

Pokemon_RL

https://github.com/IMJeongseon/pokemon_RL

피카츄 / 120250351 조정선

■ 주제 선정 배경:

- 포켓몬 배틀은 텐제 전략 게임으로, 불완전한 정보(상대방의 남은 기술, 노력치 등)와 방대한 State Space를 가지고 있어 강화학습을 적용하기에 매우 도전적이고 흥미로운 환경임.
- pokemon-env와 pokemon-showdown을 활용하여 새로운 데이터와 환경을 이용한 강화학습 프레임워크 디자인을 목표로 함.
- Showdown의 BSS Reg I 규칙을 기준으로 해서 배틀 에이전트를 생성 (2마리의 전설의 포켓몬 사용 가능)
이는 실제 포켓몬 게임에서 현 시각 (2025.12.06) 기준 공식으로 사용하는 룰임

■ 최적화 목표:

- 에이전트가 포켓몬 배틀에서 승률을 극대화하는 최적의 전략(Policy)을 학습하는 것
- 단순한 데미지 계산을 넘어, 교체 플레이이나 상태 이상 활용 등 전략적 판단을 수행하도록 유도함.



■ 환경(Environment)

- Simulator: Pokemon>Showdown (오픈소스 포켓몬 배틀 시뮬레이터)
- Interface: pokemon-env (Gymnasium/Gym interface 호환)
- pokemon-env: <https://github.com/hsahovic/poke-env>
- pokemon-showdown: <https://github.com/smogon/pokemon-showdown>

■ 데이터 전처리 (Preprocessing):

- 입력 데이터: 배틀 로그(Text/JSON) 및 현재 화면 정보.
- Feature Engineering:
 - 아군/적군 포켓몬의 정보 (HP, Type, Status Condition, Stat boosts).
 - 날씨(Weather) 및 필드(Terrain) 상태.
 - 기술(Move) 정보 (Type, Power, Accuracy).

■ Active Pkm

- 나의 행동 + 상대방의 행동 (중요 정보: HP 비율, HP/Atk/Def/SpA/SpD/Spe, 랭크상태 등)
- On-hot encoding으로 인한 다른 것들 (도구 소유 여부, 테라스탈, 기절, 졸음, 상태이상 등)

■ Move Information

- 4가지 기술 × 4가지 정보 (기술 위력, 명중, PP, 타입상성배수)

■ Team & Bench Information

- Team Summary: 생존포켓몬/기절포켓몬 비율 + 아군/적군 수적 우위 등
- Bench Details: 벤치에 있는 포켓몬의 HP, 상태이상, 기절여부 등

■ Global Information

- 현재 턴 수, 날씨, 필드, 함정, 벽, 순풍 등

■ Goal

- 나와 상대방의 상태에 대한 정보를 최대한 많이 반영하도록
- 현재 턴의 배틀 상황 뿐만 아니라 벤치상황, 날씨, 장판 등을 모두 포함하여 Long-term Strategy 수립 가능

■ Action Space

- Type: Discrete Action Space (Size = 10)
- Moves (0~3): 기본 기술 사용
- Tera + Moves (4~7): 테라스탈 발동 후 기술 사용
- Switching (8~9): bench의 포켓몬으로 교체 (Slot 0, 1)

■ Action Masking

- 기본 규칙 마스킹:
 - 현재 사용이 불가능한 기술 (구애 도구 소유, PP 0, 봉인, 트집 등)
 - 테라스탈을 이미 발동함 → 더이상의 테라스탈은 불가능 : 테라스탈 마스킹
 - 교체 마스킹: 포켓몬이 쓰러졌을 경우
- 휴리스틱 마스킹:
 - 중복 설치 방지 (스텔스록이 깔려있는데 또 스텔스록을 쓰지 않도록)
 - 중복 상태이상 방지 (상대방이 마비 상태인데 상태이상을 또다시 걸지 않도록)
→ Search Space를 효율적으로 줄여 불필요한 행동을 하지 않도록 방지함

■ Core Objectives

- Terminal Reward: Win +100 / Lose -100
- 상대 포켓몬 KO 시: +5, 공격 시 데미지의 × 1.5, 피격시 × 1.0 → 방어보단 공격을 유도하도록

