Interactive Previewing for Transfer Function Specification in Volume Rendering

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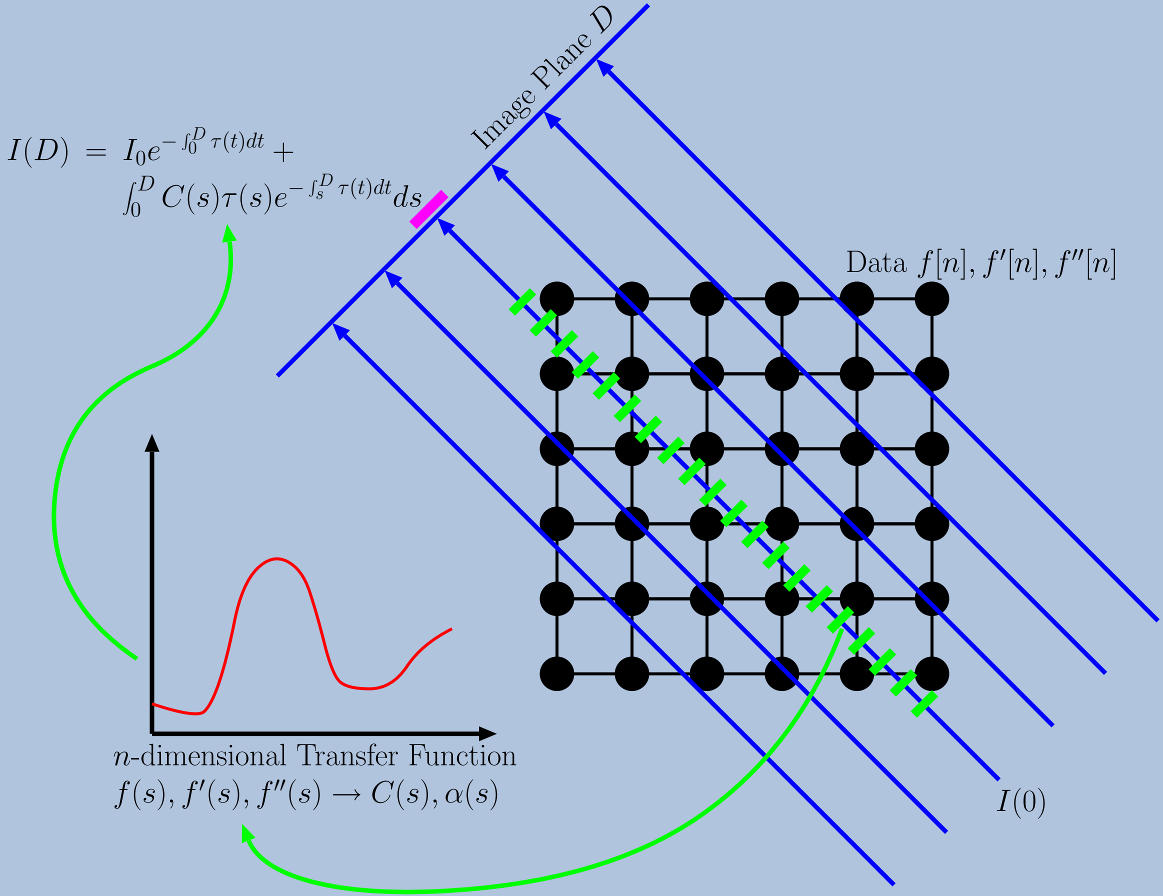
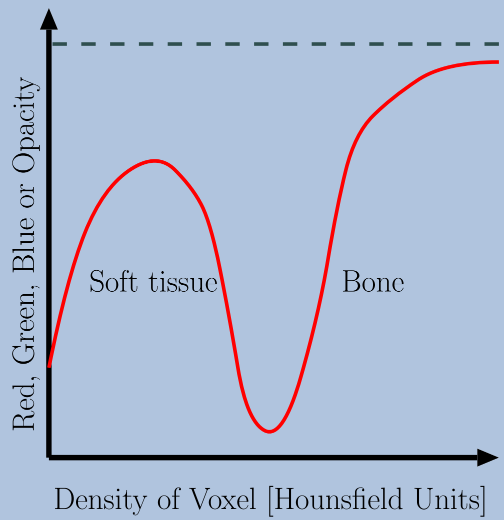
Introduction - DVR Refresher



