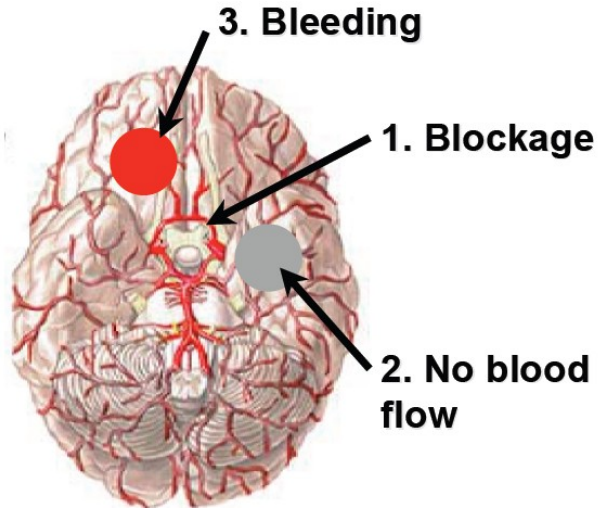
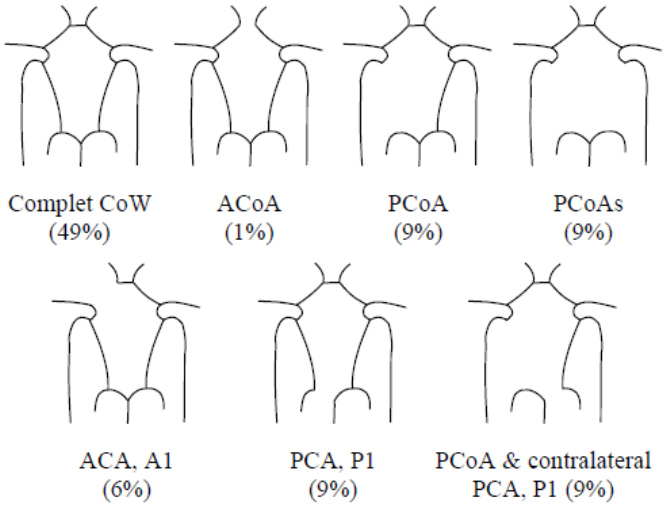
# Health/Stroke Application Plans Using SEJITS

