

INTEL EDGE AI SW 8th

WAFFLE-FI

Wi-Fi Maintenance Robot

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문두르

조민재

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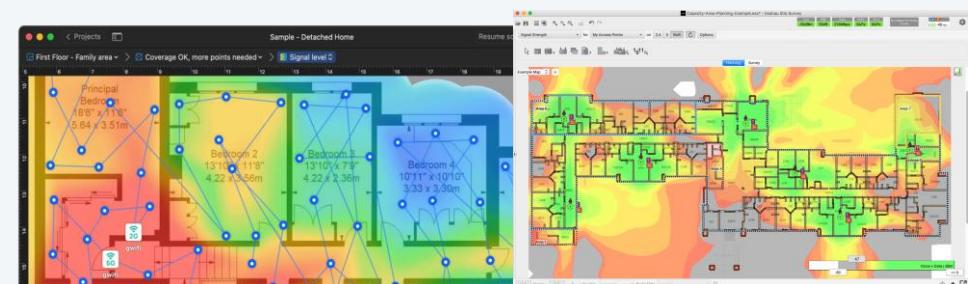
Conclusion

Project Overview

“건물 안에 Wi-Fi 안 터지는 곳이 있던데요?”

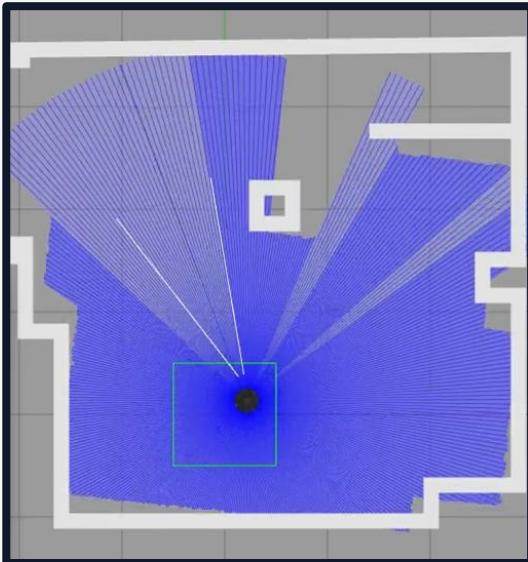


“AI Wi-Fi Maintenance Robot”



