Artificial Intelligence and Drone
Autonomous Drone

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Background

Nvidia 드론 주행(2017)

Alphabet 드론 배송(2019)

https://www.newsweek.com/wing-drone-first-commercial-delivery-1466471
https://arxiv.org/pdf/1705.02550.pdf

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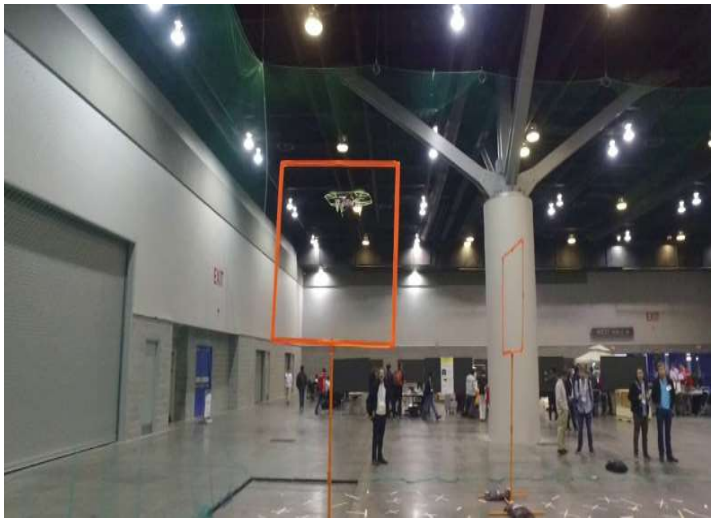
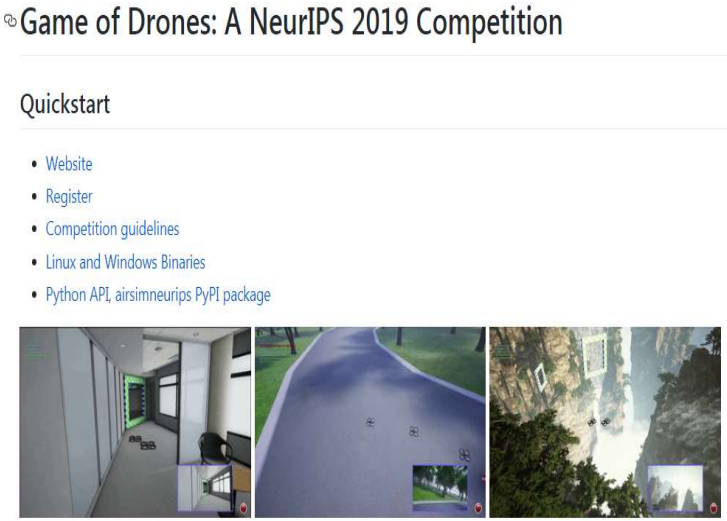
Competitions

Lockheed Martin Autonomous Drone Competition

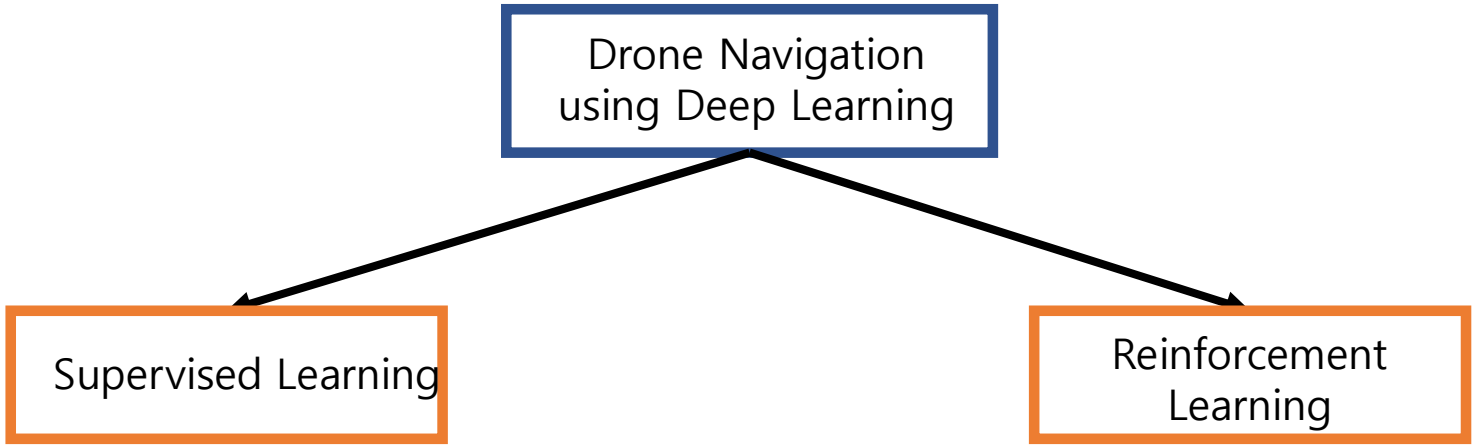


IROS Autonomous Drone Competition



NeuralPS Autonomous Drone Competition

Background – Drone Navigation using Deep Learning



Supervised Learning

Advantage

- Stable Performance
- Training for a special case
- Vision based training

Disadvantage

- Lot of data labeling
- New dataset for a new situation
- Can not check labeling accuracy

Reinforcement Learning

Advantage

- No dataset and no labeling
- Training using environment data
- Easy for new environment

