Pokémon Capture Rate Monte Carlo Simulation

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Introduction

Pokémon is a popular game created by Game Freak, first released in 1996. In the game, players take on the role of a Pokémon Trainer, capturing various wild Pokémon to build a powerful team. Players use Poké Balls to catch Pokémon they encounter in the wild, and the success of the capture depends on the Pokémon's health, Ball types and other factors. Only one ball can be thrown per turn.

Goals

Our project aims to develop a Monte Carlo simulation to analyze and optimize Pokémon capture strategies in the popular Pokémon video game series. We will simulate various factors that affect capture rates, including different **Poké Ball types, Pokémon status conditions, remaining HP, and Pokémon species rarity**. The goal is to determine the most effective capture strategies for different scenarios.

Hypotheses

1. Using Ultra Balls on legendary Pokémon with low HP and a status condition will result in a capture rate twice as high as using standard Poké Balls on the same Pokémon.

2. The capture rate for common Pokémon species will be less affected by Poké Ball type compared to rare or legendary Pokémon.

3. The most cost-effective method of capturing Pokémon is using Great Balls, regardless of the Pokémon's species, HP level, or status condition.

4. The shortest average time to capture Pokémon is achieved by using Quick Balls, regardless of the Pokémon's species or condition.

Variable Effected Capture Rate

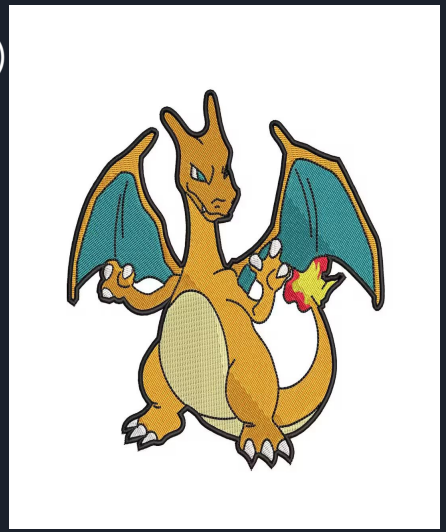
1.Pokémon species (common, rare, legendary)

2. Pokémon's current HP (percentage of max HP)

3.Pokémon's status condition (none, paralyzed, asleep, etc.)

4.Poké Ball type (standard, Great Ball, Ultra Ball, etc.)

5. Used turns



Pokémon Species

Mewtwo
catch_rate: 3
max_hp: 200
legendary

Pikachu
catch_rate: 190
max_hp: 100
common

Charizard
catch_rate: 45
max_hp: 180
rare

Gengar

Snorlax

Gyarados

Dragonite

Pokémon Species

```
# Create Pokémon and Poké Balls based on Serebii's data
# Real Catch Rate = catch_rate / 255
mewtwo = Pokemon( name: "Mewtwo",  catch_rate: 3,  max_hp: 200)
pikachu = Pokemon( name: "Pikachu",  catch_rate: 190,  max_hp: 100)
charizard = Pokemon( name: "Charizard",  catch_rate: 45,  max_hp: 180)
snorlax = Pokemon( name: "Snorlax",  catch_rate: 25,  max_hp: 250)
gyarados = Pokemon( name: "Gyarados",  catch_rate: 45,  max_hp: 190)
gengar = Pokemon( name: "Gengar",  catch_rate: 45,  max_hp: 150)
dragonite = Pokemon( name: "Dragonite",  catch_rate: 45,  max_hp: 200)

pokeballs = [
    PokeBall( name: "Poke Ball",  catch_rate_multiplier: 1,  price: 200),
    PokeBall( name: "Great Ball",  catch_rate_multiplier: 1.5,  price: 600),
    PokeBall( name: "Ultra Ball",  catch_rate_multiplier: 2,  price: 800),
    PokeBall( name: "Quick Ball",  catch_rate_multiplier: 5,  price: 1000),  # Enhanced on Turn 1
    PokeBall( name: "Timer Ball",  catch_rate_multiplier: 1,  price: 1000),  # Improves with turns passed (up to x4 multiplier)
]

# Run simulations and analyze minimum cost for each Pokémon
pokemon_list = [mewtwo, pikachu, charizard, snorlax, gyarados, gengar, dragonite]
```

Current HP Status

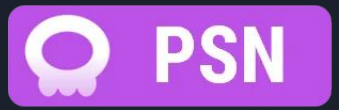
1.The lower a Pokémon's HP, the higher its capture rate.

