

Supplementary information

Groupwise image registration based on a total correlation
dissimilarity measure for quantitative MRI
and dynamic imaging data

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Cells with grey background are already included in the main article.

Table S1: TIMOLLI-HEART. Mean and standard deviation over all subjects for all evaluation measures and control point spacings 32 mm, 64 mm and 128 mm, and for reference images 1, 4, 7 and 11.

| (a) Dice [%] | | | | | | | | | | | | |
|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| | 32 | | | | 64 | | | | 128 | | | |
| | 1 | 4 | 7 | 11 | 1 | 4 | 7 | 11 | 1 | 4 | 7 | 11 |
| Mis. | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 | 48 ± 8 |
| \mathcal{D}_{MI} | 26 ± 11 | 22 ± 10 | 22 ± 15 | 39 ± 14 | 37 ± 11 | 34 ± 16 | 19 ± 15 | 52 ± 7 | 44 ± 14 | 40 ± 13 | 24 ± 17 | 51 ± 7 |
| \mathcal{D}_{PCA} | 54 ± 9 | 54 ± 9 | 54 ± 9 | 54 ± 9 | 53 ± 7 | 53 ± 7 | 53 ± 7 | 53 ± 8 | 51 ± 9 | 50 ± 9 | 51 ± 9 | 51 ± 9 |
| \mathcal{D}_{PCA2} | 52 ± 13 | 52 ± 13 | 52 ± 13 | 52 ± 13 | 52 ± 11 | 52 ± 10 | 52 ± 11 | 53 ± 10 | 52 ± 7 | 52 ± 8 | 52 ± 8 | 52 ± 8 |
| \mathcal{D}_{TC} | 52 ± 13 | 52 ± 12 | 52 ± 13 | 53 ± 13 | 53 ± 11 | 53 ± 11 | 53 ± 11 | 53 ± 11 | 53 ± 7 | 53 ± 8 | 54 ± 7 | 53 ± 8 |

| (b) $STD_{ \partial T_g / \partial x }$ [%] | | | | | | | | | | | | |
|---|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 32 | | | | 64 | | | | 128 | | | |
| | 1 | 4 | 7 | 11 | 1 | 4 | 7 | 11 | 1 | 4 | 7 | 11 |
| Mis. | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{MI} | 24 ± 8 | 28 ± 8 | 29 ± 9 | 10 ± 4 | 7 ± 2 | 7 ± 2 | 8 ± 3 | 3 ± 1 | 1 ± 0 | 1 ± 0 | 1 ± 0 | 1 ± 0 |
| \mathcal{D}_{PCA} | 6 ± 4 | 4 ± 2 | 4 ± 2 | 4 ± 1 | 2 ± 1 | 1 ± 1 | 2 ± 1 | 1 ± 1 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{PCA2} | 6 ± 2 | 5 ± 2 | 6 ± 2 | 4 ± 1 | 1 ± 1 | 1 ± 1 | 2 ± 1 | 1 ± 1 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{TC} | 7 ± 3 | 6 ± 3 | 7 ± 3 | 5 ± 1 | 2 ± 1 | 2 ± 1 | 2 ± 1 | 1 ± 1 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |

| (c) 90% \sqrt{CRLB} T_1 [ms] | | | | | | | | | | | | |
|----------------------------------|----------|----------|-----------|---------|---------|----------|----------|---------|---------|---------|----------|---------|
| | 32 | | | | 64 | | | | 128 | | | |
| | 1 | 4 | 7 | 11 | 1 | 4 | 7 | 11 | 1 | 4 | 7 | 11 |
| Mis. | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 | 92 ± 19 |
| \mathcal{D}_{MI} | 119 ± 26 | 157 ± 61 | 467 ± 610 | 93 ± 19 | 97 ± 16 | 103 ± 18 | 146 ± 52 | 83 ± 13 | 91 ± 14 | 95 ± 16 | 121 ± 29 | 81 ± 12 |
| \mathcal{D}_{PCA} | 83 ± 17 | 79 ± 17 | 78 ± 11 | 85 ± 16 | 87 ± 16 | 84 ± 20 | 83 ± 13 | 85 ± 13 | 88 ± 14 | 89 ± 21 | 103 ± 50 | 85 ± 10 |
| \mathcal{D}_{PCA2} | 81 ± 15 | 79 ± 16 | 79 ± 12 | 79 ± 12 | 83 ± 12 | 79 ± 14 | 80 ± 10 | 81 ± 10 | 84 ± 12 | 82 ± 15 | 82 ± 10 | 81 ± 11 |
| \mathcal{D}_{TC} | 77 ± 14 | 75 ± 11 | 73 ± 14 | 74 ± 12 | 77 ± 13 | 75 ± 11 | 73 ± 13 | 74 ± 11 | 79 ± 12 | 76 ± 11 | 76 ± 13 | 75 ± 11 |