Project Objectives

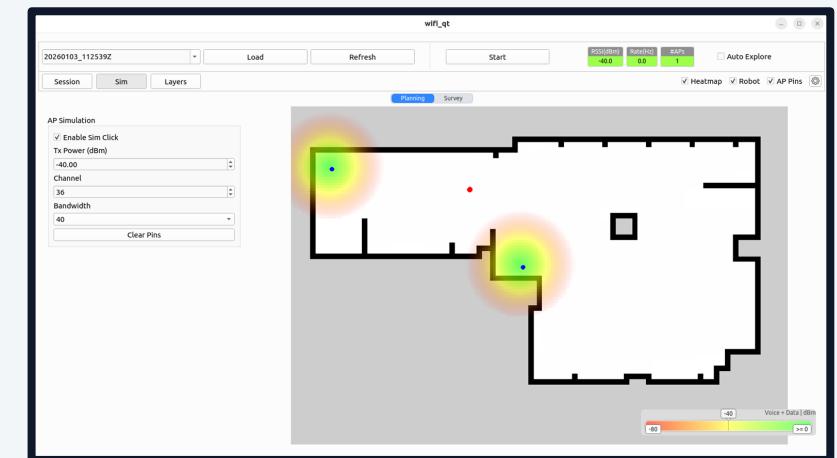
RL 커버리지 탐색



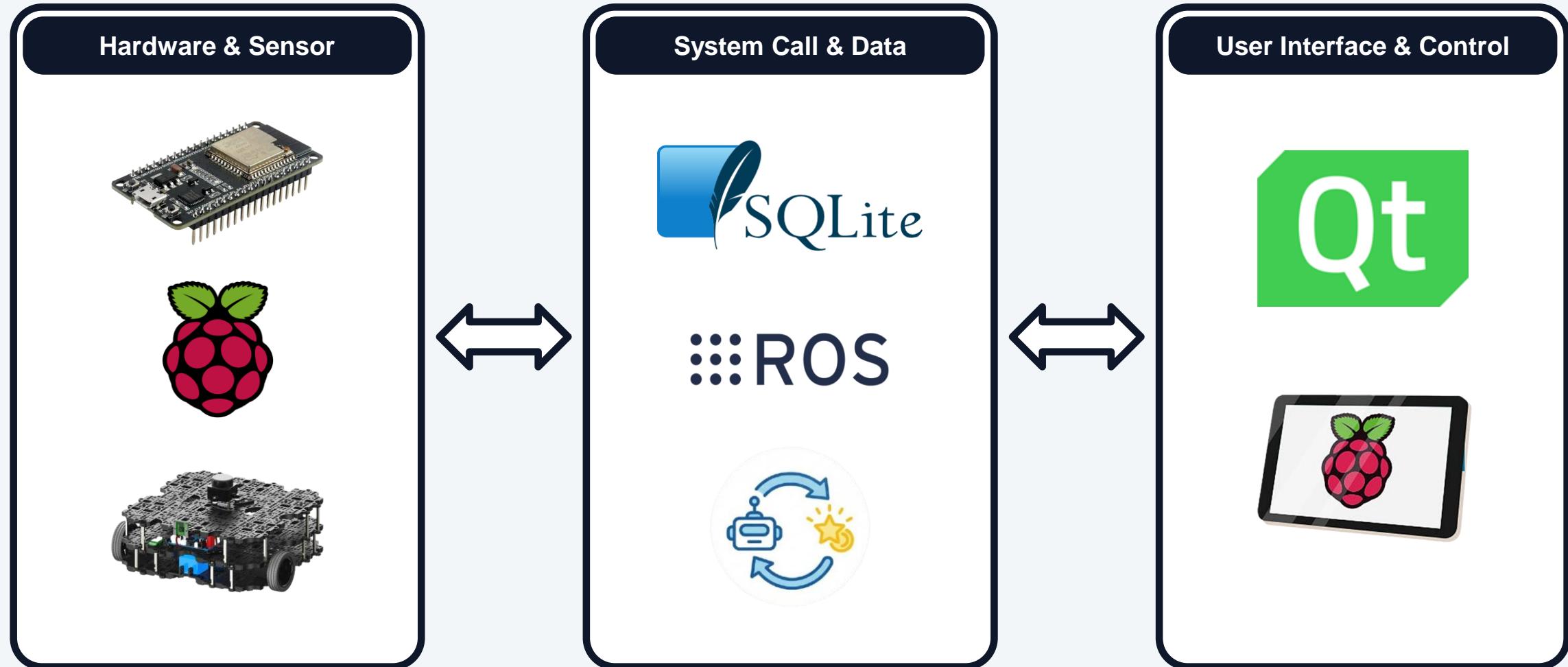
Wi-Fi AP 신호 측정

```
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

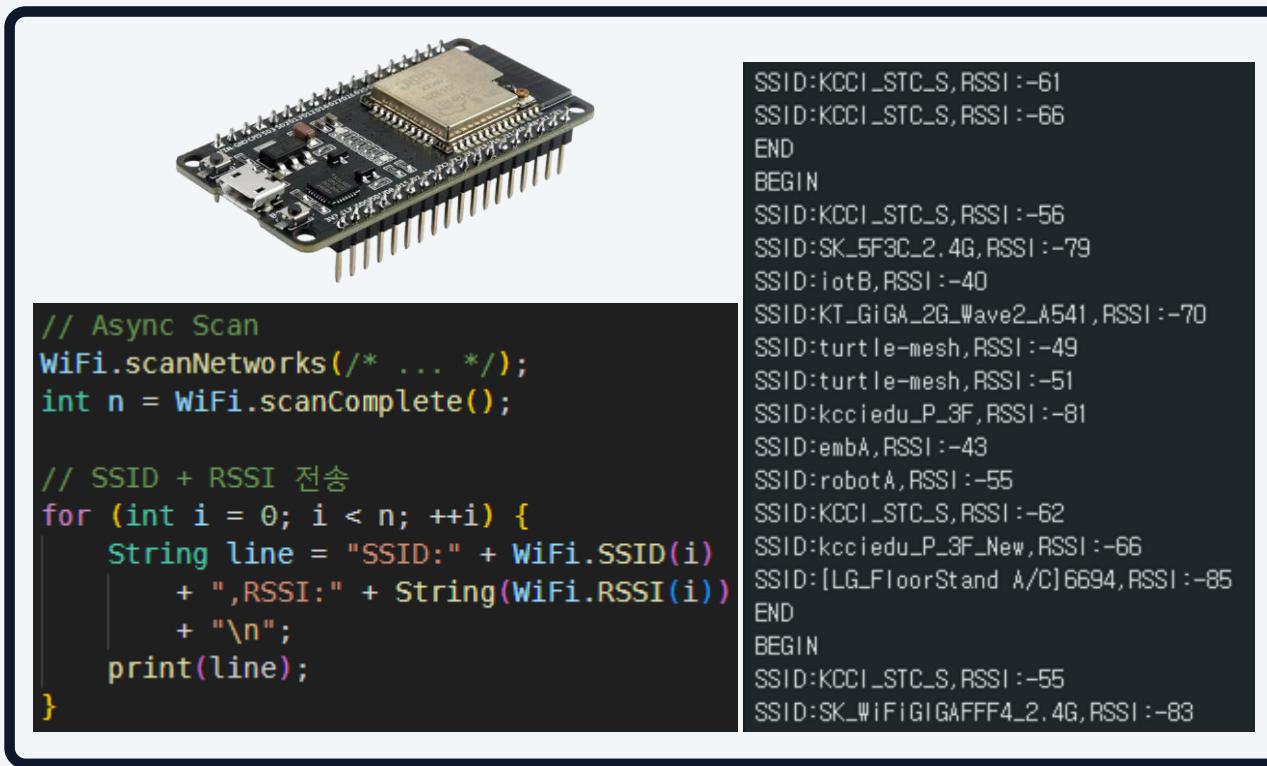


Project Architecture

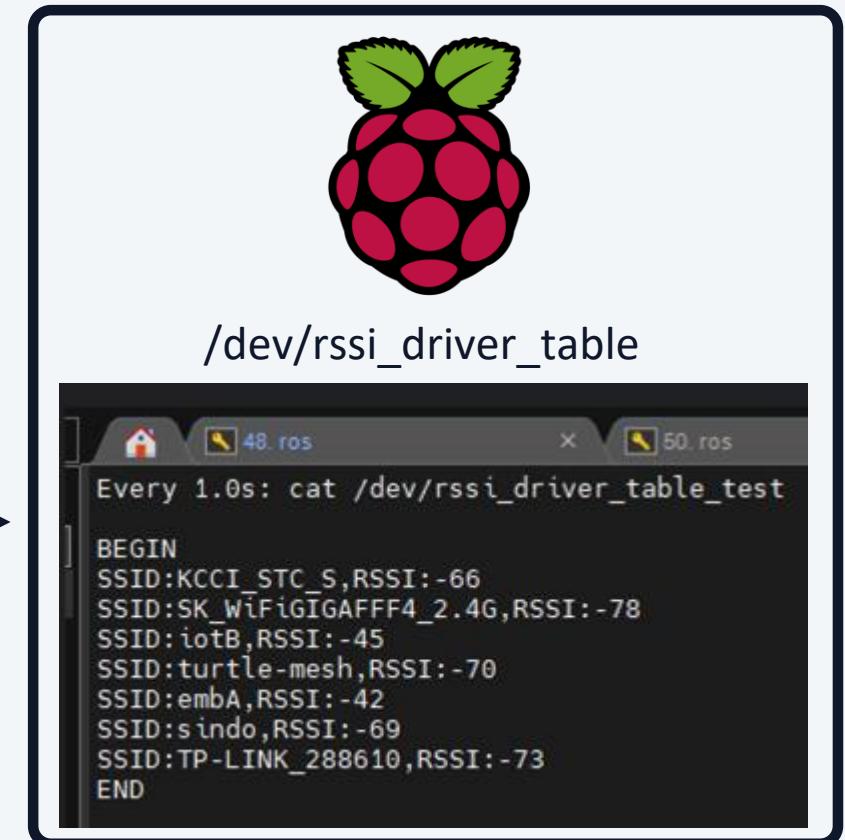


Wi-Fi

