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GRADUATION PROJECT

DEVELOPMENT OF A MULTIMODAL 3D OBJECT RECOGNITION AND VISUALIZATION SYSTEM FOR TRAFFIC ENVIRONMENTS USING CAMERA AND LIDAR FUSION

Lê Hoàng Tiến	21145617
Lê Hồ Minh Khoa	21145019
Supervisor	Trần Vũ Hoàng, PhD.

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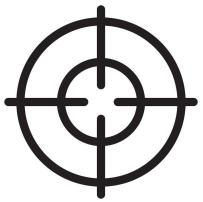

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1.1. PROBLEM STATEMENT

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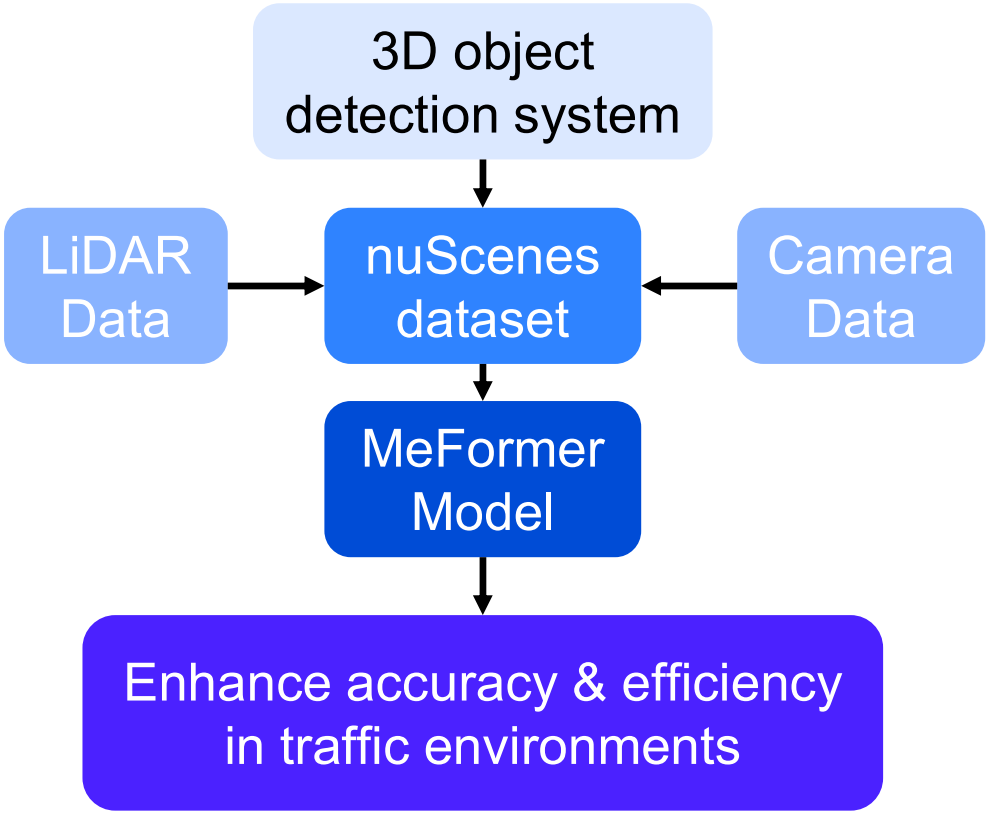
Low Lighting Scenario

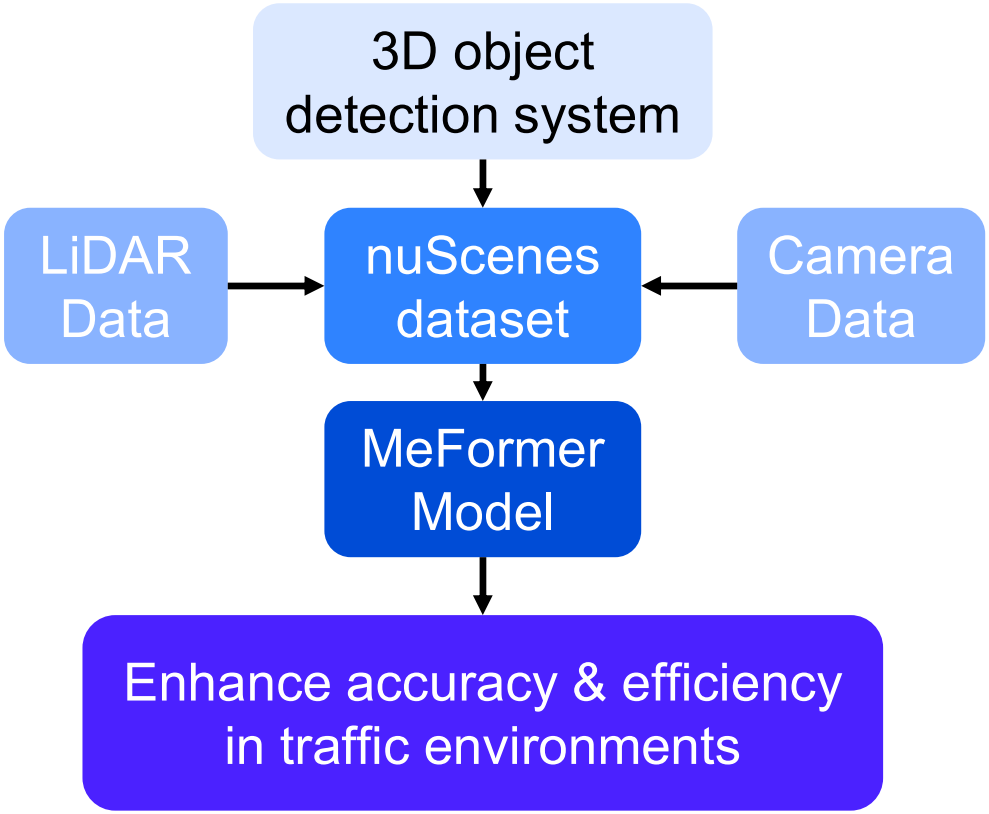
1. INTRODUCTION

1.2. RESEARCH OBJECTIVES



1. INTRODUCTION

1.2. RESEARCH OBJECTIVES



1.3. SCOPE & LIMITATIONS

DATA:
- nuScenes mini (10 scenes)
➔Restricted to specific conditions

HARDWARE:
- No real LiDAR or GPU.
➔Used cloud VPS not real-time.

TIME:
- Only 5 Months
➔No hardware optimization.

