CELLCLASSIFICATION

https://github.com/Rachel-Ruixuan/CellClassif

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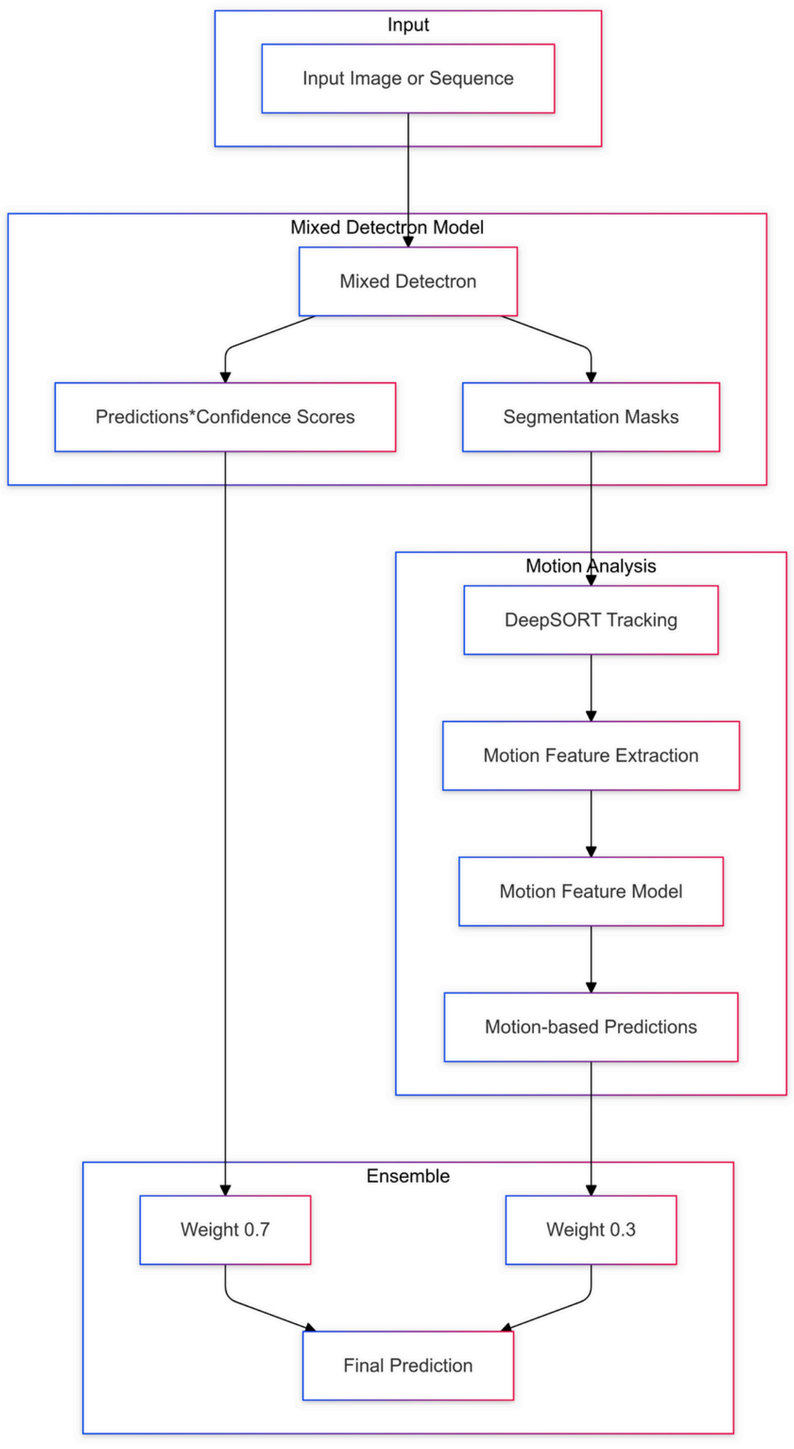
- Primary Goal:
  - Develop an automated system to identify and classify different cell types in microscopy videos
  - Replace time-consuming manual cell identification methods
- Key Challenges:
  - Distinguish between visually similar cell types
  - Capture unique behavioral patterns of different cells
  - Handle dynamic microscopic environments
- Solution Approach:
  - Combine spatial recognition (Detectron2) with motion analysis
  - Create an integrated pipeline for real-time cell tracking and classification
  - Achieve reliable automated classification through dual-model verification



