CS6240 Multimedia Analysis

Stabilization of Coronary Arteries in Angiogram Sequence

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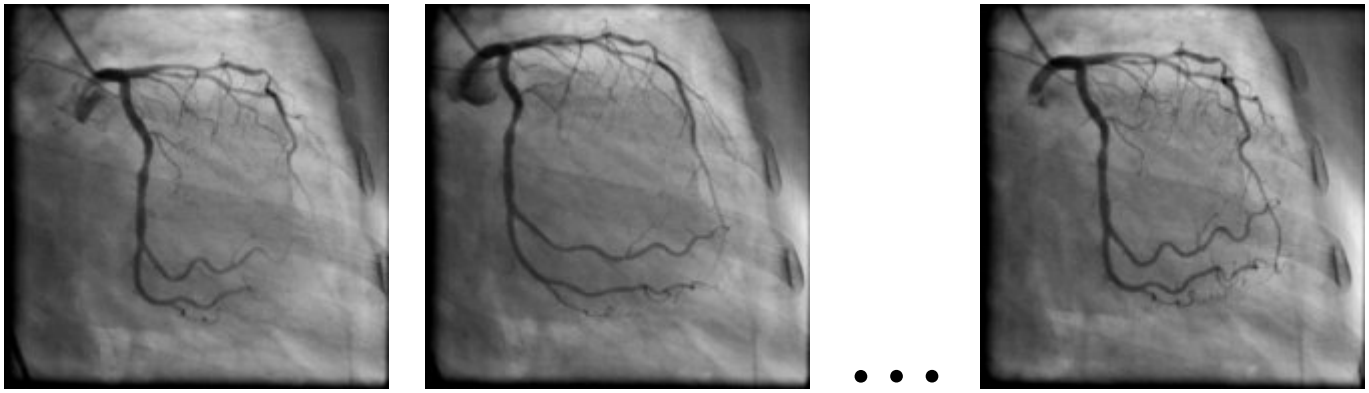
I. Problem Analysis

- Objective
  - to stabilize the angiogram sequence, i.e., to transform the images in the sequence so that the coronary arteries appear stationary



1. Problem Analysis

- General idea
  - align any two adjacent images using non-rigid registration method, which means

for $k = 1$ to $N-1$

$reference = image_k$

$source = image_{k+1}$

$result$ = REGISTER($reference$, $source$)

$image_{k+1} = result$

end

2. Problem Definition

- *Given a reference image I and a source image J, find a non-linear transformation function T that minimize the cost function*

$$E = \sum \log(c^2 / \alpha + 1)$$

- where $c = dctn(r)$ and $r = I - J(T)$; *dctn* is the forward discrete cosine transform; α is a trade-off parameter to balance the data cost and smoothness cost
- This cost function is known as Residual Complexity (CVPR09)

3. Problem Solving

- Gradient descent optimization method
  - the gradient of RC cost function is

$$\nabla E = -idctn\left(\frac{2c/\alpha}{c^2/\alpha + 1}\right)\nabla J(T)\frac{\partial T}{\partial \theta}$$

  - where *idctn* is the inverse discrete cosine transform; $\bigtriangledown J$ is the intensity image gradient and θ represents the transformation parameters (the set of control points)

3. Problem Solving

- Free form deformation transformation with multi-level B-spline control points

Φ = a $n_x * n_y$ mesh of control points $\Phi_{i,j}$

At any position x = (x, y)

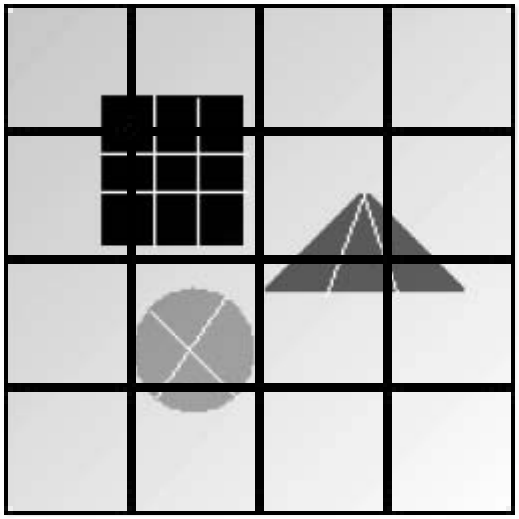
$$T(\mathrm{x}) = \sum_{l=0}^{3} \sum_{m=0}^{3} B_l(u)\, B_m(v) \Phi_{i+l,j+m}$$

$$i = \lfloor x/n_x \rfloor - 1$$
$$j = \lfloor y/n_y \rfloor - 1$$
$$u = x/n_x - \lfloor x/n_x \rfloor$$
$$v = y/n_y - \lfloor y/n_y \rfloor$$