■ Strategic Incentives

- 장판기 설치시 reward 보상 → 장판플레이 유도
- Rank 상황에 따라서 reward를 보상. 단 랭크 상태에 따라서 효율이 달라지기 단계적으로 reward를 부여
 - 장판기, 랭크에 대해서 reward를 따로 관리 → 장판 초기화 및 랭크 초기화 시 장판/랭크에 대한 reward를 쉽게 초기화 할 수 있음
- 무효화 reward: 교체 및 테라스탈로 상대의 기술을 무효로 받아낼 시 reward 부여 → 교체나 테라스탈의 빈도 증가
- 하품 방지: “졸음”상태에서 교체시 reward 부여 → 하품 맞고 잠드는 것 방지

■ Penalties

- Turn Costs: 의미 없는 턴 끌기를 위한 매 턴 -0.05의 reward
- 효과가 없는 기술 사용 시 -2 penalty 부여 → 위력이 없는 기술을 사용하지 않도록
- Risky Rank boost: 체력이 없는 상황에선 무리한 랭크업/다운보다는 공격을 유도
- Yawn sleep: 하품을 맞고 잠들었을 시 패널티 부여

$$R_{total} = R_{basic} + \sum (R_{strategic} + R_{tactic} + R_{penalty})$$

■ Maskable PPO

- Library: sb3_contrib
- 포켓몬 배틀은 상황에 따라 불가능한 행동(기절한 포켓몬 교체, PP 없는 기술 등)이 빈번함
- 일반 PPO는 불가능한 행동을 선택하고 패널티를 받으며 배우지만,
Maskable PPO는 신경망 단계에서 invalid 행동의 확률을 0으로 만들어 **Valid Action만 학습하도록 보장함.**

■ Network

- Input Layer: 164차원 Observation Vector
- Shared Hidden Layers: MLP
 - Structure: [256, 256] neurons
 - Activation Functions: tanh (SB3 Default)
- Output Heads: 10차원 discrete actions (with Masking)

■ Training Strategy

- Self-Play Mechanism:
 - 고정된 상대가 아닌 “과거의 나”를 상대로 학습
- Update Frequency: 매 10,000 step마다 상대 모델을 최신 버전으로 갱신
- Effect: 학습이 진행될수록 상대도 강해지기에, 에이전트가 점진적으로 고도화된 전략을 습득함

Hyper Parameter

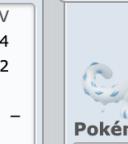
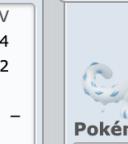
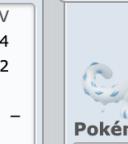
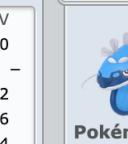
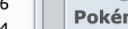
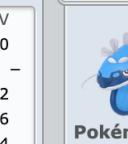
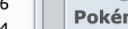
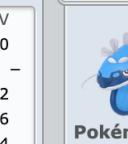
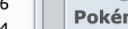
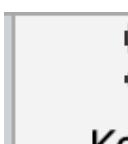
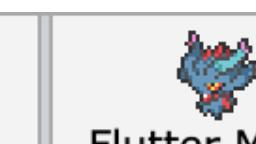
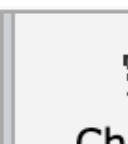
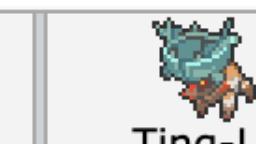
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Parameter	Value	Description
Total Timesteps	500,000	총 학습 스텝 수
Learning Rate	2e-4	학습률
Batch Size	64	업데이트 배치 크기
n_steps (Rollout)	2,048	한 번의 업데이트를 위해 수집하는 step의 길이
Gamma	0.99	할인율 (미래 보상의 가치)
Entropy Coef	0.01	탐험(Exploration) 유도를 위한 엔트로피 계수

Experiments

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■ My Team

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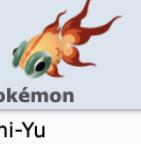
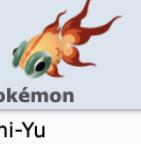
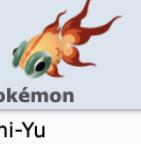
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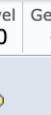
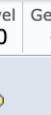
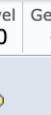
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▪ Results

- 학습된 파티 그대로 + 상대 에이전트는 학습 X (Random 행동)
- 상대방의 파티는 Enemy 1, 2, 3 중 단 하나
- 1000번 중 909승을 달성하며 90.9%의 승률

