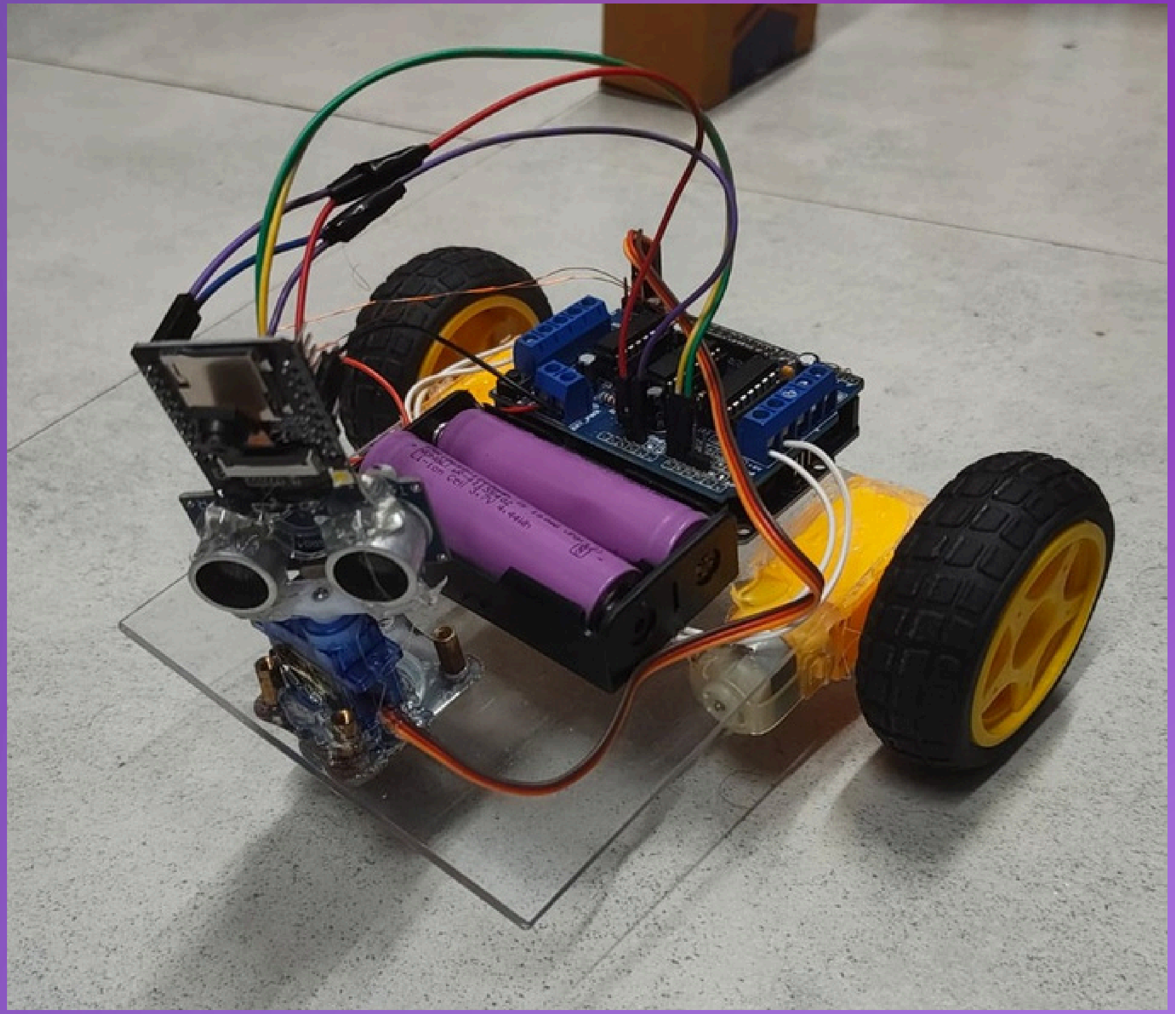
STARTATHON 2026

- **MODEL:** AI-BASED AUTONOMOUS ROVER USING SEMATIC SCENE SEGMANTATION



- **TEAM NAME:** METHXAI

- **TEAM MEMBERS:** ANIKET KUMAR
  ROHAN JARIA
  AARAV CHOUKSEY
  PARTH PANCHOLI

- **ORGANIZED BY:** HACK WITH INDIA & E-CELL VIT BHOPAL UNIVERSITY

PROBLEM STATEMENT

- Autonomous systems must navigate diverse and unpredictable environments such as urban areas, indoor spaces, and natural terrains. Variations in obstacles, lighting, and surface types make real-time navigation challenging and require continuous scene understanding.

- Training these systems — especially for pixel-level tasks like semantic segmentation — demands large amounts of accurately labeled data, which is expensive and time-consuming to collect and annotate.

- To ensure safe and adaptive navigation, autonomous platforms need robust scene understanding that identifies obstacles, surface types, and navigable regions beyond simple object detection.

