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IMAGE REGISTRATION BY MODEL CRITERIA

R. S. Schestowitz, C. J. Twining, T. F. Cootes and C. J. Taylor

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OVERVIEW

- Image registration
- Statistical models
- Experiments
  - Models as similarity
  - Toward automatic appearance model construction
- Results and conclusions

IMAGE REGISTRATION

- Results in overlap of analogous structures.
- Does so by transforming (warping) an image.
- Transformations are evaluated by similarity measures.

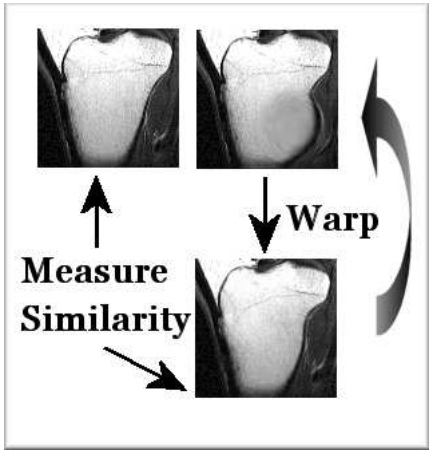

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IMAGE REGISTRATION - CTD.

- Suffers from problems in some cases:
  - Inter-subject registration: objects in images are different.
  - Registration of a set (size>2) of images.

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MODELS OF SHAPE AND APPEARANCE

- Used to analyse and synthesise data of a known class.
- Rely on principal component analysis.
- Extract sources of variability in data.
- Can synthesise plausible data.

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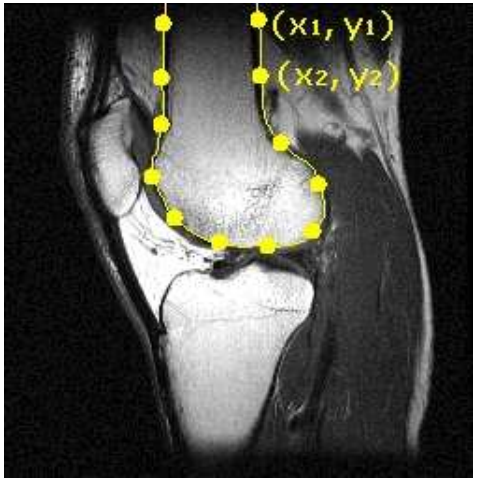
MODELS OF SHAPE AND APPEARANCE: FLAWS

♢ Correspondences need to be identified.

♢ Set size affects complexity non-linearly.



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RETURNING TO REGISTRATION: SIMILARITY

- Similarity is traditionally associated with:
  - Mutual information (MI) or normalised MI.
  - Mean of squared difference.
- Better used in the scope of image *couples*, not groups.
- Minimum description length (MDL) principle for sets.

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Reference in Registration

- Results of registration biassed to the reference.
- Reference is not robust to deviant data.

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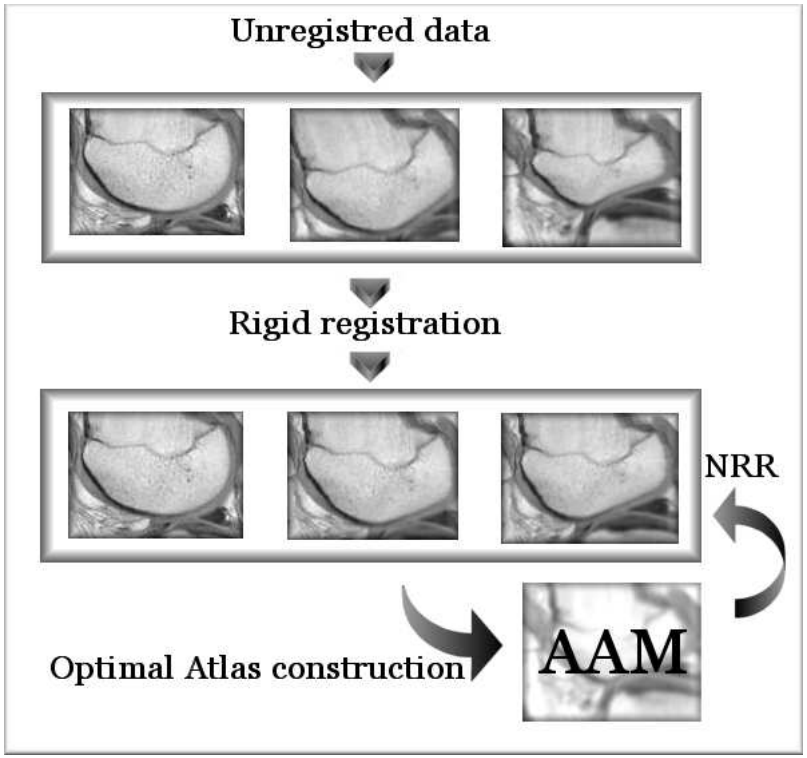
MODELS AS SIMILARITY

♢ Similarity obtained indirectly.

♢ Representative of the entire set.

