Journal of Research in Science and Engineering (JRSE)
ISSN: 1656-1996 Volume-8, Issue-10, Octobery 2026
DOI: 10.66069/ojspub.16561010

Bionic-Eye Technology for Intelligent Weapon Equipment: Enhancing Automatic Target Recognition and Precision Aiming in Complex Environments

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Abstract: ***With the continuous advancement of science and technology, battlefields are becoming increasingly unmanned, and unmanned and intelligent weapons are proliferating. These systems include weapon platforms that automatically identify and target objects and assist in aiming and firing. However, existing automatic target recognition and aiming systems still exhibit insufficient automation, limited effective recognition rates, and inadequate aiming accuracy, which restrict the operational deployment of automated shooting weapons. The main technical difficulties are twofold. First, target recognition accuracy is sensitive to field conditions, including weather and illumination, as well as to target number and distance, and is susceptible to complex-environment interference, resulting in false or missed detections. Second, during post-recognition aiming, system performance is affected by on-site environmental conditions and target motion, leading to substantial aiming errors and ineffective automatic aiming. Consequently, there is an urgent need to develop a method and system capable of automatic object identification and precise targeting while maintaining robustness to interfering factors. To address these technical problems, this paper proposes a bionic-eye technology for intelligent weapon equipment. The proposed approach is intended to provide a technical foundation for improving the environmental adaptability, recognition reliability, and aiming precision of intelligent weapon equipment.***

Keywords: Unmanned and intelligent weapons, Bionic eye, Automatic target recognition and aiming, Intelligent weapon equipment**.**

1. Introduction

With the continuous progress of science and technology, the battlefield presents the trend of unmanned development, and unmanned and intelligent weapons emerge in endlessly, including weapon systems for automatic identification and targeting of targets with auxiliary shooting weapons. However, the automation degree, effective recognition rate and aiming accuracy of the automatic identification and aiming weapon system still fail to meet the requirements of actual combat, which seriously restricts the development of shooting weapon automation. Its main technical difficulties come from two aspects: on the one hand, the effective recognition accuracy of targets to the field environment (such as weather, light, etc.) The number of targets and the distance of targets are sensitive, and they are vulnerable to the interference of complex environment, resulting in misjudgments or missed judgments. On the other hand, in the process of target aiming after target recognition, they are affected by the environment on the spot and the action of the target, resulting in large aiming errors, which make the automatic aiming form virtual. Therefore, there is an urgent need to develop a method and system that can automatically identify and precisely target without interference from other factors. In this paper, a technology of Bionic Eye in Intelligent Weapon Equipment has been put forward to solve the above technical problems.

2. Overview of the Content

This paper provides a method of automatic target recognition and accurate targeting without interference from other factors such as environment to solve the above technical problems.

2.1 AI Precise Aiming Method

The paper provides an AI precise aiming method, which includes: collecting the image information of the visual field environment and establishing the coordinate system; analyzing and processing the image information to find the target and record the coordinate parameters of the target point and the distance parameters of the target; judging the aiming target and carrying out the aiming process. First aiming; instantaneous aiming laser is fired at the target and simulated trajectory is calculated; if the instantaneous aiming laser hits the target, the second aiming is carried out according to the coordinate parameters of the target and ready to shoot; if the instantaneous aiming laser does not hit the target, the image is reanalyzed and processed. The information discovers the target and records the coordinate parameters of the new target points, and calculates the coordinate parameters of the target points according to the coordinates of the target points obtained twice to obtain the coordinate parameters of the target points needed for aiming. The instantaneous aiming laser is fired to the target again and the simulated trajectory is calculated. If the instantaneous aiming laser hits the target, the coordinate parameters of the target points are calculated according to the coordinates of the target points obtained twice. The coordinate parameters of the aiming point position are re-aimed and ready to shoot. If the instantaneous aiming laser does not hit the target, the above steps are re-carried out.

