Cell-Tracking and Classification with Transient Fluorescent Signals

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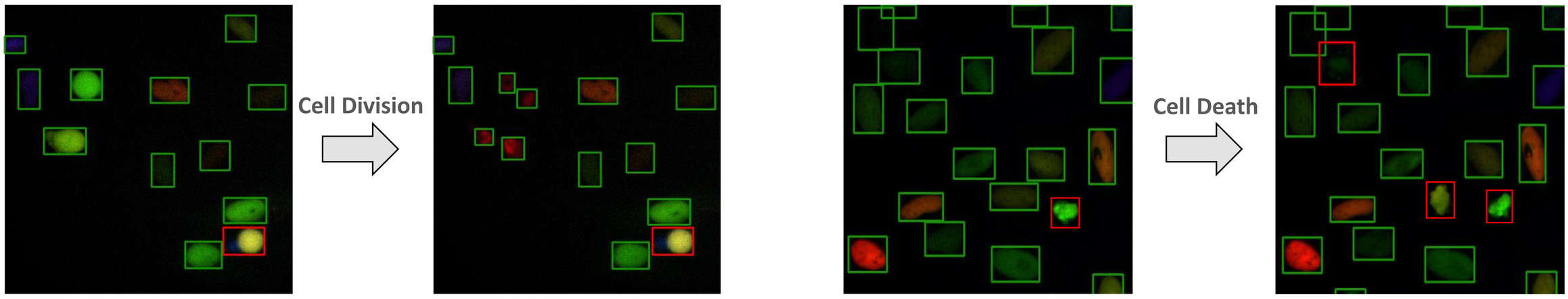
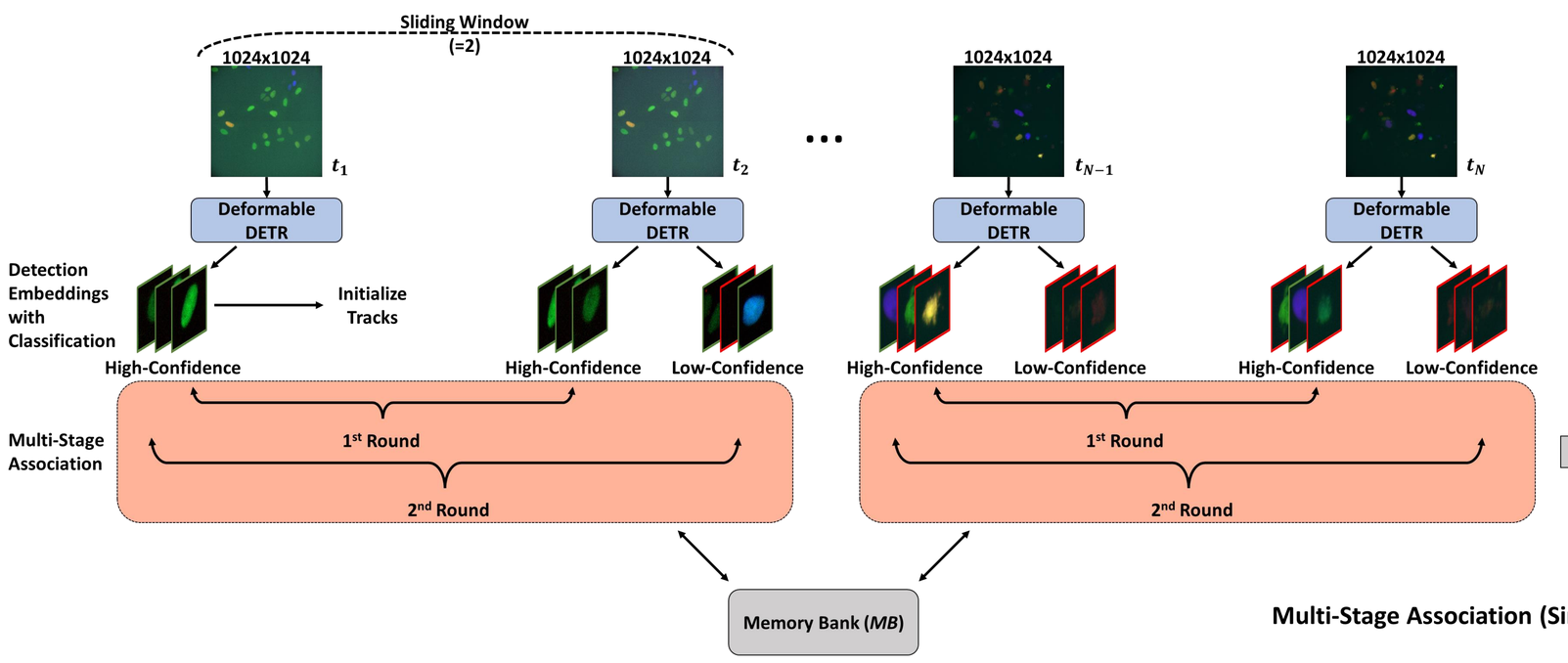
Introduction