MODELS AS SIMILARITY - CTD.



MODELS AS SIMILARITY - CTD.

♢ Complexity of combined model of shape and intensity.

♢ Infer from the covariance matrix of the model.

♢ We obtain $\sum_{i=1}^{n} log(\lambda_i + \delta)$

♢ $\lambda_{1<i<n}$ are the n Eigen-values of the covariance matrix whose magnitudes are the greatest.

MODELS AS SIMILARITY - CTD.

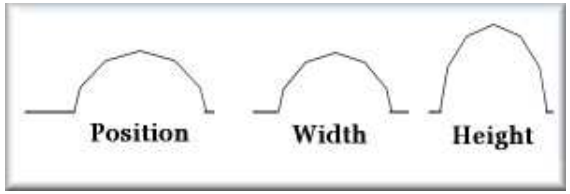
♢ It is proportional to $\sum_{i=1}^{n} log(\lambda_i + \delta) \equiv log(det(\mathbf{M} + \delta))$.

♢ δ is needed to avoid multiplication by 0.

♢ This approximates $det(\mathbf{M} + \delta) \equiv \prod_{i=1}^{n} (\lambda_i + \delta)$.

EXPERIMENTS

- Used 1-D bumps that vary in:
  - Height
  - Horizontal orientation
  - Width

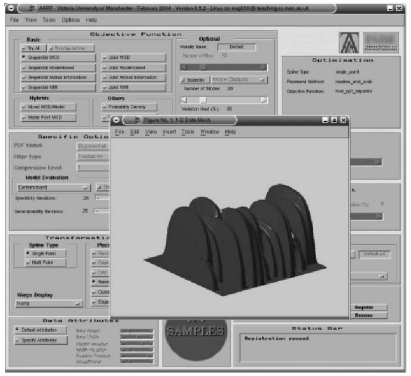


- Correct solution is known and can be used for validation.

EXPERIMENTS - CTD.

- Clamped-plate splines used for transformation.
- Experiments performed under:

Autonomous appearance-based registration test-bed (AART)
`http://www.schestowitz.com/Projects/AART/`



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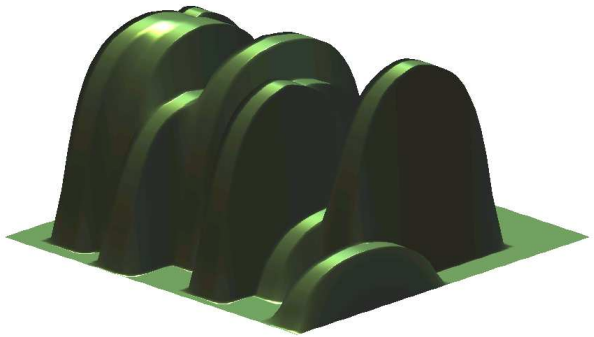
RESULTS OF REGISTRATION

♢ Warps are chosen randomly...

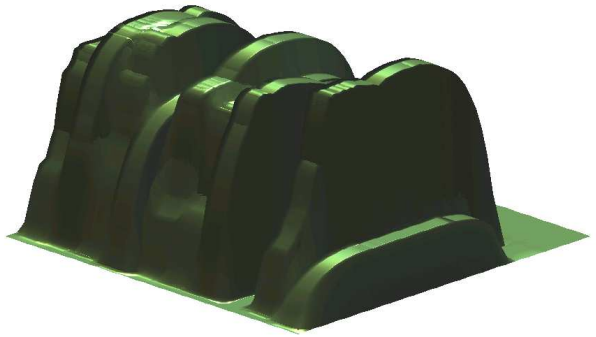
♢ Model captures/encapsulates the entire set...

♢ ...**and yet**, good alignment of the data is reached after only a few minutes.

RESULTS OF REGISTRATION - CTD.



Before registration



After registration

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RESULTS OF REGISTRATION - CTD.

♢ Result is approaching the ideal solution as defined by a model.

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Resulting Models

- The combined model fully captures the variability.
- Decomposition into the 3 dimensions of variation.
- Intensity captures height variation.
- The shape model captures width and position variation.

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REGISTRATION APPROACHES: COMPARISON

	Pair-wise	Standard Group-wise	Model-based
Model construction	X	X	$\surd$
Unique solution	X	Algorithm-dependent	$\surd$
Speed	Fast	Algorithm-dependent	Moderate
Robustness to outliers	Fair	Good	Good

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Future Work

- Extension to 2- and 3-D.
- Further algorithm speed-up, e.g. by:
  - Cunning placement of warps.
  - Stochastically choosing sub-sets.
  - Employing hybrid objective functions.

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SUMMARY

- Models require correspondence.
- Registration methods provide this correspondence.
- Unifying Modelling and registration results in:
  - High-quality registration.
  - A step towards automatic appearance model construction.
- A model-based registration produces deformable atlases.

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CONCLUSIONS

♢ Modelling need not be independent of registration.

♢ Registration by model complexity provides unique solutions.

♢ Correspondence in the set is identified in this process.

♢ Appearance models are refined without human intervention.