Homework 3: The Grand Vizier's Ledger

AVL Trees, Rotations & Parent Pointers

Scenario: "But Mahmud Pasha Received 4 Million..."[1]

The location is the *Has Oda* (Private Chamber). Sultan Süleyman decrees a significant raise for his Grand Vizier, increasing **Pargalı İbrahim Pasha**'s annual income to **3,000,000 Akçe**.

However, İbrahim is not satisfied. Driven by ambition, he protests:

> *"Hünkarım, but Mahmud Pasha received 4,000,000 Akçe!"*

Süleyman looks up, his patience wearing thin, and asks the iconic question:

> *"Sen kendini kimlerle mukayese ediyorsun İbrahim?"*
> (Who do you compare yourself with, İbrahim?)

İbrahim freezes. He realizes that to justify his demand for 4,000,000 Akçe, he needs to see the official records to confirm if Mahmud Pasha really earned that amount and to see where he stands among all Grand Viziers in history. He bows, leaves the Has Oda, and rushes to the Archives. The records are scattered in disarray. İbrahim summons you, the Head Scribe, and demands:

"Compile the records. Build me a system that lets me instantly see my place in history. I need to know who stands next to me among grand viziers."

1 Problem Definition

You must organize the scattered historical records into an **AVL Tree**, ordered by **Start Year**. The system must allow querying a specific year (e.g., **1523**) with a **"Window"** parameter to retrieve a range of neighbors (e.g., 2 Predecessors and 2 Successors).

2 Data Structure Requirements

To satisfy the requirement of efficient neighbor access ($O(k+\log n)$ where k is the window size, without re-searching from the root), you must implement a Node with **Parent Pointer**.

```c
typedef struct {
    char name[50];
    int start_year;   // KEY: Sorting Criteria
    int end_year;
    int income;
} VizierRecord;

typedef struct Node {
    VizierRecord data;
    struct Node *left;
    struct Node *right;
    struct Node *parent;     // <--- REQUIRED for navigation
    int height;
} Node;
```

Listing 1: Struct Definitions

[1] This scenario is inspired by the TV series *Muhteşem Yüzyıl*, Episode 80. Video Reference: https://www.youtube.com/watch?v=UVs-YIr4POk

3 Input Data (The Scattered Archives)

The records[2] are provided in a **random order**. You must insert them into the AVL tree.

```
static VizierRecord const history[] = {
    {"Lutfi Pasa",        1539, 1541, 155000},
    {"Mahmud Pasa",       1456, 1468, 4000000}, // <--- The Rival
    {"Piri Mehmed",       1518, 1523, 145000},
    {"Candarli Ali",      1387, 1406,  82000},
    {"Sokollu Mehmed",    1565, 1579, 2000000},
    {"Pargali Ibrahim",   1523, 1536, 3000000}, // <--- The Protagonist
    {"Koca Sinan",        1580, 1582, 210000},
    {"Alaeddin Pasa",     1320, 1331,  50000},
    {"Kemankes Mustafa", 1638, 1644, 230000},
    {"Gedik Ahmed",       1474, 1477, 115000},
    {"Koprulu Mehmed",    1656, 1661, 260000},
    {"Ayas Mehmed",       1536, 1539, 160000},
    {"Kuyucu Murad",      1606, 1611, 220000},
    {"Candarli Halil",    1364, 1387,  75000},
    {"Rustem Pasa",       1544, 1553, 2800000},
    {"Merzifonlu Kara",   1676, 1683, 290000},
    {"Semiz Ali",         1561, 1565, 170000},
    {"Ferhad Pasa",       1591, 1592, 190000},
    {"Nevsehirli Damat", 1718, 1730, 240000},
    {"Koprulu Fazil",     1661, 1676, 275000}
};
```

Listing 2: Mixed Data Array

4 Implementation Tasks

1. **Rotations:** Implement `leftRotate` and `rightRotate`. You MUST update `parent` pointers for all affected nodes (New Root, Old Root, and transferred children).
2. **Insertion:** Implement `insertVizier`. Insert records from the array above. Balance the tree using AVL logic ($|BF| \leq 1$).
3. **Comparison:** Implement `compareVizier(Node* root, int target_year, int window)`.
   - Find the target node (e.g., 1523).
   - Using parent/child pointers, traverse to find the k **Predecessors** and k **Successors**, where k is the `window` size.
   - *Example:* If `window=1`, find immediate prev/next. If `window=2`, find 2 prev and 2 next.

5 Expected Output Example

When running for **1523 (Pargalı İbrahim)** with **Window=1**:

```
--- QUERY: 1523 (PARGALI IBRAHIM) ---
[ TARGET ]
   > Pargali Ibrahim (3,000,000 Akce)

[ NEIGHBOR COMPARISON (Window: 1) ]
   (<<) PREDECESSOR: Piri Mehmed (145,000 Akce)
   (>>) SUCCESSOR: Ayas Mehmed (160,000 Akce)
```

[2]The grand vizier records are collected using Gemini Deep Research.