Disadvantage

- Difference between real and simulated environment
- Reward Function Design

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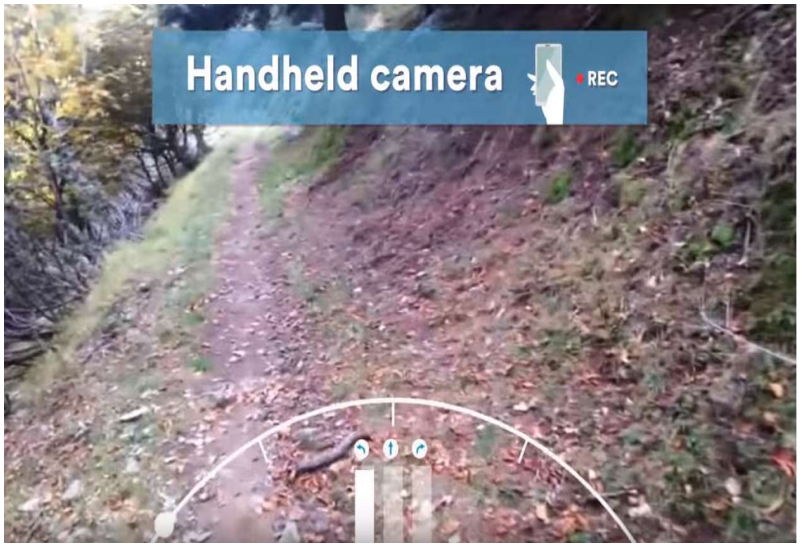
Background- Drone Navigation using Supervised Learning

Loquercio et al

- 70,000 images (street)
- bicycle
- 3 labels(regression):
  - Steering(-1~1)
  - Velocity(0~3.0)
- Parrot Bebop Flight Controller + ROS

Giusti et al



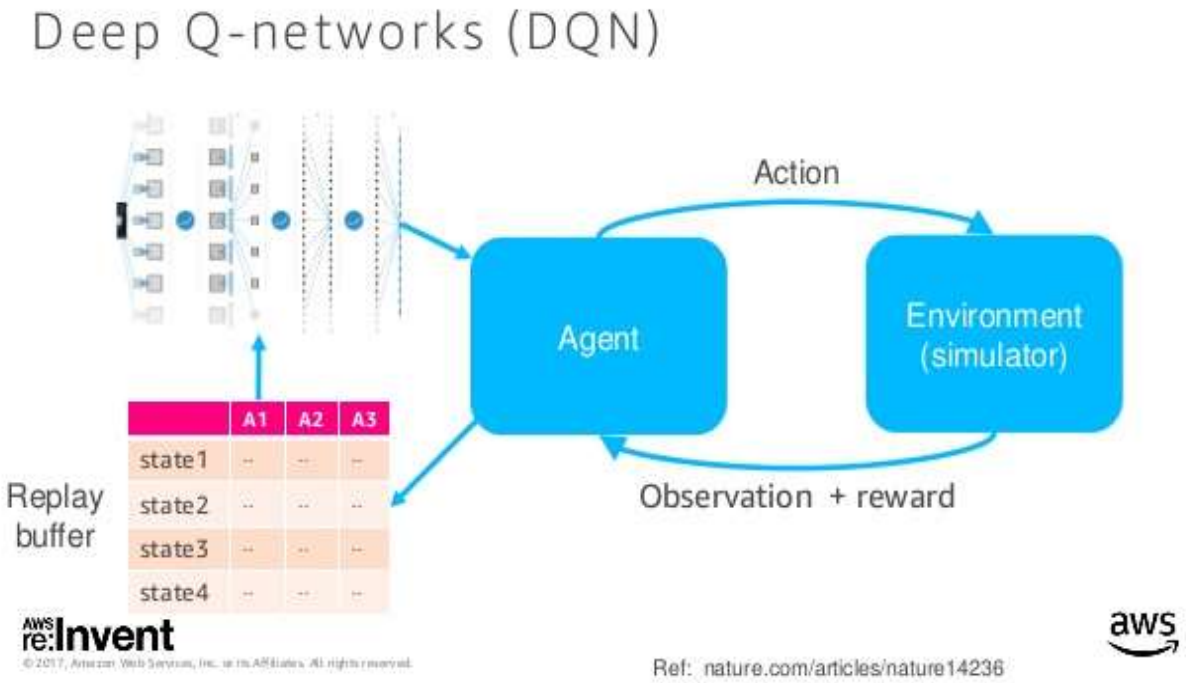
- 17,119 images(forest)
- 3 labels(Classification) :
  - Turn left(0)
  - Turn Right(1)
  - Go Straight(2)
- Parrot AR Drone Flight Controller + ROS

Background- Reinforcement Learning(Discrete)

- greedy-policy for maximize the reward

- Off-Policy algorithm

- (State, Action, Reward, Next State) are stored in buffer
  - State: images
  - Action:
  - Reward
  - Next State: images
- Image based traning



Simulation Environment

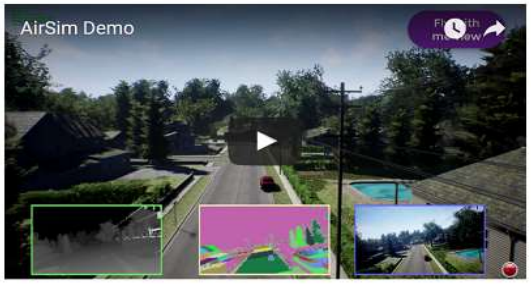
Welcome to AirSim

AirSim is a simulator for drones, cars and more, built on Unreal Engine (we now also have an experimental Unity release). It is open-source, cross platform, and supports hardware-in-loop with popular flight controllers such as PX4 for physically and visually realistic simulations. It is developed as an Unreal plugin that can simply be dropped into any Unreal environment. Similarly, we have an experimental release for a Unity plugin.

Our goal is to develop AirSim as a platform for AI research to experiment with deep learning, computer vision and reinforcement learning algorithms for autonomous vehicles. For this purpose, AirSim also exposes APIs to retrieve data and control vehicles in a platform independent way.

