Recognition and 3D Modeling of Two-Phase Alloy Microstructures

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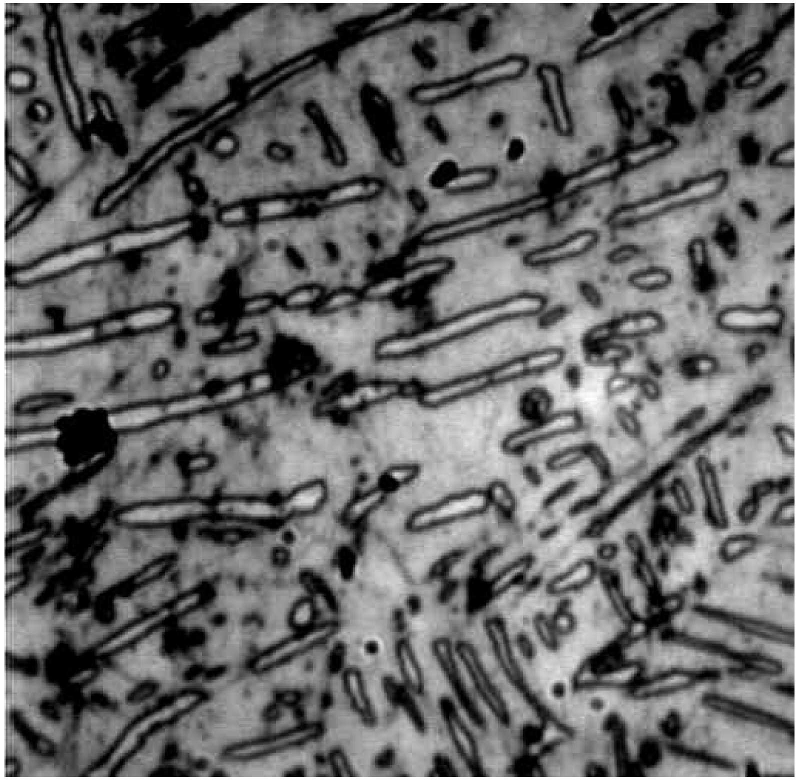
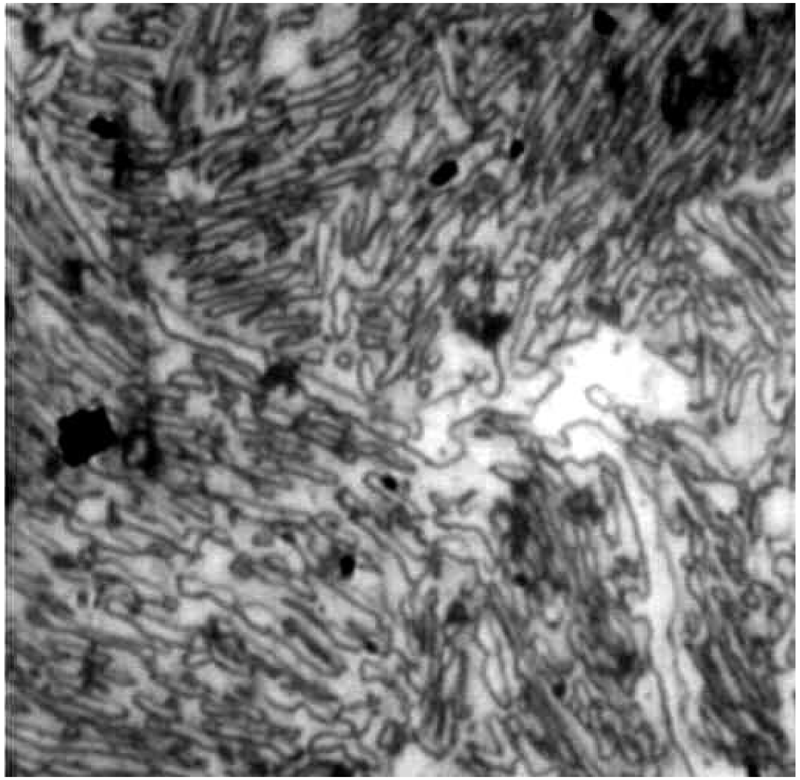
Examples of microsections