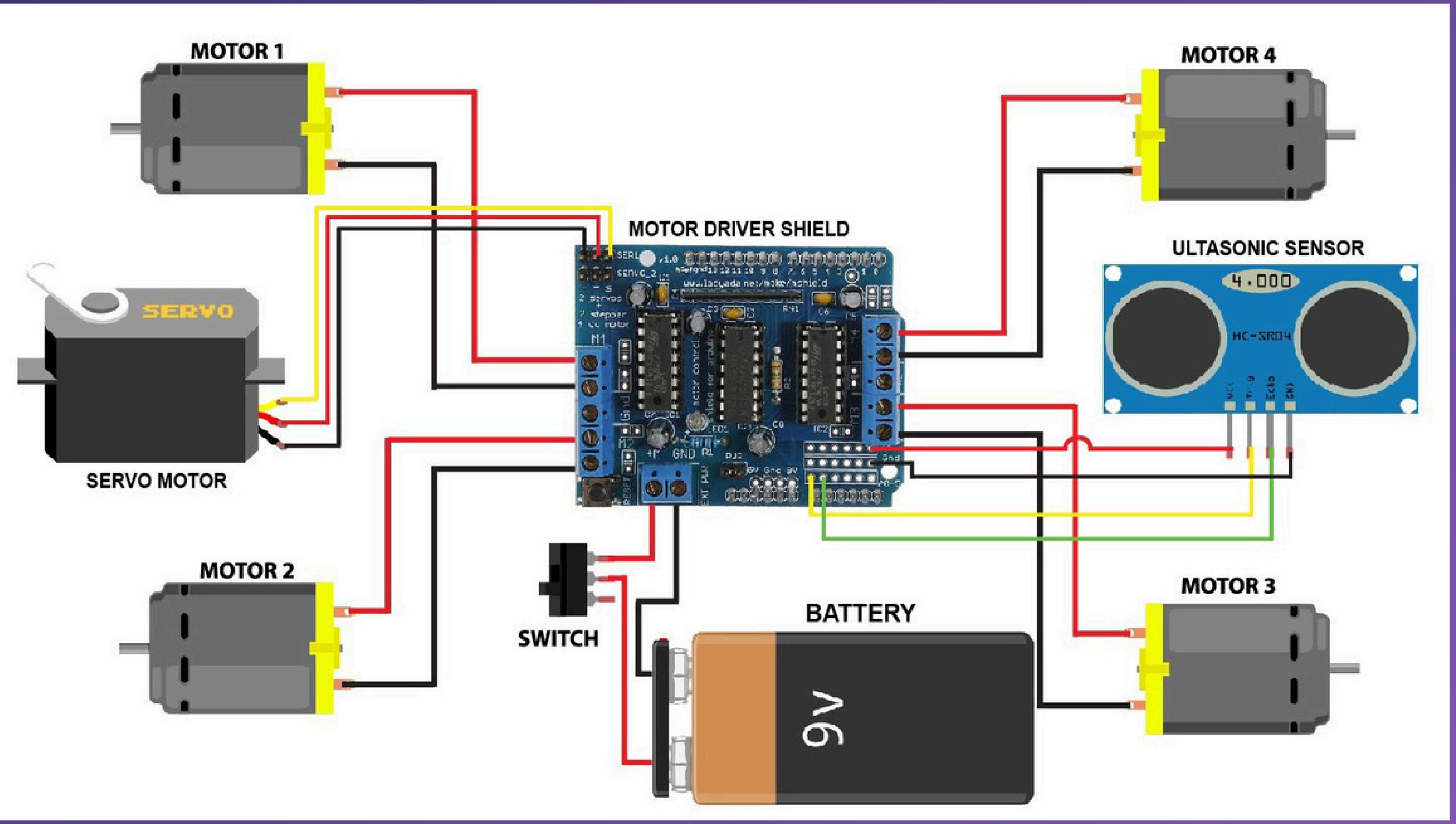
MODEL OVERVIEW

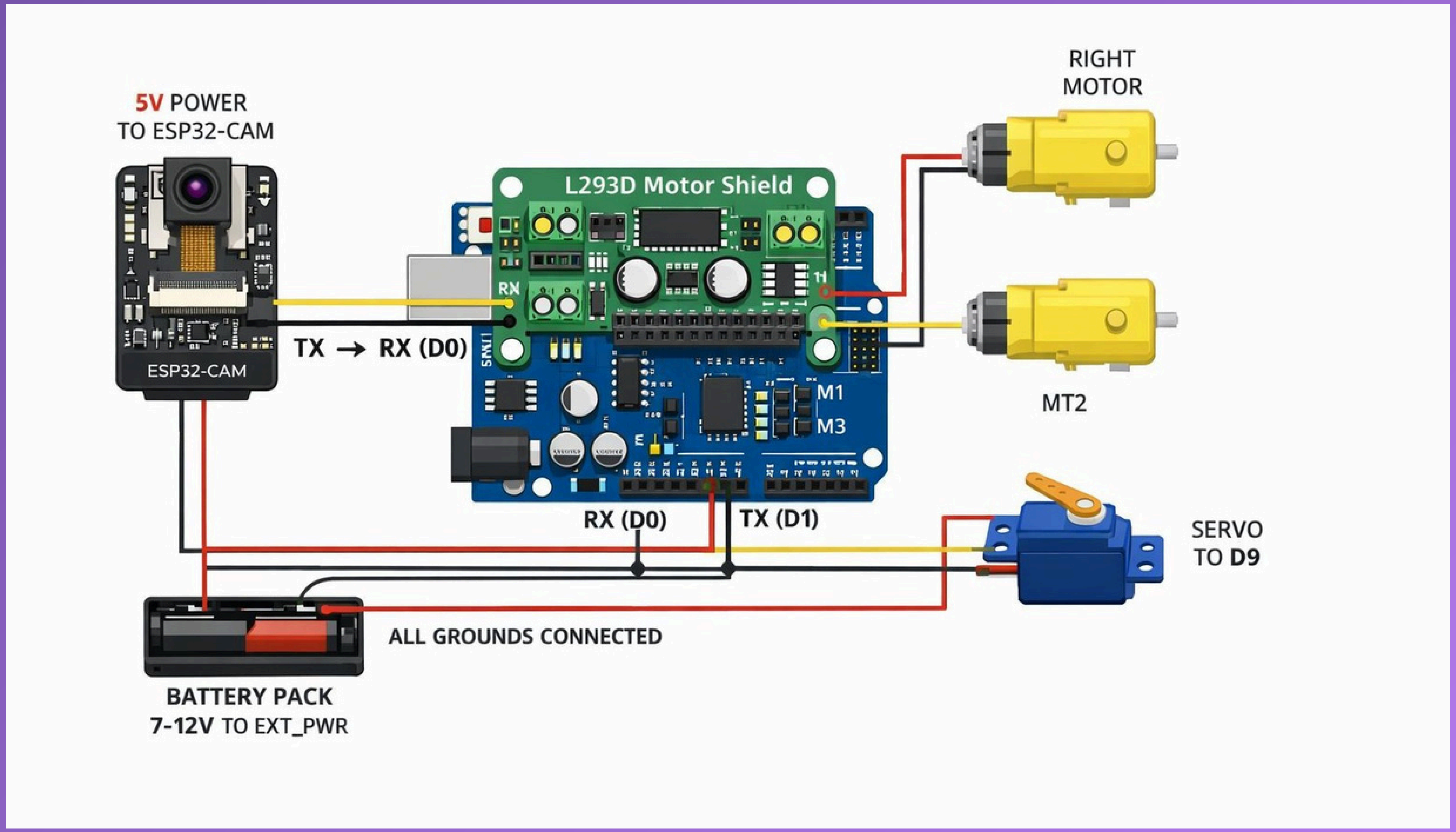
- Our model is a deep learning–based semantic segmentation system that processes live camera input and classifies each pixel as obstacle or navigable area for accurate scene understanding.