In general, in the process of collecting the image information of the environment in the field of vision, specific image collectors are selected according to the ambient illumination. For example, when the illumination is lower than 0.1

Lux/F1.2, the IR image signal acquisition card is preferred for image information acquisition, while when the illumination is not lower than 0.1 Lux/F1.2, the RGB image information is preferred. No. 1 acquisition card.

In This paper, during the AI precise aiming process, the state of the image information needs to be judged before the image information is analyzed and processed. The state includes the focus state, exposure state, backlight state and the display effect state of the target contour.

In a possible design, if the state includes the focus state, exposure state, backlight state of the image and the display effect state of the target contour are not good, in order to improve the accuracy of recognition, the State mentioned above is adjusted before the next step of analysis information, so that the State mentioned above of the image reaches the optimum level and then proceeds. Line analysis and processing.

Usually, after collecting the image information in the field of vision, there will often be multiple targets. Therefore, the number of targets is judged in the process of analyzing and processing the image information to find targets. If the number of targets is more than 1, the distance and moving speed of multiple targets are calculated. The hit probability is ranked as a priority, and the targets are aimed one by one according to the ranking order.

In This paper, the distance parameters of the acquired target are measured by two cameras. The principle is that the camera calibration of perspective projection matrix can be calculated when the internal and external parameters of the camera are known. According to the relationship between the image coordinate system and the world coordinate system, the distance information can be obtained. In binocular vision, the camera captures two images of the same object at different angles at the same time. Its three-dimensional coordinates in the world coordinates can be calculated from the position information of the same point in the two images.

2.2 AI Precise Aiming System

The paper also provides an AI precise aiming system, which includes: image information acquisition module, which is configured to collect the image information of the visual field environment and generate the original image information data for target recognition; image information processing and analysis module, which is configured to divide the image information. Analysis and processing, including the establishment of coordinate system in the image information, the identification of the target to be aimed from the image information, the recording of the coordinates of the target location and the acquisition of the distance parameters of the target; the instantaneous aiming laser transmitting module, which is configured to emit instantaneous aiming laser to the target; and the real-life information acquisition module, which is configured to emit instantaneous aiming laser to the target. In order to sense the external environment conditions and the target orientation information, to determine whether the recorded target point coordinates are consistent with the actual target point coordinates, and to collect the landing point coordinates of the instantaneous aiming laser.

2.3 Image Information Acquisition Module

In This paper, the image information acquisition module includes a RGB image signal acquisition card, an IR image signal acquisition card and a MEMS image acquisition module. The RGB image signal acquisition card and an IR image signal acquisition card are used for acquisition, compilation, storage and transmission of environmental image information. The MEMS image acquisition module is used for acquisition, compilation, storage and transmission of environmental image information. The image information transmitted by the RGB image signal acquisition card or the IR image signal acquisition card is collected, and the state of the image information is confirmed. Then the image information is transmitted to the image information processing and analysis module.

In This paper, the image information processing and analysis module includes a CPU+GPU processor for processing and analyzing the image information transmitted by the image information acquisition module. The CPU+GPU processor identifies the target of the image information and analyses the reference state of the target and calculates the simulated trajectory.

In This paper, the practical information acquisition module includes a laser calibrator and an environmental analysis module, which irradiates the target by transmitting instantaneous laser. The environmental analysis module can acquire shooting in the external environment including wind speed, rainfall, humidity, temperature, atmospheric pressure and air dust content. The data are transmitted to the CPU+GPU processor to analyze and calculate the simulation trajectory.

