

Motion measurements in low-contrast X-ray imagery

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motivation patient positioning in radiotherapy

imagery portal images (megavoltage X-ray images)

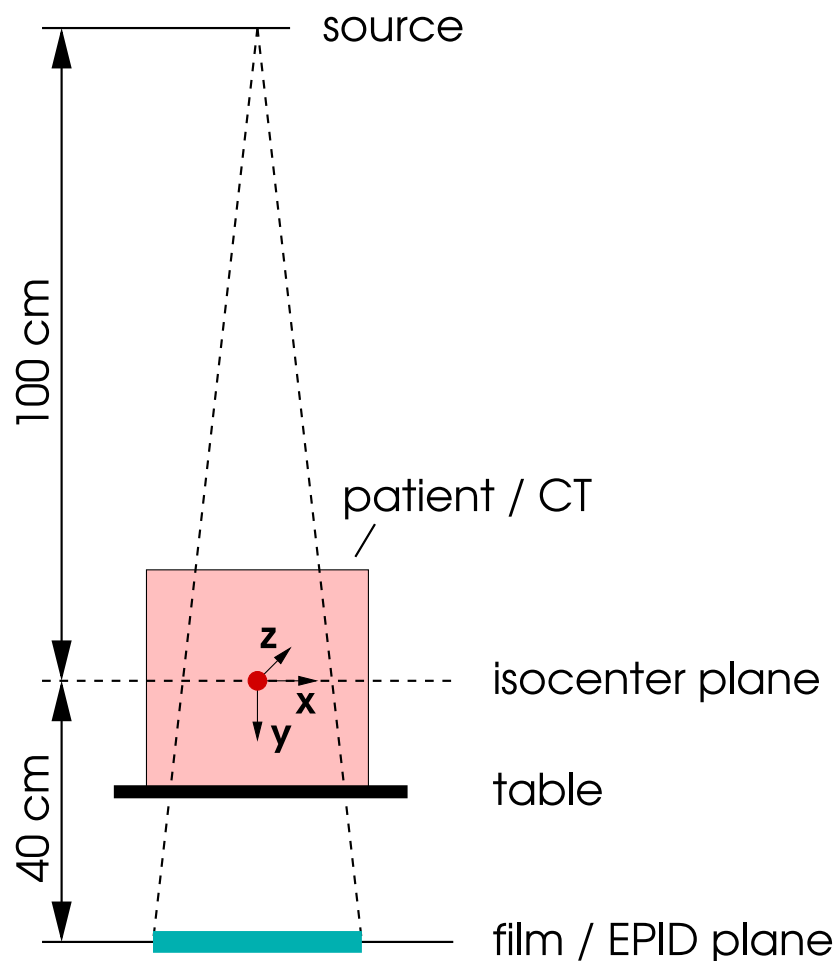
Motion measurements in low-contrast X-ray imagery

method least squares template matching (LSM)