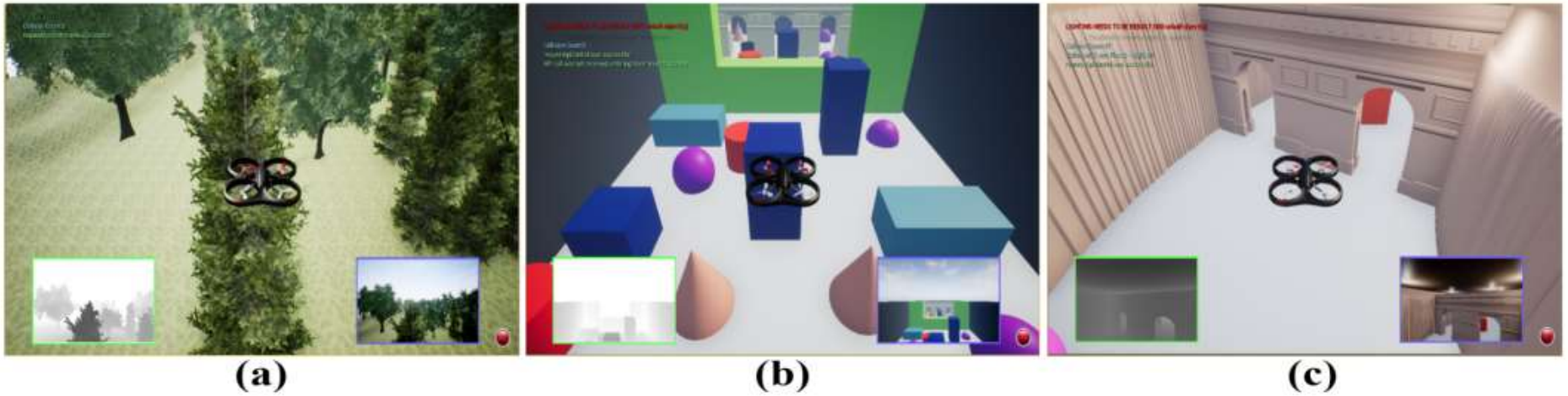
Check out the quick 1.5 minute demo

Drones in AirSim



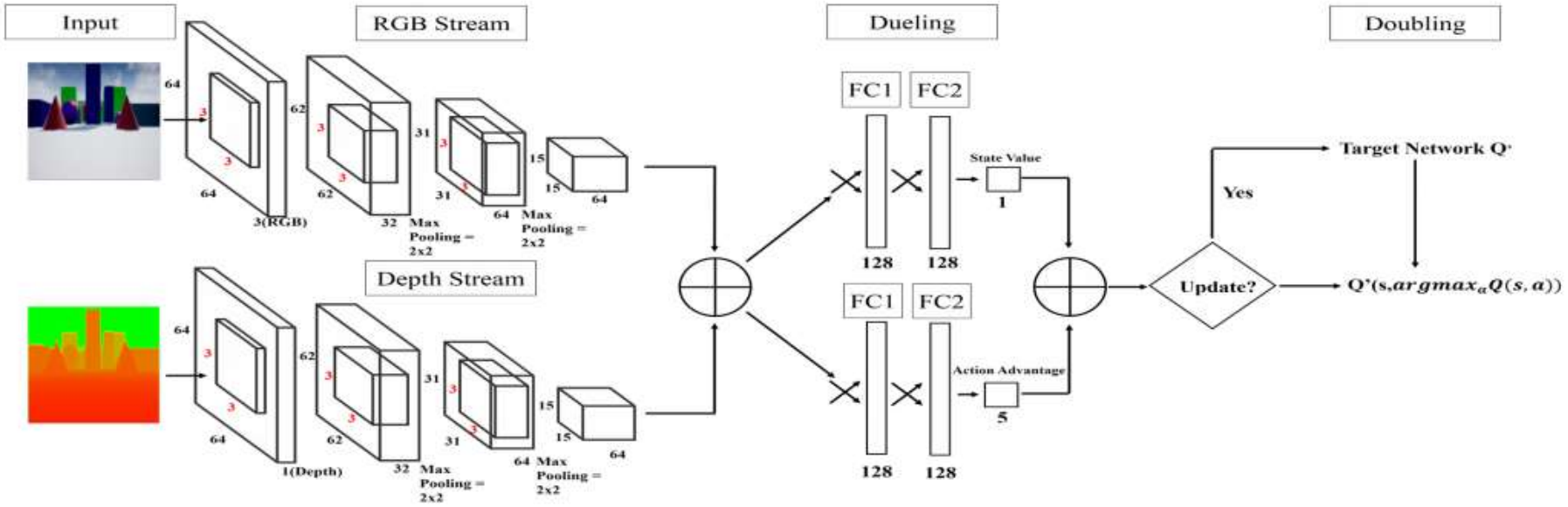
Cars in AirSim

3 VR environments

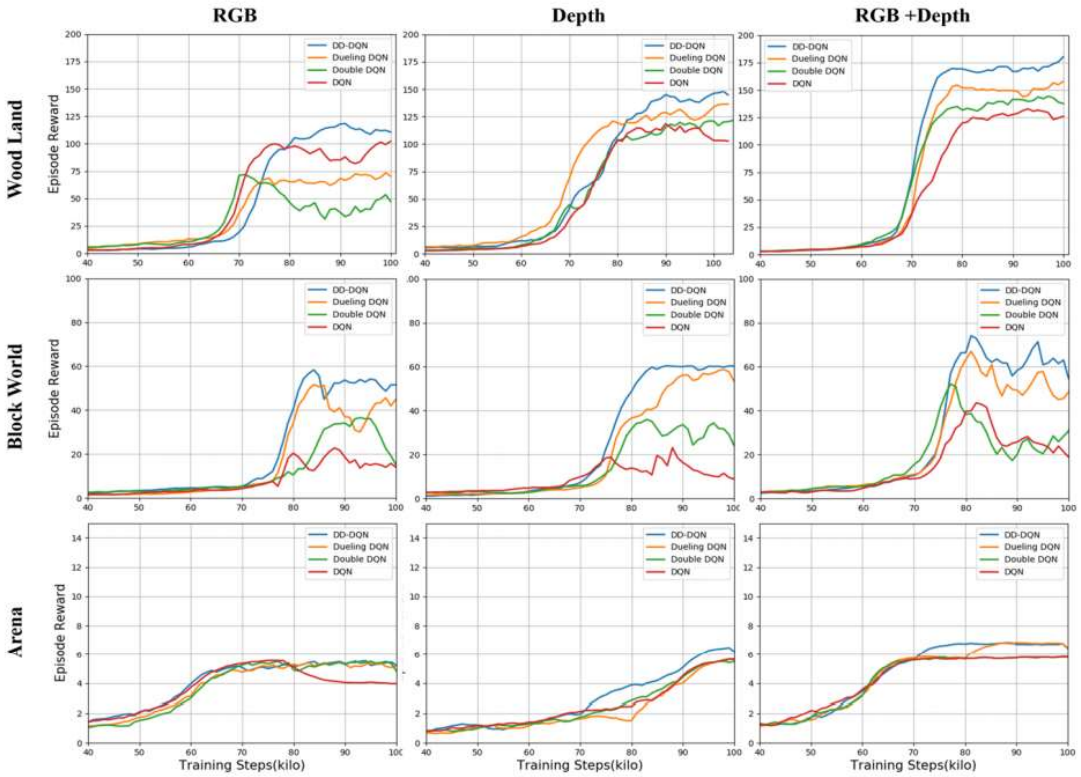


Woodland block-world Arena

DQN + Dueling DQN + Double DQN



Results


RGB
Depth
RGB +Depth
Wood Land
Block World
Arena