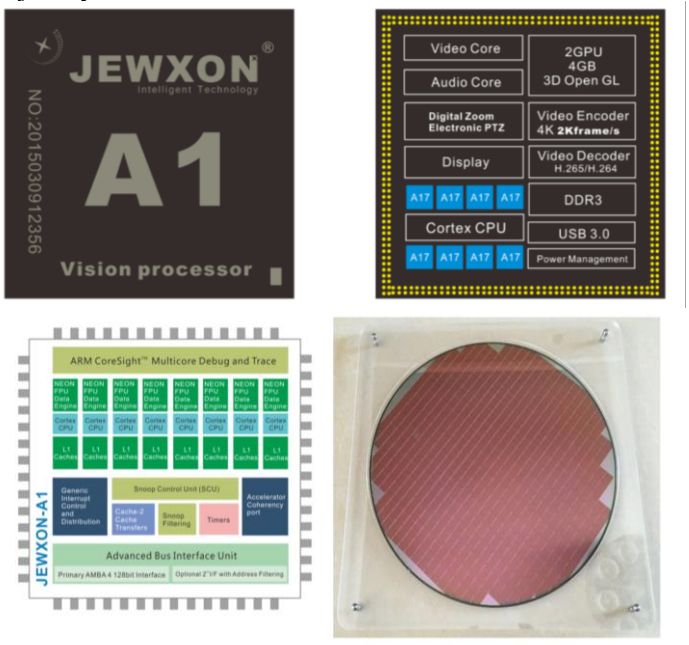


Figure 1: Bionic eye chip core architecture and wafer products

In This paper, the image information acquisition module also includes a DSP image processor and a supplementary light device. When the MEMS image acquisition module judges the difficulty of recognition caused by the exposure and backlighting of the image information, the supplementary light device is used to supplement the light and focus the image information through the DSP image processor. Distance, sharpening degree adjusted to the best effect state.

Compared with the existing technology, the beneficial effects of this paper are as follows: by using the AI precise aiming method and system provided by this paper, the target can be recognized and aimed with high accuracy, and the shooting sequence can be automatically calculated, especially through instantaneous aiming laser to simulate projectile. Through this verification step, the accuracy of automatic shooting in the existing technology can be greatly improved, thus greatly improving the practicability of the paper. In addition, the paper also has a high degree of automation. By correcting the collected image information, the accuracy of image identification can be improved, and the requirement of all-weather automatic aiming and shooting can be met.

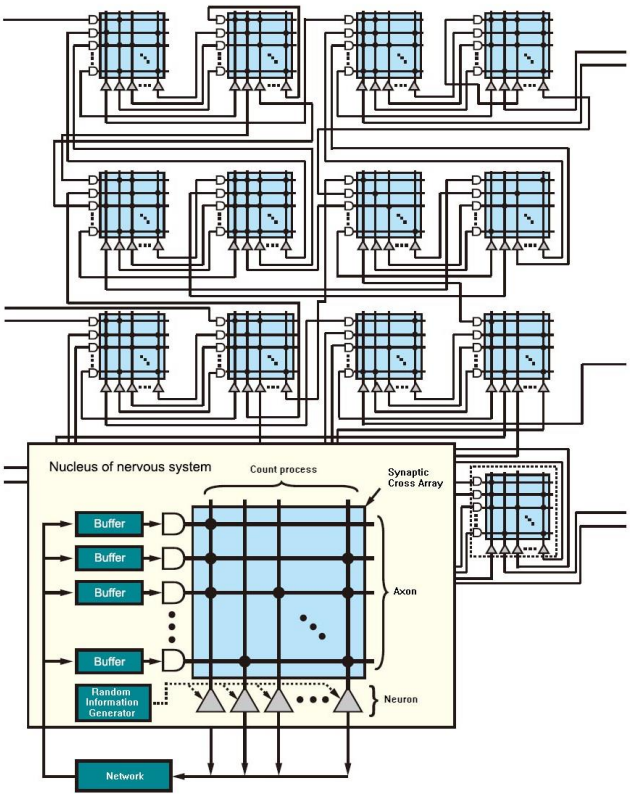


Figure 2: Internal Neural Network Architecture of Bionic Eye Chip

3. Technology Roadmap

In order to better understand the technical scheme for those in the technical field, the technical scheme in the embodiments will be described clearly and completely in connection with the drawings in the embodiments. The embodiment provides a method and system for automatic target recognition and precise targeting without interference from other factors such as environment. Figure 3 shows the flow chart of AI precise aiming method in the embodiment.