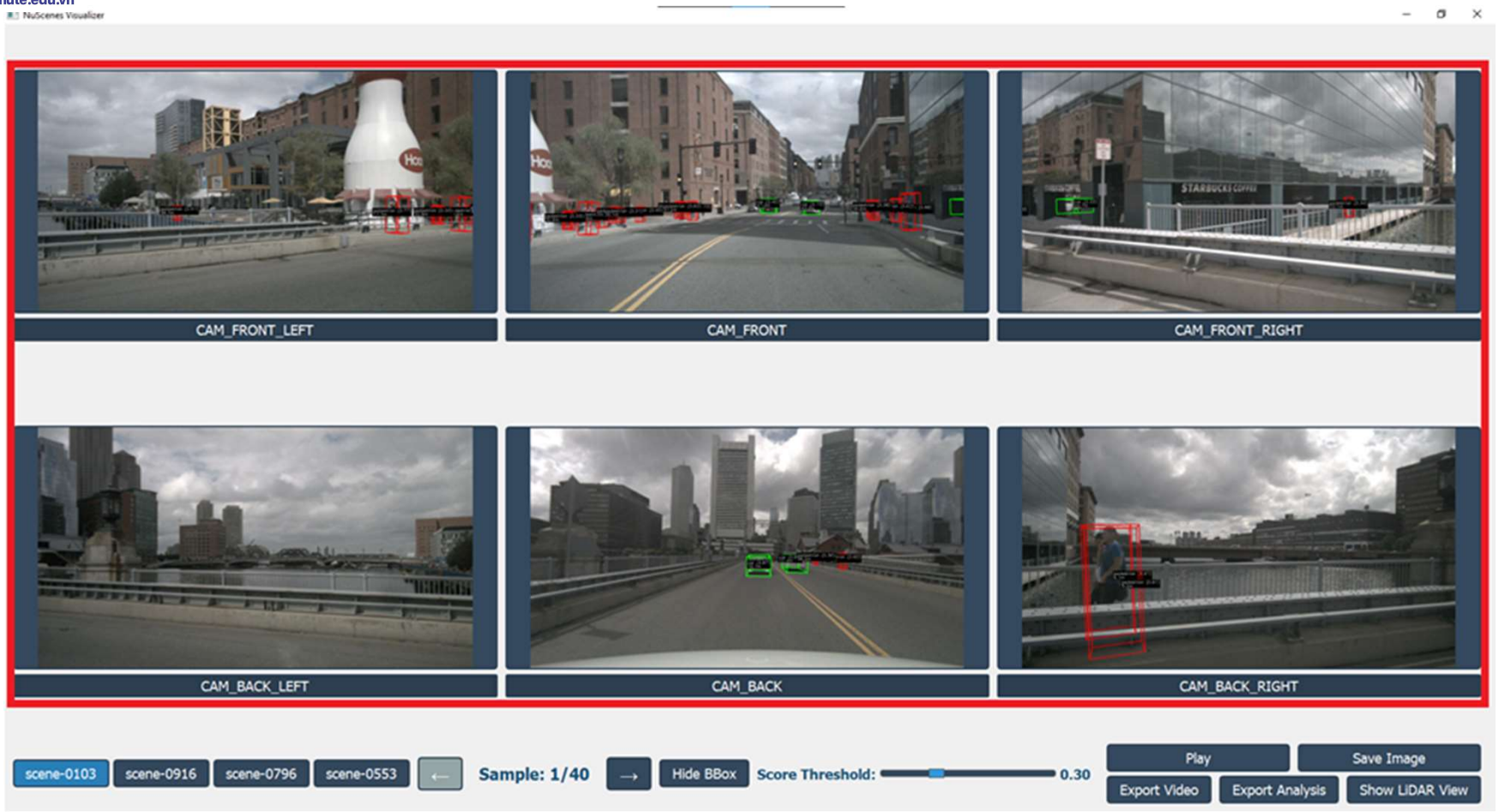
SCOPE:
- Offline 3D detection only.
➔No real-time integration.

1.4. TARGET

Final Product

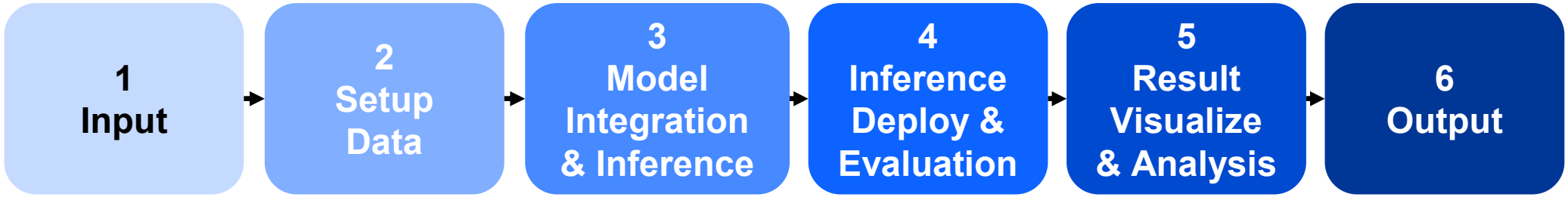
- **Prototype System**
  - An end-to-end multimodal data fusion pipeline
    - 3D object detection
- **Interactive App**
  - Visualizing
  - Evaluating
  - Exporting

1.4. TARGET



Main User Interface of the Application

2. OVERVIEW OF PIPELINE



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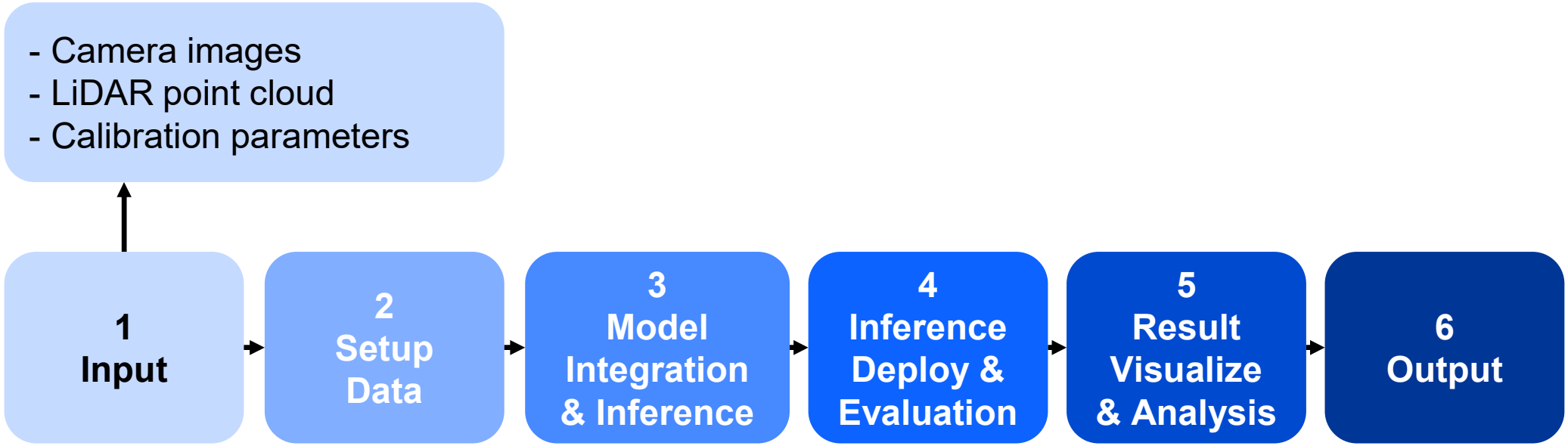

