MIC @ MICCAI: past, present and future

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Motivation

Intervention

Diagnosis/prognosis

Basic research
## Top 9

Percent of papers that claim the organ in the title in 2017 (1998)

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<thead>
<tr>
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<tbody>
<tr>
<td>Brain</td>
<td>20 (25)</td>
<td>Prostate</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Heart</td>
<td>11 (4)</td>
<td>Breast</td>
<td>3 (2)</td>
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<tr>
<td>Vessels</td>
<td>5 (4)</td>
<td>Pancreas</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Lung</td>
<td>4 (2)</td>
<td>Liver</td>
<td>2 (2)</td>
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<td>Ortho</td>
<td>2 (7)</td>
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Key Technical Problems

- Segmentation
- Registration/tracking
- Biomechanical modeling
- Statistical modeling
“Signal” imaging: d/fMRI, M/EEG, ECG

- Analysis coupled with imaging
- Sophisticated statistics
Methodological Evolution

- Physics-motivated models coupled with optimization
- Statistics and geometry of manifolds
- Generative probabilistic models
- Machine learning
Diversity of Thought

• Lie groups and statistics on manifolds
• Large-scale software packages
• Surgical navigation systems
• Robots
Open Problems

• Algorithms do not generalize
  – across acquisition parameters or patients

• Much more emphasis on average performance than patient-specific results
  – great for population studies and MICCAI papers but useless for interventions and prediction

• Missing connection to acquisition
  – opportunity to improve analysis and opportunities for cool math
What we can do today

- Research brain images with diffuse atrophy: registration, segmentation
- 3D heart image series, even with infarct: segmentation, stress/strain estimation
- Lesion detection: cancer, stroke, TBI, MS
- What else is there?

What we want to do today

- Clinical brain images with an infiltrating tumor: accurate multimodal fusion
- 3D heart with congenital pathologies: segmentation, stress/strain estimation
- Moving and deforming organs, sparse sampling, non-standard anatomy
Wrap Up

• Amazing progress
  – Medical image computing is used in clinical research
  – Many image-guided procedures use some analysis

• Impossible challenges
  – We cannot handle variability of real patients
  – Acquisition is a foe instead of a friend
  – Existing solutions do not generalize to new applications

• Fantastic opportunities
  – Time to handle patient-specific case