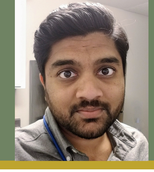
Detecting Small Objects in Large Microscopy Images



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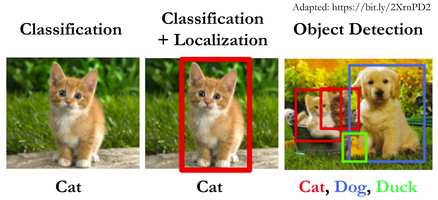
Introduction

Object Detection: Computer vision problem of localizing and classifying several different "objects" in images or videos

Limitations:

1. Detecting small objects that occur in groups of large numbers (school of fish)
2. Degraded performance with images larger than few 100px



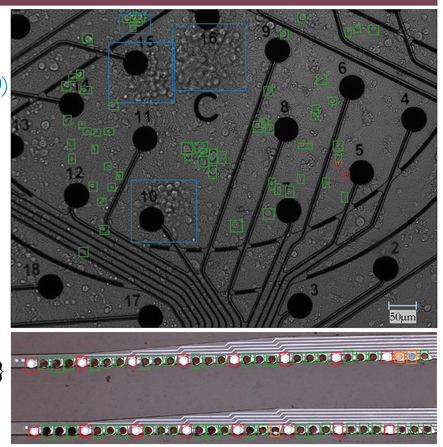
Goals: Extend YOLO object detection to

1. Detect different cell types in neuronal cell cultures from microscopy images of hundreds of cell that either occur individually or in dense clusters
   - **Long term**: Accurate automated cell detection to potentially a. reduce time, effort, and human error, b. improve characterization and differentiation of diverse culture types
2. Localize and classify electrodes in an multi-electrode device based on their material coating
   - **Long term**: Reduce electrode impedance measurement time by incorporating detection followed by impedance prediction in the electrode coating pipeline

Applications and Datasets

1. **Neuronal cell cultures**
   - Original: 54 images, ~7000 labels
   - Classes: Live (5k), Dead (900), Cluster (700)
   - Training: ~4200 crops {400, 600, 800}
   - Test: 6 labelled images
   - Hurdles: Highly imbalanced classes
     Not all objects labelled

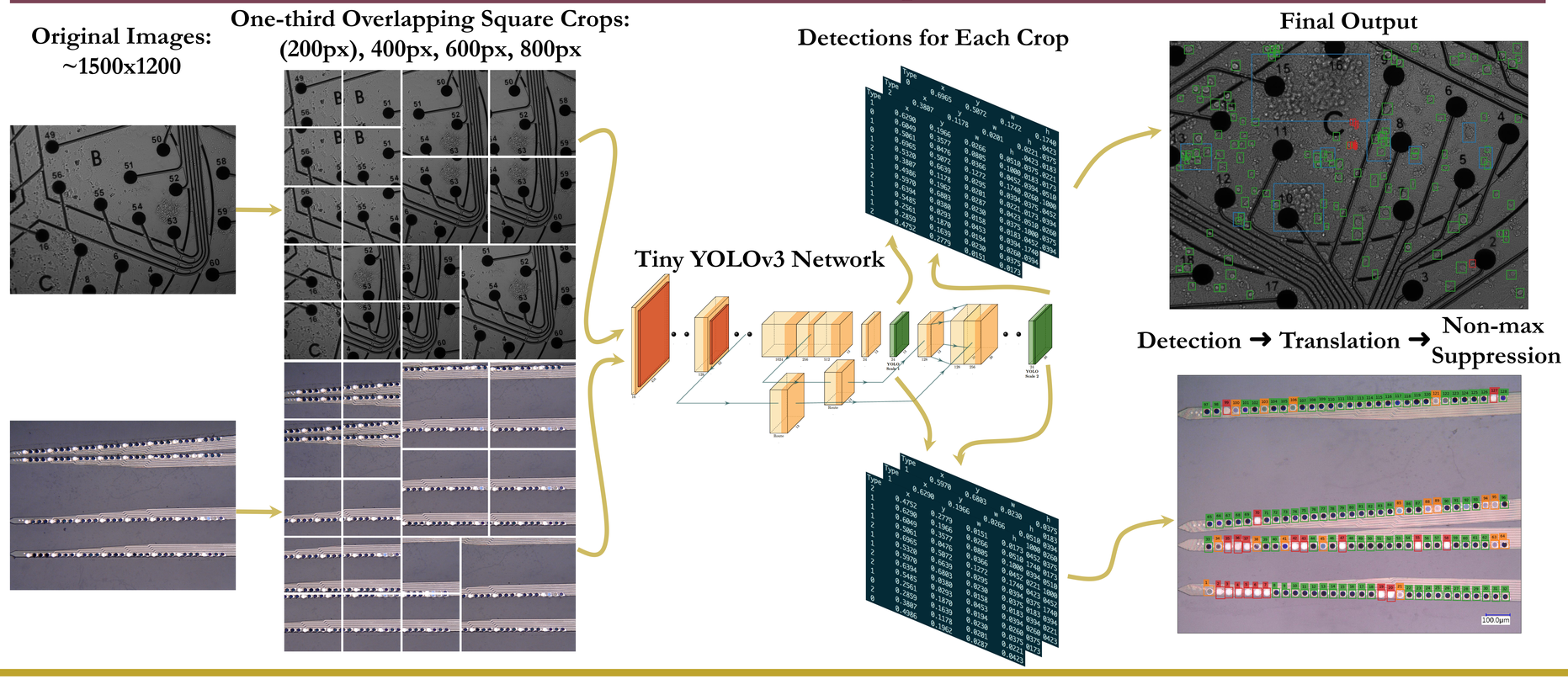
2. **Multi-electrode Devices**
   - Original: 3 images, ~350 labels
   - Classes: Coated(250), Open(75), Partially Coated(20)
   - Training: ~1300 crops {200, 400, 600, 800}
   - Test: 6 unlabeled images
   - Hurdle: Really small original dataset



Observations

1. **Neuronal cell cultures**
   - Model detects 10s-100s of cells in test images
   - Model also detects several cells that were not labelled by hand
   - Performance Quantification:
     - Used a few crops of images which were completely labelled
     - Performance significantly better on live cells
     - More complex YOLO architecture leads to small improvements
2. **Multi-electrode Devices**
   - Regularity of electrode shapes and significant color differences make the problem easier
   - Model detects all the electrodes in the image
   - There are a few (<10%) multiple label predictions of the same electrode
   - Use of simple conflict resolution rules based on electrode location distribution mitigates this problem

Object Detection Pipeline



Ongoing/Future Work

1. **Neuronal cell cultures**
   - Improving performance using further augmentation, complex models, and single class models
   - Cell count/density estimation from detected objects
   - Incorporating density estimate to improve graph based community model of neuronal cells
2. **Multi-electrode Devices**
   - Creating an end-to-end detection pipeline to be incorporated in electrode coating process
   - Using detected bounding boxes with convolutional neural networks to predict electrode impedance
   - Creating a YOLO type electrode localization network that predicts the impedance directly.

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