Application of Information Processing System Based on DSP in Electronic Information Engineering

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Abstract. On the one hand, target tracking technology is widely used in navigation, guidance, alarm and monitoring and other military fields, on the other hand, it is also widely used in civil fields such as traffic information monitoring and security. This paper mainly studies the application of information processing system based on DSP in electronic information engineering. This paper introduces DSP information processing system in detail. Aiming at the comprehensive requirements of real-time and tracking performance of the target tracking system, multi-feature fusion optimization method is adopted to improve the particle filter tracking algorithm to improve the accuracy of the tracking algorithm. In this paper, the simulation results show that the improved algorithm has a certain scale and occlusion robustness, and can adapt to long-term stable real-time tracking.

1. Introduction

Image tracking system is through a variety of sensors such as visible TV, infrared thermal imager, video image sequence, and then automatically extract and track the target, in the military field, image tracking system in missile, aircraft and other target early warning, precision guided weapons, fire control system plays a vital role. The image tracking system first captures the target from the acquired video image sequence containing the target, then calculates the coordinates of the target in the image, and sends the coordinate information to the tracking servo system to complete the target tracking function [1]. In the civil field, the image tracking system can target track and locate the vehicles on the specific road in the real-time monitoring of traffic road, and can monitor the road traffic condition in real time, and provide available information for the rapid transportation of congested road traffic. Play a key role in forest monitoring, through the establishment of data collection, data management, flexible monitoring, forecast and prediction, spread analysis, location tracking, identification and alarm, fire command integration platform, timely and accurate forecast of forest fire and other disasters. Due to the lack of bus bandwidth and processing speed, the application of DSP processor is limited to signal control and frequency domain analysis. In recent years, with the development of process manufacturing technology, the bandwidth and performance of DSP processor have been significantly enhanced. DSP based system has gradually entered into more complex video processing field, and embedded video processing system has been rapidly developed [2-3].

In the history of target tracking, tracking models can be roughly divided into three types, namely generative model, discriminant model and other models. Since the CORRELATION filter was introduced into the tracking field by THE MOSSE tracker, the tracker based on correlation filter was once concerned by researchers due to its advantages of good accuracy and fast speed, and gradually became the mainstream of discriminant model research [4]. KCF obtains a conclusion similar to
MOSSE from the point of view of training linear classifier with cyclic samples, and introduces kernel method and multi-channel feature to improve tracking performance significantly. In KCF, the use of multi-channel features can significantly improve the tracking performance more than the core skills, but the multi-channel features will increase the computational complexity and reduce the real-time performance of the tracker [5]. DSST constructs multi-scale space on the basis of KCF and searches for the best scale to improve the scale adaptability of tracker. In DSST, the construction of multi-scale space is realized by creating image pyramids. The more layers of the pyramid, the higher the accuracy of scale prediction and the greater the amount of calculation [6].

With the continuous improvement of microprocessor chips and computer computing power, target tracking algorithm has been gradually developed, and further promote the development of computer vision (CV), machine learning and deep learning, and further deepen the application of target tracking algorithm.

2. Target Tracking Based on DSP

2.1. DSP Information Processing System

(1) System structure and characteristics

In recent years, with the more and more in-depth research on DSP, DSP chip stability, speed of operation, integration and other aspects of performance have been greatly improved, and DSP chip is widely used in digital signal processing. At present, DSP is increasingly tending to real-time signal processing, and its performance in video and image processing is getting better and better [7-8].

The features of DSP hardware system include:

The kernel of DSP is a super-long instruction word structure with 8 functional units and 64*32 bit general purpose register. The execution speed of instructions can reach 8 instructions per clock cycle, and its operation speed is 4800MIPS.

DM642 uses two levels of super high speed buffer memory, the memory performance is high, the data can meet the requirements of high speed DSP core.

In order to improve the efficiency of instruction set, DSP system adds an instruction, which can directly package the data, so as to achieve seamless data flow.