- Trained on synthetic digital twin data, it performs real-time inference and converts segmentation results into steering and movement commands for autonomous navigation.

METHXAI

CIRCUIT


MOTOR 1
MOTOR 4
MOTOR DRIVER SHIELD
ULTASONIC SENSOR
SERVO
SERVO MOTOR
MOTOR 2
SWITCH
BATTERY
9V
MOTOR 3


5V POWER
TO ESP32-CAM
RIGHT
MOTOR
L293D Motor Shield
ESP32-CAM
TX → RX (D0)
MT2
M1
M3
RX (D0)
TX (D1)
SERVO
TO D9
ALL GROUNDS CONNECTED
BATTERY PACK
7-12V TO EXT_PWR

WORKING

- The camera continuously captures real-time images of the surrounding environment.
- Each captured frame is sent to the trained semantic segmentation model for pixel-level scene analysis.
- The AI model classifies every pixel into categories such as obstacles, terrain, and safe navigation areas.
- The segmentation output is converted into a terrain map highlighting obstacles and drivable regions.
- A decision-making algorithm analyzes the terrain map to determine the safest movement direction.
- Control commands such as forward motion or turning are generated based on obstacle position.
- These commands are transmitted to the Arduino controller.
- The Arduino drives the motors and servo to move the rover accordingly.
- This process runs continuously, enabling real-time autonomous navigation.

KEY FEATURES

1. **AI-Based Semantic Segmentation**
   - Uses deep learning to perform pixel-level scene understanding instead of simple object detection.

2. **Terrain-Agnostic Navigation**
   - Designed to work across multiple environments (indoor, urban, natural terrain), not limited to one specific setting.

3. **Real-Time Obstacle Detection**
   - Processes live camera input and identifies obstacles instantly for safe navigation.

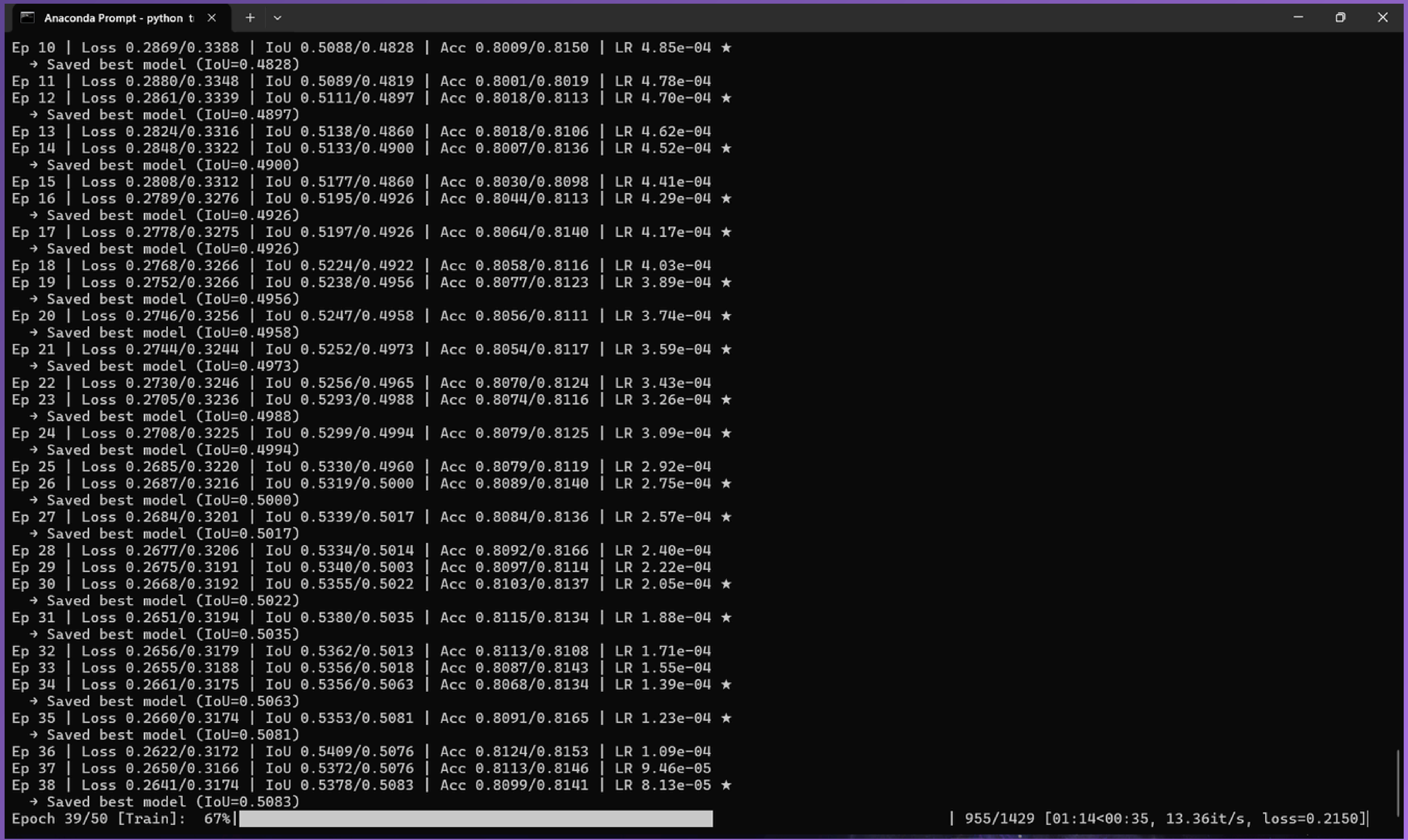
```
===========================================
EVALUATION RESULTS [TTA=ON]
Mean IoU: 0.5023
Pixel Accuracy: 0.8127
===========================================
Background                : 0.1211
Trees                     : 0.6876
Lush Bushes               : 0.6598
Dry Grass                 : 0.6014
Dry Bushes                : 0.6337
Ground Clutter            : 0.1871
Logs                      : 0.1319
Rocks                     : 0.2452
Landscapes                : 0.7891
Sky                       : 0.9667

Metrices saved to ./predictions/
All output saved to ./predictions/
```

