SLDC: an open-source workflow for object detection in multi-gigapixel images

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12th September 2016

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2. SLDC
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   - How it works
   - Features
3. SLDC at work: thyroid nodule malignancy
   - Thyroid case
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   - Workflow
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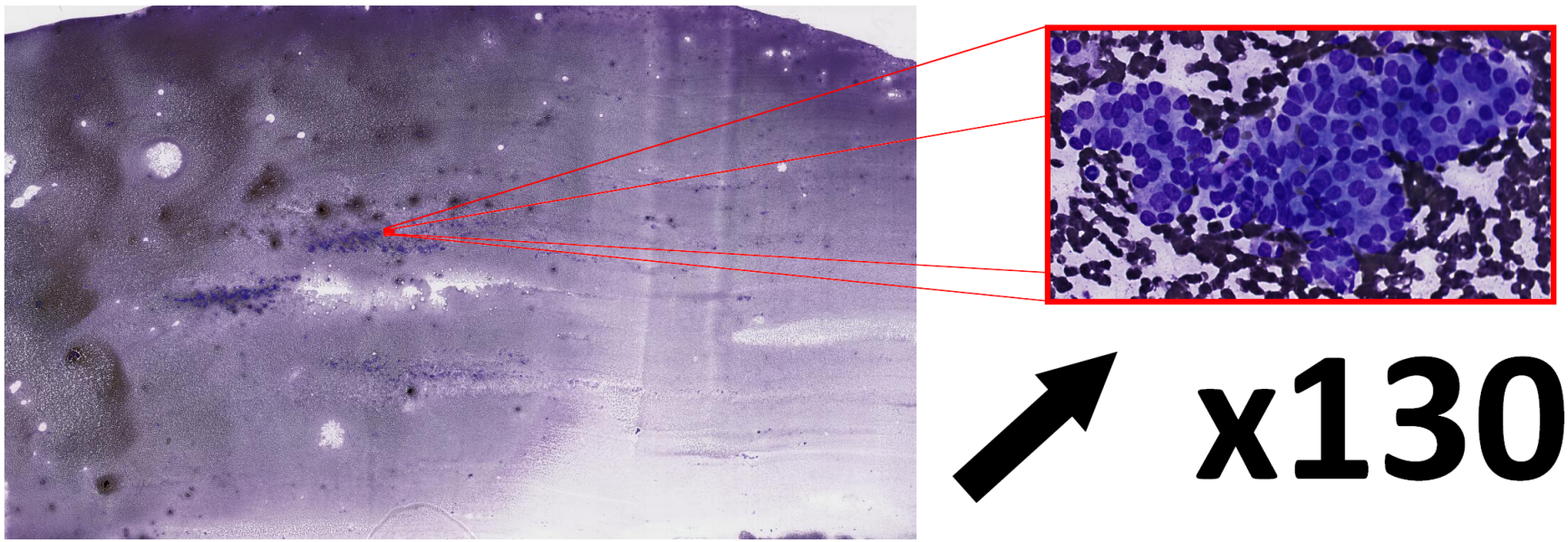
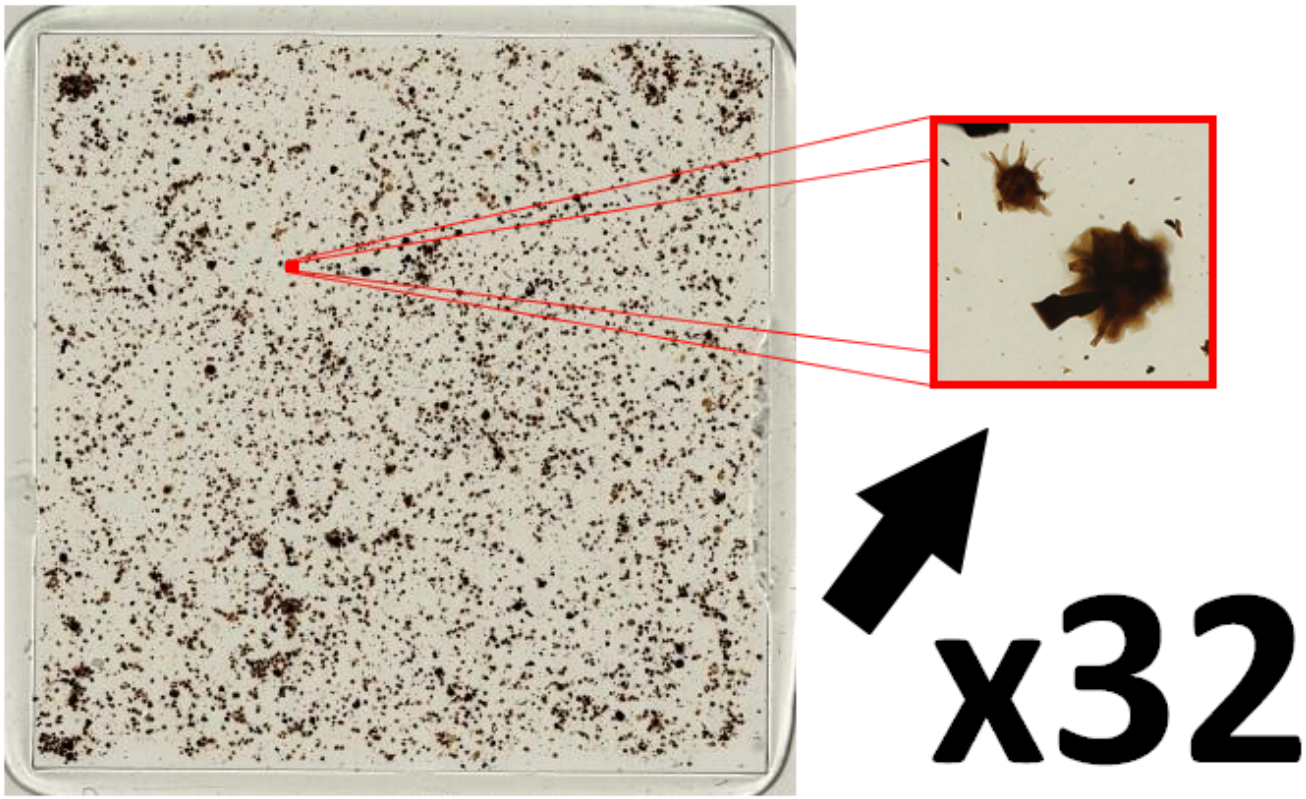
Context