Episode Reward
Training Steps(kilo)
DD-DQN
Dueling DQN
Double DQN
DQN

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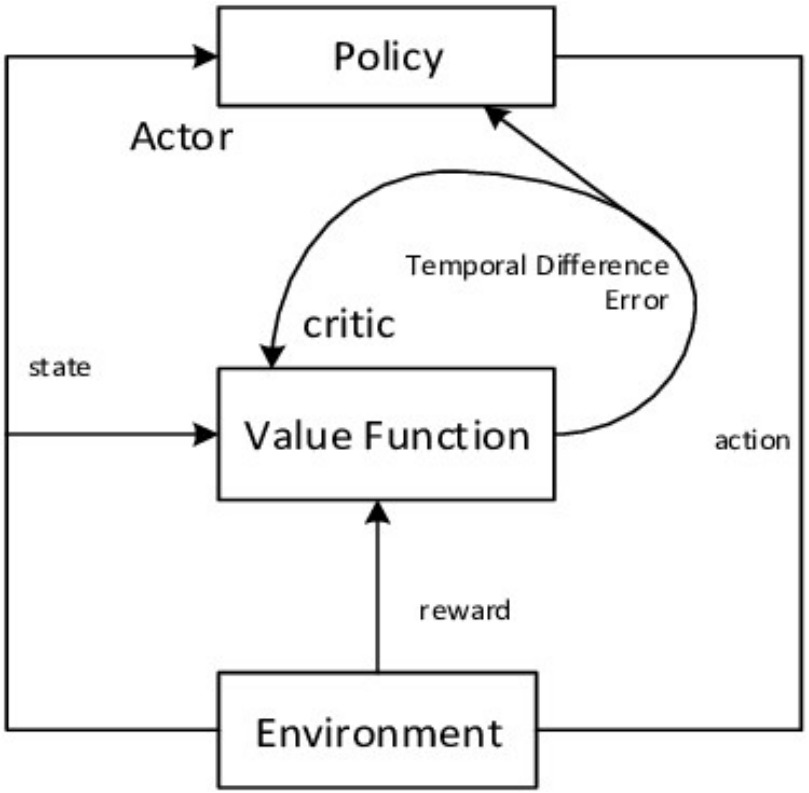
Background- Reinforcement Learning(Continuous)

- State, Action, Reward, Next State
- Policy Network and Value Network
- Continuous output
- Image -> High dimensional