2. Can’t be lower than 0

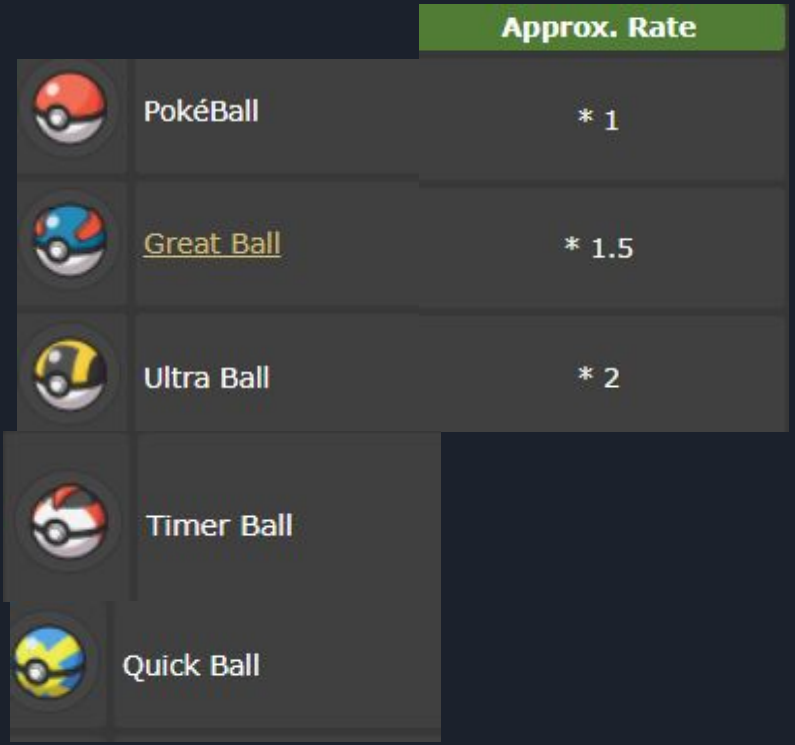
3. if HP is lower than 0, battle will automatically end.

Status Condition

1. Pokemon's different status condition can also effect capture rate
2. SLP and FRZ will bonus 2.5 , other status condition will bonus 1.5
3. Usually use Paralysis to capture, because it is more stable
4. Burn will cause a 1/16 HP decrease each turn. PSN will cause ⅛ decrease.
5. when the pokemon HP=0, the capture failed



Different Balls have Different Capture Rate



	Approx. Rate
PokéBall	* 1
Great Ball	* 1.5
Ultra Ball	* 2
Timer Ball	
Quick Ball	

1. The PokeBall has low cost but low capture rate

2. The Timer Ball's capture rate increases as the number of turns in a battle grows(*5 maximum)..

3. Quick Ball only have more Capture rate (*5)on the first turn, next turn capture rate will come back to the same as pokeball.

Basic Capture Rate Formula

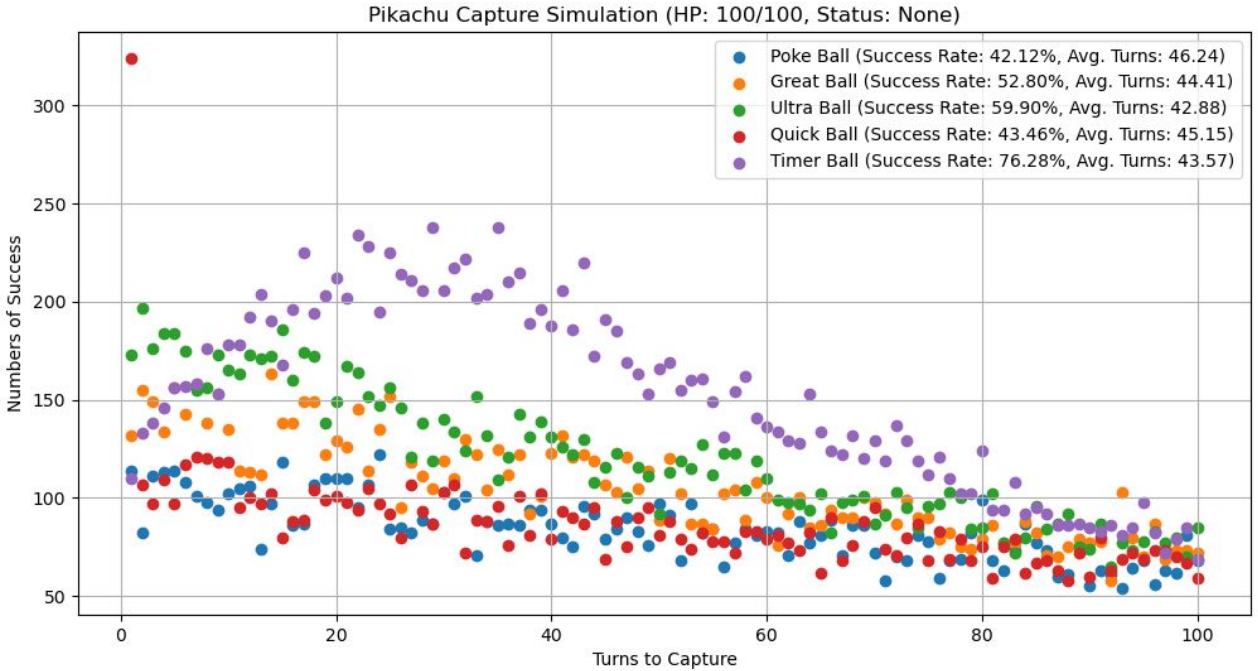
CatchValue = **hp_factor** * status_bonus * *pokeball.catch_rate_multiplier* * *pokemon.catch_rate*

E.g.: Quick Ball (pokeball.catch_rate_multiplier = 5):

