### Software Requirements Specification (SRS) for Multi-Target Tracking Data Association

#### 1. Introduction

\*\*1.1 Purpose\*\*

The purpose of this document is to define the requirements for a multi-target tracking data association system. This system will group radar plots into clusters, generate hypotheses for each cluster, compute joint and marginal probabilities, and find the best hypothesis for target plot association using various data association techniques.

\*\*1.2 Scope\*\*

This system will support improved Joint Probabilistic Data Association (JPDA), Global Nearest Neighbor (GNN), Probabilistic Data Association (PDA), and other relevant techniques. It will also include configuration capabilities via a Human-Machine Interface (HMI) and will generate plots for various data association techniques.

\*\*1.3 Definitions, Acronyms, and Abbreviations\*\*

- \*\*JPDA\*\*: Joint Probabilistic Data Association

- \*\*GNN\*\*: Global Nearest Neighbor

- \*\*PDA\*\*: Probabilistic Data Association

- \*\*HMI\*\*: Human-Machine Interface

- \*\*CSCSI\*\*: Configurable System for Cluster and Track Identification

- \*\*SRS\*\*: Software Requirements Specification

\*\*1.4 References\*\*

- Reference materials and standards relevant to multi-target tracking and data association techniques.

#### 2. Overall Description

\*\*2.1 Product Perspective\*\*

The system will be integrated with radar sensors to receive radar plots and process these plots for multi-target tracking. It will use various data association techniques to enhance tracking accuracy and reliability.

\*\*2.2 Product Functions\*\*

- Receive radar plots.

- Group plots into clusters.

- Perform clustering of plots with respect to existing tracks.

- Generate possible hypotheses for each cluster.

- Compute joint and marginal probabilities for each hypothesis.

- Determine the best hypothesis for target plot association.

- Perform data association using JPDA, GNN, PDA, and other techniques.

- Provide configuration options via HMI.

- Generate plots for various data association techniques.

\*\*2.3 User Characteristics\*\*

- Radar system operators

- Defense personnel

- Researchers in target tracking and data association

\*\*2.4 Constraints\*\*

- Real-time processing requirements.

- Handling of high volume and high frequency of radar plots.

- Accuracy and reliability of the data association techniques.

\*\*2.5 Assumptions and Dependencies\*\*

- Availability of radar plot data.

- Proper functioning of the HMI for configuration.

- Availability of computational resources for real-time processing.

#### 3. Specific Requirements

\*\*3.1 Functional Requirements\*\*

\*\*3.1.1 Plot Reception and Clustering\*\*

- The system shall receive radar plots.

- The system shall group the plots into clusters based on spatial and temporal proximity.

\*\*3.1.2 Clustering with Respect to Tracks\*\*

- The system shall perform clustering of plots with respect to existing tracks to ensure that new plots are associated with the correct tracks.

\*\*3.1.3 Hypothesis Generation\*\*

- The system shall generate possible hypotheses for each cluster, considering various potential associations between plots and tracks.

\*\*3.1.4 Probability Computation\*\*

- The system shall compute joint probabilities for each hypothesis.

- The system shall compute marginal probabilities for each hypothesis to evaluate the likelihood of each potential association.

\*\*3.1.5 Best Hypothesis Selection\*\*

- The system shall find the best hypothesis for target plot association based on the computed probabilities.

\*\*3.1.6 Data Association Techniques\*\*

- The system shall perform data association using improved JPDA, GNN, PDA, and other techniques as required.

\*\*3.1.7 Configuration via HMI\*\*

- The system shall receive configuration parameters from the HMI, allowing users to adjust settings and preferences for data association techniques.

\*\*3.1.8 Plot Generation\*\*

- The system shall generate plots to visually represent the results of various data association techniques.

\*\*3.2 Non-Functional Requirements\*\*

\*\*3.2.1 Performance\*\*

- The system shall process radar plots and perform data association in real-time.

