

INTEL EDGE AI SW 8th

WAFFLE-FI

Wi-Fi Maintenance Robot

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문두르

조민재

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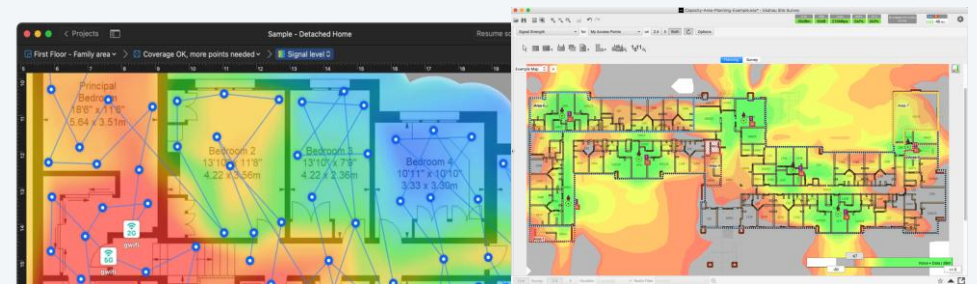
Conclusion

Project Overview

“건물 안에 Wi-Fi 안 터지는 곳이 있던데요?”

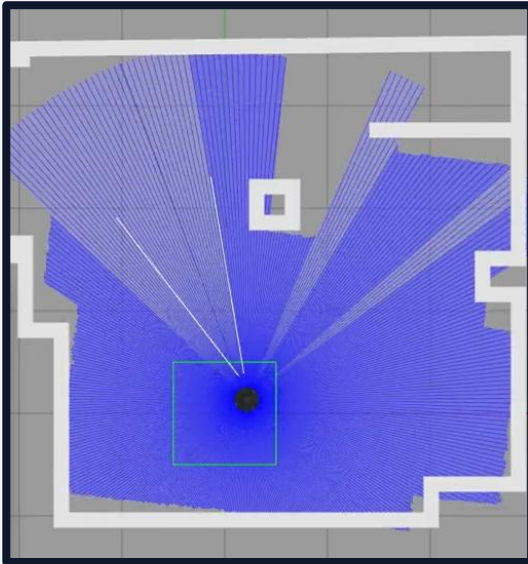


“AI Wi-Fi Maintenance Robot”



Project Objectives

RL 커버리지 탐색



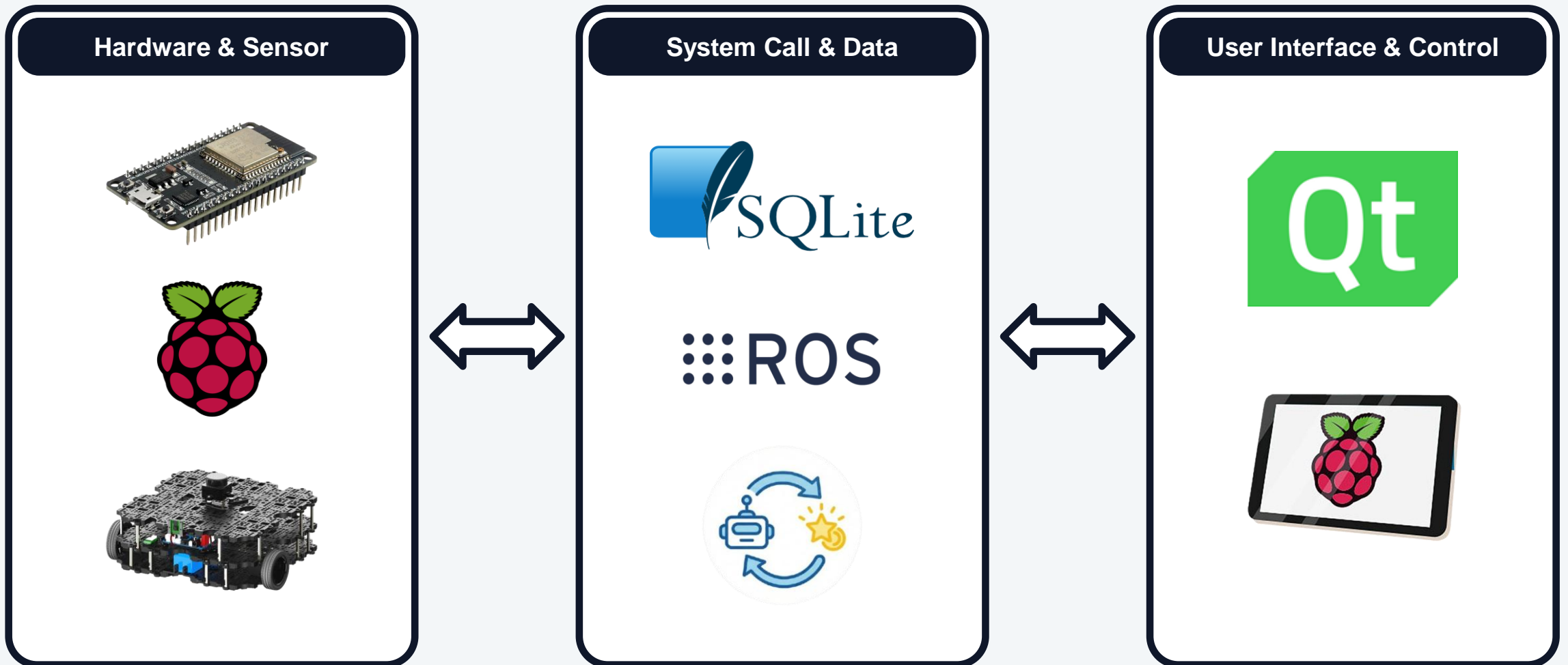
Wi-Fi AP 신호 측정

```
BEGIN
SSID:KCCI_STC_S,RSSI:-66
SSID:SK_WiFiGIGAFF4_2.4G,RSSI:-78
SSID:iotB,RSSI:-45
SSID:turtle-mesh,RSSI:-70
SSID:embA,RSSI:-42
SSID:sindo,RSSI:-69
SSID:TP-LINK_288610,RSSI:-73
END
```

