Design of 3D Image Feature Point Detection System Based on Artificial Intelligence

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Abstract. Aiming at the problems of low efficiency and accuracy in the traditional 3D image feature point detection system, an efficient 3D image feature point detection system based on artificial intelligence is designed. Firstly, the whole frame of the system is designed. Then the hardware system is designed, including the development board, peripheral equipment and interface, basic engineering reconstruction and feature point detection unit. Then the software system is designed, including image collection module, image feature point display module. Image feature point processing module, image feature point extraction module, image feature point description module, and using the combination of hardware system and software system to achieve three based on artificial intelligence Dimension image feature point detection system. Finally, the effectiveness of the 3D image feature point detection system based on artificial intelligence is verified by experiments, and the detection efficiency and accuracy are much higher than the traditional methods. This study lays a foundation for the further study of images.

Keywords: Artificial intelligence · 3d image · Feature points · Efficient detection

1 Introduction

Artificial intelligence has entered the life of modern people. In many fields of artificial intelligence, image detection is the foundation stone, especially in the field of Internet of things [1]. Image is a special data format. If we want to obtain different connotations according to different images, we need to use certain image detection technology. With the wide application of 3D image in daily life, 3D image feature point detection has gradually become a hot topic. Feature point detection of 3D image is an important part of computer vision application. With the rapid development of information technology, people rely more and more on information, how to obtain more useful information becomes more and more important. The most intuitive way to get information is to observe and recognize the outside world through the human eye, and according to statistics, it is possible to obtain external information through human vision, which is enough to show that the human visual system can image through the eyes. And then sense the three-dimensional objects in life. This ability to obtain 3D image information from two-dimensional scene images is a visual function that people have been trying to give

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computers and intelligent machines. It can replace human to complete the acquisition and processing of external scene information. Another way to obtain information is to obtain external information indirectly from the image. Photography can record all kinds of image information, that is, the process of exposing the sensitive medium inside the camera by shooting the reflected light of the scene, or "painting with light" Therefore, the general imaging method can only obtain the plane image of the scene [2]. If the three-dimensional shape information of the object scene in the image is to be obtained, the scanning mode can only be used, and the time taken by the process is longer, so that not only the real-time property obtained by the image information is affected, but also the definition of the imaging picture is affected. The commonly used 3D image feature point detection methods include feature detection method based on image edge information, corner information detection method and various interest operators. However, the traditional detection methods all have the problems of large computation and long time consuming. In order to solve these problems, a three-dimensional image feature point detection system based on artificial intelligence is designed.

2 System Overall Frame Design

When constructing the whole frame of the 3D image feature point detection system based on artificial intelligence, four modules are designed, which are shown in Fig. 1.

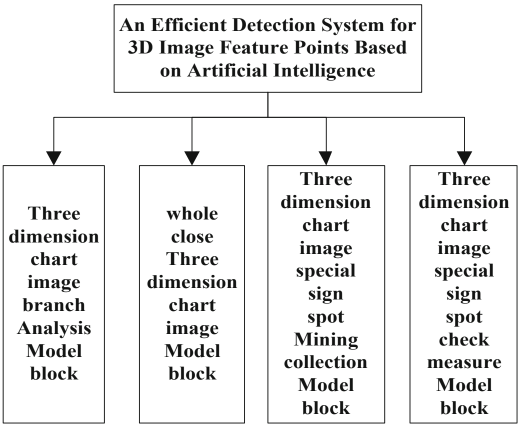


Fig. 1. Overall frame construction

For 3D image analysis module, its main function is to collect and analyze 3D image resources. The purpose of integrating 3D image module is to recombine the digital signal output from the system, generate 3D image and then complete the feature point detection of 3D image [3]. The feature point acquisition module of three-dimensional image is to extract and collect the feature point of three-dimensional image. And the three-dimensional image feature point detection module is used for realizing the high-efficiency detection system of the three-dimensional image feature point based on the artificial intelligence by detecting the three-dimensional image feature point.