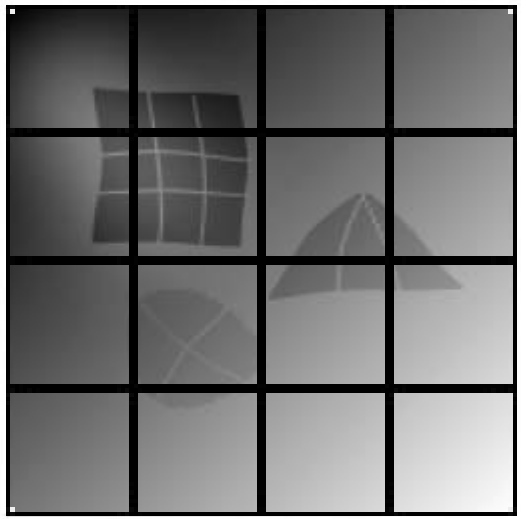
$$B_0(u) = (1-u)^3/6$$
$$B_1(u) = (3u^3 - 6u^2 + 4)/6$$
$$B_2(u) = (-3u^3 + 3u^2 + 3u + 1)/6$$
$$B_3(u) = u^3/6$$

3. Problem Solving

- Resolution of the control mesh is increasing along with the image resolution
  - 4*4 → 8*8 → 16*16
  - A coarse to fine fashion

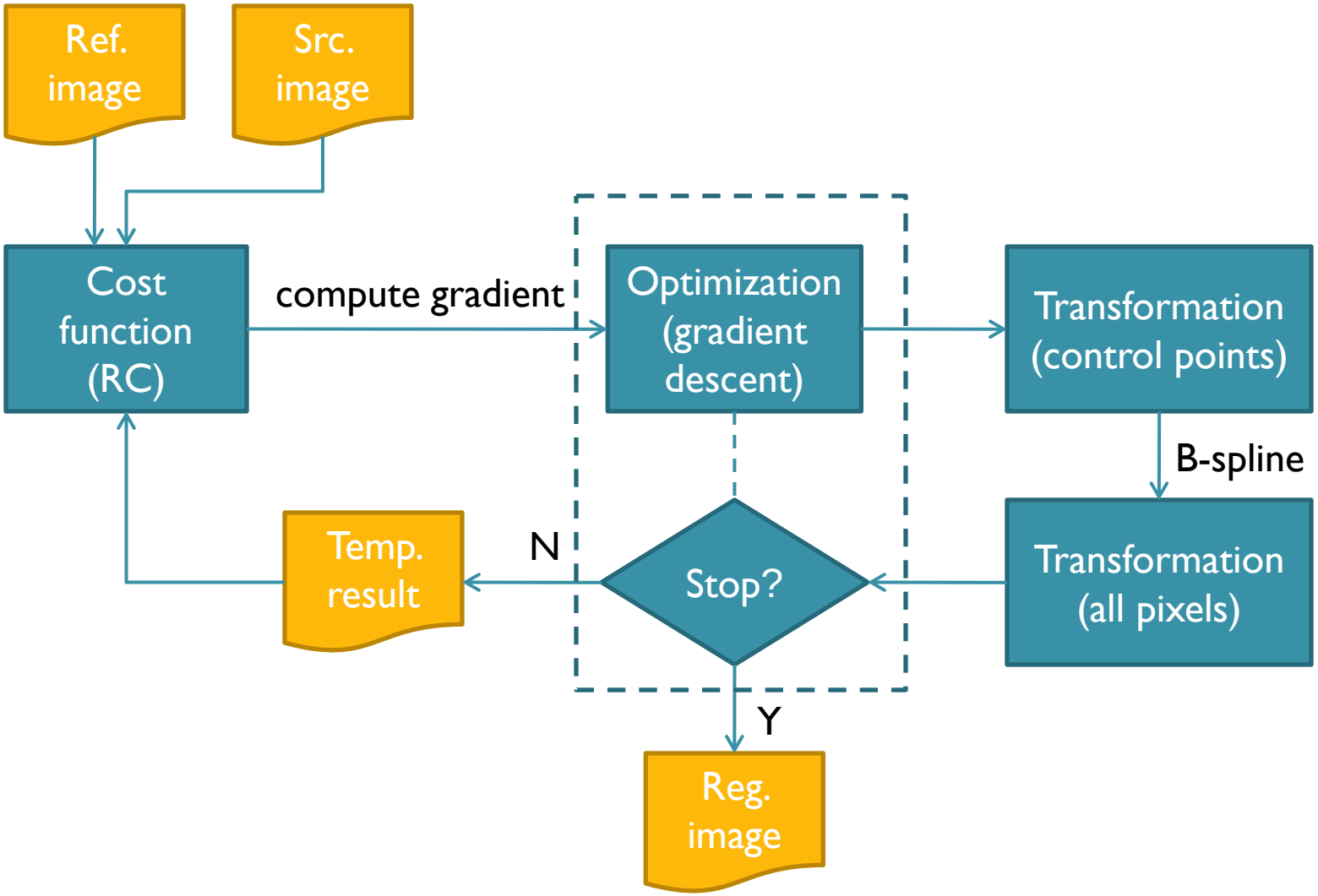


(1) reference



(2) source

Flowchart


Ref. image
Src. image
Cost function (RC)
compute gradient
Optimization (gradient descent)
Transformation (control points)
B-spline
Transformation (all pixels)
Stop?
N
Temp. result
Y
Reg. image

Result

- demo1
- demo2

Summary

- Input
  - the angiogram sequence
- Output
  - the stabilized sequence
- Things need to be improved
  - errors may be accumulated through registration procedure
  - time-consuming