Motion Segmentation in Dynamic Environments using Event Cameras

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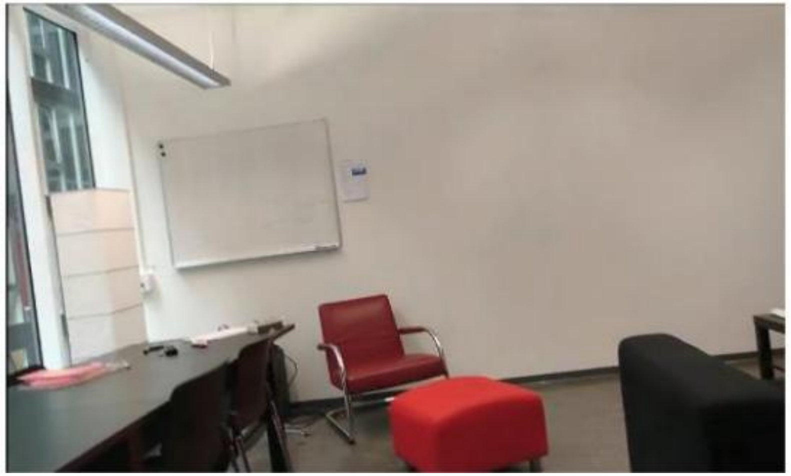
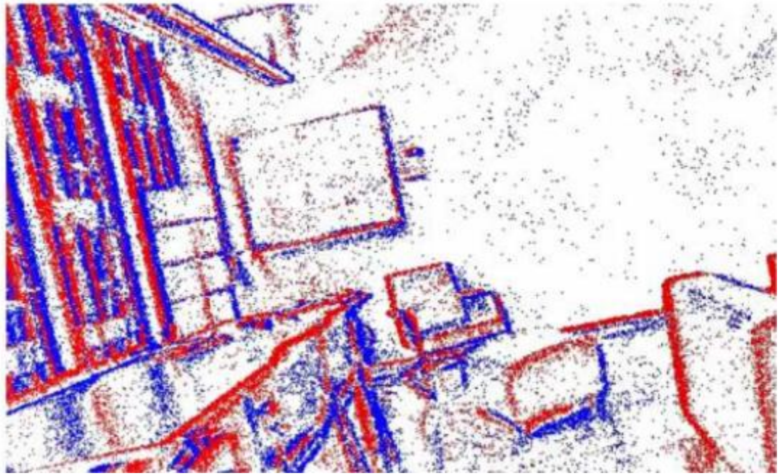
Agenda

- Introduction
- Motivation & Problem Definition
- Objectives
- Approach
- Experiments
- Results
- Challenges
- Conclusions
- Future Scope

Introduction

- **What is Motion Segmentation?**
- **What are Event Cameras?**
- **Why Event Cameras for Motion Segmentation?**





Motivation & Problem Definition

- **Challenges with Standard cameras**: Struggle with motion blur and low temporal resolution, limiting motion segmentation in complex environments.
- **Ego-Motion Problem**: Camera movement distorts image capture, complicating object segmentation and tracking.
- **Research Focus**: Investigating both classical and deep learning approaches for robust motion segmentation in dynamic environments.

Objectives

1. **Classical Approach**: Implement and test spatio-temporal graph cuts
2. **Dataset Collection**: DVXplorer event data or EV-IMO dataset
3. **Neural Network Adaptation**: Modify "EV-IMO" model for the dataset
4. **Training Pipeline**: Develop a learning pipeline
5. **Model Testing**: On pre-recorded videos and images

Approach

PHASE 1

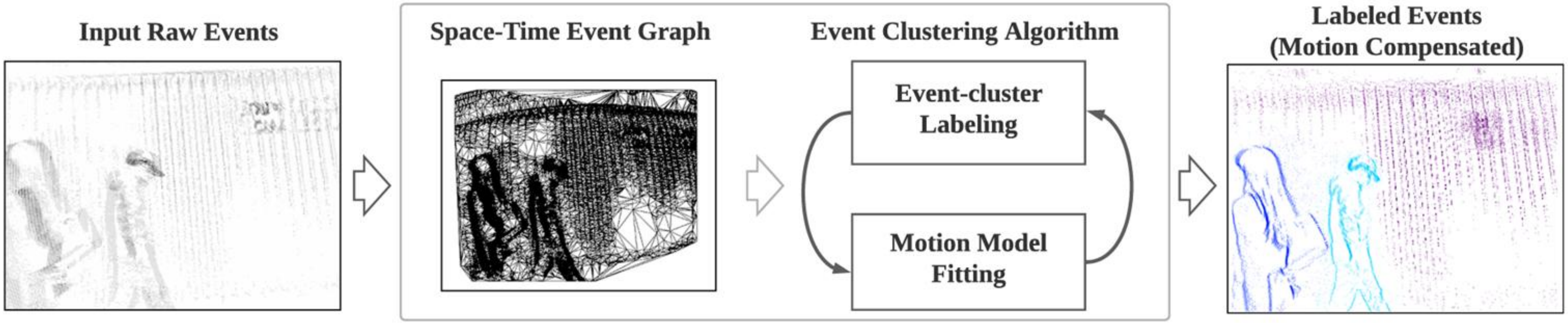
Implement and test traditional space-time graphs using energy minimization.