Actor Critic Networks



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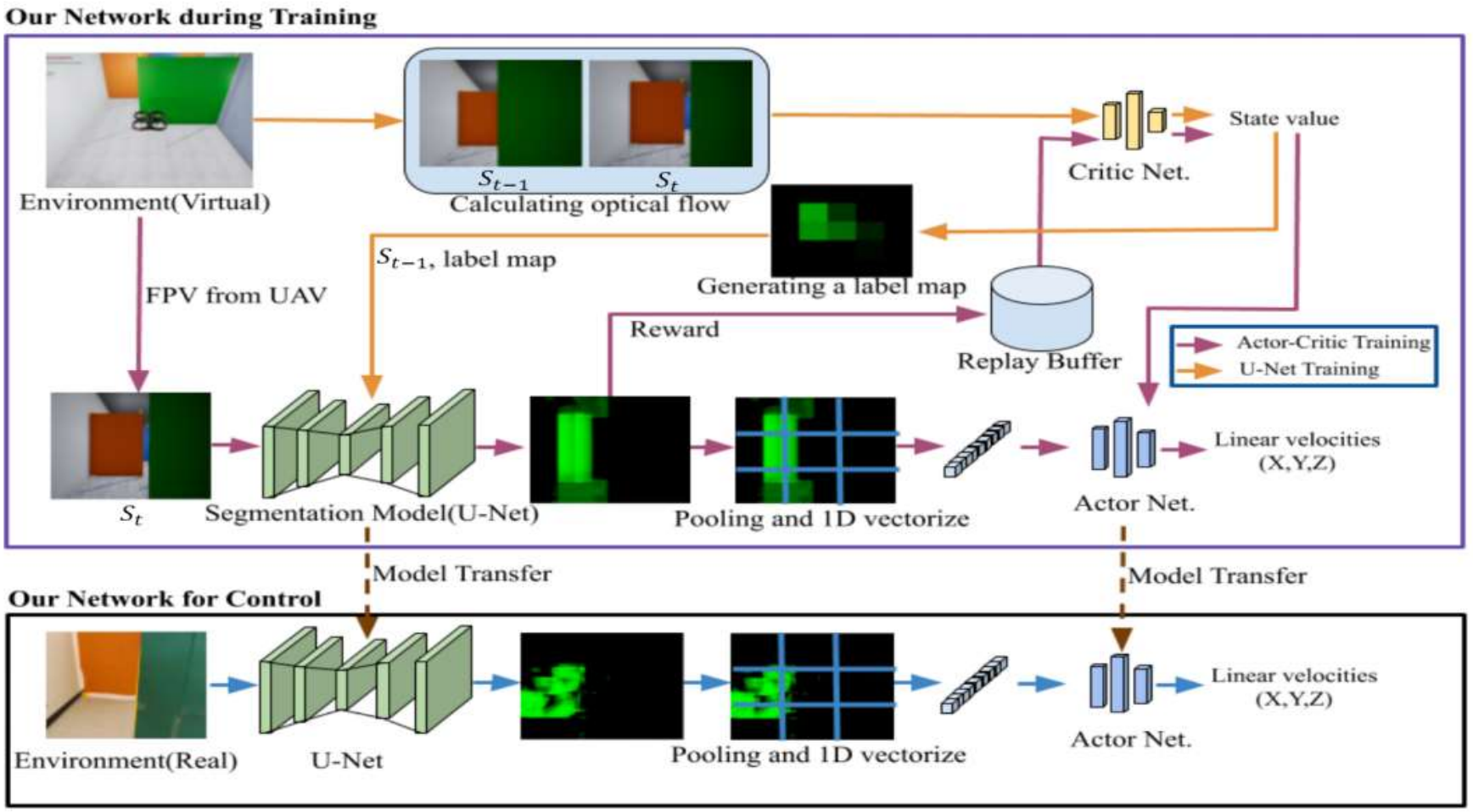
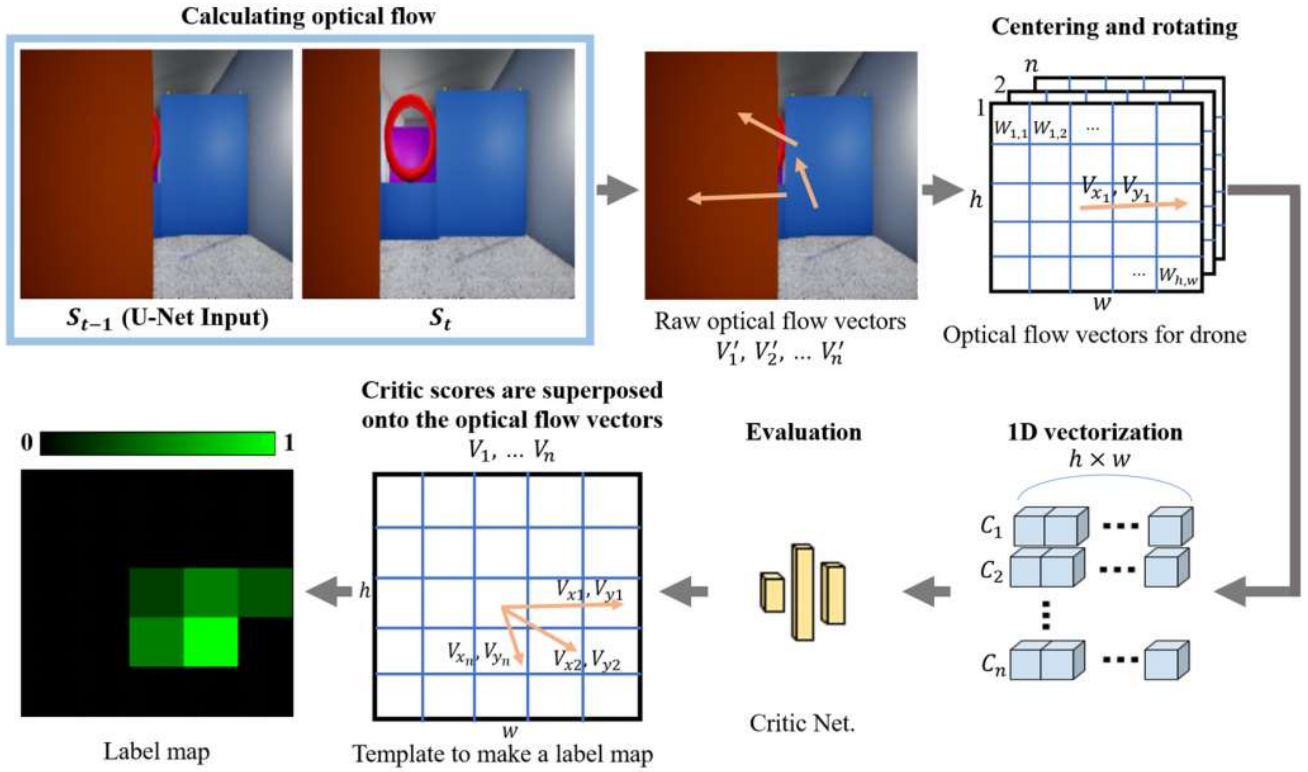
Method – System Flow Diagram



Method – Generating Label Map for U-Net

- S_{t-1} and S_t (Optical Flow algorithm[7])
- Matrix 1D Flattening
- Label Map generation

