Research of UAV Controller-pilot Data Link Real-time Processing Technique

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Abstract. In traditional flight tests, ground monitoring is based on on-board telemetry data. With the rapid development of UAV design, the monitoring data source transitions from radio telemetry transmission to ground-to-air data link transmission gradually. Traditional ground real-time processing system can’t meet the new requirements. UAV controller-pilot data link real-time processing technique doesn’t rely on traditional PCM telemetry, via controller-pilot data link which is integrated into the UAV, ground controller system and flight tests data processing system, which promotes the efficiency of flight test dramatically, the data processing duration is also reduced significantly.

1. Introduction
Real-time monitoring is not only the key aspect of UAV flight test, but also is one of the most important techniques in flight test especially for a new-designed aircraft [1]. With the rapid development of UAV design, the intensity of flight tests and the number of flight test subject will be unprecedented, during flight test, complete real-time data processing technique is essential to complete the flight tests smoothly [2]. In traditional flight tests, ground monitoring is based on on-board telemetry data, which doesn’t meet the new requirements [3]. Therefore, it is necessary to develop new real-time processing system that is matched with the characteristics of UAV data link.

UAV controller-pilot data link real-time processing system doesn’t rely on traditional PCM telemetry [4]. The real-time monitoring of UAV flying state could be realized with the inherent controller-pilot data link data of UAV, which is not only combined with PCM telemetry enhancing the cover area of monitoring data. Monitoring the UAV flying state without PCM telemetry, decreasing the cost of modification on aircraft and employees, increasing the efficiency of flight test engineers.

As the complement and backup of telemetry data link, via UAV data link, more flight parameters can be acquired beyond loads parameters. Meanwhile, it is easier to keep with the state of UAV data link and get some needed real-time safety monitoring information via real-time monitoring of UAV data link. That is an important complement of telemetry data link information. the system provides convenience for the ground commander and flight test engineers to compare the data from telemetry and UAV data link, which is important to increase flight test efficiency and safety.

2. Design Ideas

2.1 Traditional telemetry data link real-time processing technique
Traditional flight test telemetry monitoring is achieved via radio telemetry, with the telemetry antenna to receive the on-board test data from test system, completing the demodulation and synchronous
transmission, analyzing data and displaying the tested parameters of figures, images, sounds and videos [5].

Traditional telemetry data link real-time processing topological graph is shown in figure 1.

![Testing Machine](image1)

C/S Band
Telemetry Link

Receiving Antenna

PCM

Telemetry Monitoring

Figure 1 traditional telemetry data link real-time processing topological graph

2.2 Introduction of real-time processing system of UAV controller-pilot data link

UAV controller-pilot data link real-time processing topological graph is shown in figure 2.

![Testing Machine](image2)

* Band Ground-to-air Data Link

Ground Receiving Station

Network

Telemetry Monitoring

Figure 2 UAV controller-pilot data link real-time processing topological graph

Compared with traditional telemetry data link real-time processing, UAV controller-pilot data link real-time processing system is realized by sharing the same data source with UAV ground controller under the help of well-designed real-time processing system [6]. In one word, UAV controller data acceptance system is the input of data, monitoring client and data recording are output, which makes it convenient for flight test engineering monitor timely.

The frame of UAV controller-pilot data link real-time processing system is shown in figure 3.
The system receives the UAV real-time data from controller via real-time data network switch, parses and records the data according to UAV data link protocol, finally, the results are shown to the flight test engineers as images, figures, curves, electronic map and so on.

3. Implementation of System

3.1 Function of System

UAV controller-pilot data link comprises of uplink used to control the UAV by controller, and downlink used to receive the telemetry data from UAV. Uplink is mainly used to transmit the instructions from controller to UAV, downlink is mainly used to transmit the data from UAV to controller. During the process of flight test, monitoring the UAV downlink data brings more parameters besides on-board test parameters, meanwhile, we can acquire the status of UAV data link. Via real-time monitoring the UAV data link and real-time processing of telemetry data during flight test, some key parameters can be monitored timely, under the support of ground system, the flight test efficiency is enhanced dramatically, flight test period is compressed significantly.