PHASE 2

Develop and deploy data-driven models, evaluating three different structures on a dataset.

Phase 1

Classical Approach: Using Space-Time Graphs



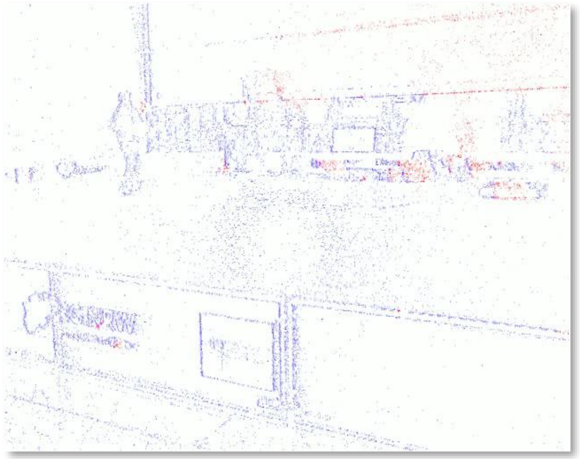
Results: Classical Approach

DVSMOTION20

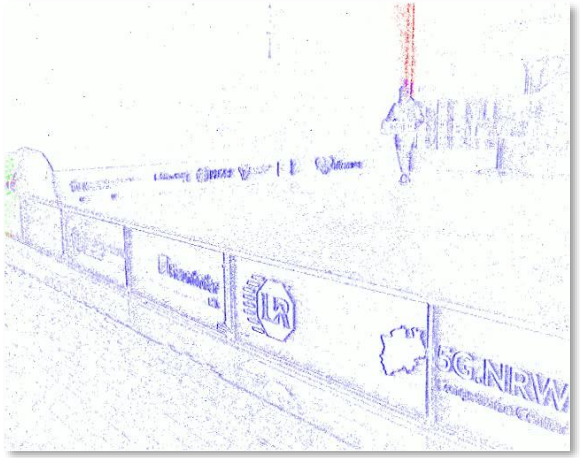
EED

EVIMO

Results: Classical Approach



fast_cam



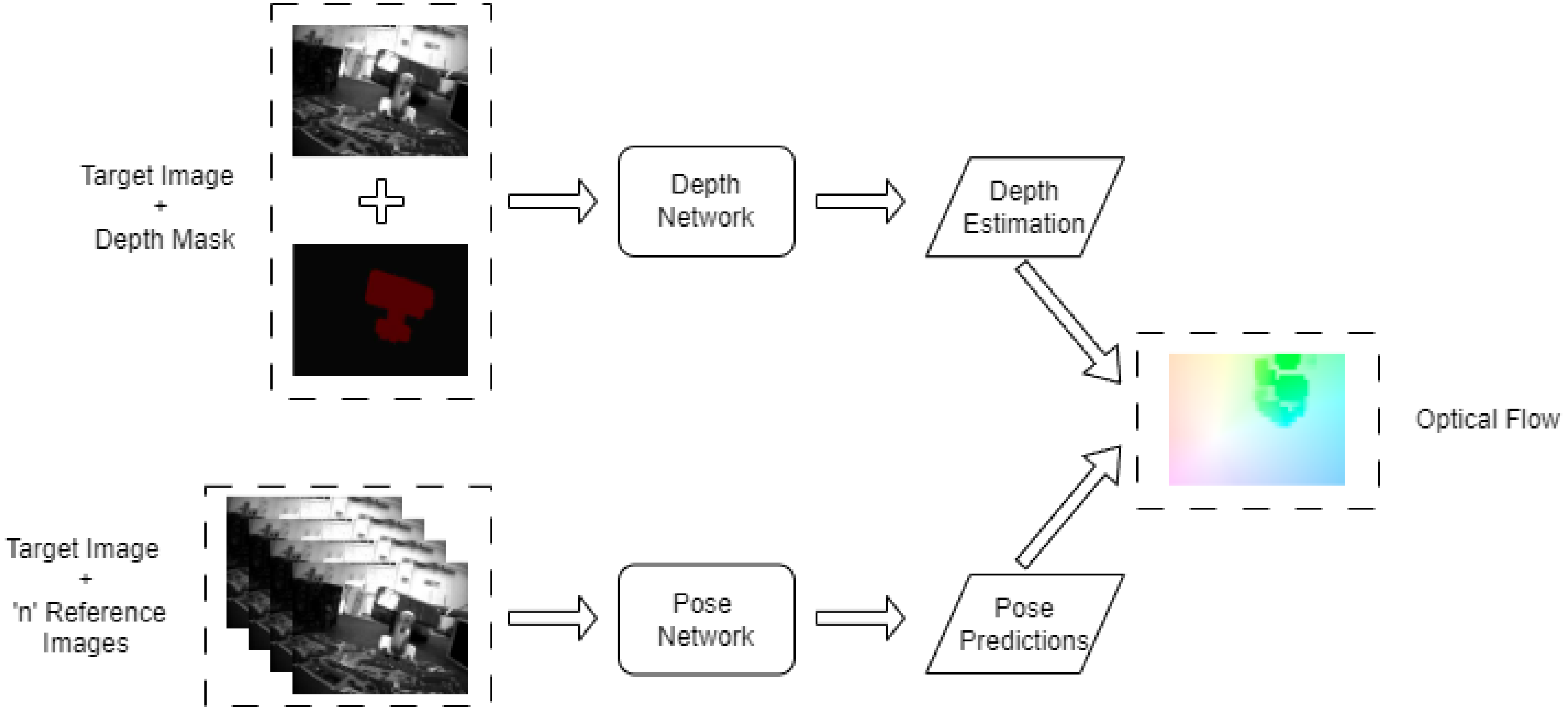