Maintenance GUI

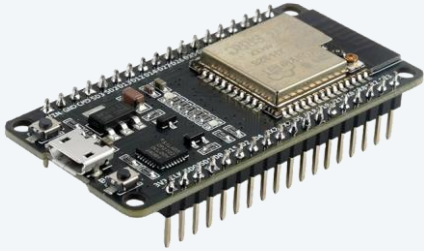


Project Architecture



Wi-Fi

»» ESP32

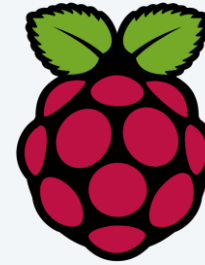


```
// Async Scan
WiFi.scanNetworks(/* ... */);
int n = WiFi.scanComplete();

// SSID + RSSI 전송
for (int i = 0; i < n; ++i) {
    String line = "SSID:" + WiFi.SSID(i)
        + ",RSSI:" + String(WiFi.RSSI(i))
        + "\n";
    print(line);
}
```

```
SSID:KCCI_STC_S,RSSI:-61
SSID:KCCI_STC_S,RSSI:-66
END
BEGIN
SSID:KCCI_STC_S,RSSI:-56
SSID:SK_5F3C_2.4G,RSSI:-79
SSID:iotB,RSSI:-40
SSID:KT_GiGA_2G_Wave2_A541,RSSI:-70
SSID:turtle-mesh,RSSI:-49
SSID:turtle-mesh,RSSI:-51
SSID:kcciedu_P_3F,RSSI:-81
SSID:embA,RSSI:-43
SSID:robotA,RSSI:-55
SSID:KCCI_STC_S,RSSI:-62
SSID:kcciedu_P_3F_New,RSSI:-66
SSID:[LG_FloorStand A/C]6694,RSSI:-85
END
BEGIN
SSID:KCCI_STC_S,RSSI:-55
SSID:SK_WiFiGIAFFF4_2.4G,RSSI:-83
```

UART



/dev/rssi_driver_table

```
Every 1.0s: cat /dev/rssi_driver_table_test

BEGIN
SSID:KCCI_STC_S,RSSI:-66
SSID:SK_WiFiGIAFFF4_2.4G,RSSI:-78
SSID:iotB,RSSI:-45
SSID:turtle-mesh,RSSI:-70
SSID:embA,RSSI:-42
SSID:sindo,RSSI:-69
SSID:TP-LINK_288610,RSSI:-73
END
```

Wi-Fi

» RSSI

Received Signal Strength Indication

무선 통신 기기가 수신하는 신호의 강도를 나타내는 지표

Signal Strength



Excellent

> -50 dBm



Good

-50 to -60 dBm



Fair

-60 to -70 dBm



Weak

< -70 dBm

$$\text{dBm} = 10 \log_{10} \left(\frac{P}{1\text{mW}} \right)$$

mW	dBm
1 mW	0 dBm
0.1 mW	-10 dBm
0.01 mW	-20 dBm
0.001 mW	-30 dBm
0.000000001 mW	-90 dBm

