Finding and tracking Bragg spots in GISAXS maps of block Co-Polymer thin films using cascade based feature extraction and circular Hough transformation

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Finding Bragg-spots in GISAXS Images of Block Co-Polymer Thin Films using Cascade Based Feature Extraction and Circular Hough Transform

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**Introduction**

By vapor annealing ~100 nm disordered thin films of block co-polymers it is possible to order them due to microphase separation. In order to monitor this change Grazing Incidence Small-Angle X-ray Scattering (GISAXS) can be used which produces scattering pattern maps in reciprocal space. One feature which can be seen in such images is a Bragg-spot. Manually going through the images produced by GISAXS to locate and track Bragg-spots is a time-consuming process which can be automated using feature extraction algorithms. A cascade based approach based on the Viola-Jones algorithm and an approach based on Circular Hough Transform have been programmed and tested.

**Examples of micro phases accessible with ABC stars:**

- **3D view**

**Pipeline**

1. **Acquisition**: Microscopy, GISAXS images from films.
2. **Segmentation**: Identification of Bragg spots.
3. **Preprocessing**: Image processing to enhance Bragg spots.
4. **Haar-like Feature Extraction**: Detection of features.
5. **Cascading Hough Transform**: Feature localization.
6. **Post Processing**: Final analysis and presentation of results.

**Input images (Dataset)**

The dataset consists of .tiff pixel intensity maps produced during two separate GISAXS experiments conducted during vapor annealing at the Cornell High Energy Synchrotron Source (CHESS).

~1500, 407x487 images are produced during each of the ~100 minute long experiments, only a few hundred of which exhibit the Bragg spotting which is sought.

**Haar-like feature cascade generation algorithm**

A sample Bragg-spot is chosen then:

1. Start by drawing first rectangle.
2. Expand until feature is present.
3. Expand second rectangle until feature is no longer present.
4. If applicable a third rectangle is expanded until end of image.

**Circular Hough Transform**

By use of canny edge detection Bragg-spots can be approximated as circular shapes.

By superimposing similarly sized circles on these edges their positions can be identified by looking for spots where the circles overlap.

To take size variances of the Bragg-spots into account a range of radii are tested.

**Grazing Incidence Small-Angle X-ray Scattering (GISAXS)**

Swelling → Drying

**Bragg Spots:**

- Bragg spots are detected on GISAXS images of block co-polymer thin films.
- The process of finding Bragg spots involves multiple steps, including acquisition, segmentation, preprocessing, and feature extraction.
- The Haar-like feature cascade generation algorithm is used to locate features within the images.
- Circular Hough Transform is applied to approximate the Bragg spots as circular shapes.

**Summary:**

- Bragg-spots exhibited in GISAXS maps can be found using the algorithms presented with a minimal number of false positives / false negatives under the right conditions.
- This will enable automatic postprocessing of size, shape, intensity and position of Bragg-spots which would otherwise be labor intensive if done manually.
- The approaches presented could be applied to simulated GISAXS experiments and other similar image-producing experiments and simulations.

**Results**

- Using the cascade based approach Bragg-spots may be found at a speed of ~18 images per second with few to no false positives / negatives.
- Using Circular Hough Transform the Bragg-spots can be found at a speed of ~70 images per second. No false positives / negatives were present for swelling images but the algorithm fails for the images captured during drying when the Bragg-spots appear more elliptical.