METHXAI

4. **Intelligent Decision-Making**
   - Converts segmentation output into steering and movement commands automatically.

5. **Hardware Integration**
   - Deploys AI model onto an Arduino-based rover for practical, real-world demonstration.

6. **Scalable & Extensible Design**
   - System can be expanded to include multi-axis stabilization, advanced path planning, or domain adaptation.



METHXAI

SYSTEM ARCHITECTURE

🧠 Software / AI
- Semantic segmentation deep learning model
- Synthetic dataset for training and testing
- Data augmentation and model optimization
- Real-time inference pipeline

📷 Perception
- Camera module for live environment capture

🤖 Hardware
- Arduino-based robotic car chassis
- Servo motors and DC motors for movement control
- Motor driver module

METHXAI

POSSIBLE IMPACT

- **Enhanced Safety in Autonomous Navigation**

Real-time semantic segmentation enables accurate obstacle detection and terrain understanding, reducing collision risks and improving navigation reliability.

- **Cost-Effective Development**

Training with synthetic digital twin data minimizes the need for expensive real-world data collection and manual annotation.

- **Scalable Across Environments**

The system can adapt to urban roads, indoor spaces, and natural terrains, making it suitable for diverse real-world applications.

- **Improved Decision-Making**

Pixel-level scene understanding allows smarter movement decisions compared to basic object detection systems.