Table S2: T1VFA-CAROTID. Means and standard deviation over all subjects for all evaluation measures and control point spacings 8 mm, 16 mm and 32 mm.

| (a) mTRE [mm] | | | |
|----------------------|-------------|-------------|-------------|
| | 8 | 16 | 32 |
| Mis. | 1.47 ± 0.54 | 1.47 ± 0.54 | 1.47 ± 0.54 |
| \mathcal{D}_{MI} | 1.26 ± 0.44 | 1.22 ± 0.43 | 1.23 ± 0.45 |
| \mathcal{D}_{PCA} | 1.25 ± 0.56 | 1.11 ± 0.42 | 1.10 ± 0.43 |
| \mathcal{D}_{PCA2} | 1.13 ± 0.46 | 1.08 ± 0.39 | 1.10 ± 0.43 |
| \mathcal{D}_{TC} | 1.19 ± 0.50 | 1.09 ± 0.40 | 1.10 ± 0.42 |

| (b) $STD_{ \partial T_g / \partial x }$ [%] | | | |
|---|-------|-------|-------|
| | 8 | 16 | 32 |
| Mis. | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{MI} | 7 ± 1 | 2 ± 0 | 0 ± 0 |
| \mathcal{D}_{PCA} | 6 ± 1 | 2 ± 1 | 0 ± 0 |
| \mathcal{D}_{PCA2} | 5 ± 1 | 1 ± 0 | 0 ± 0 |
| \mathcal{D}_{TC} | 6 ± 1 | 1 ± 0 | 0 ± 0 |

| (c) 90% \sqrt{CRLB} T_1 [ms] | | | |
|----------------------------------|-----------|-----------|----------|
| | 8 | 16 | 32 |
| Mis. | > 1000 | > 1000 | > 1000 |
| \mathcal{D}_{MI} | 530 ± 136 | 501 ± 83 | 523 ± 93 |
| \mathcal{D}_{PCA} | 540 ± 154 | 498 ± 93 | 530 ± 94 |
| \mathcal{D}_{PCA2} | 532 ± 154 | 510 ± 110 | 523 ± 87 |
| \mathcal{D}_{TC} | 533 ± 150 | 500 ± 96 | 528 ± 96 |

Table S5: DTI-BRAIN. Mean and standard deviation of the 90% \sqrt{CRLB} MD [$\mu m^2/ms$] over all subjects.

| Affine | |
|----------------------|---------------|
| Mis. | 0.096 ± 0.029 |
| \mathcal{D}_{MI} | 0.084 ± 0.028 |
| \mathcal{D}_{PCA} | 0.085 ± 0.029 |
| \mathcal{D}_{PCA2} | 0.084 ± 0.028 |
| \mathcal{D}_{TC} | 0.085 ± 0.029 |

Table S3: ADC-ABDOMEN. Mean and standard deviation over all subjects for all evaluation measures and control point spacings of 32 mm, 64 mm and 128 mm.

| (a) Dice [%] | | | | | | |
|----------------------|---------|---------|--------|--------|--------|--------|
| | 32 | | 64 | | 128 | |
| | 32 | 64 | 32 | 64 | 32 | 64 |
| Mis. | 70 ± 4 | 70 ± 4 | 70 ± 4 | 70 ± 4 | 70 ± 4 | 70 ± 4 |
| \mathcal{D}_{MI} | 61 ± 18 | 64 ± 16 | 73 ± 8 | 73 ± 8 | 73 ± 8 | 73 ± 8 |
| \mathcal{D}_{PCA} | 65 ± 13 | 71 ± 5 | 71 ± 4 | 71 ± 4 | 71 ± 4 | 71 ± 4 |
| \mathcal{D}_{PCA2} | 75 ± 7 | 75 ± 5 | 73 ± 5 | 73 ± 5 | 73 ± 5 | 73 ± 5 |
| \mathcal{D}_{TC} | 72 ± 6 | 74 ± 5 | 73 ± 5 | 73 ± 5 | 73 ± 5 | 73 ± 5 |