Par Lab Summer Retreat - May 26th, 2010

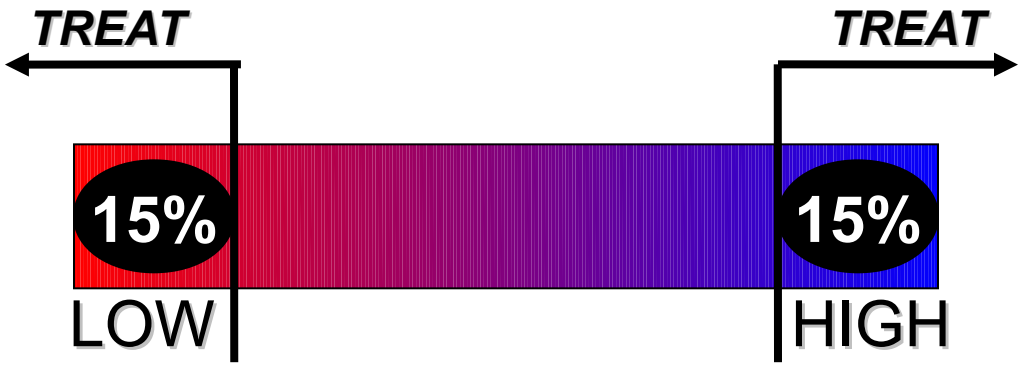
# Stroke Project Overview





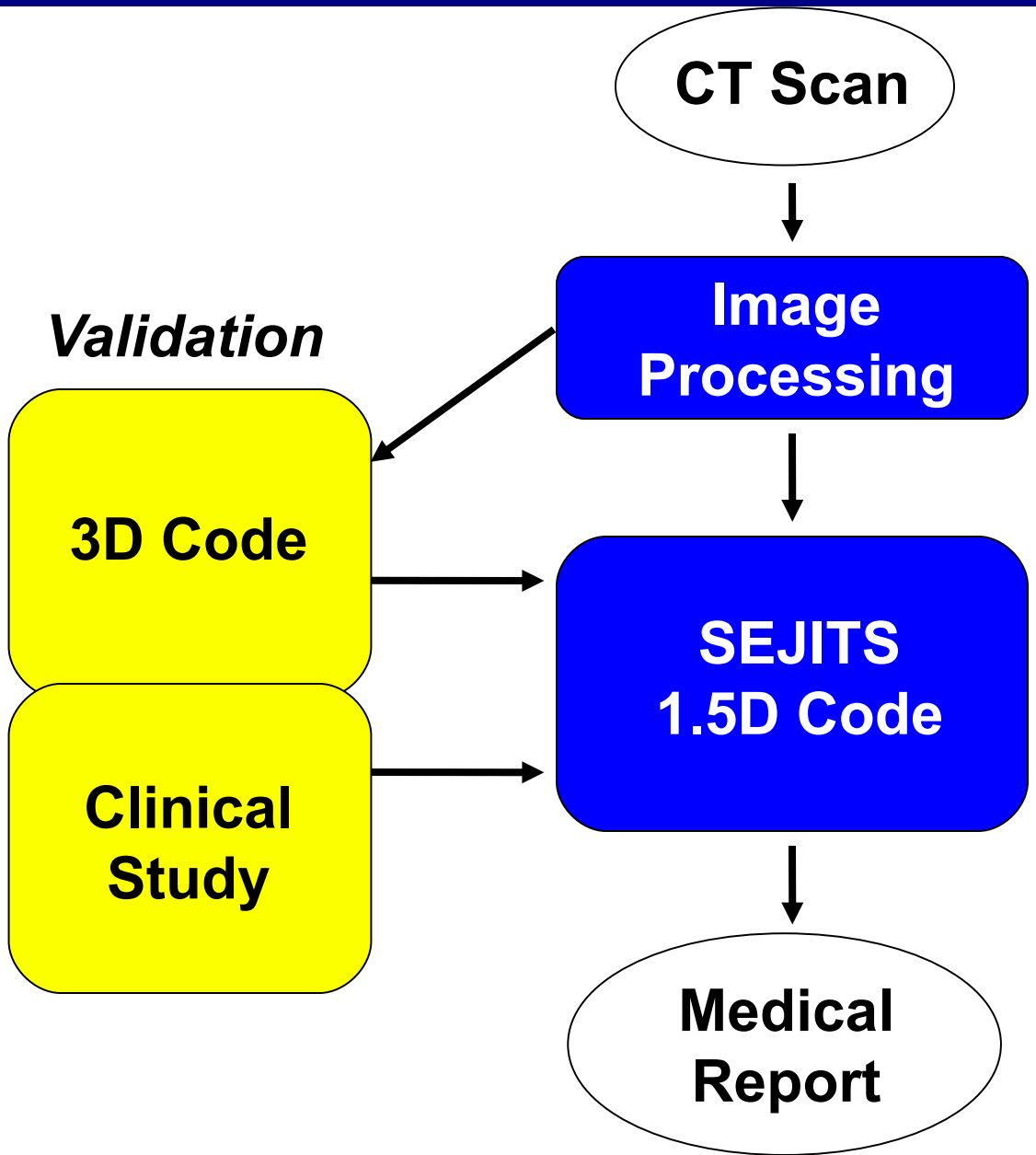




- Patient's medical image
- Blood flow analysis
- With stroke
- Simulate treatment (blood thinner)
- Validate via clinical studies
- Must run in 30s for clinical relevance