»» ESP32



UART



Wi-Fi

»» RSSI

Received Signal Strength Indication

무선 통신 기기가 수신하는 신호의 강도를 나타내는 지표



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

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

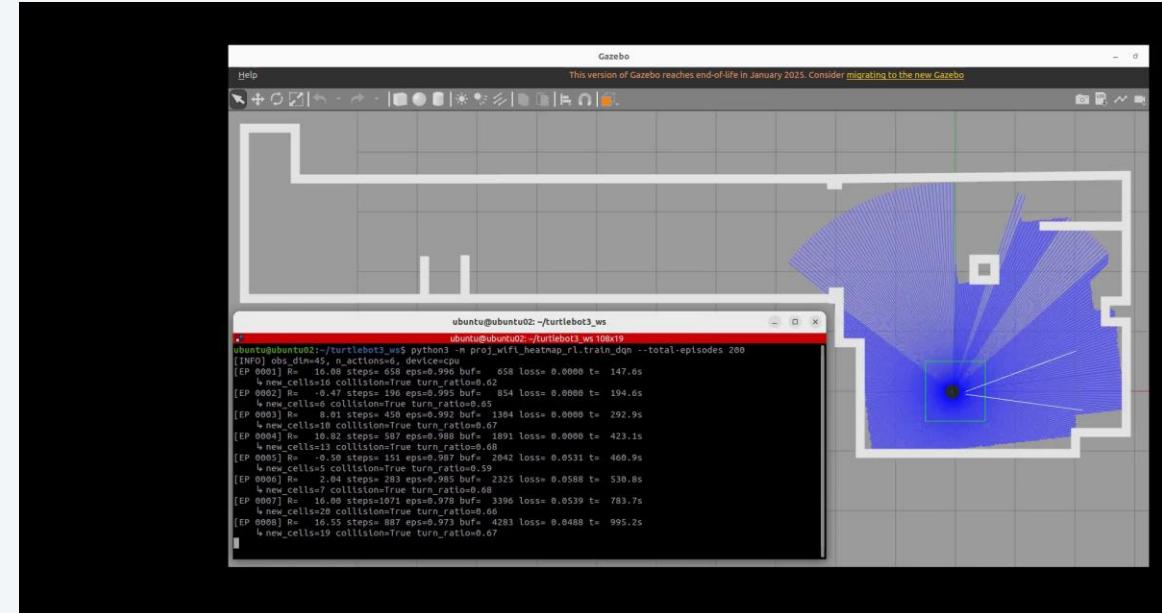
» Reward Function + Training Video (1/3)

