REGISTRATION EXPERIMENTS - CONTINUED

27th November 2004

1 General Notes

- It is not clear if there is ever a need for group-wise rigid transformation.
- There are some difficulties running group-wise optimisation. Error message comes up:

```
Additional groupwise optimisation not yet complete!!!!
```

2 Experiments

2.1 Yet Even Longer Registration

Experiments 26112004-1 and 26112004-2

Description: Different brains in (1) and (2), many levels of number of knot-points (up to 10^3) to make the experiment longer and better.

Conclusions: Results are excellent, even better than before (when optimisation was almost as long). For one of the data types, rotation was missing, but apart from that, good 3-D registration is achieved.

2.2 Increasing Resolution

Experiments 26112004-3 and 26112004-4

Description: Same as above experiments, but lower numbers of knot-points, yet increased resolution (levels). Two different experiments handle different data.

Conclusions: Judging by the later stages when resolution is increased, the enormous added computational effort is not needed. The increase in resolution does not reveal much about the image, at least not at the point where registration is yet far from being reached.

2.3 Group-wise Non-Rigid Registration

Experiment 26112004-5

Description: Group-wise after pair-wise 3 images, same parameters as pair-wise before

Conclusions: There are some encouraging results here which indicate group-wise stages after pair-wise stages make a significant difference.

Experiment 26112004-6

Description: Only group-wise. Shorter than above experiment.

Conclusions: It appears as if the images need to be close to registration before group-wise stages are carried out. Otherwise, there is far less improvement than in the previous experiment.

2.4 Very Long Group-wise Non-Rigid Registration

Experiment 26112004-7 and Experiment 26112004-8

Description: This continues the experiments in Subsection 2.1. This time group-wise will be devised too, rotation which was missing and some more iterations of NRR.

More details: 4 images in the set, 20 iteration pair-wise, then 30 pair-wise in the first experiment, group-wise in the second.

Conclusions: Having looked at all 3 images (apart from the reference) at the end, it is possible to conclude that long pair-wise registration performs fairly well; technical difficulties prevented group-wise experiments from finishing. See results in `/Comparison-Pair-Wise-Grou`

2.5 Shorter Group-wise Non-Rigid Registration

Experiment 26112004-9 and Experiment 26112004-10

Description: While the large experiments from 2.4 continue to run, shorter group-wise experiments were performed. The only difference was the number of group-wise iterations. 26112004-9 is longer than 26112004-10.

Conclusions: The group-wise stages lead to improvement in all 3 non-reference images. The improvements are quite significant too, yet they are slow to reach, especially with a set that becomes increasingly large.

3 Next Experiments

- Placeholder.

A Setting Files

A.1 Experiments in 2.1

```
////////////////////////////////////////////////////////
// GENERAL ARGUMENTS
matcher: comp_region_matcher
sampler: raw_intensity
pair_tex_objective_fn: ssd {  }
pair_shape_objective_fn: def_energy { }
pair_tex_weighting: 0.5
group_tex_objective_fn: wtd_abs_diff { }
group_shape_objective_fn: def_energy { }
group_tex_weighting: 0.00005
points_selector: all { border: 1 fi_lo: 0.10 fi_hi: 0.9 fj_lo: 0.1 fj_hi: 0.9 }
pyr_builder: gaussian
warps_affect_warp_regions:  false
images: {
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/abra_l_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/burr_r_auto
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
  warper: translation
```

```
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
  warper: scale
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
  warper: translation
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
  warper: scale
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// AFFINE STAGE
pairwise_stage: {
  warper: affine
```

```
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
pairwise_stage: {
  warper: affine
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// NON-RIGID STAGE
pairwise_stage: {
  warper: bilin_grid { ni: 4 nj: 4 nk: 4 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
pairwise_stage: {
  warper: bilin_grid { ni: 5 nj: 5 nk: 5 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
pairwise_stage: {
  warper: bilin_grid { ni: 7 nj: 7 nk: 7 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: downhill_search
```

```
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
pairwise_stage: {
  warper: bilin_grid { ni: 10 nj: 10 nk: 10 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
```

A.2 Experiments in 2.2

```
r/////////////////////////////////////////////////////////
// GENERAL ARGUMENTS
matcher: comp_region_matcher
sampler: raw_intensity
pair_tex_objective_fn: ssd {  }
pair_shape_objective_fn: def_energy { }
pair_tex_weighting: 0.5
group_tex_objective_fn: wtd_abs_diff { }
group_shape_objective_fn: def_energy { }
group_tex_weighting: 0.00005
points_selector: all { border: 1 fi_lo: 0.10 fi_hi: 0.9 fj_lo: 0.1 fj_hi: 0.9 }
pyr_builder: gaussian
warps_affect_warp_regions:  false
images: {
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/abra_l_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/burr_r_auto
}
/////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
  warper: translation
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
/////////////////////////////////////////////////////////
```

```
// SCALING STAGE
pairwise_stage: {
  warper: scale
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
  warper: translation
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
  warper: scale
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// AFFINE STAGE
pairwise_stage: {
  warper: affine
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
pairwise_stage: {
```

```
  warper: affine
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// NON-RIGID STAGE
pairwise_stage: {
  warper: bilin_grid { ni: 4 nj: 4 nk: 4 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
pairwise_stage: {
  warper: bilin_grid { ni: 5 nj: 5 nk: 5 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
pairwise_stage: {
  warper: bilin_grid { ni: 10 nj: 10 nk: 10 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 0 0
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
```