# Study Design





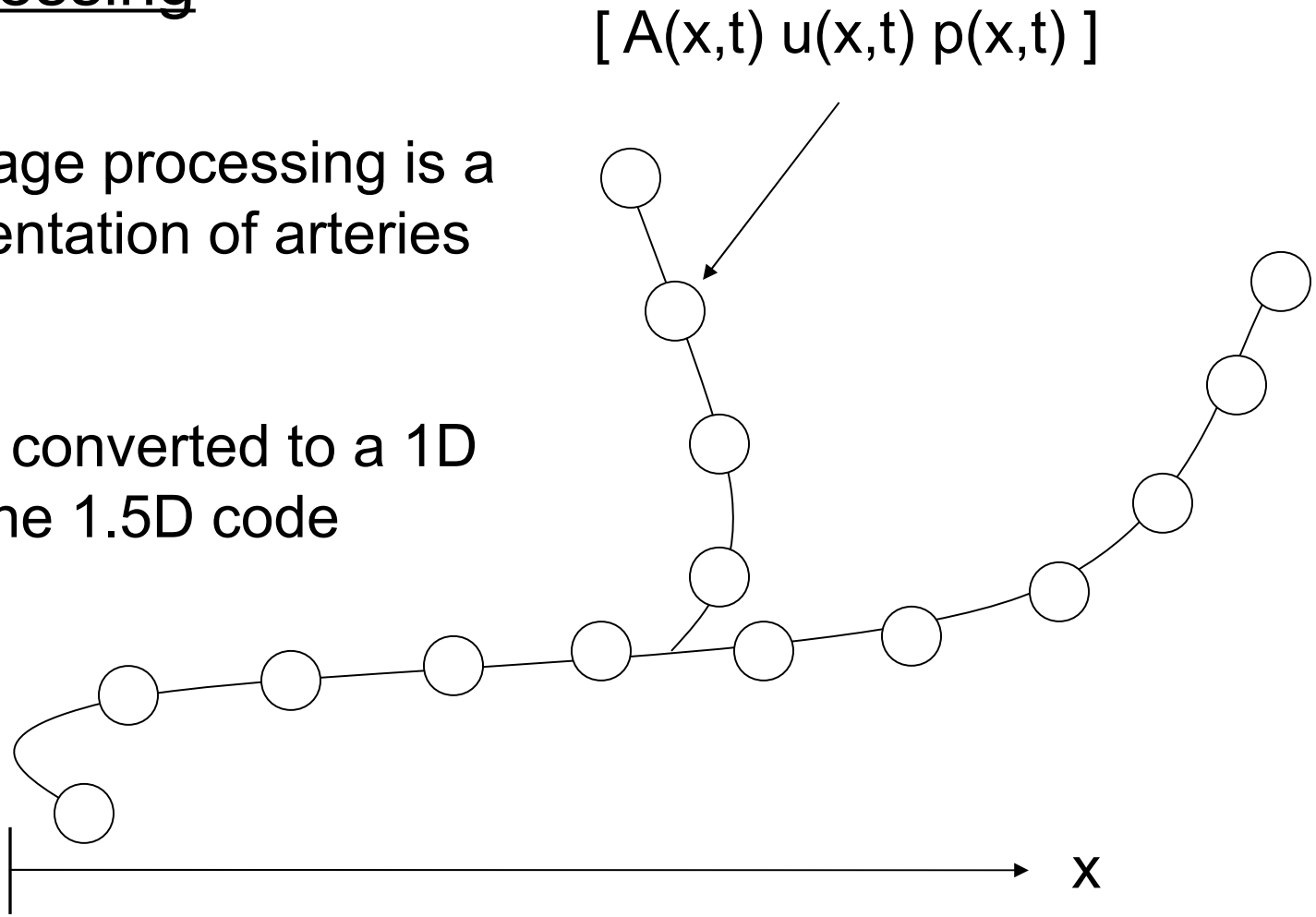
# 1.5D Algorithm - Grid



## Pre-processing

Output from image processing is a