\*\*3.2.2 Reliability\*\*

- The system shall ensure high reliability in data association to maintain accurate target tracking.

\*\*3.2.3 Usability\*\*

- The system shall provide a user-friendly interface via HMI for configuration and visualization.

\*\*3.2.4 Scalability\*\*

- The system shall handle a high volume of radar plots and multiple targets simultaneously.

\*\*3.2.5 Security\*\*

- The system shall ensure secure handling and processing of radar data.

\*\*3.3 Interface Requirements\*\*

\*\*3.3.1 Radar Data Interface\*\*

- The system shall have an interface to receive radar plot data.

\*\*3.3.2 HMI Configuration Interface\*\*

- The system shall provide an HMI for configuration of data association parameters and techniques.

\*\*3.3.3 Visualization Interface\*\*

- The system shall generate and display plots representing data association results.

#### 4. System Features

\*\*4.1 Feature 1: Plot Reception and Initial Clustering\*\*

- Description: Receive radar plots and group them into initial clusters based on proximity.

- Priority: High

- Dependencies: Radar data interface

\*\*4.2 Feature 2: Clustering with Respect to Existing Tracks\*\*

- Description: Perform clustering of plots with respect to existing tracks to enhance tracking accuracy.

- Priority: High

- Dependencies: Initial clustering, track data

\*\*4.3 Feature 3: Hypothesis Generation\*\*

- Description: Generate possible hypotheses for each cluster to evaluate potential plot-track associations.

- Priority: High

- Dependencies: Clustering with respect to tracks

\*\*4.4 Feature 4: Probability Computation\*\*

- Description: Compute joint and marginal probabilities for each hypothesis to determine the likelihood of associations.

- Priority: High

- Dependencies: Hypothesis generation

\*\*4.5 Feature 5: Best Hypothesis Selection\*\*

- Description: Select the best hypothesis for target plot association based on computed probabilities.

- Priority: High

- Dependencies: Probability computation

\*\*4.6 Feature 6: Data Association Techniques\*\*

- Description: Implement JPDA, GNN, PDA, and other data association techniques for accurate target tracking.

- Priority: High

- Dependencies: Best hypothesis selection

\*\*4.7 Feature 7: HMI Configuration\*\*

- Description: Provide an HMI for users to configure data association parameters and techniques.

- Priority: Medium

- Dependencies: Data association techniques

\*\*4.8 Feature 8: Plot Generation\*\*

- Description: Generate plots to visualize the results of data association techniques.

- Priority: Medium

- Dependencies: Data association techniques, HMI configuration

#### 5. Other Requirements

\*\*5.1 Data Requirements\*\*

- Description: Specifications for radar plot data format, structure, and frequency.

\*\*5.2 Quality Requirements\*\*

- Description: Requirements for system performance, reliability, usability, and security.

\*\*5.3 Training Requirements\*\*

- Description: Training programs for users to effectively operate the system and understand the visualization plots.

\*\*5.4 Documentation Requirements\*\*

- Description: Comprehensive documentation for system installation, configuration, operation, and maintenance.

This SRS document outlines the requirements for the multi-target tracking data association system, focusing on clustering, hypothesis generation, probability computation, and target plot association using advanced techniques such as JPDA, GNN, and PDA. The system will be configurable via HMI and will provide visualization plots for various data association methods.

### Software Requirements Specification (SRS) Document

#### 1. Introduction

##### 1.1 Purpose

The purpose of this document is to outline the software requirements for the Multi-Target Tracking System, which will include data association techniques such as Improved JPDA (Joint Probabilistic Data Association), GNN (Global Nearest Neighbor), PDA (Probabilistic Data Association), and other relevant techniques.

##### 1.2 Scope

This system is designed to process radar plots and perform clustering of plots with respect to tracks, generate possible hypotheses for each cluster, compute joint and marginal probabilities for these hypotheses, and determine the best hypothesis for target plot association. The system will also receive configuration from a Human-Machine Interface (HMI) and generate visual plots for various data association techniques.