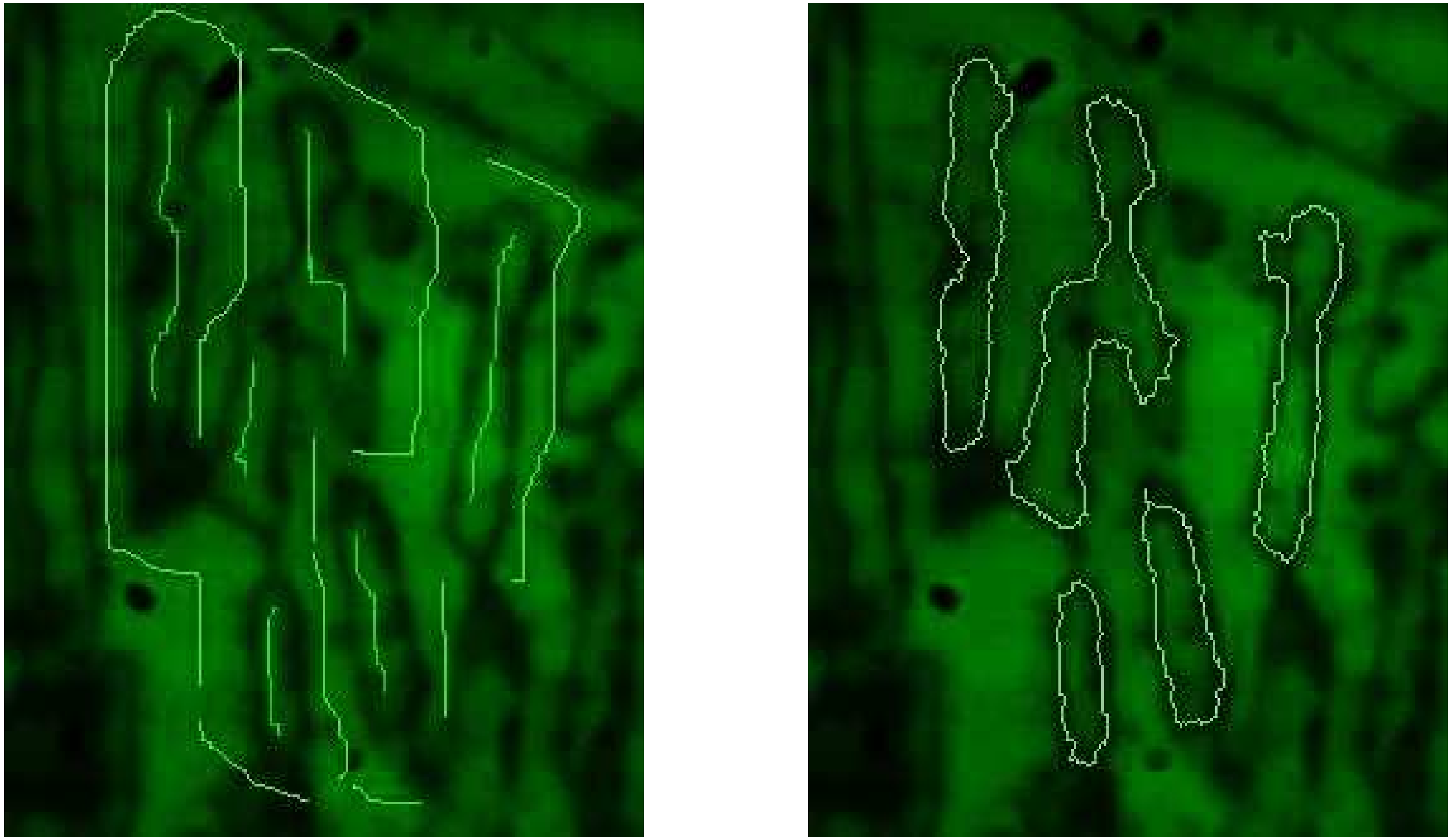
Typical computational tasks that arise when working with microsections