results measurements and error analysis

conclusion summary and discussion

motivation - patient positioning in radiotherapy



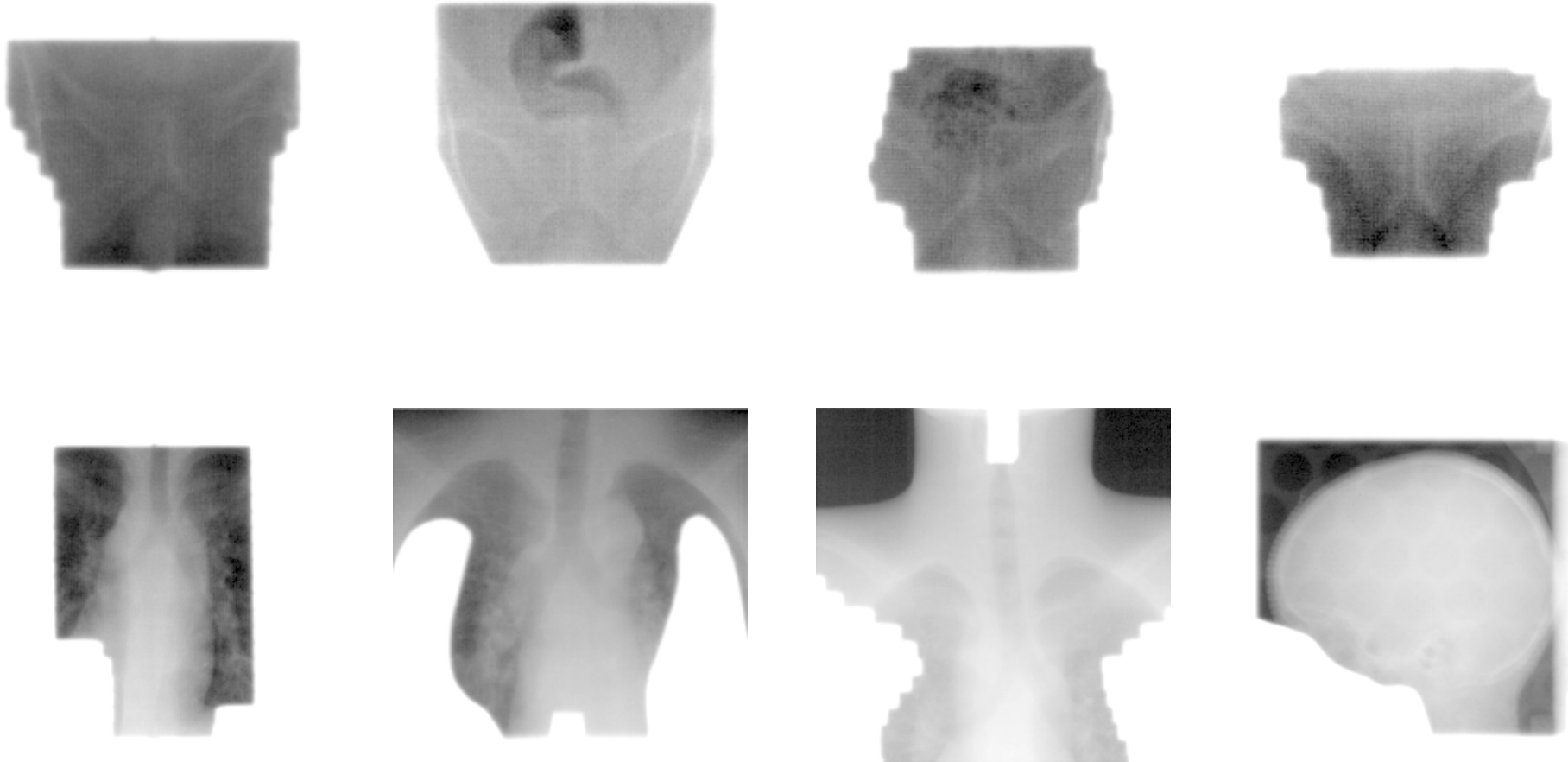
patient position

- coarse alignment by skin marks
- exact position unknown

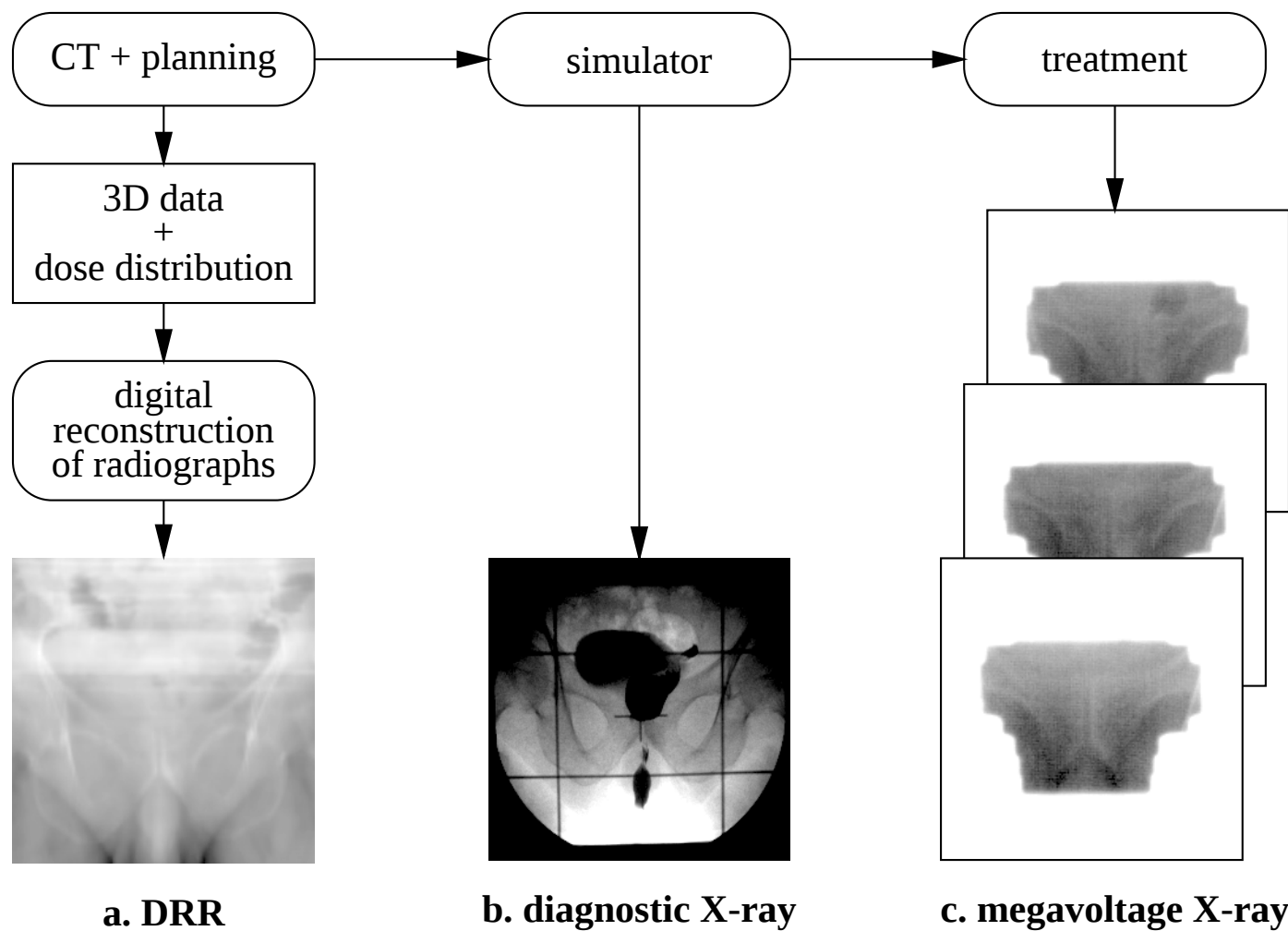
electronic portal imaging device

