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Research Article

Research on Channel Optimization of Ads-B Aviation Target Surveillance Radar Based on Improved Filtering Algorithm

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In order to improve the surveillance effect of the aviation target surveillance radar, this paper improves the traditional filtering algorithm and builds the channel optimization system of the ADS-B aviation target surveillance radar based on the improved filtering algorithm. Moreover, this paper uses algorithm improvement to ensure the positive definite or semipositive definiteness of the state covariance and uses the root mean square volume Kalman filter to avoid the filter divergence or tracking interruption caused by the nonpositive definiteness of the matrix; the filtering principle of the interactive multimodel is to use multiple filters for parallel processing and achieve the adaptive adjustment algorithm residual error by adjusting the one-step prediction covariance in the adjustment algorithm. In addition, this paper combines the actual needs to construct a system functional structure to optimize the channel of the ADS-B aviation target surveillance radar and uses software engineering methods to model and analyze the requirements. Finally, this paper designs experiments to verify system performance. The research results show that the performance of the system constructed in this paper meets actual needs.

1. Introduction

General aviation is an important part of civil aviation, and it plays a unique and irreplaceable role in the development of the national economy and social welfare undertakings [1]. General aviation control mainly serves general aviation flight so that the aircraft can be better controlled and managed during the flight process, and more reasonable flight arrangements and emergency measures can be obtained. General aviation flight dynamics refers to the general term for information such as the position information of the aircraft at each moment during the flight of the aircraft, the target track information of the aircraft, and the flight angle of the aircraft. The monitoring of the flight dynamics of the aircraft is to obtain the flight dynamics monitoring data of the aircraft and extract the desired information from the data.

As early as many years ago, the United States has begun to develop and research in the field of general aviation. Compared with the development of mature general aviation flight service stations in developed countries such as the United States, my country is seriously lagging behind in the construction of general aviation flight service guarantees. The main reason for the backward development is that under the current air traffic control system, the development of our country's general aviation is restricted [2].

In recent years, our country has gradually realized the shortcomings in the field of general aviation and started to develop general aviation and its control and monitoring system. Through the establishment of low-altitude pilot projects in several cities such as Pucheng, Shaanxi, it is convenient to conduct related tests of general aviation aircraft in low-altitude airspace. At the same time, in order to meet the needs of general aviation flight services and better develop the field of general aviation and improve the monitoring of general aviation flight dynamics, our country has continuously issued relevant policies to speed up the construction of general aviation flight service station systems. The establishment of a more complete general aviation control system can realize complete monitoring of general aviation flight dynamics, can better promote and develop the construction of the general aviation field, and can accelerate the speed of economic development, realize modernization, meet the ever-diversified flight needs, and enable general aviation to truly enter our lives [3]. At the same time, the aviation manufacturing industry is a high-tech industry, and complete general aviation control and monitoring of flight dynamics can better promote the use of general aviation aircraft, resulting in a certain increase in the number of general aviation aircraft. Moreover, it will further promote the improvement of my country's aircraft manufacturing level, better promote the development of civil aviation aircraft to a higher level, and enhance national defense capabilities. Studying the flight service requirements of general aviation and accelerating the construction of the operation process of general aviation flight control can improve the service efficiency of general aviation and better serve the civilian population.

2. Related Work

In recent decades, many domestic and foreign experts and scholars have conducted in-depth research on the relevant theories and practices of multitarget tracking methods and have achieved fruitful results. Related methods have been widely used in military fields such as air defense security reconnaissance and early warning, missile defense, battlefield target monitoring, and civil fields such as traffic control in civil aviation, vehicle automatic driving systems, and computer vision [4]. Multitarget tracking is to use the observations obtained by sensors to continuously estimate and predict the state of multiple targets. Usually, the observations received by the sensor at each moment are composed of the observations from the target and the clutter caused by neighboring interfering targets, meteorological, electromagnetic, and acoustic interference, and the two are indistinguishable. Clutter observations are often random in number, spatial location, and density. In a cluttered environment, due to the influence of random factors, a single target usually produces multiple effective echoes at any time. Multitarget tracking comprehensively applies modern scientific theories such as statistical estimation and decision-making, optimal control, and intelligent information processing to simultaneously estimate the number and status of multiple targets in the target and clutter mixed observation set. The research of multitarget tracking problem involves many aspects [5], including target state and motion model, observation model, coordinate conversion, tracking gate selection, data association algorithm, and target state estimation method. Factors such as the number and density of targets, target dynamic characteristics, sensor performance, noise and interference sources, and filter performance selected for state estimation all have an impact on the performance of the multitarget tracking system. With the development of multitarget tracking systems, such as multisource information fusion theory [6], nonlinear filtering theory [7], random finite set theory [8], and other new technologies, the performance of the multitarget tracking system has significantly improved the performance of the multitarget tracking system. Target uncertainty and observation uncertainty are two important issues that need to be resolved in a multitarget tracking system. Due to the new target, its birth, death, or noise and clutter interference, as well as the missed detection of sensors, there is uncertainty in the target in the surveillance area. Because it is difficult to obtain prior information such as noise and clutter in the tracking environment, there are various uncertainties and randomness in the correspondence between echo observation and its target source. In view of the above problems, there are currently two main types of solutions. One is the traditional multitarget tracking method based on data association [9]. This method first uses data correlation technology to determine the correlation between sensor observations and target sources and then estimates the state of each target separately. The other is noncorrelated multitarget tracking algorithms, which are mainly based on random finite set theory [10].

The French company Thales has successfully developed an advanced surface navigation guidance and control system, which has been put into use in many airports [11]. After the system receives information from multiple monitoring devices and performs data fusion, the positioning accuracy can reach within 10 m. It exchanges information with other devices through related interfaces so that multiple systems in the scene can coordinate operation. In addition to monitoring functions, the system also has functions such as conflict detection, path planning, and taxi guidance. It is currently the most advanced scene monitoring and management system. The Intelligent Airport system produced by American TransTech is also a typical A-SMGCS system [12]. The system includes functions such as airport ground and low-altitude alert monitoring, path planning, ground taxi guidance, navigation aid lighting monitoring, automatic control, etc., which can realize blind-spot ground alert monitoring of flight areas, aprons, and other key areas. The A-SMGCS system is a design concept, and the realization of the system can rely on a variety of different monitoring equipment. ADS-B is a new type of surveillance technology. Because of its inherent surveillance characteristics, it has become an important technical means to achieve A-SMGCS. ADS-B technology originated in Europe. Because of its low price and flexible deployment, it has been widely used in Europe, the United States, and Australia. EUROCONTROL implemented the CASCADE (European Integrated Air Traffic Control) program in 2004. Two of the key technologies are ADS-B and Link 2000+. ADS-B is part of the "Capstone" project initiated by FAA in 2000 [13]. At present, the ADS-B development plan has been formally formulated, and ADS-B is regarded as the basis of the next generation air transportation system [14]. Approximately 400 ADS-B ground base stations have been installed in the United States. In the next two decades, ADS-B will save the FAA about 1 billion US dollars and save 1.3 billion US dollars for system users such as airlines. A total of 29 ground base stations have been constructed by the Australian Aviation Services Corporation. In 2011, the Civil Aviation Administration of China successfully developed ADS-B surveillance equipment independently and formulated the ADS-B implementation plan in 2012. The promotion and application of ADS-B is regarded as the key for my country to move from a large civil aviation country to a powerful civil aviation country [15].

The literature [16] used Petri nets to carry out more comprehensive research on the A-SMGCS system, including path planning and conflict avoidance. The literature [17] designed a corresponding scene surveillance system in accordance with the A-SMGCS concept. The system designed in the literature [18] can receive surveillance information from surface surveillance radar, approach radar, multipoint positioning system, and ADS-B system. When there is a runway intrusion, taxiway conflict, apron occupancy, and other scene conflicts, the system can alert and prompt. The literature [19] gave a solution for realizing airport surface surveillance using ADS-B. The literature [20] discussed in detail the role of ADS-B in realizing surface surveillance from four aspects: functional design, system composition, system layout, and control and display.

3. Improved Filtering Algorithm

In a realistic environment, the target's motion model is much more complicated. If we simply rely on a model to track the target, we cannot achieve good tracking results. The reason is that the current statistical model also has better results in tracking maneuvering targets. However, it does not have a very good effect on tracking a target moving in a straight line at a uniform speed. Therefore, many academic researchers began to use multiple models that can accurately describe a certain period of time to study the movement of the target and then proposed the IMM model, the interactive multimodel, which is considered to be a better tracking model. It has better adaptive performance. We apply the filtering algorithms UKF and SCKF and the update algorithm of SCKF, which have better performance in processing nonlinear systems, to the IMM model, and compare their tracking effects to obtain a better combination of models and algorithms.

