Segmentation of hand radiographs by using multi-level connected active appearance models

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Introduction

Rheumatoid arthritis

- chronic inflammatory disease causing joint damage
- hand radiographs used for monitoring disease progression

Goal: *locate the bones in a hand radiograph*

Problems

- variabilities in finger positioning
- artifacts: rings, labels, implants, etc.
- present joint damage

Methods

- active appearance model (AAM) [1]
- connected AAMs [2]
- iterative AAM search
- multiple search levels

Training set

Connected AAMs:

- 50 digitized film radiographs
- manually outlined contours
- 'fish bone' shaped grid for defining 64 landmarks (LMs) on metacarpals, proximal and middle phalanges
- 10 LMs for carpal region and 4 LMs for distal phalanges

Modeling the hand

Compensate for variability caused by differences in hand positioning

- use sub-AAM for each bone
- define structure of subcoordinate frames
- within each frame: make submodels invariant to rotation and translation
- connect sub-AAMs in a single parametric model

AAM search

Multiple levels

- begin with a low detail model: few landmarks and low texture resolution
- initialize at center of gravity
- after search convergence, use parameters to initialize the next search with a more detailed model

Results

Test setup

- 30 test images
- two search levels,
first: 4 LMs per submodel at 8 pixels/cm
second: up to 64 LMs per submodel at 15 pixels/cm
- detected landmark locations are compared to manually placed landmarks

Results

- mean error < 1.3 mm for 22 images
- large failures in 2 images caused by poor initialization
- mean error < 4.3 mm for remaining 6 images

Performance

- fewer errors and faster compared to a single level search
- smaller errors than without rotation and translation invariant submodels

Conclusions

- The use of multiple search levels reduces search time and improves segmentation results.
- Making the model invariant to lateral finger displacements results in smaller segmentation errors.
- Improvement of the initialization of the AAM search may lead to fewer search errors.

References

- [1] Cootes, T. F., Edwards, G. J., and Taylor, C. J., "Active appearance models," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 23, no. 6, pp. 681-685, 2001.
- [2] Bukovec, M., Truyen, R., Likar, B., Bernard, R., and Pernus, F. Image Segmentation by Connected Parametrical Models. Medical Imaging 2004: Image Processing 5370, 398-409. 2004. SPIE.