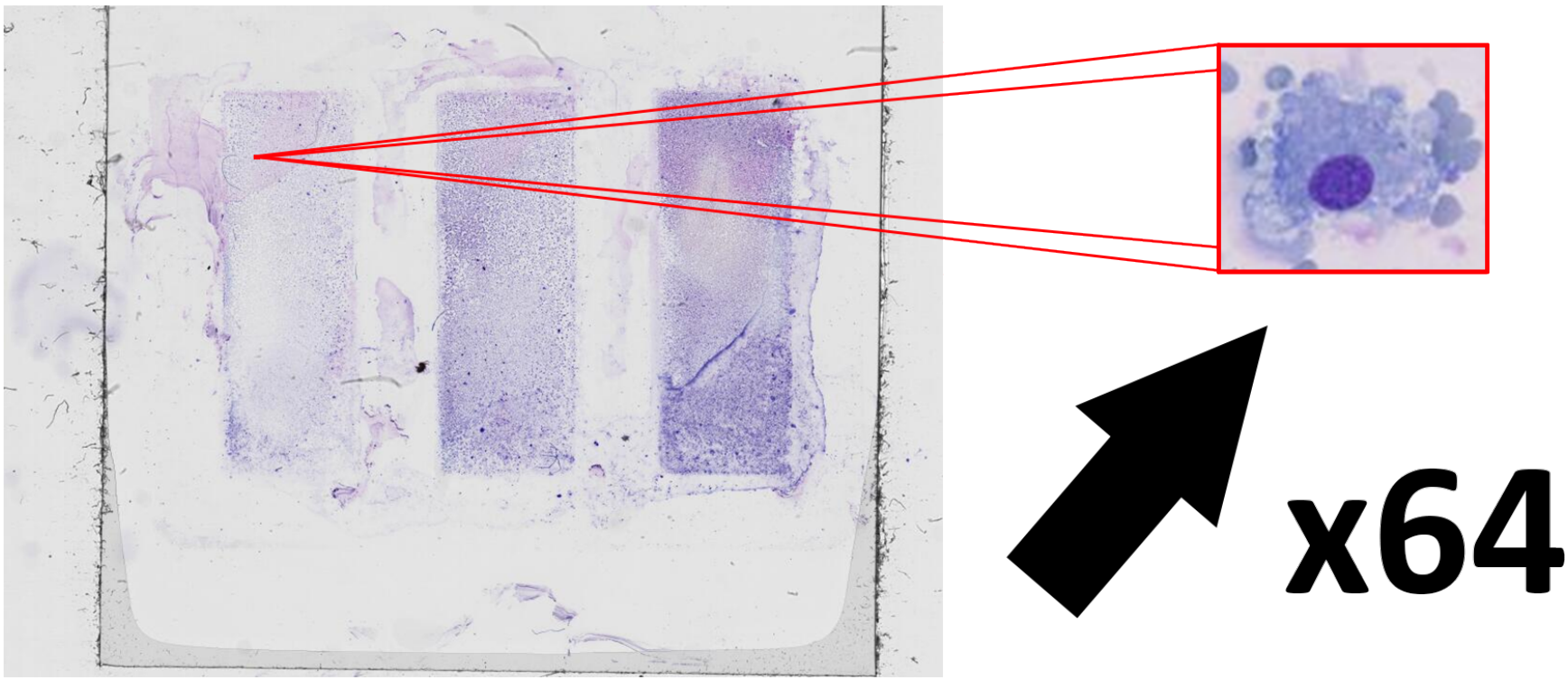
Microscope slide smeared with thyroid cell samples (15 gigapixels).

Context



Microscope slide smeared with core samples (11 gigapixels).

Context



Microscope slide smeared with lung cell samples (3 gigapixels).

Context

- Huge slides usually **analysed manually** !
- Machine learning (ML) and image processing (IP) could be used to assist humans
- Problems of **object detection and classification**