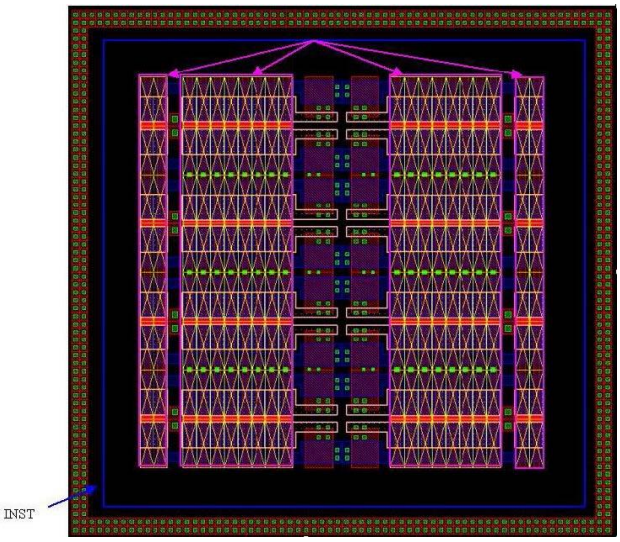


Figure 3: Chip fabrication process

This paper provides an AI precise aiming method, which can be shown in the Figure 4.

The image information of the visual field environment is collected and the coordinate system is established.

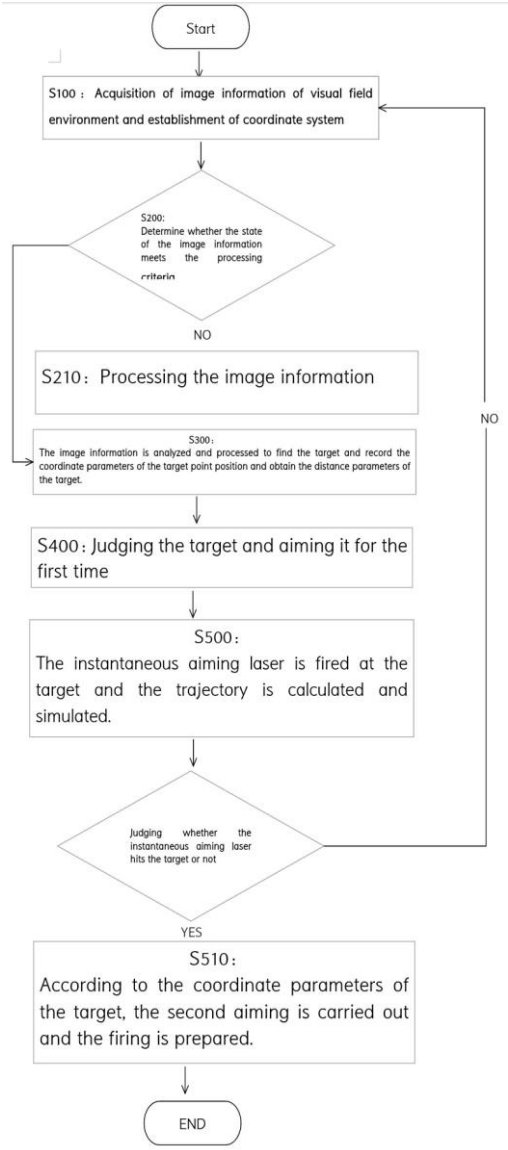


Figure 4: Flow chart of AI precise aiming method

In a preferred embodiment, two cameras are used for image information acquisition, which is to establish a corresponding relationship between three-dimensional world coordinates and two-dimensional image coordinates. The system uses two cameras for image acquisition. The distance between two cameras (i.e. baseline distance) is set. The calibration object placed in front of the camera is captured by the camera at the same time. The distance of the target can be calculated by the angle difference between the images captured by the two cameras. At the same time, the collected image information is grayed to make it a black-and-white image that can be recognized by computer.