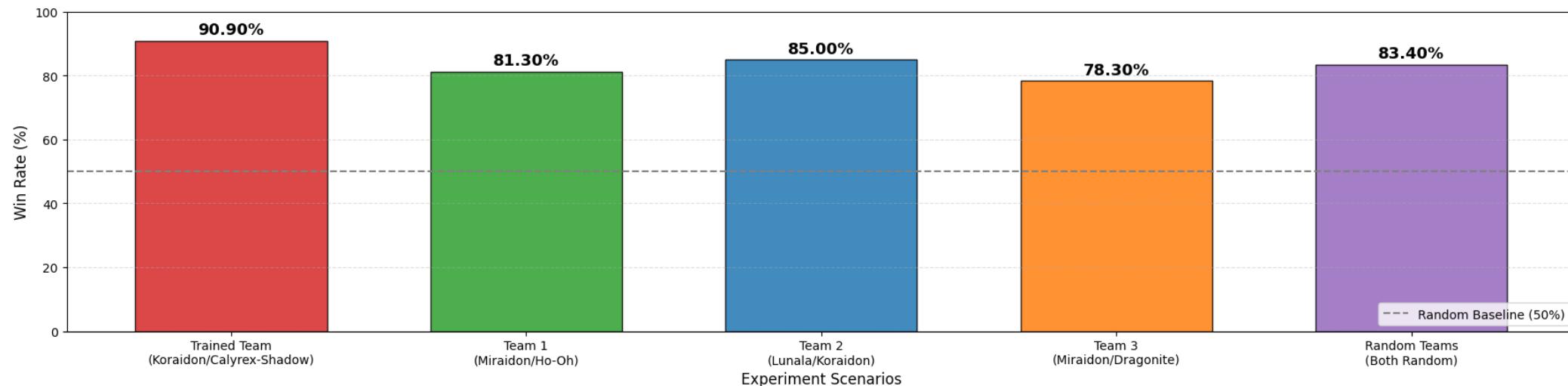
EVALUATION RESULTS

Total Battles: 1000
Wins: 909
Losses: 91
Win Rate: 90.90%
Avg Reward: 18.29 ± 9.02
Avg Episode Len: 18.9 steps
Avg Alive Diff: +9.43 Pokémon
Reward Range: [-23.14, 31.75]

