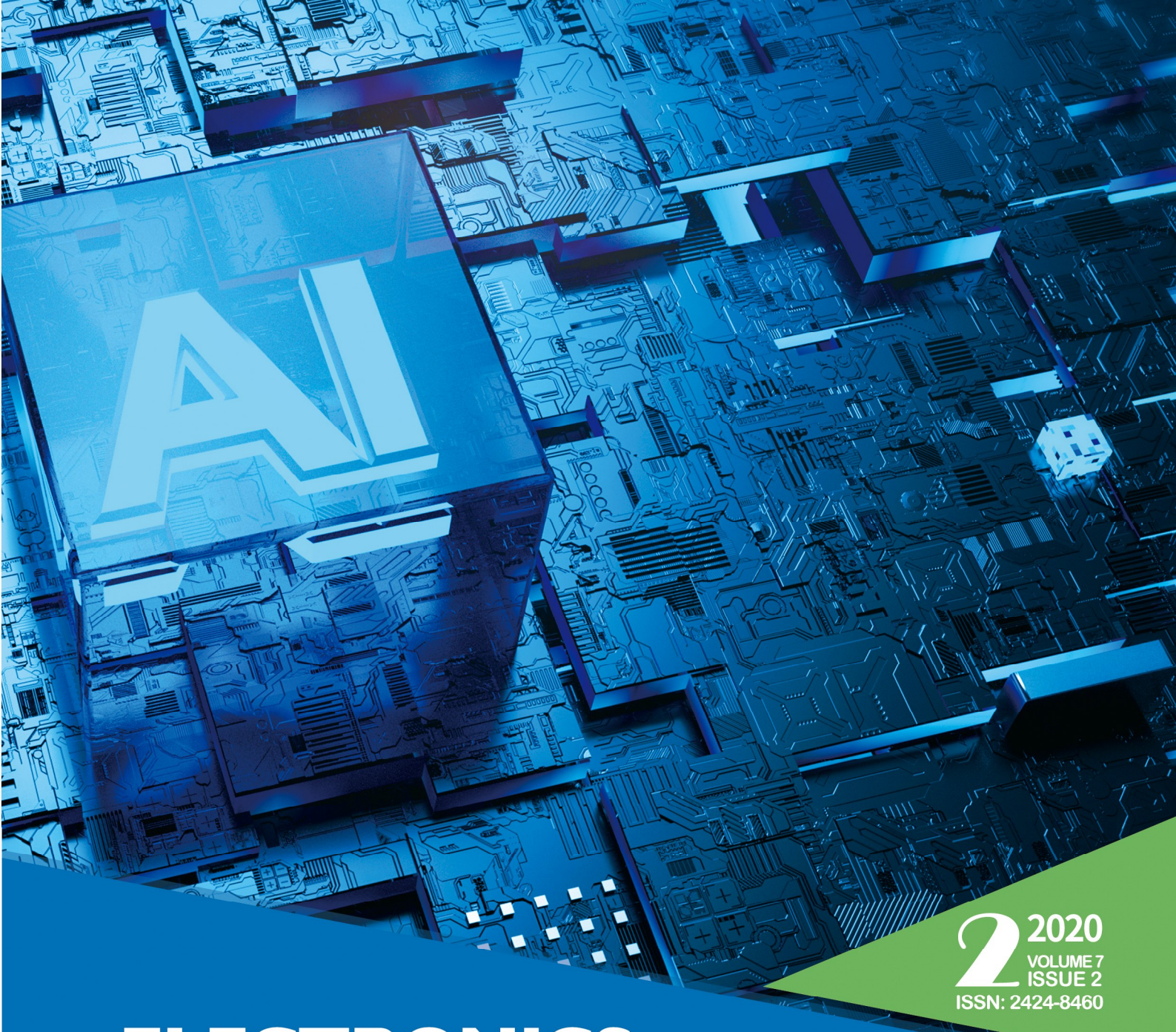

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Original Articles

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ORIGINAL ARTICLE

Application of Polarized Light in UAV Navigation

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Abstract: This paper analyzes the advantages and disadvantages of UAV from the perspective of polarization. Inspired by the LCD and the improved gray-scale difference method of auto focus, it realizes the precise navigation and positioning of UAV and improves the image quality in three aspects: improving the color saturation, enhancing the focus function and enhancing the sensitivity of image transformation.

Keywords: UAV; Polarization; Accuracy

With the development of the times and Internet technology, intelligent navigation technology is the most important technology in the field of UAV. Through the real-time monitoring and precise calculation of the target position and current motion state, the calculation results are synchronously transmitted to the positioning driving system, and then the direction coordinate parameters and other indicators of the UAV are changed in real time according to the changes of the target, so as to guide the correct routes and accurately control the UAV to avoid obstacles.