3.1 Determines Whether the State of the Image Information Conforms to the Processing Criteria.

If it meets the processing standard, the next step will be taken. If it does not meet the processing standard, the processing standard will be 210. The processing standard here includes the focus state, exposure state, backlight state and whether the target contour display effect state meets the processing requirements.

Name	Setting	Input	Output
input		$H \times W \times 3$	$H \times W \times 3$
conv0	3×3 LReLU	$H \times W \times 3$	$H \times W \times 64$
resblock0	$\begin{bmatrix} 3 \times 3 \\ 3 \times 3 \end{bmatrix}$	$H \times W \times 64$	$H \times W \times 64$
Residual ASPP Module			
resASPP 1_a	$\begin{bmatrix} 3 \times 3 & 3 \times 3 & 3 \times 3 \\ \text{LReLU}, & \text{LReLU}, & \text{LReLU} \\ \text{dila=1} & \text{dila=4} & \text{dila=8} \\ & 1 \times 1 & \end{bmatrix} \times 3$	$H \times W \times 64$	$H \times W \times 64$
resblock 1_a	$\begin{bmatrix} 3 \times 3 \\ 3 \times 3 \end{bmatrix}$	$H \times W \times 64$	$H \times W \times 64$
resASPP 1_b	$\begin{bmatrix} 3 \times 3 & 3 \times 3 & 3 \times 3 \\ \text{LReLU}, & \text{LReLU}, & \text{LReLU} \\ \text{dila=1} & \text{dila=4} & \text{dila=8} \\ & 1 \times 1 & \end{bmatrix} \times 3$	$H \times W \times 64$	$H \times W \times 64$
resblock 1_b	$\begin{bmatrix} 3 \times 3 \\ 3 \times 3 \end{bmatrix}$	$H \times W \times 64$	$H \times W \times 64$
Parallax-Attention Module			
resblock2	$\begin{bmatrix} 3 \times 3 \\ 3 \times 3 \end{bmatrix}$	$H \times W \times 64$	$H \times W \times 64$
conv2_a	1×1	$H \times W \times 64$	$H \times W \times 64$
conv2_b	1×1, reshape	$H \times W \times 64$	$H \times 64 \times W$
conv2_c	1×1	$H \times W \times 64$	$H \times W \times 64$
att_map	conv2_a $\otimes$ conv2_b	$H \times W \times 64$ $H \times 64 \times W$	$H \times W \times W$
mult	att_map $\otimes$ conv2_c	$H \times W \times W$ $H \times W \times 64$	$H \times W \times 64$
fusion	1×1	$H \times W \times 129$	$H \times W \times 64$
CNN			
resblock3 $\times 4$	$\begin{bmatrix} 3 \times 3 \\ 3 \times 3 \end{bmatrix}$	$H \times W \times 64$	$H \times W \times 64$
sub-pixel	1×1, pixel shuffle	$H \times W \times 64$	$sH \times sW \times 64$
conv3_b	3×3	$sH \times sW \times 64$	$sH \times sW \times 3$

Figure 5: Partial Neural Network Algorithmic Module

The image information is processed if it does not meet the processing criteria in Figure 5.

In a preferred embodiment of This paper, in order to improve the processing accuracy of image information, it is necessary to pre-process the image information before analyzing it, including the focus state, exposure state, backlight state and target contour display effect state of the image, if they do not meet certain standards. The image state is processed by means of supplementary light processing, focal length adjustment, image visualization and sharpening through DSP image processor and infrared transmitter.