Reinforcement Learning

»» Concepts



Q

각 행동의 누적 보상 기대값 (점수)

Epsilon

탐험 비율 파라미터

DQN

DNN + Q Learning

DDQN

선택과 평가 분리

PER

Replay Buffer / Prioritized Experience Replay

PPO

Policy-Based / Proximal Policy Optimization

Reinforcement Learning

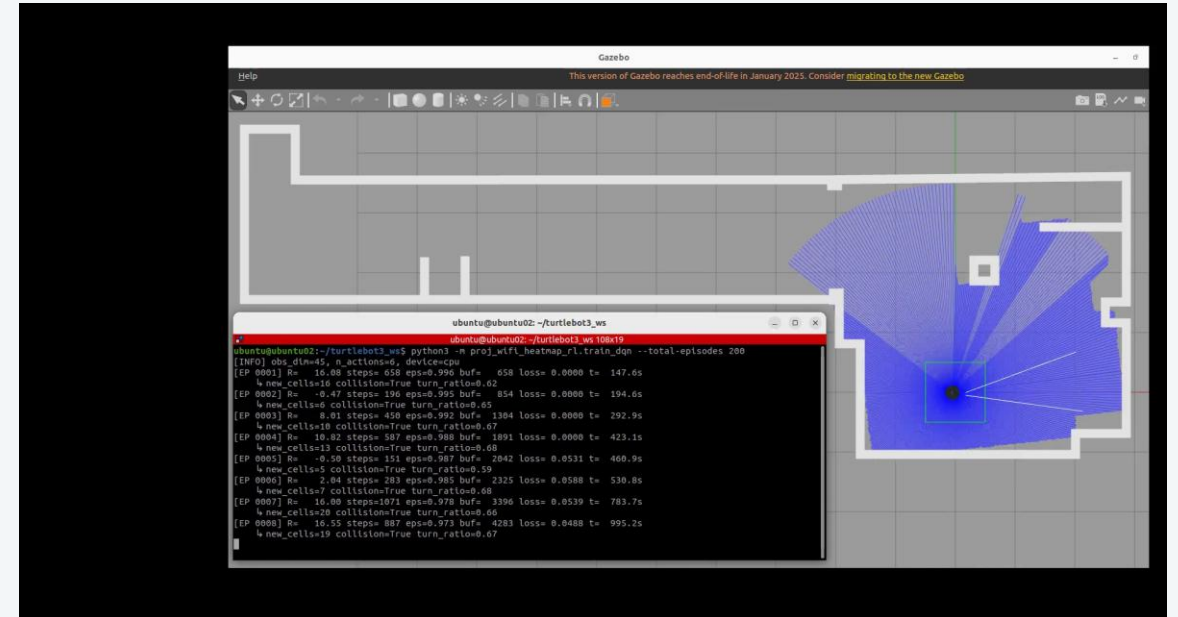
»» Reward Function + Training Video (1/3)

```
reward_new_cell: float = 2.0
reward_forward_after_turn: float = 0.05
reward_cov_progress: float = 0.5
reward_frontier: float = 0.05
penalty_step: float = -0.01
penalty_arc: float = -0.0
penalty_turn: float = -0.03
penalty_turn_streak: float = -0.1
penalty_standing: float = -0.03
penalty_near: float = -0.01
penalty_very_near: float = -0.04
penalty_collision: float = -10.0
```