The CORE CPU of the DM642 chip uses VelociTI Advanced Ultra-long instruction Word technology, which is faster than other chips in the series and can process up to eight 32-bit instructions simultaneously. The CPU of the chip contains two groups of functional units, each of which is composed of four small functional units and a register. The DM642 not only has fixed-point instructions, but also includes many 8-bit, 16-bit extended instruction sets. As a result, DM642 works efficiently. The loading memory structure of chip DM642 is a very key technology, in the loading memory structure, the instruction register is completely different from the memory register.

(2) Overall process

In the research on the recognition and tracking of target images, we need to carry out pre-processing, image segmentation, target recognition and target tracking algorithms in sequence [9]. In this system, the selection of DM642 chip, video signal acquisition, storage, analysis, signal output processing.

The CCD camera transmits the moving target image signal to the video decoder, converts the analog signal of the image into digital signal and then sends it to DSP. The digital signal is stored in SDRAM by VP port of DM642 chip. DM642 chip processes the video digital signal by recognition and tracking algorithm. The processed digital signals are converted into analog signals by the video encoder, and finally output in the form of images on the display.

As for the construction of DSP hardware platform, the parameters of each indicator are defined according to the performance indicators required by the system, and then the appropriate DSP chip is selected, the program is written and burned, and the debugging program is run at last.
2.2. Optimization and Implementation of Tracking Based on DSP
In the particle filter-based target tracking algorithm, the prior knowledge of a single feature to describe the target usually has limitations. For example, the texture feature of the image is filtered out when the histogram information reflects the grayscale feature of the target [10]. There is a large error in comparing the similarity between the sample particle and the target template by using a single feature, and the inaccurate updating of the particle weight leads to the phenomenon of tracking drift.

(1) Gray features
The comparison method of gray features is based on the pixel information in the target region and the candidate sample, and the formula is shown below.

\[ w^T = \frac{\sum_{i=0}^{M} \sum_{j=0}^{N} [f(i, j) \cdot g(i, j)]}{\sqrt{\sum_{i=0}^{M} \sum_{j=0}^{N} [f(i, j)]^2} \cdot \sqrt{\sum_{i=0}^{M} \sum_{j=0}^{N} [g(i, j)]^2}} \]  

In the formula, \( w^T \) represents normalized similarity, while \( M \) and \( N \) represent the width and height of the image. Similarity measurement by comparison of pixel regions can make full use of the information in the image, make the correlation peak of the target and sample more sharp, solve the problem of non-convergence in similarity comparison, and better improve the tracking accuracy and robustness.

(2) Histogram features
As a common feature in images, the histogram feature is a simple and efficient digital image description feature, which has been widely applied in the field of machine vision [11]. First of all, the calculation of histogram features is efficient, and it is very fast to obtain histogram information by using target template. Secondly, the feature of the histogram is to map the 2d image digital information into the 1d model by using the statistical method, which reduces the dimension of comparison, extracts the image features, and has a certain rotational robustness to the target template. The commonly used gray histogram statistics formula is as follows:

\[ H(i) = \frac{n_i}{N} \quad i = 0,1,...,L-1 \]  

Where, \( i \) represents gray level, \( n_i \) represents the number of pixels whose gray level is \( I \), \( N \) represents the total number of pixels, and \( L \) represents the total gray level type, which is generally 255.

(3) DSP algorithm optimization
In the implementation of the algorithm based on the DSP processor, the program needs to be optimized to ensure the correct operation of the algorithm and the maximum efficiency of the hardware computing resources. The particle filter algorithm in this paper is first developed on the computer using OpenCV environment to ensure the correct realization of the logic, and then the algorithm is implemented in THE DSP processor [12]. The DSP processor used in this paper is high performance TMS320C6657 processor produced by TI Company. The algorithm optimization goes through three stages, and the timing function is calculated through the TSCH/TSCL register.

EMCV is a simplified version of OpenCV library functions transplanted in embedded processor, which has built-in interface and class definition of many functions in OpenCV1.0 version. This stage is used for algorithm transplantation, and the program code is basically unchanged, which ensures the logical correctness of algorithm transplantation.