1. General principles of UAV navigation

1.1 UAV navigation category

At present, UAV navigation system develops rapidly. Not only a single navigation mode, satellite navigation, inertial navigation, geomagnetic navigation, terrain aided navigation and other navigation instruments appear with the progress of science and technology and are applied to our daily life.

1.2 Composition and principle of UAV navigation

General civil UAV navigation usually uses satellite navigation. Taking the GPS positioning system of the United States as an example, it is composed of 24 satellites, which are distributed in six orbital planes. Four satellites are distributed in each orbital plane, achieving the effect that more than four satellites appear in our sky at any time and at any place (including the South Pole and the North pole). GPS navigation uses the principle of triangle positioning through the speed of signal transmission, time and the display data of the signal receiver to calculate the index data to achieve positioning. In addition to its continuity and accuracy, its biggest feature is real-time. However, civil GPS uses C / A code, which has low accuracy and weak transmitter, making it vulnerable to external interference.

2. Application of polarization in UAV navigation

2.1 Polarization and UAV application in military

In military, in order to detect the enemy's hidden equipments or dangerous layout, the requirements for image quality are very high. Ordinary UAV navigation

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sensors[1] can not accurately identify the contour, shape, material quality and other factors, which has a negative impact on the war. The United States has successfully developed an infrared focal plane array imager[2] with the ability of spectral coordination and polarization sensitivity. It can detect the target accurately in a disorderly and scattered environment with different wavelengths.

2.2 The application of polarization and UAV in life

In life, photography, express delivery[3] and traffic monitoring are the three giants of UAV navigation. The small UAVs has been widely used in photography industry, which pays more and more attention to the overall layout and exquisite editing for aerial photography, which requires a high quality of the picture. The express industry is starting to replace human couriers with drones to improve efficiency. With more and more complex road conditions and more and more vehicles, it is difficult to monitor the traffic conditions of the city as a whole with only fixed cameras[4] and traffic police enforcement. The aviation monitoring of UAV plays an important role in the traffic road monitoring.

3. Advantages and disadvantages of integration of polarization and UAV navigation

3.1 High definition of image quality

Because the polarizer filters out the light whose vibration direction is different from that of the polarizer, only the light whose vibration direction is the same as that of the polarizer is allowed to pass through. It greatly reduces the influence of the polarized light on the image quality, reduces the light spot and enhances the definition of the image outline. Its principle is that polarizer filters the light, and another polarizer filters the missing light again to improve the accuracy.

3.2 Relatively low color saturation

At present, due to the immature technology, UAV still has low color saturation. On the one hand, the color saturation has a very direct relationship with the light exposure on the surface of the object. In the dark environment, the color saturation is lower than that in the strong light. The outdoor lighting environment is very complex. The changing of cloudy and sunny days, the different terrains in different areas have an impact on it. The sun light intensity is weak in cloudy days, the color saturation is low, and the picture is unstable. On the other hand, it is because the display screen is not completely transparent and closed, the contrast is not ideal. For UAVs with high accuracy requirements, it not only affects the resolution of image quality, but also the judgment of information processing devices. Although the use of polarizers can reduce contrast and improve color saturation, more or less, it still can not reach the ideal state.

3.3 Weak color conversion sensitivity

In fact, the appearance of blocking frame and serial frame is due to the low response speed and the lack of steep electro-optic characteristics of the display. The response time of traditional display screen to light is slow. Generally speaking, the picture of the current frame has ended, but the light of the display screen to the previous frame has not yet finished, and the light of the next frame then hits the display screen, resulting in two pictures appearing on the same display screen. The phenomenon of frame blocking and series frames appears, and the sensitivity of picture conversion is low. Moreover, the light filtering effect of the light transmitting device is not good, which causes the redundant pixels to pass through the color filter screen, resulting in confusion in the picture.

3.4 Weak perception and obstacle avoidance ability of UAV

So far, the perception system of civil UAV is not perfect, and is greatly affected by the external environment. Although the emergence of inertial system navigation [5] has greatly improved the defect of UAV perception system, due to the high accuracy requirements of inertial navigation system for acceleration needle and gyroscope, the manufacturing process is complex, the cost is high, and it is easy to be worn. The error will accumulate over time, so it can not be widely used in the daily use of UAV. From another point of view, inertial navigation is easy to diverge. It needs to be corrected by other navigation systems, otherwise it will produce deviation. Once the perception system is not sensitive,

there will be corresponding deviation for information transmission.

4. The improvement and effect of UAV

4.1 Enhance color saturation

Because each pixel on the display screen is composed of three subpixels: red (R), green (G), and blue (B), when the backlight of the display passes through the color filter, it will produce color display with the RGB color resistance on the color filter. The higher the purity of the color resistance, the higher the color saturation, and the clearer the color contrast of the image. For the same type of color resistance, the thicker the thickness, the higher the color saturation. If we improve the type, purity and thickness of the color resistor in the UAV, its color saturation[6] will be improved, and we can make the obvious contrast to improve the image quality and enhance the detail differentiation of the captured image.

