DESIGN OF MULTIPLATFORM INFORMATION FUSION AND INTELLIGENT SENSOR MANAGEMENT SYSTEM

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Abstract: Multiplatform information fusion and intelligent sensors management is important technique for CEC and NCW. Now, the practical Multiplatform Information Fusion and Intelligent Sensor Management System have been developed. It can manage the multi-sensor airborne automatically and fuse the information from RD, IR, ESM, IFF and other multi-platform provided by data-link. This paper first describes the structure, the functions and the design approaches of the system, and then, presents the results of the dynamic tests.

Key word: multi-platform fusion, multi-sensor fusion, cooperative engage, track fusion, attribute fusion, situation awareness, threat Assessment, sensors management, sensor tasking, automatic sensor control, low probability of intercept operations, automatic target cueing, silent detection, silent attack

1 INTRODUCTION

In the future, the war will be extended from land and sea to air and space and it is a multidimensional compound. Fight planes with single sensor cannot adapt for the modern war because of its complex electromagnetic environment .So, a modern tactical aircraft often carries multiple sensors, such as Radar(RD), Infrared sensor IR , Electronic Warfare (EW), Identification Friend or Foe(IFF), Laser, Television(TV), etc. However, when multi-sensor system is used, a difficult problem will occur for a pilot, that there is too much information to be processed. So, fusion technique is needed to analyze and synthesize a great deal of information automatically. It can improve the ability of aircraft on detecting, tracking, recognizing multi-targets beyond visual rage in a countermeasure environment. Moreover, it can make the pilot share the information from other platform and get better awareness of global situation. Thus, more precise estimation of kinematics and attribute of targets and threat degree can be obtained and more powerful battle effectiveness of multi-plane cooperation can be arrived.

As the complexity of the battlefield situation increases and the members engaging in battle becomes more and more, pilot does not have sufficient time or data to manage his sensors. He has to plan the attack, control the operation of his sensors, prepare and launch his weapons, and coordinate with wingman. Therefore an intelligent sensors management is needed to assign tasks to sensors , control sensors to operate and adjust sensors to proper parameters. Intelligent Sensor Management can liberate the pilots from trivialness and make them pay attention to more important job e.g. making offensive and defensive decision in a complex battlefield.

To satisfy the above requirements, Multiplatform Information Fusion and Intelligent Sensor Management System (MPIFSM) have been developed. It can manage the multi-sensor airborne automatically and fuse the information from RD, IRST, ESM, IFF and other multiplatform provided by data-link, such as wingman, AWACS, ground control center, etc. This paper describes the function, capability, structure and design approach of the system in detail and presents the results of dynamic tests.

2 COMPOSING AND FUNCTIONS

MPIFSM can be divided into four parts: Local Fusion Center(LFC), Globe Fusion Center(GFC), Situation and Threat Assessment(STA), and Sensors Management(SM). The main functions of MPIFSM includes:

1. Spatial and temporal data alignment and error compensation of multi-platform and multi-sensor

2. Data association and correlation of multi-platform and multi-sensor

3. Track generating jointly and fusing with multi-platform and multi-sensor

4. Fusion decision of target identity based on attributes provided by multi-platform and multi-sensor

5. Pseudo-track recognizing and deleting

6. Global track files management

7. Threat assessment and situation displaying dynamically

8. Sensors health and performance state Monitoring

9. Search and track tasking

10.Sensor source Coordinating and scheduling

11. Sensor functions Control and parameters calculation for their usage

12.Emission control of RF sensors

13. Countermeasures management

14. Communication management

3 STRUCTURE AND PRINCIPLES

See Fig1 Measurements from airborne sensors, such as Radar (RD), Infrared sensor(IR), Electronic Support Measure System (ESM), Identification Friend or Foe (IFF), are gathered and fused in Local Fusion Center and form a local track file which includes kinetic state and identity estimates. The fusion process involves operations such as detecting, aligning (both spatially and temporally), associating, inferring, estimating, and predicting. Then, the local tracks are correlated with the off-board tracks which come from

AWACS Wingmen, Warship, and Ground Control Center through data links and optimized to form the overall situation information. Based on which and on knowledge of enemy tactics, Situation Threat Assessment attempts to infer threat levels and predict future events. Finally, Sensor Management uses the globe situation information and threat assessment to form a plan for future sensor use.