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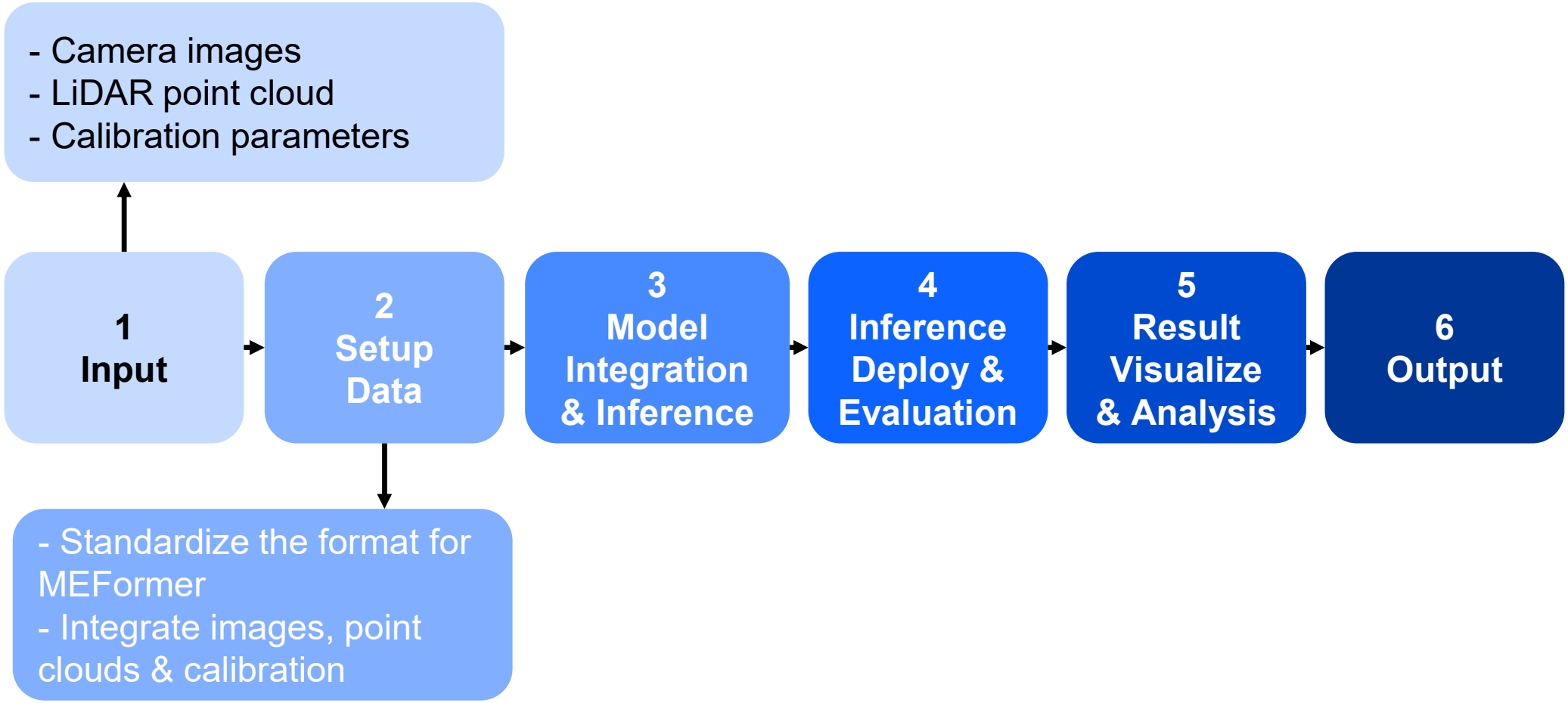

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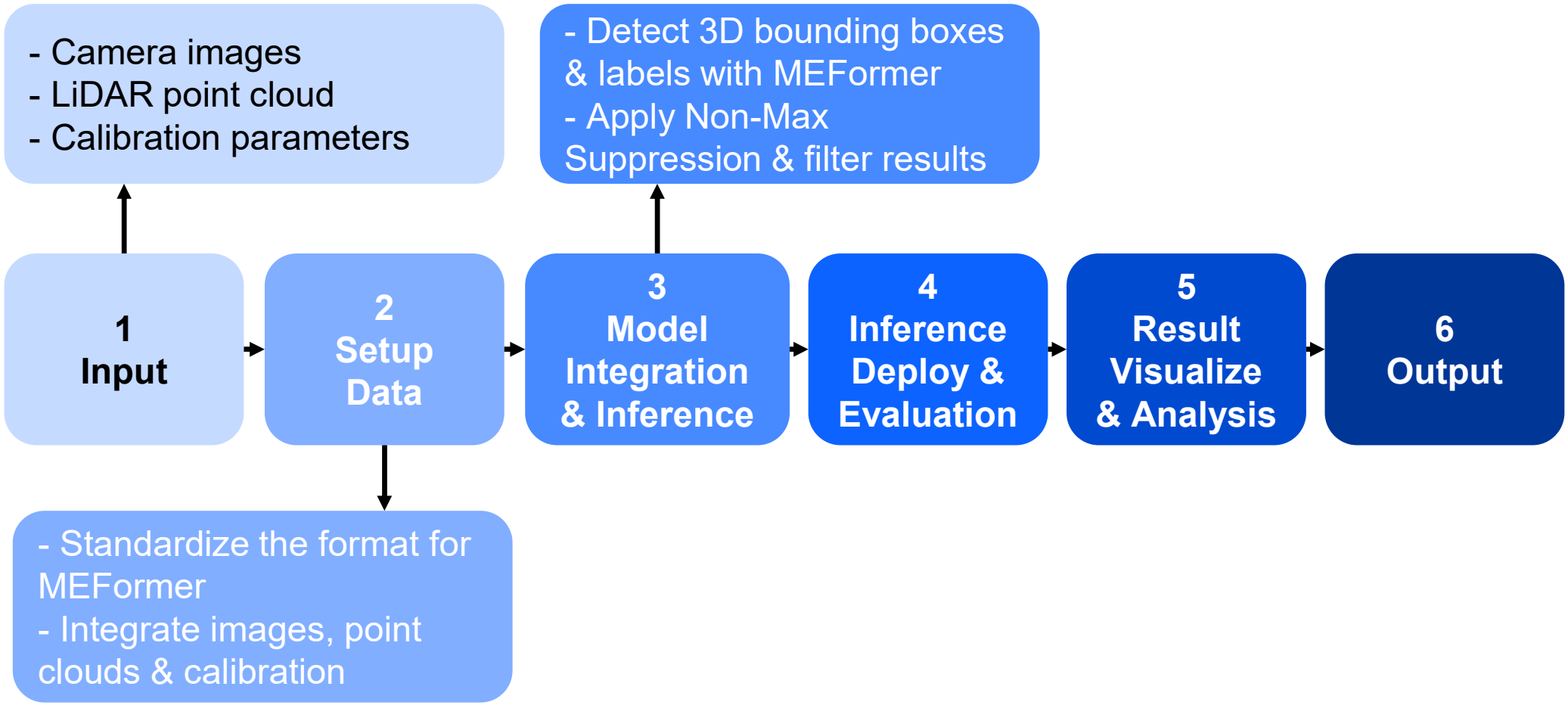

