

An Introduction to the Research on Critical Techniques in New-Generation ATC System

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After four years' research, the natural sciences foundation-supported project — the research on critical techniques in new-generation ATC system, which is supported by Sichuan University and China Civil Aviation Administration, has been completed smoothly.

According to the demand of project application and prospectus, the research was conducted on the critical techniques in ACT system from practice and theory, including air control radar network, multi-radar information processing and fusion, radar data and other air control data fusion, aircraft conflict detection and radar alarm forecast.

1 Research Accomplishments on Basic Theory

(1) In the aspect of multi-sensor detection, decision and fusion, we have induced the algorithms of Gauss-Seidal and prove that it is constringent after limited steps in discrete form and its optimal resolution in discrete form is almost equal to the one in continual form. In the aspect of optimal fusion law, we have proved that the last sub-station can implement global optimal decision only through limited communicational quantity when the other sub-stations' communicational modes have been set. Furthermore, we gave the expression of optimal fusion law in this type of system communicational mode easy to be realized, which is firstly done in the world.

(2) In the aspect of evaluation and trace fusion, we pointed out that the problem of the liner optimal fusion in the most general sense of the smallest variance is in nature the one of bi-optimize under the linear constrain. And the extract expression of the resolution has been given, and its uniqueness has been proved. Then we can

use this theory to resolve some problems such as the optimal fusions in other conditions, the optimal fusions when various sensors detect noise relation, and the best fusion when the sensors work asynchronously with feedbacks.

(3) In the aspect of successive deduction and evaluation algorithms about dynamical system, we give an algorithm of the smallest bi-multiplication to spread the successive deduction of oblivious factor, which can be used to evaluate the state of the dynamical system. We can evaluate the state without information of noise in dynamical process and noise variance detection by using this algorithm.

(4) In the aspect of Carlman filter which is an important technique for radar fusion, wavelet transform has been used to evaluate the wave shape of fractal random signal of $1/f$. An optimal threshold wave shape evaluation based on smallest variance error has been offered, which can evaluate fractal signal of instable $1/f$ without evaluation of signal variance in comparison with Carlman filter. Besides, principle to decide the degree of discrete wavelet analysis has been offer also, which make signal evaluation simpler.

(5) A optimizing trace threshold algorithm based on evaluation to data relation performance has been offered, which, in comparison with optimal trace threshold algorithm, has improved the performance of the multi-target and multi-sensor trace system effectively, especially under condition of high disturb and high pseudo-alarm.

(6) A algorithm has been offered which makes use of some pre-experience probability information to construct a function to judge the effectuation of echo. The function is used to evaluate ineffectual echo and to get ride of it so as to improve the performance of the interaction multi-model probability data relating algorithm.

(7) A fast data relating algorithm based on space nodical attribute intension has been advanced to im-

prove the precision of the algorithm and operation rate. (8) The performance of the distributed evaluation fusion with feedbacks has been analyzed theoretically. It has been found that feedbacks can effectively improve the trace performance of the sensors. So it is proved theoretically that feedbacks are important and it explains the obtained from trial observations.

There are 60 papers related to the basic research of the project, among which five are published in IEEE Transactions, other ten are published in civil Electrical Transaction, and the others are published in other important scientific journals.

2 Research Achievement on Application Technologies

This project has been achieved four important and innovative products, three of them have passed provincial or departmental qualification, and one of them has won the first award for provincial technology progress.

2.1 Research and development of "MRD2K Multi-Radar information process system and integrate display system"

"MRD2K Multi-Radar Information Process System and Integrate Display System" is the critical component for modern ATC system. This fruit has achieved leading standard in the world, and gained important creativities in some critical aspects. We have the sole ownership of the software with all copyright reserved. This product has high competition in the international market and has bright prospects in exporting.

This system is composed of three components, namely, multi-radar information process system, radar with 2k×2k resolution and flying data integrate display position.

We have innovated in many aspects of this system, intelligent radar data interface, multi-sensor multi-goal flight association and optimal self-fit trace arithmetic, the algorithm for multi-radar data fusion, interacting multiple model flight filter technique, collision alarm and low height alarm, etc.

This system has been installed on Baiyun Airport in Guangzhou, Jiangbei Airport in Chongqing, Shuangliu Airport in Chengdu. Not only huge economic utility has achieved, but also foreign exchange about USD 700 million has been saved.