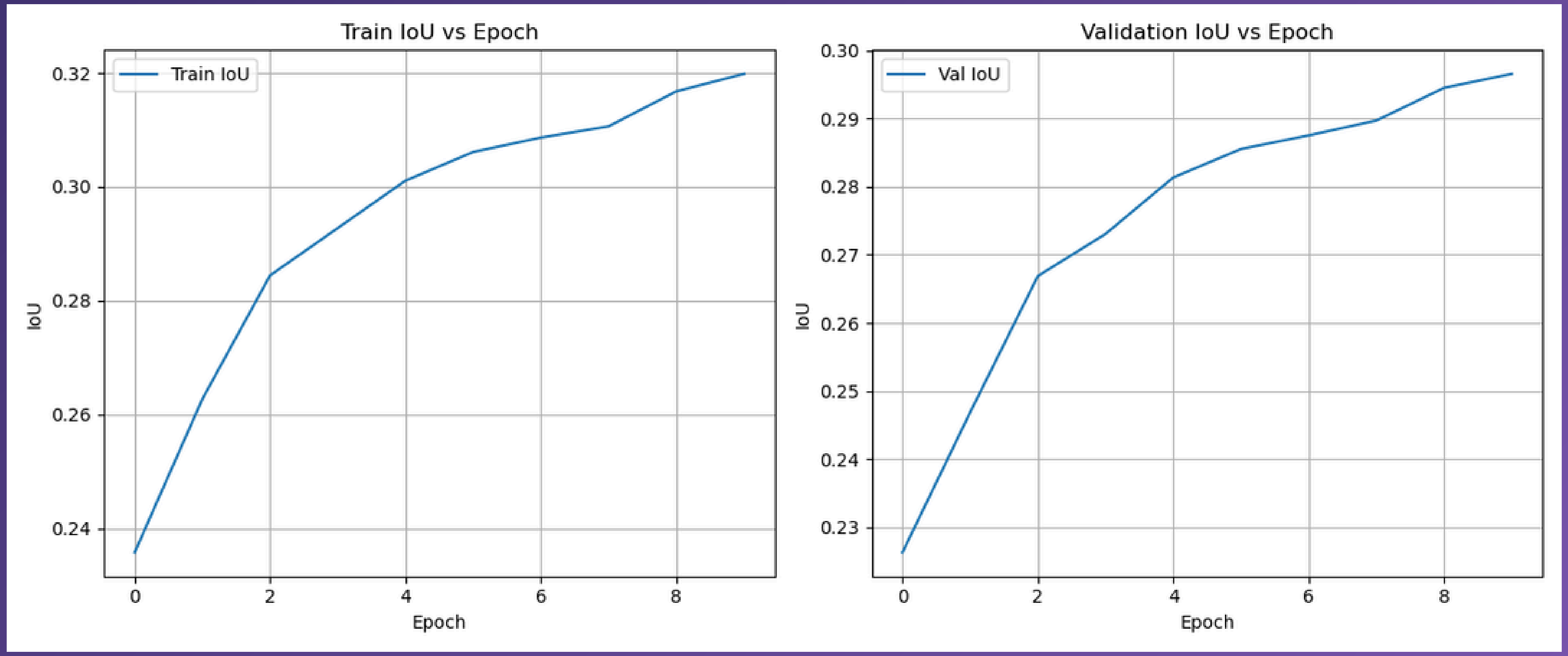
- **Foundation for Advanced Robotics**

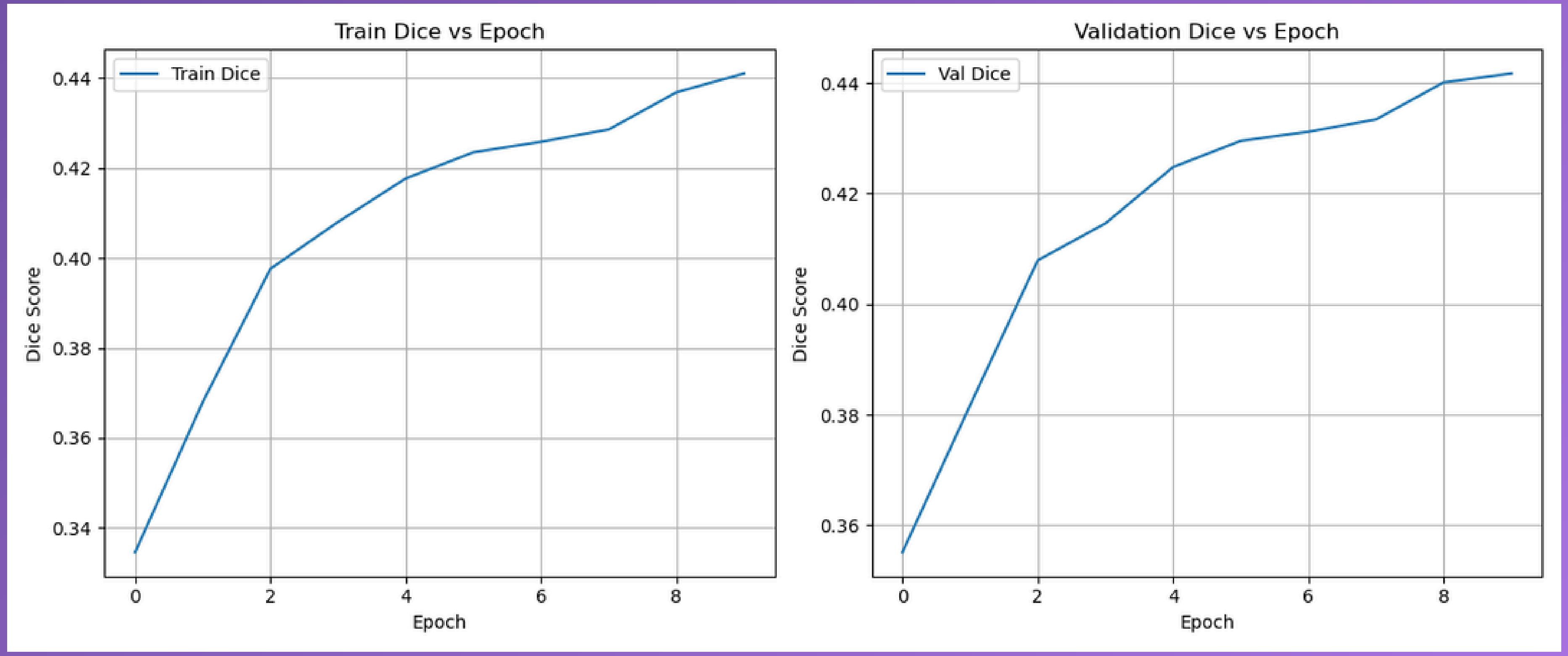
The project can be extended to applications such as delivery robots, agricultural monitoring, warehouse automation, surveillance rovers, and disaster-response systems.

