Project / Bachelor Thesis / Master Thesis

Physics-Informed Contour Selection for Robust Contour Extraction

Contact Information

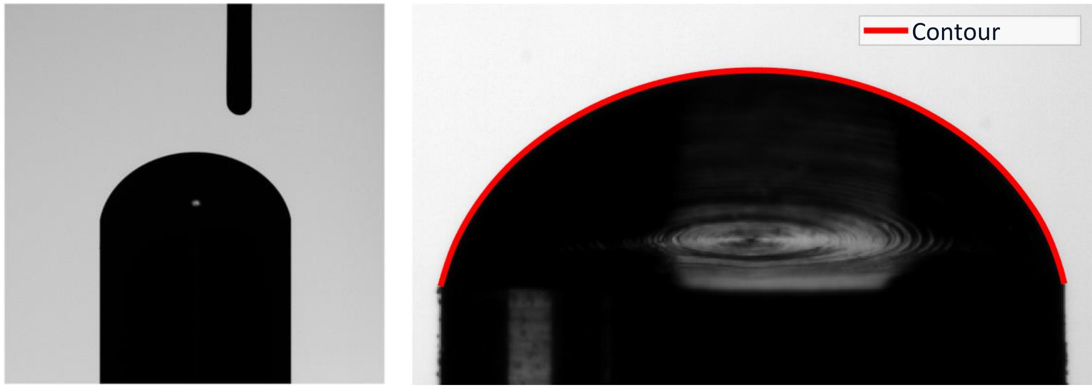
- Micro- and Nanophotonics (MNP)
- Prof.: Andreas Heinrich
- Supervisor: Annika Dehm
  (annika.dehm@hs-aalen.de)

Tasks

- Re-create the PICS approach
- Transfer the PICS concept to existing droplet image data
- Implement shape regularizers: e.g. smoothness, curvature, convexity, symmetry, area/volume
- Compare against an existing contour-extraction baseline

Motivation

Liquid polymer droplets can be electrically deformed and subsequently UV-cured to fabricate optical freeform elements. To train neural-network models that predict the deformed droplet contour, the contour extraction itself must be robust and reproducible. Physics-Informed Contour Selection (PICS) offers an alternative to manual image processing steps: a small set of contour control points is optimized directly on the image, while regularizers enforce plausible droplet shapes.



Example camera image and droplet contour

Project

Semantic Segmentation of Droplet Images

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- Micro- and Nanophotonics (MNP)
- Prof.: Andreas Heinrich
- Supervisor: Annika Dehm
  (annika.dehm@hs-aalen.de)

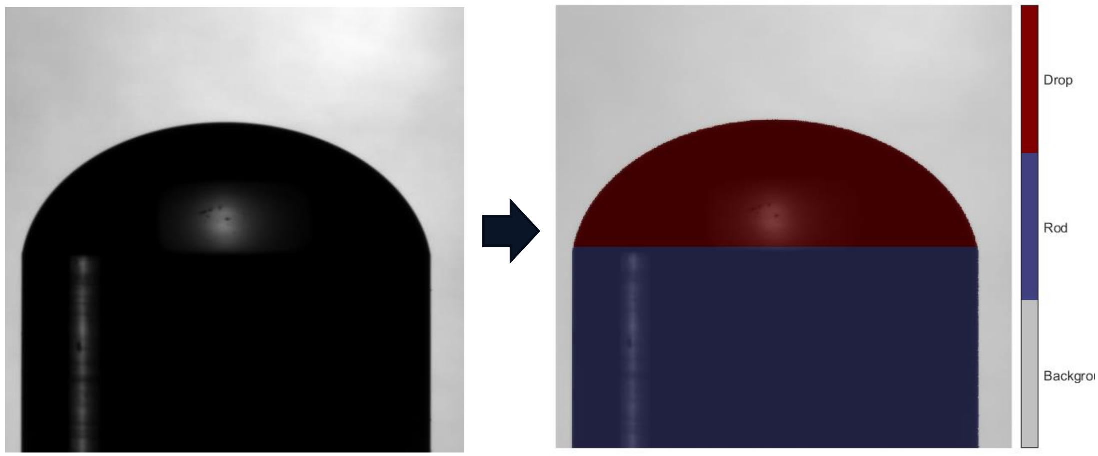
Motivation

Liquid polymer droplets can be electrically deformed and subsequently UV-cured to fabricate optical freeform elements. To train neural-network models that predict the deformed droplet contour, the input parameters need to be represented in a form that neural networks can exploit. The grayscale camera images contain the droplet edge, electrode geometry and contact points, but not process parameters like the applied voltage. A semantic segmentation network can create additional input channels for a later physics-informed neural network by separating droplet, anode, cathode, and background regions, color-coded according to their physical meaning.