slow_cam

near_obj

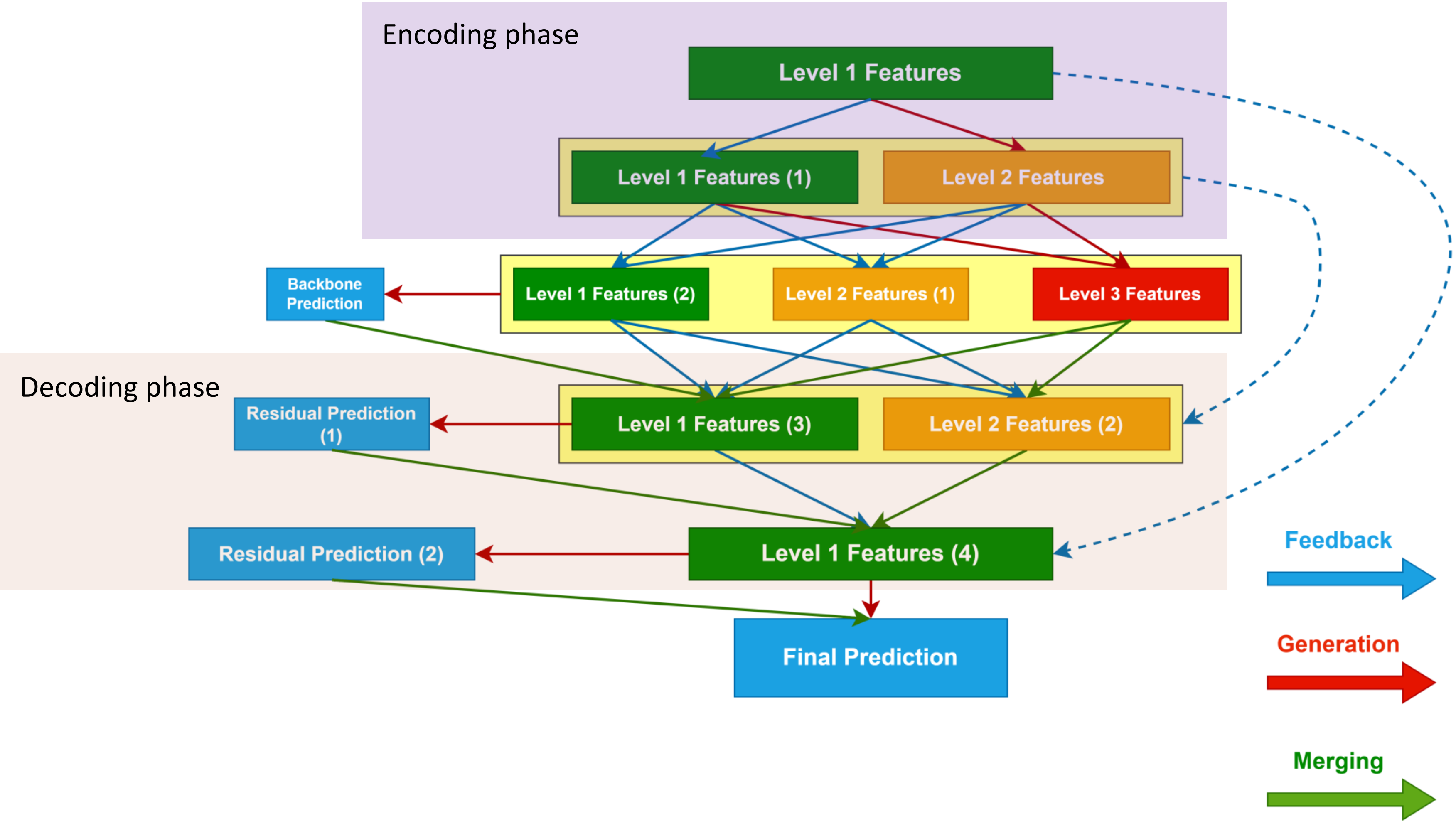
Limitations: Classical Approach

- Sensitive to Noise
- High Computational Cost for Large Datasets
- Scene-Specific Parameter Tuning
- Difficulty with Non-Rigid or Complex Motion
- Over-segmentation or under-segmentation

Deep Learning Approach: Neural Networks



Evenly Cascaded Network (ECN)