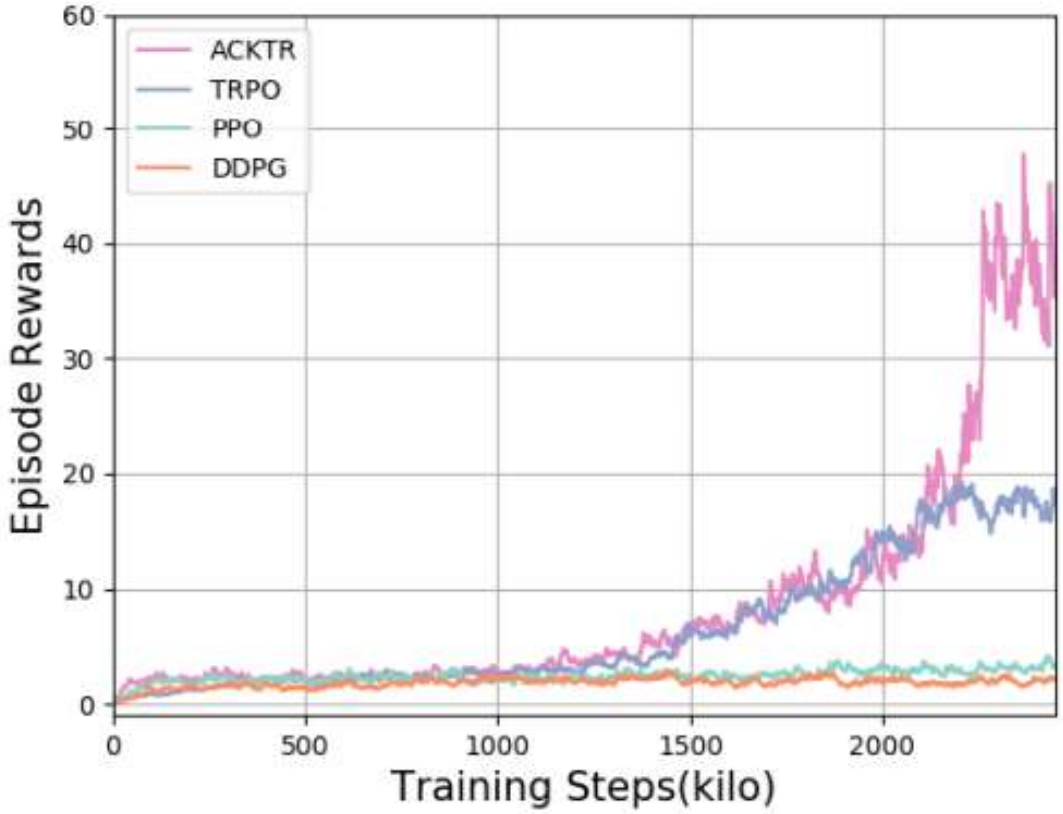


Experiment – Performances of RL Algorithms

- 4 Actor-Critic algorithms

- Deep Deterministic Policy Gradient(DDPG)
- Trust Region Policy Optimization(TRPO)
- Proximal Policy Optimization(PPO)
- Actor-Critic using Kronecker-Factored Trust Region(ACKTR)

- ACKTR outperforms others



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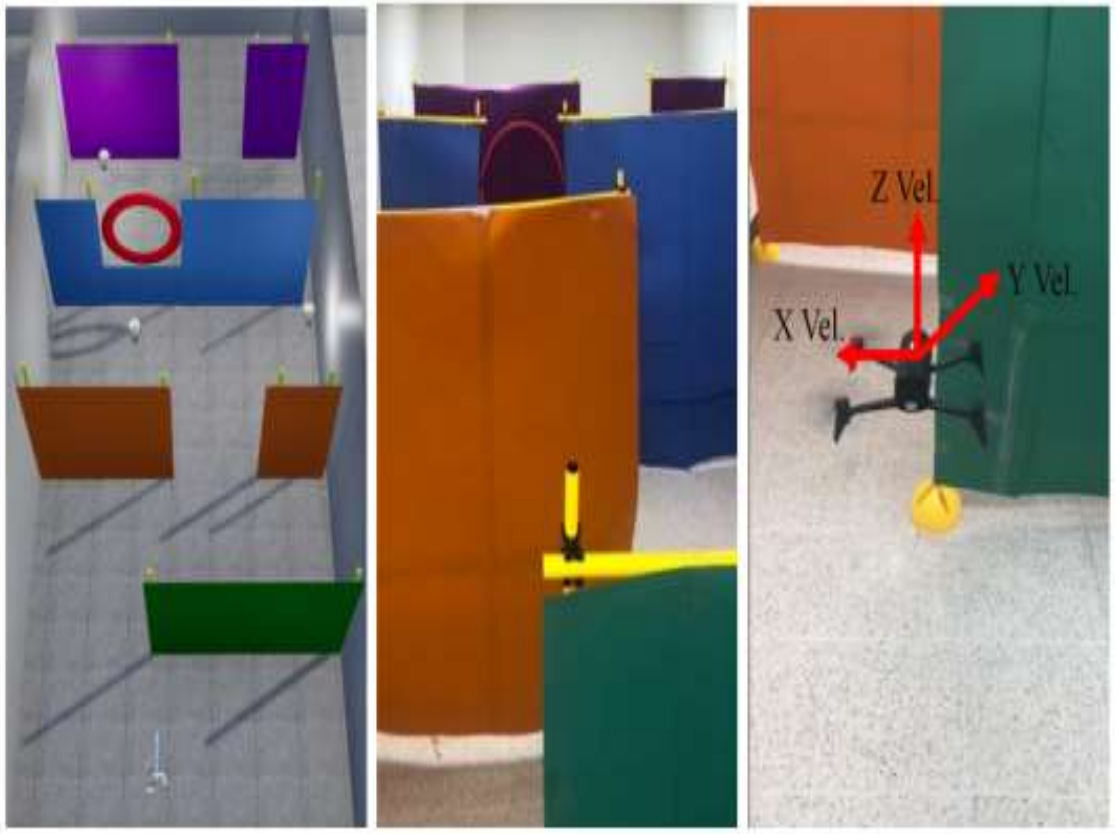
Experiment – Real Environment

- Real environment
- ACKTR의 Actor Network and U-Net
- Parrot Bebop 2.0
- ROS + Wifi
- Ubuntu 18.04 OS + Nvidia GTX 1060
- Average execution time : 83 ms
- Total memory usage : 300 MiB



(a) (b) (c)