새로운 지역 = 리워드

제자리 회전 = 페널티

숲을 보는 눈 = 리워드



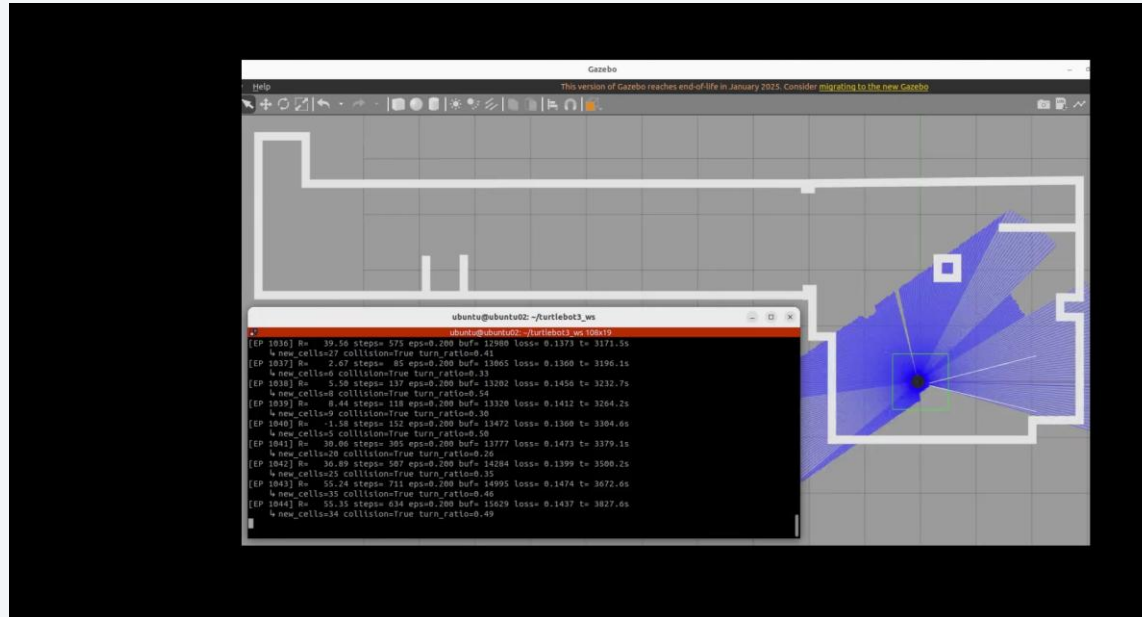
EP 1 ~ 50

50 EPs Avg Reward : 13.67

Turn Ratio : About 0.6

Reinforcement Learning

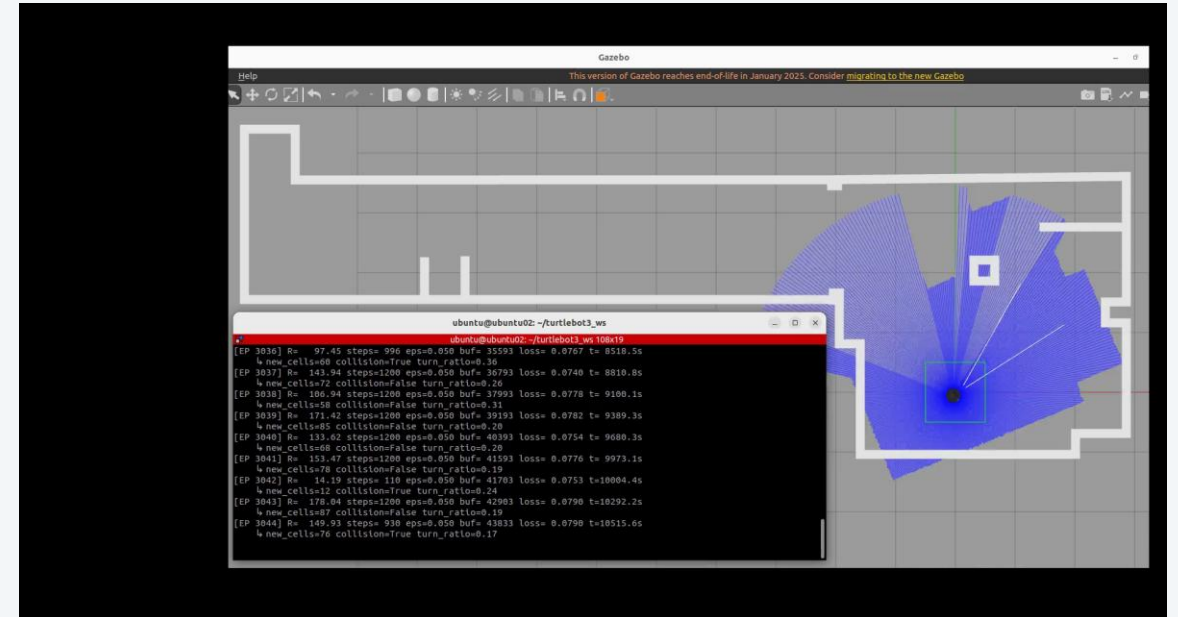
»» Training Video (2/3, 3/3)