The filtering principle of interactive multimodel is to use multiple filters for parallel processing. Among them, each filter corresponds to a state space model, and the operation mode described by each state space model is different. The basic idea of the interactive multiple model is that at each moment, if one of the models is valid at the current moment, we will use the estimated state values of all filters at the previous moment as the initial conditions at this moment and substitute them into this specific model, and then perform parallel filtering on each model. The specific steps are shown in Figure 1.

The following is the IMM algorithm, and we use the two models as examples to illustrate the following:

If it is assumed that there are r kinds of motion states of the target, then it will correspond to r motion models (that is, there are r state transition equations). We assume that the state equation of the target represented by the ith model is as follows [21]:

$$X_i(k+1) = \Phi_i(k)X_i(k) + G_i(k)W_i(k). \quad (1)$$

The measurement equation of the target is as follows:

$$Z(k) = H(k)X(k) + V(k). \quad (2)$$

In the above formula, $W_i(k)$ is a white noise sequence with zero mean and Q covariance matrix. The element p_{ij} means the probability of the target being transferred from the motion model indicated by the first subscript to the motion model indicated by the second subscript. The probability transition matrix is as follows [22]:

$$P = \begin{bmatrix} p_{11} & \cdots & p_{1r} \\ \cdots & \cdots & \cdots \\ p_{r1} & \cdots & p_{rr} \end{bmatrix}. \quad (3)$$

The IMM algorithm is carried out in a recursive manner, and each recursion is divided into the following four steps.

Step 1: input the interaction (model j).

The mixed estimate $X_{oj}(k-1|k-1)$ and covariance $P_{oj}(k-1|k-1)$ of the state estimate $\hat{X}_j(k-1|k-1)$ of the target and the model probability $u_j(k-1)$ of the different filters in the previous step are used as the current value. In this paper, the interaction model is marked as model j and model i. The parameters mentioned above are calculated as follows:

(1) The predicted probability (normalization constant) of model j is as follows:

$$\bar{c}_j = \sum_{i=1}^{r} p_{ij}\mu_i(k-1). \quad (4)$$

(2) The mixed probability of model i to model j is as follows:

$$u_j(k-1|k-1) = \frac{\sum_{i=1}^{r} p_{ij}\mu_i(k-1)}{\bar{c}_j}. \quad (5)$$

(3) The estimation of the mixed state of model j is as follows:

$$X_{oj}(k-1|k-1) = \sum_{i=1}^{r} \hat{X}_i(k-1|k-1)\mu_{ij}(k-1)(k-1). \quad (6)$$

(4) The estimation of the mixed covariance of model j [23] is as follows:

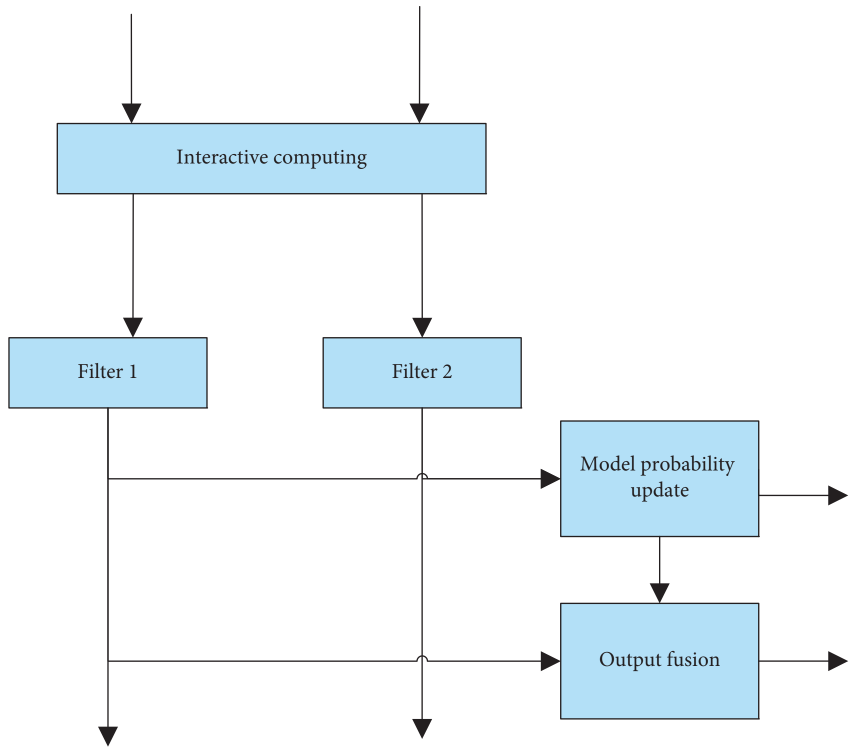

Figure 1: Interactive multimodel workflow chart.

$$P_{oj}(k-1|k-1) = \sum_{i=1}^{r} u_{ij}(k-1|k-1)\left\{\begin{array}{c} P_i(k-1|k-1)+ \\ \begin{bmatrix} \widehat{X}_i(k-1|k-1)- \\ \widehat{X}_{oj}(k-1|k-1) \\ +\widehat{X}_i(k-1|k-1)- \\ \widehat{X}_{oj}(k-1|k-1) \end{bmatrix}^T \end{array}\right\}. \quad (7)$$

In the formula, p_{ij} is the transition probability from model i to model j, and $u_j(k-1)$ is the probability of model j at $k-1$ time.

Step 2: SCKF (UKF) filtering model j.

$\widehat{X}_{oj}(k-1|k-1)$, $P_{oj}(k-1|k-1)$ and $Z(k)$ are used as input for SCKF or UKF filtering, and the input is substituted into the algorithm to update the prediction state $\widehat{X}_j(k|k)$ and the filter covariance $P_j(k|k)$.

Step 3: update the model probability.

The likelihood function is used to update the probability of each model. The probability of each model is represented by $u_j(k)$. The likelihood function of model j is as follows:

$$\Lambda_j(k) = \frac{1}{(2\pi)^{n/2}\left|S_j(k)^{1/2}\right|}\left\{-\frac{1}{2}v_j^T S_j^{-1}(k) v_j\right\}. \quad (8)$$

In the formula,

$$v_j(k) = Z(k) - h\left(\widehat{X}_j(k|k-1)\right), \quad (9)$$

$$S_j(k) = P_{zz}. \quad (10)$$

Among them, h is the measurement equation, $v_j(k)$ is the residual, and P_{zz} is the corresponding covariance. Then, the probability of model j is as follows:

$$u_j(k) = \frac{\Lambda_j(k)\bar{c}_j}{c}. \quad (11)$$

In the above formula, c is the normalization constant, and

$$c = \sum_{j=1}^{r} \Lambda_j(k)\bar{c}_j. \quad (12)$$

Step 4: output interaction.

After we update the probabilities of each model, we integrate the results of each filter with the corresponding weights and then sum all the items to obtain the total state estimation result $\widehat{X}(k|k)$ and the total covariance estimation $P_{k|k}$. The total state is estimated to be as follows [24]:

$$\widehat{X}(k|k) = \sum_{j=1}^{r} \widehat{X}_j(k|k)\mu_j(k). \quad (13)$$

The total covariance is estimated as follows:

$$P(k|k) = \sum_{j=1}^{r} \mu_j(k)\left\{P_j(k|k) + \left[\widehat{X}_j(k|k) - \widehat{X}(k|k)\right]\cdot\left[\widehat{X}_j(k|k) - \widehat{X}(k|k)^T\right]\right\}. \quad (14)$$

The result obtained in this way will be smaller than the unupdated algorithm error and closer to the true value.

The steps of the SCKF-IMM measurement update algorithm are as follows [25]:

Step 1: input interaction:

$$\widehat{X}_{oj}(k-1|k-1) = \sum_{i=1}^{r} \widehat{X}_i(k-1|k-1)\mu_{ij}(k-1|k-1), \quad (15)$$

$$P_{oj}(k-1|k-1) = \sum_{i=1}^{r} u_{ij}(k-1|k-1)\left\{P_i(k-1|k-1) + \begin{bmatrix}\widehat{X}_i(k-1|k-1)- \\ X_{oj}(k-1|k-1)\end{bmatrix}\cdot\begin{bmatrix}\widehat{X}_i(k-1|k-1)- \\ X_{oj}(k-1|k-1)\end{bmatrix}^T\right\}. \quad (16)$$

Step 2: SCKF filtering.