##### 1.3 Definitions, Acronyms, and Abbreviations

- \*\*JPDA\*\*: Joint Probabilistic Data Association

- \*\*GNN\*\*: Global Nearest Neighbor

- \*\*PDA\*\*: Probabilistic Data Association

- \*\*HMI\*\*: Human-Machine Interface

- \*\*SRS\*\*: Software Requirements Specification

- \*\*CSCSI\*\*: Computer System Configuration

#### 2. Overall Description

##### 2.1 Product Perspective

The Multi-Target Tracking System will be an integral part of radar processing systems, providing robust and efficient tracking capabilities. It will interface with radar data sources and the HMI for configuration and visualization.

##### 2.2 Product Functions

- \*\*Plot Grouping\*\*: Group radar plots into clusters.

- \*\*Clustering\*\*: Perform clustering of plots with respect to the tracks.

- \*\*Hypothesis Generation\*\*: Generate possible hypotheses for each cluster.

- \*\*Probability Computation\*\*: Compute joint and marginal probabilities for each hypothesis.

- \*\*Best Hypothesis Selection\*\*: Find the best hypothesis for target plot association.

- \*\*Data Association\*\*: Implement data association using Improved JPDA, GNN, PDA, and other techniques.

- \*\*Configuration Management\*\*: Receive configuration settings from the HMI.

- \*\*Visualization\*\*: Generate visual plots for various data association techniques.

##### 2.3 User Classes and Characteristics

- \*\*Radar Operators\*\*: Primary users who monitor and analyze radar plots.

- \*\*System Administrators\*\*: Users who configure and maintain the system.

- \*\*Developers\*\*: Users who develop and maintain the software.

##### 2.4 Operating Environment

The system will operate in real-time environments where radar data is continuously processed and updated. It will be implemented on a high-performance computing platform with connectivity to radar data sources and the HMI.

#### 3. Specific Requirements

##### 3.1 Functional Requirements

###### 3.1.1 Plot Grouping

- \*\*Requirement\*\*: The system shall group radar plots into clusters.

- \*\*Rationale\*\*: To efficiently manage and process radar data.

###### 3.1.2 Clustering

- \*\*Requirement\*\*: The system shall perform clustering of plots with respect to the tracks.

- \*\*Rationale\*\*: To facilitate the association of plots to the correct targets.

###### 3.1.3 Hypothesis Generation

- \*\*Requirement\*\*: The system shall generate possible hypotheses for each cluster.

- \*\*Rationale\*\*: To explore all potential associations of plots to tracks.

###### 3.1.4 Probability Computation

- \*\*Requirement\*\*: The system shall compute joint and marginal probabilities for each hypothesis.

- \*\*Rationale\*\*: To evaluate the likelihood of each hypothesis.

###### 3.1.5 Best Hypothesis Selection

- \*\*Requirement\*\*: The system shall find the best hypothesis for target plot association.

- \*\*Rationale\*\*: To ensure accurate target tracking.

###### 3.1.6 Data Association

- \*\*Requirement\*\*: The system shall perform data association using Improved JPDA, GNN, PDA, and other techniques.

- \*\*Rationale\*\*: To improve the accuracy and robustness of the tracking system.

###### 3.1.7 Configuration Management

- \*\*Requirement\*\*: The system shall receive configuration settings from the HMI.

- \*\*Rationale\*\*: To allow customization and control over the tracking process.

###### 3.1.8 Visualization

- \*\*Requirement\*\*: The system shall generate visual plots for various data association techniques.

- \*\*Rationale\*\*: To provide users with a clear understanding of the tracking process and results.

##### 3.2 Non-Functional Requirements

###### 3.2.1 Performance

- \*\*Requirement\*\*: The system shall process radar data in real-time with minimal latency.