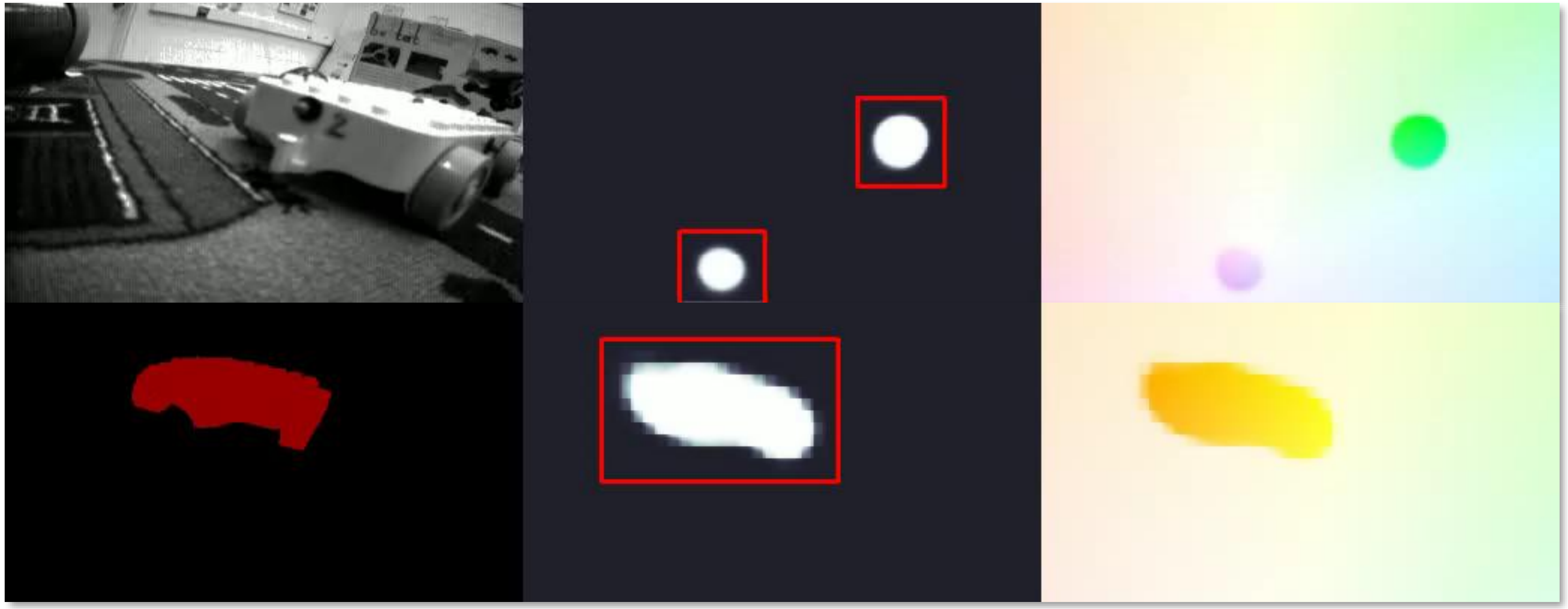
Experiments - ECN

Motion Segmentation task

Sr. No	learn_rate	epochs	batch_size	growth_rate	final_map_size
1	5e-05	100	15	8	4
2	1e-03	30	32	4	8
3	1e-05	500	32	4	8

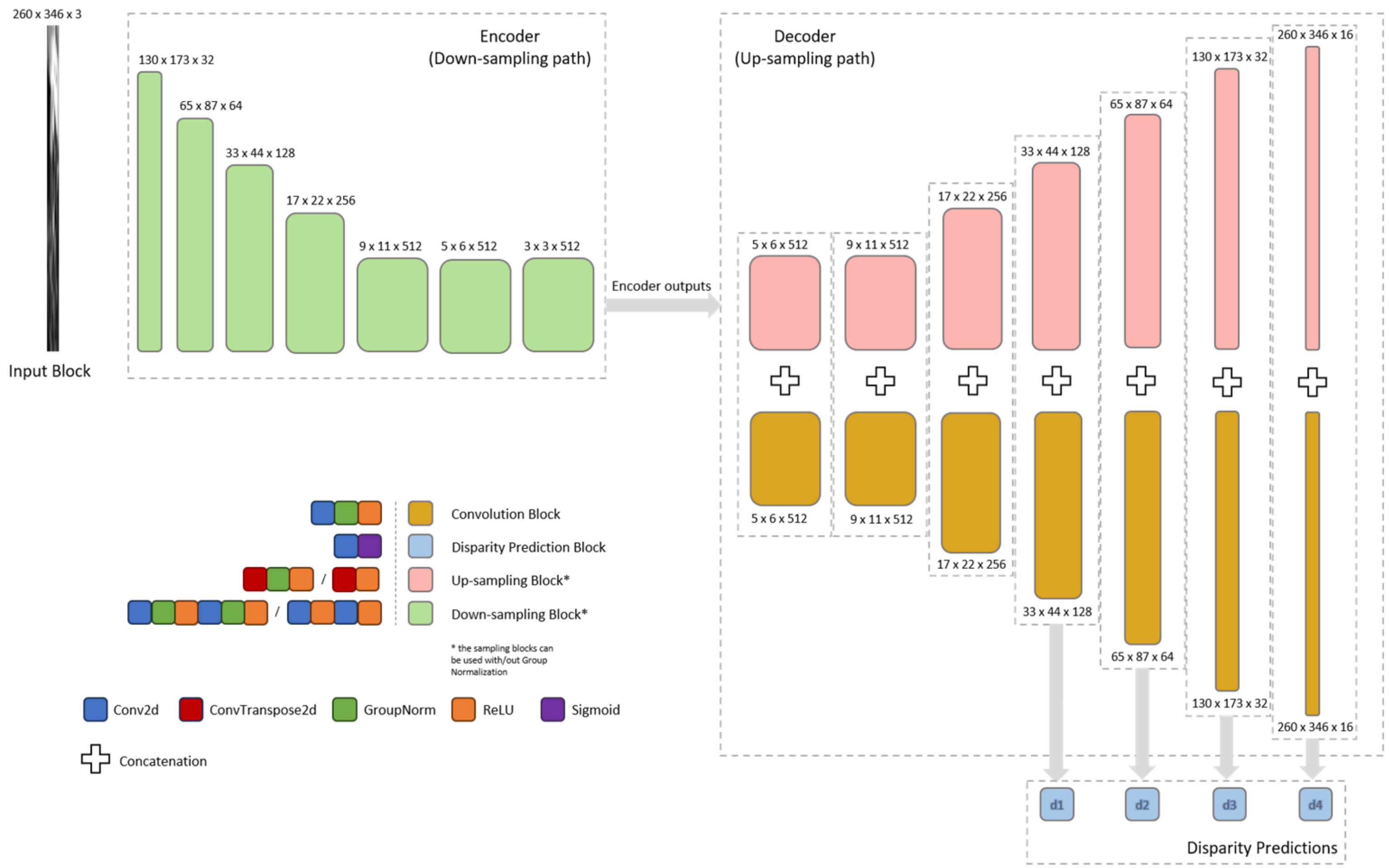
Table: Overview of the hyperparameters used in ECN experiments, with varying results across configurations