2.2 Research and development of K/LLQ304 radar MMC system

K/LLQ304 radar is the first generation radar whose working principle is one dimension frequency-phase scanning and full-phase system, designed and produced by ourselves (for short 390 radar). As one important part, the MMC (Main Monitoring and Controlling) software is used to monitor the status of radar and to control the way of its work in real-time, and it can complete information fusion function.

In this system, it is the first experiment to apply information integration into radar MMC system. There are many innovations in intelligent communication controller and interface technique, multi-radar information fusion technique, real time control analysis and design technology, the development of efficient, practical and special map editing software.

Now the software has installed in the troop of navigation and air force in Hong Kong.

2.3 Research and development of ACT radar alarm forecast system

ACT radar alarm forecast system can detect the flight conflict between the aircrafts and the conflict between aircraft and terrain, objects currently and in future, and can help air controller find and deal with the conflict, in order to confirm the security of flight.

The system includes the parts as follow: radar data managing server, area-schedule termination, near-intotermiation, leader on guard termination, database manage system, network subsystem, GPS receiving clock and dispatching clock, outside clock, and so on. The system uses the opening structure so that the hardware and software can be easily upgraded. We followed the demand of China air control system and international tradition in function design, system configuration and machine-man interface.

(1) Flight conflict alarm forecast. We get the position and velocity of air plane by tracing the flight path and compute all flight path pairs whose intervals are under the scheduled security standard after a certain time. Moreover, we can foretell the time nearly the danger happening after filter wave processing. To reduce the false alarm information, we use high level protecting method for the flight traces that have the height data and detect the height conflict. When the system detects the horizontal and vertical distance of flight path pairs is less than a certain number, the system will foretell the

conflict forecast for the flight path pairs.

(2)Low height alarm forecast. We compare the modified sea pressure height with the safe height of foretell position. If the difference between the two numbers is less than safe height, the alarm information will produce.

Now, the system has been used in Chongqing Jiangbei Airport for one and half years. It foretold many flight conflicts, avoided a lot of air matters, and gained USD100 millions indirectly. The system is safe and dependable, and it is a real time system which can send the alarm forecast in time. It is the necessary and meaningful device of safe flight.

2.4 Research and development of MDSL

MDSL, multi-channel data synchronized recorder, is a special record device mainly used to record dozens or hundreds of the plant-air radio calls, and the information is recorded in different channel and in 24 hours continuously. Its main application areas are the civil aviation ATC departments, the airports, airlines, and navy airmen. Moreover, it can be used in electrical power regulation, railway regulation, chief system, finance system, security system, public security system, maritime affairs control system and pager station.

MDSL is consistent in the international advanced technique in the machine control PC platform, commonly use memory media, basic audio compress technique. And the system has important creation and exclusive knowledge property right in special 32-channel audio compress, control FPAG chip compress card, exclu-

sive voice and noise recognition and second compress technique, intelligent radar interface card, radar coding technique, RDP technique and radar motion display, etc.

Now, the project has been developed to a mature product, being used in many airports in Chinese civil aviation system. The economic utility produced by this product is beyond USD10 millions.

3 Prospect for the Application of Research Achievement

The scientific meaning of the research fruits of the project in basic theory is highly appraised. In application techniques, the 4 fruits will form the high technique product which has the exclusive knowledge property right, which dedicate themselves to the development of Chinese modern ACT system. The benefit produced by the 4 fruits has beyond to ten millions US dollars. At the same time, under the support of the projects, we have cooperated with Thomson Company to establish the real-time software engineering research center and real-time software engineering master training center, which has been the culture communication cooperated project of China and France government. Its main purpose of this co-operation supported by France government and financed by Thomson Company is to research and development the new generation air transposition management software. Other cooperated projects included the interflow with America Syracuse University, America New Orleans University and Japan Shanli University.

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applied problems in material science; on the other hand, it provides material guarantee and technical support for information/life science, via the study of material technology and application related to information/life science.

Finally, further encourage the study of mental science, brain science and human science. Even though it is hard to attain their theoretical and practical value, they are the advanced and complex forms of scientific

development and the destination of science research in the future. In the long run, we should previously invest in future science and technology, acting as a leading role, to occupy its dominant position at length. Meanwhile, we should be aware of their potential theoretical and practical value in the fields like science, education, work, life, medical care and entertainment. We should take enough account of these subjects since America and Japan have paid considerable attention to them.