Tasks

- Define label classes for droplet, anode, cathode, and background
- Train a compact segmentation model
- Encode voltage, material, or electrode state as color-coded channels
- Quantify mask quality and test its benefit for downstream contour prediction

Camera image Labeled image



Example camera image and example segmentation

Bachelor Thesis / Master Thesis

Data Fusion Strategies for Droplet Deformation Prediction

Contact Information

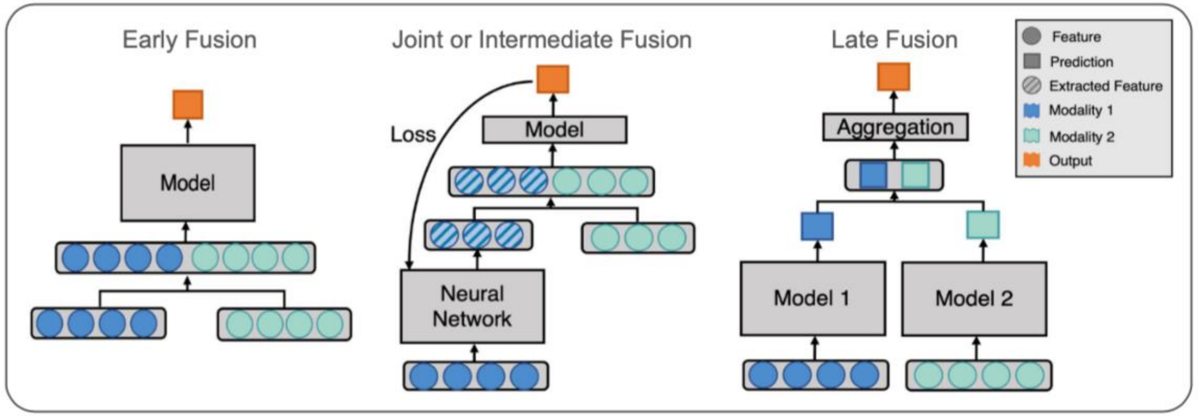
- Micro- and Nanophotonics (MNP)
- Prof.: Andreas Heinrich
- Supervisor: Annika Dehm
  (annika.dehm@hs-aalen.de)

Motivation

Liquid polymer droplets can be electrically deformed and subsequently UV-cured to fabricate optical freeform elements. The deformation of a polymer droplet is driven by applied voltage, material properties, and electrode configuration. A single camera image does not contain all of this information explicitly. This thesis compares how discrete process parameters could be fused with image information so that a neural or physics-informed neural network predicts droplet shape more reliably.

Tasks

- Define input variants: e.g. grayscale image, masks, voltage, material, and electrode configuration
- Compare different data fusion strategies
- Perform studies to identify which information is actually useful
- Evaluate contour or parameter prediction accuracy and model complexity
- Recommend a standardized input representation for future models



Example of data fusion strategies

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From Two Camera Views to a 3D Droplet Representation

Contact Information

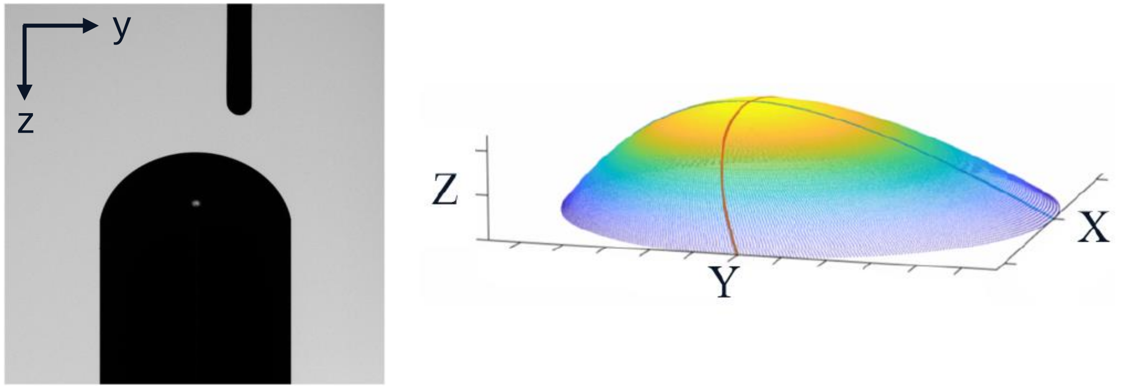
- Micro- and Nanophotonics (MNP)
- Prof.: Andreas Heinrich
- Supervisor: Annika Dehm
  (annika.dehm@hs-aalen.de)

Motivation

Liquid polymer droplets can be electrically deformed and subsequently UV-cured to fabricate optical freeform elements. Two calibrated camera views observe different projections of the same droplet. For optical design, a 3D surface representation is often more meaningful than two separate 2D contours. Using the already available paired image data, this work investigates which neural or geometric approaches are suitable for reconstructing a plausible 3D droplet shape from only two views.

Tasks

- Use the existing paired camera data
- Compare height-field, implicit-surface, point-cloud or mesh-based representations
- Combine geometric consistency with neural prediction modules
- Validate consistency and physical shape plausibility
- Identify what can and cannot be recovered from only two perspectives



Example camera image and 3D representation