3 Hardware System Design

3.1 Development Boards

The hardware platform used in the 3D image feature point detection system based on artificial intelligence is the PYNQ-Z1 development board, which integrates the 7000 series ZYNQ chip of Syringes Company. It can realize the heterogeneous processing of ARM and FPGA so as to realize the efficient detection of 3D image feature points [4]. The PYNQ development board is an artificial intelligence development board developed by Dizzelon and Syringes. It is simple in shape and equipped with ZYNQ artificial intelligence chip. It simplifies and improves the design of software and hardware related to APSOC. Because it integrates features that other ZYNQ development boards do not have, based on the heterogeneity of ARM and FPGA: It can utilize Python, an efficient language with rich third party libraries, and apply the API command based on Python language to the control of FPGA. It can detect feature points by controlling FPGA. Its integrated Jupyter Notebooks framework compiler tool has high visibility and is very suitable for the development process of detection system [5]. In addition, the embedded platform can effectively collect the feature points of 3D images, and the feature points can be analyzed by integrating the collected feature points. Based on the advantages of PYNQ and the requirement of high efficiency detection of 3D image feature points based on artificial intelligence, The PYNQ development board is selected as the hardware system of the 3D image feature point detection system based on artificial intelligence [6]. In addition, the PYNQ-Z1 board can be started from the JTAG, Quad-SP flash memory and the microSD card. There is a digital-to-analog converter on the chip, and the on-chip system and peripheral interfaces are shown in Fig. 2.

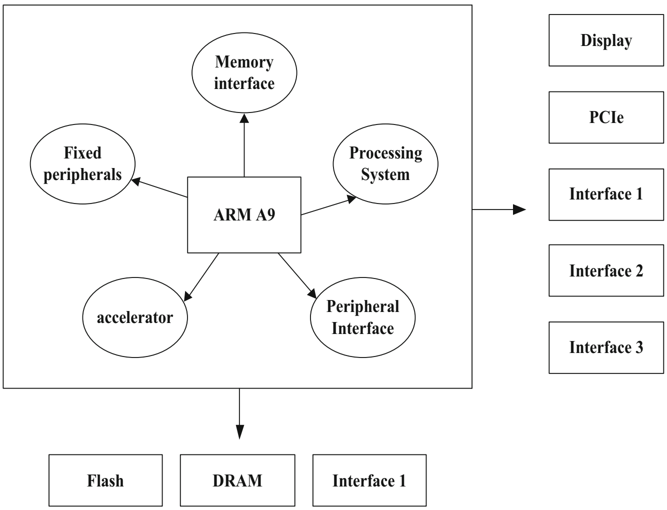


Fig. 2. System and peripheral interface

3.2 Peripherals and Interfaces

ZYNQ PL can support multiple types of external protocols and interfaces. PYNQ-Z1 has two Pmod ports and a ArduINo interface for connecting peripherals directly to ZYNQ PL, allowing peripheral devices to be controlled by hardware. Other peripherals can be connected to the above port through adapters or breadboards [7].

Although the FPGA architecture is reconfigurable and used to achieve high performance in hardware, the design of FPGA is a task that requires in-depth knowledge of hardware engineering and expertise. OVERLAY is a programmable/configurable FPGA design. Extend user application from ZYNQ processing system to programmable logic [8]. Software programmers can use OVERLAY, in a similar way to the software library to run some 3D image feature point processing functions on the FPGA architecture, such as edge detection, threshold, etc. [9].

3.3 Reconstruction of Basic Engineering

Since all the configurations required for the pre-defined ZYNQ SoC PS are provided on the basic OVERLAY, and the PS-PL interface is defined, the hardware OVERLAY, which creates a custom PYNQ, can use the existing Base OVERLAY as the starting point to add the required feature IP core to achieve the desired function [10, 11]. The connection information of four AXI interface information is as follows: GP0 has 13 interfaces, which is in charge of LEDS GPIO, Buttons GPIO, BRAM, Video HPD, Video GPIO, Video Dynamic Clock, Video VDMA, Audio, RGB LEDS and HP0 is mainly responsible for Video VDMA function; GP1 and HP2 are responsible for PMOD and Arduino. Of which, basic workers The program allocates a total of 512 megabytes of space for memory in advance, and HP0,HP2 shares this address space.