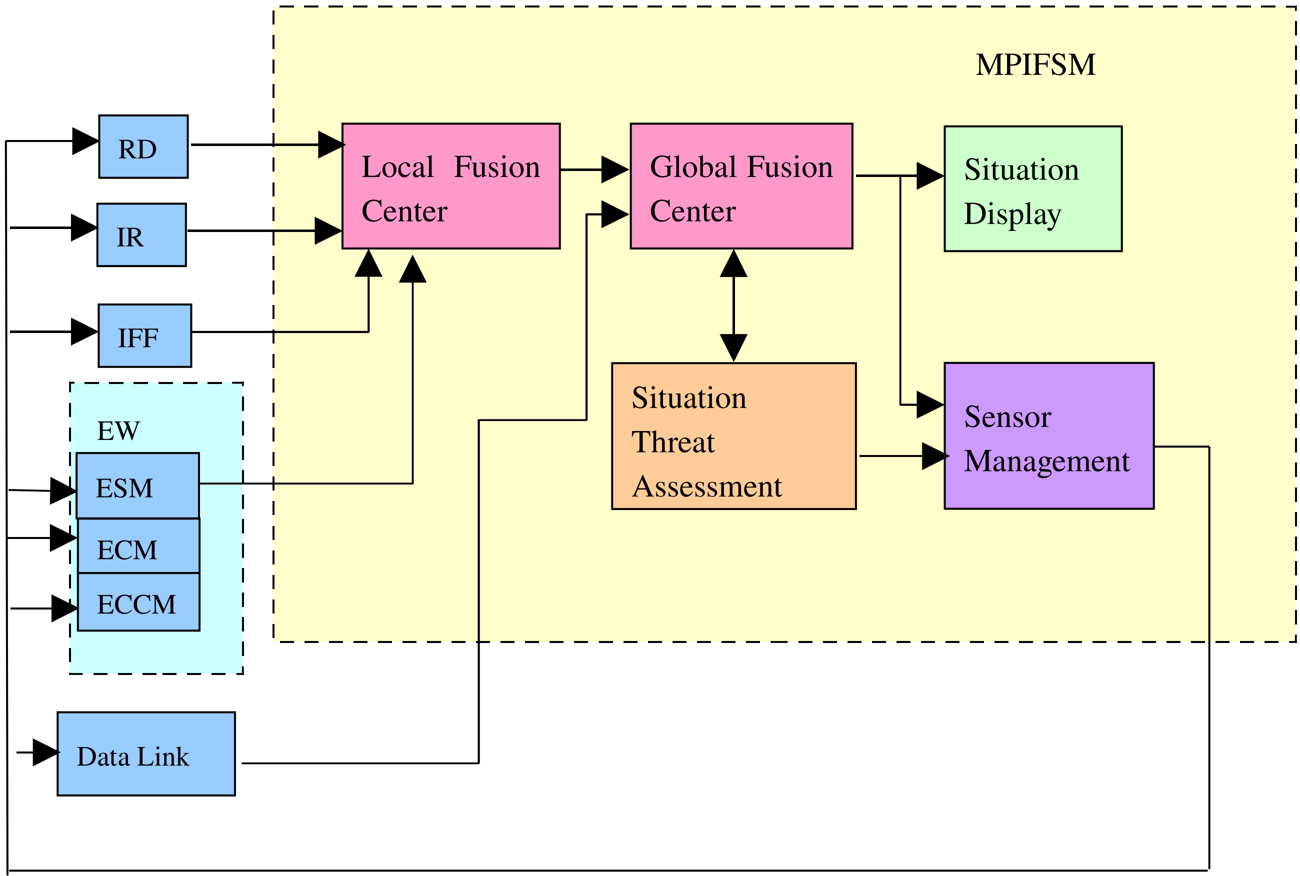

Fig 1. Multiplatform Information Fusion and Intelligent Sensor Management System Block Diagram

3.1 DESIGN OF LOCAL FUSION CENTER

Local Fusion Center is based on hybrid structure of data fusion. That is, the measurement of each sensor and its processed results are all used at the same time. Fast track origination and less information losing are the advantage of hybrid structure of data fusion.

