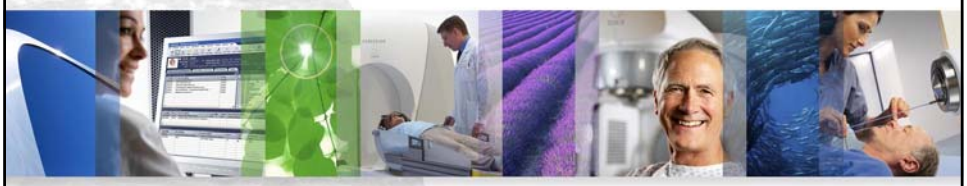

Dose planning from MRI using machine learning for automatic segmentation of skull and air

Jens Sjölund
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Human Care Makes the Future Possible

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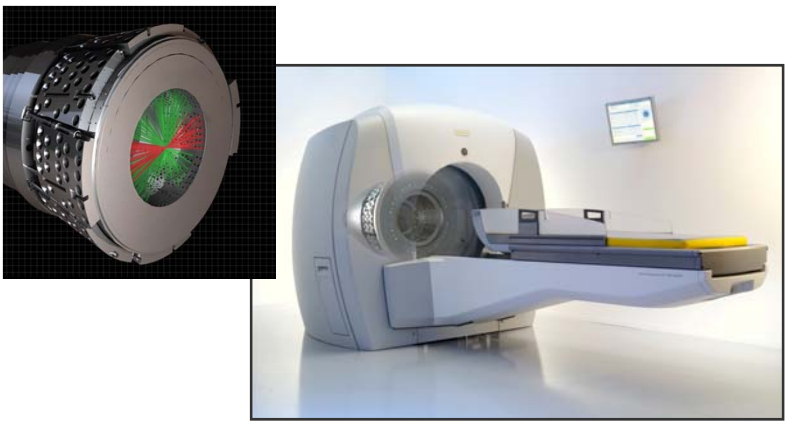
Gamma knife surgery – high precision treatment of brain disorders



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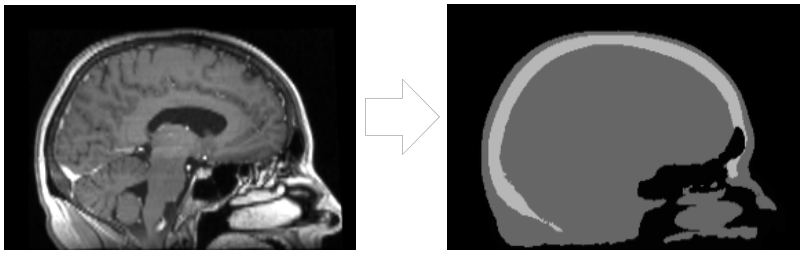
In short

- Goal
  - Improve dose calculations based solely on MRI
- Method
  - Automatic segmentation of the head into soft tissue, bone and air



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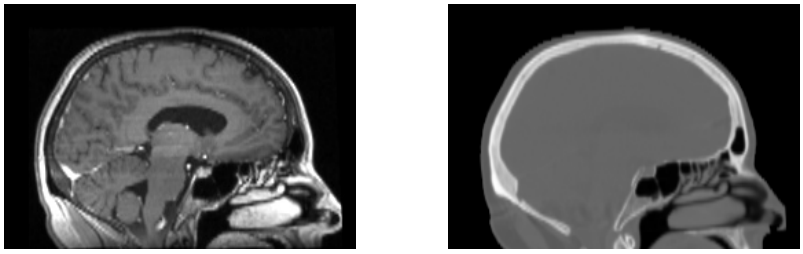
CT and MRI in radiosurgery

- MRI is safe and has superior soft tissue contrast. The preferred choice for target delineation
- CT enables more accurate dose calculations



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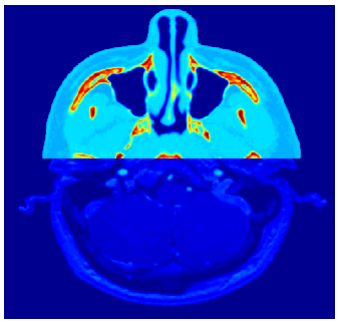
Combining CT and MRI

- Possibility
  - Acquire both CT and MRI and combine the information by registering them
- Problems
  - Additional dose
  - Extra work
  - Uncertainty in registration