3.4 Feature Point Detection Unit

The characteristic point detection unit is mainly composed of a programmable controller and an industrial personal computer operating panel. The main purpose of IPC is to realize the data transmission, display and statistics of the 3D image feature points of the detection unit, and to realize the detection and control of the field equipment by using the IPC [12, 13]. Among them, the operation panel can be used to modify the parameters, and can also achieve the function of setting. The feature point detection unit needs to complete its own task independently, and the detection results are transmitted to CPU through USB hub and interface.

4 Software System Design

4.1 Image Collection Module

Many algorithms are involved in the software system of 3D image feature point detection system based on artificial intelligence. For 3D image stratigraphic processing algorithm, FPGA is generally used to realize it, and DSP is used for high-level image processing algorithm. The system allocates the algorithm to each processing unit, and then realizes the task processing by pipeline, so that the efficiency of the system can be further improved. The main function of image collection card is to convert the microscopic image signal which has been converted into analog video signal in CCD camera device to digital signal direction. Use an image collection card that meets your own performance and price, depending on your work needs. In the software system of 3D image feature point detection system based on artificial intelligence, multimedia 3D image collection card is mainly used to realize 3D image analog preference A/D transform, digital signal storage and so on. And computer to achieve text, image, graphics and voice artificial intelligence integrated processing.

4.2 Image Feature Point Display Module

Image feature point display module can effectively collect and display 3D image feature points and capture 3D images. The capture refers to storing the scene image in memory, then copying the image into the buffer, then storing the data and BMP file format in the image buffer to the hard disk to show that it has been called. First of all, we initialize the acquisition, start the image acquisition process, and turn off the image to screen function in real time, so as to prepare for the image to memory acquisition. The parameters of the image resolution are set, and the input and output windows are determined, then the window is set by using the corresponding functions. After the setup is completed, the image is called into the memory function, and the resource allocation of the file information is realized in the memory, and the file information header is set. After the installation, BMP file information and image data information will be written to the empty file. If the function is executed successfully, BMP file will be written to disk and 3D image capture is completed.

4.3 Image Feature Point Processing Module

Image feature point processing module mainly deals with 3D image feature points, including gray processing, threshold segmentation, median filtering, edge detection, thinning, coordinates and distance calculation. Grayscale processing means that it is difficult to collect 32 true color images, so it is necessary to transform them into 256-color grayscale images. Threshold segmentation means that there are gray noise points in the process of collecting 3D image feature points, which can be removed by threshold method. Median filter refers to the use of 3×3 modules, a point as the center, if there is only this pixel value in the module region, then this point is noise, the pixel value will be changed to remove it. Edge detection refers to the use of functional Gauss algorithm to remove noise and then implement edge detection because noise points have a certain effect on edge detection. Thinning refers to the realization of thinning the image, effectively highlighting the geometric features of the image and reducing the amount of redundant information. Coordinate and distance are calculated by Hough algorithm, and the distance between two circles is calculated.

4.4 Image Feature Point Extraction Module

ORB descriptor is an improved algorithm of BRIEF algorithm proposed at the International Conference of computer Vision, which has the characteristics of invariance and anti-noise of 3D image rotation. The algorithm also combines the calculation flow of corner detection operator algorithm, which is recognized to be faster at present, and is a new matching algorithm. When extracting feature points, the algorithm gives the feature points a direction information after corner detection, which can keep the rotation invariance of 3D images. When matching feature points, in order to overcome the sensitivity to noise, the pixel block is used to determine the gray value in the pixel block, and the corresponding feature descriptor is generated, which improves the attack ability of the algorithm against noise, and has rotation invariance. The algorithm is a combination of operators and descriptors, which combines the advantages of the two algorithms. Extracting feature points is also an interesting part of the extraction image. The general feature points include boundary points, spots and corners. These points not only contain a lot of information of the image, but also determine the attributes of the image. Using the FAST feature detection operator to extract the corner information of the image, this is a fast feature extraction method, this method is mainly divided into two steps: The first step is to select and determine the gray value of the peripheral pixels compared with the points to be detected, and the second step to compare the gray values between the detection points and the peripheral pixels, and to determine the corner points according to the preset conditions. First, the pixel points should be selected, and the distribution of the peripheral pixel values determines whether the correct image feature points can be extracted. If we take a pixel point P in the image and judge whether point P is a feature point, you need to create a circle with radius r = 3 centered on a point P as a template graph, which is a discrete circle. The generation of discrete circle needs to use the algorithm of drawing circle in computer graphics, and through multiple iterations and traversing 16 pixels. The selection process of 16 pixels around the 3D image feature points is as follows:

```
Initial conditions: radius rn 3 D ~ (1) ~ (-1) ~ (-1) ~ (-1).
Termination condition: X > y.
Iterative steps: starting point (XY) = (0nr)
IF(x<y),IF(d<0),d=d+2x+3;

ELSE (dapd 2 (x-y) 5Cy -X);
END.
```