- \*\*Rationale\*\*: To ensure timely and accurate target tracking.

###### 3.2.2 Reliability

- \*\*Requirement\*\*: The system shall provide consistent and accurate tracking results.

- \*\*Rationale\*\*: To maintain trust and reliability in the tracking system.

###### 3.2.3 Usability

- \*\*Requirement\*\*: The system shall have an intuitive and user-friendly interface.

- \*\*Rationale\*\*: To ensure ease of use for radar operators and administrators.

###### 3.2.4 Scalability

- \*\*Requirement\*\*: The system shall be scalable to handle increasing amounts of radar data.

- \*\*Rationale\*\*: To accommodate future growth and expansion.

###### 3.2.5 Security

- \*\*Requirement\*\*: The system shall ensure data security and integrity.

- \*\*Rationale\*\*: To protect sensitive radar data and configurations.

##### 3.3 Computer System Configuration

###### 3.3.1 Hardware Requirements

- \*\*Requirement\*\*: The system shall operate on high-performance servers with multi-core processors and sufficient memory (e.g., 32 GB RAM or higher).

- \*\*Rationale\*\*: To handle the computational demands of real-time radar data processing.

###### 3.3.2 Software Requirements

- \*\*Requirement\*\*: The system shall run on a Linux-based operating system.

- \*\*Rationale\*\*: To provide a stable and secure environment for the application.

###### 3.3.3 Network Requirements

- \*\*Requirement\*\*: The system shall have high-speed network connectivity to receive radar data and communicate with the HMI.

- \*\*Rationale\*\*: To ensure real-time data transmission and configuration management.

###### 3.3.4 Database Requirements

- \*\*Requirement\*\*: The system shall use a robust database system for storing radar plots, track information, and configurations.

- \*\*Rationale\*\*: To ensure efficient data management and retrieval.

#### 4. External Interface Requirements

##### 4.1 User Interfaces

- \*\*Requirement\*\*: The HMI shall provide an interface for configuring the system and visualizing tracking results.

- \*\*Rationale\*\*: To allow users to interact with the system effectively.

##### 4.2 Hardware Interfaces

- \*\*Requirement\*\*: The system shall interface with radar data sources through standard communication protocols.

- \*\*Rationale\*\*: To ensure compatibility and data exchange.

##### 4.3 Software Interfaces

- \*\*Requirement\*\*: The system shall interface with external software components for data processing and visualization.

- \*\*Rationale\*\*: To enable integration and extend functionality.

##### 4.4 Communication Interfaces

- \*\*Requirement\*\*: The system shall support communication protocols for real-time data transmission.

- \*\*Rationale\*\*: To facilitate efficient data exchange between system components.

#### 5. Other Non-Functional Requirements

##### 5.1 Performance Requirements

- \*\*Requirement\*\*: The system shall process radar data within 50 milliseconds of receipt.

- \*\*Rationale\*\*: To ensure timely tracking and data association.

##### 5.2 Safety Requirements

- \*\*Requirement\*\*: The system shall include fail-safe mechanisms to handle data corruption or system failures.

- \*\*Rationale\*\*: To maintain operational integrity and safety.

##### 5.3 Security Requirements

- \*\*Requirement\*\*: The system shall implement encryption for data transmission and storage.

- \*\*Rationale\*\*: To protect sensitive information from unauthorized access.

##### 5.4 Software Quality Attributes

- \*\*Requirement\*\*: The system shall be modular to allow easy maintenance and upgrades.

- \*\*Rationale\*\*: To ensure long-term sustainability and flexibility.

##### 5.5 Business Rules

- \*\*Requirement\*\*: The system shall comply with industry standards for radar data processing and tracking.

- \*\*Rationale\*\*: To ensure compatibility and adherence to best practices.

This SRS document outlines the requirements for the Multi-Target Tracking System, providing a comprehensive guide for development, implementation, and maintenance.