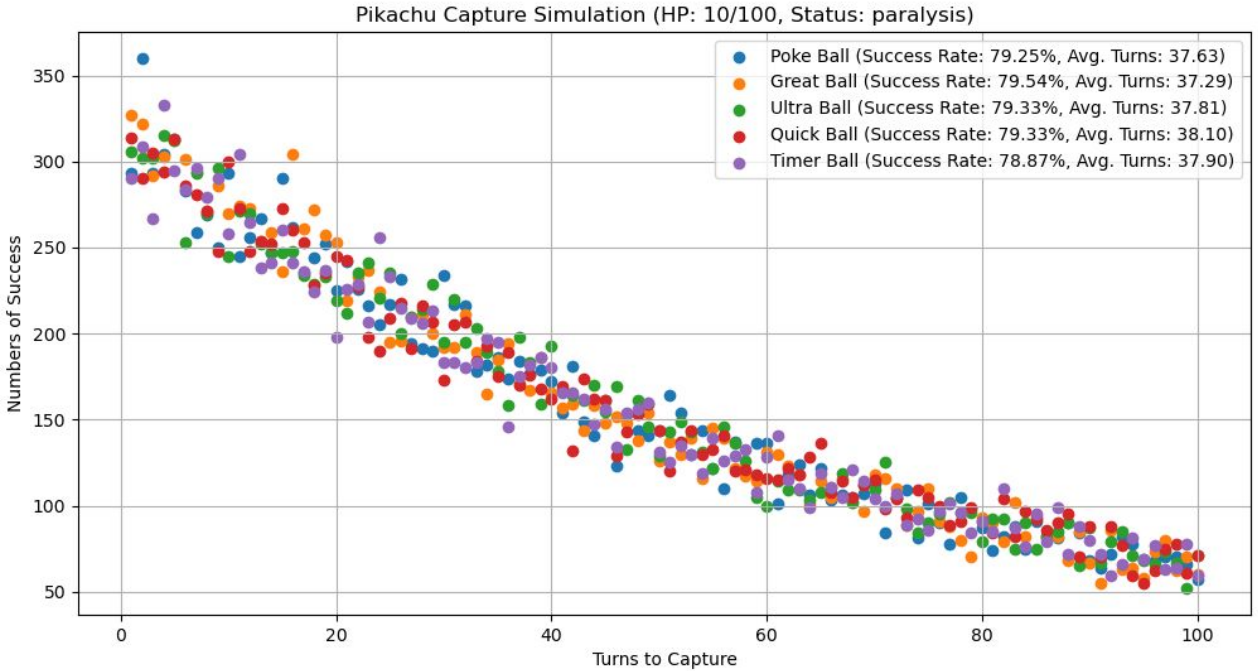
CatchValue =

((3 * Max HP - 2 * HP) / (3 * Max HP)) * Status Modifier * (*pokeball.catch_rate_multiplier * Catch Rate*)