4.2 Enhanced focus

The function of UAV shooting not only needs to make the image quality clear, but also needs to automatically capture and enlarge the local suspicious object images. If the UAV is equipped with automatic focusing equipment, it is more advantageous for image capture. Focusing, in essence, is the principle of convex lens imaging. For an infinite scene, the imaging position is at the focus, while for a close-up object, the imaging position is in front of the focus. Auto focus is actually to adjust the image distance according to the distance data driving lens, so as to achieve the effect of auto focus. When focusing, the system needs to detect whether the image is clear at this time. Generally, the gray difference method[7], which uses the sum of the absolute values of the adjacent pixel differences of the image as the focus evaluation function is used.

$$F(x,y) = \sum_{x,y} \{|f(x,y) - f(x,y-1)| + |f(x,y) - f(x-1,y)|\} \quad (1)$$

It is the improved gray difference method [8]

$$F(x,y) = \sum_{x,y} \{(f(x,y) - f(x,y-1))^2 + (f(x,y) - f(x-1,y))^2\} \quad (2)$$

The evaluation of focusing effect is more accurate and more suitable for hardware.

4.3 Improve the sensitivity of picture conversion

Optical waveguide effect: the polarization direction of the polarized light of the incoming ray rotates synchronously along the molecular helix structure during transmission. Therefore, when the linearly polarized light incident perpendicular or parallel to the long axis of the molecule propagates in the liquid crystal box, the plane of polarization rotates synchronously along the molecular twist. It is still linearly polarized light after exiting the box, and its polarization direction is determined by the molecular twist angle[9].

Led by the optical properties of liquid crystal display: the optical anisotropy of liquid crystal into a single pump changes the polarization state or polarization direction of the incident light. When the incident light passes through the polarizer, it becomes a linearly polarized light. Under the action of the external electric field, it is deflected by 90 °; the polarizer and another polarizer are perpendicular to each other at the exit, and the polarized light rotating by 90 ° can pass through. At this time, the picture shows light transmission state. When the electric field is greater than a certain value, the long axis of the liquid crystal molecules are arranged along the electric field direction, so the incident linearly polarized light can not rotate 90 ° to through the polarizer, and the dark state appears at this time[10]. The principle is further improved. When the twist angle is increased to 180 ° ~ 270 °, the response speed of electro-optic characteristics is faster, so as to enhance the sensitivity of image conversion.

5. Summary

From the perspective of polarization, this paper describes the influence of clarity, color conversion sensitivity, color saturation, obstacle avoidance ability and information interpretation ability on the UAV's precise navigation. The inspiration comes from the LCD and the improved gray-scale difference method of auto focus in order to clarify the improved concept of achieving accurate navigation and positioning and

improve the quality of the image. This paper focuses on three aspects: improving color saturation, focusing function and improving image conversion sensitivity.

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ORIGINAL ARTICLE

Studies on Computer Intelligent Image Recognition Algorithm and Technology

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Abstract: With the rising level of economic development in China year by year, there have been obvious technological advances in many fields of science and technology, including the computer field. Relevant Chinese ministries attach importance to computer technology. The technology has been updating and developing all the time while researchers in the computer field are also constantly improving their researches on the intelligent technology in order to study and explore more new things. One can better be recognized with the current computer intelligent technology, even in an environment that is difficult to identify. In this article, the algorithm and application of computer image recognition technology is studied and analyzed to lay a theoretical foundation for its further development and application.

Keywords: Image Recognition Technology; Algorithms; Computer Technology

As far as the current development is concerned, the image recognition technology has been widely used and it is not limited to scientific research. For example, image recognition technology is applied when the police simulate the facial features of criminal suspects to draw simulated images during investigation. It is common to use carriers when applying the image recognition technology to ensure its successful working, which means it is not advisable to use this technology without the carrier. Currently, most common carriers are embedded terminal equipments, personal computers, smart mobile phones and so on, which have a positive impact on the technologies of fingerprint identification, facial identification, etc. It is of great practical significance for both society and individuals to carry out in-depth research and development that can be scientifically used.

1. Studies on computer intelligent image recognition algorithm

Image recognition is a relatively important category in artificial intelligence technology. It can be used to recognize different targets or objects. In current researches, two most common algorithms are *Hu* invariant moments and *D-S* evidential reasoning, which are discussed as follows.

