Evolutionary Optimization of Filter Parameters for Image Segmentation

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Problem to Solve

- Medical imaging equipment is expensive
- Medical data has limited resolution
- Available data is sparse
Solution

- Make axial slices of specimen
- Segment images into important regions
- Reconstruct 3D model of specimen
Motivation

- Rapid medical image modeling
- Bring specimen modeling to the masses
- Automate tedious region creation
- Self-adapting algorithms
Approach

- Predefined filters and algorithms for image segmentation
  - Gradient Anisotropic Diffusion
  - Gradient Magnitude
  - Watershed
- Human-Machine based evolutionary algorithms for parameter control
Evolutionary Strategies

- Parameters consist of various data types
- Cross-parameter mixing is unacceptable
- Incremental changes allow guidance
- User-defined initial values are allowed
Initialization

- Create seed parents
- Generate initial population from children
- Quickly starts population on a better path
Representation

\[
\begin{array}{cccccc}
X_1 & X_2 & X_3 & X_4 & X_5 & \sigma_1 & \sigma_2 & \sigma_3 & \sigma_4 \\
\end{array}
\]
Selection

- Aiming for high selective pressure
- Ranked selection
- Tournament selection from entire population
- Chosen parents are paired based on fitness.
Recombination

Parent 1

Parent 2

Child

Random

Local

Global
Mutation

- Sigma values are mutated
- Parameter values are mutated based on new sigma values
Evaluation

- Human interaction
- Scoring individuals based on acceptance or rejection
- Accepted individuals get points whereas rejected individuals don’t
Survival

- (μ+λ) - Avoid excess evaluations
- Deterministic rejection of worst individuals
- Dynamic rejection of worst individuals
- Facilitates higher selective pressure
Fitness

- Age - One point per generation
- Score - Given by user
- Fitness = Score / Age
- Fitness will vary over time
Difficult Issues

- Image scoring is very subjective
- Segmentation algorithm is very expensive
- Expensive segmentation is bad for users
Experimental Data

- Start off with very easy tasks
- Increase complexity
- Test with real medical image
Divided Image

Source

Result
Simple Shapes

Source

Result
Complex shapes

Source

Result
Medical Cross-section
Initial Result
Better Result
Future Research

- Faster image segmentation
- Vary the type of filters
- Use hybrid techniques
- Create correlated slices
Questions?