```
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



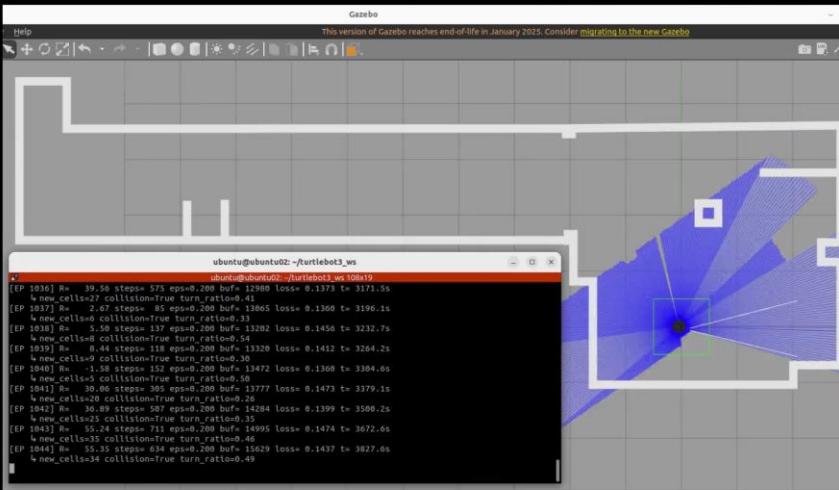
EP 1 ~ 50

50 EPs Avg Reward : 13.67

Turn Ratio : About 0.6

Reinforcement Learning

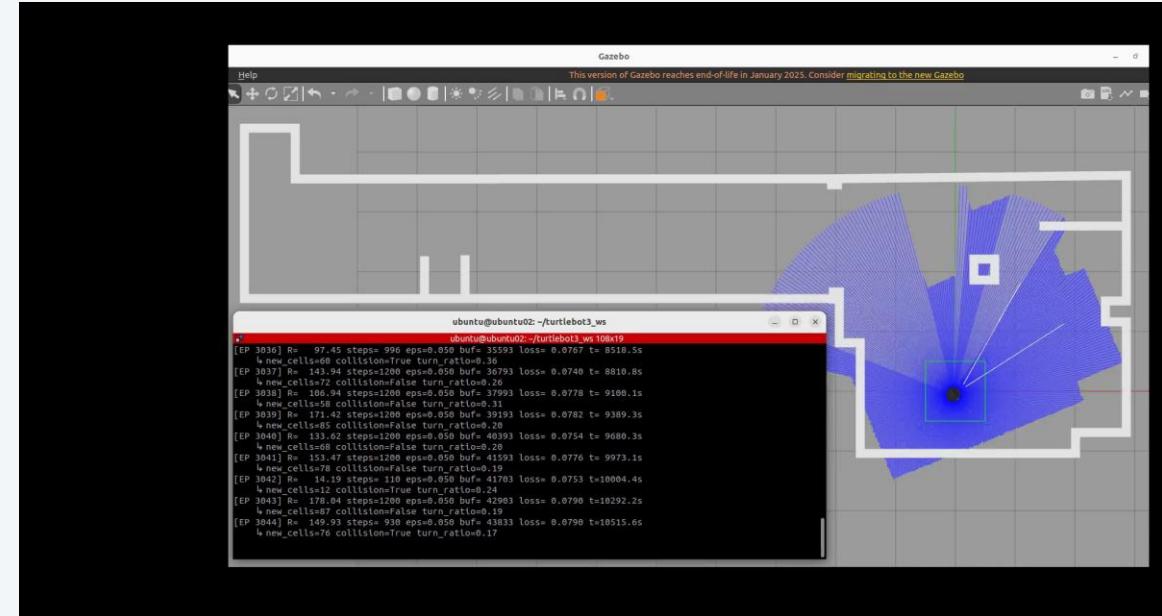
