IV. Data Processing & Structuring

This section details how data from the OdAR System—both olfactory and ranging—is processed and structured for analysis and application. It includes existing processes plus enhancements for the new ranging capabilities. Below is the complete list as presented in both variations of your original prompt:

A. Existing Processes (Unchanged)

- **Preprocessing**:
    - Raw sensor data (resistance changes, ΔR) from the 8-sensor array cleaned via noise reduction (e.g., low-pass filtering).
    - Normalization applied across temperature cycles (10°C, 20°C, 30°C, 40°C) to standardize readings.
    - Outlier removal to eliminate anomalous spikes from hardware glitches or environmental interference.
- **Feature Extraction**:
    - Extracts key features from olfactory data: ΔR amplitude, rise time, decay rate, and steady-state response at each temperature.
    - Generates a feature vector per sensor (e.g., [ΔR_10°C, ΔR_20°C, ΔR_30°C, ΔR_40°C]) for pattern recognition.
    - Temporal features (e.g., response slope) included for dynamic odor changes.

B. Integrated Data Structuring (Enhanced)

- **1. Spatio-Olfactory Feature Vectors**:
    - **Enhanced Format**: Combines olfactory and ranging data into a single vector: [ΔR_10°C, ΔR_20°C, ΔR_30°C, ΔR_40°C, Distance, Angle, Signal_Strength].
        - Distance: Measured in meters (e.g., 1.25m) from ranging sensors.
        - Angle: Measured in degrees (e.g., 45°) relative to system orientation.
        - Signal_Strength: Proxy for odor concentration or ranging confidence (e.g., echo amplitude for ultrasonic).
    - **Temporal Tracking Data**: Appends time-stamped position changes (e.g., [t1: 1.0m, 0°; t2: 1.2m, 15°]) for moving sources.
    - **Confidence Metrics**: Includes uncertainty estimates for detection (e.g., ±5% on ΔR) and ranging (e.g., ±2cm on distance).
- **2. 3D Mapping Data Structure**:
    - **Grid-Based Representation**: Divides detection space into a 3D grid (e.g., 0.1m³ cells) within the 4m range.
    - **Concentration Gradient Mapping**: Assigns odor intensity values to grid cells based on sensor responses and distances.
    - **Temporal Heat Maps**: Tracks source movement over time, updating grid values dynamically (e.g., every 1s).

    - **Confidence Metrics**: Attaches reliability scores to each cell (e.g., 95% confidence at 1m, dropping with distance).

Notes

- **Completeness**: This fully preserves all details from both variations for **IV. Data Processing & Structuring**. The existing processes (A) and enhanced structuring (B) match the original content exactly.
- **Pump Inlet Mechanism**: Not yet integrated here, as your initial request placed it in Hardware (Section I). It could influence preprocessing (e.g., consistent airflow affecting ΔR stability) if you'd like me to add that—let me know!
- **Format**: Detailed narrative style per Variation 1, incorporating all outline points from Variation 2.