Ensemble Strategy

Final Prediction = 0.7 * Detectron_Prediction + 0.3 * Motion_Features_Prediction

Rationale

- Detectron (70%)
  - Strong shape feature extraction
  - Immediate classification capability
  - More reliable for static features
- Motion Features (30%)
  - Temporal pattern recognition
  - Behavioral characteristics
  - Complementary dynamic information

Inference Workflow

Phase 1: Frame Processing

- Process each frame to obtain segmentation and tracking data.
- Save all detections and tracking information.

Phase 2: Motion Feature Extraction

- After all frames are processed, extract motion features from the accumulated tracking data.
- Perform inference using the motion feature model.

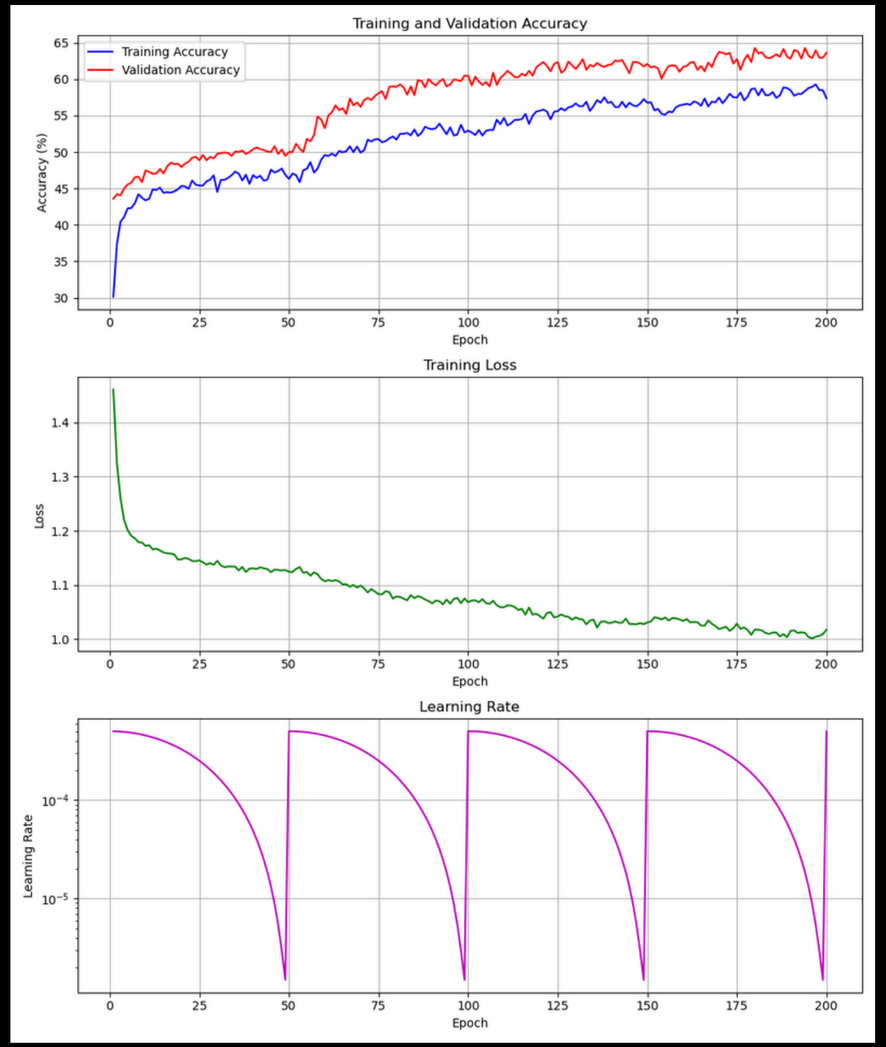
Phase 3: Ensembling and Visualization

- Combine Detectron2 and motion model predictions.
- Annotate frames with the final ensemble predictions.
- Generate the final video.