- mounted on retractable arm
- position not fixed

imagery — electronic portal images



imagery — overview of radiotherapy procedure



method — least squared template matching

observation

$$f[u] + e[u] = \bar{g}(x)$$

geometric transformation

$$\tilde{g}[u] = \bar{g}(x = \psi(\xi, u))$$

linearized vector notation

$$f + e = \tilde{g}^\circ + A \cdot \Delta\xi$$

least squares goal function

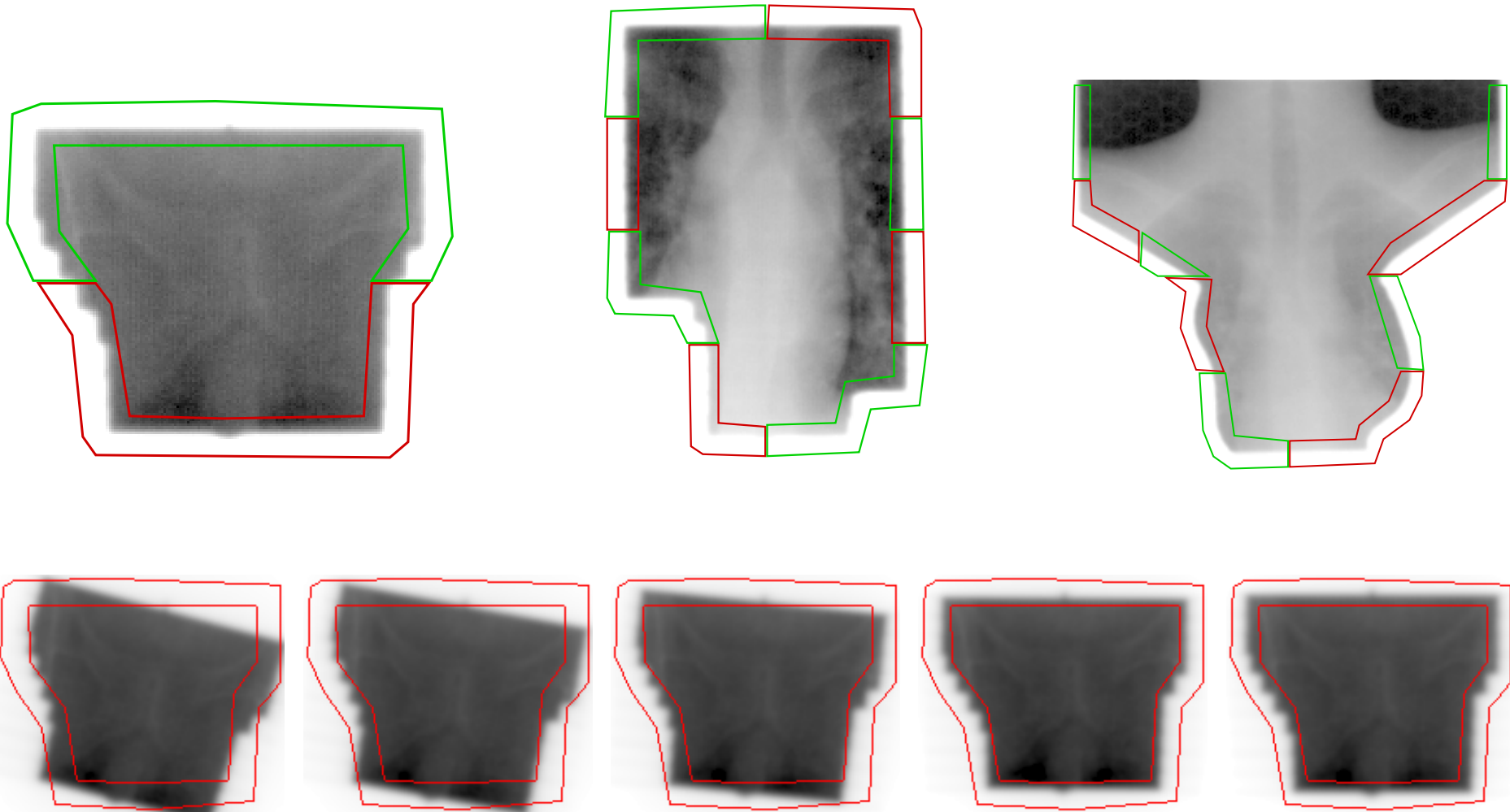
$$e^T P e \rightarrow \text{minimal}$$

normal equation

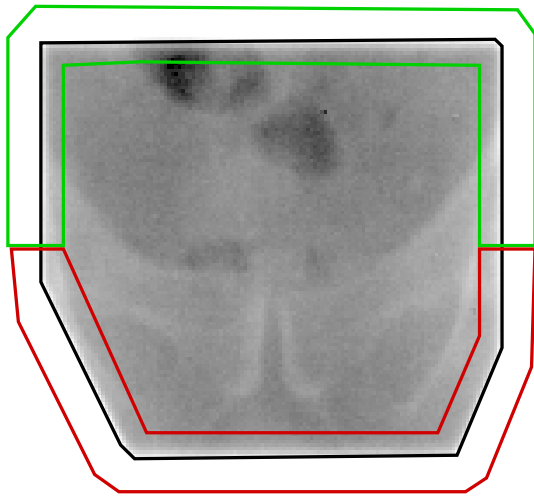
$$A^T P A \cdot \Delta\xi = -A^T P (\tilde{g}^\circ - f)$$

cf. (Lucas and Kanade 1981), (Grün 1985), (Förstner 1987)