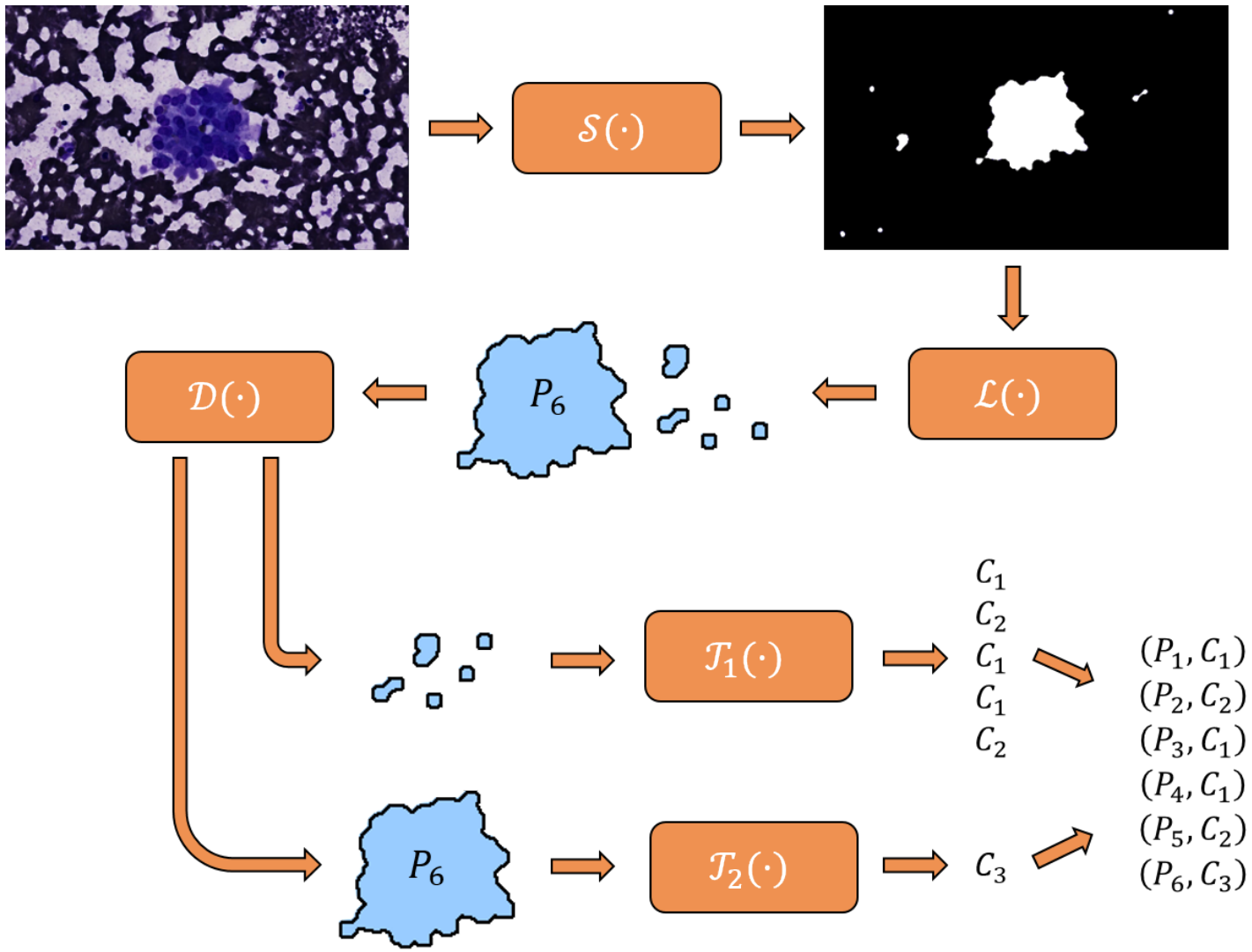
SLDC: framework

SLDC is an **open-source Python framework** created for accelerating development of large image analysis workflows.

How ?

- It encapsulates problem-independent logic (parallelism, memory limitation due to large images handling,. . .)
- It provides a concise way of declaring problem dependant components (segmentation, object classification,. . .)

SLDC: how it works

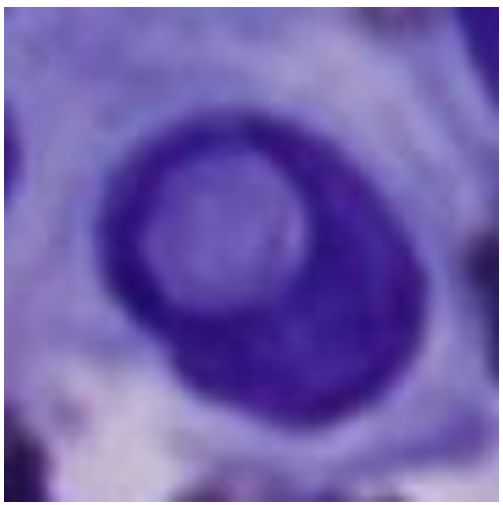


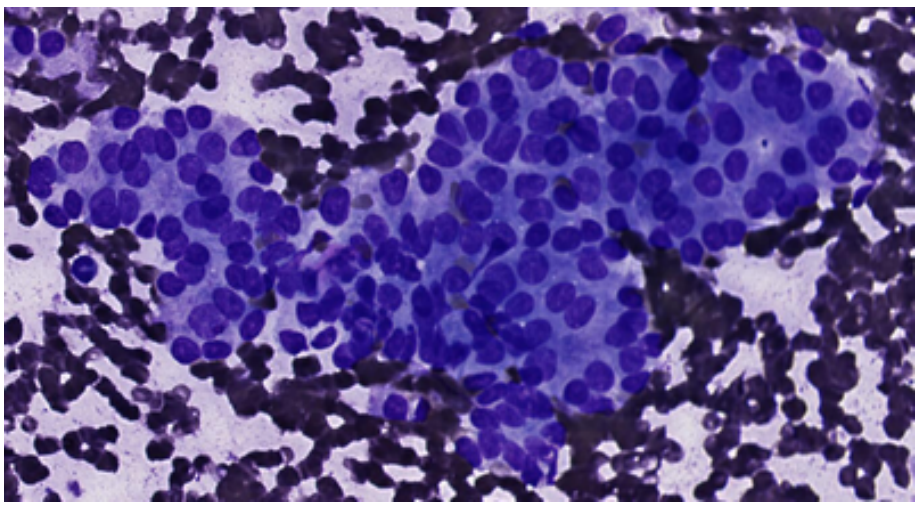
SLDC: features

- **Tile-based processing** to avoid loading a full image into memory
- Several level of **parallelism**: tiles, objects, images,...
- A **customizable logging system** providing a rich feedback about the execution
- **Effortless integration** with other Python libraries: scikit-learn (ML), open-cv (IP), PyCuda (GPU),...

SLDC at work: thyroid case

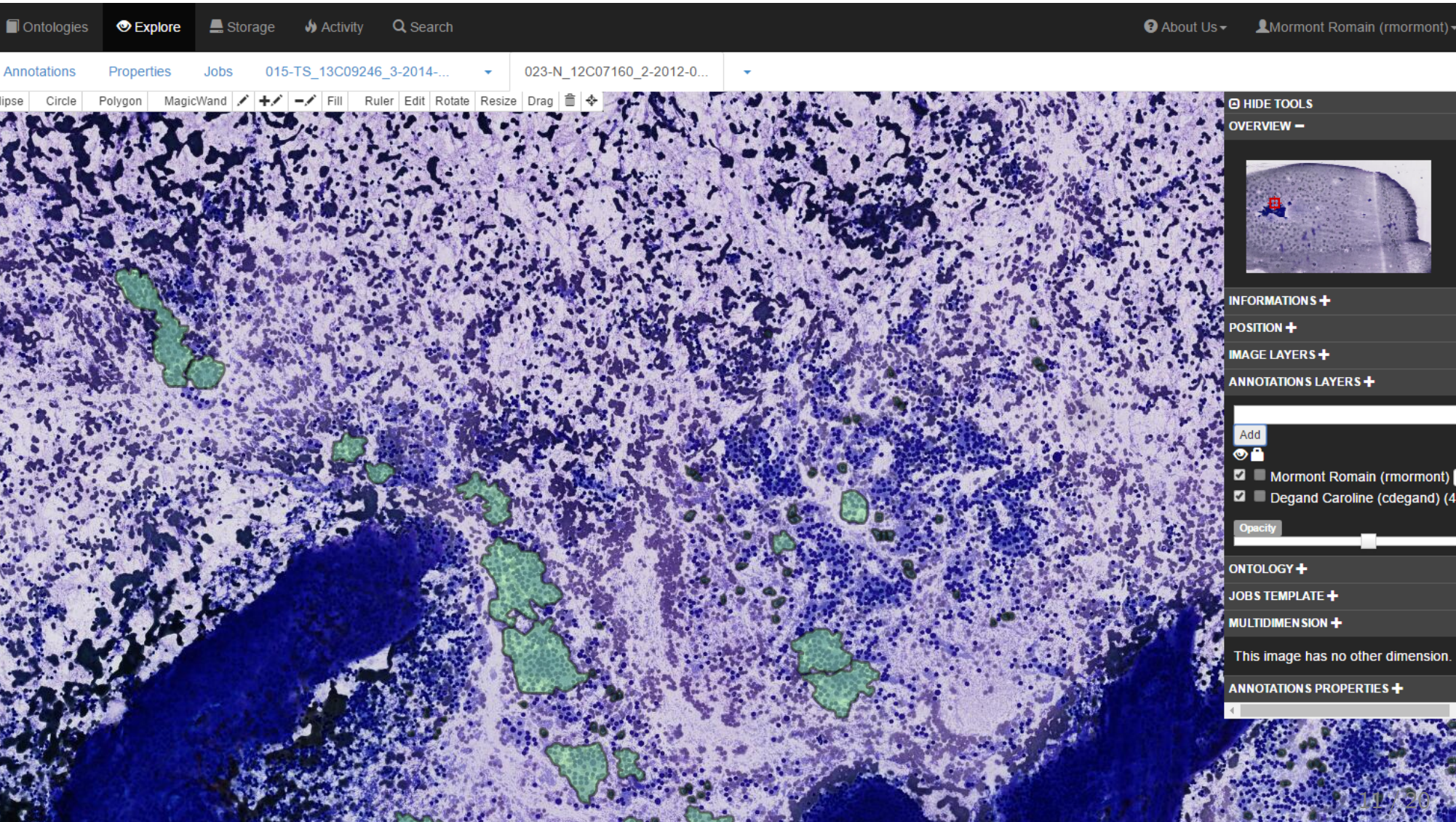
Aim: detect **cells with inclusion** and **proliferative architectural patterns**