The algorithm takes $\widehat{X}_{oj}(k-1|k-1)$ and $P_{oj}(k-1|k-1)$ as input to perform volumetric Kalman filtering and updates the prediction state $\widehat{X}_j(k|k)$ and filter covariance $P_j(k|k)$.

Step 3: ipdate the model probability.

The likelihood function of the calculation model j is as follows [26]:

$$\Lambda_j(k) = \frac{1}{(2\pi)^{n/2}\left|S_j(k)^{1/2}\right|}\exp\left\{-\frac{1}{2}v_j^T S_j^{-1}(k)v_j\right\}, \quad (17)$$

$$u_j(k) = \frac{\Lambda_j(k)\overline{c}_j}{c}. \quad (18)$$

The n in the formula represents the dimension of the observation vector.

Step 4: output the interaction and get the state estimate $\widehat{X}(k|k)$ and total covariance estimate $P_{k|k}$:

$$\widehat{X}(k|k) = \sum_{j=1}^{r} \widehat{X}_j(k|k)\mu_j(k|k), \quad (19)$$

$$P(k|k) = \sum_{j=1}^{r} \mu_j(k)\left\{P_j(k|k) + \left[\widehat{X}_j(k|k) - \widehat{X}(k|k)\right]\cdot\left[\widehat{X}_j(k|k) - \widehat{X}(k|k)^T\right]\right\}. \quad (20)$$

Step 5: output measurement update.

We perform a measurement update based on the observed value z_k at time k, and obtain the final output results $\widehat{X}_{\text{update}}(k|k)$ and $P_{\text{update}}(k|k)$. The calculation steps are as follows [27]:

(1) The algorithm calculates the nonlinear observation matrix:

$$H_k = \frac{\partial h(X)}{\partial X}\bigg|_{X=\widehat{X}(k|k)}. \quad (21)$$

(2) The algorithm calculates the innovation covariance, where R is the observation noise:

$$S_k = H_k P(k|k)(H_k)^T + R. \quad (22)$$

(3) The algorithm updates the Kalman filter gain:

$$K_k = P(k|k)(H_k)^T S_k^{-1}. \quad (23)$$

(4) The output status is updated:

$$\widehat{X}_{\text{update}}(k|k) = \widehat{X}(k|k) + K_k\left(Z_k - h(\widehat{X}(k|k))\right). \quad (24)$$

(5) The covariance is updated:

$$P_{\text{update}}(k|k) = P(k|k) + K_k H_k P(k|k). \quad (25)$$

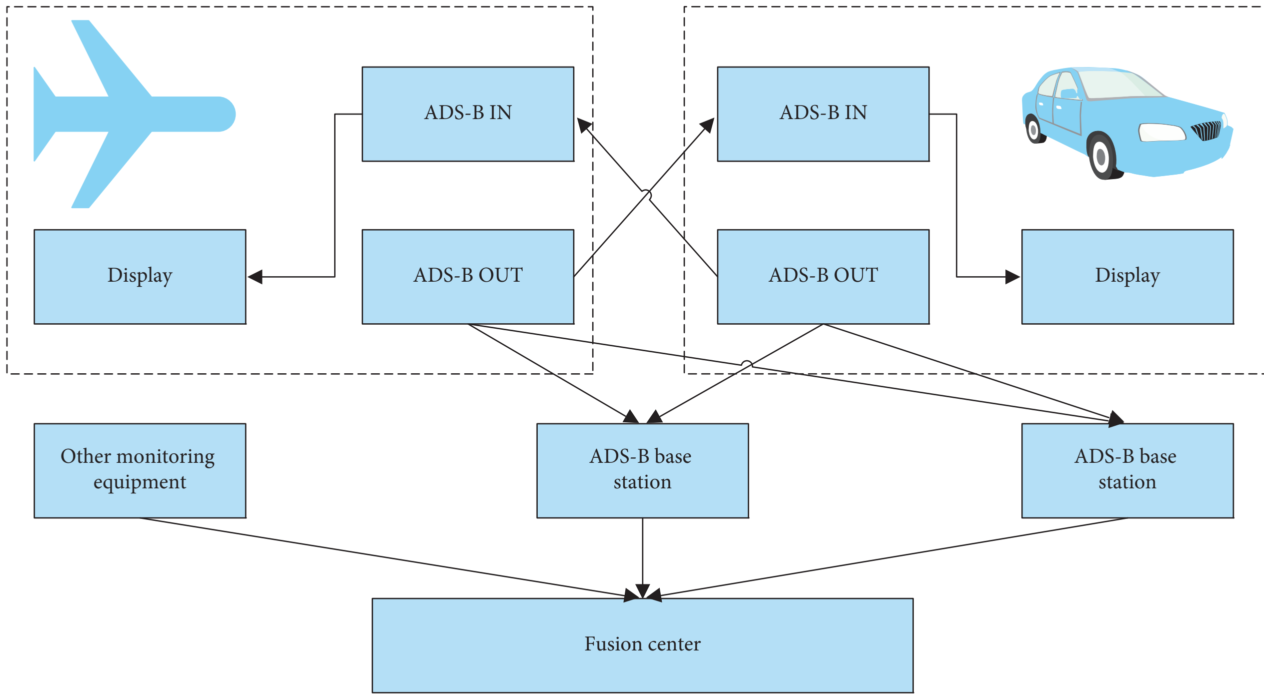

Figure 2: Schematic diagram of a surface surveillance system based on ADS-B.

4. Analysis of ADS-B Aviation Target Monitoring Based on Improved Filtering Algorithm

The surface surveillance system based on ADS-B should be divided into airborne (vehicle) equipment, airborne (vehicle) display system, receiving base station, and fusion center, as shown in Figure 2 [28].

ADS-B data preprocessing includes ADS-B data decoding and ICAO address association to form a single ADS-B track. According to the Zone coding, Bin coding, and CPR decoding methods, the latitude and longitude of the aircraft are calculated. The ADS-B information only transmits Bin code during transmission, and the receiver needs to calculate the longitude and latitude according to the Bin code. CPR decoding has two methods: global decoding and local decoding. When the target information is received for the first time, global decoding is used, and then local decoding is used to update the position of the target. The single-channel ADS-B track forms the ADS-B system track through track correlation, tracking, and fusion. Figure 3 shows the ADS-B data processing system view. ADS-B data processing receives ADS-B information sent by multiple ADS-B ground stations, and each ADS-B data preprocessing module collects a large amount of ADS-B track information. ADS-B trajectory correlation is to determine whether two local ADS-B trajectories from different ADS-B ground stations represent the same target and finally perform ADS-B trajectory fusion [29].

The data frame structure is shown in Figure 4 [30].

The ADS-B trajectory tracking process is to update the aircraft target information in the formed ADS-B trajectory table. The ADS-B track update cycle is the update cycle of the ADS-B position report. The existence, extrapolation, and disappearance of the target can also be obtained while updating, and different situations can be handled differently. Figure 5 mainly includes the following contents: (1) The system obtains the properties of each ADS-B trajectory in the ADS-B trajectory table, including the existence, extrapolation, and disappearance of the ADS-B trajectory; (2) When the nature of the target is existence, the system updates the ADS-B trajectory information of the aircraft target and updates the existing information; (3) When the nature of the target is extrapolation, the system generates the extrapolated ADS-B track, and the extrapolated ADS-B track is marked with a specific identifier on the monitoring screen to indicate the difference between the extrapolated ADS-B track and the real ADS-B track; (4) When the number of extrapolation times of an aircraft's target ADS-B trajectory reaches an adaptive parameter specified by the system, the system determines that the ADS-B trajectory is terminated, sends the termination report of the ADS-B track, cancels the existence of the ADS-B track in the ADS-B track table, and clears the content related to the ADS-B track; (5) When the aircraft target disappears, the system immediately clears the status of the aircraft target in the ADS-B trajectory table; (6) When the system receives a termination report from the radar source of an aircraft target's ADS-B trajectory, the system immediately terminates the ADS-B trajectory.

Figure 6 shows the processing view of the ADS-B flight safety warning system.