EP 1001 ~ 1050

50 EPs Avg Reward : 51.89

Turn Ratio : About 0.3 ~ 0.5



EP 3001 ~ 3050

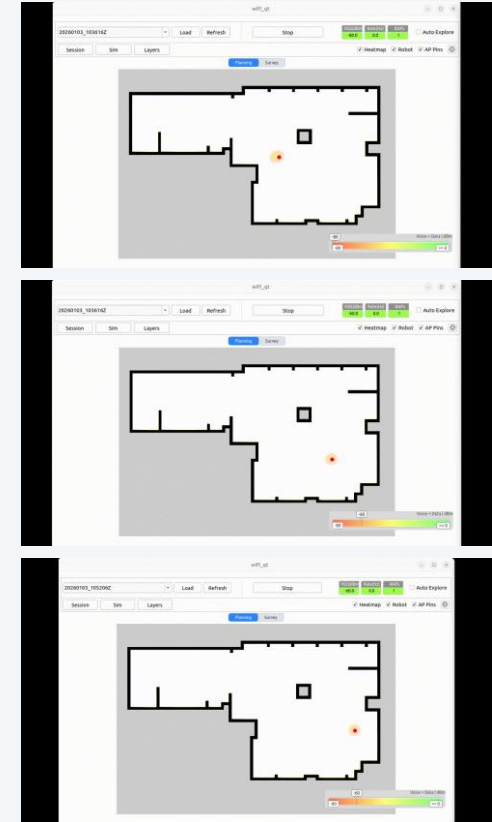
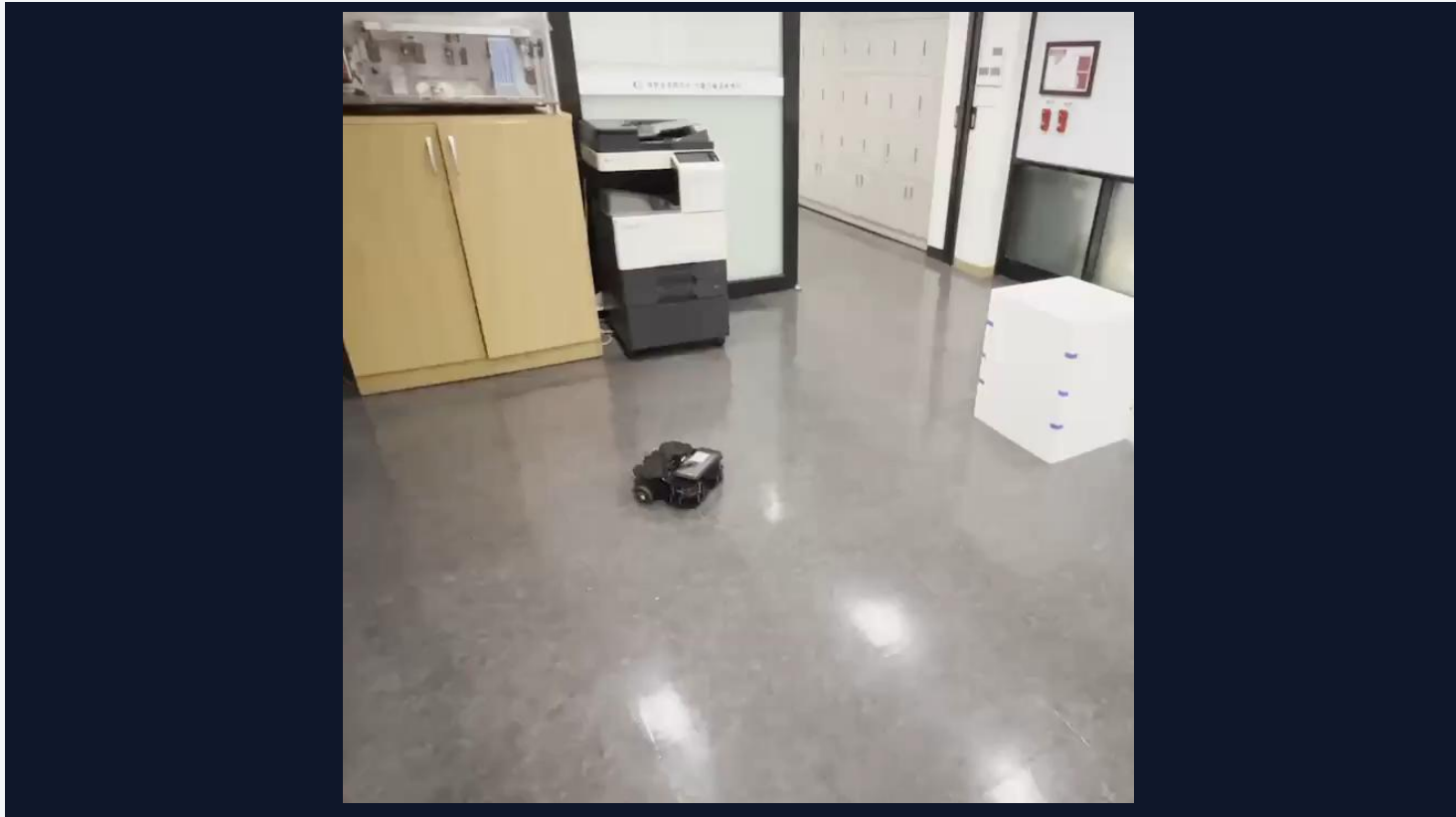
50 EPs Avg Reward : 144.57