Results - ECN

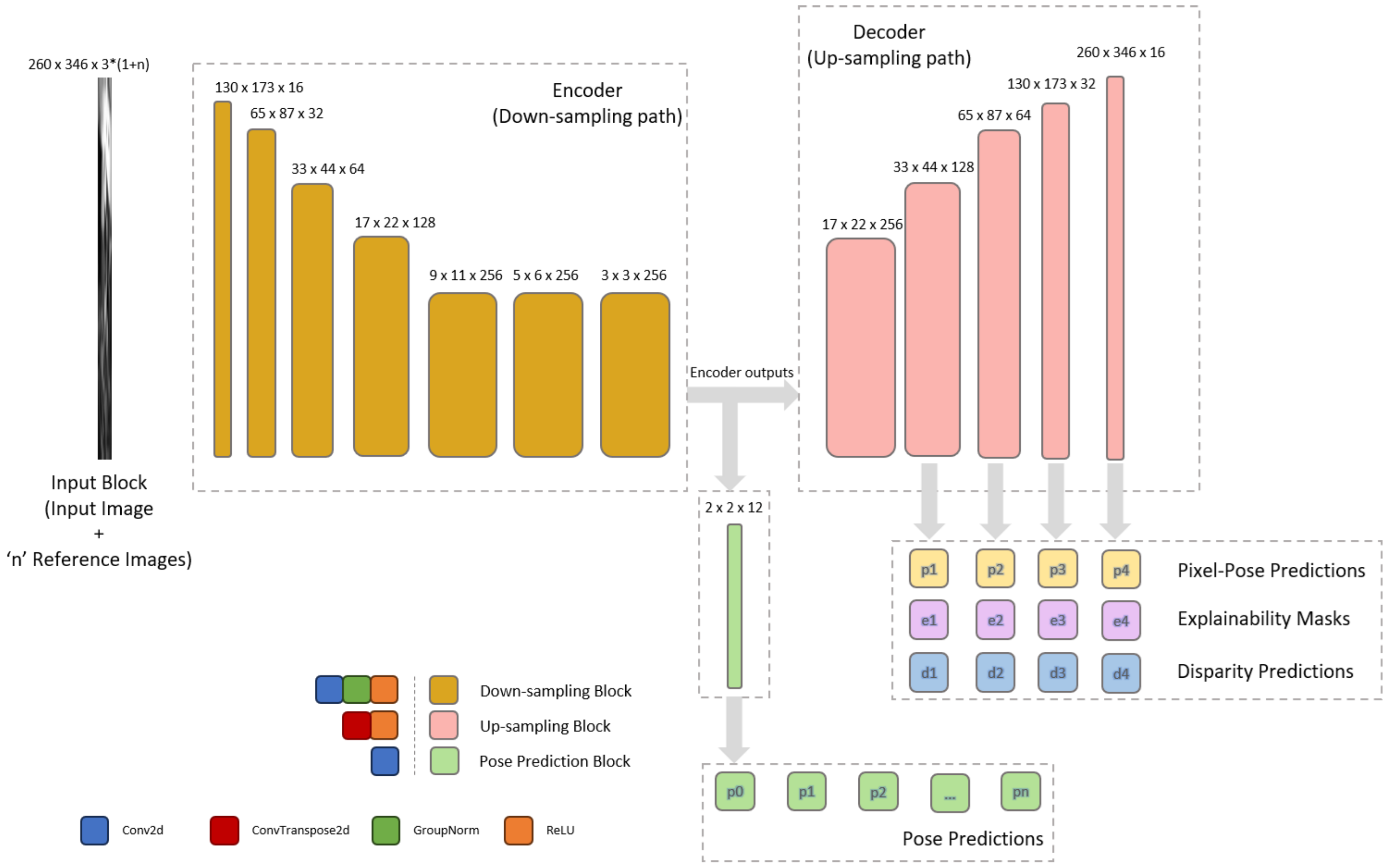


ECN: learn_rate = 1e-03, epochs = 30, batch_size = 32, growth_rate = 4, final_map_size = 8