Evaluation Framework Comparative Analysis

1. Detectron-Only Performance
    - Baseline accuracy
    - Shape-based classification metrics
2. Motion-Features-Only Performance
    - Temporalpattern recognition
    - Movement-based classification accuracy
3. Ensemble Model Performance
    - Combined accuracy
    - Feature importance analysis
    - Confusion matrix comparison

- Motion Feature Model :
- Measures classification accuracy (identifying cell types based on movement patterns)
  - Final validation accuracy: ~63-65%
  - Uses temporal features like speed, acceleration, direction changes



- Detectron Model has two types of metrics:
  - Bounding Box Detection (bbox):
    - Overall AP: 59.1%
    - Per-class AP: MDA (70.4%), FB (66.1%), M1 (50.8%), M2 (49.1%)
  - Segmentation (segm):
    - Overall AP: 45.3%
    - Per-class AP: MDA (69.3%), FB (11.6%), M1 (50.2%), M2 (50.3%)

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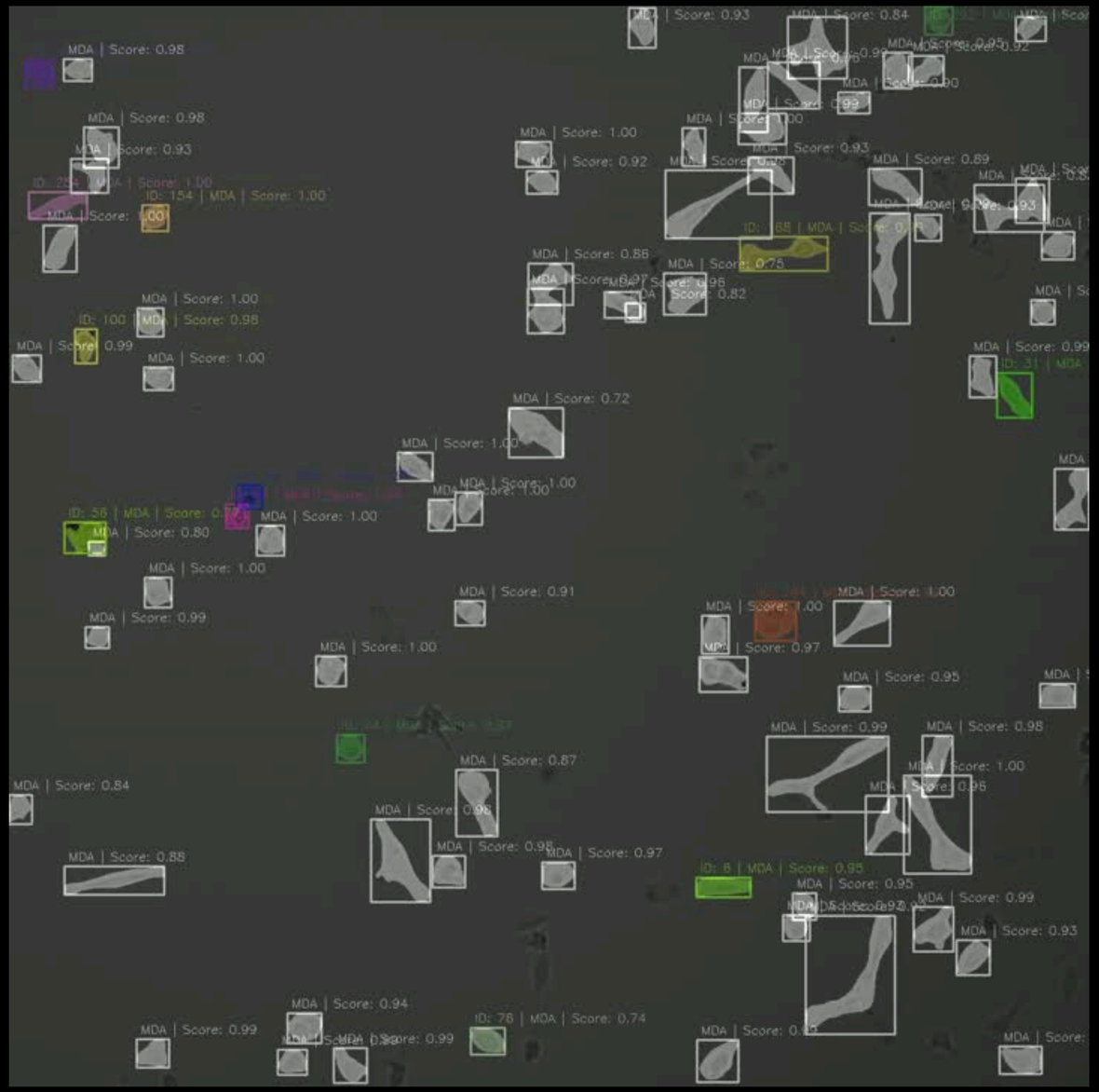
[11/26 18:32:13 d2.evaluation.coco_evaluation]: Evaluation results for bbox:
|   AP   |  AP50  |  AP75  |  APs   |  APm   |  APl   |
|:------:|:------:|:------:|:------:|:------:|:------:|
| 59.093 | 76.246 | 71.749 | 58.139 | 62.647 | 35.192 |
[11/26 18:32:13 d2.evaluation.coco_evaluation]: Per-category bbox AP:
| category   | AP     | category   | AP     | category   | AP     |
|:-----------|:-------|:-----------|:-------|:-----------|:-------|
| MDA        | 70.449 | FB         | 66.066 | M1         | 50.798 |
| M2         | 49.059 |            |        |            |        |
```