| (b) $STD_{ \partial T_g / \partial x }$ [%] | | | | | | |
|---|---------|-------|-------|-------|-------|-------|
| | 32 | | 64 | | 128 | |
| | 32 | 64 | 32 | 64 | 32 | 64 |
| Mis. | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{MI} | 25 ± 11 | 8 ± 3 | 2 ± 1 | 2 ± 1 | 2 ± 1 | 2 ± 1 |
| \mathcal{D}_{PCA} | 11 ± 3 | 3 ± 1 | 1 ± 0 | 1 ± 0 | 1 ± 0 | 1 ± 0 |
| \mathcal{D}_{PCA2} | 8 ± 2 | 3 ± 1 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{TC} | 16 ± 5 | 5 ± 2 | 1 ± 0 | 1 ± 0 | 1 ± 0 | 1 ± 0 |

| (c) 90% \sqrt{CRLB} ADC [$\mu m^2/ms$] | | | | | | |
|--|-------------|-------------|-------------|-------------|-------------|-------------|
| | 32 | | 64 | | 128 | |
| | 32 | 64 | 32 | 64 | 32 | 64 |
| Mis. | 0.24 ± 0.06 | 0.25 ± 0.05 | 0.29 ± 0.05 | 0.29 ± 0.05 | 0.29 ± 0.05 | 0.29 ± 0.05 |
| \mathcal{D}_{MI} | 0.20 ± 0.08 | 0.23 ± 0.10 | 0.35 ± 0.16 | 0.35 ± 0.16 | 0.35 ± 0.16 | 0.35 ± 0.16 |
| \mathcal{D}_{PCA} | 0.15 ± 0.04 | 0.23 ± 0.06 | 0.46 ± 0.27 | 0.46 ± 0.27 | 0.46 ± 0.27 | 0.46 ± 0.27 |
| \mathcal{D}_{PCA2} | 0.23 ± 0.03 | 0.27 ± 0.05 | 0.41 ± 0.18 | 0.41 ± 0.18 | 0.41 ± 0.18 | 0.41 ± 0.18 |
| \mathcal{D}_{TC} | 0.33 ± 0.05 | 0.32 ± 0.05 | 0.38 ± 0.14 | 0.38 ± 0.14 | 0.38 ± 0.14 | 0.38 ± 0.14 |

Table S6: CT-LUNG. Mean and standard deviation over all subjects for all evaluation measures and control point spacings 6 mm, 13 mm and 20 mm.

| (a) mTRE [mm] | | | | | | |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | 6 | | 13 | | 20 | |
| | 6 | 13 | 6 | 13 | 6 | 13 |
| Mis. | 6.72 ± 2.51 | 6.72 ± 2.51 | 6.72 ± 2.51 | 6.72 ± 2.51 | 6.72 ± 2.51 | 6.72 ± 2.51 |
| \mathcal{D}_{MI} | 1.78 ± 0.40 | 1.43 ± 0.23 | 1.45 ± 0.21 | 1.45 ± 0.21 | 1.45 ± 0.21 | 1.45 ± 0.21 |
| \mathcal{D}_{PCA} | 1.47 ± 0.60 | 1.40 ± 0.37 | 1.45 ± 0.34 | 1.45 ± 0.34 | 1.45 ± 0.34 | 1.45 ± 0.34 |
| \mathcal{D}_{PCA2} | 1.72 ± 0.78 | 1.56 ± 0.55 | 1.59 ± 0.49 | 1.59 ± 0.49 | 1.59 ± 0.49 | 1.59 ± 0.49 |
| \mathcal{D}_{TC} | 1.48 ± 0.62 | 1.42 ± 0.40 | 1.47 ± 0.37 | 1.47 ± 0.37 | 1.47 ± 0.37 | 1.47 ± 0.37 |

| (b) $STD_{ \partial T_g / \partial x }$ [%] | | | | | | |
|---|--------|--------|--------|--------|--------|--------|
| | 6 | | 13 | | 20 | |
| | 6 | 13 | 6 | 13 | 6 | 13 |
| Mis. | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{MI} | 28 ± 8 | 15 ± 4 | 11 ± 3 | 11 ± 3 | 11 ± 3 | 11 ± 3 |
| \mathcal{D}_{PCA} | 12 ± 3 | 8 ± 2 | 7 ± 2 | 7 ± 2 | 7 ± 2 | 7 ± 2 |
| \mathcal{D}_{PCA2} | 10 ± 2 | 7 ± 2 | 6 ± 1 | 6 ± 1 | 6 ± 1 | 6 ± 1 |
| \mathcal{D}_{TC} | 12 ± 3 | 8 ± 2 | 7 ± 2 | 7 ± 2 | 7 ± 2 | 7 ± 2 |