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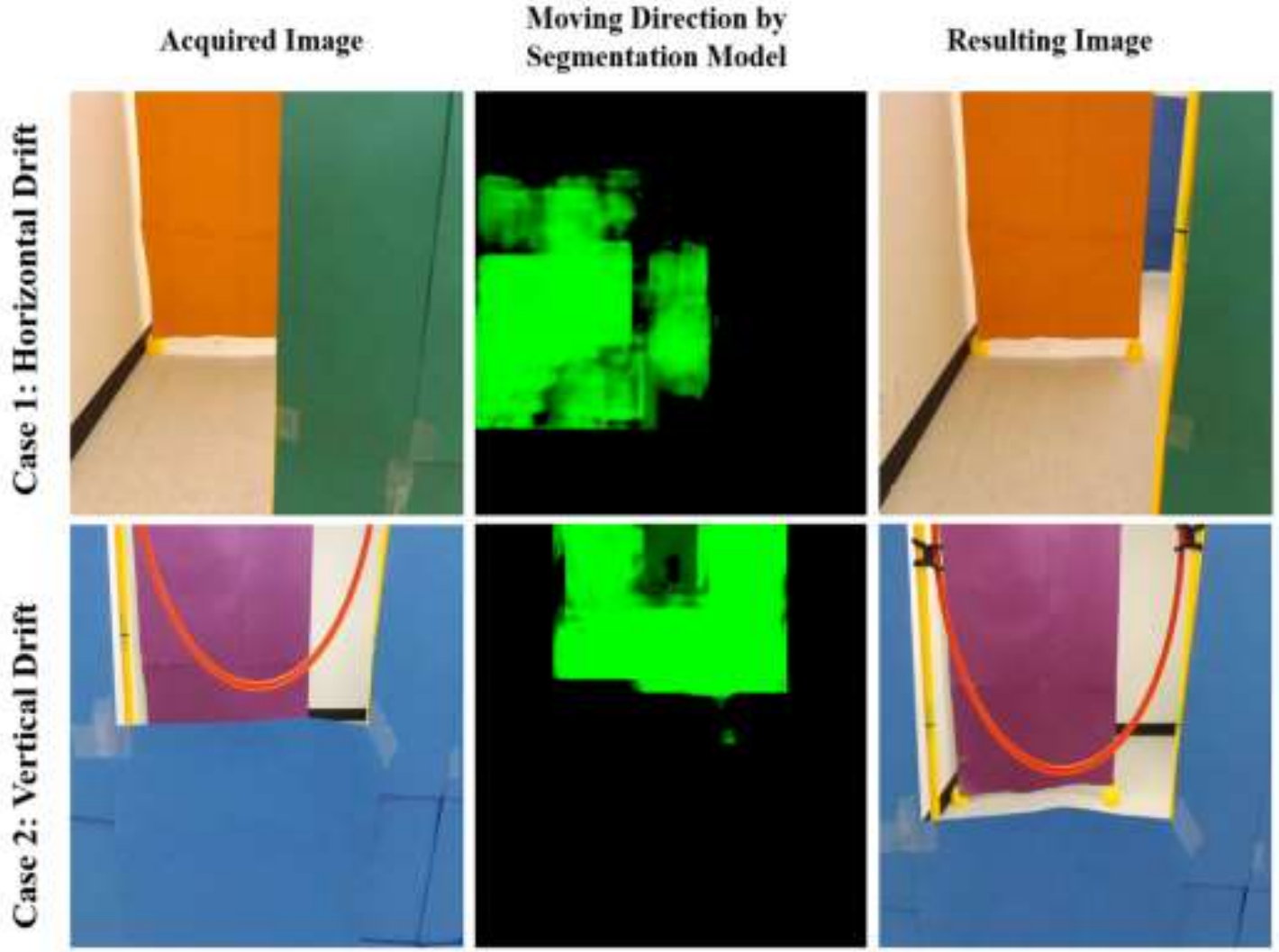
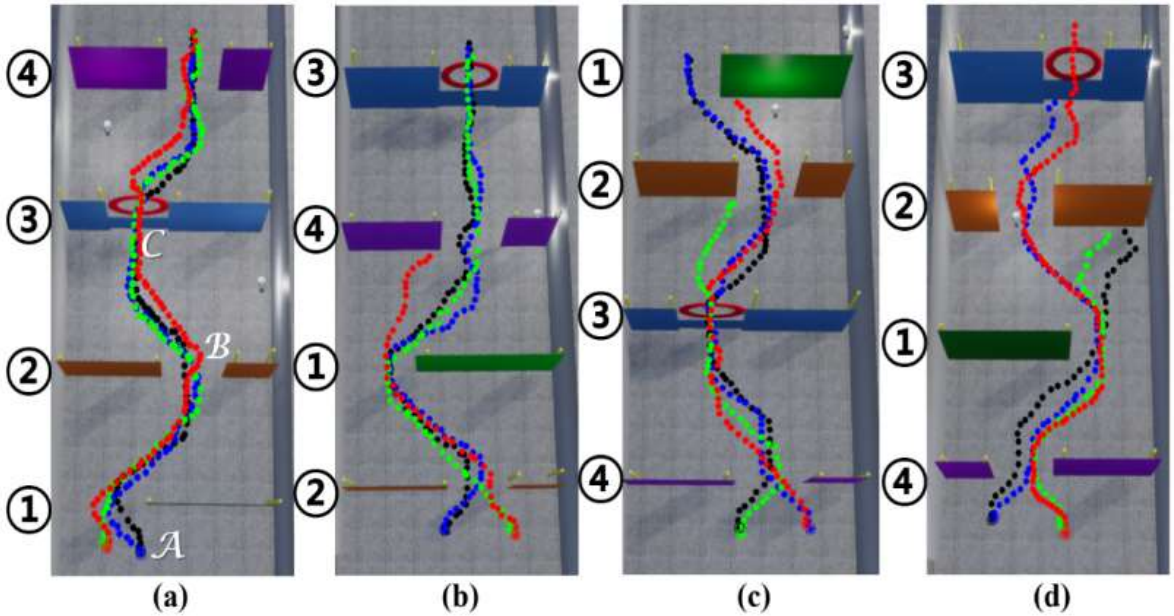
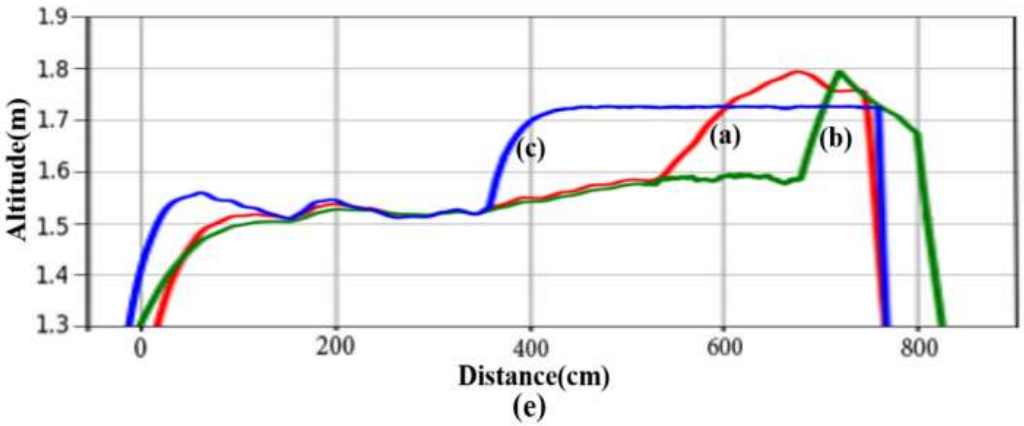
Experiment – Segmentation Map and Moving Direction