### Computer Software Configuration Item (CSCI)

#### 1. Introduction

##### 1.1 Purpose

The purpose of this section is to define the detailed contents and configuration of the Computer Software Configuration Item (CSCI) for the Multi-Target Tracking System. This includes the software components, interfaces, and configuration parameters required to implement the system's functionality.

##### 1.2 Scope

This document covers the software architecture, modules, interfaces, configuration management, and dependencies for the CSCI. It provides a comprehensive view of how the software components are structured and how they interact to achieve the system's objectives.

#### 2. Software Architecture

##### 2.1 Overview

The software architecture of the Multi-Target Tracking System is designed to be modular and scalable, facilitating easy maintenance and upgrades. The architecture includes several key modules:

- \*\*Data Ingestion Module\*\*

- \*\*Clustering Module\*\*

- \*\*Hypothesis Generation Module\*\*

- \*\*Probability Computation Module\*\*

- \*\*Data Association Module\*\*

- \*\*Configuration Management Module\*\*

- \*\*Visualization Module\*\*

##### 2.2 Module Descriptions

###### 2.2.1 Data Ingestion Module

- \*\*Description\*\*: Responsible for receiving radar plots and pre-processing the data.

- \*\*Functions\*\*:

- Receive radar data from external sources.

- Pre-process data to remove noise and irrelevant information.

- Format data for further processing.

###### 2.2.2 Clustering Module

- \*\*Description\*\*: Performs clustering of plots with respect to the tracks.

- \*\*Functions\*\*:

- Implement clustering algorithms to group radar plots.

- Maintain and update clusters as new data arrives.

- Provide clustered data to the Hypothesis Generation Module.

###### 2.2.3 Hypothesis Generation Module

- \*\*Description\*\*: Generates possible hypotheses for each cluster.

- \*\*Functions\*\*:

- Create potential associations between plots and tracks.

- Enumerate all plausible hypotheses for further evaluation.

###### 2.2.4 Probability Computation Module

- \*\*Description\*\*: Computes joint and marginal probabilities for each hypothesis.

- \*\*Functions\*\*:

- Calculate the likelihood of each hypothesis using statistical methods.

- Provide probability values to the Data Association Module.

###### 2.2.5 Data Association Module

- \*\*Description\*\*: Performs data association using techniques such as Improved JPDA, GNN, and PDA.

- \*\*Functions\*\*:

- Evaluate hypotheses based on computed probabilities.

- Select the best hypothesis for target plot association.

- Update track information with associated plots.

###### 2.2.6 Configuration Management Module

- \*\*Description\*\*: Manages configuration settings received from the HMI.

- \*\*Functions\*\*:

- Receive and apply configuration settings.

- Allow dynamic adjustment of system parameters.

- Ensure configuration changes are logged and tracked.

###### 2.2.7 Visualization Module

- \*\*Description\*\*: Generates visual plots for various data association techniques.

- \*\*Functions\*\*:

- Create graphical representations of tracking results.

- Display real-time data and tracking information.

- Provide interactive tools for users to analyze tracking performance.

#### 3. Interfaces

##### 3.1 External Interfaces

###### 3.1.1 Radar Data Interface

- \*\*Description\*\*: Interface for receiving radar data from external sources.

- \*\*Protocol\*\*: TCP/IP or other standard communication protocols.

- \*\*Data Format\*\*: Structured format (e.g., JSON, XML).

###### 3.1.2 HMI Interface

- \*\*Description\*\*: Interface for receiving configuration settings and providing visualization outputs.

- \*\*Protocol\*\*: HTTP/HTTPS.

- \*\*Data Format\*\*: JSON for configuration settings, graphical formats for visualization (e.g., SVG, PNG).

##### 3.2 Internal Interfaces

###### 3.2.1 Data Ingestion to Clustering Module

- \*\*Description\*\*: Passes pre-processed radar data to the Clustering Module.

- \*\*Data Format\*\*: Internal structured format.