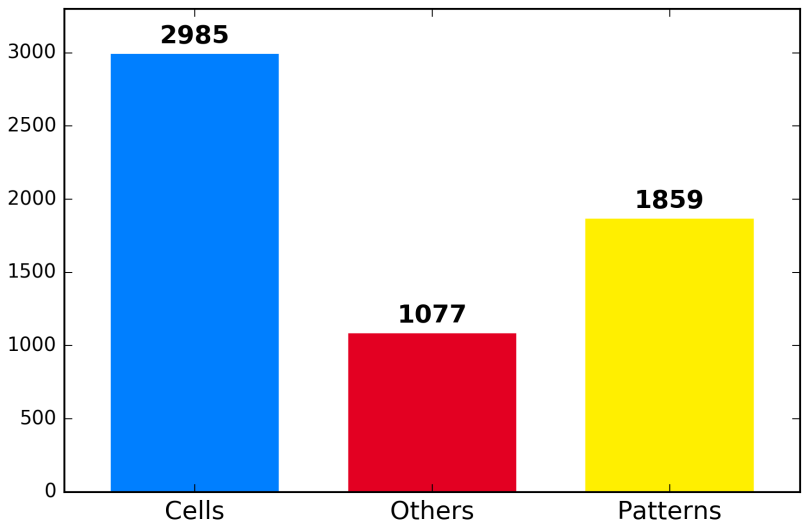
SLDC at work: Cytomine

cytomine is a web-based environment enabling collaborative multi-gigapixel image analysis. (Website: `www.cytomine.be`. Marée & al., Bioinformatics; 2016).

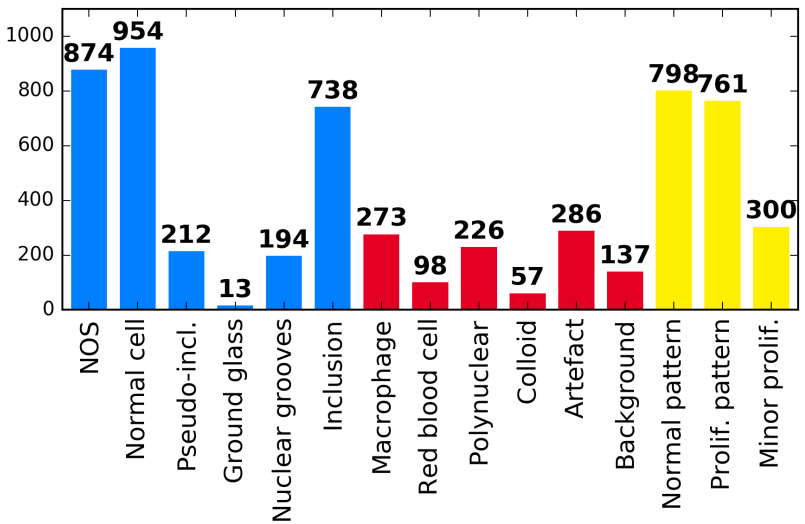


SLDC at work: data

- **84 images** with size ranging from 4 to 18 gigapixels
- **68 annotated images**
- **5921 labelled annotations** made by cytopathologists[1]