3.2 Modules of System

The modules of UAV controller-pilot data link real-time processing system are shown in figure 4, the process management module controls all the processes, data collection module collects data, data reception module receives all the link data from UAV, data processing module parses the received data according to the different protocol of links, transferring the true form to decimal. Data merging module eliminates the redundant data via merging processing technique, data sending module sends the decimal data to client, data display module displays the processed result via data driver, the main interface display module displays the decimal data via electronic map, figures, curves and so on, for flight test engineers.
Figure 4 the modules of UAV controller-pilot data link real-time processing system

UAV controller-pilot data link real-time processing system aims to realize the following functions: 1) reception and parser data from UAV data link timely, 2) real-time multi-source merging of multi-band telemetry link data, 3) real-time visual monitoring of the key parameters from UAV data link, 4) real-time visual monitoring of video data from UAV data link, 5) management platform establishment of parameter configuration and information calibration 6) decision assistant function for pilot under emergency, 7) real-time recording and replaying of data.

4. the Key Technique

4.1 High bandwidth network data real-time processing technique
According to the frame of data package and the position definition of parameters in configuration file, the data analysis and processing system extracts true form from real-time data flow, then, through calibration category in parameter configuration file, transferring the true form to decimal data. UAV link data usually transfers via multi-link, the bandwidth of every band reaches several Mbps, even higher. The realization of real-time synchronous data processing of all bands will contribute a lot to the data link monitoring system of UA function and performance.

Adopting multi-core CPU as data processing platform ensures the data processing time is in microsecond magnitude, avoiding the bottleneck of massive data processing, ensuring the real-time capability of system. Under the available bandwidth, the system finishes receiving high-speed network data flow, via applying independent thread and buffer queue, ensuring the data collection without missing. Shown as figure 5, in an independent thread, establishing buffer queue, parsing the collected data package and pushing to buffer queue, data reception and data unpacking are performed simultaneously, which makes sure that the data collection is real-time and without missing data packages.

Figure 5 multi-flow data merging and processing sketch map

4.2 High-speed data flow driver technique
UAV controller-pilot data link real-time processing system adopts ping-pang buffer mechanism, enhancing the writing efficiency of driver, ensuring high-speed data flow continuous storage. According to the requirement of system data, establishing needed data buffer space, after receiving the data package,
refreshing the data according to the corresponding position, shown as figure 6, after every refreshing of buffer data, all the data will be written in the driver avoiding frequent dynamic condition application and RAM release, enhancing the processing efficiency.

\[
\begin{array}{cccccc}
\text{Number} & B_0 & B_1 & B_2 & B_3 & \ldots & B_n \\
\text{Data} & D & C & A & O & O & O \\
\end{array}
\]

Figure 6 the data ping-pong buffer implementation diagram

4.3 multi-flow data merging and processing technique
During the real-time monitoring process of UAV data link real-time processing system, the telemetry real-time data integrated processing unit adopts multi-flow merging processing technique which merges the data from multi-data links effectively, processes test parameters from different data links comprehensively, selects the redundant parameters from multi-data links according to corresponding criterions, finally, the merging result is displayed and analyzed.

4.4 Synchronous analysis of parameters based on time matrix
Usually, several data links are necessary to be monitored by UAV pilot-controller real-time processing system, and network data package of every data link has its independent time, therefore, during one data analysis process, it is needed to coordinate data analysis to unify the time. For the time-discreted series of network data package, in order to efficiently realize synchronous analysis of huge number of network data, via rapid synchronization analysis technique, designing synchronous analysis algorithm based on time matrix, giving instructions for synchronous processing technique of flight test data.

For the original network data of UAV flight test, every single network data has a time mark, which is randomly stored in original file. The data needed in flight test usually locates in several network data packages, and the data in the different network data packages are always not collected at the same time, that is to say, the time marks are not always the same. For the characteristics of network data package, in order to analyze the time marks of network data package rapidly, time matrix synchronous algorithm is developed.

Acknowledgments
UAV controller-pilot data link real-time processing technique is researched in this article, giving the design thought and realization philosophy of UAV controller-pilot data link real-time processing system. The system doesn’t rely on traditional PCM telemetry, via the inherent controller-pilot data link of UAV, the support of ground system, and flight test data processing system, enhancing the flight test efficiency and decrease the flight test period. This plan can be referred by subsequent flight tests based on network data collection.

References
[1] Zhou Ziquan. Culture and Connotation of Aircraft Flight Test (Down) [J]. International Aviation. 2010 (12)
[2] Zhou Ziquan. Culture and Connotation of Aircraft Flight Test (Up) [J]. International Aviation. 2010 (11)
[3] Zhou Ziquan, Liang Chen. Zhou Ziquan J-10 Test Flight Master [J]. Aviation Manufacturing Technology. 2012 (Z1)
[4] Aerospace [J]. Modern Weapon. 2010 (04)
[5] Li Guoen, Xu Bingjun. Enlightenment from the Experience of Flight Test in Aviation Developed Countries
[6] International Aviation. 2010 (09)