###### 3.2.2 Clustering to Hypothesis Generation Module

- \*\*Description\*\*: Provides clustered data for hypothesis generation.

- \*\*Data Format\*\*: Internal structured format.

###### 3.2.3 Hypothesis Generation to Probability Computation Module

- \*\*Description\*\*: Sends generated hypotheses for probability computation.

- \*\*Data Format\*\*: Internal structured format.

###### 3.2.4 Probability Computation to Data Association Module

- \*\*Description\*\*: Transfers computed probabilities for data association.

- \*\*Data Format\*\*: Internal structured format.

###### 3.2.5 Data Association to Visualization Module

- \*\*Description\*\*: Provides associated plot data for visualization.

- \*\*Data Format\*\*: Internal structured format.

#### 4. Configuration Management

##### 4.1 Configuration Parameters

###### 4.1.1 Clustering Parameters

- \*\*Description\*\*: Parameters that control the clustering algorithms.

- \*\*Examples\*\*:

- Distance threshold for clustering.

- Minimum number of plots per cluster.

###### 4.1.2 Hypothesis Generation Parameters

- \*\*Description\*\*: Parameters for generating hypotheses.

- \*\*Examples\*\*:

- Maximum number of hypotheses per cluster.

- Criteria for hypothesis validity.

###### 4.1.3 Probability Computation Parameters

- \*\*Description\*\*: Parameters for computing probabilities.

- \*\*Examples\*\*:

- Statistical models used for probability computation.

- Parameters for joint and marginal probability calculations.

###### 4.1.4 Data Association Parameters

- \*\*Description\*\*: Parameters for data association techniques.

- \*\*Examples\*\*:

- Algorithm selection (Improved JPDA, GNN, PDA).

- Parameters specific to each algorithm.

##### 4.2 Configuration Management Tools

- \*\*Description\*\*: Tools used to manage and apply configuration settings.

- \*\*Examples\*\*:

- Configuration files (e.g., JSON, YAML).

- Configuration management interfaces in the HMI.

- Logging mechanisms to track configuration changes.

#### 5. Dependencies

##### 5.1 Software Dependencies

- \*\*Operating System\*\*: Linux-based OS for stability and security.

- \*\*Libraries\*\*: Statistical and machine learning libraries for probability computation and clustering (e.g., NumPy, SciPy, scikit-learn).

- \*\*Visualization Tools\*\*: Libraries for generating visual plots (e.g., Matplotlib, D3.js).

##### 5.2 Hardware Dependencies

- \*\*Processing Power\*\*: Multi-core processors for handling real-time data processing.

- \*\*Memory\*\*: Sufficient RAM (e.g., 32 GB or higher) to manage large datasets.

- \*\*Network\*\*: High-speed network connectivity for real-time data transmission.

#### 6. Testing and Validation

##### 6.1 Unit Testing

- \*\*Description\*\*: Testing individual modules for correctness.

- \*\*Tools\*\*: Unit testing frameworks (e.g., pytest for Python).

##### 6.2 Integration Testing

- \*\*Description\*\*: Testing the interactions between modules.

- \*\*Tools\*\*: Integration testing frameworks and tools.

##### 6.3 System Testing

- \*\*Description\*\*: Testing the complete system to ensure it meets requirements.

- \*\*Tools\*\*: System testing frameworks, performance testing tools.

##### 6.4 User Acceptance Testing (UAT)

- \*\*Description\*\*: Testing by end-users to validate the system against real-world scenarios.

- \*\*Process\*\*: Conducted in collaboration with radar operators and system administrators.

This detailed outline for the CSCI provides a comprehensive understanding of the software components, their interactions, and the configuration management required for the Multi-Target Tracking System. It ensures that all aspects of the system are well-defined and ready for development and implementation.