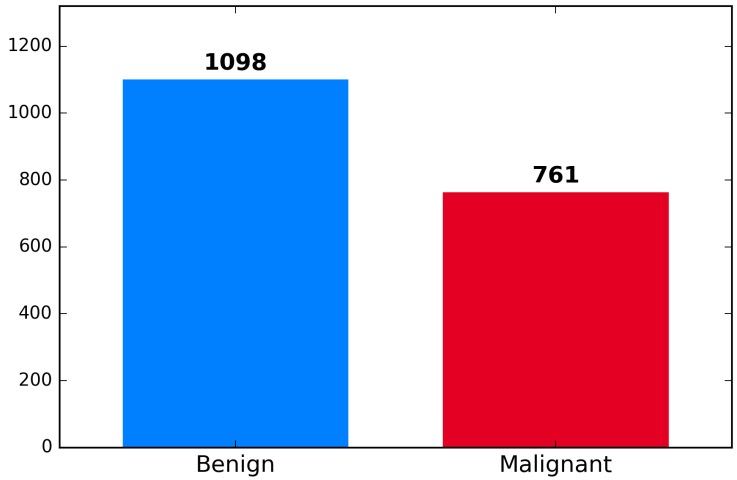
(a) Annot. per group



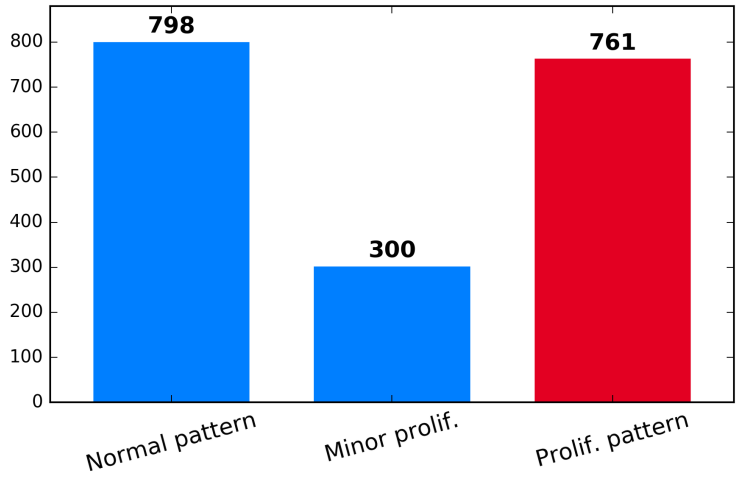
(b) Annot. per term

[1]Team of Pr. Isabelle Salmon, Department of Pathology, Faculty of Medecine, ULB

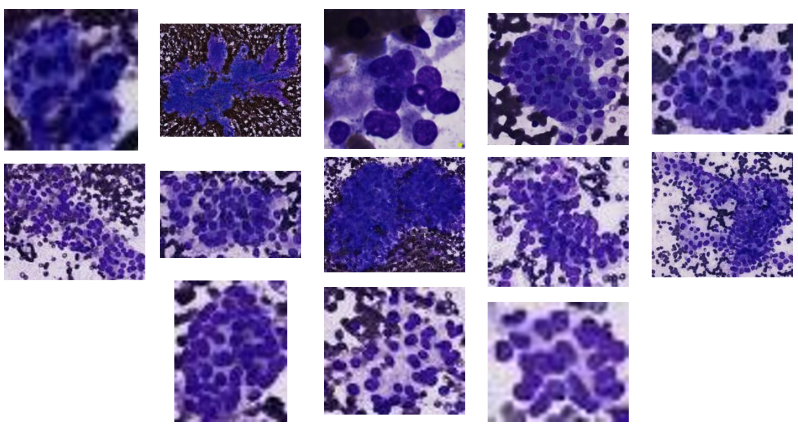
SLDC at work: data (cont'd)



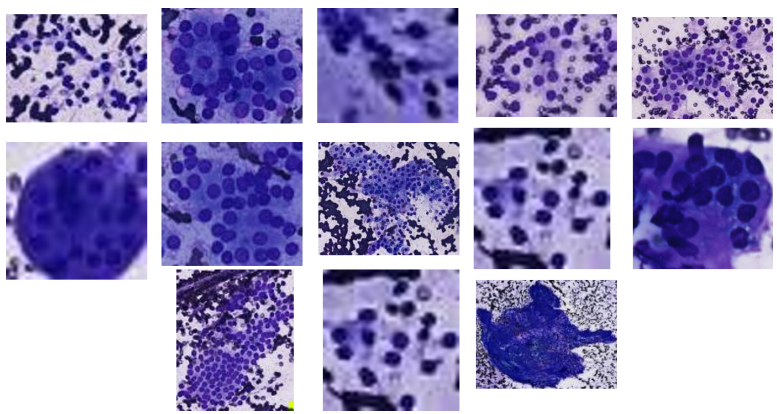
(c) Pattern annot. per group



(d) Pattern annot. per term

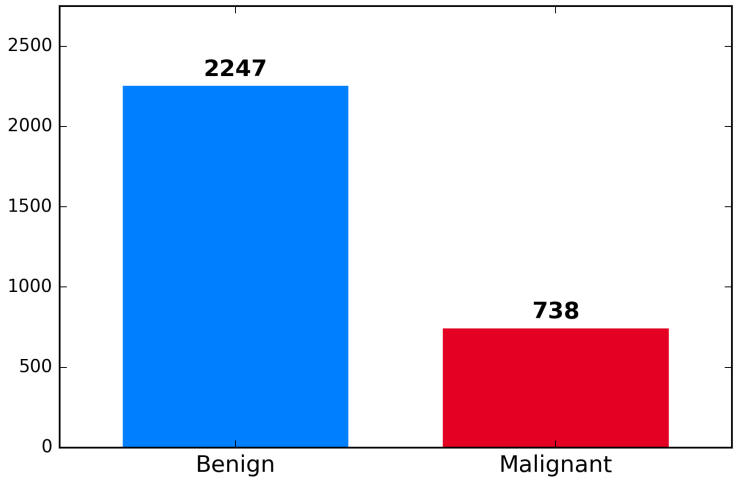


(e) Proliferative (malignant)

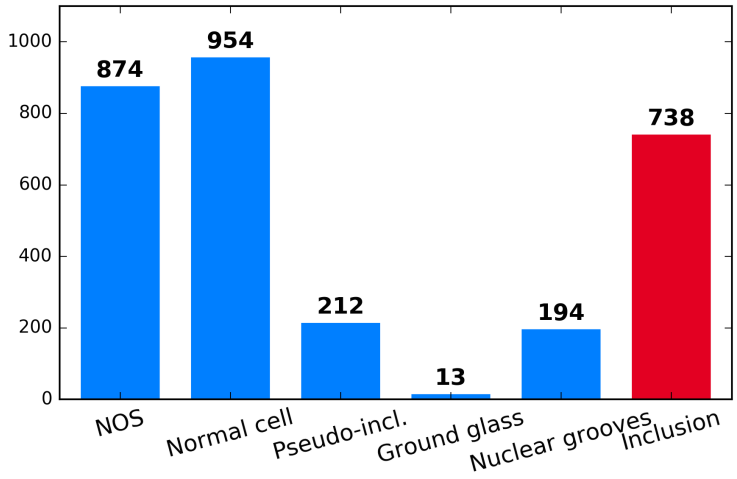


(f) Normal patterns (benign)

