Volume Analysis Using Multimodal Surface Similarity

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Motivation

- Multimodal data:
  - Same object, different acquisition techniques
  - One modality evens out drawback of the other

![Industrial CT]

- low energy CT
- high energy CT
Motivation

- Multimodal data:
  - Same object, different acquisition techniques
  - One modality evens out drawback of the other

Medical Modalities

CT

MRI
Motivation

- Multimodal visualization:
  - Side-by-side view
    - Difficult for comparison of both modalities
  - Volumetric fusion
    - Differences and/or similarities between modalities vanish through fusion

- Using similarity information to analyze and visualize multimodal data
  - Similarity of isosurfaces for combinations of isovalues
Multimodal Similarity Map (MSM)
Multimodal Similarity Map (MSM)
MSM Calculation

modality 1

modality 2

isosurface extraction

modality 2

isovalue 1

modality 1

isovalue k

0

0

dist. to isosurface 1
max

dist. to isosurface 2

max

isovalue modaliry 2
max

isovalue modaliry 1
max

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MSM Calculation

modality 1
modality 2

distance field

modality 2
isovalue 1

modality 1
isovalue k

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modality 1

modality 2

modality 2
isovalue l

modality 1
isovalue k

joint distance histogram

dist. to isosurface 1 max
dist. to isosurface 2 max

isoval. modality 2 max

isoval. modality 1 max
MSM Calculation

modality 1

modality 2

multimodal similarity map

modality 2

iso-value l

modality 1

iso-value k
MSM Calculation

modality 1

modality 2

multimodal similarity map

modality 2

isovalue l

modality 1

isovalue k

dist. to isosurface 1

max

dist. to isosurface 2

max

isovalue modality 1

max

isovalue modality 2

max
MSM Example
Applications for multimodal similarity map:

- Similarity-based exploration
  - Multimodal similarity map as guidance map
- Maximum similarity isosurfaces
  - Comparison of isosurfaces from two modalities
- Similarity-based classification
  - Directly classify multimodal data based on the multimodal similarity map
Similarity-Based Exploration

- The multimodal similarity map can be used to detect important structures
  - E.g. regions of high similarity
- Guidance map for the classification
Similarity-Based Exploration
Similarity-Based Exploration
Similarity-Based Exploration

- Similarity-Based Weighting
  - Use similarity value to manipulate opacity
Similarity-Based Exploration

- Similarity-Based Weighting
  - Use similarity value to manipulate opacity
Maximum Similarity Isosurfaces

- Using multimodal similarity map to find most similar isosurface
  - One isovalue for one modality is given
  - Lookup in the MSM provides isovalue for most similar isosurface in modality 2

- Useful for finding differences in both modalities
  - E.g. artifacts
Maximum Similarity Isosurfaces
Similarity-Based Classification

- Classify multimodal data directly in the multimodal similarity map
- Individual transfer functions are not necessary
- User defines set of control points
- Combination of isovalues is classified with control point which is most similar
  - Metric is based on similarity values
Similarity-Based Classification

\[
\begin{align*}
\dot{s}_i(k) &= \text{MSM}(k, \dot{h}_i) \\
\ddot{s}_i(l) &= \text{MSM}(\dot{h}_i, l)
\end{align*}
\]

\[
\begin{align*}
s_i(k, l) &= \dot{s}_i(k) \ddot{s}_i(l)
\end{align*}
\]

\[
m(k, l) = \arg \max_i s_i(k, l) w_i
\]
Similarity-Based Classification

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Generate clusters based on user-specified control points $c_i$

Calculate the cluster centroids $h_i$ and use these points to finally generate the clusters

The original control point $c_i$ is the centroid of this cluster

- More intuitive user interaction
Similarity-Based Classification
Similarity-Based Classification
Conclusion

- Multimodal similarity map can be used to analyze multimodal data
  - Detect similarities/differences in two modalities
- A sub-sampled version of the volumes can be used for calculation
  - Reduce calculation time to seconds
- MSM can either be used as guidance map in an existing framework or to classify multimodal data directly
Thank you!

Questions?