**What works, Gap analysis**

Assessment of “solved” based on methodology that is well-published w.r.t. the methodology itself and clinical papers demonstrating usefulness in a (pre)-clinical setting.

**Image to Image registration**

Single modality, single subject, no pathology:

Brain: solved: MRI-MRI, CT-CT (Freesurfer, MNI animal/insect, UCLA packages, fsl, SPM (Air, deformable), linear and nonlinear, demons, fluid,

Abdomen:

CT-CT, if ROI constrained -> b-spline provides encouraging solution

In general not solved (sliding organs, discontinuous transformation)

Bony structures, joints: Othopedics: Commercial systems to register articulated bony structures (knee, pelvis, spine, …): Seems to have found a solution

Vasculature: work in progress, solutions presented for brain and cardiac

WM diffusion:

DTI to DTI registration: solutions available

DWI Hardi: early research in progress, not yet solved, promising

 Single organs:

Lung: CT to CT, publicly available, approaching maturity

 Liver: Approaching to become mature

 Cardiac: not solved

 Multimodality, single subject, no pathology:

Brain: solution exists (linear: mutual information registration, nonlinear: b-spline registration.

Non-brain: MRI-MRI, CT-MRI, research in progress (prostate)

Single subject including pathology:

Brain, MS lesions: lots of activities, low-dimensional registration with lesion analysis exists

More complex pathology: challenging, not yet solved

Non-brain: In general not solved, case-specific lab prototypes are published (tumor staging, MS lesions)

**Group Image Registration**

**Brain, being read as normal:** Starting to become mature (SPM,VBM, DTI population, congealing, …), available,

**Non-**brain: Cardiac, spine, ???

**Image to Model or Model to Image Registration:**

In general solved by deformable object segmentation (atlas deformation, ASM/AAM) Segmentation obtained by deformable object segmentation (e.g. ASM, AAM, etc.) by definition defines a pairwise or groupwise registration

**Model-to-Model Registration: Assuming that anatomical models are available from preceding segmentation via user-guided or automatic segmentation:**

Brain/Non-brain:

With available structural descriptions of organs and organ complexes of interest, shape matching, determining correspondence is available

Sparse registration problem: transformation defined for organs of interest, interstitious space to be interpolated

Problem of registration shifted to problem of segmentation

**Image&Model to Image&Model: Dense image data and selective model information available**

Point landmarks as constraints for linear and nonlinear registration: solved, exists

AAM framework: Trained variability/modes of geometry and appearance: Single organ segmentation, multiple-organ segmentation: exits, needs probabilistic model

More generic: Features such as surfaces, lines, tissue probabilities etc. in addition to dense volumetric information: Work in progress, e.g. scientific community working on “currents” for correspondence free registration

**Current Trends, Future**: Joint registration/segmentation framework, including domain-specific priors: Tasks of segmentation of organs of interest and registration should not be separated

What is it that we can’t do today? Current algorithms are not suited to the solve the problem

Problem with bringing in segmentation: you have to know too much about images, contrasts, anatomy etc., a lot of assumptions, too many constraints

User-interaction: GPU, computational steering, user drags, controls,