Introduction - TF example



Example Transfer Function for rendering CT-data

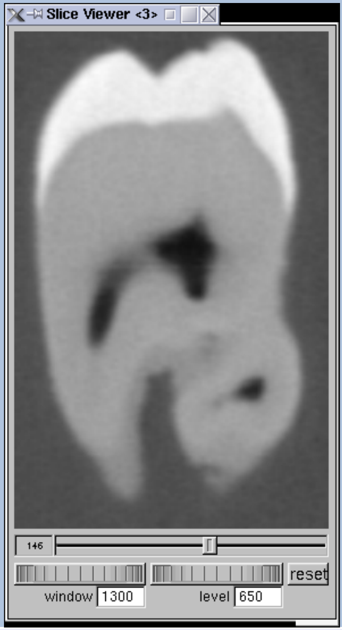
Introduction - Background

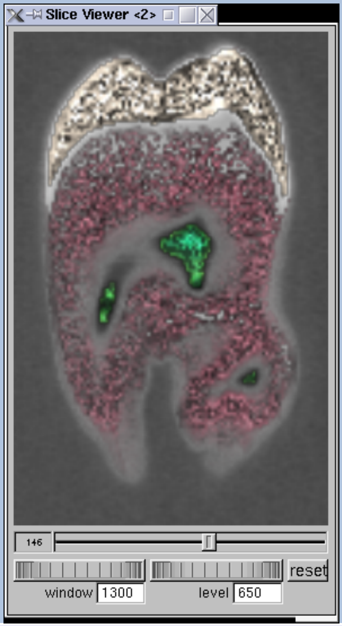
- DVR - important visualisation technique
- Important component: Transfer Function
  - Data values $\longrightarrow$ Optical properties
- TF specification: prohibitively difficult
- New scheme
  - Feedback-based (DVR preview)
  - Current TF quality $\leftrightarrow$ domain-specific comprehension/expectation
  - Simple; requires no special hardware

Introduction - Preview

Our work:

- slice-based DVR preview
- overlaid on greyscale slice of data
- serves as real-time feedback on DVR changes





Related Work on TF Specification

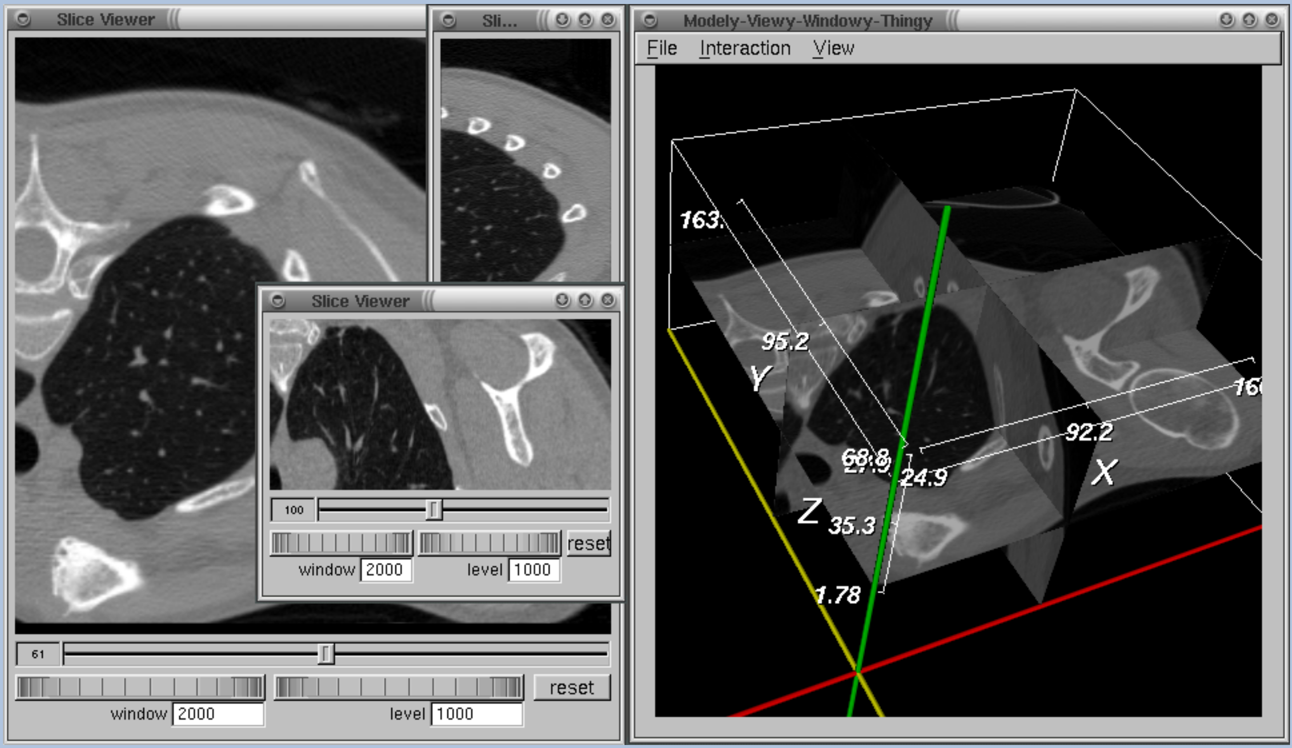
- Trial-and-error with DVR feedback
- Design galleries
- Bajaj's Contour spectrum
- Kindlmann's semi-automatic TF generation

