Ductales - Extension documentation

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1 Introduction

Ductales is a QuPath extension that aims to compute ducts features based on their cells and their neighbors. The extension detects nuclei and their class by using the StarDist extension, compute ducts and their features from the cells organization.

The extension is designed to work on multi-channels images (including whole slides) and any custom model for segmentation.

2 Installation

The extension can installed in QuPath v0.3 by following those steps:

1. Download and install QuPath from here.
2. Download StarDist and Ductales jar file and put it in the extension folder of QuPath (in QuPath menu: Extensions/Installed extensions/Open extension directory).
3. Restart QuPath if open.

3 Execute Ductales with command line

It is possible to execute Ductales directly from command line with a correctly configured QuPath (see Installation) using the available scripts]. See QuPath documentation.

4 Duct regions detection

To speed up the cell detection, it is interesting to get a first estimation of the duct regions. This estimation is based on the thresholding of a lower resolution of the image using a specific deconvolution stain (DAB, Hematoxylin, Eosin).

4.1 Parameters

Downsample The downsampling factor to apply on the image.

Deconvolution stain The deconvolution stain to use to get a single channel image for thresholding.

Gaussian sigma A gaussian sigma that will reduce impact of image imperfection.

Threshold method The automatic thresholding method to use.

Minimum area The minimum area (number of pixels) for a duct region (region too small might not be relevant).

Dilatation Apply a dilatation (in pixel) to make sure the region is not too restrictive.

5 Cell detection

The extension allows the detection of nuclei and cells by using the StarDist extension. StarDist perform the segmentation tile by tile.

5.1 Parameters

Channels The expected channels by the StarDist model.

Model file The path of the StarDist model to use (must be compatible with StarDist extension).

Normalize percentile min/max The boundaries used when normalizing to reduce outliers.

Tile size The size (in pixel) of the tile provided to StarDist.

Tile overlap The overlap (in pixel) between the tiles provided to StarDist. Should be greater the expected detection size.

Classes The name of the expected classes generated by the model.

Cell Delineation thickness The cells are estimated with a dilation of some size (micrometer).

6 Measure cells infos

The extension allow to compute some basic features of the detected cells. It includes features related to the shapes, the intensities of the channels and the texture in the nucleus/cell region (Haralick texture features).

7 Compute duct structures

The extension can compute clusters of cell to estimate duct structures. Features can then be extracted from these structures like their size, the number of holes, the number of cells layer, ... Neighbors and holes are detected using a Delaunay graph.

7.1 Parameters

Excluded classes The classes that should not be considered as part of a duct.

Duct max distance The maximum distance (micrometers) between cells to be considered in the same duct.

Duct min cell size The minimum number of cell a duct is expected to have. Allow to avoid false detection.

Duct classes The classes that are expected in a duct and that should be used in measurements.

Holes min distances The minimum distance (micrometers) between cells to be considered disconnected. Can also be considered as the minimum distance of a hole. Multiple distances can be checked to detect various hole organization. These distances should never be greater than the duct max distance.

Hole min cell size The minimum number of cells the boundary of a hole is expected to contain.

Refine boundary The boundaries (hole/perimeter) can miss some relevant cells (cell between connected cells of boundaries). A refinement step is possible to include theses cells based on the angle they form with the cells in the boundary (triangle where basis is cells of boundary).

Triangle to refine min angle The min angle (in degree) to consider for the boundary refinement. Triangle with bigger angle will be merge in the boundary.

7.2 Features description

- QuPath Shape features: classic features for a QuPath shape such as centroid, area, solidity, perimeter length,.... It is computed on the duct structure, the annotation corresponding to the union of all the cells shapes.
- Cell density: the area of the duct structure divided by the number of cells. Also available per classes.
- Number of holes: the number of detected holes (be cautious might miss some holes or overdetect them), see also: porosity.
- Porosity: the ratio between the area of the outer perimeter of the duct structure divided by the summed area of the holes. Indicate of the amount of holes in the structure.
- Perimeter solidity: the solidity of the outer perimeter. Solidity is the ratio between the area of the convex hull with the area. Indicate how regular/simple the outer shape is.
- Number of mono-layered cells: the number of cell that are considered to be in a mono-layer (connected to at least two boundaries).
- Number of cells (layer=0): the number of cells that are connected to a boundary (holes or perimeter).
- Number of cells (layer¿0): the number of cells not connected to a boundary (holes or perimeter).
- Mean cell distance to borders: the mean distance of the cells to a boundary (holes or perimeter).

- Number of detection: the number of cells detected in the structure. Also available per classes.