- Reduce noise
- Detect contours of grains
- Compute parameters of grains, e.g. size, shape, orientation, length of border
- Compute distributions of parameters
- Make conclusions about the 3D grain structure (using some additional information)
- Visualize the 3D grain structure
- Automatically determine the microstructure type of the alloy

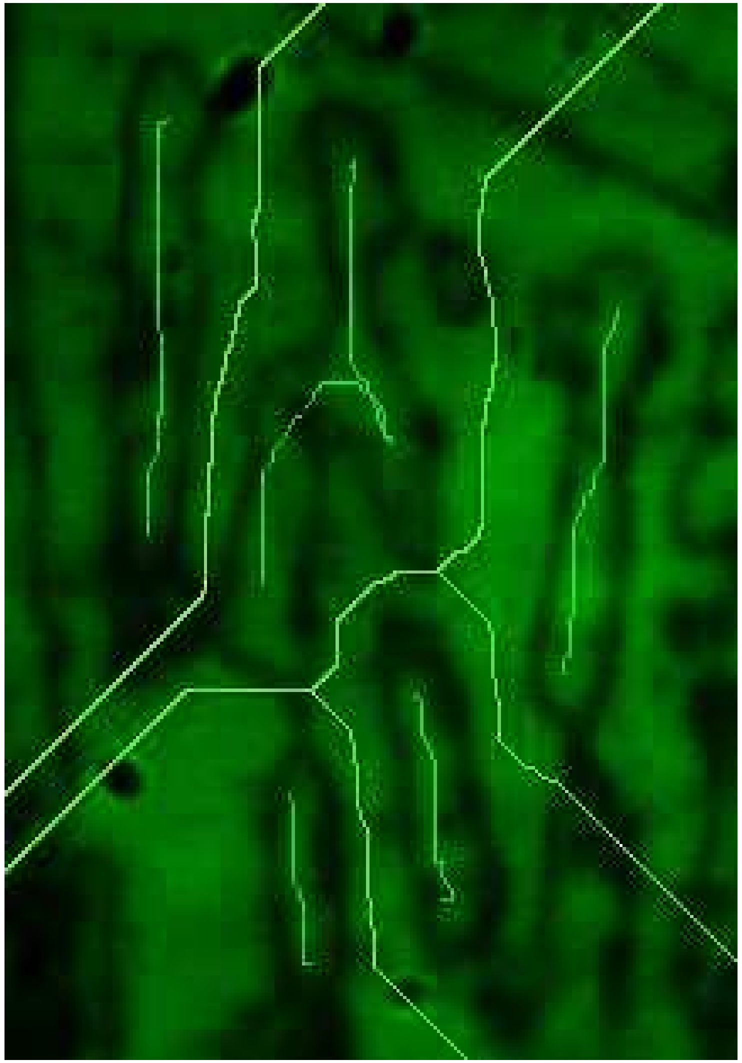
Some approaches to the border detection problem

- Gradient methods (Roberts and Sobel gradients, thresholding, the Canny algorithm)
- Laplacian of Gaussian (LoG)
- Hough transform
- Watershed methods
  - regular watershed
  - using markers
  - SKIZ / Watershed
  - hierarchical watershed
  - automatic placement of alpha markers

Markers and the resulting watershed borders



Markers and the resulting SKIZ



Detection and visualization of 3D grains: the general approach

- The source data is two sets of ellipses in two planes (e.g. ellipses of inertia of previously detected grains)
- The 3D grain is considered approximately an ellipsoid, whose sections by two planes are a pair of ellipses
- Compute a (possibly incomplete) correspondence between two sets of ellipses
- For each detected pair, find the corresponding ellipsoid in space