Trial-and-error and design-galleries

- feedback-based
- real-time rendering, continually changing TFs
- no explicit data-DVR relation

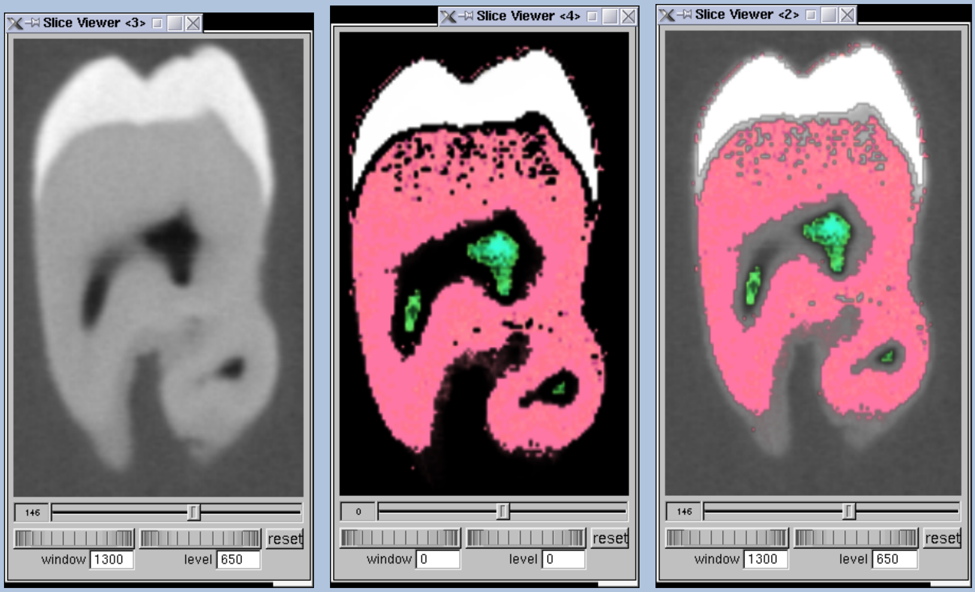
New method: fast, explicitly registered feedback; extension of our previous work.

Method - Clinical Expertise



Method - Overlaid feedback scheme

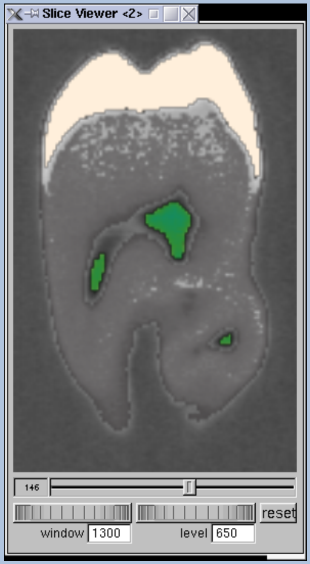
- Greyscale $X = \langle C_g, \alpha_g \rangle$
- Mapping $M = \langle C_m, \alpha_m \rangle = f(v)$
- Alpha-Blending $(1 - \alpha_m)X + \alpha_m M$:



Method - Mappings

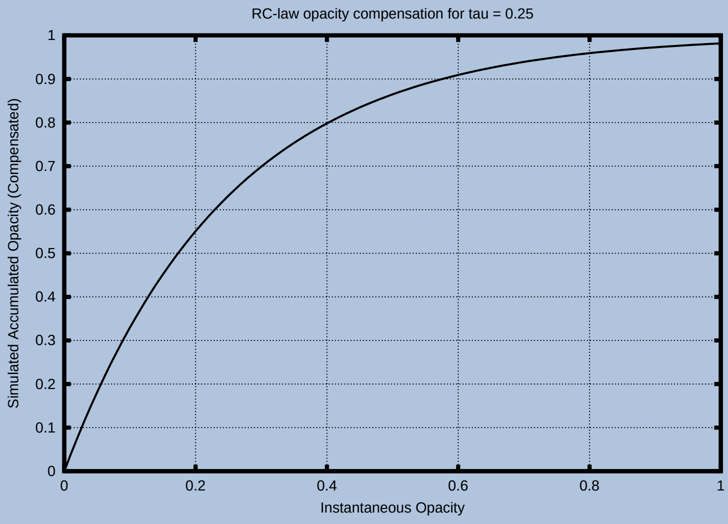
Mappings $M = f(v)$:

$$\langle M = C_t * \alpha_t, \alpha_t \rangle \text{ vs } \langle M = C_t, c_{rc}(\alpha_t) \rangle$$



