Drape Image Processing

Progress report summary on image pre-processing, segmentation and further stages

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Plan Overview and Current Progress:

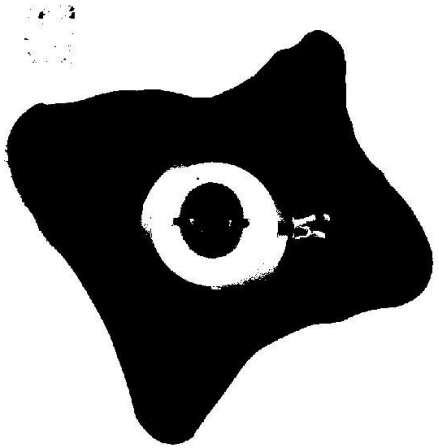
- ✓ Image pre-processing: grayscale, resize
- ✓ Geometric correction: inverse barrel distortion model
- ✓ Segmentation: optimal thresholding, edge detection
- ✓ Boundary registration: cubic spline interpolation, resample

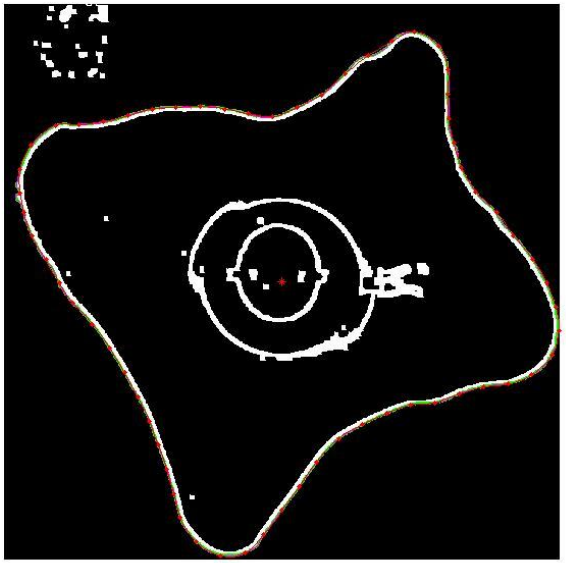
- Enhancements to the segmentation process
- Drape shape registration: shape descriptors (features)
- Drape shape classification: training of classifiers
- System optimization and evaluation

Current status (implemented modules):

- Standard pre-processing: rescale input image to predefined size (bicubic spline resize), noise suppression, convert RGB to 8-bit grayscale.
- Geometric correction: inverse barrel distortion model (analytical) from camera calibration for one-time parameter evaluation (instead of complete re-calibration estimation per-image).
- Drape shape identification: Optimized bimodal histogram thresholding, edge detection in binary image, shape boundary definition.
- Boundary detection: shape perimeter tracing, dilation/erosion filters for speckle removal, skeletonization for line thinning.
- Boundary registration: complex-valued cubic spline interpolation (full boundary), boundary sub-sampling for “smoothed” reference points (x,y).

Example of “good” processing:



