Introduction

- The size and shape of tissues depend on the number, size, shape, and arrangement of the constituting cells.
- To better understand the mechanisms that guide tissues into their final shape, it is important to investigate the cellular arrangement within tissues.
- We are studying the epithelial morphogenesis of the developing wing of the fruit fly Drosophila melanogaster at the late larval stage.
- Goal: Create a detailed 3D model of the individual cells in the Drosophila wing imaginal disc, a simple single cell-layered epithelium.
- Our approach includes several stages:
  - Processing images to create 2D apical cell mesh
  - 3D reconstruction with MPU implicit surfaces
  - Projecting the 2D cell mesh onto the 3D apical surface
  - Defining & projecting a basal Region-of-Interest (ROI)
  - Projecting 3D apical cell mesh to the basal surface
  - Calculating & visualizing 3D cell geometric parameters

Input Data

- Confocal microscopy images of the central region of larval wing imaginal discs.
- Samples stained for E-cadherin, a marker of adherens junctions, and phalloidin, a marker of filamentous actin.

Create 2D Cell Mesh

- Use maximum intensity projection to merge stack of edited images into a single image.
- 2D geometric model of the cell mesh is extracted from the image using “packing analyzer v2.0” [1].

Param. Calculation

- Cell Length - distance between apical and basal cell face centroids.
- Apical Cell Face Area - sum of the areas of the triangles that define a cell’s apical face.
- Cell Volume - Cell Length × average area of projected apical and basal cell faces.

Mesh Projection

- 2D cell mesh is projected (in the Z direction) onto the apical side of the 3D surface.

ROI Projection

- ROI polygon is projected onto the basal surface.
- Vertices projected to apical surface in normal direction.

3D Reconstruction

- Edited images are manually contoured and filled.
- Stack of filled images provides the input for a 3D reconstruction technique based on MPU implicit models [2].

Length, Area and Volume Visualization

- Lengths are mapped to the hue color channel with ((max length - length)/(max length - min length)) × 240.
- Areas are mapped to the hue color channel with ((max area - area)/(max area - min area))² × 240.
- Volumes are mapped to the hue color channel with ((max volume - volume)/(max volume - min volume))² × 240.
- Quadratic form highlights differences in smaller cells.

• Cells in a broad central region of the wing disc pouch are, on average, longer compared to cells in the periphery of the wing disc pouch.
• Cells at the center of the wing imaginal disc, in close proximity to the signaling sources of the morphogens Dpp and Wingless, are more constricted than cells further away from the sources.