skeletal representation of arteries

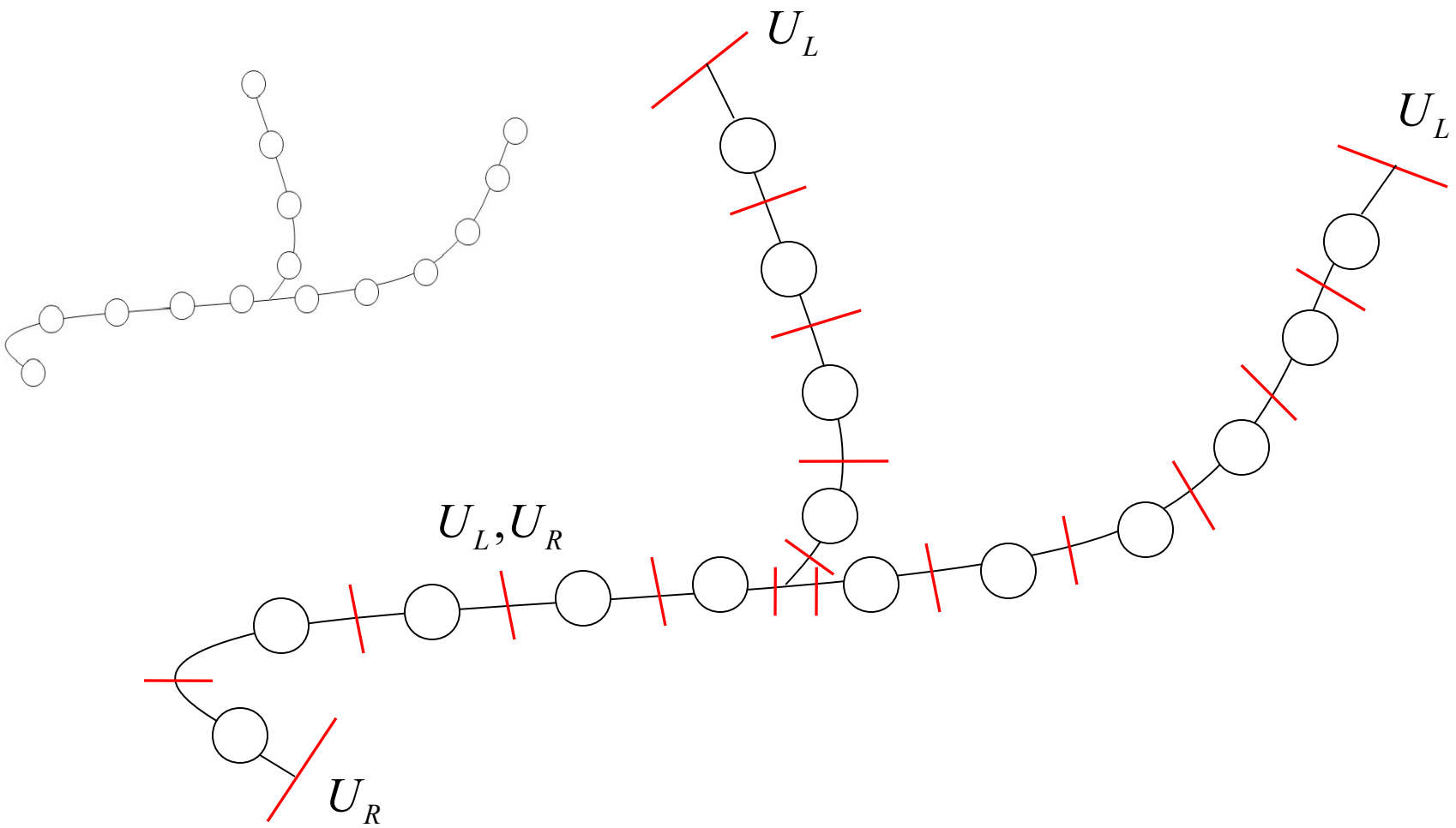
The skeleton is converted to a 1D grid for use in the 1.5D code