Detections and tracks of multi-target together with their estimate covariance, obtained from Radar and Infrared system, are all sent to Local Fusion Center. After recognizing primarily by ESM, the state and attributes of each target, as well as its azimuth data, is also passed to Local Fusion Center. First of all, these measurements are transformed to a common spatial coordinate and temporal reference because the reports and tracks arrive from the sensors with different measure spaces and measure times. Then, association hypotheses can be developed and scored to determine probable report-track or track-track assignment. When unique assignment of new report or track data is made to existing track, an adaptive Kalman filter based on dynamic model of the target well update the estimates of the target kinematics. Uncorrelated reports or tracks are preserved to organize new tracks. Finally, the attributes of each target is couple with different tracks and identity of the target is determined based on its attributes, velocity, acceleration, maneuvering, etc.

Before attacking, the Radar primarily works at interval emission, thus reducing the probability of the aircraft being intercepted. During this time, Local Fusion Center tracks the targets adaptively with the infrared system which is assisted by the Radar discontinuously. As the aircraft approaches the targets and prepares to attack them, the Radar will emit continuously to track target and Local Fusion Center will implement association and synthesis of the tracks coming from Radar and infrared system. If the Radar works at TAS mode, the tracking precision is so high that the track fusion of the Radar and infrared system doesn’t needed. Then the Radar and infrared system can work at different viewing fields respectively to expand the overall scope of searching and tracking.

3.2 DESIGN OF GLOBE FUSION CENTER

Distributed fusion structure is used to Globe Fusion Center because the hybrid structure and centralized structure of data fusion will result in the high load of communication and computation. Moreover, it is difficult to align data from various platforms.

Target tracking and identifying based on each platform are completed respectively. Then, intelligence data of enemy, track kinematics and ID of targets including their estimate covariance and confidence data, are all sent to Globe Fusion Center though tactical data link (e.g. IFDL, Link 16.). The states (i.e. position, velocity, acceleration, attitude, etc.) of the friend aircrafts arrive at the same time. Unification of time and space to data of multiplatform is done at first in Globe Fusion Center. Then, for the same target, local tracks from various platforms will be correlated and fused or synthesized, and Fusion identify based on local ID information of multi-platform is implemented using Demspter-Shafer evidential combination algorithm. To increase the correctness of track-to-track correlation, we use the history information of the local tracks. At last, all tracks are numbered and the Pseudo-tracks are wiped off. The globe situation information of battlefield is obtained.

There are two status of Globe Fusion Center. 1) When the sensor system of ownship is active, the track data from Local Fusion Center and other platform will be synthesized or optimized 2) When the sensor system of ownship is entirely silent, a Radar of wingman in a safe zone is needed to operate and track fusion of onboard IR and off-board RD will be implemented to supports the aircraft to attack silently.

Since data traffic through communication links is getting busier and busier in a modern multiplatform system, it is necessary to cut down the data communication rate for exchanging track and covariance data, but still maintain high-quality globe fusion results. Therefore, certain data compression technique have been adopt, which is depended on the dynamic behaviors of the targets.

3.3 DESIGN OF SITUATION AND THREAT ASSESSMENT

The high level function of MPIFSM is situation and threat assessment which attempt to infer the intention of maneuver, routs of attack, threat scope and lethality of the enemy force according to relative geometric situation, temporal behavior (i.e. velocity, acceleration, maneuvering, direction of travel, etc.) and tactical activities (emitter status/mode, jamming, deception, deliver weapon, etc). Situation and Threat Assessment predicts future engagement events and estimates the degree and the order of threat, which is passed to the sensor management to form the sensors task schedule.