1.1 Hu moment invariants

Hu invariant moments is the algorithm that appeared and was applied earlier in intelligent image recognition technologies. It appeared around 1960. M. K. Hu first proposed that the normalized center distance in low order in the image should be combined into 7 variables[1], as follows:

This $f(x,y)$ graphical moment is defined as a representation of a two-dimensional digital image:

$$m_{pq} = \sum_x \sum_y x^p y^q f(x,y), (p,q = 0,1,2,L) \quad (1)$$

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Meanwhile, the center distance of (p+q) is defined as follows:

$$\mu_{pq} = \sum_{x}\sum_{y}(x-x_0)^p(y-y_0)^q f(x,y) \tag{2}$$

among which, $x_0 = \frac{m_{10}}{m_{00}}\ y_0 = \frac{m_{01}}{m_{00}}$

For two-dimensional digital graphics, the centroid coordinate is (x_0, y_0), among which x_0 refers to the centroid of a grayscale image in the horizontal direction. Relatively, y_0 refers to the centroid of a grayscale image the vertical direction. The normalized center distance of (p+q) is defined as follows:

$$\eta_{\mathrm{pq}} = \frac{\mu_{pq}}{\mu_{00}^{r}} \tag{3}$$

among which $r = (p+q+2)/2$, $p+q = 2,3,L$.

1.2 D-S evidence reasoning

Image recognition technology belongs to the category of multi-source information processing. Data fusion in similar information processing technologies is a relatively late-model and common technology. *D-S* evidence reasoning is the most major research approach which relies on non-empty sets, θ. θ is also known as discrimination framework. This framework can describe the sets of elements in all the constituent hypothesis spaces. Its requirement for elements is to ensure mutual exclusion. Formed from θ subset, power set is usually described using 2^{θ}, and trusted assignment function is defined for power sets[2].

Among $m(A) \to [0,1]$, A mainly describes random subsets in the framework, and $m(A)$ refers to how much is the evidence supports proposition A. Therefore, it is necessary to ensure that $m(A)$ meets the following conditions:

$$m(\phi) = 0 \quad \sum_{A \subset 2^{\theta}} m(A) = 1$$

The total trust generated for A can be described by $Bel(A)$. The trusted function is defined as follows:

$$Bel(A) = \sum_{B \subset A} m(B)$$

With the usage of appropriate combination rules, two or more confidence functions can be obtained, and new confidence functions can be defined by using orthogonal sums.

2. Researches of computer intelligent image recognition technology

Based on computer system, intelligent image recognition is a critical field in the development of artificial intelligence technology, which provides an effective way for image recognition. Overall, under the background of such rapid development and progress made in science and technology, the basic characteristics of intelligent image recognition and its main applications are discussed as follows.

2.1 Basic characteristics

Generally, image recognition system analyzes images with the support of computer. It converts them effectively into digital information content, ensuring accurate recognition at the same time. In order to considerably improve its basic performance, operators need to define image features according to spatial mapping. Image recognition technology is of much technical nature. Conventional comprehensive performance is presented in aspects of overall analysis ability of data, strengthening internal coordination of the system, the image analysis quality level, and *et al*[3].

Referring to its basic characteristics, the technology is considered to have the following advantages:

Firstly, the technology can carry a relatively rich amount of information. After being processed by the computer, the image is converted into two-dimensional information. The continuously increased two-dimensional information may slow down its running speed during the process of usage of the computer. If the configuration is low, the computer system may crash and lead to a declining performance. However, image recognition can be completed by referring to the image transmission when the intelligent recognition technology is used for imaging, so the information load is relatively large.

Secondly, the technology is of high accuracy. For the traditional image processing technology, in most cases, analog images are converted into digital images. In this process, merely two-dimensional combinations can be obtained. The pixels is not higher than 32 bits, and it cannot be handled properly beyond 32 bits[4]. However, under the intelligent recognition technology, more accurate image information can be obtained to

meet the needs of different audiences through different image accuracies. Intelligent recognition technology can properly handle the relationship between images and information, and it can store image information completely to prevent image loss. In addition, the technology can restore images in almost all cases.

Thirdly, there is a more significant correlation. In the process of recognizing images with the aid of computer systems, specific analysis and exploration must be carried out for different images, and the images should be compressed appropriately to obtain and classify information related to the images, so that higher pixels can be generally allocated. For 3D images, it is difficult to obtain 3D geometric images when inputting. It is required to re-measure images with hypothesis based on experience. In intelligent recognition technology, however, 3D objects can be directly displayed and guided to prevent recognition problems[5].

Fourthly, high degree of flexibility. In the process of processing images, intelligent recognition technology can enlarge and recognize images anytime and anywhere, such as large-area celestial body schematic diagram and fine cell schematic diagram, etc. By means of combination of nonlinear and linear, information completeness can be enhanced. Detailed combination can be completed by computer after images are compiled. It is flexibility, and the definition of the image is ideal as well.