Encoder-Decoder Network (EDN) - DispNetS



Encoder-Decoder Network (EDN) - PoseExpNet



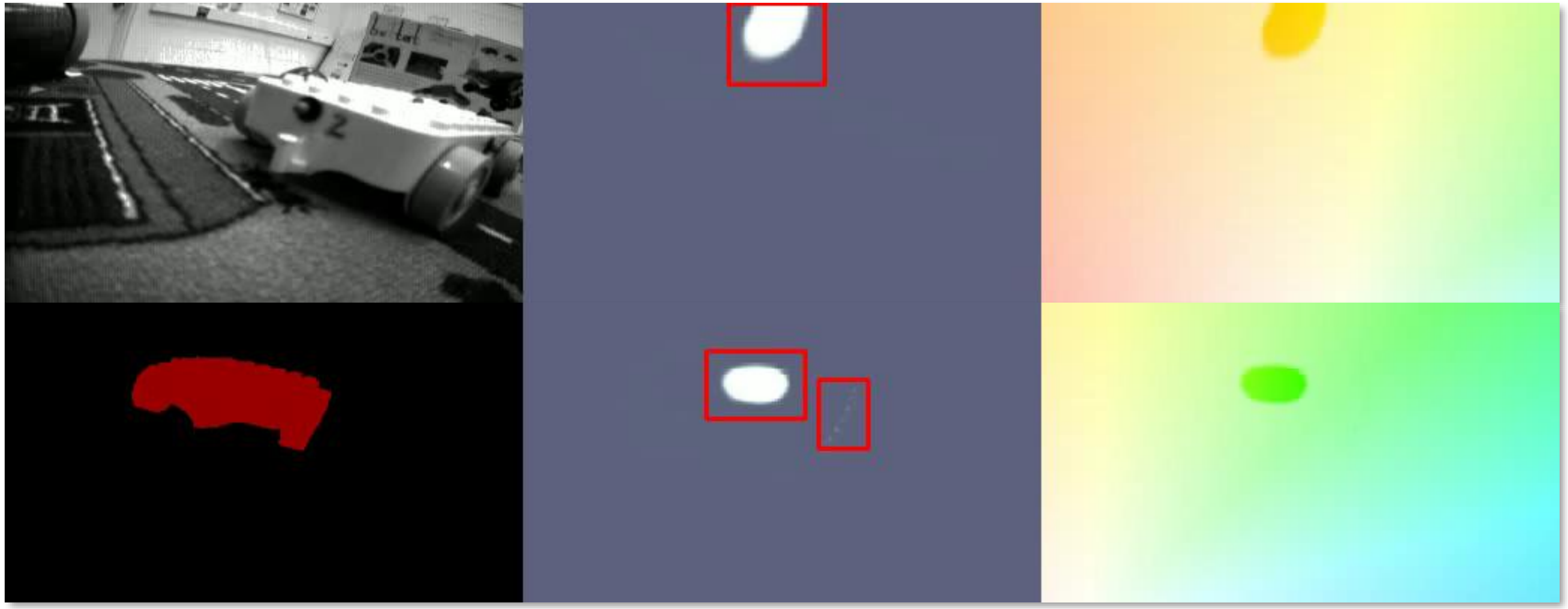
Experiments - EDN

Motion Segmentation task

Sr. No	learn_rate	epochs	batch_size	growth_rate	final_map_size
1	5e-04	30	32	4	8
2	5e-05	30	15	8	4
3	1e-05	30	20	8	4