The current position speed of the adopted aircraft target is extrapolated to the adaptive time or the adaptive distance according to the flying direction of the aircraft. If the aircraft

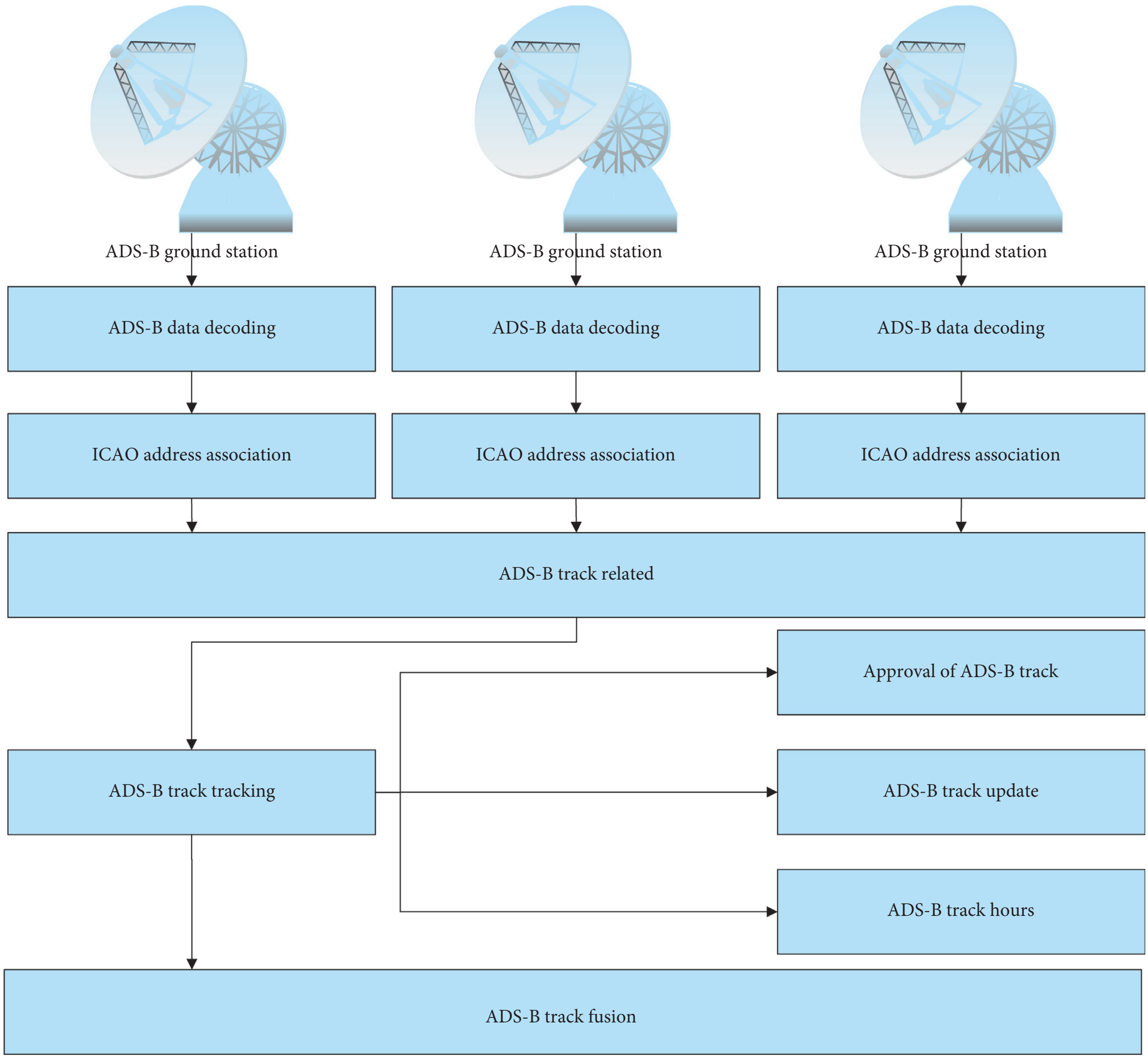

Figure 3: View of ADS-B data processing system.

target falls into the effective intrusion warning area or flies through the effective intrusion warning area, an intrusion warning is given to the aircraft target, and the corresponding intrusion warning sign is displayed on the sign of the aircraft target. The schematic diagram of the intrusion warning is shown in Figure 7.

In Figure 8, aircraft A does not generate an intrusion warning in the current model, nor does it generate an intrusion warning in the speculative mode. Aircraft B does not generate an intrusion warning in the current model, but generates an intrusion warning in the speculative mode. Aircraft C does not generate an intrusion warning in the current mode but generates an intrusion warning in the speculative mode.

5. ADS-B Aviation Target Monitoring System Architecture Based on Improved Filtering Algorithm

The schematic diagram of system operation is shown in Figure 9. The airborne equipment broadcasts its position and status information from the aircraft airborne equipment and navigation system equipment through the 1090ES ground-to-air data link. The ADS-B ground station is responsible for receiving the broadcast data of ADS-B and sending it to ADS-B for monitoring data processing. ADS-B monitoring data processing is responsible for the completion of the decoding of ADS-B information, the formation of ADS-B trajectory by association, and the tracking of ADS-B

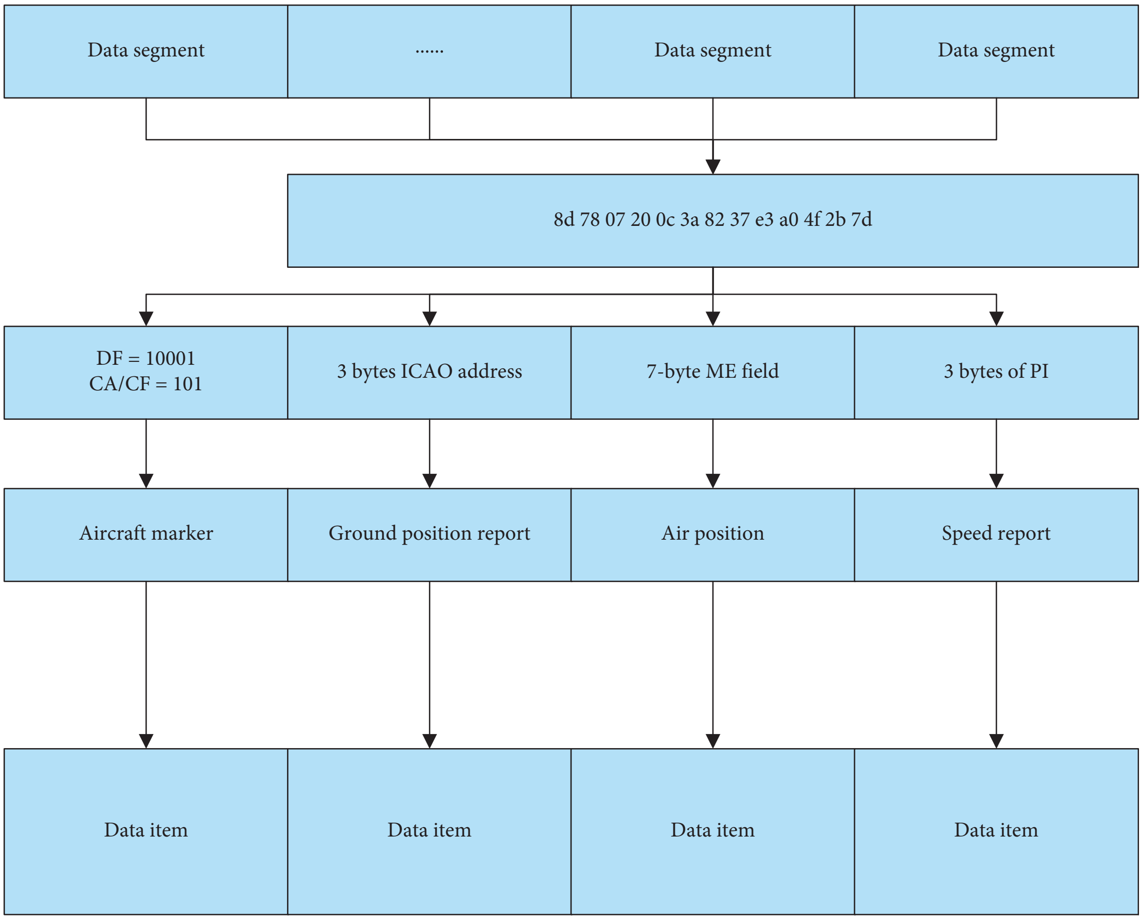

Figure 4: ADS-B data frame.