Experiment – Trajectory in Real Environments

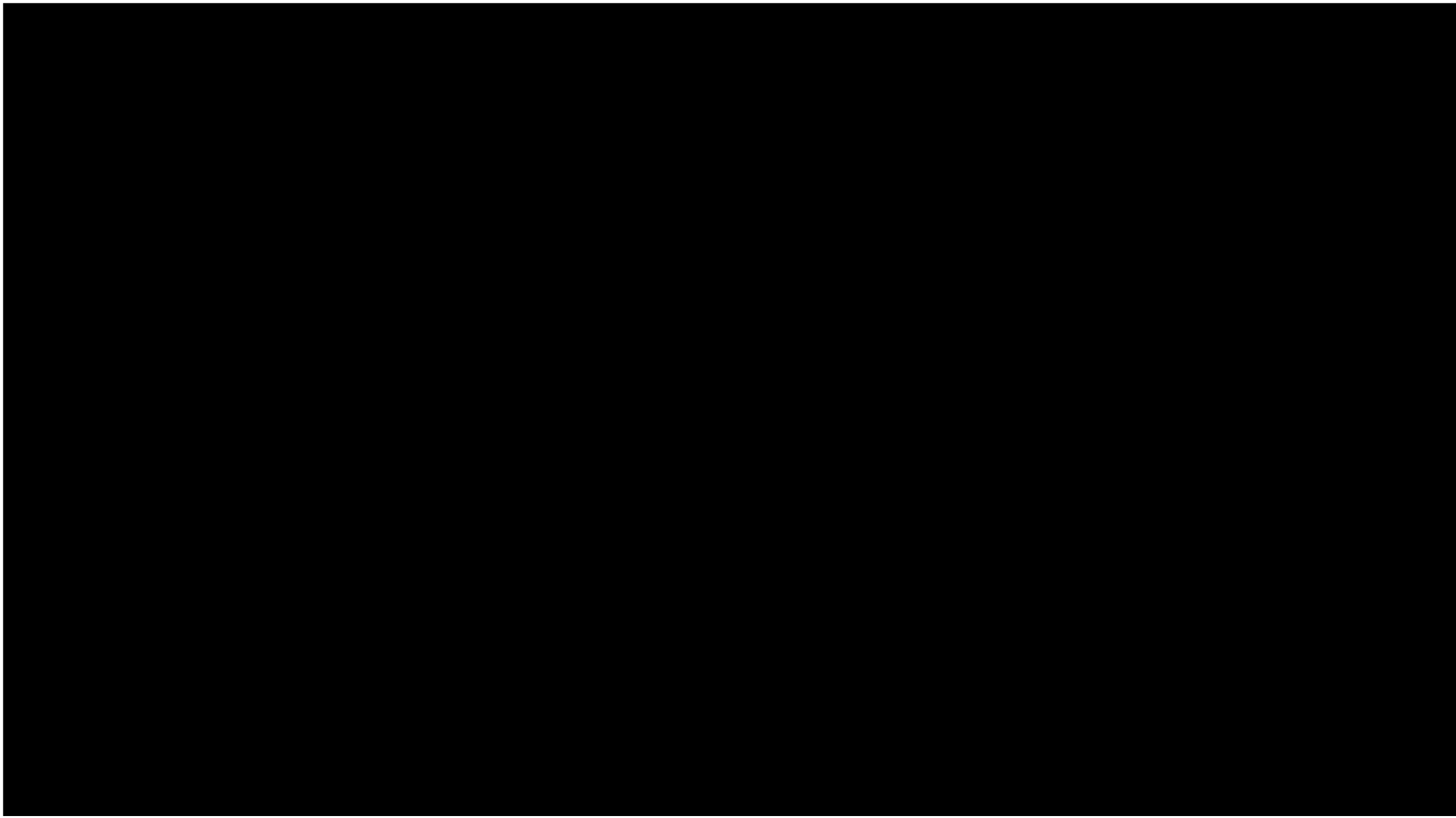
- Trajectories from Real Environment
- Parrot ROS Library
- Altitude control





Experiment – Success Ratio

Real Environments	Trials	Complete/Non-Complete
conf. 1 (Fig. 8a)	20	19/1
conf. 2 (Fig. 8b)	20	17/3
conf. 3 (Fig. 8c)	20	15/5
conf. 4 (Fig. 8d)	20	11/9



Conclusion

- Actor-Critic and U-Net for obstacle avoidance drone
- Cooperation between Neural Networks
- High dimensional data(Image) for Continuous case
- Segmentation network
- Reconfigured environments