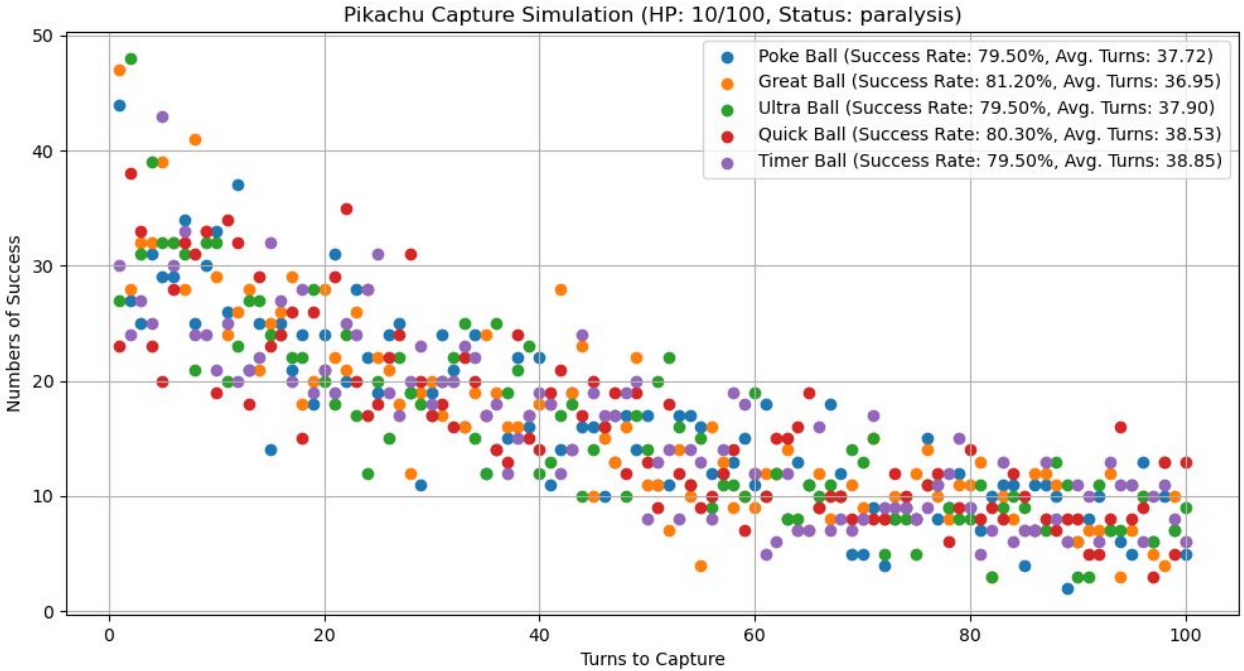
Pokémon in full HP - 20,000 Simulations



Pokémon in low HP - 20,000 Simulations



Convergence - 2,000 Simulations