The image information is analyzed and processed to discover the target and record the coordinate parameters of the target point position as well as the distance parameters of the target. Specifically, in the embodiment, the implementation of this step can adopt a variety of currently mature technologies, such as image acquisition by two or more cameras. Because of the known distance between cameras, the image acquired by the camera can be compared and calibrated, and at the same time, more and more cameras can be used. The disparity map is formed by superimposing the images. The features of the images are analyzed to find the target. Finally, the coordinates and distances of the target are obtained. In this process, if the number of targets is more than 1, the hitting probability should be calculated according to the moving speed and distance of the target, and the firing sequence should be arranged according to the hitting probability, or the firing sequence can be selected manually by the operator. In the present embodiment, it is also possible to verify whether the target is an organism by infrared radiation, thus avoiding identifying the non-organism as a target.

3.2 Judge the Target and Aim It for the First Time.

In a possible design, the aiming device is placed on a weapon base that can be adjusted, such as an automatic platform, so that the coordinates and distances of the target can be obtained, and the automatic aiming can be carried out after calculating the shooting formula.

3.3 The Instantaneous Aiming Laser Is Fired at the Target and the Trajectory Is Calculated and Simulated.

In order to verify the accuracy of the above steps, in the embodiment, the method of launching laser to target is selected as the priority, and the method of launching instantaneous aiming laser in actual combat has the advantages of strong concealment. According to the two results obtained in the first 500, the following steps are carried out respectively:

If the instantaneous aiming laser hits the target, the second aiming is carried out according to the coordinate parameters of the target, and the shooting is prepared.

If the instantaneous aiming laser hits the target, it proves that the result of the first aiming is completely correct, so the shooting will also hit the target.

If the instantaneous aiming laser fails to hit the target, then the target 200 is re-executed.

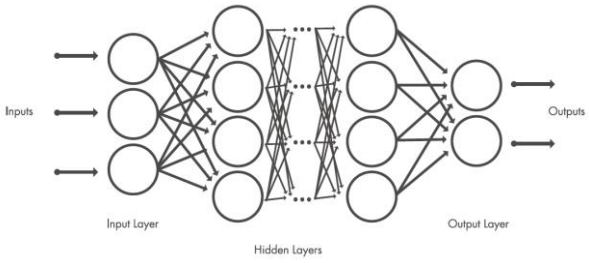


Figure 6: Neuron Structure of Convolutional Neural Network

Thus, the core technology in the embodiment is to verify the result of automatic aiming by transmitting instantaneous

aiming laser. It is imperceptible to irradiate the target with instantaneous aiming laser. Once the instantaneous aiming laser can irradiate the target effectively by the target parameters acquired by automatic aiming. It means that the probability of successful target hit by live ammunition is almost 100%, which greatly improves the probability of successful automatic aiming shooting.

In addition, based on the above-mentioned AI precise aiming method, an AI precise aiming system is also disclosed in the paper embodiment. As shown in Figure 7, the structure schematic diagram of AI precise aiming system in the paper embodiment is shown in Figure 7, which includes: for collecting image information of the visual field environment and generating image information for use in the visual field. An image information acquisition module for identifying the original image information of the target; used for analyzing and processing the image information, including establishing a coordinate system in the image information, identifying the target to be aimed from the image information, recording the

coordinates of the point of the target and obtaining the image of the distance parameter of the target. Information Processing and Analysis Module; Instantaneous Aiming Laser Emission Module for launching Instantaneous Aiming Laser for Target; Sensing Environmental Conditions and Target Azimuth Information to determine whether the recorded target point coordinates are consistent with the actual target point coordinates and to collect the landing point coordinates of the instantaneous aiming laser. Reality information acquisition module.