50 Eps Avg New Cell : 73.36

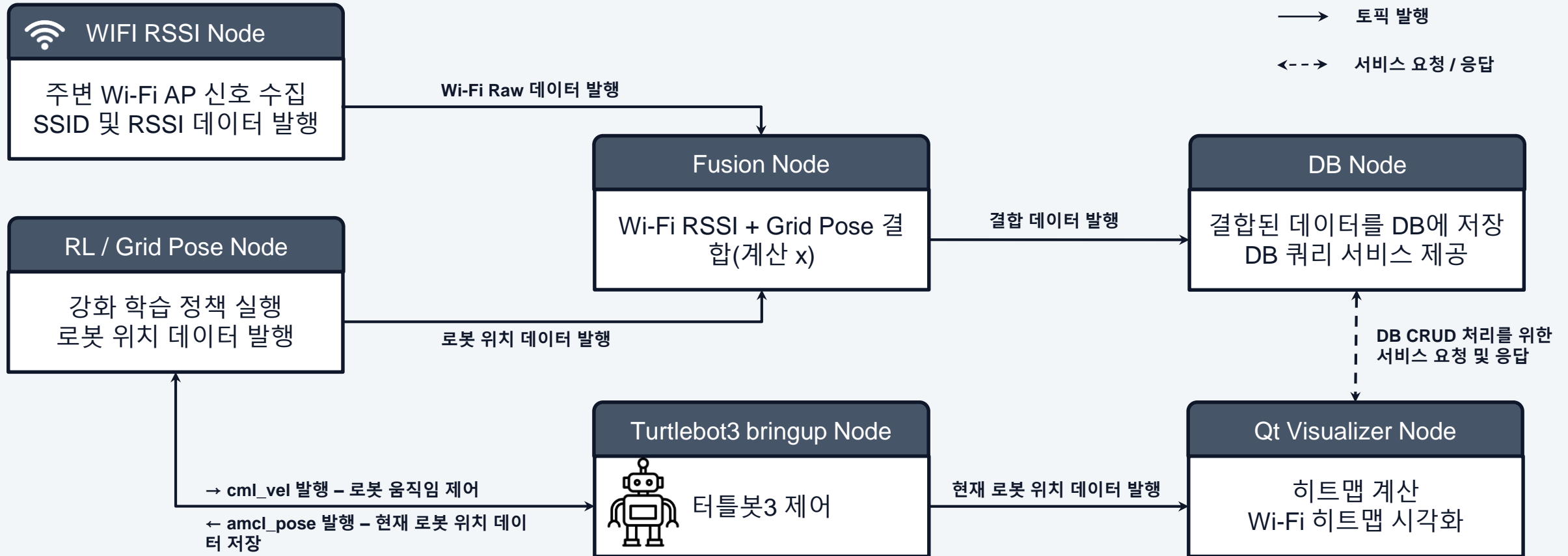
Turn Ratio : About 0.3

Reinforcement Learning

»» Driving Video



ROS



Qt GUI

»» Main

Main

Robot

Heatmap

Start : Create Session



Qt GUI

»» Session & SSID

Session

wifi_qt

20260103_110114Z
20260103_110114Z
20260103_105206Z
20260103_103616Z
20260103_103222Z
20260103_084948Z
20260103_084758Z
20260103_084625Z
20260103_084051Z
20260103_082830Z
20260103_065016Z

RSSI ≥ -40 dBm

Apply

Delete

Load Refresh

Planning Survey

SSID

wifi_qt

20260103_082830Z

Session Sim

Session (DB)

