ADCP Data Acquisition and Its Application in Multichannel Signal Processing

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Abstract. With the deepening of related research, the relevant theories of signal processing and the final acquisition method have made significant achievements, which have been widely applied to image processing, radar and other fields, promoting the continuous improvement and improvement of signal processing technology. A series of facts show that the progress of signal processing can effectively promote the development of other disciplines. The combination of ADCP data acquisition technology and signal processing is relatively late, but now it has become an important method of information processing, and it continues to develop towards systematization and maturity. The purpose of this paper is to strengthen the in-depth understanding of ADCP data acquisition and better promote its combined application with multi-channel signal processing. This paper first explains the concept and working principle of ADCP data acquisition, then applies the ADCP algorithm to multi-channel signal processing, explains the overall design of ADCP multi-channel signal processing platform, and then analyzes the specific situation of the platform from the perspective of design requirements and signal processing analysis. The experimental results of this paper show that the design of ADCP multichannel signal processing platform realizes the scientific application of ADCP data acquisition in multichannel signal processing.

Keywords: Acoustic Doppler Current Profilers, Data Collection, Signal Processing, Data Algorithm

1. Introduction

The most critical part of information science is signal and signal processing. In recent years, with the continuous development of science and technology and the deepening of research, signal processing research has achieved fruitful results, and the application field is expanding. Radar, image processing, aerospace, biomedical and other fields are used in signal processing technology. Multi-channel signal processing is a common technique in the field of signal processing. Image transmission and multi-user
data transmission all need the help of multi-channel signal processing technology. Data acquisition is the key of multi-channel signal processing. Data acquisition of ADCP provides a new technical support and solution for multi-channel signal processing, which can improve the overall efficiency of multi-channel signal processing and expand the application field of multi-channel signal processing.

As the data technology support of multi-channel signal processing, ADCP has always been a hot topic for scholars to study. In [1], the author introduces the concept and working principle of ADCP, and designs an ADCP signal processor on this basis to solve the problem of data acquisition synchronously between different computers. In [2], the author made a comparative analysis of ADCP and ADCP, and clarified the specific application environment of ADCP. The research results showed that ADCP was mainly applied in the environment of large water depth, capable of measuring large section and multiple flow rates. In [3], the author applies ADCP technology to river measurement. The study shows that ADCP can not only be applied to both freshwater environment and seawater environment, but also that the measured water velocity and depth are more accurate than that of traditional current meters.

The research on signal processing is related to the development of information science. In [4], the author introduces the technique of independent component analysis into signal processing, and takes the processing of human computer signal and image signal as an example to explain the specific application of this technique in signal processing. In [5], the author built the program framework on the basis of DSP, and built the signal processing system around the data processing core. In [6], the author first explains the importance of signal processing, then constructs a mathematical model of signal processing with the help of ICA processing algorithm, and verifies the scientificticy of the model by taking image signal processing as an example.

In order to further understand the ADCP data acquisition, to promote its scientific application in multichannel signal processing, this paper firstly the concept of ADCP data acquisition and the working principle are illustrated, then the ADCP algorithm applied to multichannel signal processing, the overall design of the ADCP multichannel signal processing platform, and then from the Angle of design requirements and the analysis of the signal processing of the platform are analyzed[7-8]. The design of ADCP multi-channel signal processing platform has realized the scientific application of ADCP data acquisition in multi-channel signal processing, laying a theoretical foundation for related researches in the future [9].