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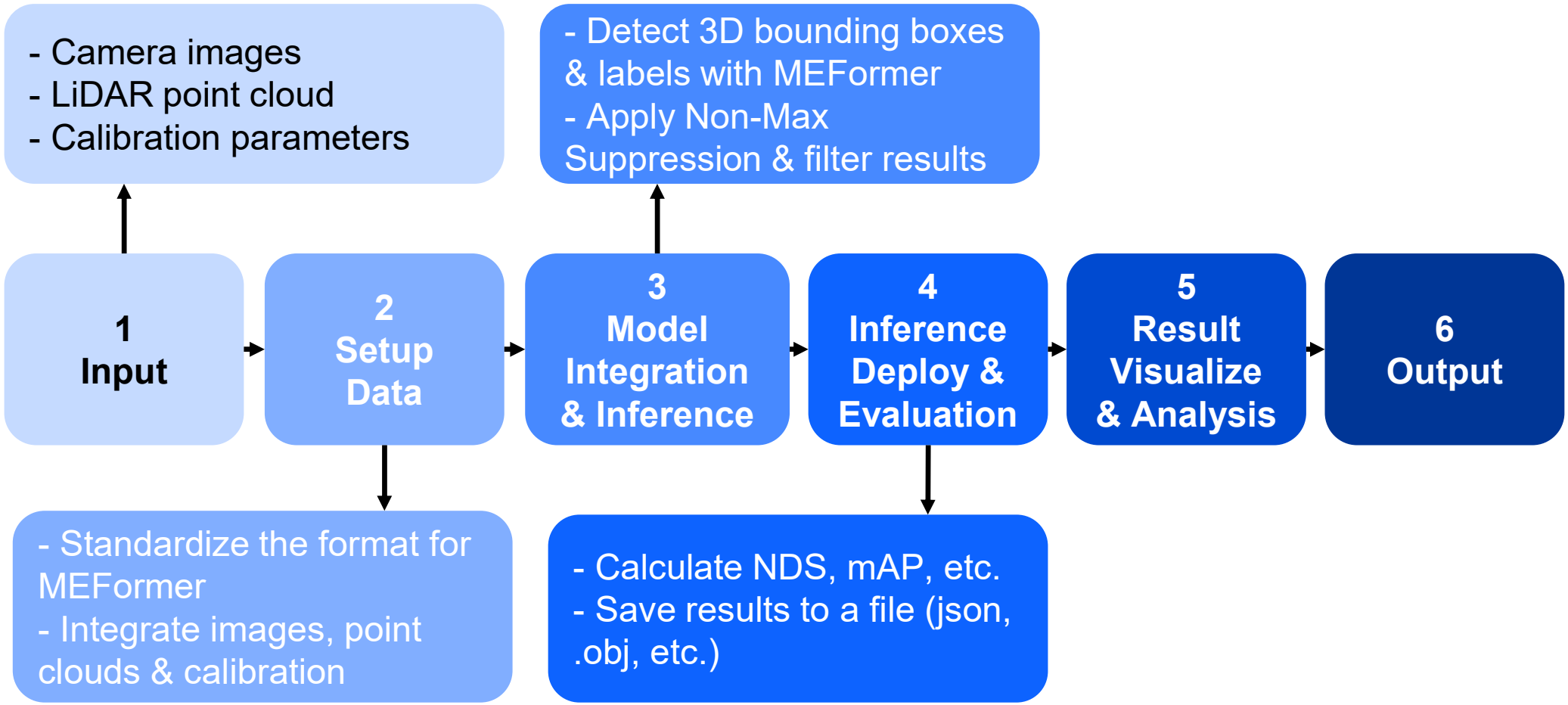