Here's a more detailed version of the SRS document, with expanded explanations and additional information for each section:

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# Software Requirements Specification (SRS) for Data Association Module

## 1. Introduction

### 1.1 Purpose

This Software Requirements Specification (SRS) document outlines the requirements for the data association module used in multi-target tracking systems. The primary function of this module is to process radar plots, group them into clusters, generate hypotheses, compute probabilities, and determine the best hypothesis for associating plots with targets. This module will be implemented as a Computer Software Configuration Item (CSCI) within the tracking system.

### 1.2 Scope

The data association module is designed to work within a multi-target tracking system, leveraging various data association techniques such as Improved Joint Probabilistic Data Association (JPDA), Global Nearest Neighbor (GNN), and Probabilistic Data Association (PDA). The module will interface with the Human-Machine Interface (HMI) for configuration and will generate visual plots to illustrate the performance of different data association techniques.

### 1.3 Definitions, Acronyms, and Abbreviations

- \*\*CSCI\*\*: Computer Software Configuration Item

- \*\*JPDA\*\*: Joint Probabilistic Data Association

- \*\*GNN\*\*: Global Nearest Neighbor

- \*\*PDA\*\*: Probabilistic Data Association

- \*\*HMI\*\*: Human-Machine Interface

## 2. General Description

### 2.1 System Overview

The data association module is a critical component of a multi-target tracking system. It processes radar plots, performs clustering to group plots into potential targets, generates hypotheses for plot associations, and computes probabilities to select the best hypothesis for associating plots with targets. This module enhances the tracking system's ability to accurately track multiple targets in real-time.

## 3. Specific Requirements

### 3.1 Functional Requirements

#### 3.1.1 Plot Grouping

- \*\*Requirement\*\*: The system shall group radar plots into clusters based on spatial and temporal proximity.

- \*\*Explanation\*\*: Radar plots detected within close spatial proximity and within a short time interval should be considered as part of the same cluster, representing a potential target.

#### 3.1.2 Radar Plot Reception

- \*\*Requirement\*\*: The system shall receive radar plots as input.

- \*\*Explanation\*\*: The module must be able to intake raw radar plot data from the radar sensors or pre-processing units.

#### 3.1.3 Clustering

- \*\*Requirement\*\*: The system shall perform clustering of plots with respect to existing tracks to form potential target clusters.

- \*\*Explanation\*\*: Existing tracks must be taken into account when clustering new plots, ensuring that new data is associated with ongoing tracks when appropriate.

#### 3.1.4 Hypothesis Generation

- \*\*Requirement\*\*: The system shall generate possible hypotheses for each cluster, representing potential associations between plots and targets.

- \*\*Explanation\*\*: For each cluster, the module should generate multiple hypotheses, considering different possible associations of plots to targets.

#### 3.1.5 Joint Probability Computation

- \*\*Requirement\*\*: The system shall compute joint probabilities for each hypothesis to evaluate the likelihood of each possible association.

- \*\*Explanation\*\*: The system should calculate the joint probability of all plot-to-target associations within a hypothesis to determine the overall likelihood of that hypothesis.

#### 3.1.6 Marginal Probability Computation

- \*\*Requirement\*\*: The system shall compute marginal probabilities for each hypothesis to assess individual associations.

- \*\*Explanation\*\*: Marginal probabilities for each plot-to-target association should be computed to evaluate the likelihood of each individual plot being associated with a target.

#### 3.1.7 Best Hypothesis Selection

- \*\*Requirement\*\*: The system shall determine the best hypothesis for target plot association based on computed probabilities.

- \*\*Explanation\*\*: Using the joint and marginal probabilities, the system should select the hypothesis that most likely represents the correct plot-to-target associations.

### 3.2 Data Association Techniques

#### 3.2.1 Improved JPDA

- \*\*Requirement\*\*: The system shall perform data association using Improved Joint Probabilistic Data Association.

- \*\*Explanation\*\*: Improved JPDA enhances the traditional JPDA by incorporating additional context or optimization techniques to improve association accuracy.