Where x is the x-axis coordinate value of generating the peripheral pixel point, y is the y axis coordinate value of generating the peripheral pixel point, and d is the constant changing threshold value.

4.5 Image Feature Point Description Module

The concept of gray moment is used to calculate the corner direction of feature points. The determination of corner direction is mainly divided into two parts [14, 15]. Firstly, the gray balance point of the small pixel block with the feature point as the center of 7×7 is determined, that is, the centroid point; The offset between the centroid point and the feature point, that is, the primary direction of the corner point, is then calculated. In the circular neighborhood radius r, the formula for calculating the offset m is as follows:

$$m_{pq} = \sum_{x,y} x^p y^q I(x, y) \tag{1}$$

Where the $I(x, y)$ table does not have a gradation value at the coordinates of (x, y), and p and q are the order number. The centroid point C can be obtained by using the following formula:

$$C = \left(\frac{m_{01}}{m_{10}}, \frac{m_{01}}{m_{00}}\right) \tag{2}$$

If the characteristic point is P, the vector PC is the main direction of the angle point, and the main direction of the ER angle point can be obtained by using the following formula:

$$\theta = \arctan\left(\frac{m_{01}}{m_{10}}\right) = \arctan\left(\frac{\sum_{x,y} yI(x, y)}{\sum_{x,y} xI(x, y)}\right) \tag{3}$$

5 Experimental Results and Discussion

In the process of experiment, a 3D image is used as the experimental object to detect the feature points of the 3D image. The connection between the PC machine and the PYNQ development platform is carried out by using the HDMI to USB connection line, and then the PYNQ development platform and the display screen are connected by the same

Fig. 3. Experimental sample

connection wire. After completing the environment connection, we load the original 3D image on the Jupyter Notebook, and the 3D image loaded is 720 or 1280 pixels.

In the experiment, part of the action screenshot in a 3D animation is selected as the experimental sample through the 3D image simulation system, as shown in Fig. 3.

The feature points are extracted from the 3D image by using the 3D image feature point detection system based on artificial intelligence and the traditional 3D image feature point detection system. The extraction results are shown in Fig. 4.