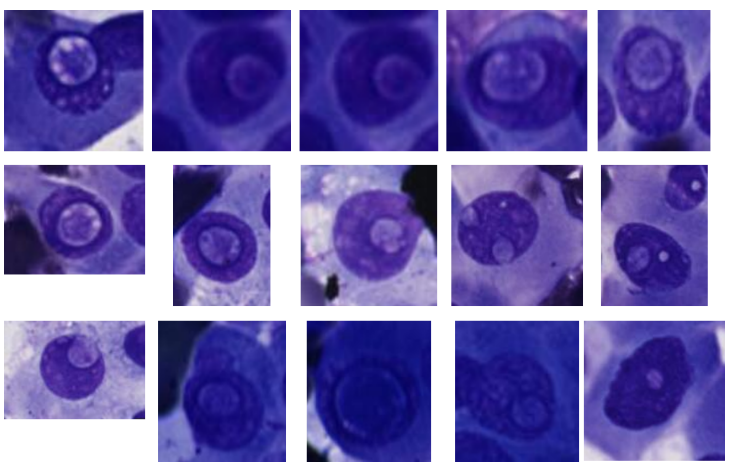
SLDC at work: data (cont'd)



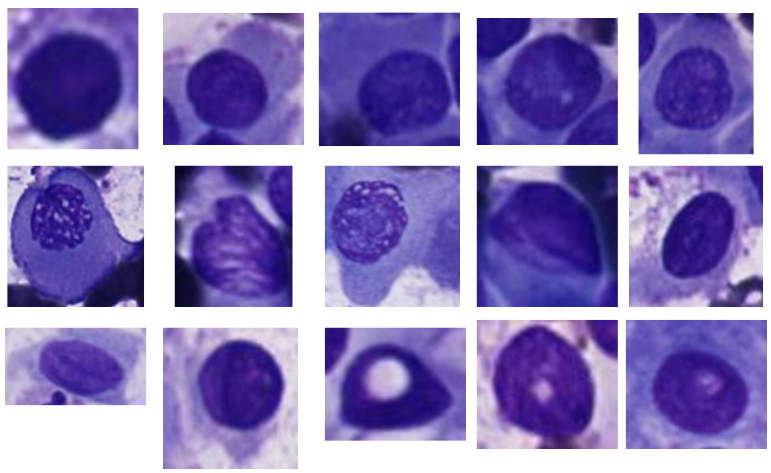
(g) Cell annot. per group



(h) Cell annot. per term

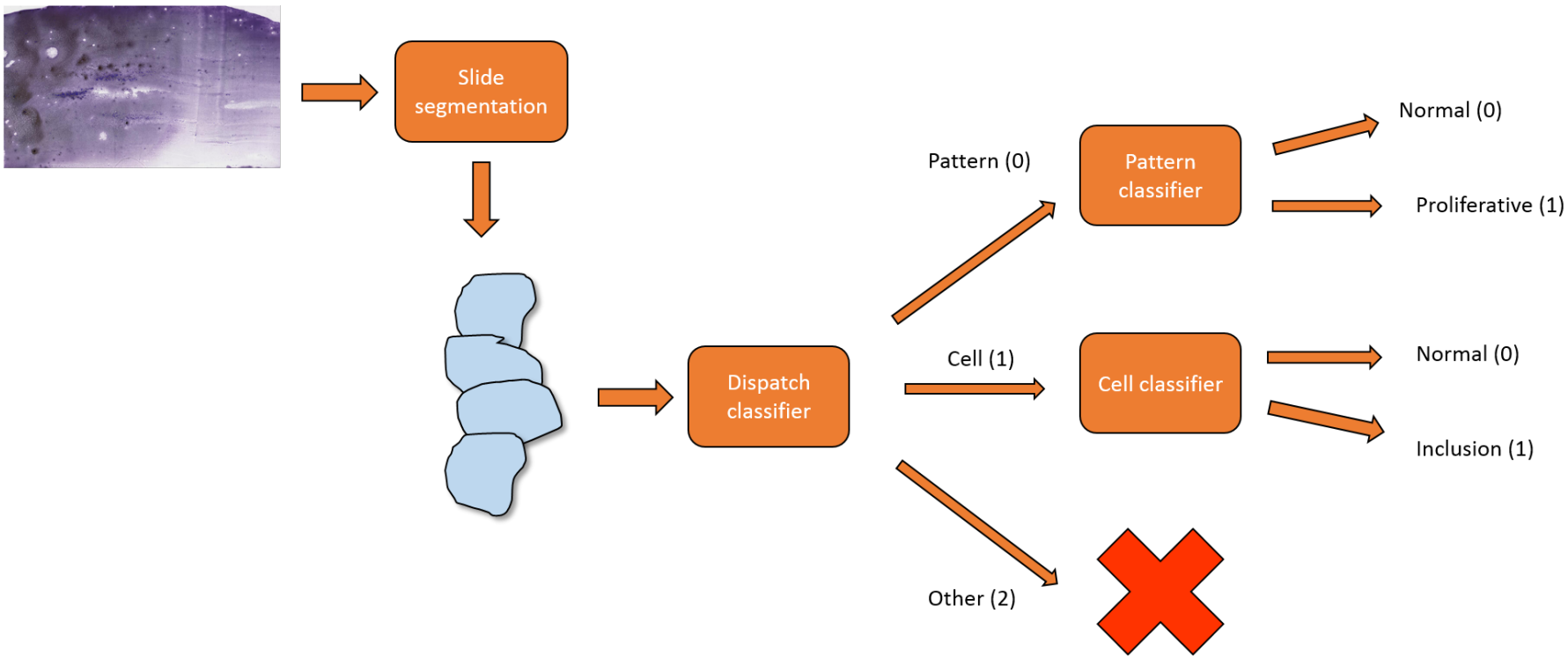


(i) Cells with incl. (malignant)