# 1.5D Algorithm - Solution



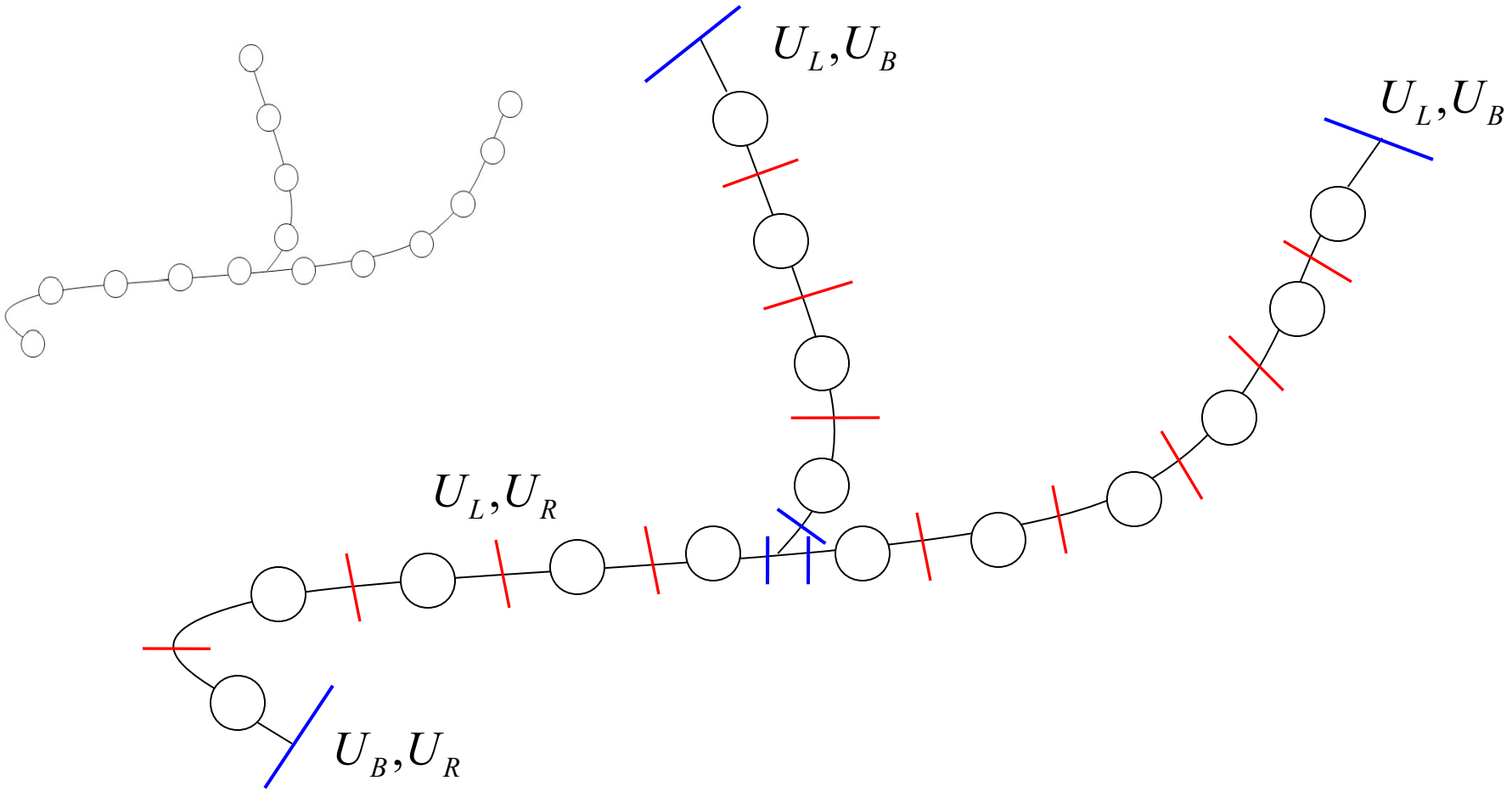
1. Define twin cell-interface values (stencil)