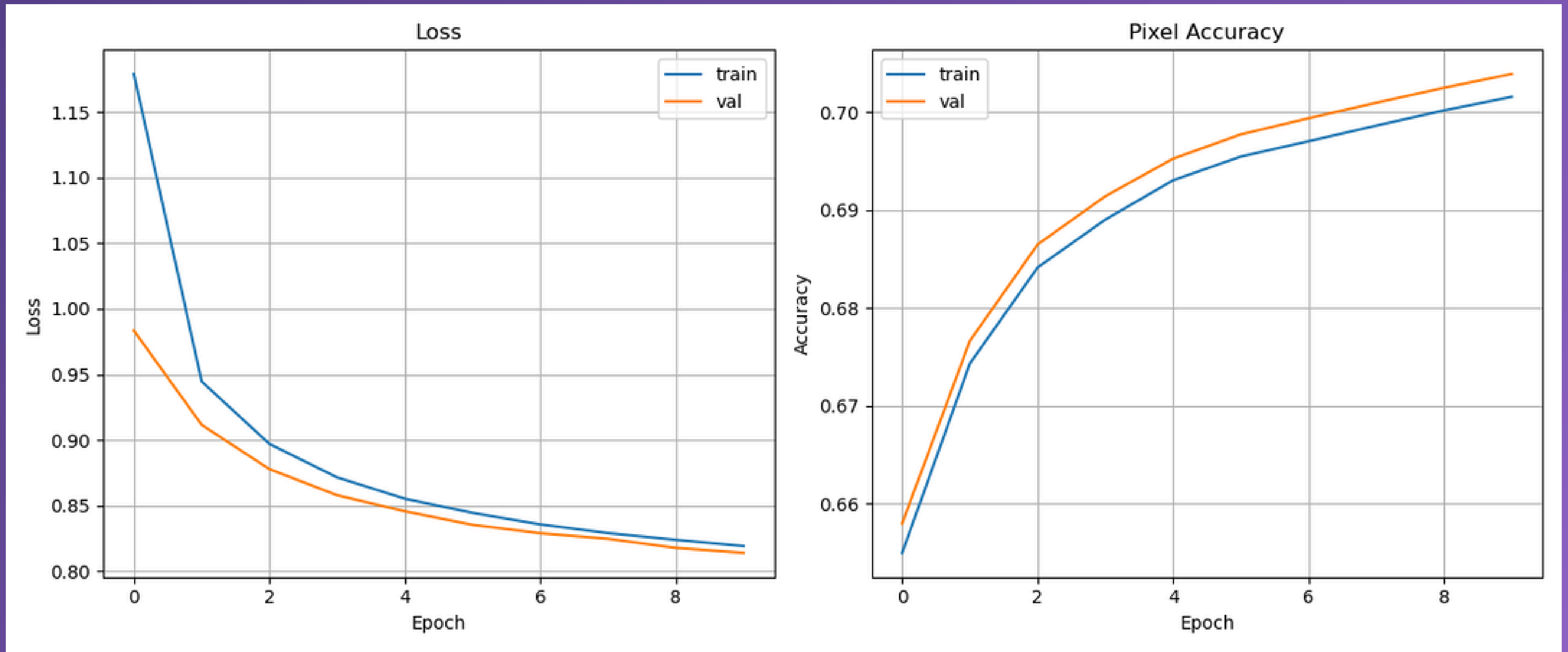
- **Educational and Research Value**

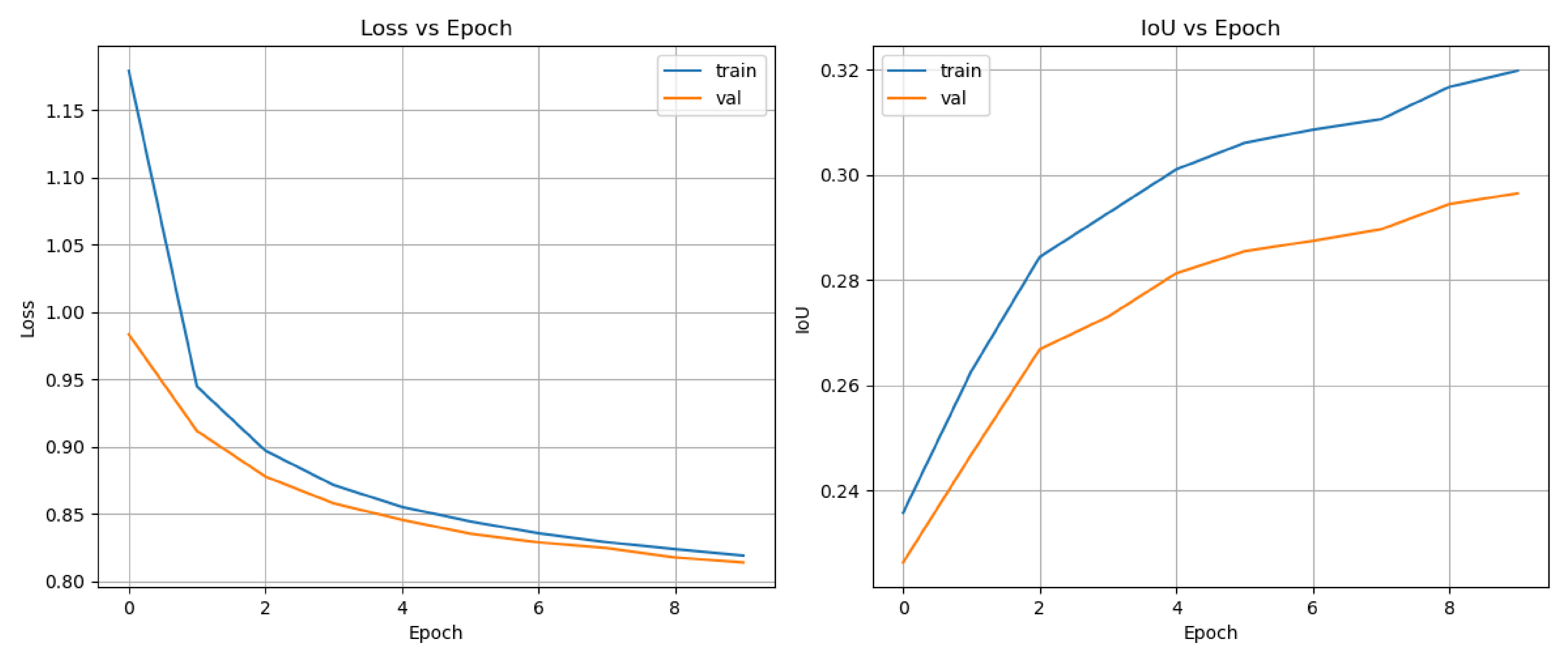
Provides a practical framework combining AI perception with embedded hardware (Arduino-based control), useful for robotics and autonomous systems research.