2.2 Main applications

With the widely application of computer technology, it has positive significance in many fields, especially in image recognition, which has been generally recognized because of its strong performance. There are many derivatives with significant advantages emerged as the times require, which changed the way people live in daily life. Besides, some micro or macro things are also possible to be identified, the most representative of which is the traffic management system in daily life. Through comprehensive analysis with the help of image technology and vehicle information, data of vehicles that violate traffic regulations can be judged in a short time, and the comprehensive management system will give the penalty[6]. Moreover, it is the same for security cameras which are commonly seen in our life. It is helpful for safety management and criminal investigation judgment, and so on.

There are three common carriers by analyzing the differences of graphic identification carriers. They are personal computers, mobile phones and embedded terminals. Among them, personal computers and mobile phones are more inclined to personal applications. Basically, every family or individual will own at least one mobile phone. People can successfully complete communication activities and information exchange through image recognition technology. The newer mobile phones can combine image recognition technology to carry out face recognition too. After setting fixed information, one can unlock the phone screen or make the payment by using face scanning, without using complicated manual operations, and therefore improving the use efficiency. On the other hand, embedded terminals are mainly inclined to public facilities, such as monitoring equipment or the traffic management system mentioned above, which are usually combined with big data and cloud technologies to effectively relieve staff working pressure with less work time loss[7].

In addition to the main application fields, intelligent identification technology go deep into many other fields due to the rapid development of science and technology in China. For example, intelligent identification technology is widely used in the urban planning work. Aerial photography is used to obtain the layout data of the whole city. There are still many deficiencies combined with big data analysis in the urban planning. Image recognition technology can also be used to monitor the construction of roads and bridges in cities to ensure that the engineering quality can meet the requirements in the construction plan[8].

Although as a whole, there are some contents that still need to be improved and optimized as soon as possible in the current recognition technology. For example, processing technologies of gray scale processing and gray scale stretching also need to be improved during image preprocessing. It will comprehensively improve the image processing efficiency of operators, and these technologies can also make the obtained data more perfect and accurate if the problems have been solved. In the identification process, taking instant samples' characteristics as the basis for research, one should pay attention to the algorithm to

effectively classify the existing data with active convertion of the required format that is stored in the corresponding path.

3. Conclusion

To sum up, image recognition technology is of practical value for the development of computer science and technology, and its algorithm is the core content. Meanwhile, it is necessary to be clear and familiar with the relevant process to effectively ensure the expected rational effect in the process of practical application of this technical means. For a long period of future development, it is needed to emphasize the in-depth research of the technology. In addition to improving this algorithm, it is also inevitable to improve some other derived technical means so that the intelligent image recognition technology can be widely popularized and applied in depth.

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ORIGINAL ARTICLE

Application and Feasibility Analysis of Proactive Anti-cheating Algorithm Based on ML

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Abstract: Nowadays, most Internet application contents based on modern Internet service providers are realized through human-computer interaction. Therefore, the application scenarios of HCI in life are very wide, and the visual operation path provides great system availability and user-friendliness. And its security is an important fulcrum for service providers (SP) to obtain benefits, or fund transactions between terminals. According to the trigger mechanism of cheating, it is mainly divided into exposure cheating, click cheating, and conversion cheating. Cheating will greatly pollute the network environment and it even violates laws and regulations. Therefore, ISPs are deploying and continuously improving anti-cheat algorithms and mechanisms during the service development stage. The location of these operating mechanisms is generally the network server used by the SP to provide services, and some algorithms and monitoring behaviors significantly increase the load of the server, thereby increasing service costs.

Based on machine learning (ML) technology, this paper introduces a feasibility analysis of anti-cheat algorithm for human operation based on object terminal, which is suitable for behavior recognition level and data level. The algorithm learns user behavior through their active participation. It finds the path of the request by combining with packet matching of abnormal behavior characteristic of cheating behavior updated regularly by the service provider. This algorithm also detects cheating behavior through local controller. When the two peers have the same or a high probability of prejudgment after calculation, the server is triggered to actively identify user behavior, using the trust profile to analyze and log the cheating path. The compatibility and friendliness of terminal equipment characteristics and hardware level with AI algorithms in the current environment is helpful to reduce the load caused by the server mounting of the ISP and costs.

Keywords: Human-Computer Interaction (HCI); Machine Learning (ML); Artificial Intelligence (AI); Anti-cheat; Algorithm; Localization

1. Introduction

Machine learning is an important part in the field of artificial intelligence. This kind of program can promote the performance of this logic evaluation by evaluating a specific performance index of the task and learning the experience gained from its index evaluation to reach an increasingly perfect level. If this goal can be achieved, the corresponding program will be interpreted as the ability to learn from experience, which is called machine learning (ML). It takes classification, clustering, regression, and dimensionality reduction as the main principles of learning[1].