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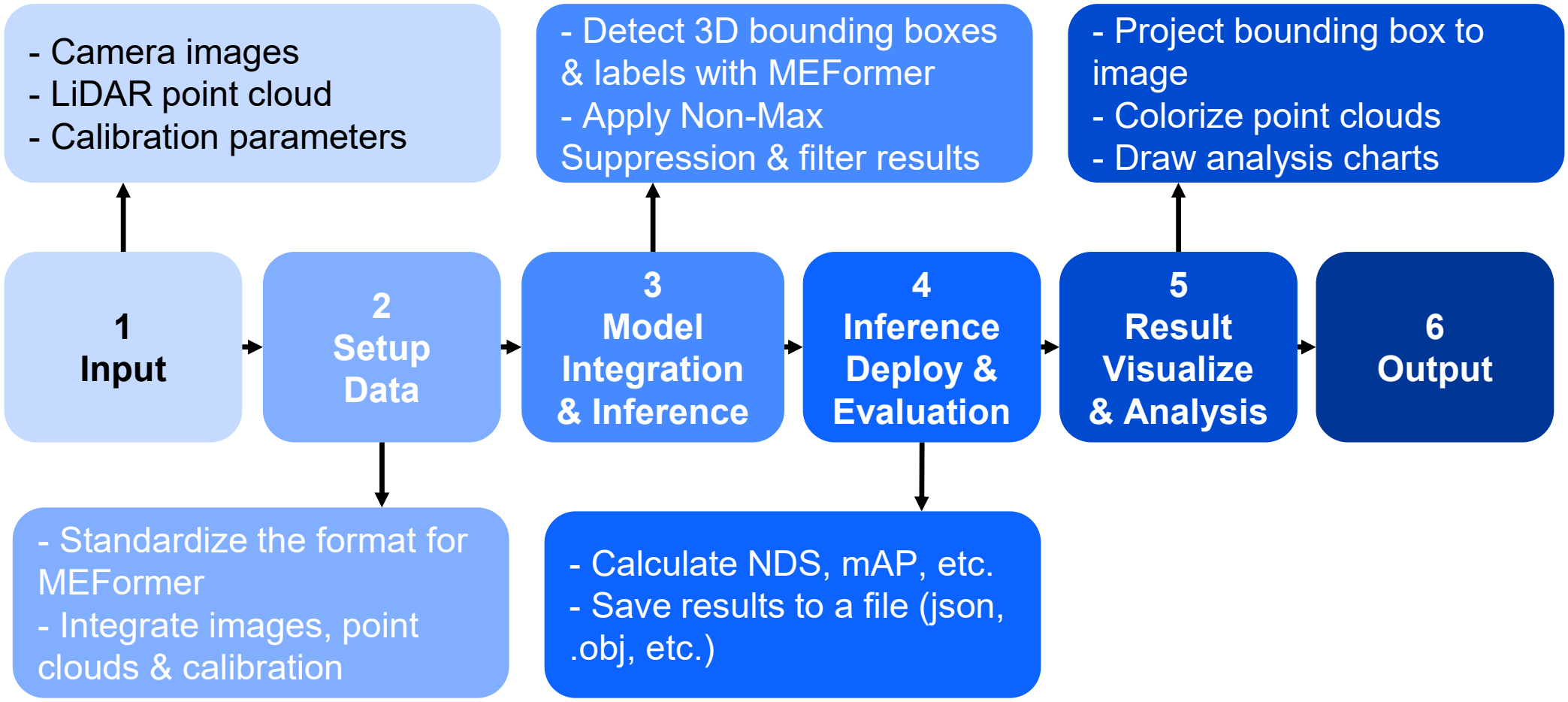

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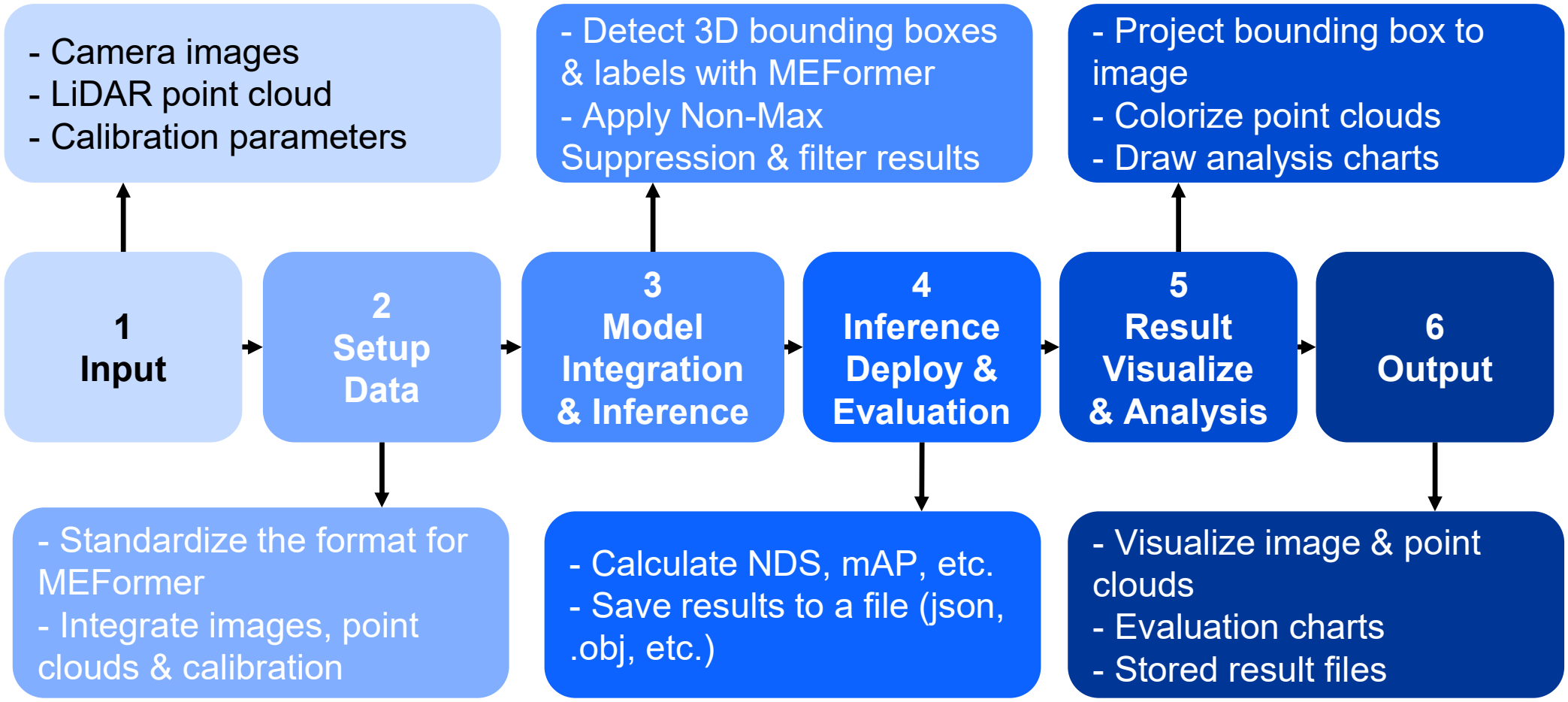
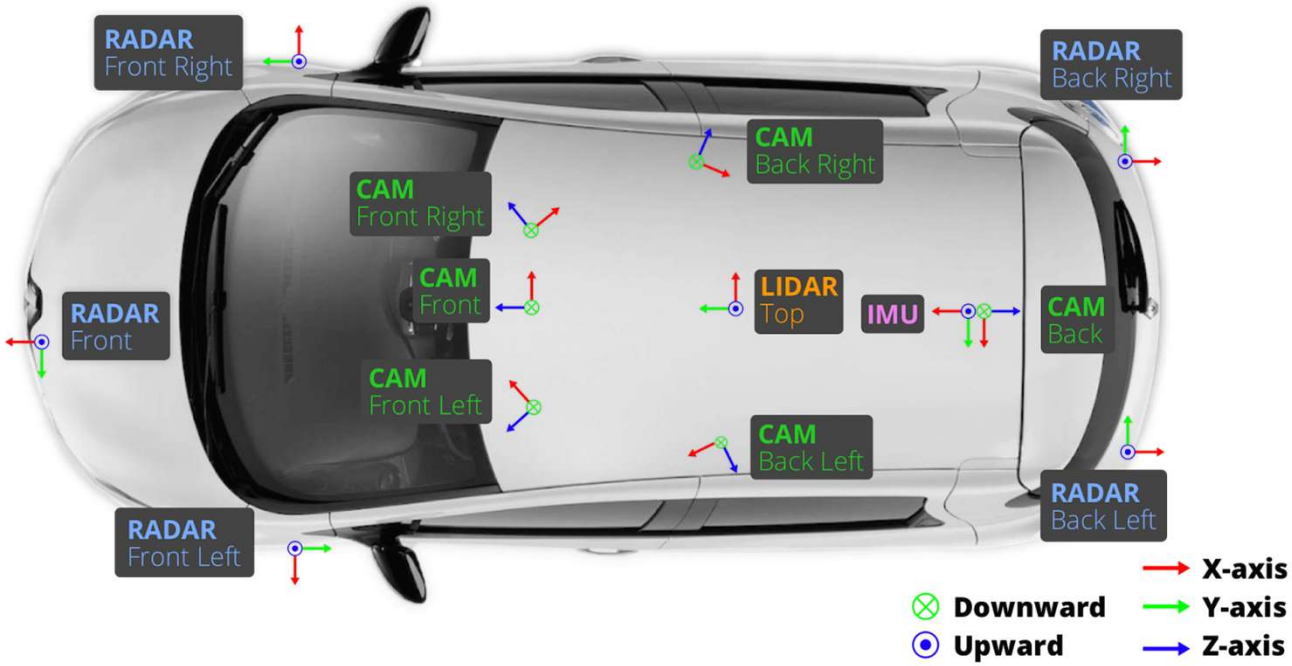


