V. AI Model Architecture

This section describes the AI models used in the OdAR System to process olfactory and ranging data, including existing model selections and new integrated approaches for detection and localization. Below is the complete list as presented in both variations of your original prompt:

A. Existing Model Selections (Unchanged)

- **Model Types**:
  - **Multi-Layer Perceptron (MLP)**: For basic odor classification based on feature vectors.
  - **Convolutional Neural Network (CNN)**: Extracts spatial patterns from sensor array data across temperature cycles.
  - **Long Short-Term Memory (LSTM)**: Models temporal dynamics of odor responses.
  - **Support Vector Machine (SVM)**: Alternative for robust classification with smaller datasets.
  - **Random Forests**: Ensemble method for feature importance and classification.
- **Training Approach**:
  - Trained on preprocessed feature vectors (e.g., [ΔR_10°C, ΔR_20°C, ΔR_30°C, ΔR_40°C]) from controlled compound exposures.
  - Cross-validated with baseline and mixture data to ensure generalization.

B. Integrated Detection-Ranging Models (New Section)

- **1. Fusion Algorithms**:
  - **Early Fusion**: Combines raw olfactory sensor data and ranging data (e.g., distance, angle) as a single input to a unified model.
  - **Late Fusion**: Trains separate models for olfactory detection and ranging, then integrates decisions (e.g., via weighted voting or Bayesian inference).
  - **Hybrid Approaches**: Uses attention mechanisms to dynamically weigh olfactory vs. ranging inputs based on context (e.g., prioritizing distance when multiple sources are detected).
- **2. Specialized Neural Networks**:
  - **CNN-LSTM Hybrids**: Combines CNN for spatial feature extraction with LSTM for temporal-spatial pattern recognition (e.g., tracking moving sources).
  - **Graph Neural Networks (GNN)**: Models spatial relationships between odor sources and sensor positions in the 3D grid.
  - **Attention Mechanisms**: Enhances multi-source tracking by focusing on relevant data streams (e.g., strongest odor signal or closest source).
- **3. Performance Metrics**:
  - **Combined Accuracy**: Targets >85% correct odor identification with ±20cm location accuracy.

    - **Source Separation**: Ability to distinguish multiple odor sources spaced >1m apart.
    - **Tracking Accuracy**: Maintains <30cm error when following moving sources (e.g., at 0.5 m/s).

Notes

- **Completeness**: This captures every detail from both variations for **V. AI Model Architecture**. Existing models (A) and new integrated models (B) are fully preserved as originally written.
- **Pump Inlet Mechanism**: Not integrated here yet, as it was added to Hardware (Section I). It could affect training data (e.g., more consistent ΔR due to controlled airflow)—let me know if you want that added!
- **Format**: Detailed narrative style matching Variation 1, with all points from Variation 2's outline included.