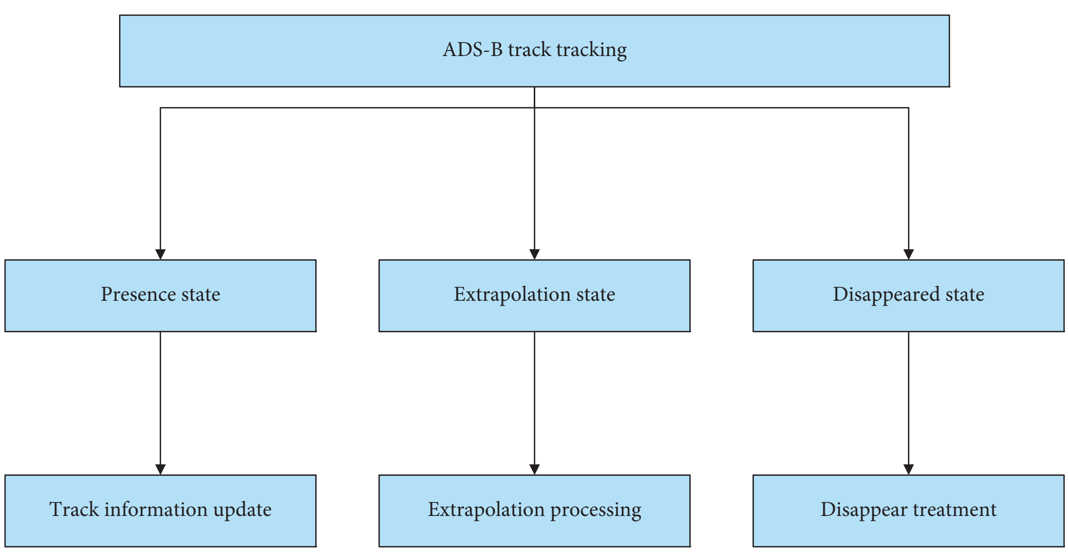

Figure 5: Schematic diagram of ADS-B track tracking processing.

trajectory. Moreover, it performs short-term conflict warning detection, minimum safe altitude warning detection, airspace intrusion warning detection, and other flight safety detections between aircraft and aircraft. At the same time, it provides users with real-time, accurate, and safe monitoring information.

From a logical point of view, the software adopts a hierarchical architecture. The software uses a four-layer model,

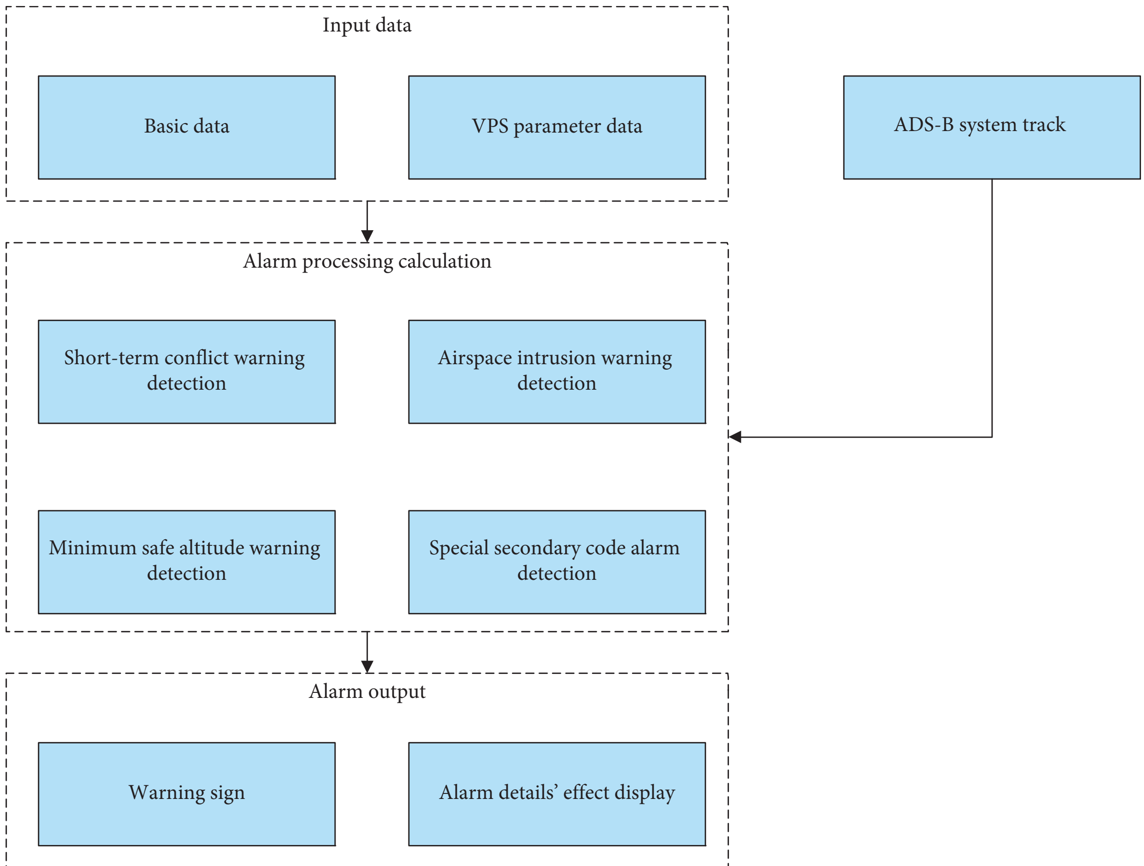

Figure 6: Processing view of ADS-B flight safety warning system.

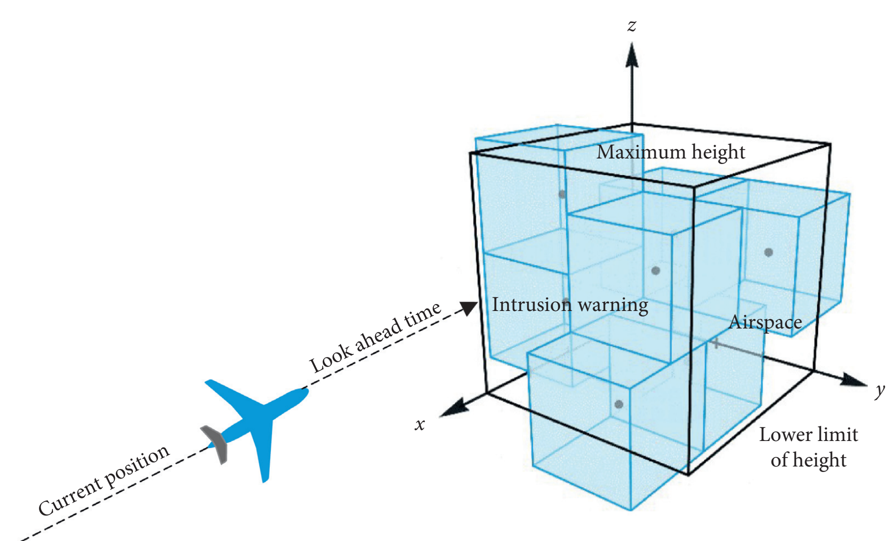

Figure 7: Schematic diagram of airspace intrusion warning processing.

including system layer, service layer, business processing layer, and presentation layer. The software is organized according to a hierarchical structure, and each layer provides services to its upper layer, and at the same time, is a customer of its lower layer, and each layer modification does not affect other layers. Except for adjacent layers, an internal layer is hidden from other layers. The interaction within the software is restricted to adjacent layers, the data fusion technology in this article can effectively avoid the impact of software interaction, and the interaction is carried out in accordance with a certain protocol, as shown in Figure 10. The system layer mainly includes an operating system, a database system, and a

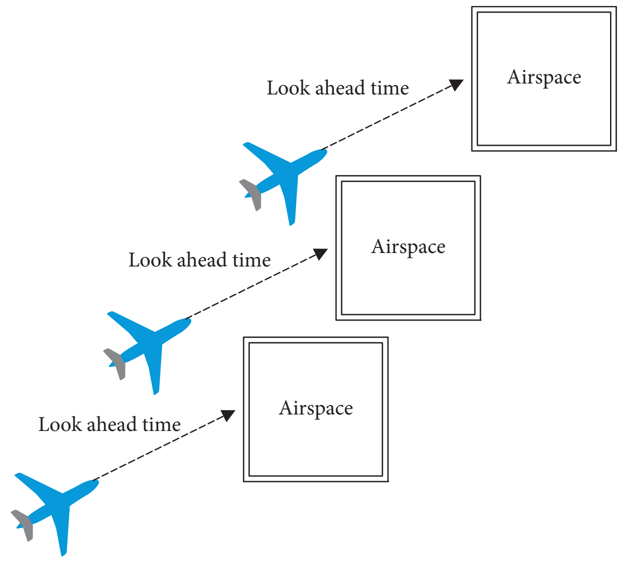

Figure 8: Schematic diagram of detailed airspace intrusion warning processing.