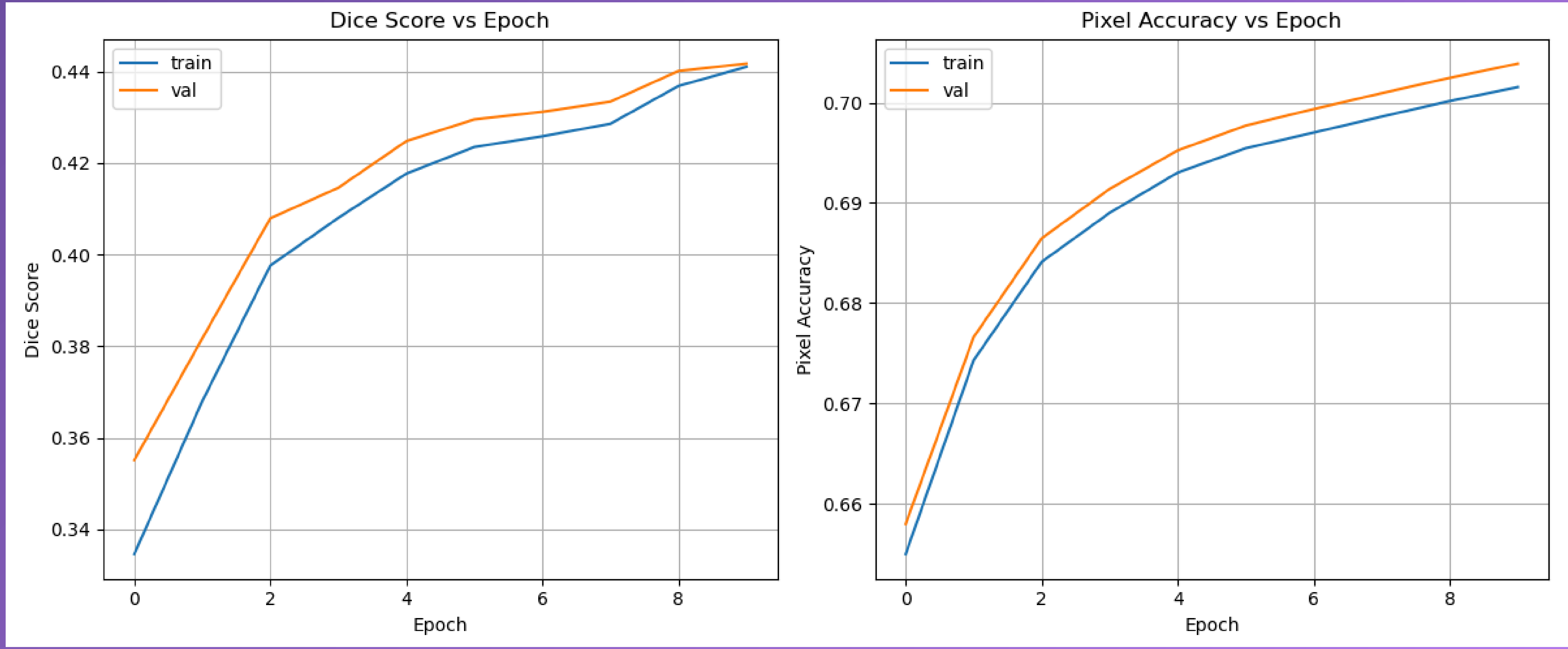
INITIAL GRAPHS



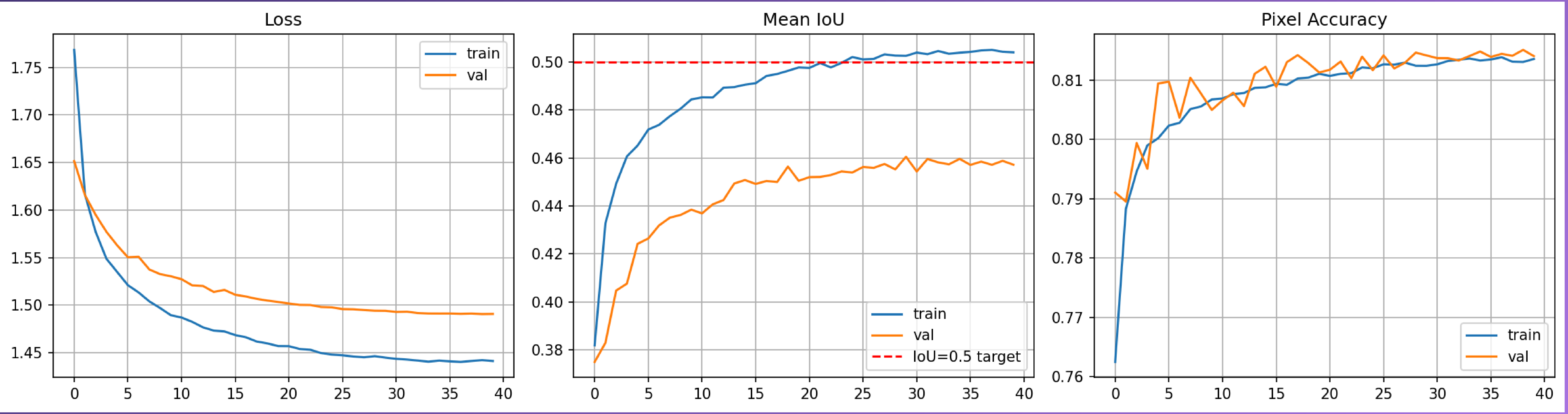




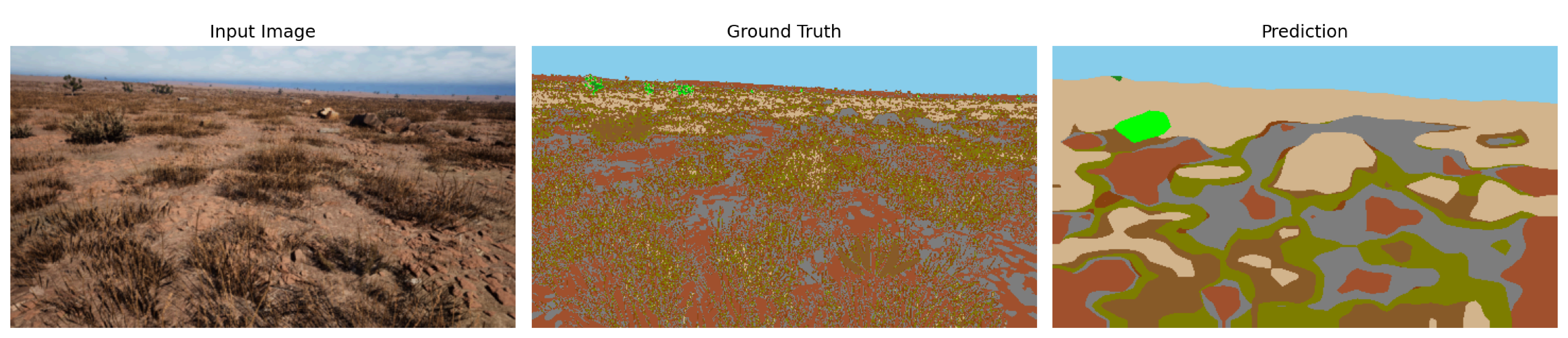

Loss vs Epoch
train
val
Loss
Epoch
IoU vs Epoch
IoU

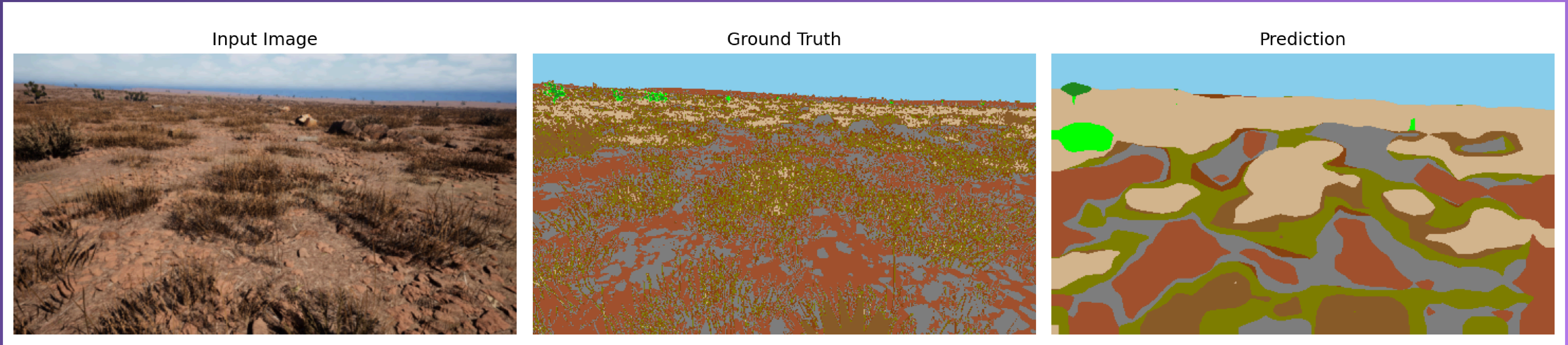