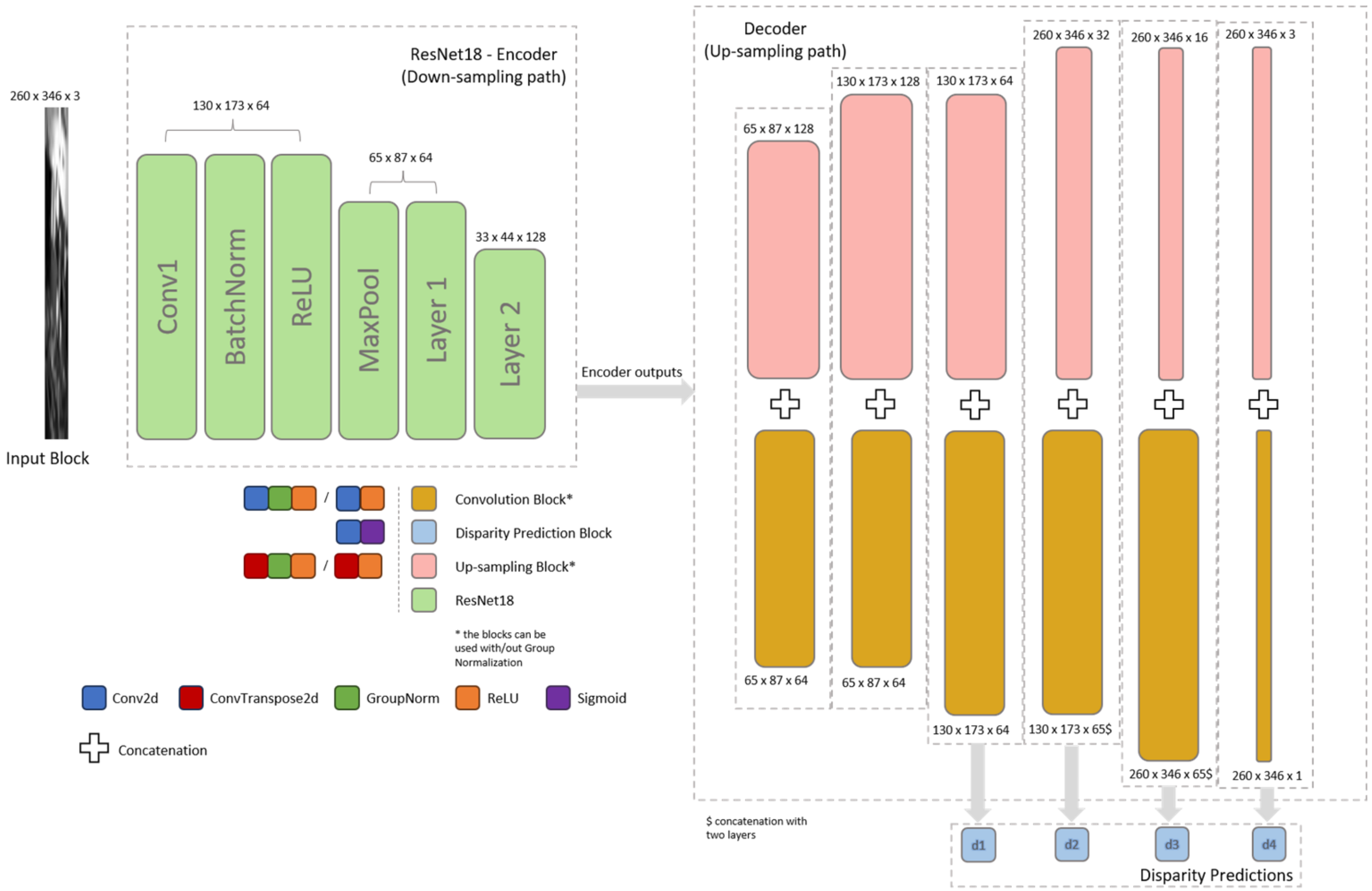
Table: Overview of the hyperparameters used in EDN experiments, with varying results across configurations

Results - EDN

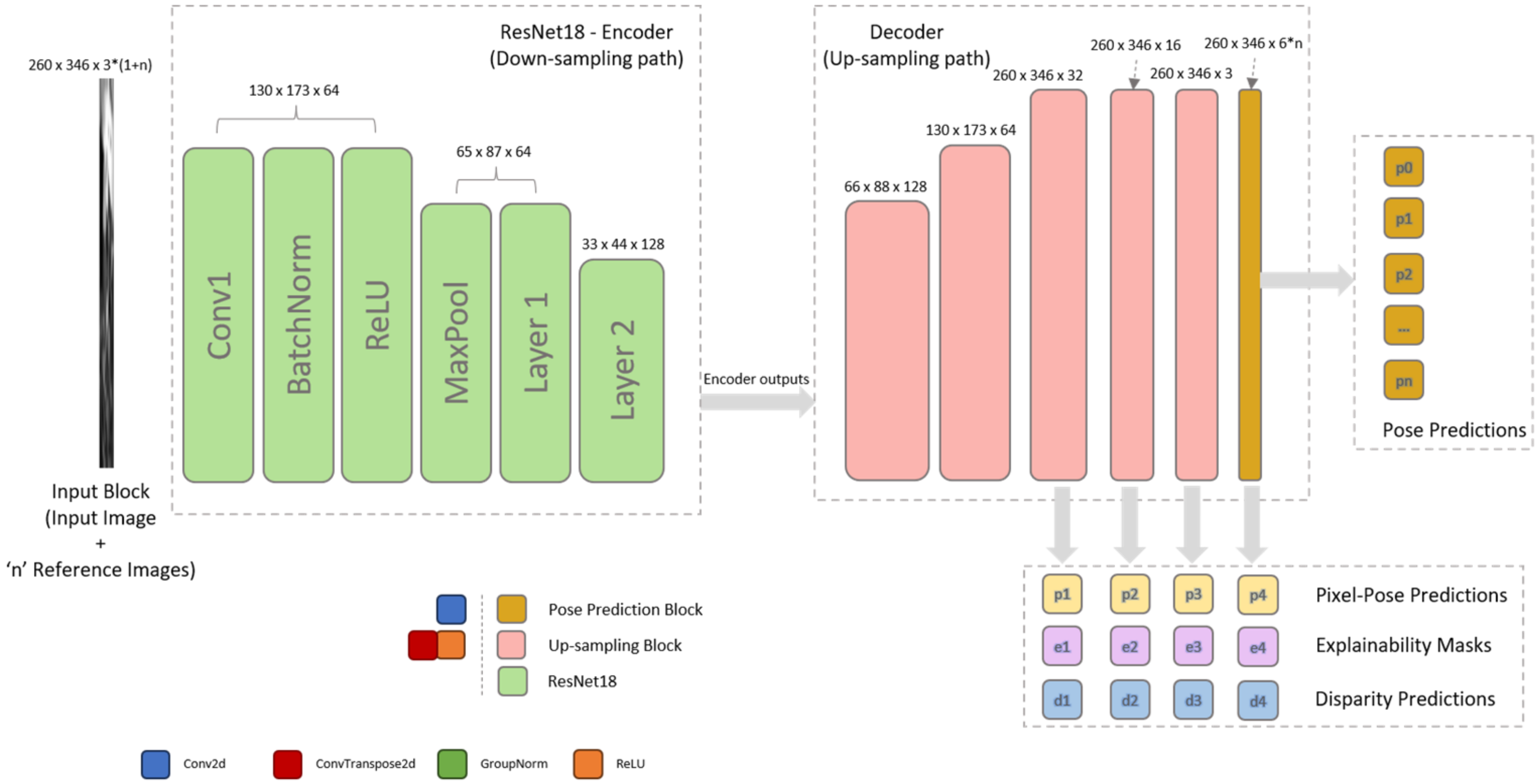


EDN: learn_rate = 5e-04, epochs = 30, batch_size = 32, growth_rate = 4, final_map_size = 8

