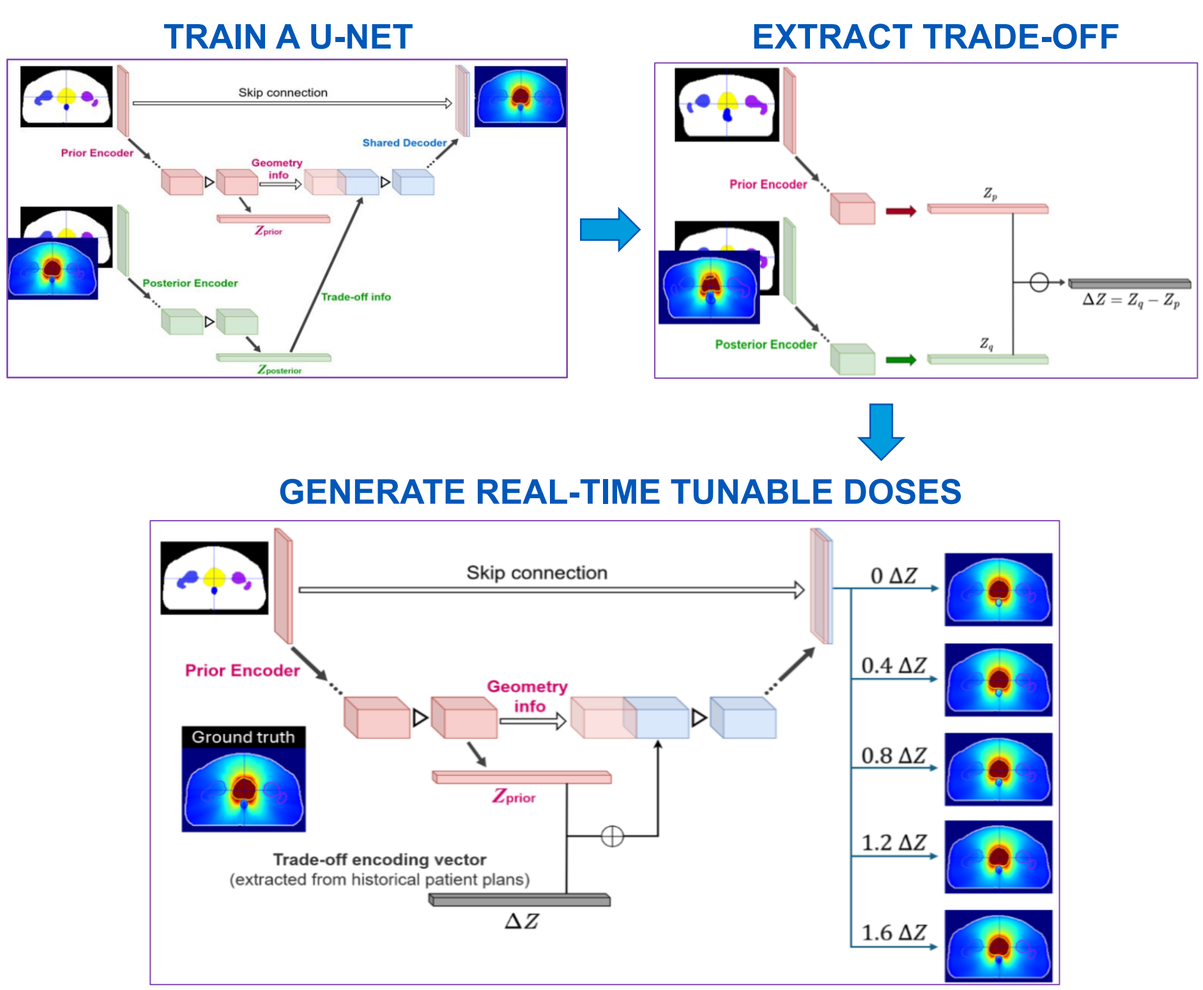
3(B). RESULTS II

We verified that the model generated correct outputs under several vertical, horizontal, and diagonal shifts





2. METHODS: U-NET MODELS



4. CONCLUSIONS

- DeepTuning will enable physicians to adjust dose distributions in real-time, streamlining treatment planning by minimizing iterative communication
- To achieve the shift equivariance shown in our results, anti-aliasing down-sampling is essential

REFERENCES

[1] DeepTuning: Tune Radiotherapy Plan Dose Distribution in Real Time by Deep Learning. 2024 ICCR proceedings, page 614 https://hal.science/hal-04720234/

[2] Making Convolutional Networks Shift-Invariant Again, ICML 2019, arXiv:1904.11486

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