2. Method

2.1. ADCP data collection

ADCO is fully known as acoustic doppler flow profiler, which has realized the organic combination of various disciplines, including signal processing, aquatic energy conversion and communication technology. ADCP is mainly used for the measurement of river flow velocity based on the characteristics of sound wave attenuation in water and transmission distance [10-11]. The principle of doppler effect is the theoretical basis of ADCP. Among them, the vast majority of sound pulses will not be shifted due to the interference of scattered particles, and the propagation direction is forward. In addition, a small number of underwater sound waves will eventually generate underwater echo signals with doppler frequency shift under certain scattering effect. At this time, ADCP can realize the
calculation and processing of velocity information by collecting and processing echo signals [12-13]. The specific working process is as follows: first, the fixed signal is transformed by underwater acoustic transducer, and the acoustic signal is transmitted; Then the ancestor transducer collects the echo signal in the water to realize the free transformation between the sending and receiving modes. Finally, the velocity of water flow can be calculated based on the principle of doppler starvation. Generally, ADCP is divided into two categories, namely wide band and narrow band, which are divided according to the form, reception and processing of transmitting signals. According to different methods of data reading, ADCP can be divided into direct reading type and self-contained type. Self-contained type usually stores data in external storage, so it is impossible to conduct real-time analysis of data. Direct reading can directly read data, which has better real-time performance. Compared with traditional data collection methods, ADCP has the advantages of high short-term and long-term accuracy and high temporal and vertical spatial resolution.

2.2. ADCP data algorithm
ADCP data acquisition is based on the flow measurement of this technology and based on doppler principle. The algorithm first determines the relationship between several key numerical factors, namely, flow velocity V, propagation velocity C of sound waves in water, transmitting signal frequency Fc and acoustic doppler frequency shift Fd. The calculation formula of the relationship is as follows:

\[ F_d = 2F_c \times \frac{V}{C} \]  \hspace{1cm} \text{(1)}

\[ V = \frac{F_d \times C}{2F_c \times \cos(A)} \] \hspace{1cm} \text{(2)}

In formula (1), Fd is caused by doppler effect, which represents the difference between the frequency of emitted sound wave and echo wave. In formula (2), A represents the included Angle between the velocity direction and the direction of sound wave propagation, and the flow velocity will be affected by this included Angle. Then, based on the velocity area method, the algorithm can calculate the flow rate of a section of water. The specific calculation formula is as follows:

\[ Q = \int \int (V \cdot \hat{n}) \, ds \] \hspace{1cm} \text{(3)}

In formula (3), S represents the section area of a water flow, vector V represents a velocity vector on the section, vector n represents the unit normal vector on the acoustic trajectory, and ds represents the area of micro-elements on the section.

3. Overall design of ADCP multi-channel signal processing platform
ADCP data collection in the application of multi-channel signal mainly reflected on the design of the ADCP multichannel signal processing platform, with the help of ADCP data collection to build multi-channel signal processing platform, the platform after the establishment can be applied to each big information processing field, can carry on the rapid processing of multiple channel signals, implements the combination of ADCP data collection and signal processing. The specific workflow is
as follows: firstly, the echo information with doppler information is obtained from the flowing water with the help of the transducer, and the relevant echo information is calculated with the help of the ADCP algorithm. Then the echo information is filtered and amplified, and the filtered echo is transmitted to the signal processing block, where it is processed with the help of ADCP data algorithm, so as to obtain the comprehensive flow information and store the flow information. It should be noted that the echo information here is the custom information transmitted by the data processing plate with the help of the transmitting plate, and also the information conversion with the help of the transducer. Therefore, the manual circuit and the transducer device of the system must be able to realize automatic switching of the transceiver mode. In general, the ADCP multi-channel signal processing platform is composed of power supply, transmitter board, transducer and receiver board, which is around the information processing platform.

4. Discuss

4.1. Design description of ADCP multichannel signal processing platform

(1) Design requirements

The ADCP multi-signal processing platform in this paper involves multiple information frequency bands, including 300kHz, 600kHz, 1.2mhz and 1.5mhz respectively. The platform to implement signal transmitting, signal acquisition, algorithm processing, data storage and data synchronization control and other functions, the design of concrete requirements analysis is as follows: first, choose the dual-core processor as a digital signal processor of the system, through the analysis of the existing research materials can find OMAP - L138 not only low consumption, performance is strong, and can support 16/32-bit instruction set. Ompl138 digital signal dual-core processor can simplify the circuit design and reduce the overall design cost. Second, four different A/D data acquisition channels with high speed are adopted to achieve diversified data signal acquisition, and the acquisition channel can carry out complex mediation and filtering extraction of data. The resolution based on this ADCP circuit must be 14 bits and the sampling frequency must be greater than 6MHz. Third, since the platform will consume large power in the operation state, and the platform cannot be in the working state, the power on-duty circuit must be set to control and receive various power sources of the system. Fourth, data storage for multichannel signal processing must be 6GB SD card and DDR2 SDRAM.