```
[11/26 18:32:22 d2.evaluation.coco_evaluation]: Evaluation results for segm:
|   AP   |  AP50  |  AP75  |  APs   |  APm   |  APl   |
|:------:|:------:|:------:|:------:|:------:|:------:|
| 45.348 | 64.427 | 53.917 | 35.570 | 48.350 | 51.980 |
[11/26 18:32:22 d2.evaluation.coco_evaluation]: Per-category segm AP:
| category   | AP     | category   | AP     | category   | AP     |
|:-----------|:-------|:-----------|:-------|:-----------|:-------|
| MDA        | 69.286 | FB         | 11.576 | M1         | 50.181 |
| M2         | 50.347 |            |        |            |        |
```


MDA | Score: 0.98
MDA | Score: 0.98
MDA | Score: 0.93
ID: 154 | MDA | Score: 1.00
MDA | Score: 1.00
MDA | Score: 1.00
MDA | Score: 0.98
ID: 100
MDA | Score: 0.99
MDA | Score: 1.00
MDA | Score: 0.72
MDA | Score: 1.00
MDA | Score: 1.00
MDA | Score: 1.00
MDA | Score: 0.80
MDA | Score: 1.00
MDA | Score: 0.91
MDA | Score: 0.99
MDA | Score: 1.00
MDA | Score: 0.87
MDA | Score: 0.84
MDA | Score: 0.88
MDA | Score: 0.97
MDA | Score: 0.94
MDA | Score: 0.99
ID: 76 | MDA | Score: 0.74
MDA | Score: 0.99
MDA | Score: 1.00
MDA | Score: 0.97
MDA | Score: 0.95
MDA | Score: 0.99
MDA | Score: 0.98
MDA | Score: 1.00
MDA | Score: 0.95
MDA | Score: 0.99
MDA | Score: 0.93
MDA | Score: 0.89
MDA | Score: 0.86
MDA | Score: 0.75
MDA | Score: 0.82
MDA | Score: 0.99
MDA | Score: 1.00
MDA | Score: 0.92
MDA | Score: 0.93
MDA | Score: 0.84

Next Steps

1. Mixed Detectron Model Evaluation
    - Validate per-class accuracy using results from the mixed Detectron2 model.
2. Pipeline Integration
    - Experiment with motion feature ensembling to enhance classification accuracy.
3. Performance Analysis
    - Compare individual vs ensemble results
    - Conduct cross-validation studies to evaluate robustness across different datasets.
    - Perform error analysis per cell type to identify and address misclassification patterns.