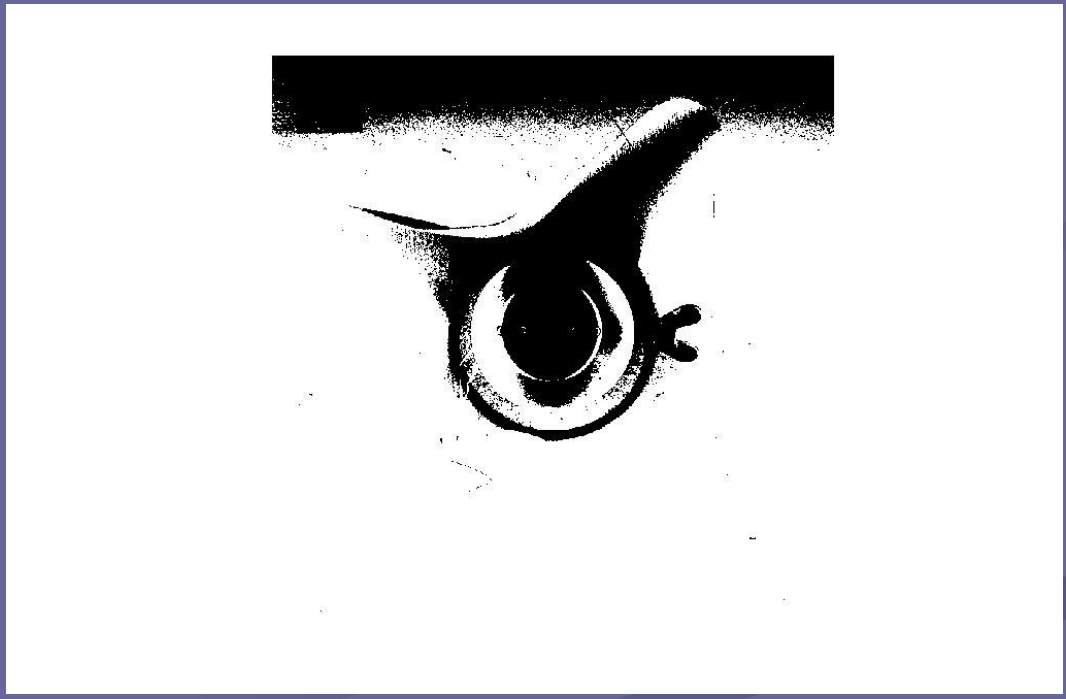


Red dotted line is the spline-interpolated analytical complex (2D) function of the drape shape, subject to further analysis via shape descriptors (features).

Current problems (partially addressed):

- Cloth color confusion: Many sample images contain semi-transparent, non-uniform or same-color (with background) cloth samples, which make the whole segmentation process extremely difficult to automate.
- Screw distortion: Many sample images contain drapes that are partially obstructed by the fixed mechanism (metallic screw), which creates significant information loss inside and around these areas (no boundary).
- Non-uniform illumination: Background seems to be illuminated in a non-uniform way, especially near the corners and the border of the box.
- Calibration box distortion: Some sample images with wide-angle drapes have their top-left section partially obstructed by the calibration box, which creates information loss inside and around these areas (discontinuities).
- Non-trimmed cloth samples: The presence of floating fibers around the drape shape creates false boundary indications in some samples.

Example of “bad” processing:



Excessive color similarity between the cloth sample and the background makes segmentation via optimal thresholding extremely difficult and inaccurate.

Proposed corrections for new image acquisitions:

- Blue/Green BG: Exploit full RGB potential and use pure “green” or “blue” background, in order to make image thresholding much simpler.
- Screw distortion: Make sure every sample is well-fit onto the fixed plate with no obstruction from the screw before taking the image.
- Flat-field correction: Image restoration (illumination, noise, etc) requires a complete set of “empty” images, i.e., with no cloth sample present (only fixed mechanism + background) and well-illuminated plane.
- Camera calibration: Instead of the calibration box (top-left), which may obstruct view, instead a set of reference points can be present all around the outer box (panel edges), for better model approximation.
- Fixed camera position: Image center differs slightly between samples, mostly because of some non-constant tilt. Using a camera fully embedded in the system should fix non-stationarity problems.

Proposed corrections for new image acquisitions (*cont*):

- Fixed camera position: Image center differs slightly between samples, mostly because of some non-constant tilt. Using a camera fully embedded in the system should fix non-stationarity problems.
- Image annotation: No date/time labels should be present in the image, as it may lead to incorrect segmentation (histogram, thresholding, shapes, etc).

Additional issues for new image acquisitions:

- Distribution of samples: The complete image set should be constructed in a way that is well-suited for the related problem of statistical learning, i.e., it should include proportional number of samples per classification category (instead of per cloth type, color, texture, etc).

Future Work (AUA):

Next major phases:

1. Shape features: Analytical content-rich functions (descriptors) for the drape shape boundary, create a complete training dataset against the pre-specified class categories.

2. Classification: Employ a wide range of linear and non-linear statistical classifiers, as well as statistical analysis on the shape features, to establish optimal configurations for the final system.

3. Enhance shape registration: Enhance the drape shape segmentation and feature extraction data into final stage.

4. Optimize classification: Enhance and integrate one or two classifiers of best performance for the final system evaluation.