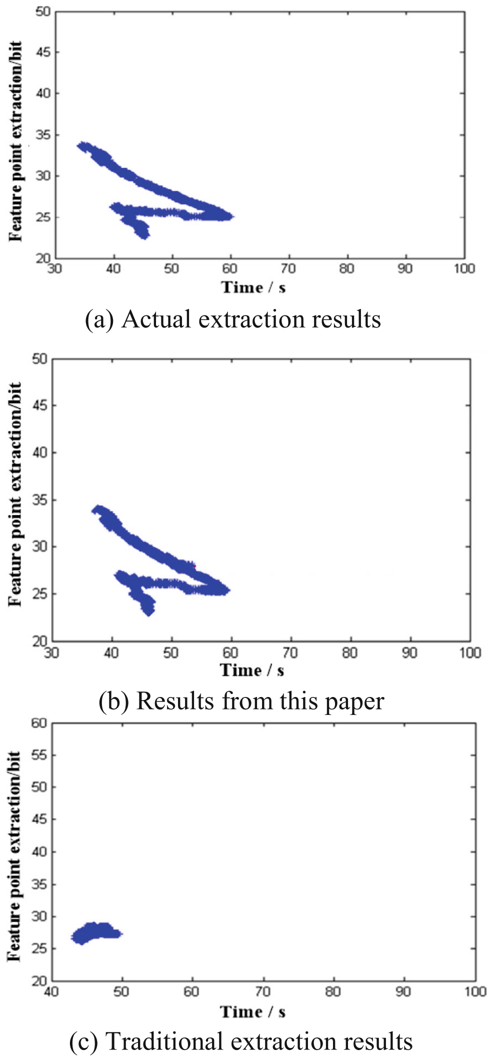
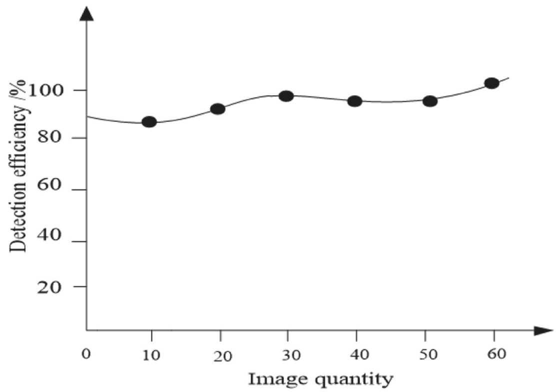


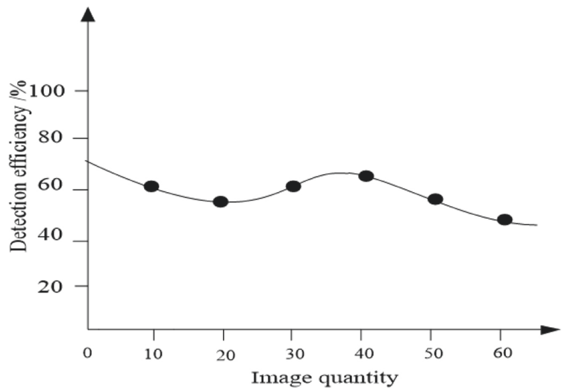
Fig. 4. Three-dimensional image feature point extraction results of two systems

According to Fig. 4, the extraction results of 3D image feature points in this system are consistent with the actual three-dimensional image feature points extraction results, while the traditional system's three-dimensional image feature point extraction results are quite different from the actual three-dimensional image feature point extraction results, which shows that the system in this paper can accurately extract three-dimensional image feature points.

In order to verify the effectiveness of the system in this paper, the efficiency of feature point detection in 3D image of this system and traditional system is compared and analyzed. The comparison results are shown in Fig. 5.



(a)Detection efficiency of 3D image feature point detection system based on Artificial Intelligence

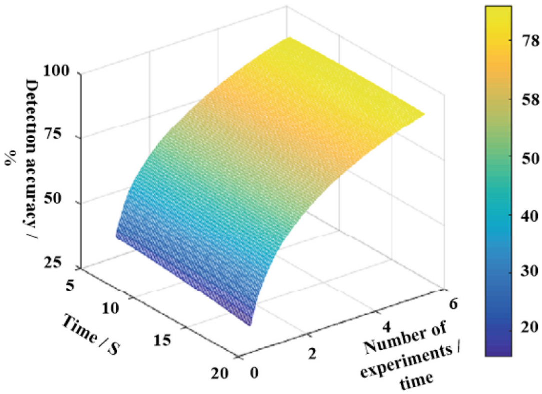


(b)Traditional 3D image feature point detection system

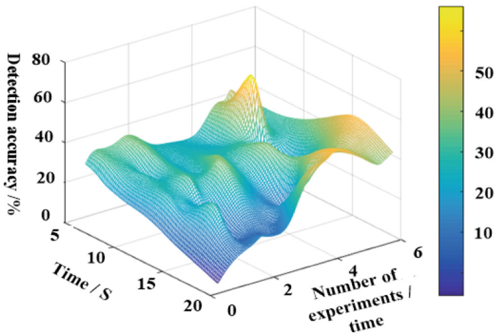
Fig. 5. Comparison of detection efficiency of 3D image feature point detection

Figure 5 shows that the high efficiency of 3D image feature point detection based on artificial intelligence is higher than that of traditional 3D image feature point detection system.