SSID

RSSI ≥

Ap

Delete

Refresh

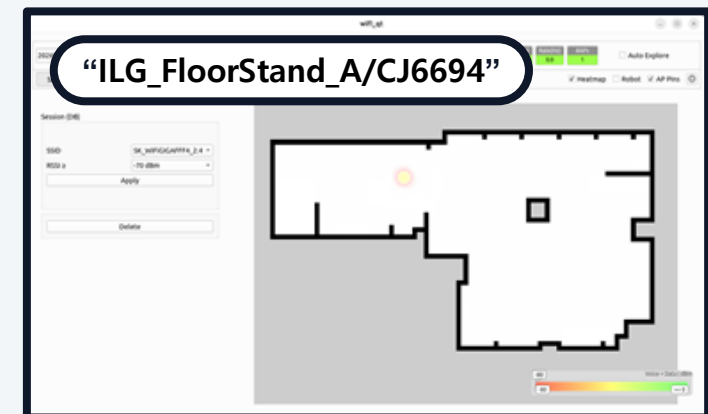
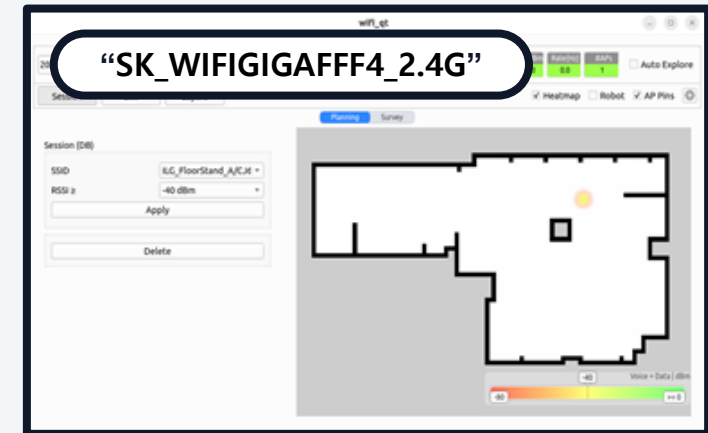
Planning

ALL
ILG_FloorStand_A/CJ6694
KCCI_STC_S
KT_GiGA_2G_Wave2_A541
SK_5F3C_2.4G
SK_WiFiGIGAFFF4_2.4G
TEST_AP
emba
iotB
kcciedu_P_3F
kcciedu_P_3F_New
robotA
sindo
turtle-mesh

Qt GUI

»» Session & SSID

SSID



Qt GUI

»» Simulation

Simulation

Custom AP



```

13:44:24.691 -> SSID:TP-LINK_28861D, RSSI: -73
13:44:24.724 -> SSID:SK_WiFiGIGADC08_2.4G, RSSI: -79
13:44:24.822 -> SSID:SK_WiFiGIGAF2A0_2.4G, RSSI: -79
13:44:25.079 -> SSID:KCCI_STC_S, RSSI: -69
13:44:25.079 -> SSID:KCCI_STC_S, RSSI: -70
13:44:25.079 -> SSID:kcciedu_P_3F_New, RSSI: -78
13:44:25.079 -> SSID:U+Net80CB, RSSI: -82
13:44:25.079 -> SSID:Barona, RSSI: -86
13:44:25.079 -> SSID:kcciedu_P_3F, RSSI: -89
13:44:25.079 -> SSID:[LG_CeilingCassette A/C]db2b, RSSI: -93
13:44:25.079 -> END
13:44:25.079 -> BEGIN

```

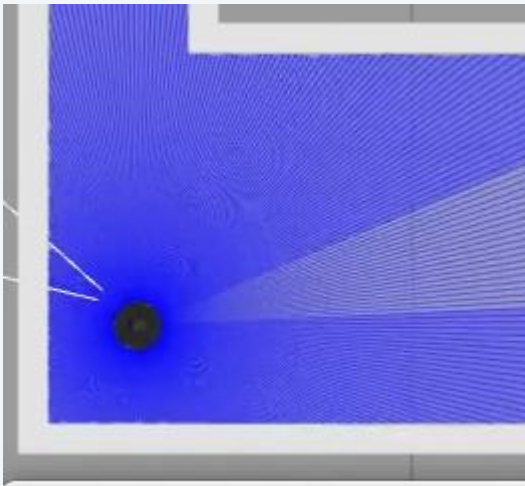
```
13:56:31.177 -> SSID:[LG_CeilingCassette A/C]db2b, RSSI:-86
13:56:31.177 -> SSID:Barona_2G, RSSI:-86
13:56:31.177 -> SSID:[LG_CeilingCassette A/C]bb10, RSSI:-87
13:56:31.177 -> SSID:[LG_CeilingCassette A/C]dafd, RSSI:-90
13:56:31.177 -> END
```

Troubleshooting

»» Reinforcement Learning

Issue

작은 충돌
제자리 회전 多



Cause

행동 4개 → 충돌을 회피할 행동 부족
리워드 및 페널티 불충분

```
# Action (4):  
# 0: forward, 1: left, 2: right, 3: stop
```

```
reward_new_cell: float = 2.0  
reward_forward_after_turn: float = 0.05  
  
penalty_step: float = -0.01  
penalty_arc: float = -0.0  
penalty_turn: float = -0.03  
  
penalty_standing: float = -0.03  
  
penalty_collision: float = -10.0
```