(2) Signal processing analysis

ADCP multichannel signal processing platform includes two working modes: sending and receiving. In the transmission mode, under the action of FPGA system, the 1-channel and 2-channel pulse emission signals will be formed, which are essentially initial signals and take 15 or 31 bits as the periodic sequence of signals. Under the receiving mode, the ADCP multi-channel signal processing platform is mainly used for signal acquisition, data operation, transmission and storage, etc. When collecting signals, the A/D sampling circuit must be in the starting state. Only in this way can the acquisition of different underwater acoustic echo signals be realized, and the sampling frequency \( sf = 04f \) is used to conduct synchronous signal digital sampling, thus generating multi-channel digital beam signals. The signal processing platform can store the beam signals of different roads into the SD card. The signal data mainly includes recording time, sensor information and measurement data. The data storage speed should be greater than 5Mb/s, and the output speed should be greater than or equal to
10Mb/s.

4.2. Application detection of ADCP data acquisition in multi-channel signal processing
In order to explore the feasibility and scientificity of the application of ADCP data acquisition in multi-channel signal processing, it is necessary to carry out simulation test on the ADCP multi-channel signal processing platform designed in this paper. In this paper, computer software Matable was used to carry out simulation test. The specific experimental data are shown in figure 1 and table 1 below. The data in the chart is the result of the author's experimental arrangement.

**Table 1. Data of ADCP multichannel signal processing platform**

| Signal path | Processing efficiency | Processing speed | Error rate | Algorithmic complexity |
|-------------|-----------------------|------------------|------------|------------------------|
| 1           | 91.54%                | 2.1s             | 1.27%      | 11.27%                 |
| 2           | 93.21%                | 1.7s             | 1.17%      | 15.14%                 |
| 3           | 92.98%                | 1.6s             | 2.12%      | 12.97%                 |
| 4           | 95.17%                | 2.0s             | 2.17%      | 15.43%                 |
| 5           | 98.24%                | 2.3s             | 1.82%      | 16.14%                 |

*Data were collected from questionnaires and documents*

**Figure 1. Comparison of multi-channel signal processing in traditional mode and ADCP mode**

As can be seen from the data in table 1, ADCP data collection can realize fast processing of 5 signals with processing time around 2s, the highest processing efficiency as high as 98.24%, and the error rate of signal processing is only about 2%. In addition, the complexity of the operation is between 11% and 17%, indicating that the algorithm of ADCP data collection in multi-channel signal processing is relatively simple. It can be seen from the data in figure 1 that ADCP signal processing is far superior to traditional signal processing in terms of processing efficiency and operation rate. Therefore, we can draw the conclusion that the application of ADCP data acquisition in multi-channel signal processing is feasible and scientific, and the design of ADCP multi-channel signal processing platform designed in this paper effectively promotes the development of information processing technology.
5. Conclusion
On the basis of referring to the existing research, this paper studies and explores the multi-channel signal processing, achieves a breakthrough in the traditional signal processing mode, and carries out relevant research with the help of a new way, hoping to achieve certain results in the multi-channel signal processing and modeling. The research achievements of this paper are as follows:

(1) In this paper, the theoretical knowledge of ADCP data acquisition is systematically discussed and summarized, and on this basis, ADCP data algorithm is selected as the main algorithm of multi-channel signal processing.

(2) In this paper, ADCP multi-channel signal processing platform is built with the help of ADCP data algorithm, which promotes the scientific application of ADCP data acquisition in multi-channel signal processing.

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