Processor chips produced after 2015 can reach a relatively sufficient level in terms of computing frequen-

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-cy. Our study found that in the daily human-computer interaction scenarios, the utilization rate of the processor did not exceed 50% in 75.51% cases and 75% in 97.33% cases. Therefore, the equipment processing chips produced after that have sufficient capacity to merge processing and calculate the anti-cheating mechanism based on behavior monitoring.

In this article, an anti-cheat algorithm strategy based on ML peer-to-peer systems is proposed. Since the peer node is responsible for calculating the path, the feasibility of a single child node to judge cheating goes very high. Since the intent cheater has the ultimate terminal to implement cheating, all actions of the cheater have a high probability of running on this terminal, so the key goal is to design a low-cost path and efficient cheating behavior using the terminal as the computing carrier computer system, thus replacing the operation of the original single node anti-cheat mechanism.

2. Problem description

Path discovery requires a lot of resources, especially in data carriers with many instantaneous users, such as online games or online shopping. Therefore, an efficient and cheap method is needed, otherwise the Internet provider's anti-cheating mechanism will consume a huge amount of server memory, increasing the operating cost. In the human-computer interaction experiment, most of the user's operations are converted into digital signals from the computer's external equipment and then they are collected by it. But for the purpose of realizing a function, it needs to run an algorithm in the background to determine the path to be followed. Considering that the operation to complete a specific goal may have different logical properties, this may be a complex decision operation, and it will be more complicated in a specific irregular artificial environment. Therefore, a near-optimal path is necessary if it is suitable in terms of computation time and memory[2].

To explain this problem accurately, a location model from the source point S to the destination point D is designed. According to the distribution model, the regional path $Z_8 \rightarrow Z_6 \rightarrow Z_5 \rightarrow Z_1$ is set. Then, in the conversion of each regional grid level, drawing a data distribution map of all normal points and discrete points, and sampling the data delivered from the "experience" learned in the above principles and the server of the service provider are what to do. The next step is to compare, and when the shortest distance between a feature and other feature values exceeds the threshold of the system, the server should be alerted in advance, and an anti-cheat mechanism is triggered in both directions. The aim of this paper is to find an automatic anti-cheating path split into two parts for separate deployment at the given source and target with the minimum computational cost.

3. Solution

Initially, the design and implementation of this problem was a simple multi-terminal "clustering anomaly detection" mechanism supplemented by data packets. But for this problem, according to the existing information, it cannot be realized normally. The main anti-cheating mechanism is composed of "green dill algorithm" represented by engine optimization and "abnormality discovery model" represented by behavior monitoring. The difficulties are as follows:

First, it needs to be ensured that the original web server running the anti-cheat algorithm and the user terminal mentioned in this design remain stable in the same time domain. To solve this problem, the terminal is regarded as a node, and a specific node is identified within a short time range in the transmission path of the data packet during the connection between the terminal and the server. Then a set of packets is mounted with localized behavior identification and interaction with the server. However, regarding the location of the target terminal, the data content between any terminal and the server is not unique and continuous. The reliability of the data packet content is limited.

Secondly, in the human-computer interaction application scenario based on application nesting environment, it is not easy to deploy a computer program with independent running ability locally, and the user's hardware performance is uneven, which makes it impossible to accurately predict the feasibility of the behavior. So, it is not easy to find a credible path.

Therefore, to overcome these limitations, some rule changes and logical adaptations are required. First, to correctly understand the proposed anti-cheat algorithm, this article briefly introduces the path discovery

algorithm through participating nodes. Detailed algorithm aspects can be found as follows. Second, to correctly understand the advantages of this strategy, this article briefly analyzes the feasibility and application mechanism of this strategy.

3.1 Apply page-rank-based weight model

Page Rank is an algorithm that sorts the importance of the triggered content. It initializes all the weights of the page to the same value when treating it as a rectangular directed graph with four endpoints. It starts from an arbitrary point in a random page and then it jumps to the link attached to it, where the web pages are regarded as nodes. Starting from page A, the probability of jumping to B, C, and D are all 1/3, so it can be deduced that if a link has K outgoing links, then the probability of the target position of the next jump is 1 /K. Similarly, the jump probability from B to C is 0, and D has a 1/2 probability to jump to B or C. Then for every link that goes out of the chain (I) there is a matrix F[i][j] = 1/K. With the appearance of the iterative jump process, the weights will also be propagated to the next level of pages. The weight value after the stable iteration occurs is called the Page Rank Value, which are going with the probability of eventually stopping pointing.

So, it can be deduced that:

$$V'=\alpha FV + (1-\alpha)e$$

At the same time, using the ranking mechanism BRank to measure the importance of the page to change the weight of the search results and using the reverse pointer (to increase the value of Page Rank) to implement anti-cheat are crucial. The local blacklist is established and maintained in the server and the BRank value E(x) is assigned to the links in the blacklist for majority assignment. Then if a link is nested with links with blacklist directivity, then BRank will be assigned repeatedly.