Multiple layer structure of reasoning and multiple attribute decision making (MADM) are used to Situation and Threat Assessment. As shown in Fig.2, the process of reasoning may be divided into four levels. On the first level, the attributes of targets are collected from Globe Fusion Center and knowledge databases, which includes the number of targets, the class and type of platform, characters of emission resource and position, velocity, acceleration, direction of travel, capability of weapon and sensor of foe aircraft, and so on. On the second level, we deduce the cooperative relationship, tactical importance, probably of survivance, intention of maneuver, routs of attack, capability of fight, etc. about foe platform. On the level 3, the exponents which describe respectively on the relative situation, attack capability, and threat degree about enemy force are calcul[illegible] we conclude the integrated threat order of globe battle-filed by synthesizing these exponents.

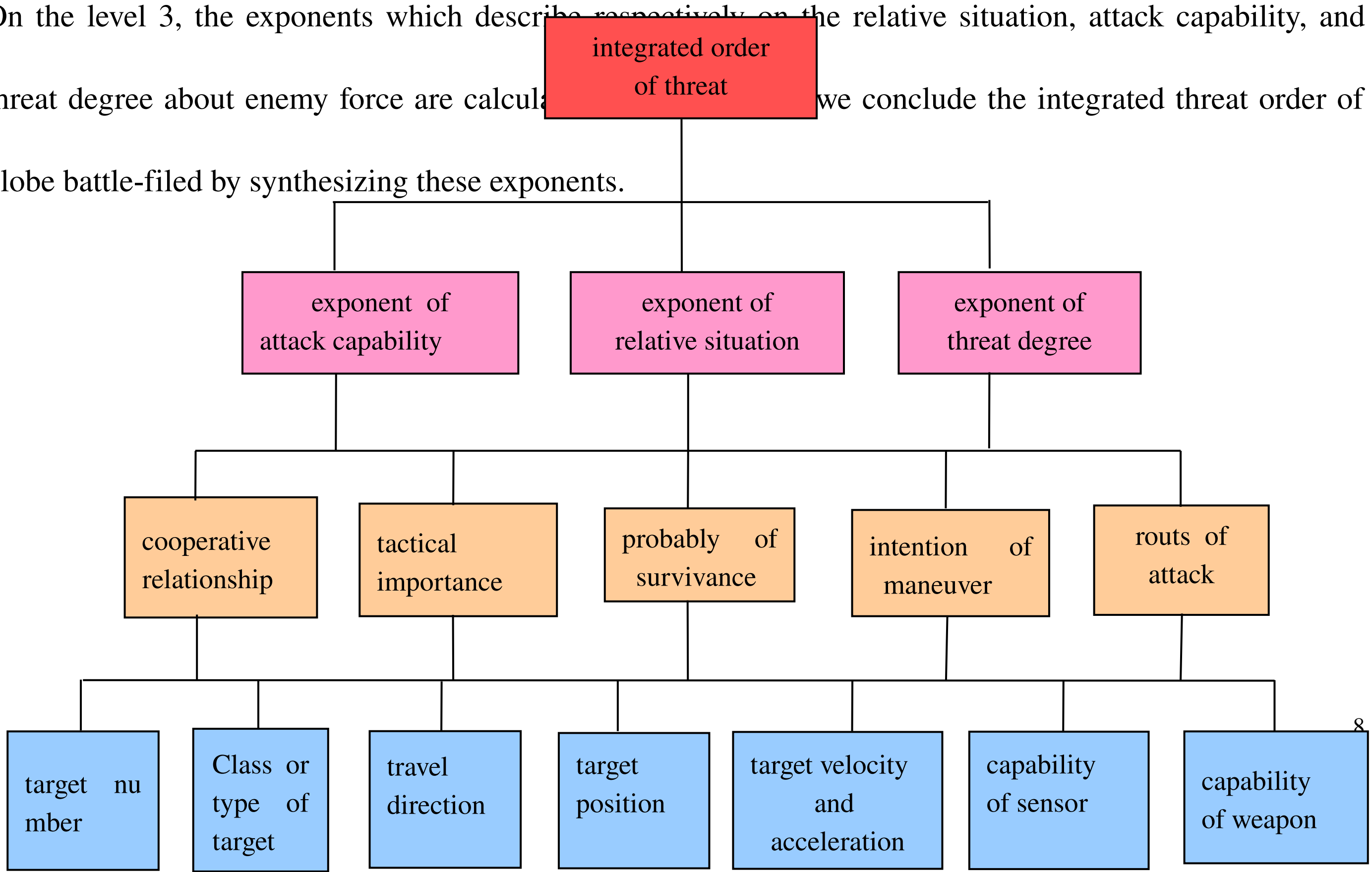

Fig 2. Situation and Threat Assessment Block Diagram

3.4 DESIGNE OF SENSOR MANAGEMENT

Sensor management is based on the data fusion layer. According to the information of battle situation, the guidance from AWACS or ground control center(GCC), the commands of pilot, the requirements of cooperation , the status of fire control , the assistant tactical decision and the threat estimation, Sensor Management accomplishes the search and track tasking, function and emission controlling, and countermeasures and communication managing automatically.

An open architecture is used to Sensor Management, which can load the different rule-base according to different battle environment. By establishing service lists, various tactical missions and service requirements can be met easily.

The Sensor Management is partitioned into the following sub-functions:

- Service Requirements Processor
- Track Service Prioritization
- Sensor Load Allocation
- Search Area Definition
- Sensor Monitor
- Sensor controller

Service Requirements Processor determines the requirement for next tracks service according to the requirements of the system mission and battlefield situation and gives out the detect service list, interfere service list, and communication service list. If the tracks service lists is formulated, it is needed to prioritize all possible services which may be track creation, track update, track identification and track raid assessment. Considering all aspect requirements of the system and the result of threat assessment, Track Service Prioritization assigns the priorities to each track service by using following rules:

- The requests from the pilot are given the highest possible priority
- Fire control requests are assigned priorities greater than those requests from the cooperative function
- Cooperative requests are assigned priorities greater than those requests from the multi-source integration function.

After all, a prioritized list of all track services is passed to Sensor Load Allocation.

According to the order of service prioritization, the boundary of the searching area and the restriction of emission, Sensors Load Allocation creates a plan of sensor operation which includes a series of schedule for each controllable sensor. Based on the schedule and the pilot's manual control, Sensor Controller forms a series of commands to control the operation modes and parameters of the Radar, IR and EW.

4. RESULS OF DYMATIC TEST

The Multiplatform information fusion and intelligent sensors management system has passed the dynamic tests successfully. It has been proved that the system is able to complete the following functions:

1) Associating data and optimizing information from Multi-platform and multi-sensor, which enable the aircraft to share the information from other platform and engage the enemy with wingman cooperatively
2) Track fusing and attribute fusing of radar , IR ESM, IFF and datalink, which improve the continuity of track and reliability of target identification and enhance the capability of the Beyond Visual Range Operation in a complicated electromagnetic environment.
3) Automatic target cueing and guiding for Radar by passive sensor or wingman through data-link, which reduce the system reaction time
4) Adaptive tracking of target with passive sensor assisted intermittently by active sensor or wingman Radar by data-link , which enable aircraft to approach and attack target silently
5) Controlling sensor operation mode and , which will reduce the pilot's workload

5 CONCLUSION

The technology of information fusion and sensor management has become more important in military, especially for CEC and NCW . Now, the key techniques have been successfully developed. Dynamic tests proved that some excellent capabilities, such as improved awareness of situation, lower false track rate, higher accuracy of target tracking and recognizing, low probability of intercept operations, automatic target cueing and lightened pilot's workload, can be achieved. MPIFSM will enable aircraft to engage enemy with wingman cooperatively and enhance attack efficiency in Beyond Visual Range Air-to-Air Combat.

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