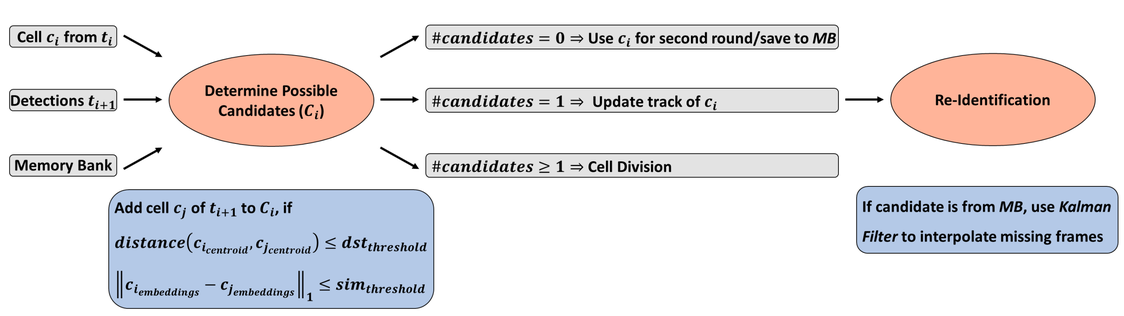
- Time-lapse **Cell Tracking** is essential for studying cell division and death in biomedical research
- Critical for evaluating cancer cell response to treatments
- Unique challenges in comparison to traditional **Multi-Object Tracking (MOT):**



- State-of-the-art methods from the Cell Tracking Challenge [1] are benchmarked on time-lapse videos with single, constant fluorescent signals, overlooking cell death events
- We present a hybrid tracking method that classifies **living** and **dead** cells and detects cell division events
- Overcoming the issues of transient signals by interpolating tracks with Kalman Filter [2] after re-identification and the usage of Low-Confidence detections

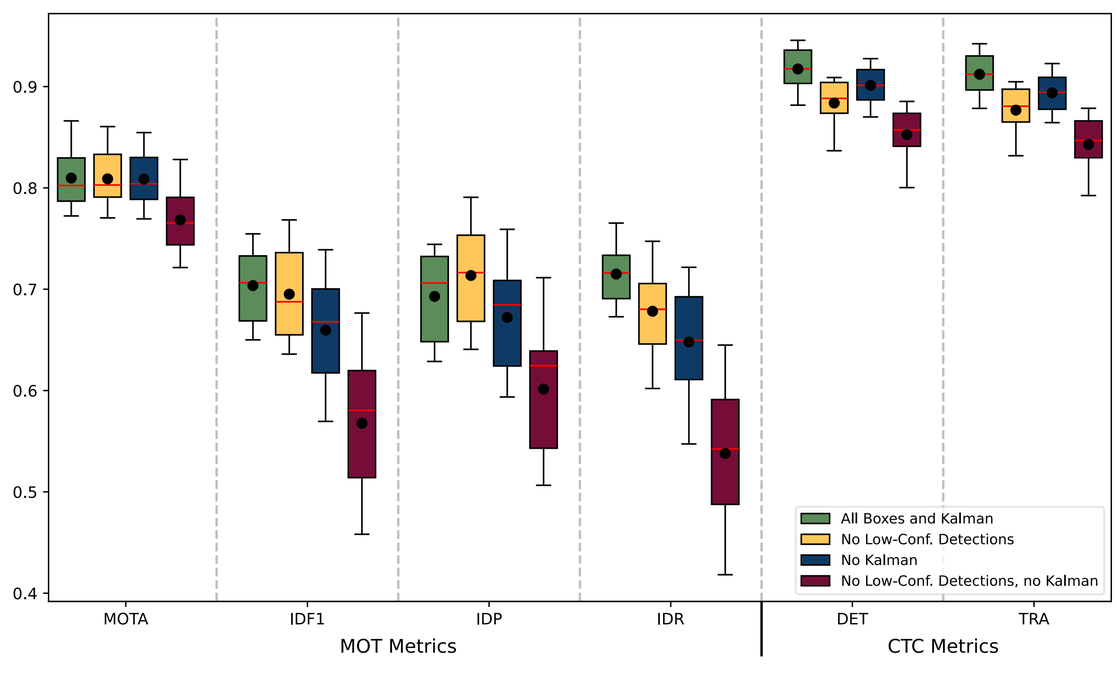
Method





- Tracking-by-detection
- **Deformable DETR** [3] is used for detection
- Usage of **High-Confidence** and **Low-Confidence** detections [4]
- **Multi-Stage Association** to match cells of subsequent frames, similar to [5]
- Storing lost cells for n frames
- **Kalman Filter** is used to interpolate missing frames after re-identification
- Assume division if more than one possible candidate is found

Results



Limitations

- CTC Metrics only consider continuous tracks
  - GT cells re-entering the frame require new ID assignments
- Silver-Truth bounding box annotations

Conclusion

- Detection remains the primary bottleneck
- Proposed methods mitigate challenges from transient signals
  - Incorporating a Kalman Filter and Low-Confidence detections improves performance
  - Kalman Filter alone achieves comparable MOT metric results to combining it with Low-Confidence detections, but lower CTC results

References

[1] https://celltrackingchallenge.net/
[2] Kálmán, R. E., *A new approach to linear filtering and prediction problems*, Journal of Basic Engineering (1960)
[3] Zhu et al., *Deformable DETR: Deformable Transformers for End-to-End Object Detection,* ICLR (2021)
[4] Zhang et al., *ByteTrack: Multi-Object Tracking by Associating Every Detection Box,* ECCV (2022)
[5] Wang et al., *SMILEtrack: SiMIlarity LEarning for Occlusion-Aware Multiple Object Tracking*, AAAI (2024)