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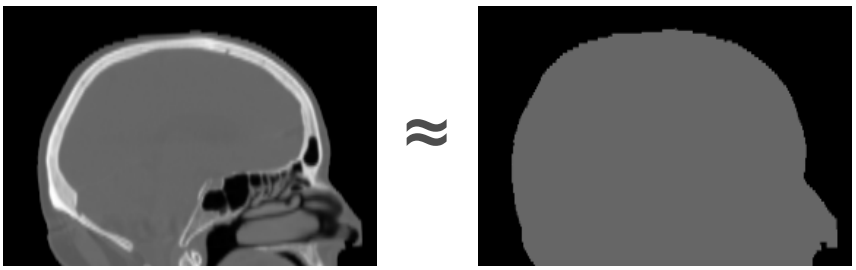
The reality of radiosurgery

- Many Gamma Knife users do not make an additional CT scan
- Dose calculations based on water approximation. Decent in central regions, worse close to skull and air
- Improve by automatically segmenting bone and air



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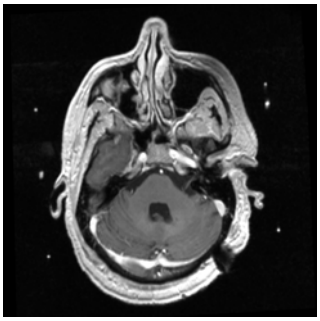
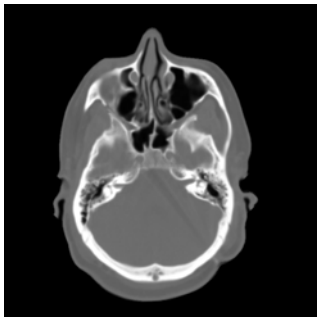
Complications when relating MRI to CT

- CT and MRI not possible to relate on physical grounds
- No signal from bone or air, makes pure image processing approach difficult





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The idea: mimic human reasoning

- How would a human identify bone and air?
  - Prior expectations on shape and locations
  - Combine with actual image information
  - Performance improves with experience
- Mimic using a machine learning algorithm (support vector machines)
- Registered pairs of CT and MRI used for training

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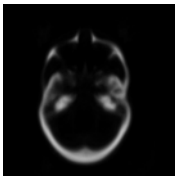
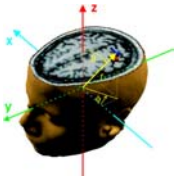
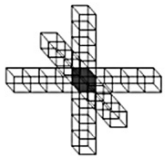
Features used for prediction



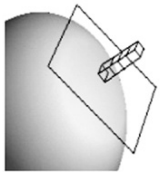
1 probability value



3 spherical coordinates



12 neighbour intensitites



9 intensities along gradient

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Data set

- 753 patients with both CT and T1-weighted MRI covering full head
- Probability values by averaging over these
- 20 patients for training
- 5 patients for evaluation

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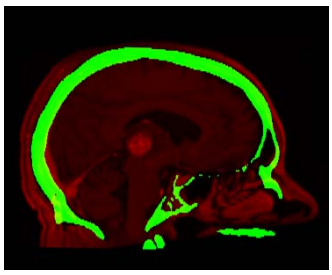
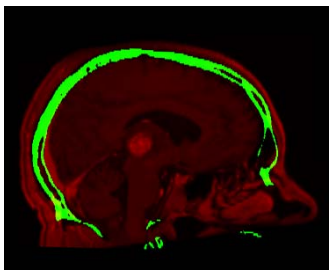
Complications when choosing bone treshold and density

1. Two types of bone
2. Partial volume effects
3. Large variations among patients





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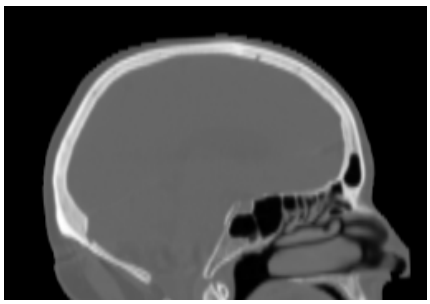
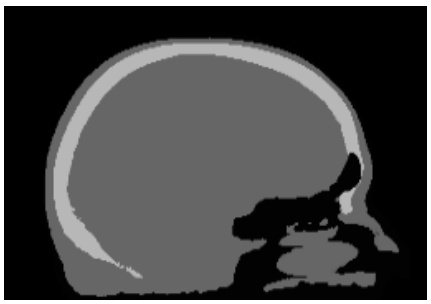
Comparison of true and predicted CT