#### 3.2.2 GNN

- \*\*Requirement\*\*: The system shall perform data association using Global Nearest Neighbor techniques.

- \*\*Explanation\*\*: GNN techniques involve associating each plot with the nearest target based on a global optimization strategy.

#### 3.2.3 PDA

- \*\*Requirement\*\*: The system shall perform data association using Probabilistic Data Association techniques.

- \*\*Explanation\*\*: PDA calculates the probability of each plot-to-target association based on probabilistic models, accommodating uncertainties in plot positions.

#### 3.2.4 Additional Techniques

- \*\*Requirement\*\*: The system shall support additional data association techniques as configured.

- \*\*Explanation\*\*: The system should be extensible to support future data association techniques as they become available or are developed.

### 3.3 Configuration and Visualization

#### 3.3.1 HMI Configuration

- \*\*Requirement\*\*: The system shall receive configuration parameters from the Human-Machine Interface (HMI).

- \*\*Explanation\*\*: Users should be able to configure the data association module through the HMI, setting parameters such as thresholds, techniques to use, and visualization preferences.

#### 3.3.2 Plot Generation

- \*\*Requirement\*\*: The system shall generate visual plots for various data association techniques to aid in analysis and debugging.

- \*\*Explanation\*\*: Visual representations of the data association process should be generated to help users understand and evaluate the performance of different techniques.

## 4. Performance Requirements

### 4.1 Processing Time

- \*\*Requirement\*\*: The system shall process radar plots and perform data association within a specified time frame to meet real-time tracking requirements.

- \*\*Explanation\*\*: The module must operate efficiently to provide timely updates to the tracking system, ensuring that targets are tracked in real-time without significant delays.

### 4.2 Accuracy

- \*\*Requirement\*\*: The system shall achieve a high level of accuracy in associating plots with targets to ensure reliable tracking performance.

- \*\*Explanation\*\*: Accurate data association is crucial for maintaining reliable tracks on multiple targets, reducing errors in target identification and tracking.

## 5. Design Constraints

### 5.1 Hardware Requirements

- \*\*Requirement\*\*: The system shall operate on specified hardware platforms to ensure compatibility and performance.

- \*\*Explanation\*\*: The data association module must be designed to run on the hardware specified for the overall tracking system, ensuring it meets performance and compatibility requirements.

### 5.2 Software Compatibility

- \*\*Requirement\*\*: The system shall be compatible with existing tracking software and interfaces.

- \*\*Explanation\*\*: The module should integrate seamlessly with the existing software ecosystem, including data ingestion, processing, and output interfaces.

## 6. Software System Attributes

### 6.1 Reliability

- \*\*Requirement\*\*: The system shall provide reliable performance with minimal downtime.

- \*\*Explanation\*\*: The data association module should be robust, handling errors gracefully and maintaining consistent performance under various conditions.

### 6.2 Maintainability

- \*\*Requirement\*\*: The system shall be designed for ease of maintenance and updates.

- \*\*Explanation\*\*: The module should have a clean, modular design that allows for straightforward maintenance, updates, and improvements.

### 6.3 Usability

- \*\*Requirement\*\*: The system shall provide a user-friendly interface for configuration and visualization.

- \*\*Explanation\*\*: Users should find it easy to configure the module and interpret the visual plots generated, facilitating effective use and analysis.

## 7. Verification

### 7.1 Testing

- \*\*Requirement\*\*: The system shall undergo rigorous testing to verify that all requirements are met and that the system performs as expected under various conditions.

- \*\*Explanation\*\*: Comprehensive testing should be conducted to ensure the data association module meets its requirements and functions correctly in all scenarios.

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This expanded version of the SRS document provides more detailed explanations for each requirement and includes additional sections to ensure a thorough understanding of the data association module's functionalities, constraints, and attributes. This level of detail will help guide the development, implementation, and verification processes.