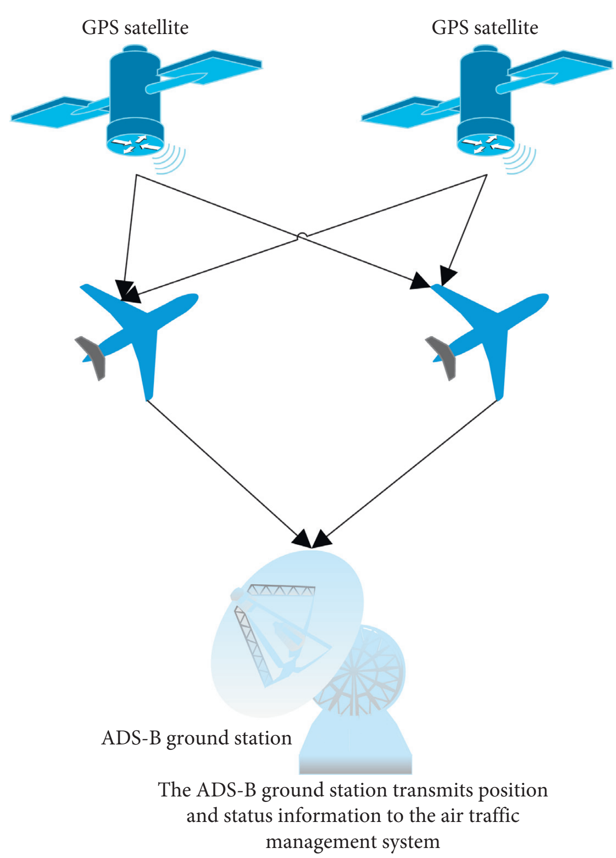

Figure 9: Schematic diagram of system operation.

basic graphics library. The service layer is built on the system layer and provides data communication related services, including network transmission, database access, system clock, and basic software function library.

ADS-B monitoring data processing software mainly uses database and data files to store VSP parameters and run processes to generate data and uses database access, basic data services, and file reading to achieve data information access and query. In order to ensure the high reliability and high availability of the data in the software, the database composition and interface are shown in Figure 11.

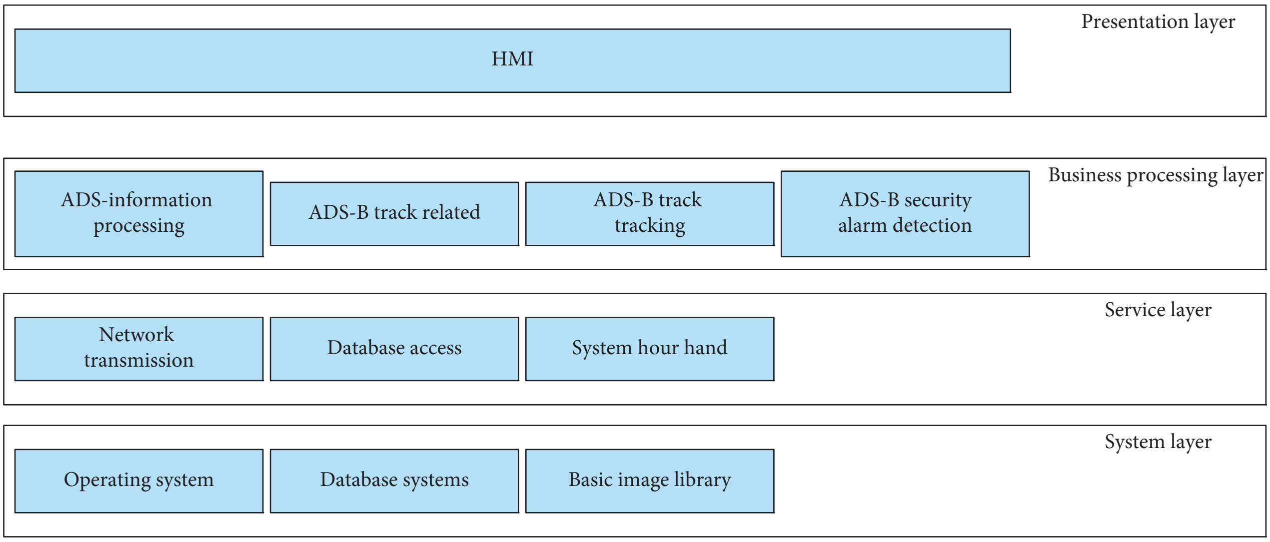

FIGURE 10: Hierarchical structure diagram.

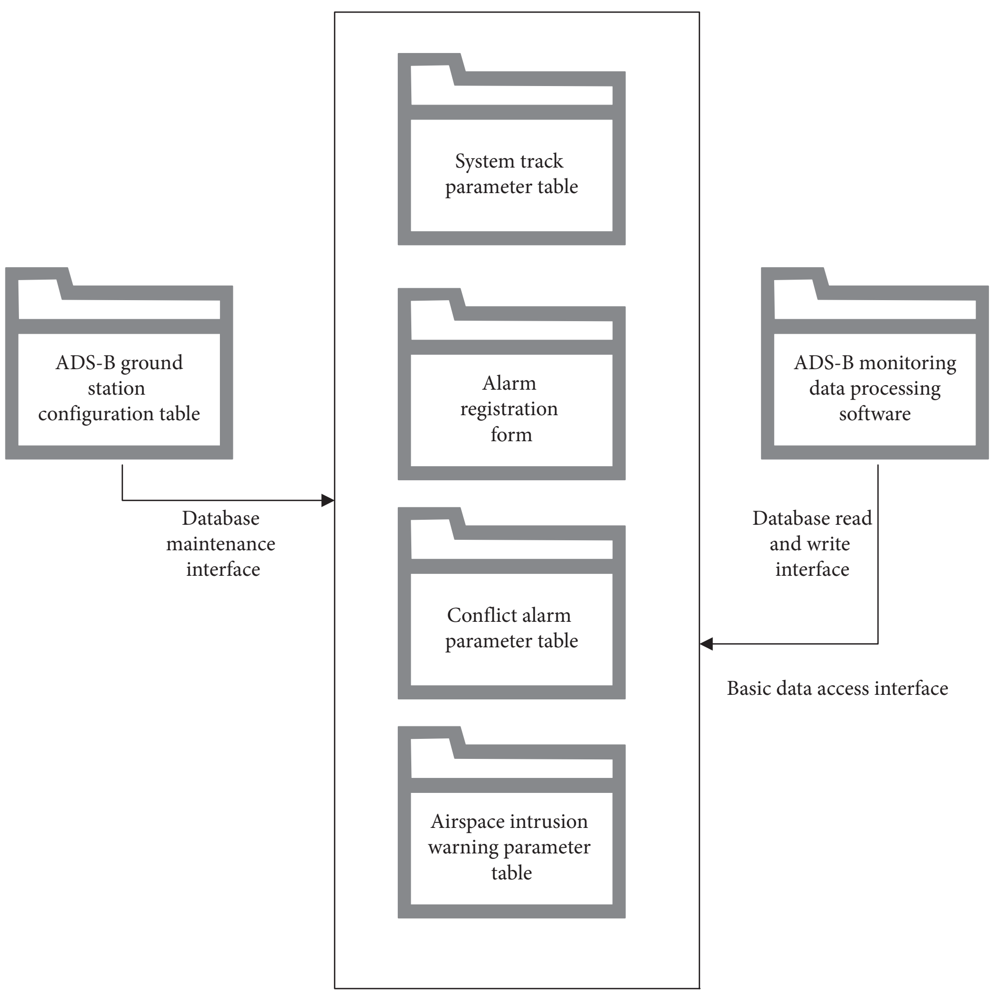

FIGURE 11: Database structure diagram.

According to the demand analysis and structural design of the system, the network topology of the system is shown in Figure 12.

At the same time, after the controller workstation processes the data, it also sends the data to the flight plan data center through the network switch for storage.