Through analogy, the formula is:

$$BR(x) = E(x)(1-d)+d(BR(t1)/C(t1)+\ldots BR(tn)/C(tn))$$

(C(tn) represents the number of tn chains and d represents the damping coefficient)

For this topic, it is necessary to establish a simpler whitelist mechanism. Then a whitelist mechanism like the Hilltop algorithm is introduced, so that it can not only mark users with lower frequency to avoid the risk of obtaining a larger BRank value, but also balance the data link.

3.2 Localized deployment and implementation of anti-cheating algorithm

The basic communication model combines different aspects of client-server and peer-to-peer communication concepts. According to the design, the path is composed of many segments, each of which is composed of (Anchor Point → Gateway). The path discovery process requires the help of all other peers in the middle segment. But the first and last parts are always operated by users who need to access the path[3].

Let's consider, for example, there are two extreme target users named real user and cheaters simulating real user. The cheating controller maintains a trust configuration file for each peer based on the path discovery operation. When the cost of the path segment of the same source and target does not match, it will recalculate the path cost and then the cheater is identified. This process is very simple and it does not always use the controller. Through this process, we can easily capture cheating behavior with a low-cost risk control.

A localized application (plug-in or integrated software) is designed to apply quantitative indicators to the operation of specific objects for data analysis, and ML algorithms is used to learn the user's conventional operation logic and operation content. It is necessary to download and analyze the operation data package with cheating characteristics. When the user who obviously deviates from the normal operation path is close to a certain sub-data in the data package, the application will issue a cheating warning to the user and the server respectively. In this way, the server can target potential users who commit cheating. It also reduces the impact of widely used anti-cheat algorithms on hardware load in some simple operating environments that do not involve economic property security.

4. Discussion and experiment

For example, Final Fantasy XI provides quasi-periodic reports to help to eliminate cheaters. Many terminals have conducted case studies on cheating when discussing the scale of cheating from different angles. Even with full control of the client, the cheater can hide its existence by modifying the operating system,

spoofing anti-cheat software, and more. Therefore, the key step of cheating control is to understand cheating with solutions to the behavior of cheaters.

An Internet shopping application scenario was assumed and the cheating behavior of "swipe order" was stimulated. The computer was used to simulate 10^8 main action frauds. It was found that 99.6% of the scenarios can be directly captured by the local computer through eigenvalue calculation, and the detection efficiency has also increased by 6.29% per month.

5. Conclusions

This paper presents a simple decentralized anti-cheat algorithm and its working mode. This mode discovers the requested path through the participation of peers. When the two peers are inconsistent in path cost, the local controller triggers the implementation of a two-way anti-cheat system. In addition, because the participating peers help during the path discovery process, the load on the server may also decrease. Considering all the characteristics and advantages, it is a feasible solution. Careful research and experiments are still needed to avoid the occurrence of peer-to-peer cheating.

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ORIGINAL ARTICLE

Pre-IdentifyNet: An Improved Neural Network for Image Recognition

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Abstract: With the rise and development of artificial intelligence, image recognition and classification technology has received more and more attention as an important branch of its research field. Among them, the introduction of deep learning networks and the construction of neural network structures not only avoid a lot of the tedious work of manual extraction, but also improve the accuracy of image recognition. Convolutional neural networks have many advantages that conventional neural networks do not have. Therefore, image classification systems based on convolutional neural networks emerge in endlessly, but there is still much room for improvement in terms of recognition accuracy and recognition speed. Based on this, this paper proposes an improved deep convolutional neural network to improve the accuracy of the network by changing a series of parameters such as the number of channels of the convolution layer, the size of the convolution kernel, the learning rate, the number of iterations, and the size of the small batch with speed. In this paper, three data sets were selected, namely sewage, animals and the Simpson Family. Comparing the improved convolutional neural network network with the existing SqueezeNet and GoogleNet. It is found that the accuracy of the network is maintained while maintaining a similar speed. Both F1-score and F1-score have been improved with a higher recognition rate and better recognition effect in image recognition classification.

Keywords: Convolutional Neural Network; Image Recognition and Classification; Pre-IdentifyNet

1. Introduction

Image recognition is the next important technology in the current information age. Due to the increase in computer operation speed, image recognition technology has developed tremendously in recent years. Some classic classification algorithms, for example, image classification algorithms based on SVM classifier[1] have been gradually replaced by convolutional neural networks[2]. Among them, the convolutional neural network plays an important role in image recognition. The features extracted by convolution focus more on the locality. It is not necessary for each neuron to perceive the global image. It only needs to perceive the locality, and then the higher layer integrates the local information to obtain the global information. It can share parameters, which greatly reduces the amount of calculation. Therefore, models such as AlexNet[3] and LeNet-5[4] were born, making it possible for image recognition to be widely used in real life.