A.3 Experiments in 2.3

```
////////////////////////////////////////////////////////
```

```
// GENERAL ARGUMENTS
matcher: comp_region_matcher
sampler: raw_intensity
pair_tex_objective_fn: ssd {  }
pair_shape_objective_fn: def_energy { }
pair_tex_weighting: 0.5
group_tex_objective_fn: ssd { }
group_shape_objective_fn: def_energy { }
group_tex_weighting: 0.5
points_selector: all { border: 1 fi_lo: 0.10 fi_hi: 0.9 fj_lo: 0.1 fj_hi: 0.9 }
pyr_builder: gaussian
warps_affect_warp_regions:  false
images: {
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/abra_l_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/bowl_i_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/burr_r_auto
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
  warper: translation
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
  warper: scale
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
  warper: translation
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
```

```
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
  warper: scale
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// AFFINE STAGE
pairwise_stage: {
  warper: affine
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
pairwise_stage: {
  warper: affine
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: simplex
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
}
////////////////////////////////////////////////////////
// NON-RIGID STAGE
pairwise_stage: {
  warper: bilin_grid { ni: 4 nj: 4 nk: 4 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
```

```
  optimise_many_warps:  false
  n_opt_its: 10
}
pairwise_stage: {
  warper: bilin_grid { ni: 5 nj: 5 nk: 5 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 10
}
groupwise_stage: {
  warper: bilin_grid { ni: 4 nj: 4 nk: 4 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 2 2
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 5
}
groupwise_stage: {
  warper: bilin_grid { ni: 5 nj: 5 nk: 5 }
  warp_penalty_fn: zero { }
  region_picker: all { }
  levels: 1 1
  optimisation_method: downhill_search
  param_tol: 0.001
  use_exhaustive_search:  false
  n_per_dim: 5
  optimise_many_warps:  false
  n_opt_its: 5
}
```

A.4 Experiments in 2.4

```
////////////////////////////////////////////////////////
// GENERAL ARGUMENTS
matcher: comp_region_matcher
sampler: raw_intensity
pair_tex_objective_fn: ssd { }
pair_shape_objective_fn: def_energy { }
pair_tex_weighting: 0.5
group_tex_objective_fn: ssd { }
group_shape_objective_fn: def_energy { }
group_tex_weighting: 0.5
```

```
points_selector: all { border: 1 fi_lo: 0.10 fi_hi: 0.9 fj_lo: 0.1 fj_hi: 0.9 }
pyr_builder: gaussian
warps_affect_warp_regions: false
images: {
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/abra_l_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/burr_r_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/bowl_i_auto
/home/S00/schestr0/NRR/BrainExperiments/DemBrains/daws_k_auto
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
warper: translation
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 2
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
warper: scale
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 2
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
////////////////////////////////////////////////////////
// ROTATION STAGE
pairwise_stage: {
warper: rotation
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 2
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
////////////////////////////////////////////////////////
// TRANSLATION STAGE
pairwise_stage: {
warper: translation
```

```
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 2
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
////////////////////////////////////////////////////////
// SCALING STAGE
pairwise_stage: {
warper: scale
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 2
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
////////////////////////////////////////////////////////
// AFFINE STAGE
pairwise_stage: {
warper: affine
warp_penalty_fn: zero { }
region_picker: all { }
levels: 2 2
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
pairwise_stage: {
warper: affine
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 1
optimisation_method: simplex
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
}
////////////////////////////////////////////////////////
// NON-RIGID STAGE
pairwise_stage: {
warper: bilin_grid { ni: 4 nj: 4 nk: 4 }
warp_penalty_fn: zero { }
region_picker: all { }
```

```
levels: 2 2
optimisation_method: downhill_search
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
n_opt_its: 10
}
pairwise_stage: {
warper: bilin_grid { ni: 10 nj: 10 nk: 10 }
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 1
optimisation_method: downhill_search
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
n_opt_its: 10
}
pairwise_stage: {
warper: bilin_grid { ni: 5 nj: 5 nk: 5 }
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 1
optimisation_method: downhill_search
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
n_opt_its: 10
}
pairwise_stage: {
warper: bilin_grid { ni: 7 nj: 7 nk: 7 }
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 1
optimisation_method: downhill_search
param_tol: 0.001
use_exhaustive_search: false
n_per_dim: 5
optimise_many_warps: false
n_opt_its: 10
}
pairwise_stage: {
warper: bilin_grid { ni: 10 nj: 10 nk: 10 }
warp_penalty_fn: zero { }
region_picker: all { }
levels: 1 1
optimisation_method: downhill_search
param_tol: 0.001
use_exhaustive_search: false
```

```
n_per_dim: 5
optimise_many_warps: false
n_opt_its: 10
}
```