Project Name: Conway s Game of Life

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First, The imperative code

in this block:

```
InitialGrid = []
for i in range(rows):
    row = []
    for j in range(columns):
        row.append(random.randint(0, 1))
    InitialGrid.append(row)
```

we apply:

1 - List construction

2- State mutation (Change the list contents by append)

3- Loops

In this block:

```
    if InitialGrid[row][column] == 1:
    if neighbors < 2:
```

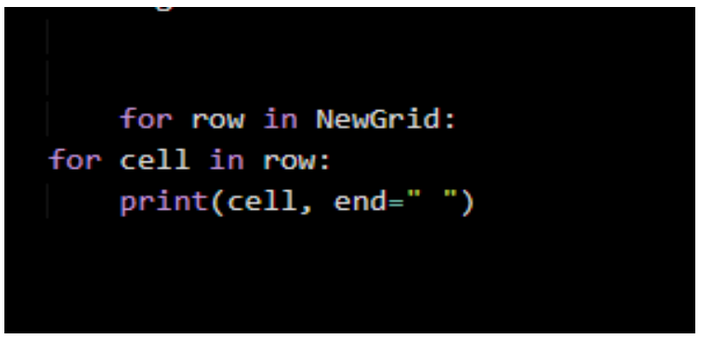
We apply:

1- Conditional branching (Section 4)

2- Imperative State Updates (Section 1)

3- Invariant idea (Section 3)

In this block:



We apply:

List traversal (list of lists) (Section 4)

Throughout the entire code

1 - Imperative paradigm

2 - State manipulation

3 - Sequential execution

4 - Invariant programming

5 - Loops

Functional 1:

```
def sum_tail(list):
def helper(remaining_elements, acc):
    if not remaining_elements:
        return acc
    return helper(remaining_elements[1:], acc + remaining_elements[0])
return helper(list, 0)
```

We apply:

1- Tail recursion (Section 3)

2- Recursive function matching recursive data (Section 4)

3- Accumulator pattern (Section 3)

4- Higher-order idea (function inside function) (Section 5)

In these blocks:

```
def render_row_tail(row):
def helper(remaining_cells, acc):
    if not remaining_cells:
        return acc
```

```
return tuple(tuple(rng.randint(0, 1) for _ in range(cols)) for _ in range(rows))
```

```
return helper(remaining_rows[1:], acc + sum_tail(remaining_rows[0]))
```

We apply:

1- Building strings using recursion (recursive structure like lists)

2- Closure (inner function uses outer variables) (Section 5)

3- Tail recursion

4- Immutable data structure (Section 5)

5- Declarative-like comprehension

6- No mutation

7- Recursion over grid

8- Calling another recursive function [sum_tail] ((higher order use))

9- Accumulator logic

Throughout the entire code

1 - Tail recursion - Accumulator patterns – Recursion – Closures - contextual environment (inner helper accessing outer args)

Functional 2:

In this block:

```
    return sum(
    grid[r + dr][c + dc]
    for dr, dc in deltas
    if 0 <= r + dr < rows and 0 <= c + dc < cols
)
```

We apply:

1-Pure function

2-Declarative rule application

3- Higher-order style //sum takes the function like iterable

5- No state mutation

In this block

```
def next_generation(grid: Grid) -> Grid:
    rows, cols = len(grid), len(grid[0])
    return tuple(
    tuple(
        apply_rule(grid[r][c], count_neighbors(grid, r, c))
        for c in range(cols)
    )
    for r in range(rows)
    )
```

We apply:

1- Nested functional transformations

2- **Functions as transformations** [apply_rule + count_neighbors] it's the (higher order flow) {Section 5}

Throughout the entire code

1 - immutable tuples

2 - pure functions

3 -recursive data shape (grid = rows: each row is a list of cells) but without the actual recursion

4 - functional transformation