**Documentation for Bulls and Cows Game with Entropy and Information Gain**

**Project Overview**

This project implements the **Bulls and Cows** game using **Python** with an added layer of **entropy** and **information gain** calculations. The player guesses a secret 4-digit number, and after each guess, the game provides feedback on how many digits are correct and in the correct position (bulls) and how many digits are correct but in the wrong position (cows). The game also calculates and displays the **entropy** and **information gain** with each guess, providing players with real-time insights into how much uncertainty remains about the secret number.

**Features**

* **Game Logic**: Standard Bulls and Cows game mechanics, with feedback on bulls and cows.
* **Entropy Calculation**: Measures the uncertainty of remaining possibilities after each guess.
* **Information Gain**: Quantifies the reduction in uncertainty after each guess.
* **Interactive User Interface**: Built using **Streamlit**, where players input their guesses and receive immediate feedback.
* **Visualization**: Entropy and information gain are visualized on line graphs, and bulls and cows are displayed using LiquidFill charts.

**File paths:  
for presentation🡪**[**COWS\_BULLS\_ENTROPY.pptx**](COWS_BULLS_ENTROPY.pptx)

**for presentation\_video🡪**[**Video\_Presentation.mp4**](Video_Presentation.mp4) **for video\_demonstration of game->**[**GAME\_PLAY.mp4**](GAME_PLAY.mp4) **for code->**[**WORKING\_GAME.py**](WORKING_GAME.py)

**For git->**[**https://github.com/SainathChettupally/MFDS\_EXAM\_3.git**](https://github.com/SainathChettupally/MFDS_EXAM_3.git)

**Note:**

**Install all the packages mentioned in requirements.txt found in this folder**[**link to view**](requirements.txt) **streamlit==1.19.0**

**plotly==5.0.0**

**pandas==1.5.3**

**numpy==1.23.5**

**sympy==1.11.1**

**streamlit-echarts==0.2.0**

**In order to run the code you need to use the following command in your terminal(open terminal in the same file path where you have all the files as they have dependencies)  
streamlit run WORKING\_GAME.py**

**Code Overview**

**Imports and Libraries**

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* **Streamlit**: Used for creating the interactive user interface.
* **random**: For generating random secret numbers.
* **itertools**: To generate all possible 4-digit combinations.
* **math**: For logarithmic calculations required in entropy.
* **pandas**: Used for data manipulation.
* **plotly.express & streamlit\_echarts**: For visualization of entropy and information gain.
* **numpy**: For mathematical operations and calculations.

**Functions**

**1. start\_new\_game()**

* **Purpose**: Initializes the game by generating a random 4-digit secret number, setting up history, and defining possible guesses.
* **Parameters**: None
* **Returns**: None

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**2. calculate\_bulls\_and\_cows(secret, guess)**

* **Purpose**: Compares the player’s guess with the secret number and returns the number of bulls and cows.
* **Parameters**:
  + secret: The secret 4-digit number.
  + guess: The player’s 4-digit guess.
* **Returns**: A tuple (bulls, cows) representing the number of bulls and cows.

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Description automatically generated**3. filter\_possibilities(possibilities, guess, bulls, cows)**

* **Purpose**: Filters the list of remaining possible secret numbers based on the bulls and cows feedback from the player’s current guess.
* **Parameters**:
  + possibilities: A list of remaining possible secret numbers.
  + guess: The current guess.
  + bulls: The number of bulls in the current guess.
  + cows: The number of cows in the current guess.
* **Returns**: A list of remaining valid possibilities.

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**4. calculate\_entropy(possibilities, guess, bulls, cows)**

* **Purpose**: Calculates the entropy based on the remaining possible secret numbers. Our Entropy calculation does not determine how close our guess to the secret number but based on the remaining possibilities which can potentially have same or more number of cows and bulls sent from the filter\_possibilities function.
* **Parameters**:
  + possibilities: A list of remaining possible secret numbers.
  + guess: The current guess.
  + bulls: The number of bulls in the current guess.
  + cows: The number of cows in the current guess.
* **Returns**: A float representing the calculated entropy.

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**5. display\_graph()**

* **Purpose**: Displays the line graph for entropy and information gain over time using **Plotly** and **ECharts**.
* **Parameters**: None
* **Returns**: None

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**6. display\_attempt\_history()**

**Purpose:**

Displays the history of the player's previous guesses, showing the number of bulls and cows for each attempt.

**Parameters:**

* **None** (Uses session state to track guesses).

**Returns:**

* **None** (Directly displays the attempt history on the UI).

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**7. display\_bulls\_and\_cows()**

**Purpose:**

Visualizes the bulls and cows feedback using **LiquidFill** charts, one for bulls (green) and one for cows (yellow).

**Parameters:**

* **bulls** (int): Number of bulls.
* **cows** (int): Number of cows.

**Returns:**

* **None** (Displays the visualizations on the UI).

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**8. play\_game()**

* **Purpose**: Runs the main game loop, allowing the player to input guesses and receive feedback.
* **Parameters**: None
* **Returns**: None

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