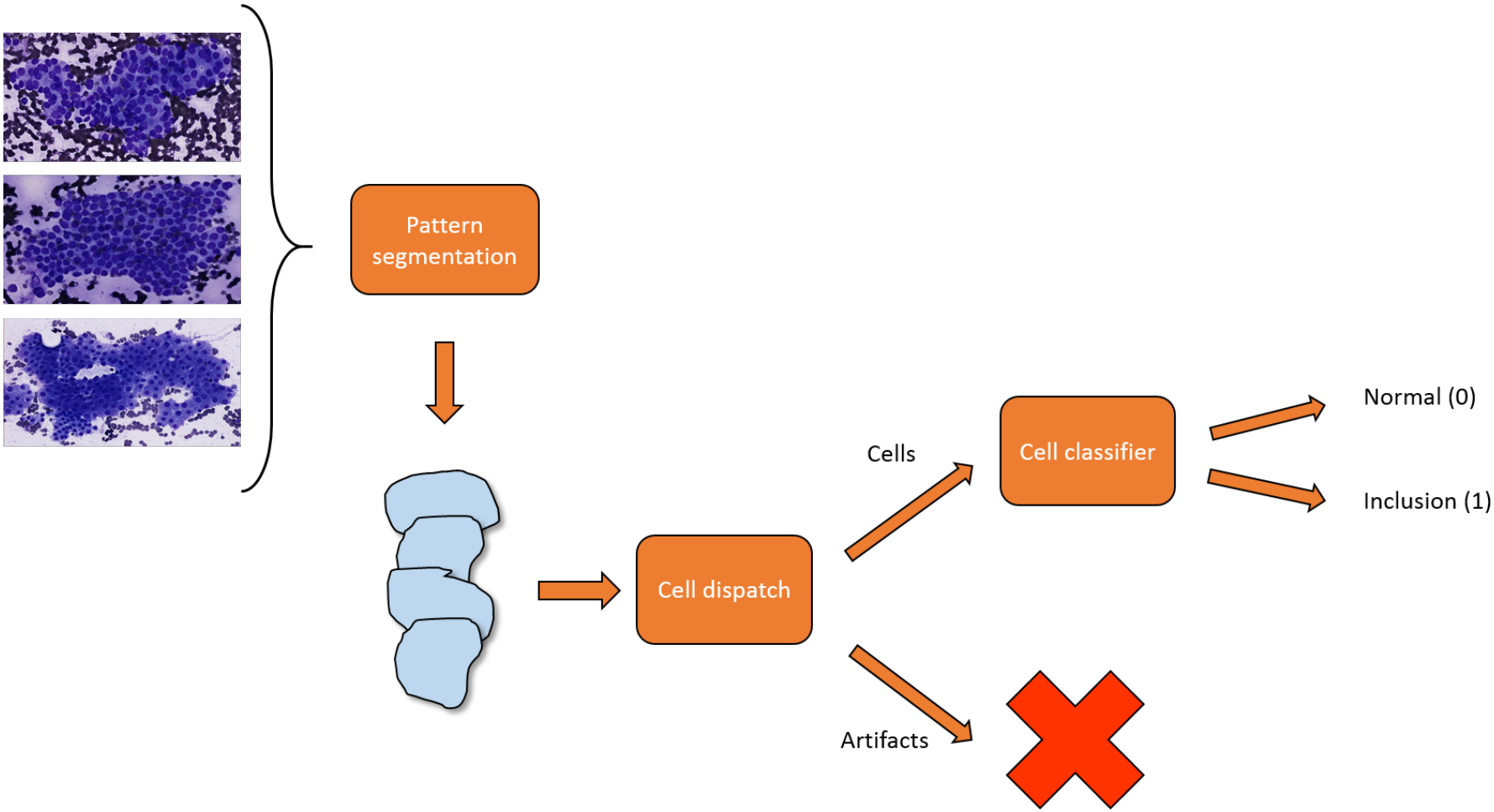


(j) Normal cells (benign)

SLDC at work: workflow



SLDC at work: workflow (cont'd)



SLDC at work: workflow (cont'd)

Classification is performed based on the detected object's crop image using **random subwindows and extremely randomized trees**[2].

Cell with inclusion vs. normal cells:

Accuracy:	0.8523
Precision:	0.6310
Recall:	0.4930

	Normal	Inclusion
Normal	881	62
Inclusion	109	106

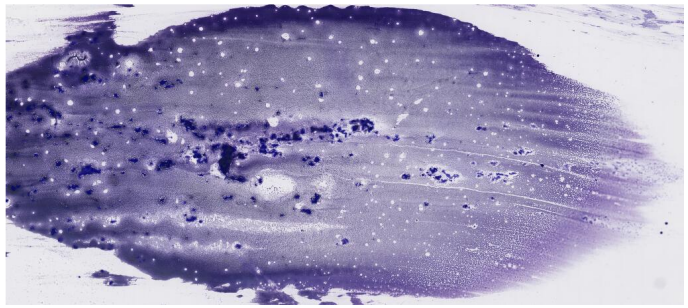
Proliferative vs. normal patterns:

Accuracy:	0.8625
Precision:	0.8363
Recall:	0.9493

	Normal	Prolif.
Normal	158	55
Prolif.	15	281

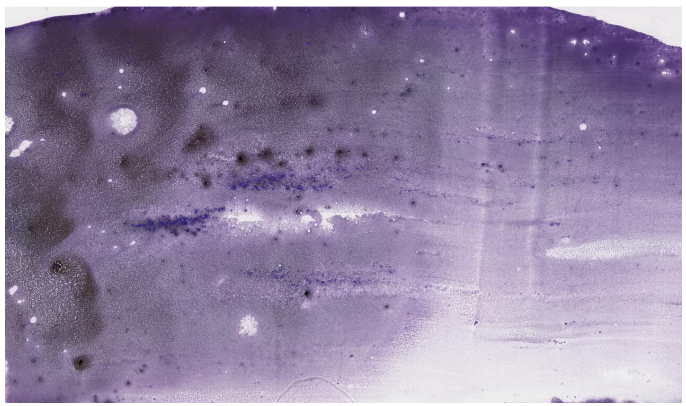
[2] Marée et al., Pattern Recognition Letters ; 2016

SLDC at work: results



Size: 131072 × 57856

Time (1st pass):	**4 min 38 sec**
Time (2nd pass):	**2 min 04 sec**
Objects found:	**18882**
Cells found:	17802
Patterns found:	1080
Jobs:	64
Max memory usage:	159.414 Go



Size: 163840 × 95744

Time (1st pass):	**12 min 24 sec**
Time (2nd pass):	**7 min 10 sec**
Objects found:	**76133**
Cells found:	69820
Patterns found:	6313
Jobs:	64
Max memory usage:	179.855 Go