- Bone thickness slightly overestimated
- Performance depends on threshold value, parameter tuning, features and registration

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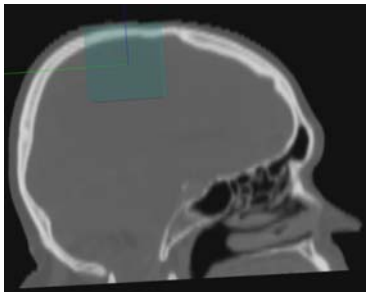
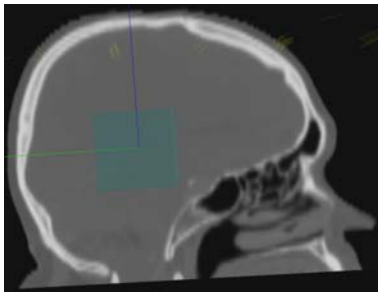
Dosimetric evaluation

- Monte Carlo simulations of the Gamma Knife
- One irradiation at the time in two locations
- CT used as ground truth





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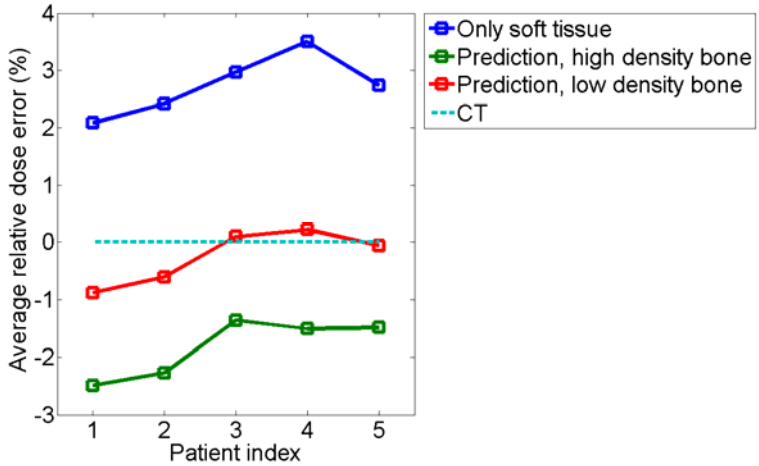
Relative dose error close to skull

- Average over voxels receiving at least 10% of max dose



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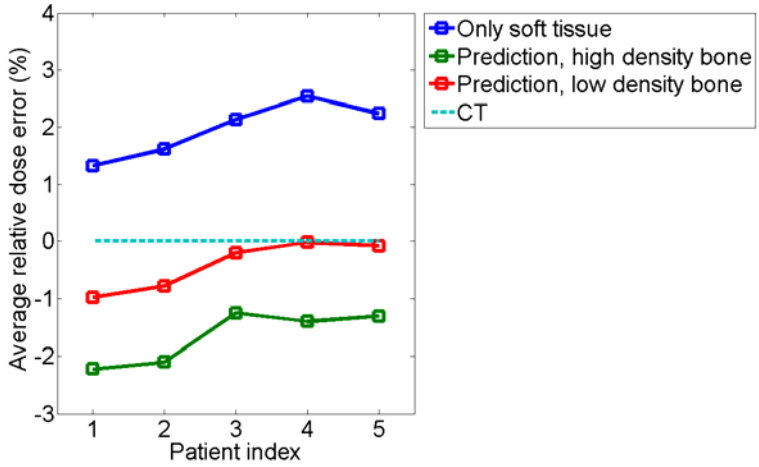
Relative dose error at center of head

- Average over voxels receiving at least 10% of max dose



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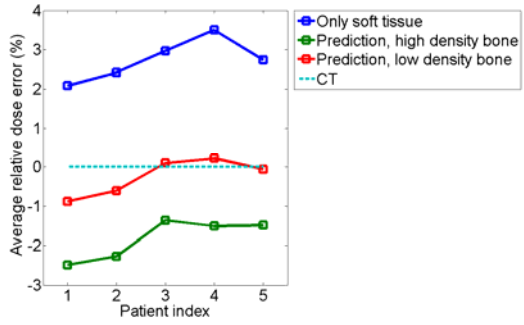
Conclusions

- Prediction not perfectly reliable in boundary regions
- Nevertheless, clear improvement in dose calculation accuracy (from about 2-3 % to <1 %)



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Questions?

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