■ Ablation Results

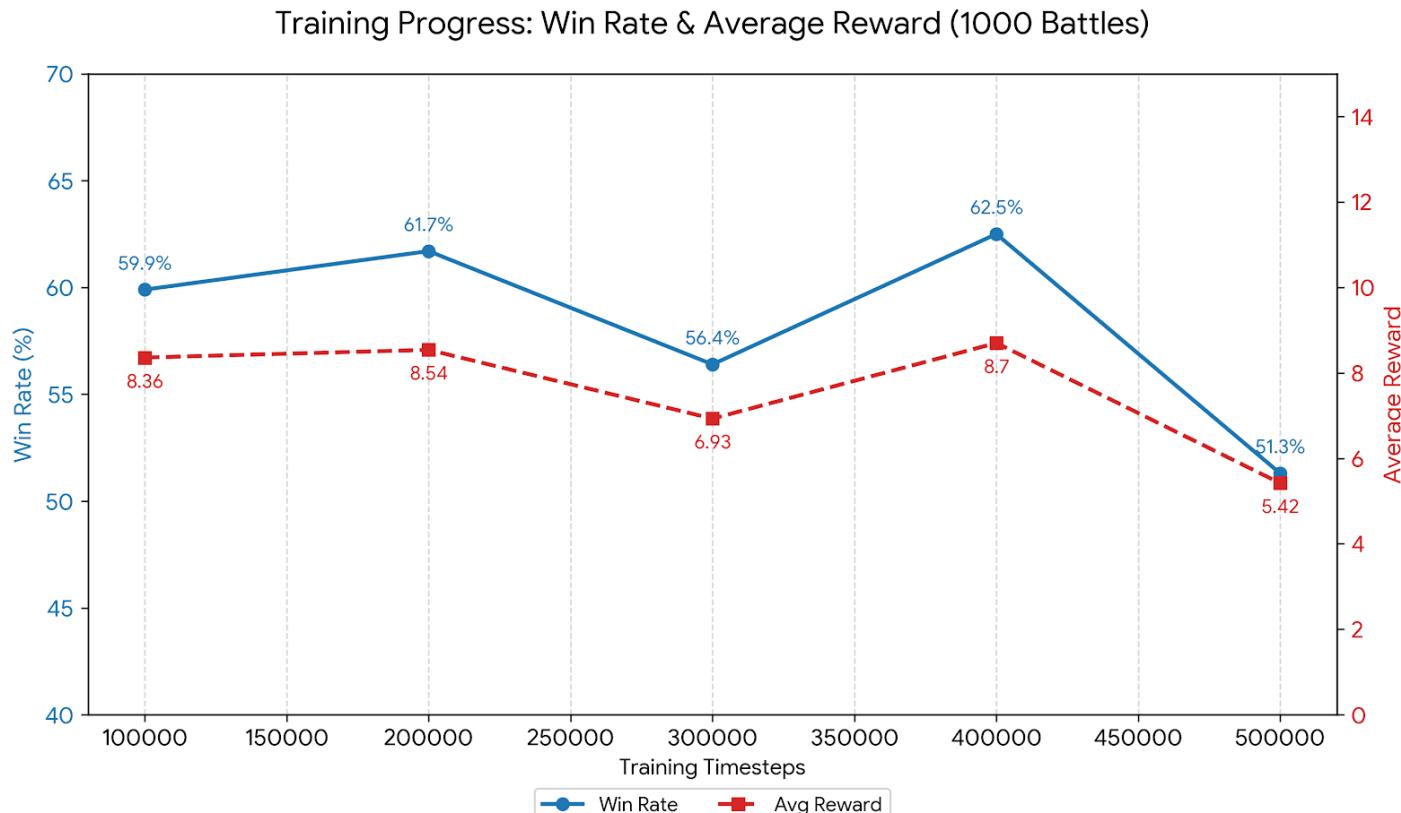
- 학습된 팀이 아닌 다른 팀에서도 어느정도의 승률을 가지는지 평가
- 각각 Enemy team 1, 2, 3로 My Team으로 학습한 전략을 사용
- 각각의 팀들은 다음과 같은 성격을 가짐
 - Enemy Team1: 학습한 팀과 유사한 성격의 화력으로 밀어붙이는 조합
 - Enemy Team2: Gliscor과 Dondozo의 회복 능력을 바탕으로, 놀러 앓는 조합
 - Enemy Team3: Glimmora가 장판을 설치한 후, 장판기를 힘을 바탕으로 다른 포켓몬이 활약하는 조합
- My Team 0| Enemy Team 1, 2, 3 중 Random으로 결정
- 1000 steps

Agent Win Rate Comparison (5 Scenarios)



■ Mirror Battle (1000 episodes)

- 이전의 step들보다는 강력한 마지막의 final checkpoint
but final vs final에서는 51.3%의 Win rate를 기록 (거의 반반)



■ Performance Summary

- 제안된 Action Masking 및 Dense Reward Shaping 기법을 통해, 500,000 Step 학습만으로 90.9%의 승률을 달성함
- 특정 팀에 국한되지 않고, 각기 다른 상대로도 평균 80% 이상의 승률을 기록하여 일반화 성능을 입증함

■ Strategic Behavior

- 단순 데미지 딜링뿐만 아니라, 교체(Switching) 및 테라스탈(Terastallization)을 활용한 방어적 플레이가 관측됨

■ Limitations & Future Work

• 상대 모델의 단순함:

현재 평가는 Random/Simple Heuristic 상대를 기반으로 함. 향후 더 강력한 Pre-trained Agent나 사람과의 대전을 통해 검증 필요.

• 방어 상성 학습:

현재 State에는 방어 상성 정보가 잠재적(Latent)으로만 존재함. 이를 명시적 정보로 추가하면 학습 효율이 개선될 것으로 예상됨

• 파티 선택 학습:

현재는 6마리 중 맨 앞의 3마리만 선출되고 있는 상황으로 builder를 업데이트 해야 파티 중 어떤 포켓몬을 선출할지 학습함

• 더 많은 상태 학습:

멸망의 노래, 선공기, 트릭룸에 따라서 state와 reward를 재정의해서 바르게 대처할 수 있도록 업그레이드 해야함