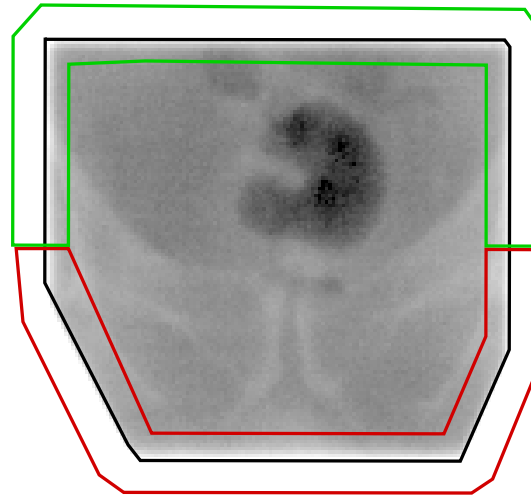
results — field edge extraction and alignment



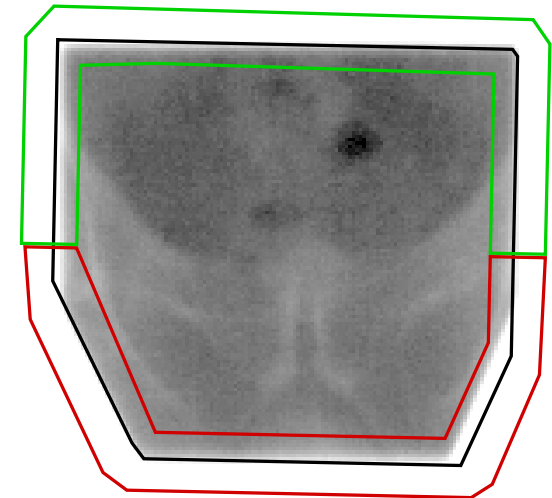
results — field edge: cross correlation values



reference



$\lambda = 0.991$



$\lambda = 0.970$

- high cross correlation value for correct shape ($\lambda > 0.99$)
- robust detection of shape differences

conclusions — summary and discussion

summary

- reliable control of field edge shape
- error analysis for 2D estimates of 3D displacements
- promising results on multi-modal match

discussion

- choice of suitable templates is important
- out-of-plane rotation must be limited
- suitable for using DRR as reference image
- quality assurance for field edge shape and patient position

method — area-based or feature-based?