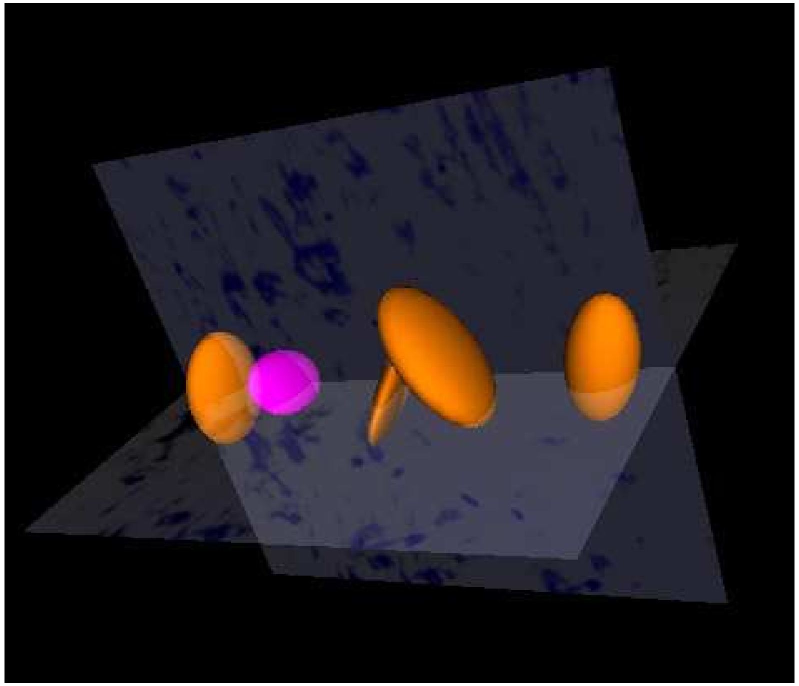
The abstract problem of finding a projective quadric from its two planar sections

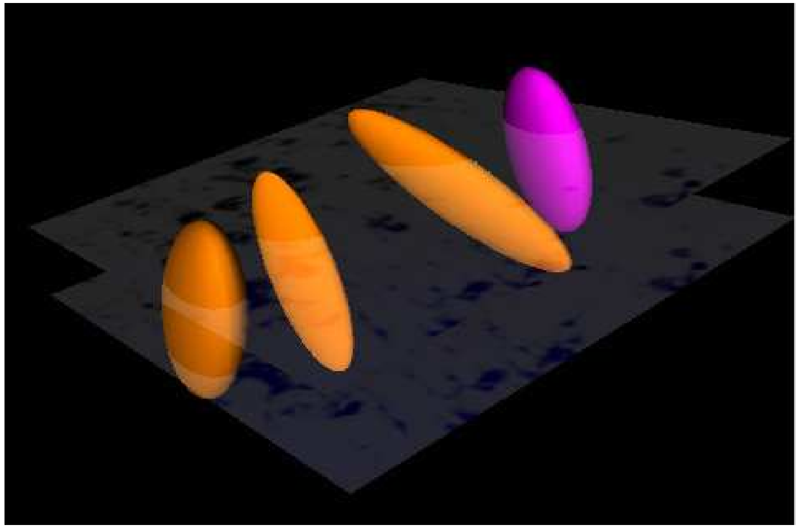
- no solutions in the general case (problem over-defined)
- the existence of one solution leads to the existence of a one-parametric family of solutions
- one of the solutions is a cone
- all solutions are linear combinations of this cone and the product of the two planes
- for the solution quadric to be an ellipsoid, the parameter must belong to a certain interval, which can be effectively computed

General structure of the ellipsoid detection algorithm

- Weight matrix computation, based on a metric
  - metric explicitly defined
  - metric as the result of a minimization algorithm
- Finding the correspondence between the sets of ellipses (the Kuhn-Munkres algorithm and its extensions)
  - for different numbers of ellipses
  - for thresholding the metric values
- Finding the families of ellipsoids, finding the acceptable intervals for parameter values

The visualization application - screenshots





3D grain detection – future work

- Extensive testing
- Finding effective metrics for correspondence detection; configuration evaluation
- In-depth research of the case of two parallel planes
- Evaluating the algorithm’s performance for large number of grains
- Using statistical information