2.1. INPUT & SETUP DATA



Autonomous Vehicle Sensor Layout in nuScenes Dataset

6 CAMERAS

- Front
- Front-left
- Front-right
- Rear
- Rear-left
- Rear-right

1 LIDAR

- A 32-channel device

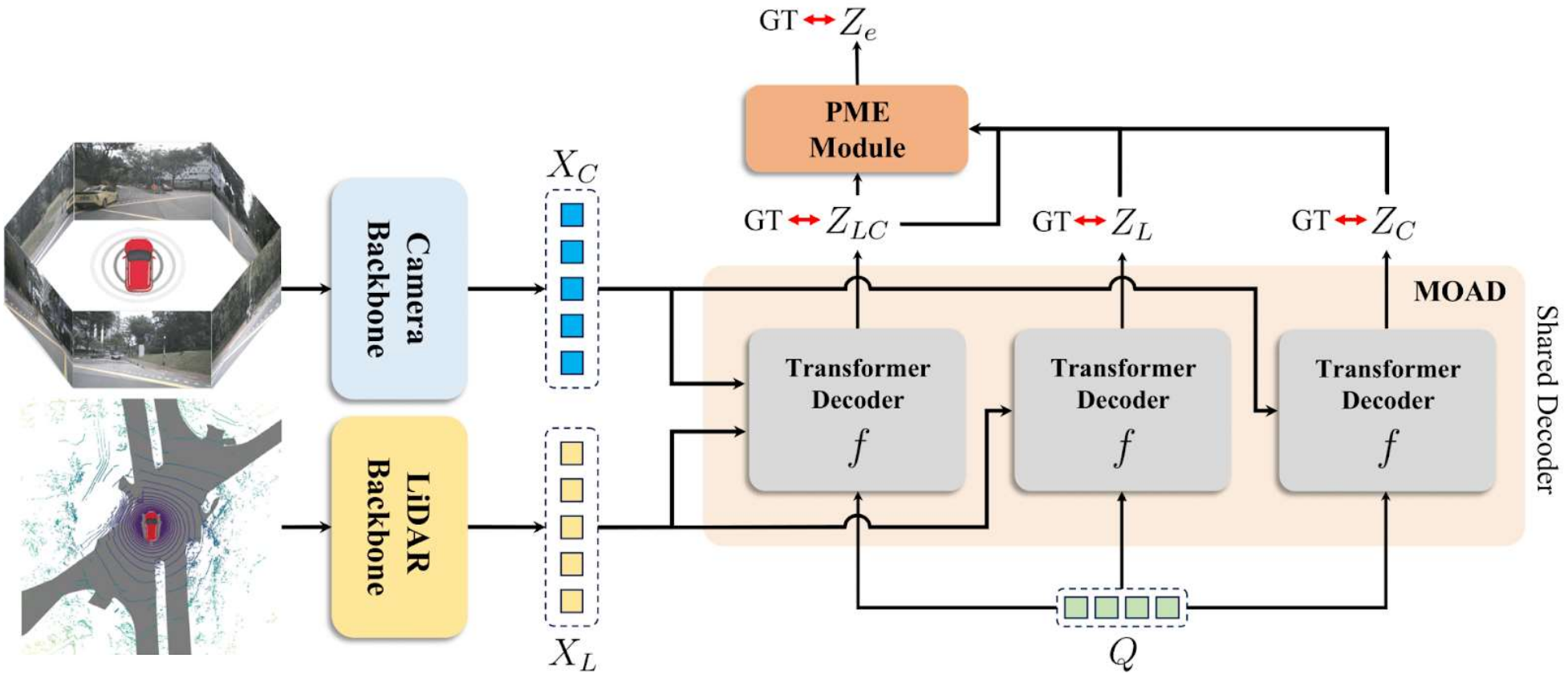
5 RADARS

- Front & 4 Edges

1 IMU

- On the roof

2.2. MODEL INTEGRATION & INFERENCE



The overall architecture of MEFormer

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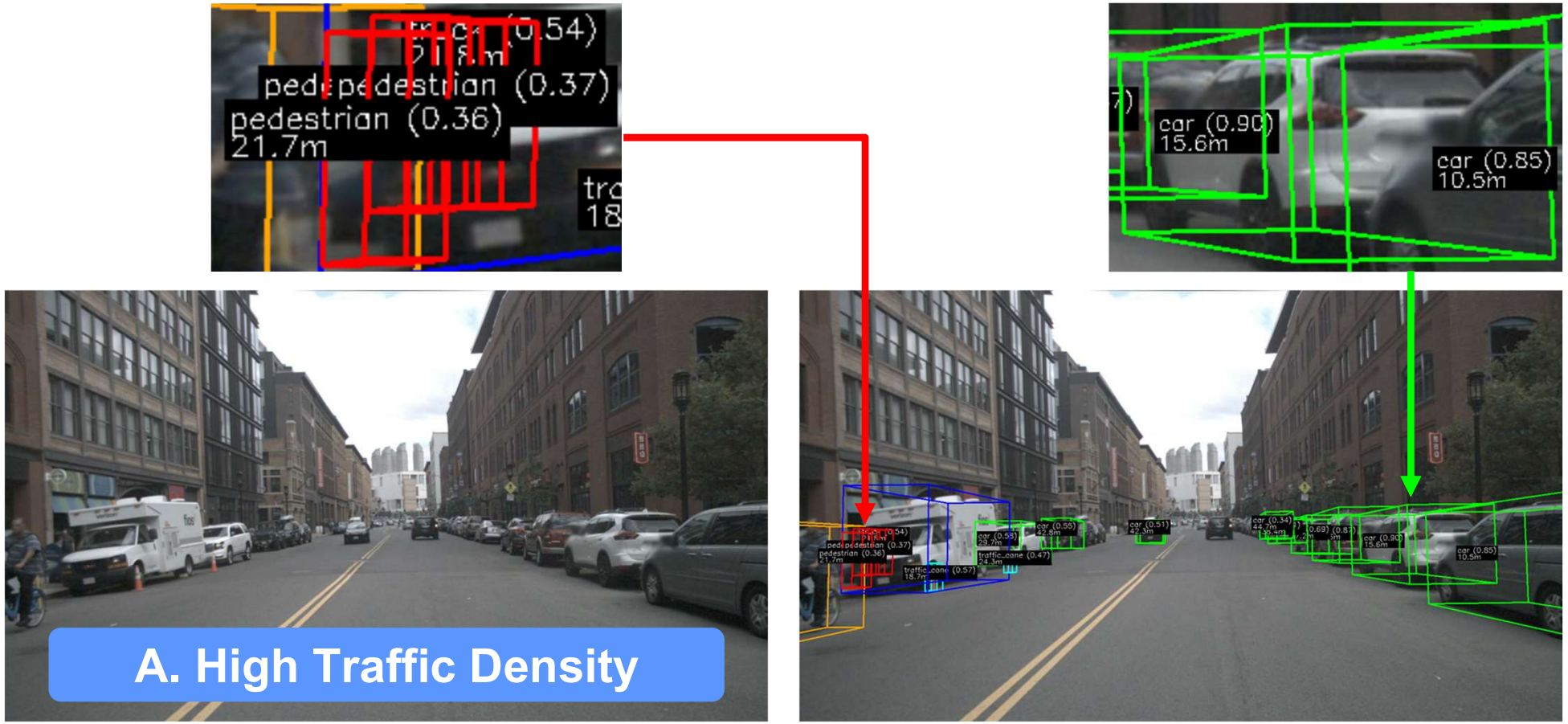
2.2. MODEL INTEGRATION & INFERENCE