Dice Score vs Epoch
train
val
Dice Score
Epoch
Pixel Accuracy vs Epoch
Pixel Accuracy

FINAL GRAPHS

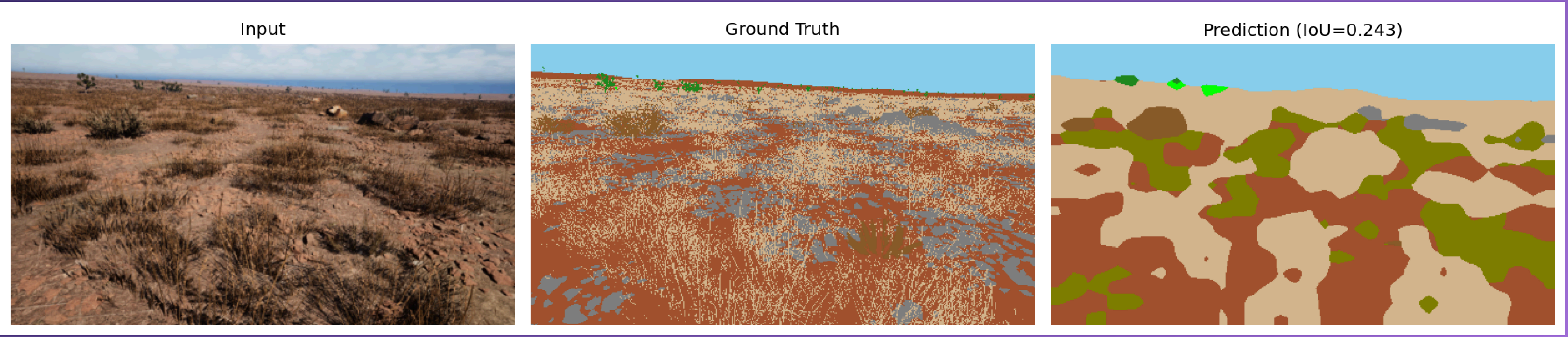


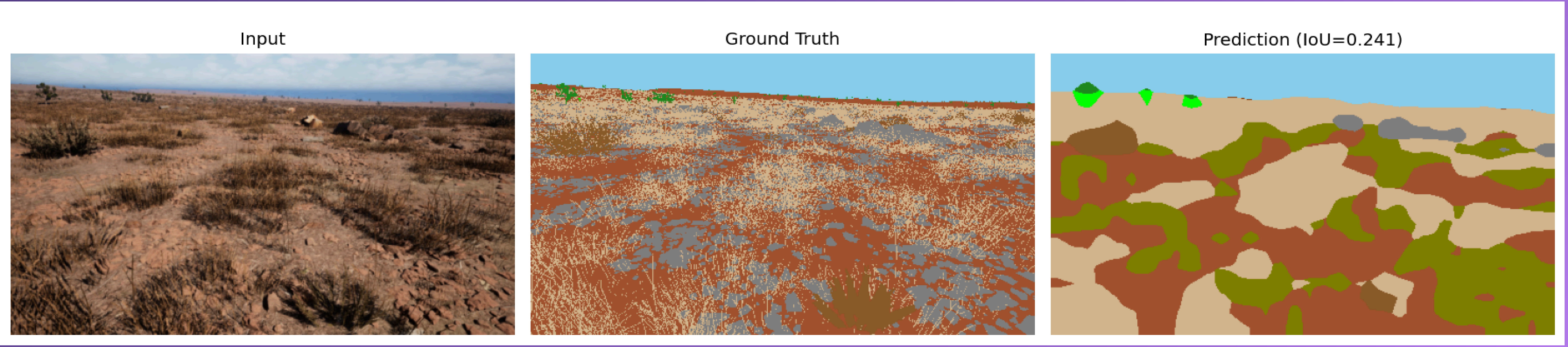
INITIAL SEMATIC SEGMENTATION





FINAL SEMATIC SEGMENTATION





THANK YOU