area-based

based on full information content

dependent on greyvalue characteristic

no feature extraction

high precision, robust against noise

feature-based

reduction of information content to features

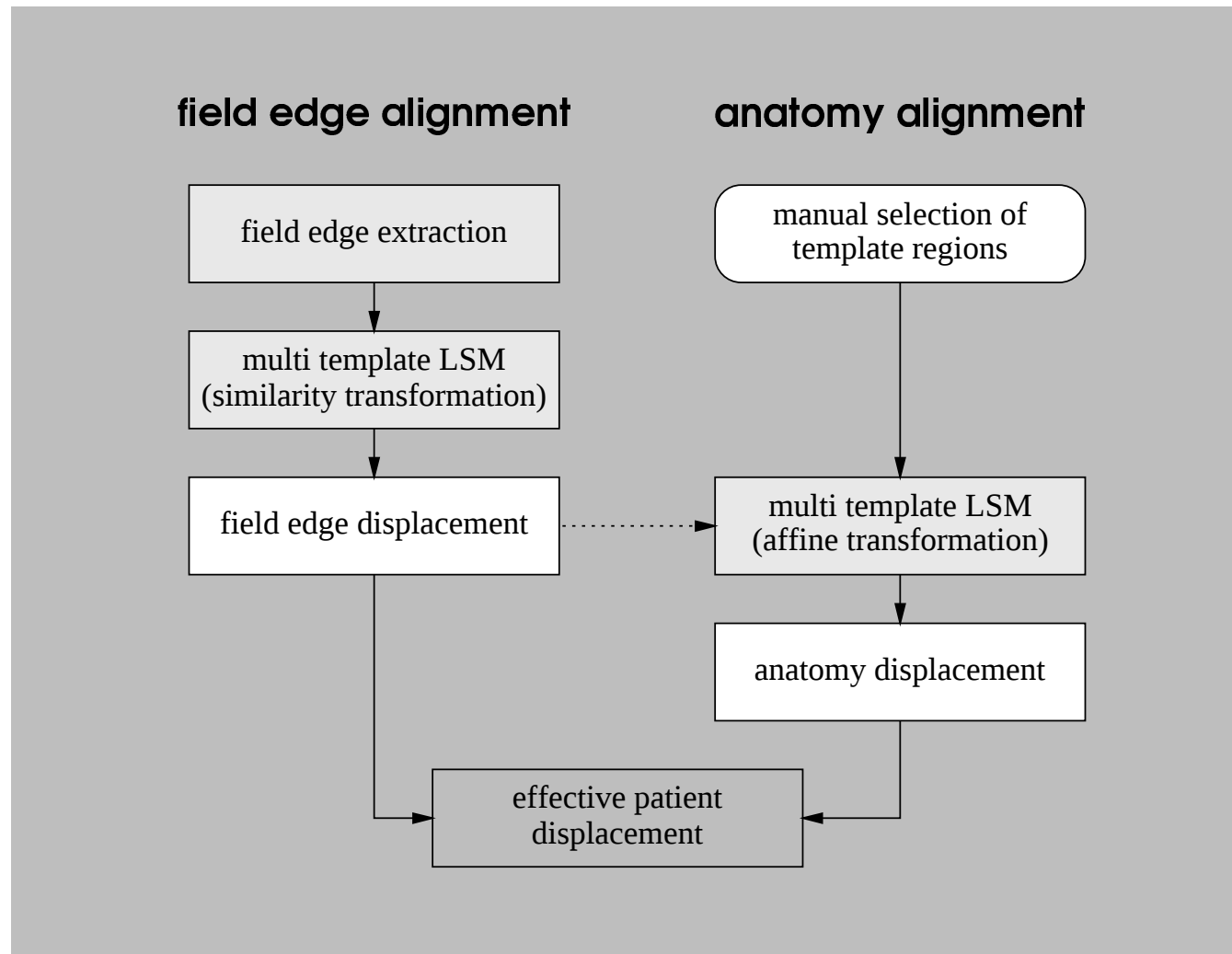
feature extraction necessary

problematic in low-contrast imagery

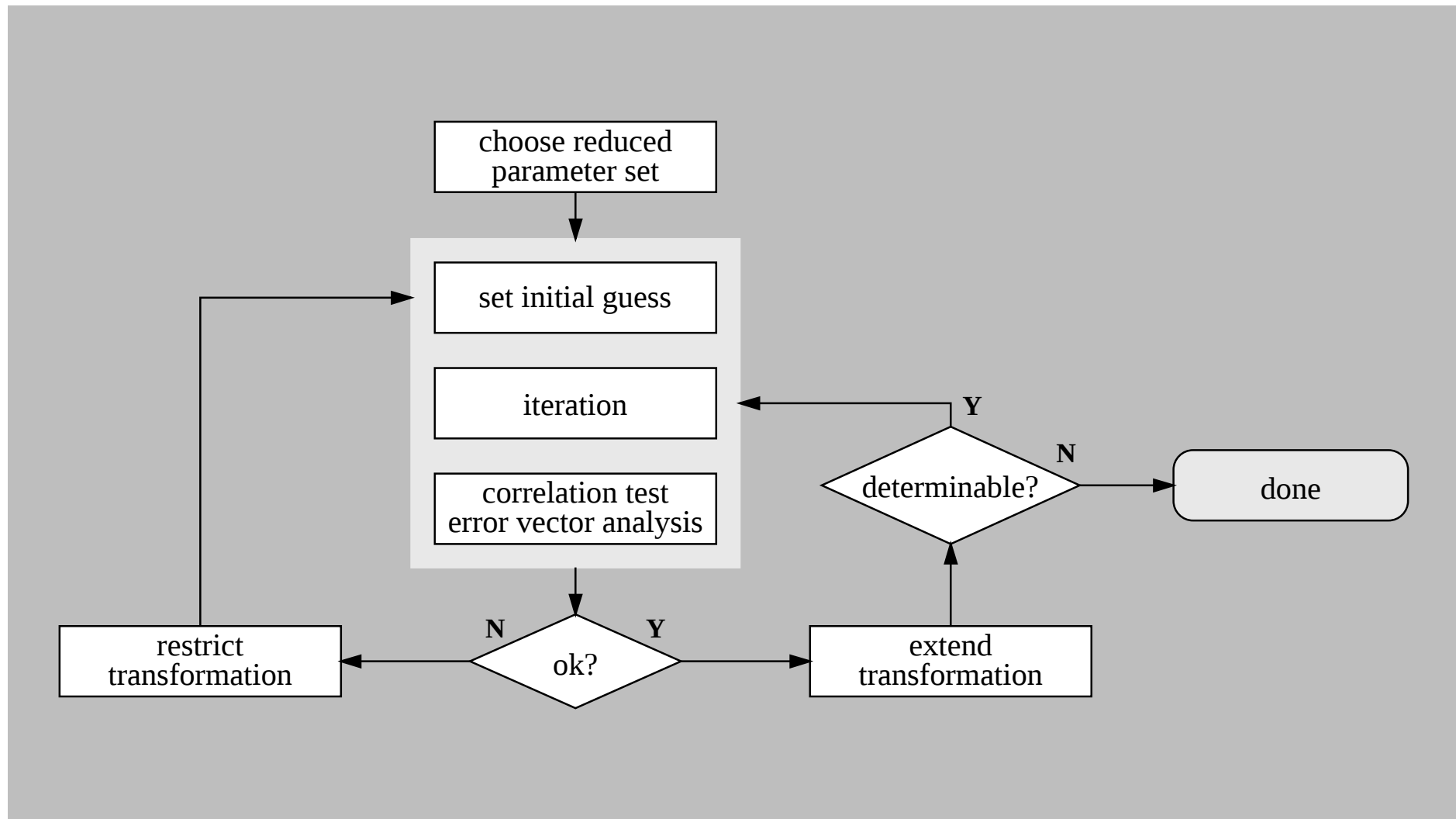
precision dependent on feature extraction