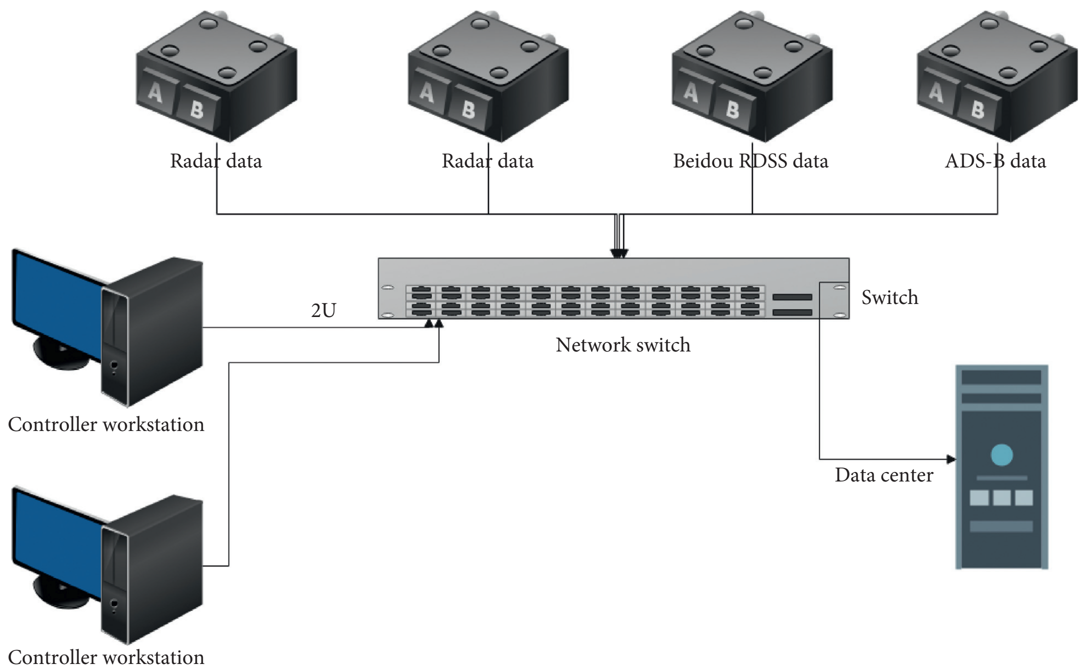

Figure 12: Network topology diagram of the general aviation surveillance system.

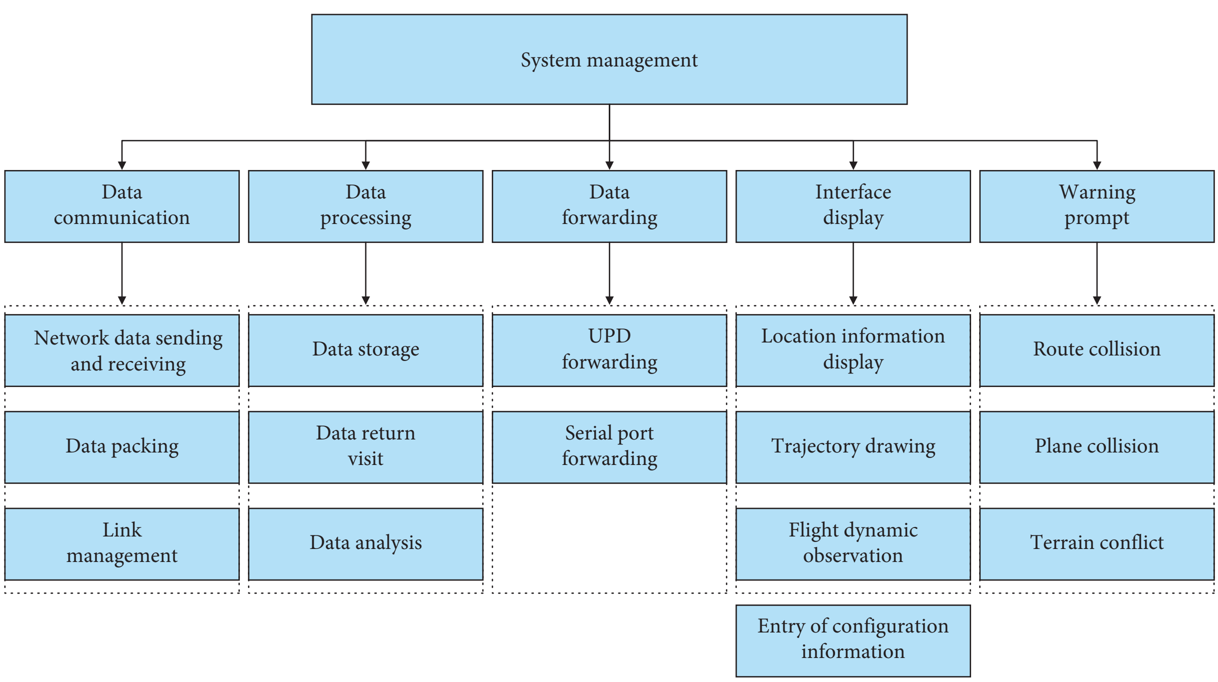

Figure 13: Exploded view of system modules.

According to the forwarding rules, the position data information is sent to each corresponding controller work platform to complete the flight dynamic monitoring and management of general aviation aircraft.

According to the demand analysis of the general aviation flight dynamic monitoring system in the demand analysis, the system can be divided into five major modules: data communication module, data forwarding module, data processing module, interface display module, and alarm prompt module. The alarm module can issue an alarm when the system detects an abnormality, and the control center can perform corresponding emergency operations after obtaining the alarm information. The data processing module also contains two major submodules in the processing process, that is, the storage module and the parsing module. The various modules work together to complete the

Table 1: Statistical table of the score of the data processing effect of the channel optimization system of the ABS-B aviation target surveillance radar based on the improved filtering algorithm.

Num	Display effect	Azimuth distance measurement	Track display data	Data forwarding	Data analysis	Data storage
1	85.8	87.2	85.4	86.2	92.9	92.8
2	87.1	93.7	83.0	89.5	88.7	87.8
3	93.8	83.7	94.9	90.8	92.3	84.6
4	89.5	86.5	90.5	85.6	92.4	93.5
5	91.2	91.8	87.8	85.9	91.0	93.4
6	93.9	84.0	89.8	94.8	93.4	86.3
7	88.4	84.7	89.3	87.9	89.6	89.7
8	89.3	83.2	83.9	89.6	91.8	90.0
9	84.4	94.9	88.2	94.7	84.4	87.8
10	87.7	90.2	89.3	85.0	87.4	84.0
11	91.8	84.1	87.3	91.6	84.2	86.8
12	92.6	89.8	90.1	91.1	83.3	92.1
13	84.8	94.3	85.2	95.0	91.5	88.2
14	93.9	83.8	93.4	84.1	88.9	93.6
15	87.9	94.9	94.7	88.3	94.4	91.4
16	91.6	85.7	94.2	83.2	91.1	86.1
17	90.2	92.2	93.4	89.9	90.5	93.9
18	89.1	87.5	86.5	93.8	94.9	89.0
19	86.4	93.2	89.6	85.2	83.5	88.0
20	88.6	88.3	92.8	85.9	86.3	83.2
21	84.5	90.2	89.4	91.3	89.0	83.8
22	88.1	86.5	89.2	87.8	94.4	88.0
23	89.1	95.0	93.7	90.7	83.0	92.7
24	91.9	92.3	91.0	90.8	87.6	84.7
25	92.5	84.3	92.4	90.7	91.7	87.3
26	89.7	90.3	88.8	84.2	93.7	93.5
27	84.4	92.8	89.7	92.5	86.8	83.7
28	86.2	85.6	90.0	83.4	89.7	92.8
29	90.7	85.9	84.5	87.7	94.4	89.2
30	92.4	87.3	89.6	83.3	84.4	84.3
31	90.9	86.6	94.1	88.2	89.7	91.6
32	89.5	89.6	93.9	84.2	89.2	92.6
33	84.4	88.9	87.3	86.8	83.6	93.3
34	86.0	94.8	84.8	84.7	94.1	89.9
35	84.1	83.2	94.2	87.1	83.4	83.4
36	92.7	90.3	89.6	89.2	86.4	90.9
37	84.0	94.3	93.5	89.0	87.9	85.1
38	88.6	89.5	94.2	92.3	94.8	90.8
39	85.5	89.7	92.6	84.4	84.6	88.7

monitoring of general aviation flight dynamics and achieve business support. The module exploded view is shown in Figure 13.

The data communication module is mainly responsible for the maintenance of the communication link and the sending and receiving of position data in the system. The data processing module is mainly responsible for storing, analyzing, and replaying the received location data. The data forwarding module is mainly responsible for the data forwarding between the source control station and the subsidiary control station so that the subsidiary control station can correctly receive the relevant position data.

6. System Function Test

The simulator produces the same data scenario as the actual working environment, mainly including simulating ADS-B ground station and simulating ADS-B data, and sending ADS to the ADS-B monitoring data processing software using "Annex10 to the Convention on International Civil Aviation" as the interface -B data to verify the correctness of the software function. First of all, this paper mainly conducts testing data processing and testing from several aspects of data interface display effect, azimuth and distance measurement, track display data, data forwarding, data analysis, and data storage and conducts 40 sets of data tests and scores. The results are shown in Table 1 and Figure 14.