Solution

행동 4개 → 6개
충돌 근접 페널티 추가
회전 페널티 강하게 수정

```
Action (6):  
0: forward, 1: left-arc, 2: right-arc  
, 3: left-turn, 4: right-turn, 5: stop
```

```
reward_new_cell: float = 2.0  
reward_forward_after_turn: float = 0.05  
  
penalty_step: float = -0.01  
penalty_arc: float = -0.0  
penalty_turn: float = -0.03  
penalty_turn_streak: float = -0.1  
penalty_standing: float = -0.03  
penalty_near: float = -0.01  
penalty_very_near: float = -0.04  
penalty_collision: float = -10.0
```

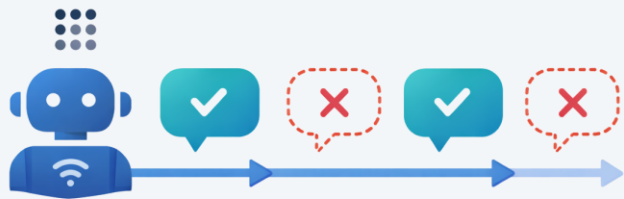
Troubleshooting

»» ROS

Issue

불규칙적인 토픽 메시지 손실
Publisher / Subscriber 비정상 동작

Irregular Topic Message Loss



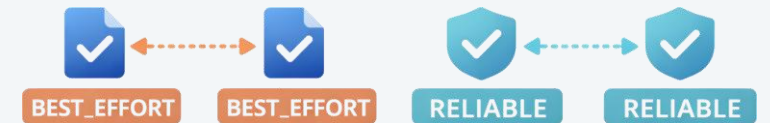
Cause

Publisher / Subscriber QoS 불일치
(RELIABLE / BEST_EFFORT)

```
QoS profile:
Reliability: RELIABLE
History (Depth): UNKNOWN
Durability: VOLATILE
Lifespan: Infinite
Deadline: Infinite
Liveliness: AUTOMATIC
Liveliness lease duration: Infinite
```

Solution

QoS 통일
센서류/고주기 데이터 : BEST_EFFORT
제어/중요 명령 : RELIABLE

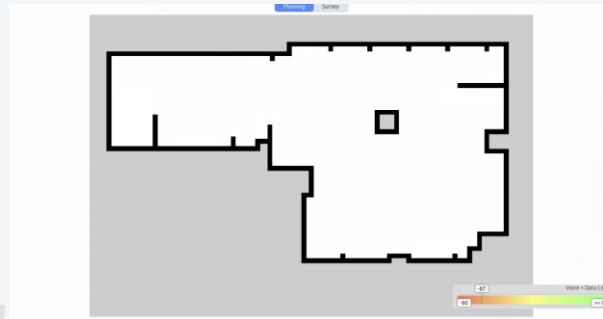
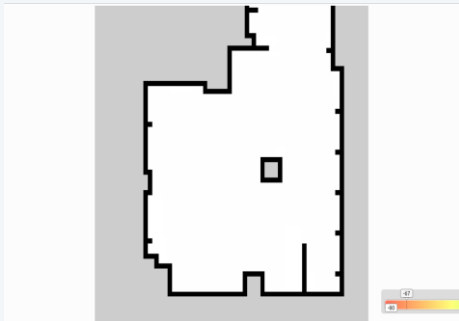


Troubleshooting

»» Qt GUI

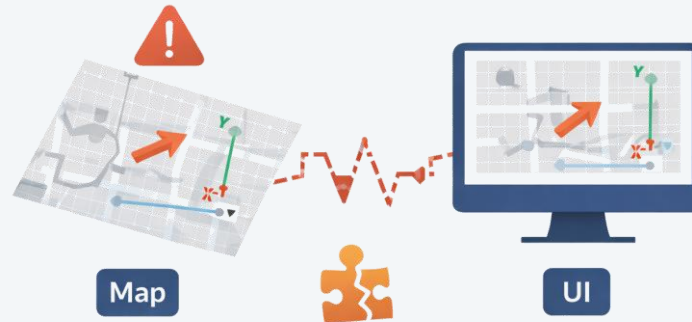
Issue

지도 회전 후
로봇 위치 손실
히트맵 손실



Cause

지도 회전 시 로직 상 오류로
좌표계 불일치 (맵 vs UI)



Solution

좌표계에 직접 회전 X
최종 렌더를 담당하는 View 만 회전



Meet the Team



김다현

Project Management
Qt GUI



나지훈

ROS
DB



문두르

Project Lead
Reinforcement Learning



조민재

ESP32 Firmware
Device Driver

THANKS