In order to further verify the effectiveness of the method in this paper, the detection accuracy of three-dimensional image feature points based on artificial intelligence and traditional three-dimensional image feature point detection system is compared and analyzed, and the comparison results are shown in Fig. 6.



(a)Detection accuracy of 3D image feature point detection system based on Artificial Intelligence



(b)Detection accuracy of traditional 3D image feature point detection system

Fig. 6. Comparison of detection accuracy of feature points in 3D image

According to Fig. 6, the 3D image feature point detection accuracy of the 3D image feature point detection system based on artificial intelligence can reach up to 95%, which is higher than that of the traditional 3D image feature point detection system.

6 Concluding Remarks

The traditional 3D image feature point detection system has the problems of low detection accuracy and long detection time, which leads to the poor detection effect of 3D image feature points. Therefore, this paper designs a 3D image feature point detection system based on artificial intelligence. Through the design of system hardware and software, the design of efficient detection system of 3D image feature points based on artificial intelligence is successfully realized. Experimental results show that the detection accuracy of the system is high, which improves the detection efficiency and detection effect, which proves that the system has good application value.

References

1. Zhang, H.: Design and implementation of artificial intelligence image detection system based on Internet of Things. Comput. Measur. Control **25**(22), 215–218 (2017)
2. Cui, Y.: Design of artificial intelligence image detection system based on Internet of Things. J. Liaoning Univ. Sci. Technol. **23**(24), 222 (2018)
3. Jin, Z., Cao, J., Zhang, Y., et al.: Novel visual and statistical image features for microblogs news verification. IEEE Trans. Multimedia **19**(3), 598–608 (2017)
4. Slave tree: Design of embedded image recognition and detection system based on ARM. Comput. Measur. Control **25**(29), 136–138 (2017)
5. Tien, N.D., Danh, P.T., Rae, B.N., et al.: Combining deep and handcrafted image features for presentation attack detection in face recognition systems using visible-light camera sensors. Sensors **18**(3), 699–702 (2018)
6. Gao, Q., Wang, J., Ma, X., et al.: CSI-based device-free wireless localization and activity recognition using radio image features. IEEE Trans. Veh. Technol. **66**(11), 10346–10356 (2017)
7. Testolin, A., Stoianov, I., Zorzi, M.: Letter perception emerges from unsupervised deep learning and recycling of natural image features. Nat. Hum. Behav. **1**(9), 657–664 (2017)
8. Eichinger, P., Alberts, E., Delbridge, C., et al.: Diffusion tensor image features predict IDH genotype in newly diagnosed WHO grade II/III gliomas. Sci. Rep. **7**(1), 13396 (2017)
9. Fu, W., Liu, S., Srivastava, G.: Optimization of big data scheduling in social networks. Entropy **21**(9), 902 (2019)
10. Jaccard, N., Szita, N., Griffin, L.D.: Trainable segmentation of phase contrast microscopy images based on local basic image features histograms. Comput. Methods Biomech. Biomed. Eng. Imaging Visualiz. **5**(5), 359–367 (2017)
11. Wan, T., Cao, J., Chen, J., et al.: Automated grading of breast cancer histopathology using cascaded ensemble with combination of multi-level image features. Neurocomputing **229**, 34–44 (2017)
12. Liu, S., Pan, Z., Cheng, X.: A novel fast fractal image compression method based on distance clustering in high dimensional sphere surface. Fractals **25**(4), 1740004 (2017)
13. Lu, Mengye, Liu, Shuai: Nucleosome positioning based on generalized relative entropy. Soft. Comput. **23**(19), 9175–9188 (2018). https://doi.org/10.1007/s00500-018-3602-2
14. Johnson, P.B., Young, L.A., Lamichhane, N., et al.: Quantitative imaging: correlating image features with the segmentation accuracy of PET based tumor contours in the lung. Radiotherapy Oncol. **123**, 257–262 (2017). S0167814017301044
15. Shuai, L., Weiling, B., Nianyin, Z., et al.: A fast fractal based compression for MRI images. IEEE Access **7**, 62412–62420 (2019)