Method - RC-law compensation

- DVR absorption $I(D) = I_0 e^{-\int_0^D \alpha(t)dt}$
- Simulate integral accumulation: RC-law opacity
- Instant $\longrightarrow$ Integral: $c_{rc}(\alpha_t) = 1 - e^{\frac{-\alpha_t}{\tau}}$



Method - FD estimation of DVR

Need more accurate way to estimate accumulation:

$$I(D) = I_0 e^{-\int_0^D \tau(t)dt} + \int_0^D C(s)\tau(s)e^{-\int_s^D \tau(t)dt} ds$$

can be reduced to:

$$I(0) = I_D e^{-N\alpha_k} + C_k \alpha_k \frac{1 - e^{-N\alpha_k}}{1 - e^{-\alpha_k}}$$

without too much cheating*.

Method - FD estimation of DVR: $*$

$$I(0) = I_D e^{-N\alpha_k} + C_k \alpha_k \frac{1 - e^{-N\alpha_k}}{1 - e^{-\alpha_k}}$$

1. Ray is cast through N voxels with identical (or very similar) C_k and α_k.
2. Ray-sampling distance Δs is of the same dimension as a voxel.

Method - FD estimation of DVR

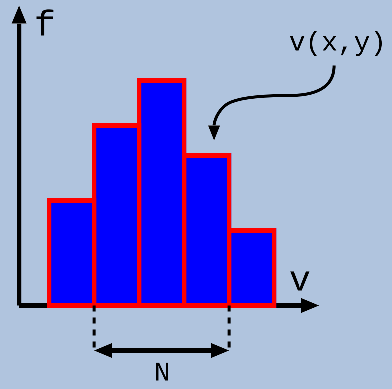
Previewing single slice:

1. Iterate through each $v(x, y)$ in current slice:
   - Transform to $\langle C_t, \alpha_t \rangle$.
   - Optional: perform shading.
   - Calculate N.
   - Evaluate simplified equation.
2. Blend with greyscale.

Answers question for all slice voxels: What would the result be of casting a ray through *all* the optical material represented by the current voxel.

Method - FD estimation of DVR

For every $v(x, y)$ in slice, we need N:

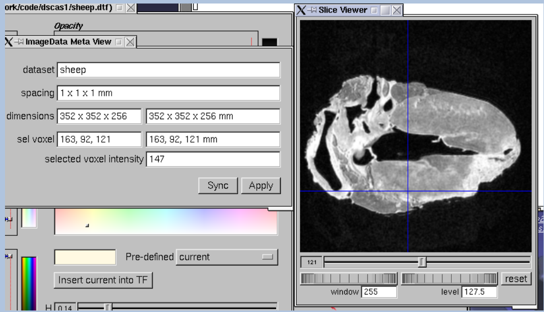


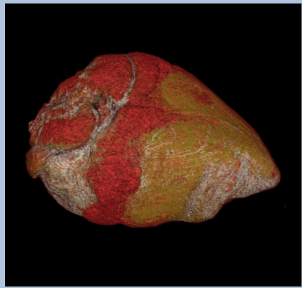
Frequency distribution for (x, y)

1. Get FD for current (x, y)
2. Binary search bin containing current $v(x, y)$
3. Perform merging based on C_t and α_t
4. N is number of voxels in merged bins.

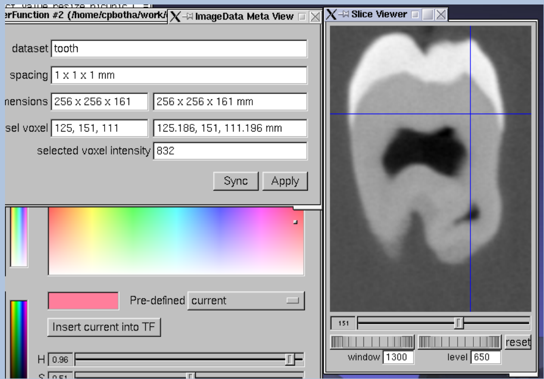
Results

MRI data of a sheep heart:





CT data of a tooth:



. . . another tooth preview.

Conclusions

Interactive Previewing for TF specification

- Simple to implement
- Fast, requires no special hardware
- Feedback on visibility and optical characteristics
- Voxel-registration: correspondence, fidelity
- Small changes visibly, incrementally fed back
- Effective use of user's knowledge of the data
- Super-imposed segmentation = expectations $\Rightarrow$ TF optimised
- Speeds up TF specification

Acknowledgements

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