»» Training Video (2/3, 3/3)



EP 1001 ~ 1050

50 EPs Avg Reward : 51.89

Turn Ratio : About 0.3 ~ 0.5



EP 3001 ~ 3050

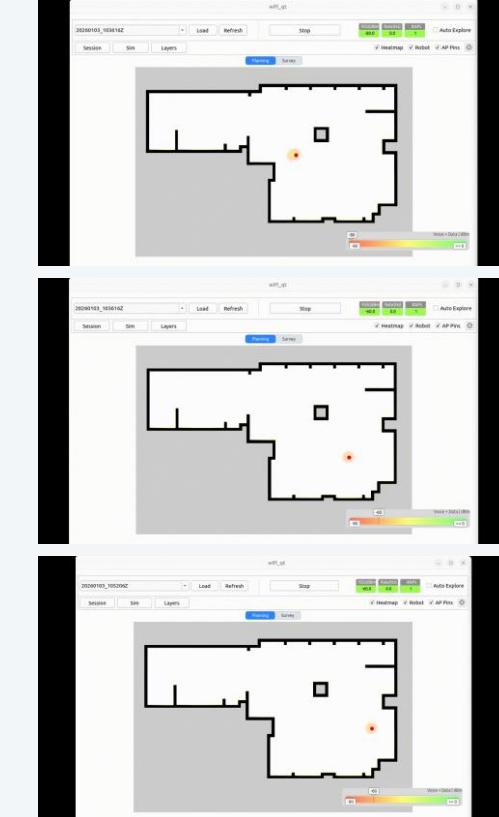
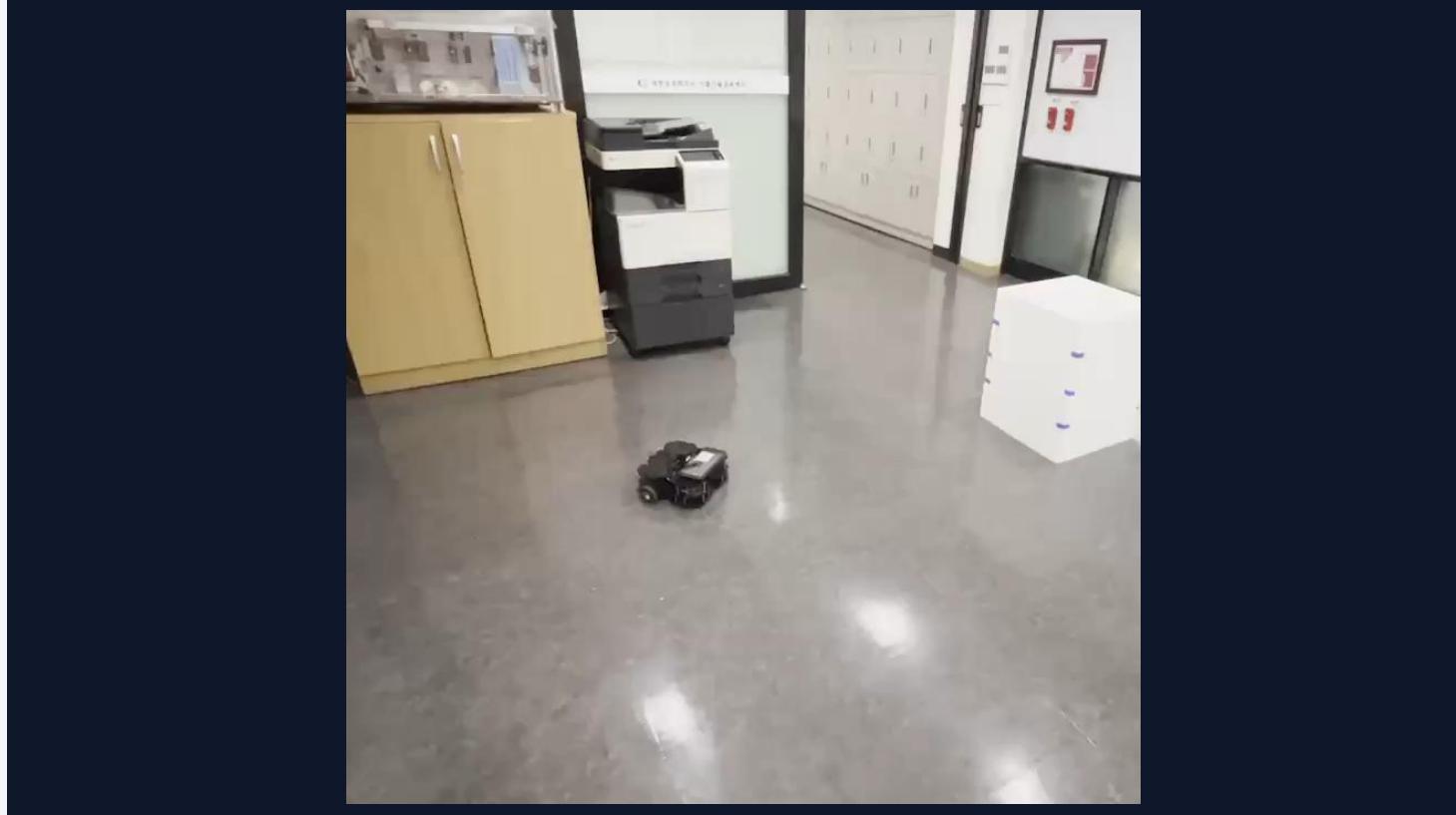
50 EPs Avg Reward : 144.57