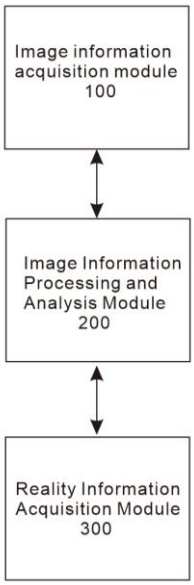


Figure 7: The structure schematic diagram of AI precise aiming system

3.4 The Image Information Acquisition Module

Figure 8 shows that: the image information acquisition module 100 can include RGB image signal acquisition card 110, IR image signal acquisition card 120, and MEMS image acquisition module 130. The RGB image signal acquisition card 110 and IR image signal acquisition card 120 are used for acquiring, compiling, storing and storing environmental image information. Transmission, the MEMS image acquisition module 130 is used to collect image information transmitted by the RGB image signal acquisition card 110 or the IR image signal acquisition card 120, confirm the state of the image information, and then transmit the image information to the image information processing and analysis module 200. Usually, in the process of collecting image information of the environment in the field of vision, a specific image collector is selected according to the ambient illumination. For example, when the illumination is lower than 0.1 Lux/F1.2, the IR image signal acquisition card 120 is selected first for image information acquisition, and the IR image signal acquisition card 120 is good for image information acquisition. It is not only difficult to detect the target in low illumination, but also because the target is an organism with strong infrared radiation. Using these infrared radiation to capture the target can greatly reduce the target's misrecognition rate, and RGB image signal acquisition card 110 is preferred when the illumination is not less than 0.1 Lux/F1.2. In addition, the image information acquisition module 100 also includes a DSP image processor 140 and a supplementary optical device 150 including an infrared transmitter. When the MEMS image acquisition module 130 judges that identification difficulties are caused by exposure or backlighting of the image information, it can supplement light through the supplementary optical device 150 and through the DSP. The image processor 140 adjusts the focal length and sharpening degree of the image information to the best effect state, so as to facilitate subsequent analysis and processing.

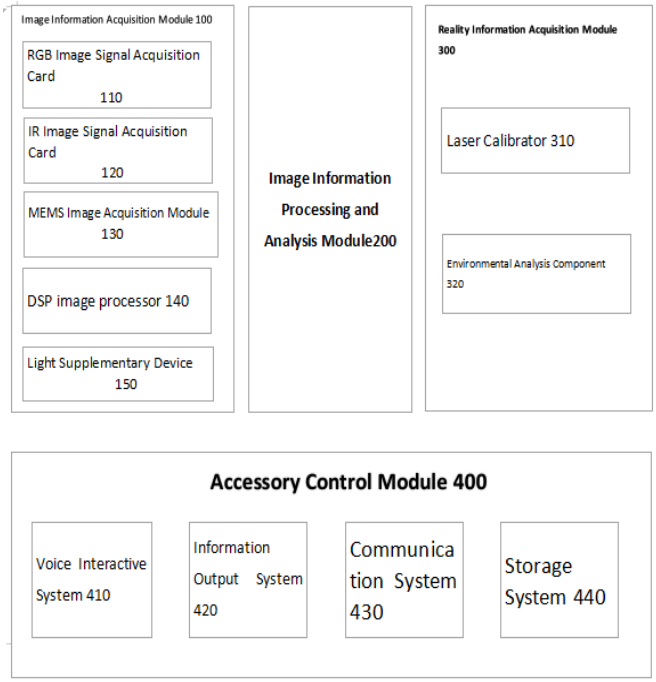


Figure 8: The content of image information acquisition module 100

3.5 The Image Information Processing and Analysis Module 200

Further, the image information processing and analysis module 200 includes a CPU+GPU processor for processing and analyzing the image information transmitted by the image information acquisition module 100. The CPU+GPU processor identifies the target of the image information and analyses the reference state of the target and calculates the simulated trajectory.