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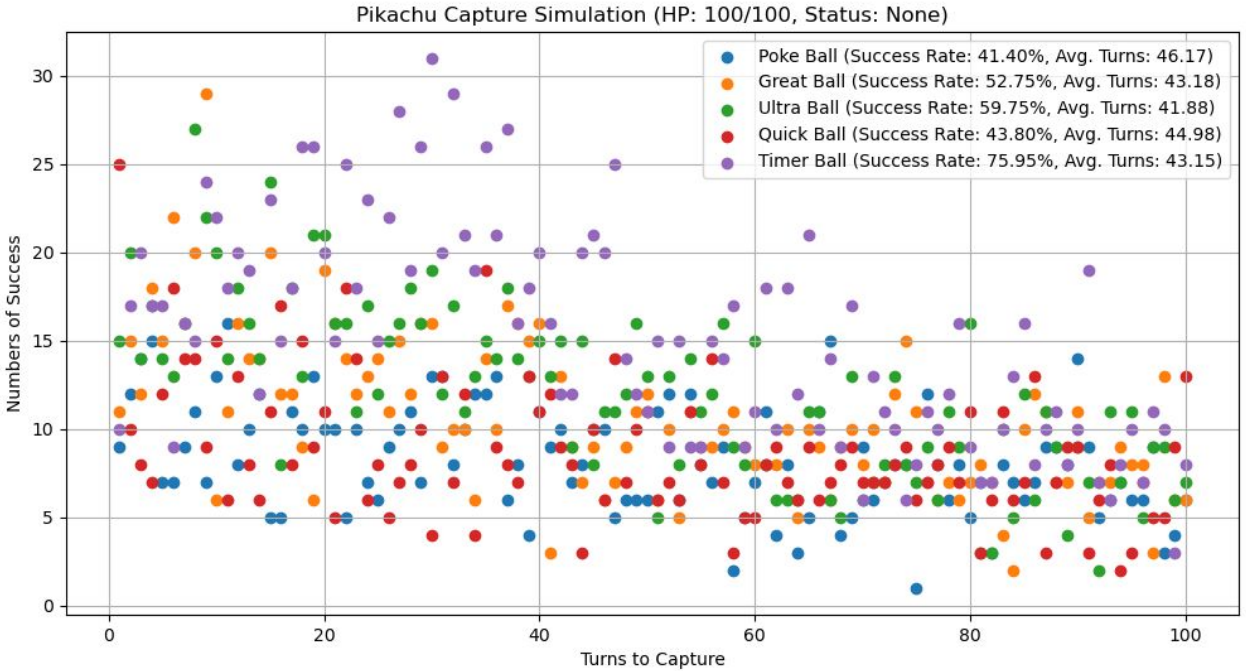
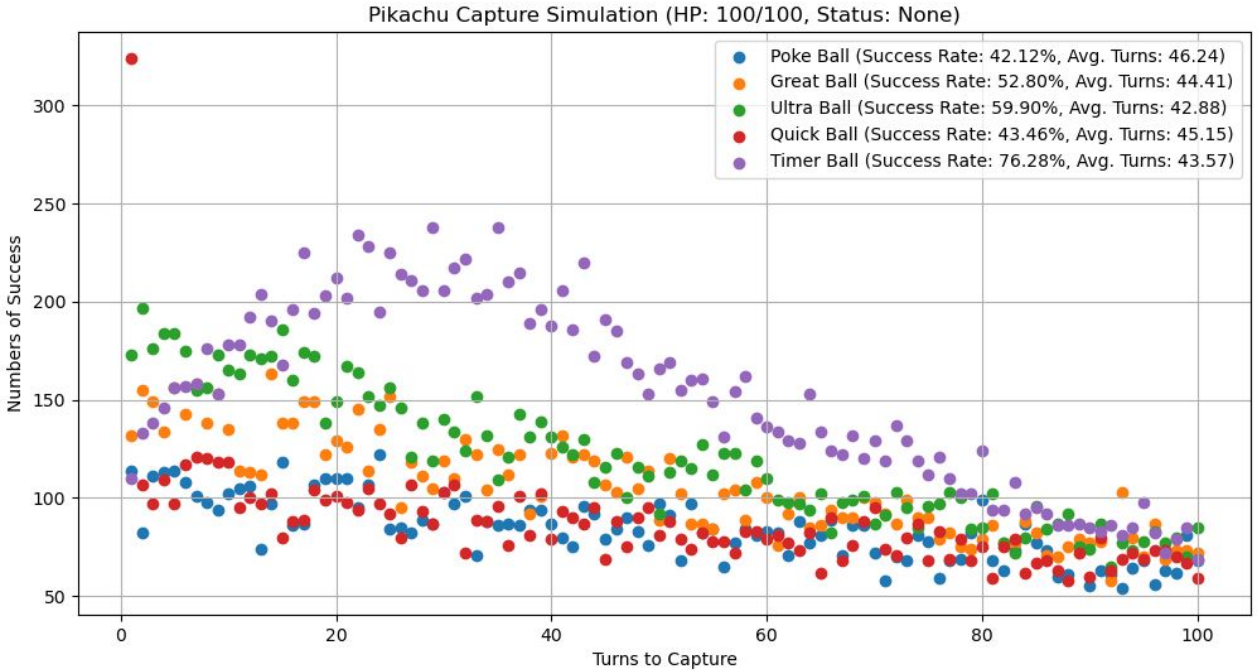
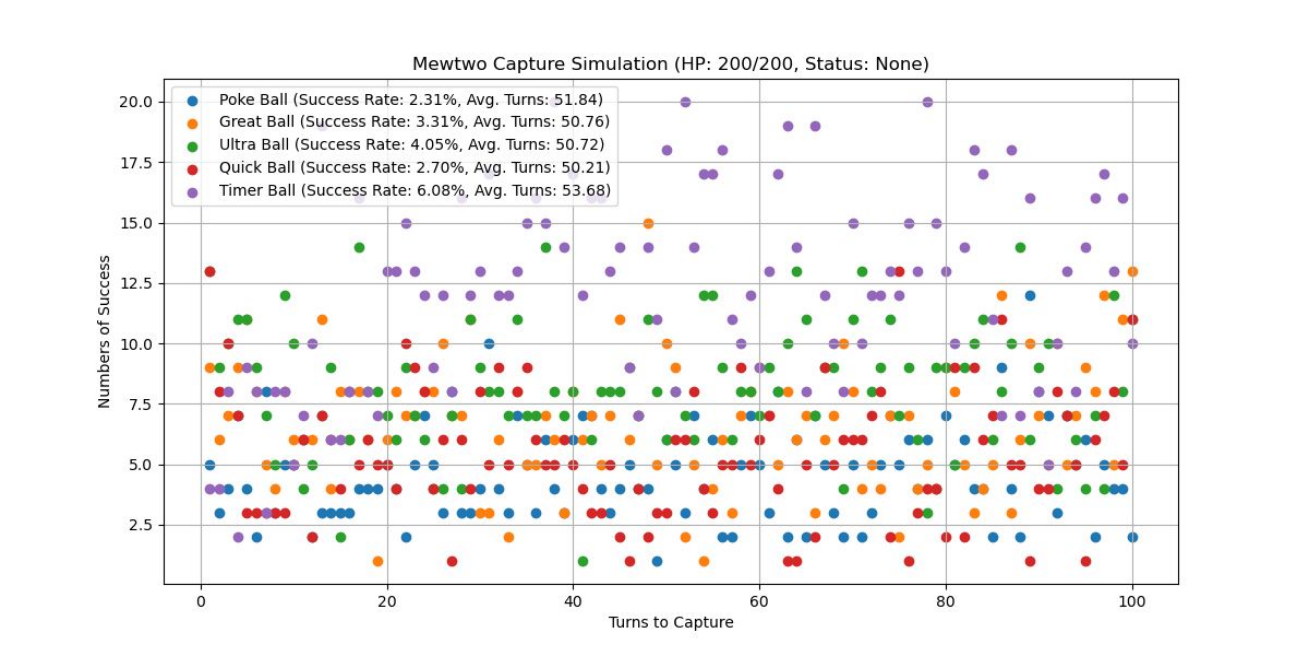