50 Eps Avg New Cell : 73.36

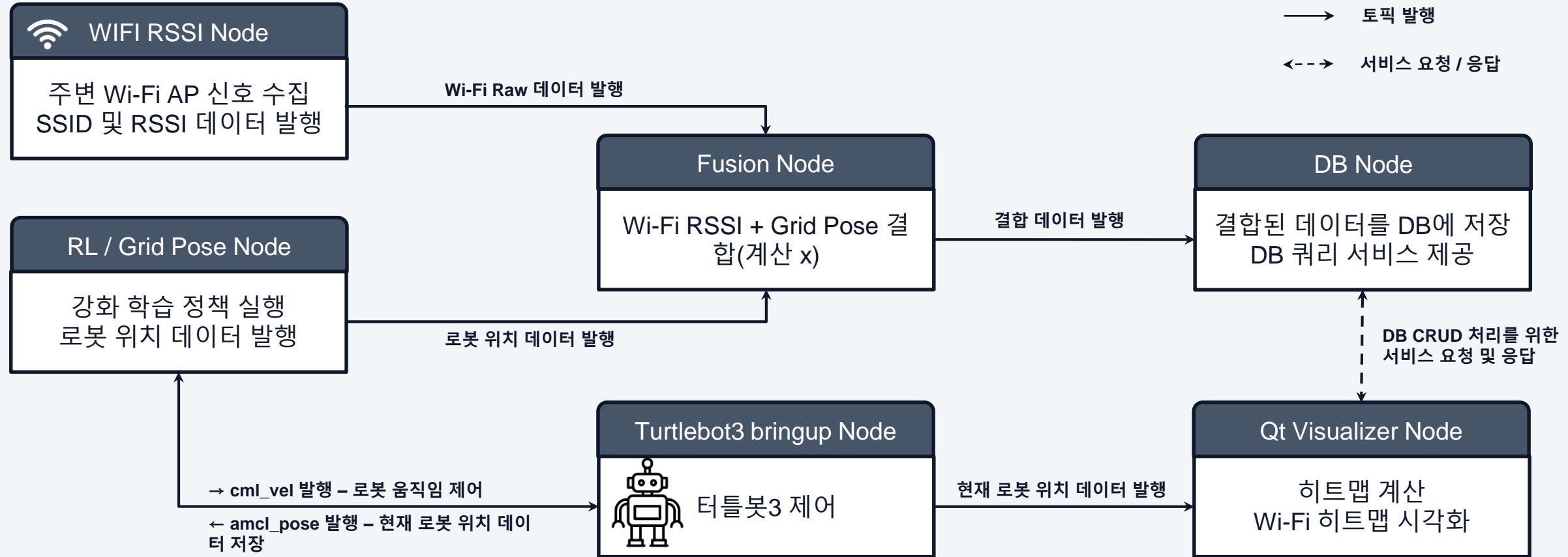
Turn Ratio : About 0.3

Reinforcement Learning

»» Driving Video

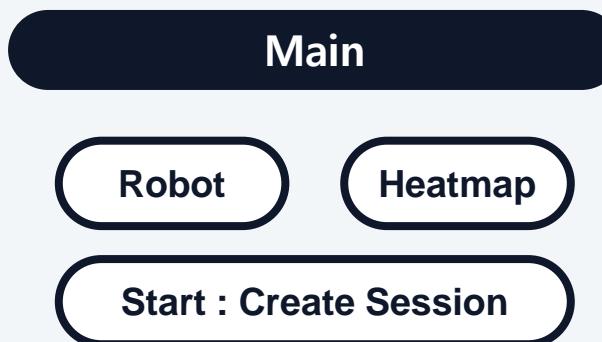


ROS



Qt GUI

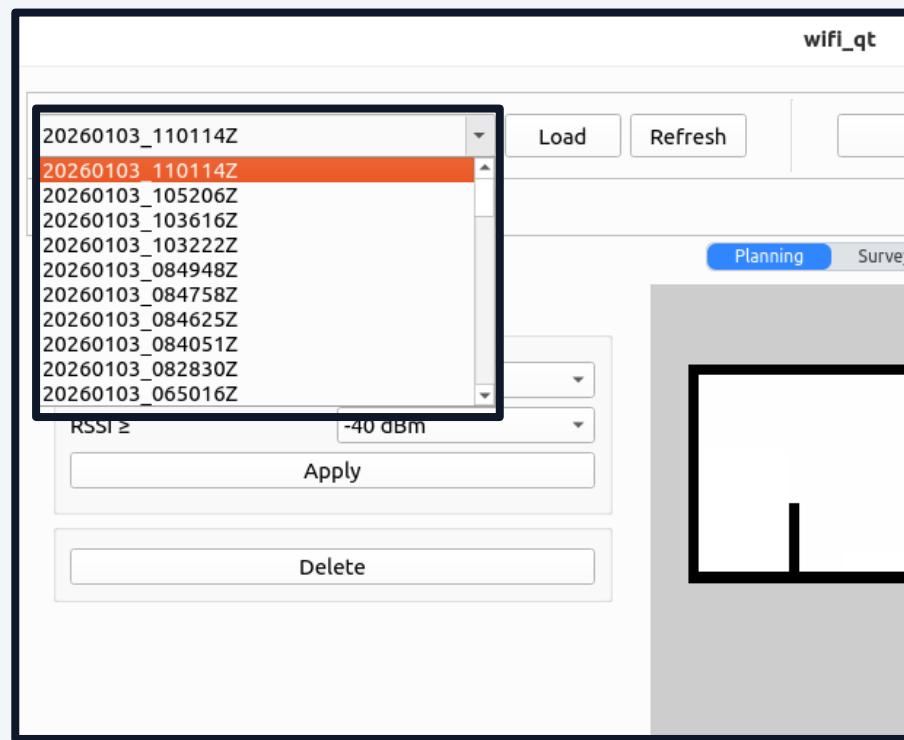
»» Main



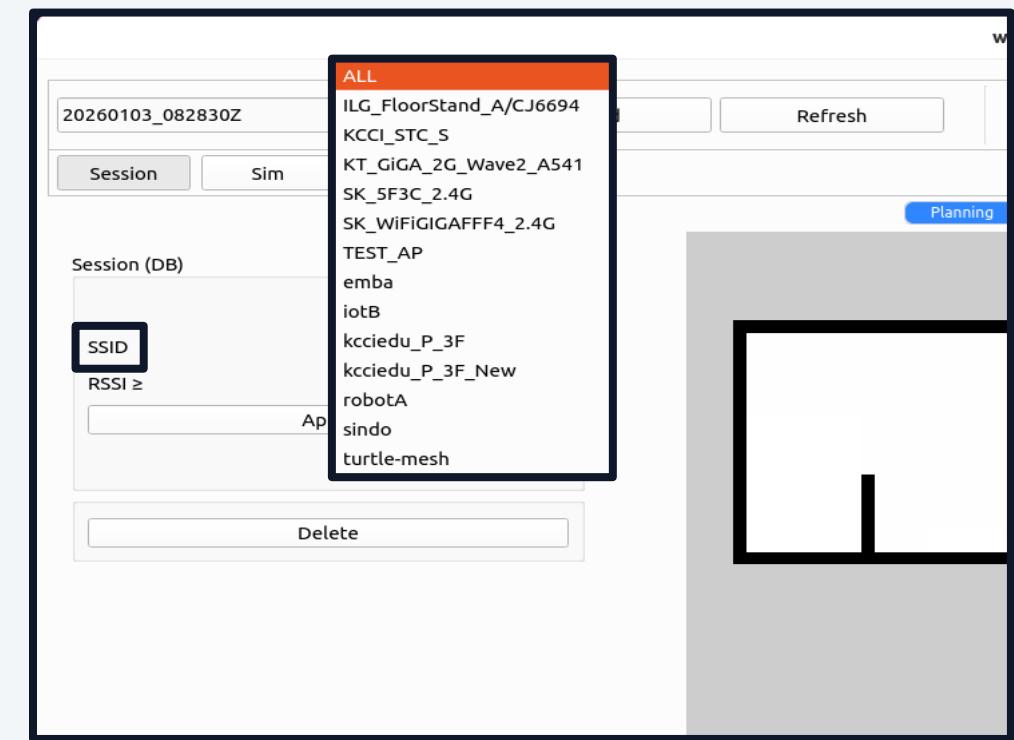
Qt GUI

»» Session & SSID

Session

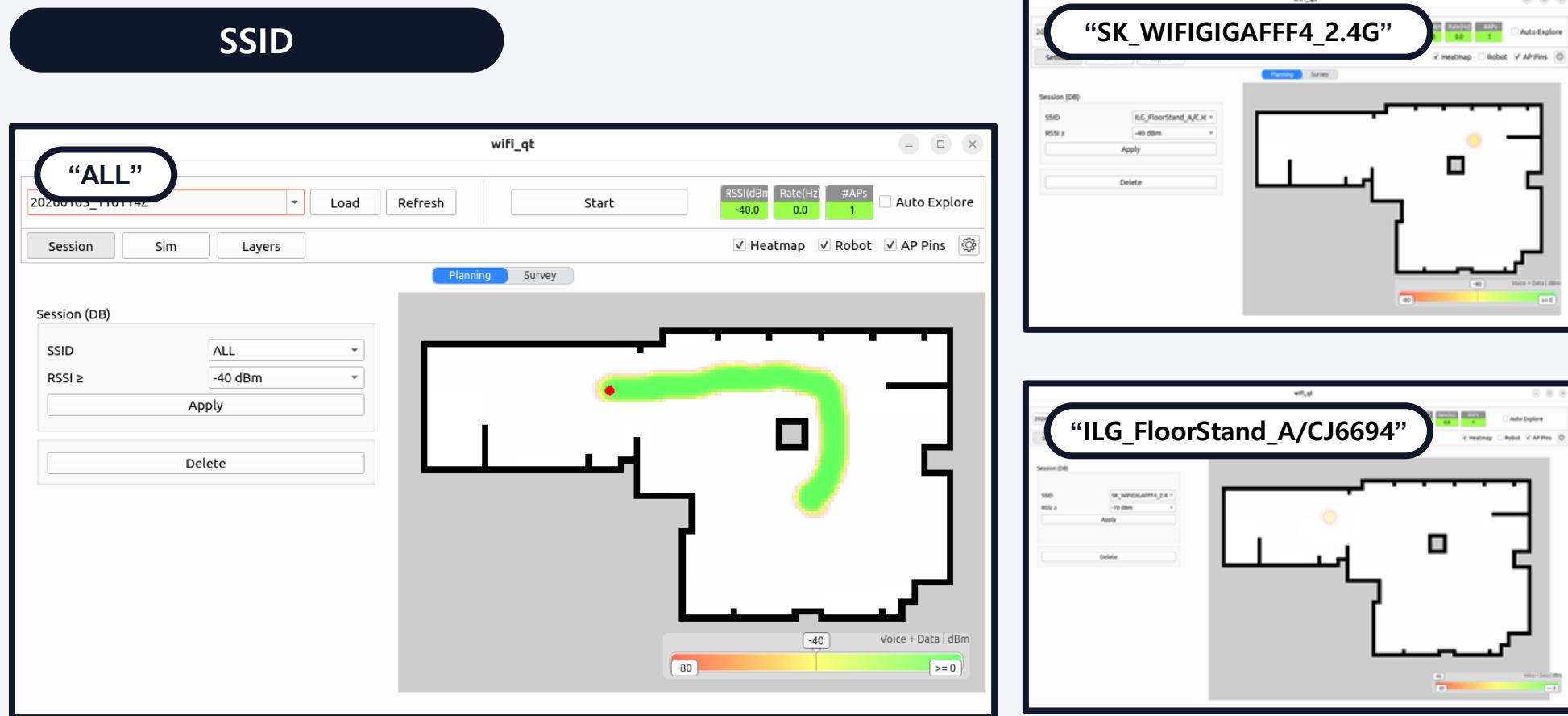


SSID



Qt GUI

»» Session & SSID



Qt GUI

»» Simulation

Simulation

Custom AP



Troubleshooting

»» ESP32

Issue

Wi-Fi 스캔 소요 시간 1.8s

```
13:44:23.295 -> END  
13:44:23.295 -> BEGIN  
13:44:23.423 -> SSID:KCCI_STC_S,RSSI:-46  
13:44:23.423 -> SSID:KCCI_STC_S,RSSI:-59  
13:44:23.423 -> SSID:KCCI_STC_S,RSSI:-72  
13:44:23.749 -> SSID:iotB,RSSI:-46
```

13:44:23.295 -> BEGIN

13:44:23.423 -> SSID:KCCI_STC_S,RSSI:-46

```
13:44:24.200 -> SSID:KCCI501,RSSI:-68  
13:44:24.200 -> SSID:robotA,RSSI:-69  
13:44:24.200 -> SSID:KCCI_STC_S,RSSI:-70  
13:44:24.200 -> SSID:kang_ap,RSSI:-74  
13:44:24.200 -> SSID:U+NetE70C,RSSI:-90  
13:44:24.200 -> SSID:sk,RSSI:-98  
13:44:24.332 -> SSID:U+Net9DE0,RSSI:-78  
13:44:24.332 -> SSID:SK_#IFI1GIGAF25B,RSSI:-87
```

13:44:25.079 -> SSID:[LG_CeilingCassette]

13:44:25.079 -> END

```
13:44:24.691 -> SSID:TP-LINK_288610,RSSI:-73  
13:44:24.724 -> SSID:SK_#IFI1GIGADOD8_2.4G,RSSI:-79  
13:44:24.822 -> SSID:SK_#IFI1GIGAF240_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+Net8CEB,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
```