MODELS	mAP (%)	mATE (m)	mAOE (rad)
BEVFormer (C)	44.5	0.58	0.38
DETR3D (C)	41	0.64	0.39
BEVFusion (L+C)	71.3	0.25	0.36
MEFormer (L+C)	**72**	**0.27**	**0.3**
Expected Metrics	≥ 53	≤ 0.49	≤ 0.38
Result	**74**	**0.27**	**0.21**

Performance Comparison of 3D Object Detection Models

2.3. EVALUATION AND VISUALIZATION



Scene-0103, Sample 34 with threshold > 0.3

2.3. EVALUATION AND VISUALIZATION

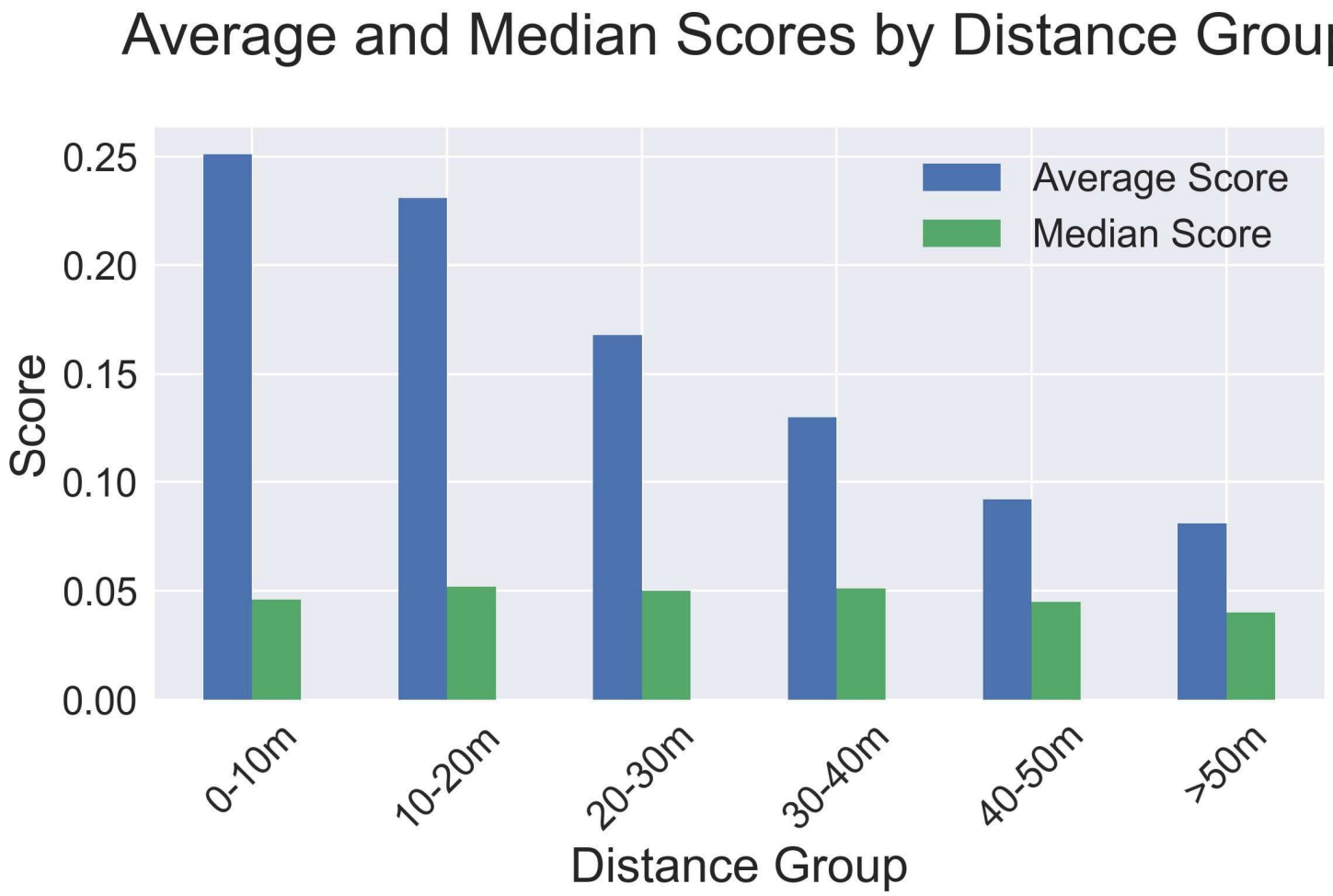
Scene-0916, Sample 8 with threshold > 0.3