# 1.5D Algorithm - Solution



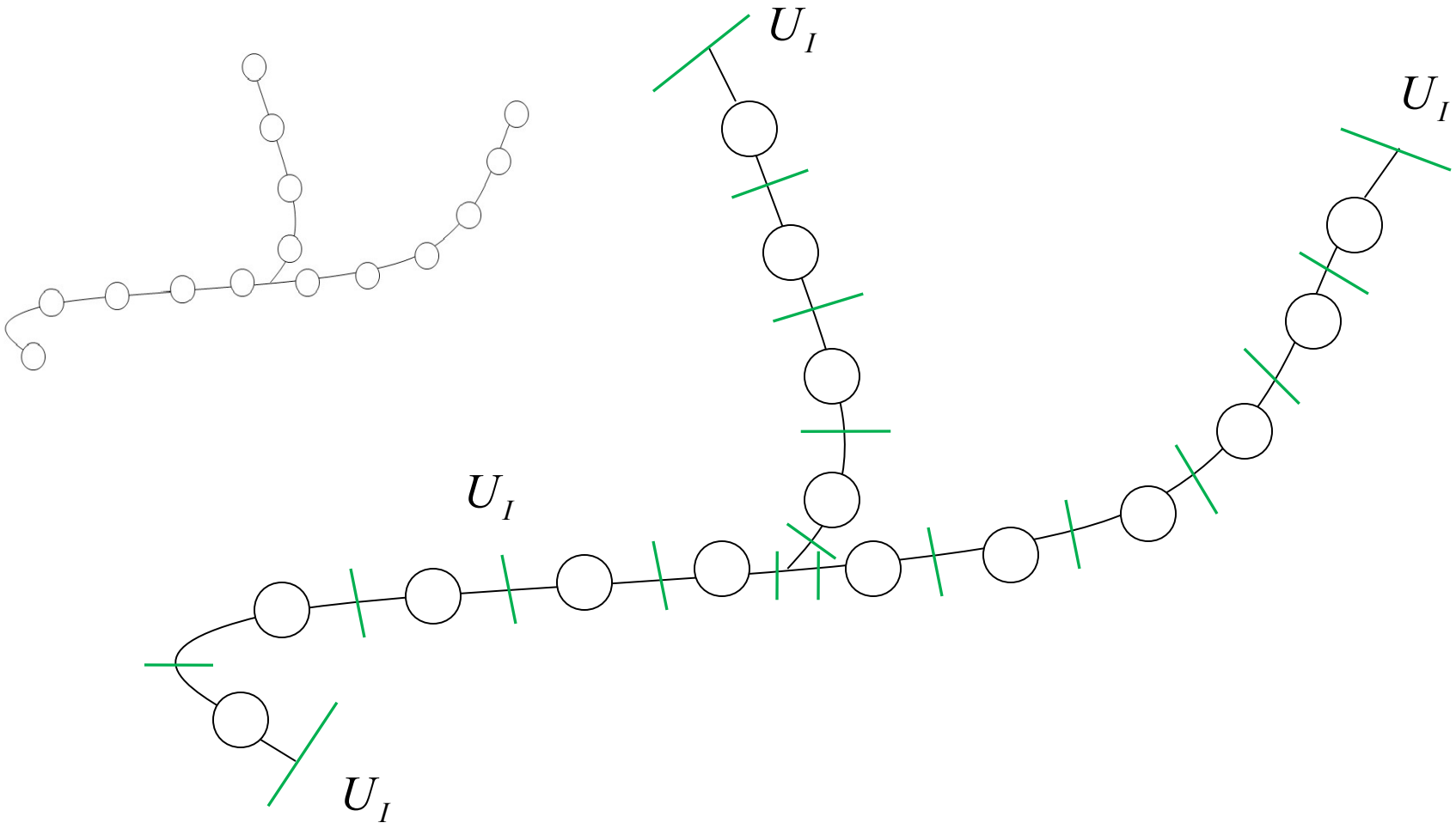
1. Apply boundary values (small number of iterative solves on small dense systems)