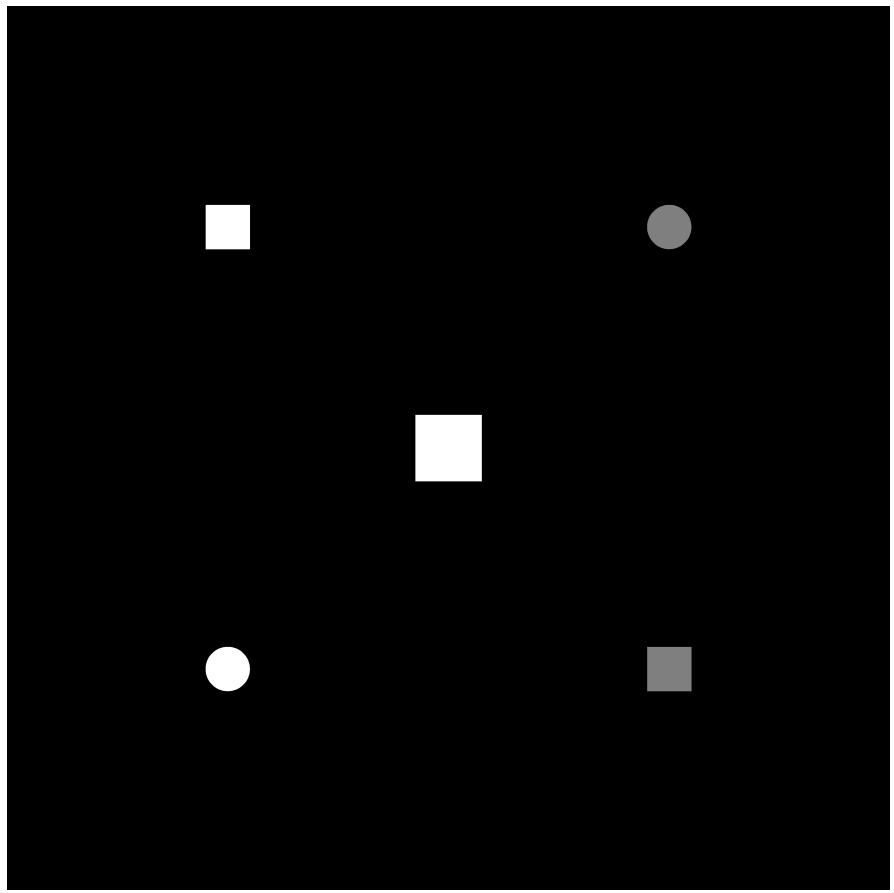
Conclusion and future works

1. Framework
   - Production-ready !
   - Open-source and generic.
   - Still some minor improvements to make (parallelization, dispatching,...)
   - **Feel free to use it**: https://github.com/waliens/sldc
2. Thyroid workflow:
   - At this point, too many false positives.
   - Need to improve the classifiers and the segmentation procedures

Thank you for your attention !
Any question ?

SLDC: toy example

The aim is to detect circles in the following image. As a bonus, we want to know their center color.



SLDC: toy example (cont'd)

```
# Defining a segmenter
class CustomSegementer(Segmenter):
    """All non-black pixels are in an object of interest"""
    def segment(self, image):
        return (image > 0).astype(np.uint8)

# Defining a dispatching rule
class CircleRule(DispatchingRule):
    """A rule which matches circle polygons"""
    def evaluate_batch(self, image, polygons):
        return [circularity(p) > 0.85 for p in polygons]

# Defining a polygon classifier
class ColorClassifier(PolygonClassifier):
    """
    A classifier which returns the color (greyscale)
    of the center pixel of the object
    """
    def predict_batch(self, image, polygons):
        classes = [center_pxl_color(image, p) for p in polygons]
        probas = [1.0] * len(polygons)
        return classes, probas
```

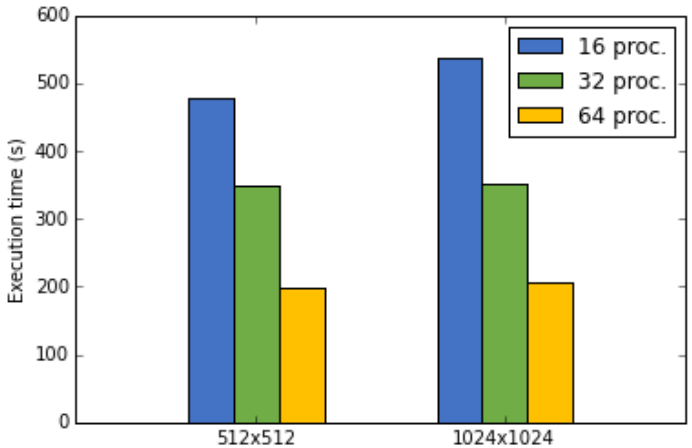
SLDC: toy example (cont'd)

```
# Build the workflow
builder = WorkflowBuilder()
builder.set_n_jobs(100)
builder.set_segmenter(CustomSegementer())
builder.add_classifier(CircleRule(), ColorClassifier(), disp_label="circle")
workflow = builder.get()

# Process an image
results = workflow.process(image)

# Go through the detected objects
for polygon, dispatch, label, proba in results:
  print "Detected polygon {}".format(polygon)
  print "Dispatched by '{}'".format(dispatch)
  print "Predicted class {}".format(label)
  print "Probability {}".format(proba)
  print ""
```

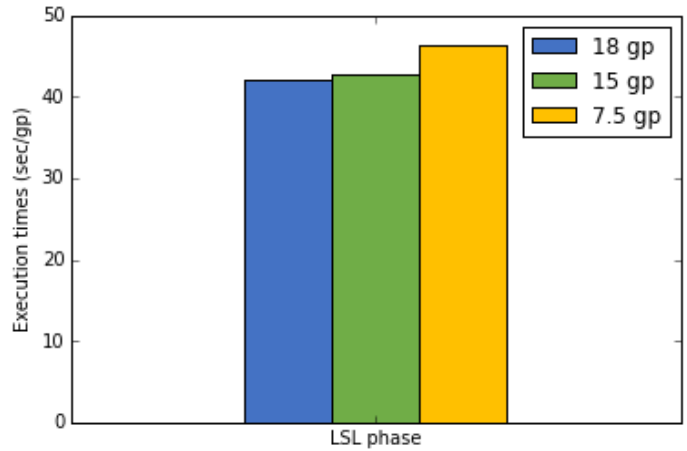
SLDC: toy example (cont'd)

```
Detected polygon POLYGON ((...))
Dispatched by 'circle'
Predicted class 128
Probability 1.0

Detected polygon POLYGON ((...))
Dispatched by 'circle'
Predicted class 255
Probability 1.0
```

SLDC: scalability



(a) Evolution of the execution times when varying the number of available processors



(b) Execution times per gigapixels.