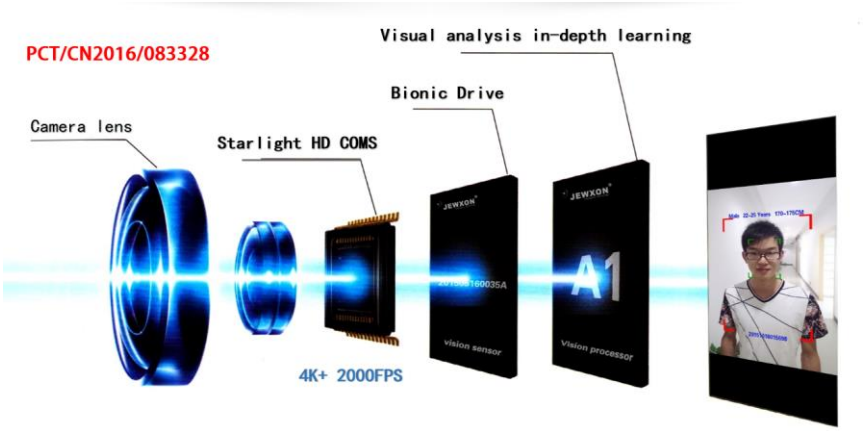


Figure 9: Principle of Fully Automatic Realization of Bionic Eye

In the embodiment, the real-life information acquisition module 300 includes a laser calibration 310 and an environmental analysis module 320. The laser calibration device irradiates the target by transmitting an instantaneous laser. The environmental analysis module can acquire wind speed, rainfall, humidity, temperature, atmospheric pressure and air in the external environment. The shooting data of dust content are transmitted to the CPU+GPU processor to analyze and calculate the simulation trajectory.

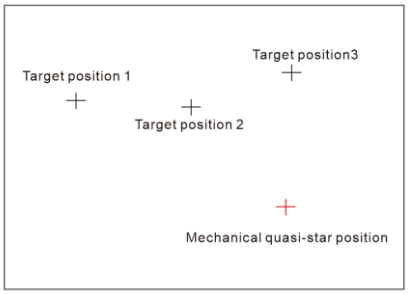


Figure 10: The terminal interface when multiple targets

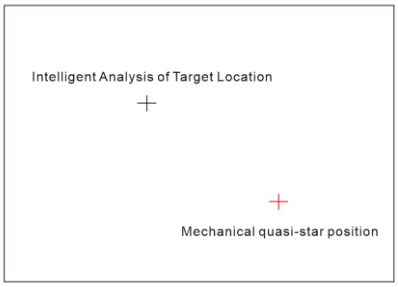


Figure 11: The display schematic diagram of the terminal interface

On the basis of the present embodiment, an additional control module 400 can also be improved, which can include other end control systems such as voice interaction system 410, information output system 420, communication system 430 and storage system 440, in which the role of the voice interaction system 410 is attached. Near users can control or issue commands to the system through voice to achieve the device and personnel to perform tasks together; the information output system 420 can transmit the acquired image information to the command or user terminal in the form of wired or wireless, such as the operator's display device, specifically. Referring to Figure 10 and 11, the display schematic diagram of the terminal interface when multiple targets are shown in Figure 10, and 11, the display schematic diagram of the terminal interface when intelligently analyzing targets are shown in Figure 11. During the specific implementation, especially when multiple targets need to be fired, the embodiment can be based on the distance and moving speed of the targets. The degree calculates the hit probability, arranges the shooting order according to the size of the hit probability, or actively chooses the shooting order through the operator. The specific selection can take many forms. The more common way is to select manually through the touch screen. This operation is more accurate and fast, and touch at the same time. The touch screen can also display the specific action of the device in the process of automatic aiming and shooting in real time. After the command or terminal acquires relevant information, the communication system 430 can establish a connection with the command or terminal, and perform tasks according to the command or terminal's command in special cases. The storage system 440 can store important data in the whole process of aiming and shooting to prevent it from being in the information output system. Data loss occurs when the system fails.

4. Conclusion

Compared with the existing technology, this paper can achieve high-precision target recognition and aiming by using the AI precise aiming method and system provided by the embodiment of this paper. It can also automatically calculate the importance of the target and select the shooting sequence. Especially, it can simulate the trajectory by instantaneous aiming laser. The range improves the hit rate of automatic shooting in the prior art, thus greatly improving the practicability of the embodiment of this paper. In addition, the implementation of this paper also has a high degree of automation. By correcting the collected image information, the identification accuracy of the image can be improved, and the requirement of all-weather automatic aiming and shooting can be satisfied.

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