Convergence - 20,000 Simulations



Hypothesis 1

Using Ultra Balls on legendary Pokémon with low HP and a status condition will result in a significantly higher capture rate compared to using standard Poké Balls on the same Pokémon.



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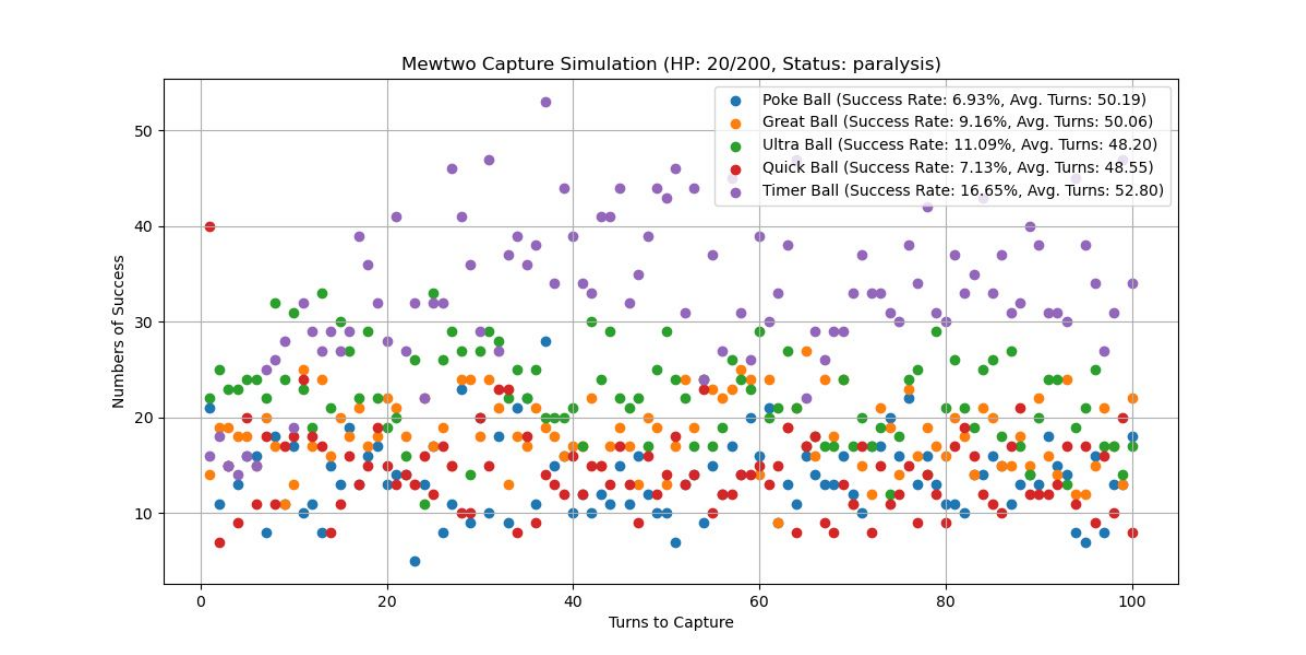
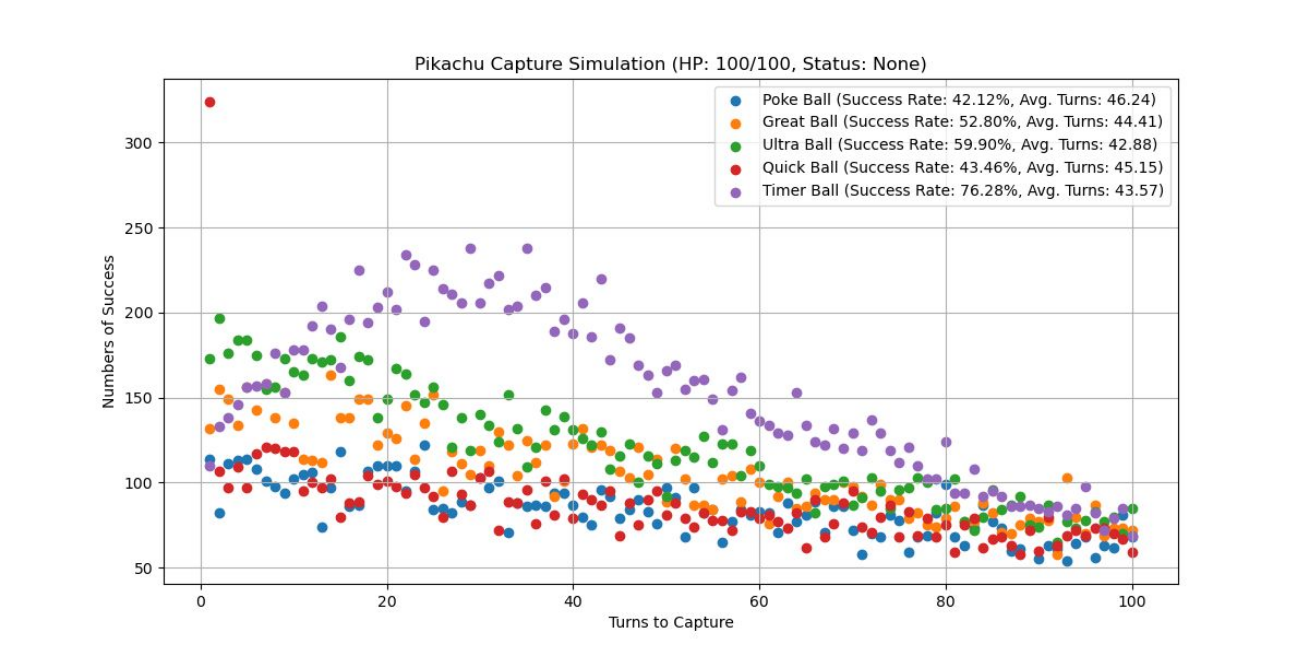
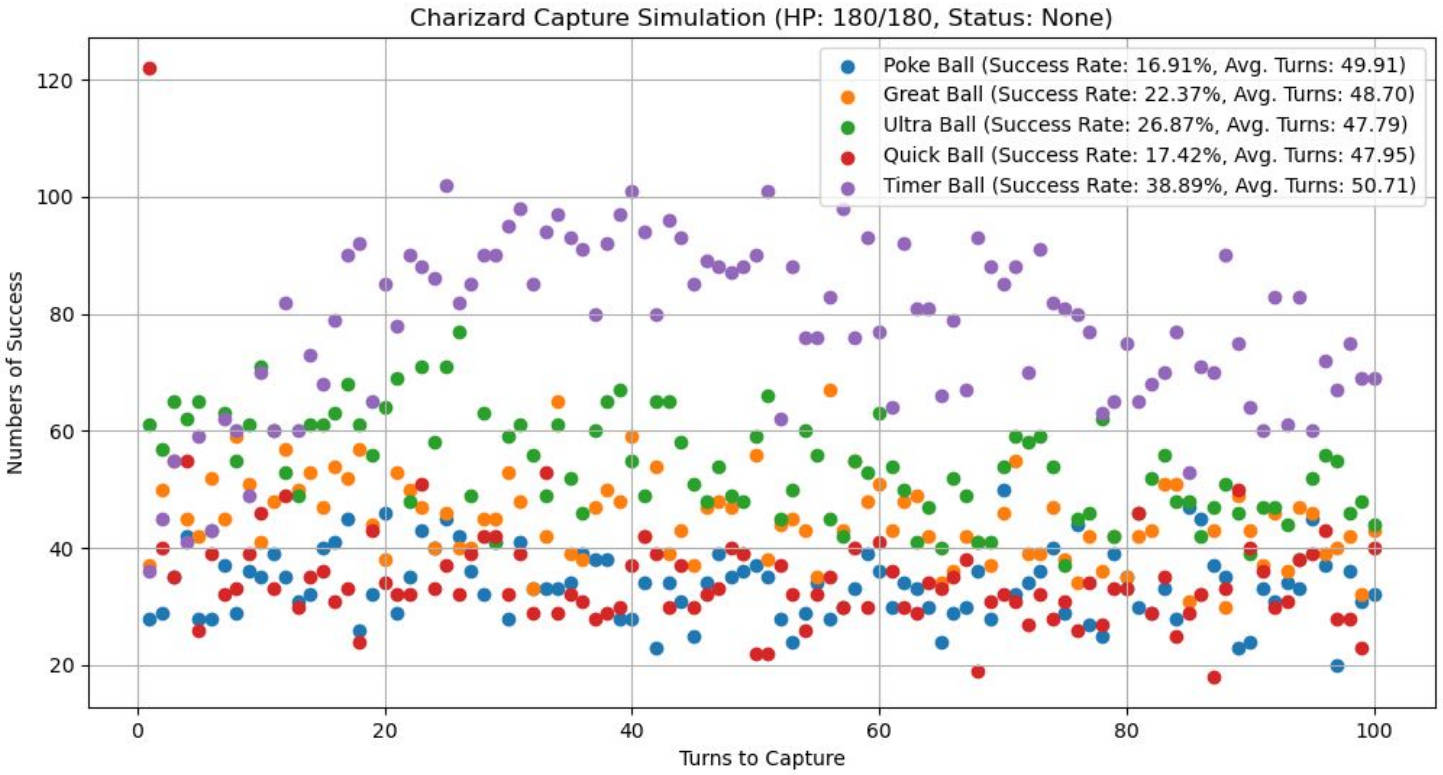