# 1.5D Algorithm - Solution



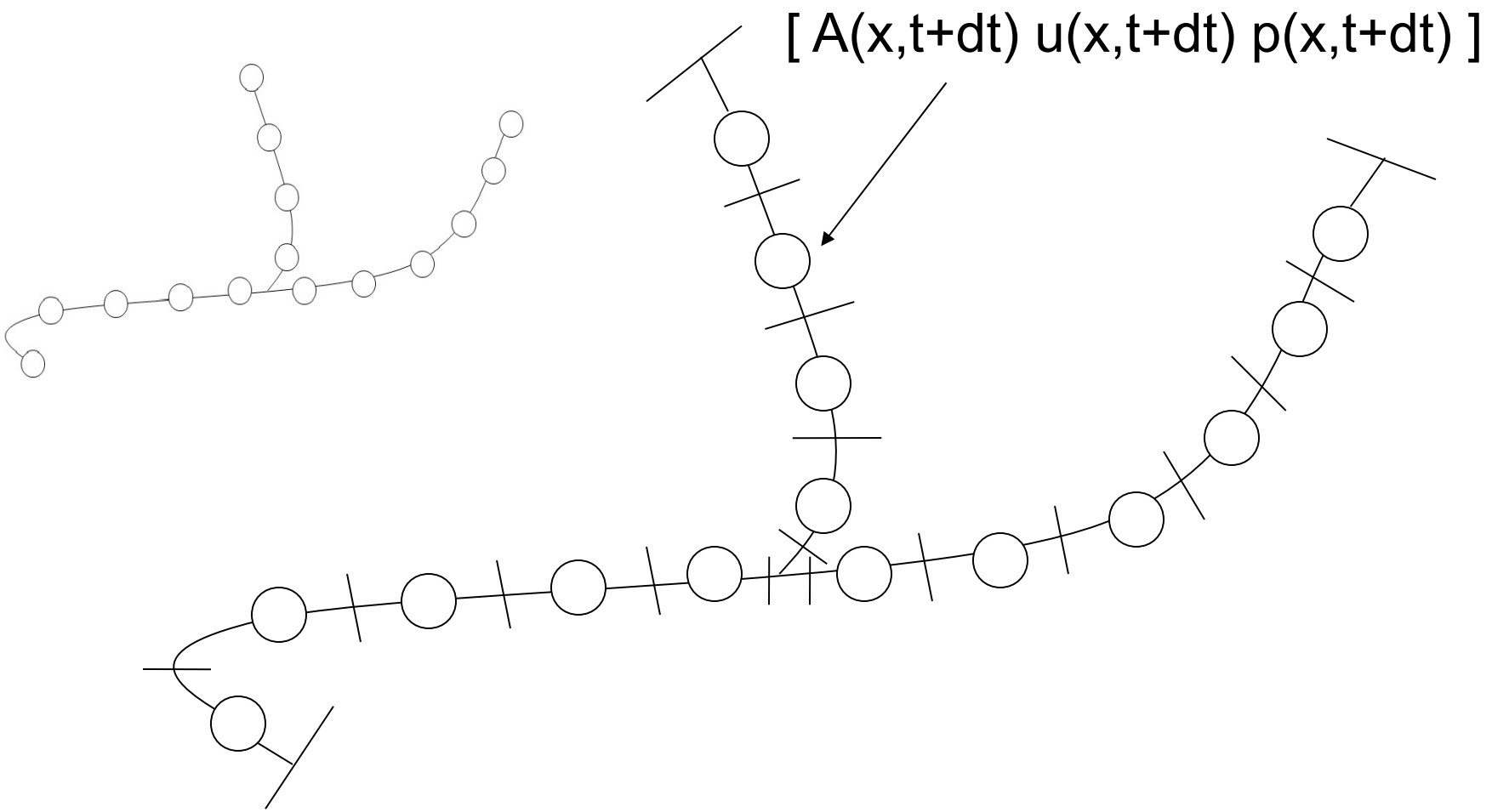
1. Find single cell-interface values (stencil)



# 1.5D Algorithm - Solution



1. Update cell-center values (stencil)



# Performance Criteria



- # Grid points: O(10^4) [0.1mm spacing]
- # Time steps: O(5*10^6) [10μs step size]
- Flops / Point: O(160)
  - 45 x
  - 30 +
  - 15 divide
  - 3 sqrt
- Time Allotted: O(30s)

- Required Gigaflops / sec: O(240)

# Status & Goals



- Matlab Implementation
  - Size: 600 lines
  - Performance: 10,000 seconds on typical problem instance
- Matlab to Python
  - Well-supported activity in scientific & Python communities
  - Berkeley short course in summer
  - Use standard APIs: NumPy & SciPy
- Python to SEJITS
  - Leverage pre-existing APIs
  - Minimal changes needed to Python code as SEJITS evolves
  - Target: 300-fold increase in performance vs. Matlab code
  - Robust to changes in Python algorithm