Cause

불필요한 Wi-Fi 채널 스캔
소요 시간 ↑

```
--- Scan Finished: 30 networks found ---  
SSID:KCCI_STC_S,RSSI:-42, Ch:1  
SSID:embA,RSSI:-42, Ch:9  
SSID:iotB,RSSI:-45, Ch:3  
SSID:turtle-mesh,RSSI:-48, Ch:6  
SSID:KCCI_STC_S,RSSI:-52, Ch:11  
SSID:turtle-mesh,RSSI:-54, Ch:6  
SSID:robotA,RSSI:-57, Ch:11  
SSID:KCCI_STC_S,RSSI:-58, Ch:1  
SSID:sindo,RSSI:-58, Ch:9  
SSID:KCCI_STC_S,RSSI:-63, Ch:1  
SSID:KCCI_STC_S,RSSI:-63, Ch:6  
SSID:KCCI501,RSSI:-65, Ch:3  
SSID:KT_GiGA_2G_Wave2_A541,RSSI:-65, Ch:3
```

Solution

필요한 Wi-Fi 채널만 스캔

```
const int targetChannels[] = {1, 3, 6, 9, 11};
```

소요 시간 0.5s (- 1.3s)

```
13:56:30.627 -> BEGIN  
13:56:30.724 -> SSID:KCCI_STC_S,RSSI:-59  
13:56:30.724 -> SSID:SK_#F3C_2.4G,RSSI:-72  
13:56:30.724 -> SSID:KCCI_STC_S,RSSI:-74
```

13:56:30.627 -> BEGIN

13:56:30.724 -> SSID:KCCI_STC_S,RSSI:-59

```
13:56:30.853 -> SSID:iotB,RSSI:-47  
13:56:30.853 -> SSID:KT_GiGA_2G_Wave2_A541,RSSI:-64  
13:56:30.853 -> SSID:KT_GiGA_Mesh_94E3,RSSI:-88  
13:56:30.950 -> SSID:turtle-mesh,RSSI:-55  
13:56:30.950 -> SSID:robotA,RSSI:-65  
13:56:30.950 -> SSID:KCCI_STC_S,RSSI:-72  
13:56:30.950 -> SSID:kang_ap,RSSI:-76  
13:56:30.950 -> SSID:sk,RSSI:-93
```

13:56:31.177 -> SSID:[LG_CeilingCassette A/C]db2b,RSSI:-86

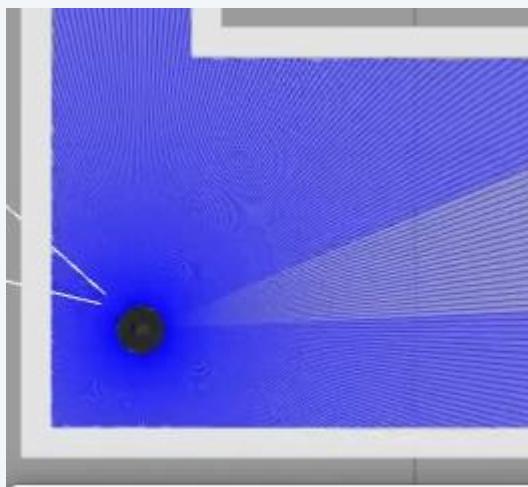
```
13:56:31.177 -> SSID:Barona_2G,RSSI:-86  
13:56:31.177 -> SSID:[LG_CeilingCassette A/C]bb10,RSSI:-87  
13:56:31.177 -> SSID:[LG_CeilingCassette A/C]dafd,RSSI:-90  
13:56:31.177 -> END
```

Troubleshooting

»» Reinforcement Learning

Issue

잦은 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
```

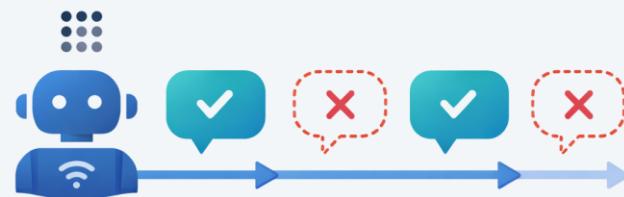
```
reward_new_cell: float = 2.0  
reward_forward_after_turn: float = 0.05  
  
penalty_step: float = -0.01  
penalty_arc: float = -0.0  
penalty_turn: float = -0.03  
penalty_turn_streak: float = -0.1  
penalty_standing: float = -0.03  
penalty_near: float = -0.01  
penalty_very_near: float = -0.04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

Troubleshooting

»» ROS

Issue

불규칙적인 토픽 메시지 손실
Publisher / Subscriber 비정상 동작



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

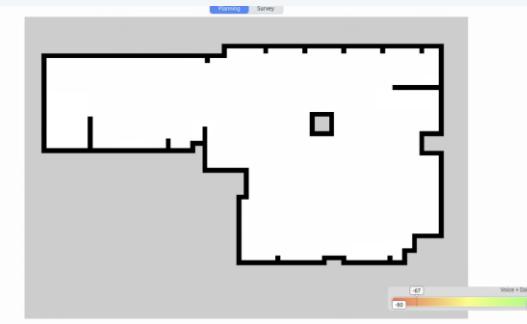
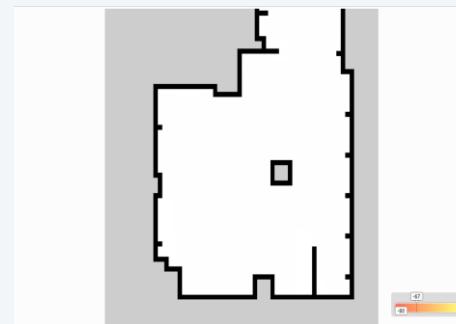


Troubleshooting

»» 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