In the last stage, using the EMCV library migration algorithm, the program target tracking results are correct, but the single frame processing time is long, which can not meet the real-time demand of processing time, and the program code is optimized at the language level.

Language level optimization, the first use of C language code to adapt the program, out of OpenCV library function support. Second, use operations that cost less to replace operations that cost more, and use shift operations to replace multiplication and division operations. After that, the functions that
require less computation are modified to inline functions, such as size comparison functions, using inline functions. Finally, you can use the DSP processor support library VLIB to implement the barbarian distance calculation with library function calls.

In THE DSP processor, the HAver structure memory is used in the DSP, and the three-level memory memory mode is set, that is, L1, L2 and DDR3 memory architecture. In this article, the program is placed in THE L2 cache area, and the compiler is optimized at -3.

3. System Test Simulation Experiment

3.1. Experimental Scheme

In order to evaluate the tracking algorithm proposed in this paper, the performance of the algorithm is evaluated experimentally. Firstly, the algorithm was tested in THE DSP development environment, and the tracking performance of the algorithm was verified in the laboratory environment from the perspective of intuitive and qualitative.

The ideal test environment for this experiment is to embed the development system into the moving platform and carry out tracking and verification on the moving platform. However, due to the high cost of moving platform equipment, this test was completed in the laboratory simulation test. The camera used in this test was black and white, so the video collected was in black and white mode.

3.2. Algorithm Comparison

In this paper, the experimental data set Carscale and David of OTB-100 and the data set Pedestrian algorithm in VOT-2013 are selected to test the tracking effect. Clutter, partial occlusion and object deformation exist in the Data set of Carscale, while the data set of David is mainly influenced by illumination. Pedestrian1 scored background wobble, and scored MF and KCF respectively.

4. Simulation Results

4.1. Video Frame Recognition

As shown in Figure 1, the improved algorithm proposed in this paper can correctly identify 542 frames, incorrectly identify 41 frames, and reject 17 frames. The correct identification frame number of MF algorithm is 498, the wrong identification frame number is 64, and the rejected identification frame number is 38. The KCF algorithm correctly identifies 519 frames, incorrectly identifies 52 frames, and
rejects 29 frames. The above results show that the algorithm proposed in this paper has the highest accuracy in video frame recognition, and the recognition rate reaches 90%, which meets the performance requirements of the algorithm.

4.2. Tracking Success Rate of Different Data Set Algorithms

| Table1. Success rate table of tracking results of different algorithms |
|--------------------------|----------------|----------------|
|                        | Carscale | David | Pedestrian |
| Ours                    | 93      | 44    | 35         |
| PF                      | 84      | 42    | 21         |
| KCF                     | 91      | 98    | 26         |

As shown in Table 1 and Figure 2, on Carscale data set, the success rate of the improved algorithm proposed in this paper reaches 93%, which is better than PF algorithm (84%) and KCF algorithm (91%). On David data set, the success rate of the improved algorithm proposed in this paper is only 44%, far behind the 98% success rate of the KCF algorithm. On Pedestrian data set, the success rate of the algorithm in this paper reaches 35%, leading PF algorithm 14%, and KCF algorithm 9%. The improved algorithm optimizes the target scale changes, and the tracking box can be scaled appropriately to adapt to the target scale, which reduces the center position offset error and significantly improves the success rate on Pedestrian data set. At the same time, the algorithm has good processing speed, can run in real time and adapt to DSP engineering applications.

5. Conclusions

Target tracking technology has been widely used in military fields such as navigation, guidance, alarm and monitoring, and has great potential in civil fields such as vehicle autonomous driving and robot vision. This paper focuses on the software design of HIGH definition image tracking system based on DSP, and designs the frequency domain tracking and correlation tracking algorithm, which can realize the target stable tracking function under complex background. The experiment shows that the improved tracking algorithm can run in real time and adapt to DSP engineering application.
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