ResNet18 Encoder-Decoder Network (REDN) - ResDepthNet



ResNet18 Encoder-Decoder Network (REDN) - ResPoseNet



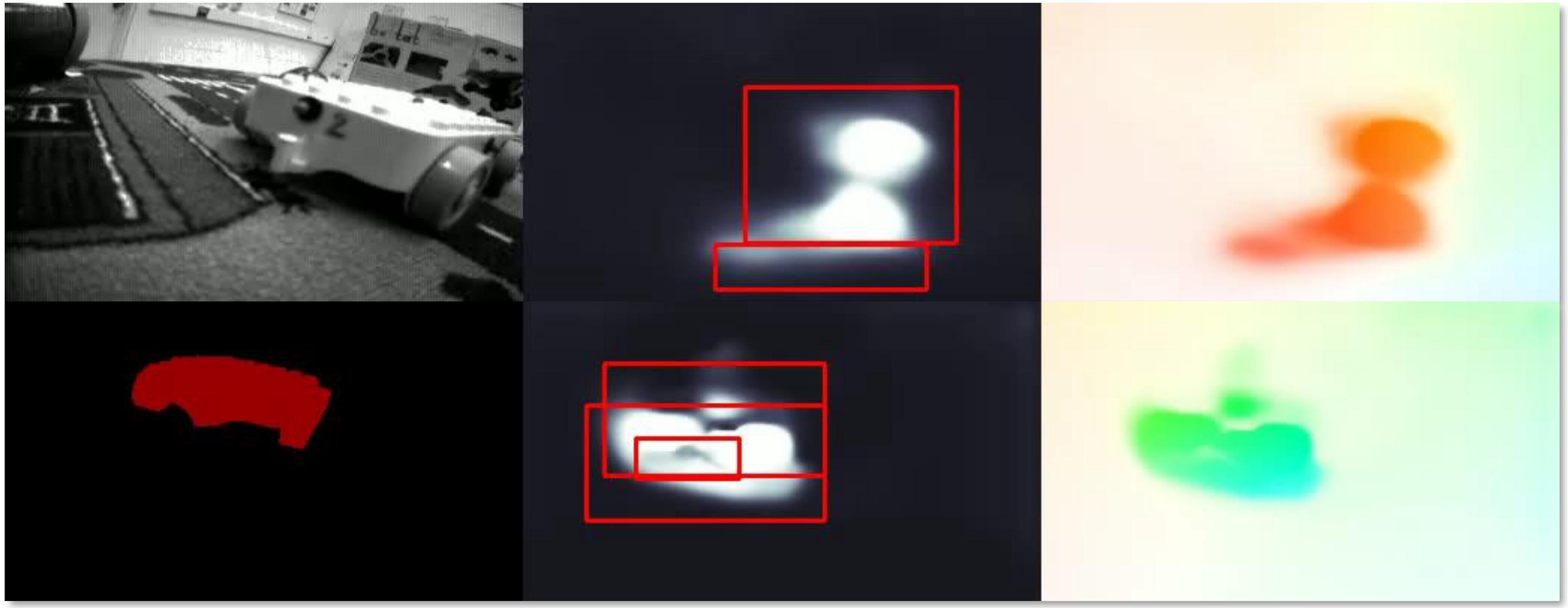
Experiments - REDN

Motion Segmentation task

Sr. No	learn_rate	epochs	batch_size	growth_rate	final_map_size
1	1e-02	50	32	4	8
2	1e-05	50	25	8	4

Table: Overview of the hyperparameters used in REDN experiments, with varying results across configurations

Results - REDN



REDN: learn_rate = 1e-02, epochs = 50, batch_size = 32, growth_rate = 4, final_map_size = 8

Challenges

- High Computational Demand
  - High quality and diverse dataset required
  - HPC is required to cater to the significant computational resources
- Optimization Complexity
  - Limitations of the approach to generalize across different scenes and variations is limited
  - Extensive hyperparameter tuning

Conclusions

Classical Approach:

- Strong performance in controlled settings, but slow processing and scene-specific parameter tuning limit scalability
- Impractical for real-time applications

Deep Learning Approach:

- Applied optical flow logic via deep learning, achieving better results:
  - **ECN** Model: Most accurate and reliable
  - **EDN** Model: Mixed results, needs optimization
  - **REDN** Model: Underperformed due to lower-quality training data and sub-optimal hyperparameters

Future Scope

- Enhancing Data Quality
- Optimizing for Real-Time Performance
- Expand to Multi-Object Segmentation
- Multi-Sensor Fusion

Q & A

Thank You!