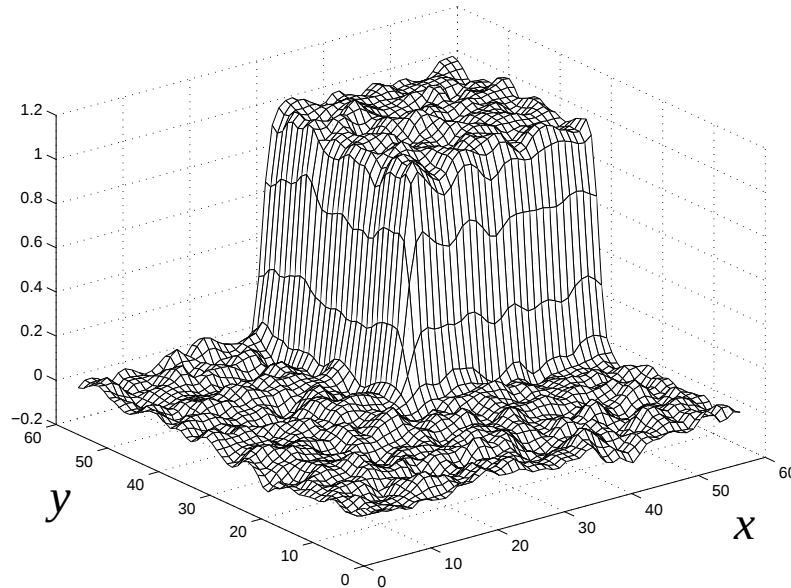
good separability of individual features

method — alignment procedure



method — diagnostic measures





test image

(matched onto itself)

$$\begin{bmatrix} \delta_{m_1} & \delta_{s_1} \\ \delta_{s_2} & \delta_{m_2} \end{bmatrix} = \begin{bmatrix} 0.4424 & 0.0922 \\ 0.0958 & 0.3731 \end{bmatrix}$$

contribution values

δ_{m_i} (scale) : high

δ_{s_i} (shear) : low