SELF-AFFINE SNAKE:
A NEW PARAMETRIC ACTIVE CONTOUR

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INTRODUCTION

Snakes are parametric curves that can move toward desired features within an image domain under the influence of internal forces coming from within the curve itself and external forces derived from the image data. Snake models suffer three key difficulties:

i) they should be usually initialized by an initial contour close to the object boundary.

ii) they have difficulties to reconstruct the edge openings and progress into boundary concavities.

iii) they may likely converge to wrong results for weak edges, especially, when they lie beside strong edges.

In this paper, a new active contour model called self-affine snake is proposed which integrates the self-affine mapping system (SAMS), wavelet transform, and snake model. It inherits wide capture range from the wavelet transform, both accurate fit to weak edges and effective reconstruction of boundary concavities from SAMS, and topological consistency from the snake model while avoiding their weak points.

SELF-AFFINE MAPPING SYSTEM

Contractive Self-Affine model $\{M_i, m_i, u_i\}$ with domain $M_i \subset G$ $(i=1,\ldots,l)$:

$$m_i(\boldsymbol{x}) = r_i(\boldsymbol{x} - \tilde{\boldsymbol{x}}_i) + (\boldsymbol{\tau}_i + \tilde{\boldsymbol{x}}_i), \qquad r_i < 1$$

$$u_i(z) = p_i z + q_i, \qquad z = m_i(\boldsymbol{x}), \qquad 0 \le p_i \le 1$$

PARAMETRIC SNAKES

A traditional snake is a curve that moves in the spatial domain of an image to minimize the following energy functional [1]:

$$E = \int_0^1 \frac{1}{2}\left[\alpha|\boldsymbol{x}'(s)|^2 + \beta|\boldsymbol{x}''(s)|^2\right] + E_{\text{ext}}(\boldsymbol{x}(s))ds$$

A snake that minimizes E must satisfy the Euler equation given by:

$$\alpha\, \boldsymbol{x}''(s) - \beta\, \boldsymbol{x}^{(4)}(s) - \nabla E_{\text{ext}} = 0$$

PROPOSED APPROACH

As shown in Figure 3, the algorithm consists of five steps: i) Computing biorthogonal spline wavelet transform, ii) extracting self-affine maps in each scale using disk domains, iii) computing forces in each scale, iv) combining the forces of different scales to make self-affine forces, and v) deforming the snake using dynamic force formulation.

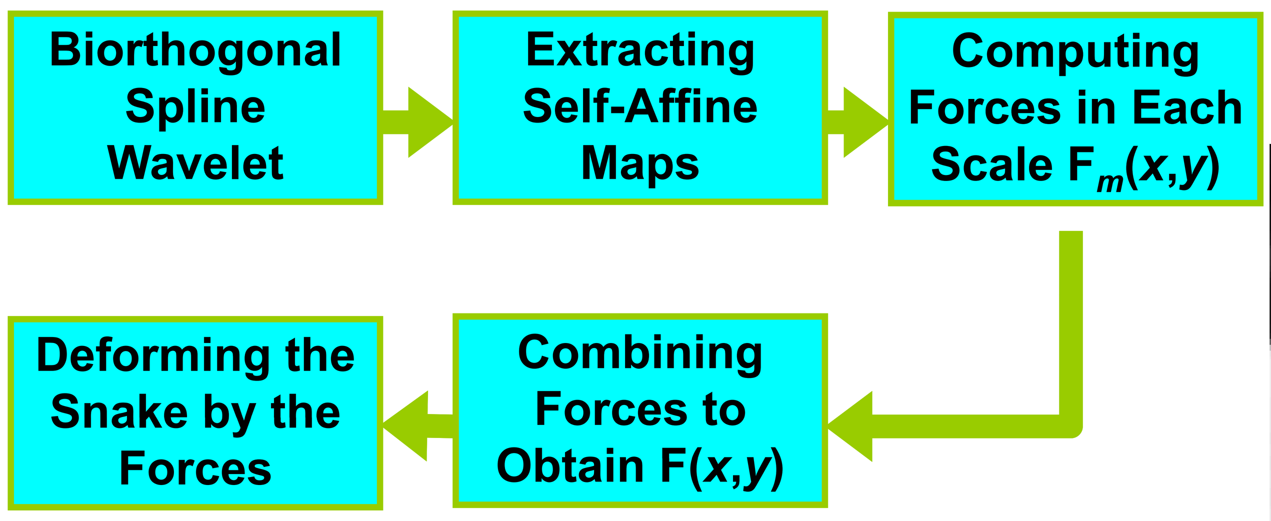

figure 3. Block diagram of the proposed self-affine snake.