Hypothesis 2

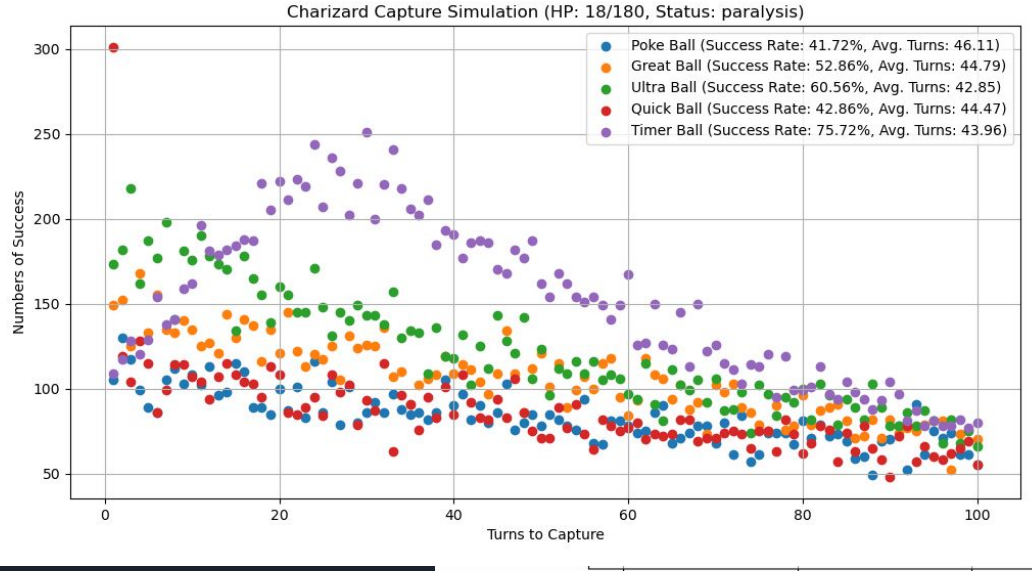
The capture rate for common Pokémon species will be less affected by Poké Ball type compared to rare or legendary Pokémon.

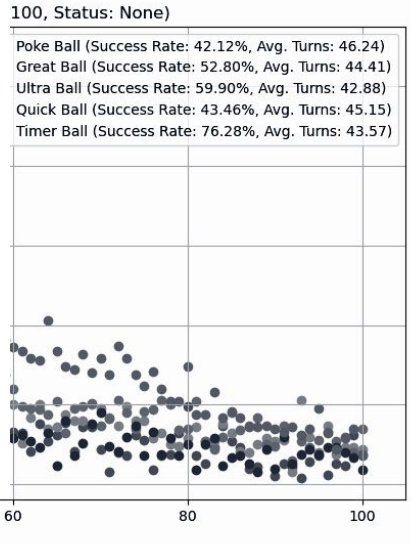



Charizard Capture Simulation (HP: 180/180, Status: None)
Poke Ball (Success Rate: 16.91%, Avg. Turns: 49.91)
Great Ball (Success Rate: 22.37%, Avg. Turns: 48.70)
Ultra Ball (Success Rate: 26.87%, Avg. Turns: 47.79)
Quick Ball (Success Rate: 17.42%, Avg. Turns: 47.95)
Timer Ball (Success Rate: 38.89%, Avg. Turns: 50.71)
Numbers of Success
Turns to Capture
120
100
80
60
40
20
0
20
40
60
80
100

Hypothesis 2

The capture rate for common Pokémon species will be less affected by Poké Ball type compared to rare or legendary Pokémon.