# Milestones

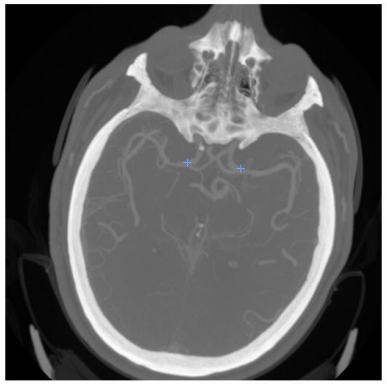


- Finish debugging Matlab version
- Python conversion using NumPy & SciPy
- Integration of autotuned sparse-matrix (OSKI) support via PySKI
- Develop and integrate additional specializers
  - Stencil
  - Communication Avoiding Algorithm
- Use a similar approach to migrate image processing steps to use SEJITS

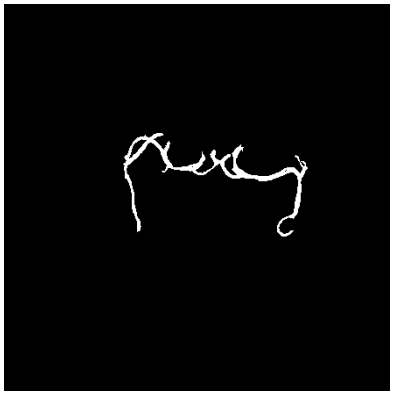
# Overall Image Processing



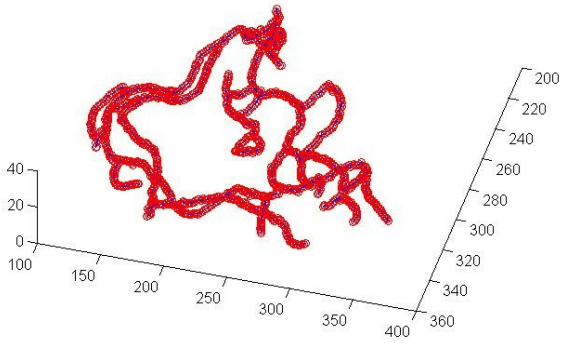
Object Identification



Segmentation

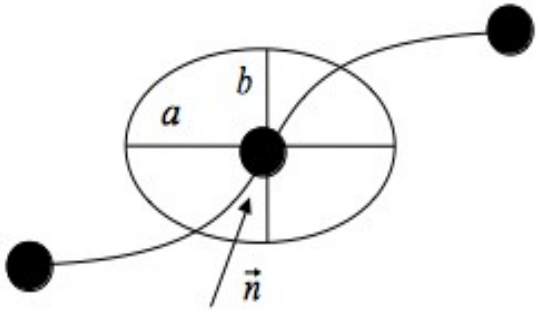


Skeletonization




1.5D

Geometric Measurement




Mesh Generator

3D

# 1.5D Image Processing



- Image Size: [512,512,400] 16 bit
- Time scales:
  - Current Implementation
    - Total time for processing: O(1 hour)
    - Object Identification: O(1 hour)
    - The rest: O(5 minutes)
  - Goal
    - Total time: O(30s)
- Implementation Plan
  - Automate Object Identification
    - Leverage work done on SVM for classification
  - Use SEJITS framework for all or some part of the process

# 3D Code



## ATHENA — Solids

Finite element code for solid deformation

## CHOMBO — Fluids

Finite difference code for fluid flow

Progress to Date

Codes modified to handle a wider range of boundary conditions and mechanical properties

Both codes have been adapted to process the updated geometries and forces at specified surfaces (inner surface of the blood vessel), effectively coupling the simulations

# Clinical Study



- Necessary for validation
- NIH R01 proposal to be submitted Q1 2011
- Multi-center study (UVA, UCSF, & more)
- Pre-existing data (prospective study)
  - 200 patients with clinical outcomes

# Next Year (Year 3)



- Complete serial implementation and testing of the 1.5D analysis code
- Complete SEJITS version of 1.5D code
- Refine image processing
- Further integrate 3D analysis
- Submit NIH proposal

# Future Plans (Years 4-5)



- Optimize 1.5D code for clinical deployment
- Migrate image processing to use SEJITS
- Validate 1.5D approach by direct comparison with 3D code
- Initiate Clinical Study

# End



Questions?