It can be seen from the above analysis that the channel optimization system of the ABS-B aviation target surveillance radar based on the improved filtering algorithm constructed in this paper can meet the expected goals when processing radar monitoring data. Therefore, the system constructed in this paper is basically no problem in the data processing. Next, this paper conducts an experimental analysis of target monitoring accuracy and flight strategy

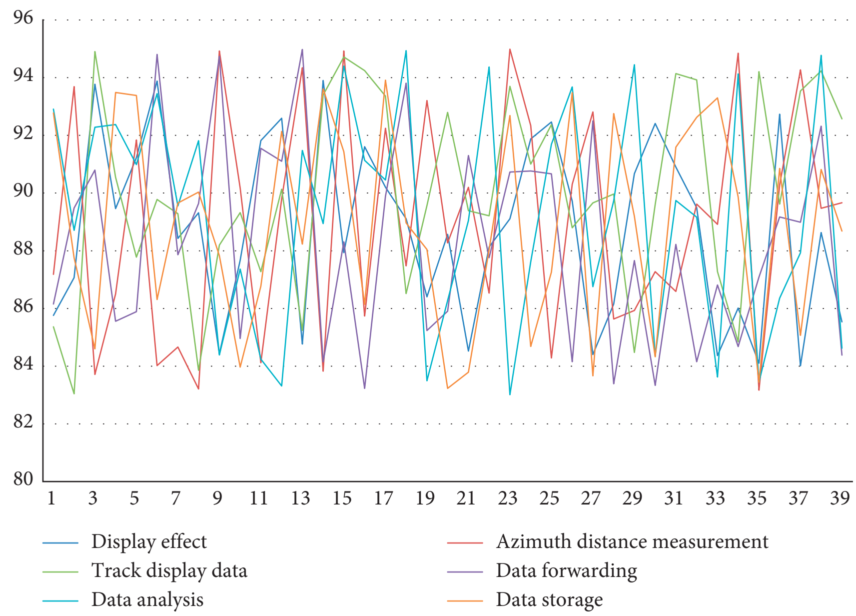

FIGURE 14: Statistical diagram of the score of the data processing effect of the channel optimization system of the ABS-B aviation target surveillance radar based on the improved filtering algorithm.

TABLE 2: Statistical table of practical effect analysis of the channel optimization system of the ABS-B aviation target surveillance radar based on the improved filtering algorithm.

Num	Target monitoring accuracy	Flight strategy evaluation	Num	Target monitoring accuracy	Flight strategy evaluation	Num	Target monitoring accuracy	Flight strategy evaluation	Num	Target monitoring accuracy	Flight strategy evaluation
1	97.6	93.7	26	97.8	94.4	51	97.4	93.0	76	97.3	94.4
2	97.7	92.3	27	98.1	93.5	52	97.2	91.0	77	97.6	91.7
3	98.0	93.1	28	98.6	92.0	53	98.8	94.2	78	98.1	92.9
4	97.9	94.7	29	97.6	91.9	54	98.9	91.2	79	98.0	93.8
5	97.2	94.3	30	98.4	94.5	55	97.2	94.0	80	97.8	91.2
6	98.9	91.6	31	98.4	91.0	56	98.4	93.4	81	97.1	93.1
7	97.4	94.1	32	97.3	94.2	57	97.6	91.8	82	99.0	92.8
8	98.8	93.1	33	98.5	91.3	58	98.8	91.5	83	97.8	93.3
9	97.5	92.0	34	98.1	93.5	59	97.8	92.8	84	97.8	94.6
10	97.5	91.1	35	98.7	91.7	60	98.0	93.4	85	97.7	94.7
11	97.9	92.8	36	98.4	93.9	61	99.0	94.0	86	98.8	93.0
12	98.9	92.9	37	98.9	92.6	62	97.5	94.1	87	97.9	94.7
13	98.9	93.7	38	98.4	93.7	63	97.4	94.5	88	97.4	94.7
14	98.7	93.6	39	98.9	91.1	64	98.5	91.4	89	97.3	91.2
15	98.0	92.5	40	98.9	94.6	65	97.0	94.8	90	97.1	93.6
16	98.6	92.3	41	97.1	94.3	66	97.6	93.8	91	98.8	93.3
17	97.2	92.8	42	98.5	92.2	67	97.8	94.0	92	97.6	94.9
18	98.5	91.7	43	97.2	93.2	68	98.0	92.1	93	98.2	93.2
19	97.4	91.5	44	98.2	93.8	69	98.4	92.9	94	98.9	94.9
20	98.6	92.6	45	97.3	92.9	70	97.5	92.6	95	98.3	93.1
21	98.1	94.1	46	98.9	91.2	71	97.6	92.8	96	97.8	94.1
22	98.9	93.8	47	98.4	91.3	72	97.3	92.6	97	98.6	93.2
23	97.6	92.0	48	98.1	93.7	73	97.1	93.1	98	98.5	93.5
24	98.0	91.5	49	97.5	92.9	74	97.5	93.8	99	97.4	92.4
25	97.9	94.4	50	97.1	92.5	75	98.0	94.1	100	97.3	91.5

and conducts experimental research through 100 sets of data. The statistical test results are shown in Table 2 and Figure 15.

From the above analysis results, it can be seen that the system constructed in this paper basically meets the expected needs, and all functional tests meet the actual needs.

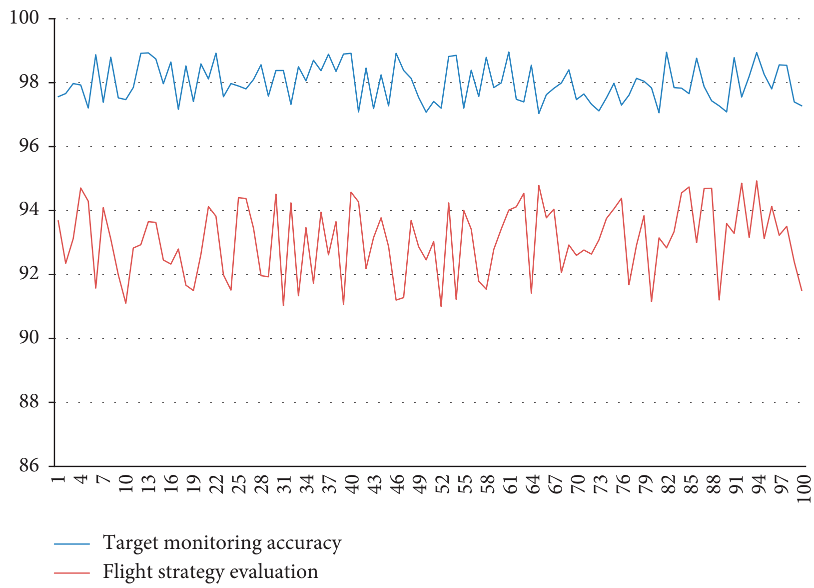

Figure 15: Statistical table of practical effect analysis of the channel optimization system of the ABS-B aviation target surveillance radar based on the improved filtering algorithm.

7. Conclusion

ADS-B surveillance data processing technology is the core of the air traffic control system. The quality of ADS-B surveillance data processing has a major impact on the air traffic control system. ADS-B technology is one of the important monitoring technologies of the new generation air traffic control system. Compared with radar surveillance technology, it has the characteristics of high accuracy, strong real-time performance, and low cost. In response to the surveillance requirements in the traditional air traffic control and general aviation fields, this paper focuses on the ADS-B surveillance information processing technology. This paper improves the traditional filtering algorithm, optimizes the ADS-B aviation target surveillance radar channel, uses software engineering methods to model and analyze the requirements, and understands the relationship between each functional module and the content contained. Moreover, this paper establishes the overall system architecture and selects appropriate software development technologies to complete and realize these business functions. In addition, this paper designs the system functions in detail, analyzes and describes the processes that each function needs to complete, and cooperates with the realization of business functions through various models such as flowcharts. Finally, this paper designs an experiment to verify the performance of the system constructed in this paper. The research results show that the system constructed in this paper has a certain effect.

For the noise problem mentioned in this article, we have always assumed that the measurement noise and system noise are independent of each other. The actual environment is very complicated. The state of the moving target is always changing, and the environment is always changing. At every moment, measurement noise and system noise are independent of each other. We should conduct research in this area to make it more widely applicable.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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