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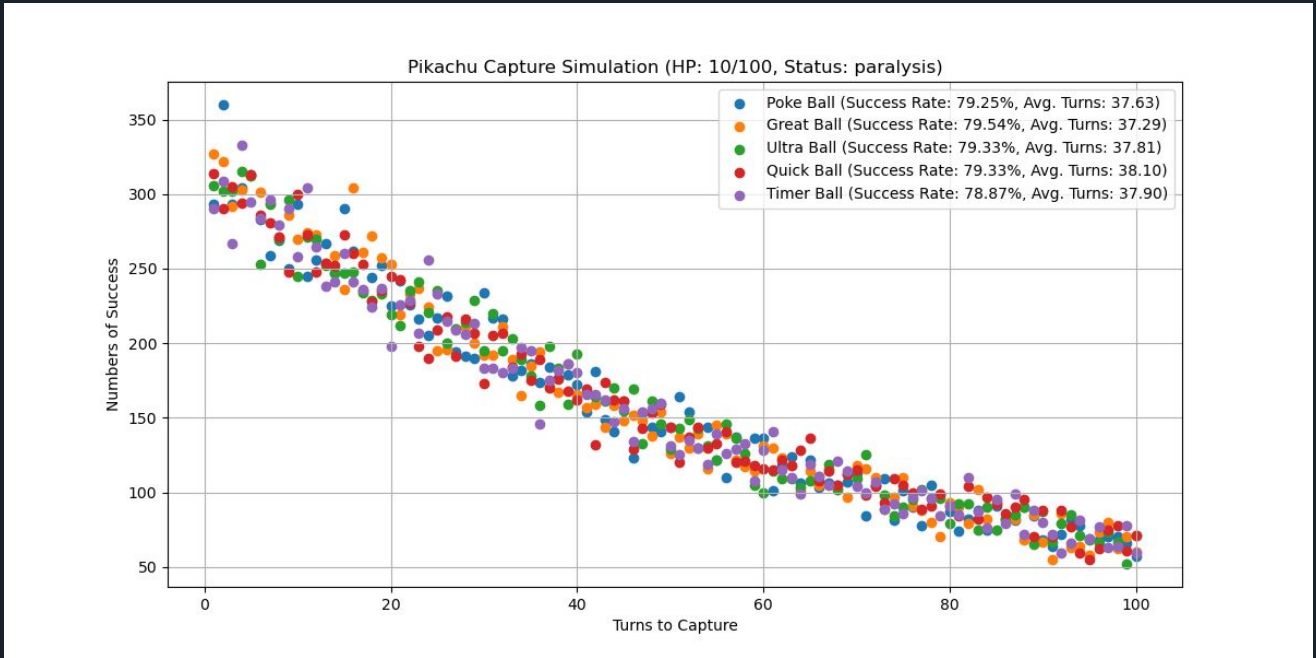

Hypothesis 3

The most cost-effective method of capturing Pokémon is using Great Balls, regardless of the Pokémon's species, HP level, or status condition.

```
Analyzing minimum cost for capturing Charizard at low HP with status:
Poke Ball: Success Rate = 40.85%, Avg. Turns = 45.82, Avg. Cost = 9164.26
Great Ball: Success Rate = 53.65%, Avg. Turns = 44.08, Avg. Cost = 26446.41
Ultra Ball: Success Rate = 60.55%, Avg. Turns = 43.83, Avg. Cost = 35061.93
Quick Ball: Success Rate = 43.65%, Avg. Turns = 45.63, Avg. Cost = 45632.30
Timer Ball: Success Rate = 74.85%, Avg. Turns = 42.55, Avg. Cost = 42553.77
Recommended Ball at Low HP: Poke Ball with Avg. Cost = 9164.26

Analyzing minimum time for capturing Charizard:
Poke Ball: Avg. Turns = 48.07
Great Ball: Avg. Turns = 43.54
Ultra Ball: Avg. Turns = 42.37
Quick Ball: Avg. Turns = 44.23
Timer Ball: Avg. Turns = 42.47
Recommended Ball for Minimum Time: Ultra Ball with Avg. Turns = 42.37
```

Hypothesis 4

The shortest average time to capture Pokémon is achieved by using Quick Balls, regardless of the Pokémon's species or condition.

```
Analyzing minimum cost for capturing Charizard at low HP with status:
Poke Ball: Success Rate = 40.85%, Avg. Turns = 45.82, Avg. Cost = 9164.26
Great Ball: Success Rate = 53.65%, Avg. Turns = 44.08, Avg. Cost = 26446.41
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Timer Ball: Success Rate = 74.85%, Avg. Turns = 42.55, Avg. Cost = 42553.77
Recommended Ball at Low HP: Poke Ball with Avg. Cost = 9164.26

Analyzing minimum time for capturing Charizard:
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Ultra Ball: Avg. Turns = 42.37
Quick Ball: Avg. Turns = 44.23
Timer Ball: Avg. Turns = 42.47
Recommended Ball for Minimum Time: Ultra Ball with Avg. Turns = 42.37
```

Discussion

- For common species, first mitigate their HP and then just use the most basic Poke Ball! The effects are almost at the same level.
- Most of the time, the more expensive ball works better.
- Great Balls are not always ‘great’, and Quick Balls are not always ‘quick’.
- Applying negative status conditions provides a more stable outcome.

Future Works

Make a more powerful and realistic design:

Escape Rate: A pokemon may escape from a battle after a certain turns;

Status condition duration: Some Pokémon may have resistances to certain status conditions, causing the applied status conditions to wear off after a few turns.

Code improvement:

Write doctests and detailed docstrings for each function;

Optimize the code logic to reduce redundant calculations in similar situations.

References

[1] Bulbapedia. (2024, November 22). Catch rate. https://bulbapedia.bulbagarden.net/wiki/Catch_rate

[2] Capturing pokémon. Serebii.net Header. (n.d.). https://www.serebii.net/games/capture.shtml