2.3. EVALUATION AND VISUALIZATION

C. Faraway Objects

Scene-0796, Sample 11 with threshold > 0.3

2.3. EVALUATION AND VISUALIZATION



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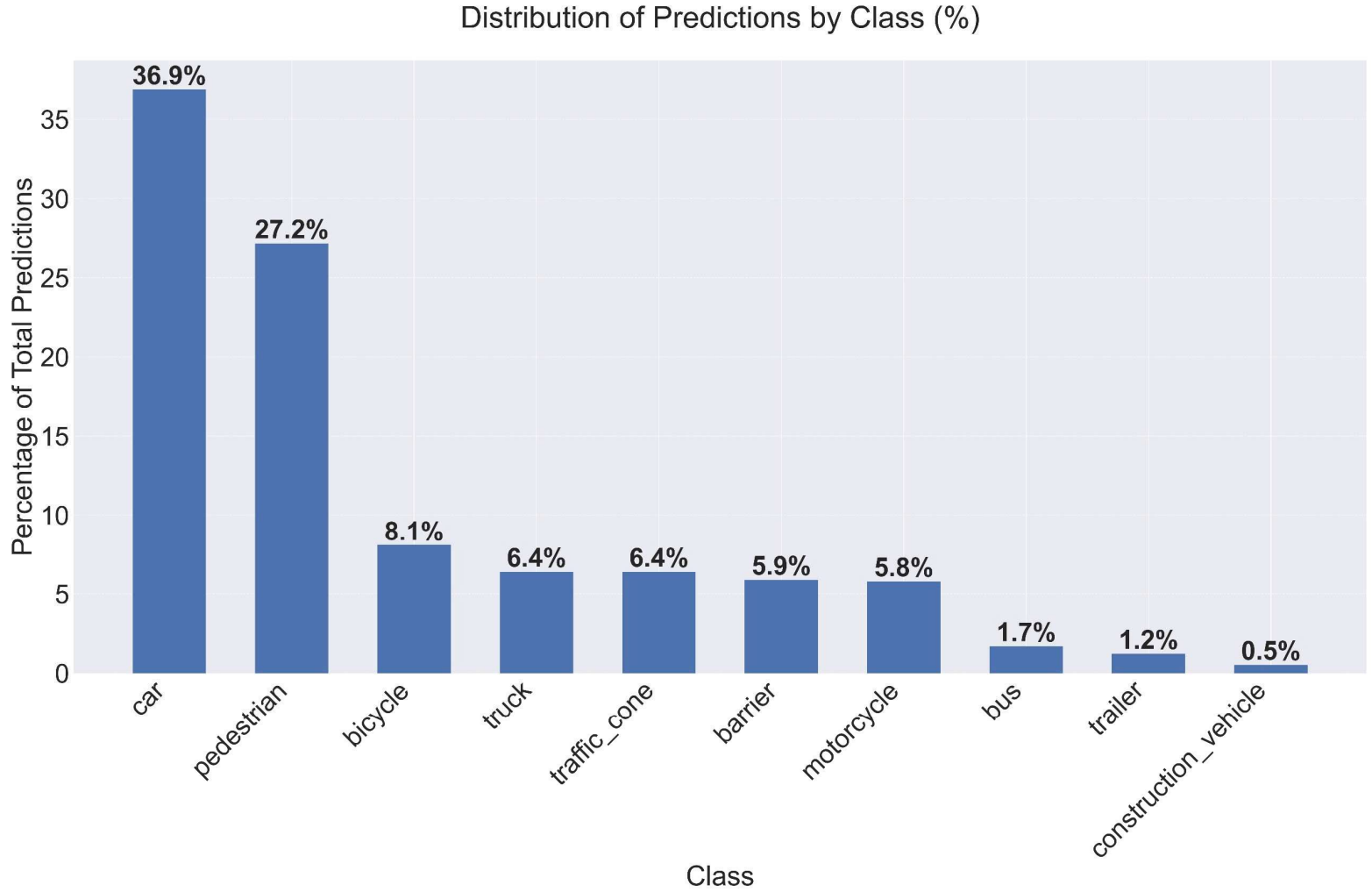

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THE 3-SECOND RULE

A traffic safety guideline for drivers

~2.5-second reaction distance
at 50 km/h (~13.9 m/s)

Recommended Distance = 2.5s x 13.9m/s = 34.75m

Our MEFormer model is most reliable under 40 meters

Our MEFormer model meets the 3-Second Rule

DEMO PRODUCT

3. CONCLUSION

Summary

1. Implemented MeFormer with MMDetection3D on nuScenes.
2. Achieved high mAP & NDS, good for car, bus, pedestrian.
3. Best performance <40m (aligns with **3-Second Rule**).
4. Struggles with faraway, rare, or diverse objects.

3. CONCLUSION

Summary

1. Implemented MeFormer with MMDetection3D on nuScenes.
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Future Development

- **A** **HARDWARE SYSTEM:** Build LiDAR/camera system for collecting real-world data.
- **B** **REAL-WORLD TEST:** Deploy on vehicles/simulators to check performance & latency.
- **C** **RARE CLASS BOOST:** Use augmentation/transfer learning for rare/small classes.
- **D** **DYNAMIC THRESHOLDS:** Tune score thresholds by distance or application.

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THANK YOU!

Development of a multimodal 3D object recognition and visualization system for traffic environments using camera and LiDAR fusion

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