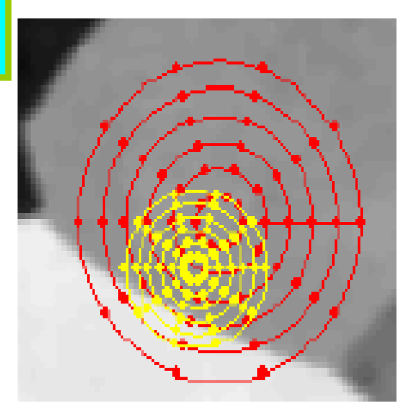

Figure 4. A Disk domain.

EXPERIMENTAL RESULTS

Experiment results demonstrated good performance for self-affine snake compared to the balloon for a number of synthetic and biomedical benchmark images.

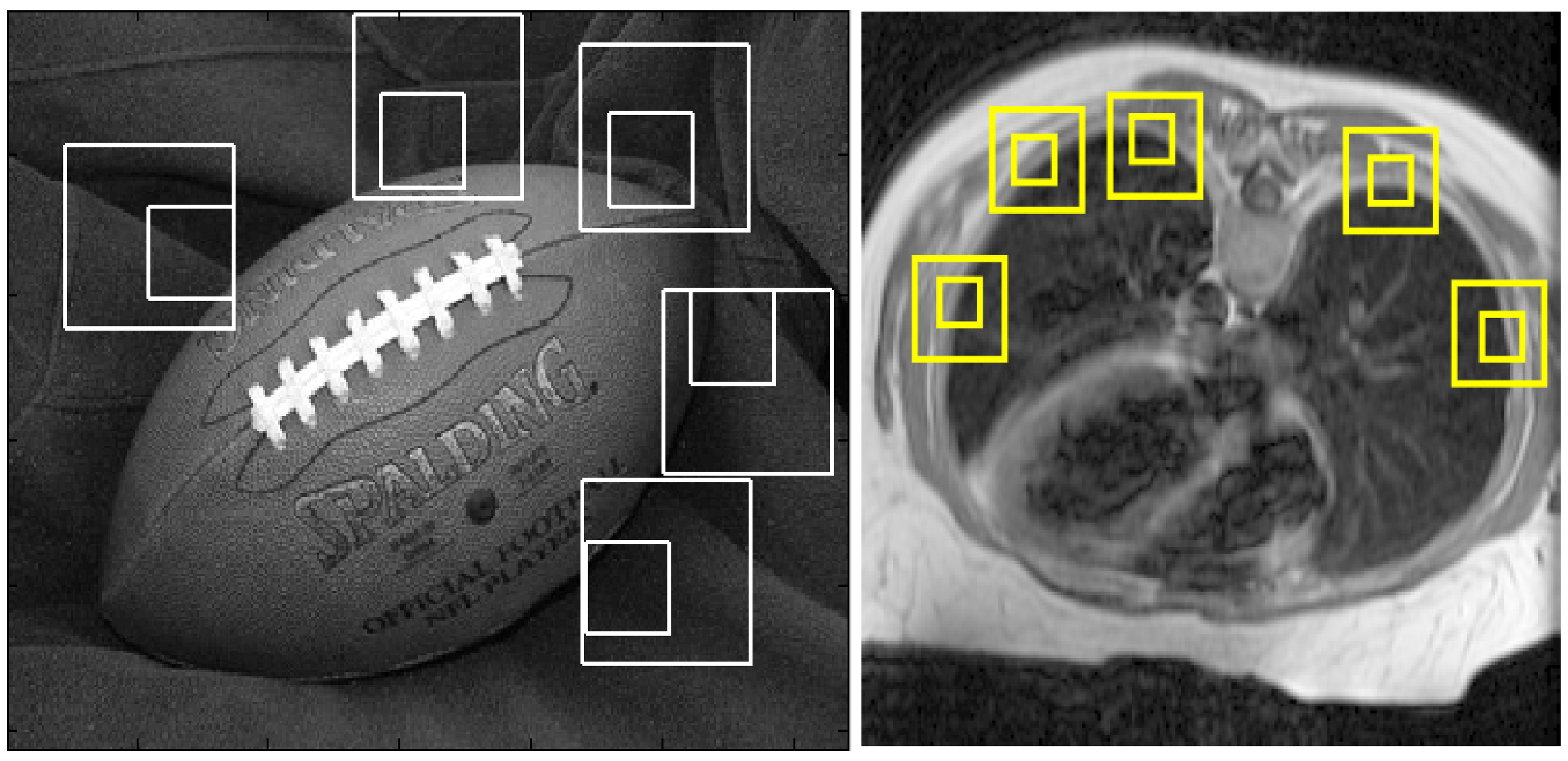

Figure 1. Self-affine models with *l=5* square domains.

Figure 2. The initial contour with square domains (left) and the final contour obtained enhanced by Ida's algorithm (right).