Table S4: DCE-ABDOMEN. Mean and standard deviation over all subjects for all evaluation measures and control point spacings 32 mm, 64 mm and 128 mm.

| (a) mTRE [mm] | | | | | | |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | 32 | | 64 | | 128 | |
| | 32 | 64 | 32 | 64 | 32 | 64 |
| Mis. | 8.49 ± 4.54 | 8.49 ± 4.54 | 8.49 ± 4.54 | 8.49 ± 4.54 | 8.49 ± 4.54 | 8.49 ± 4.54 |
| \mathcal{D}_{MI} | 6.73 ± 2.02 | 6.46 ± 2.32 | 6.47 ± 2.37 | 6.47 ± 2.37 | 6.47 ± 2.37 | 6.47 ± 2.37 |
| \mathcal{D}_{PCA} | 6.21 ± 2.25 | 6.11 ± 2.32 | 6.24 ± 2.37 | 6.24 ± 2.37 | 6.24 ± 2.37 | 6.24 ± 2.37 |
| \mathcal{D}_{PCA2} | 5.89 ± 2.23 | 5.99 ± 2.17 | 6.18 ± 2.27 | 6.18 ± 2.27 | 6.18 ± 2.27 | 6.18 ± 2.27 |
| \mathcal{D}_{TC} | 7.01 ± 1.82 | 6.18 ± 2.40 | 6.23 ± 2.30 | 6.23 ± 2.30 | 6.23 ± 2.30 | 6.23 ± 2.30 |

| (b) $STD_{ \partial T_g / \partial x }$ [%] | | | | | | |
|---|--------|-------|-------|-------|-------|-------|
| | 32 | | 64 | | 128 | |
| | 32 | 64 | 32 | 64 | 32 | 64 |
| Mis. | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{MI} | 20 ± 9 | 4 ± 2 | 1 ± 1 | 1 ± 1 | 1 ± 1 | 1 ± 1 |
| \mathcal{D}_{PCA} | 11 ± 4 | 4 ± 2 | 1 ± 0 | 1 ± 0 | 1 ± 0 | 1 ± 0 |
| \mathcal{D}_{PCA2} | 6 ± 3 | 2 ± 1 | 0 ± 0 | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| \mathcal{D}_{TC} | 11 ± 4 | 4 ± 2 | 1 ± 0 | 1 ± 0 | 1 ± 0 | 1 ± 0 |

| (c) 90% \sqrt{CRLB} K^{trans} [min^{-1}] | | | | | | |
|--|-------------|-------------|-------------|-------------|-------------|-------------|
| | 32 | | 64 | | 128 | |
| | 32 | 64 | 32 | 64 | 32 | 64 |
| Mis. | 2.84 ± 2.30 | 2.84 ± 2.30 | 2.84 ± 2.30 | 2.84 ± 2.30 | 2.84 ± 2.30 | 2.84 ± 2.30 |
| \mathcal{D}_{MI} | 3.85 ± 2.41 | 3.64 ± 4.13 | 2.54 ± 2.58 | 2.54 ± 2.58 | 2.54 ± 2.58 | 2.54 ± 2.58 |
| \mathcal{D}_{PCA} | 1.69 ± 1.48 | 1.52 ± 1.18 | 1.46 ± 1.09 | 1.46 ± 1.09 | 1.46 ± 1.09 | 1.46 ± 1.09 |
| \mathcal{D}_{PCA2} | 1.17 ± 0.87 | 1.27 ± 0.92 | 1.38 ± 1.16 | 1.38 ± 1.16 | 1.38 ± 1.16 | 1.38 ± 1.16 |
| \mathcal{D}_{TC} | 1.78 ± 1.74 | 1.87 ± 1.81 | 1.54 ± 1.38 | 1.54 ± 1.38 | 1.54 ± 1.38 | 1.54 ± 1.38 |