In recent years, many countries have applied convolutional neural networks[5-7] for image recognition. Kai Zeng *et al*. proposed a multi-convolutional neural network to automatically obtain a local metric map for defocus blur detection[8]. Foo Chong Soon *et al*. used convolutional neural networks based on principal component analysis to extract the main features from existing vehicles for the recognition of vehicle models.

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With the continuous development of artificial intelligence technology, artificial intelligence methods for building deep network structures of multi-level feature learning have achieved great success in the field of large-scale picture classification[11]. In order to improve its speed and accuracy through image recognition, this paper attempts to apply the improved convolutional neural network to image recognition. The Pre-IdentifyNet proposed in this paper accelerates the recognition of images, which improves the accuracy and timeliness of image recognition and processing with less manpower, material resources and time. It also reduces the limitations of manual recognition to realize the automation of finding images.

The rest of the article is organized as follows. The second part briefly summarizes the convolutional neural network and it introduces the improved network in detail. The third part mainly introduces experiments on the designed network, including the data set used in the experiment, image preprocessing, training network and performance evaluation, which gives the experimental results. Finally, the fourth part summarizes the conclusion of this article.

2. Network design

2.1 Convolutional neural network

Taking neurons as a model, convolutional neural network (CNN) is a biologically-inspired artificial intelligence algorithm that obtains input from a layer of cells, performs mathematical transformations, and provides the output to the next group of neurons, which is very suitable for computers visual task.

GoogleNet is carefully prepared by the Google team to participate in the ILSVRC competition, and it has been learned and used by many researchers. GoogleNet proposed that the most direct way to improve deep neural networks is to increase the size of the network, including width and depth. Depth is the number of layers in the network, and width refers to the number of neurons used in each layer. To this end, GoogleNet proposed a new structure, called inception. The entire inception structure is composed of multiple inception modules connected in series. There are two main contributions of the inception structure: one is to use 1x1 convolution to perform up-down dimension; the other is to perform convolution and aggregation on multiple sizes at the same time.

SqueezeNet was proposed by UC Berkely and others in 16 years and it is one of the current mainstream convolutional neural networks. The network is a network model that can reduce the input volume for the advanced AlexNet and VGG Net models with increasing parameters. The core part of the model is the Fire Module. The structure is divided into squeeze and expand structures. Squeeze contains S 1×1 convolution kernels, and the expand layer contains E1 1×1 kernels and E3 3×3 convolution kernels, and the model satisfies $S < (E1 + E3)$. The model reduces the size of the network convolution kernel on the basis of the AlexNet network, and it replaces the fully connected layer with an average pooling layer, thereby maximizing the calculation speed, but it may reduce the model accuracy and model parameters.

2.2 Network design

In this study, MATLAB's Deep Net Designer toolbox was used to synthesize SqueezeNet and GoogleNet. The main job is to test the pre-trained neural network with different numbers of modules to determine the number of fire modules and inception modules.

In order to reduce the computational complexity, this study only analyzes and designs the shallower network. The 8 combinations of designs are shown in **Table 1**. According to the data in the table, when a fire module is combined with two inception modules, the accuracy of picture recognition is the highest.

Fire Module	Inception Module	Accuracy
0	1	65.26%
1	0	57.85%
1	1	86.13%
1	2	95.83%
1	3	92.04%
2	1	83.38%
2	2	89.93%
3	1	87.69%

Table 1. Effect of different number of fire module and inception module on recognition accuracy

Subsequently, based on the number of fixed modules, a fire module and two inception modules are arranged and combined, and it is found that the fire module is in front of the two inception modules with the highest accuracy rate, and the improved neural network Pre-IdentifyNet is obtained. The specific structure is as follows **Figure 1.**

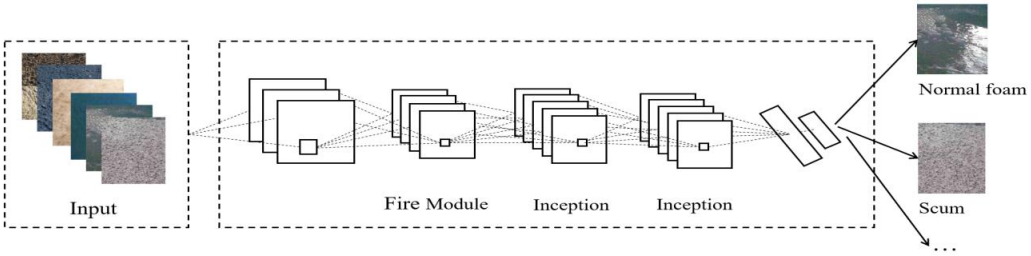

Figure 1. The structure of a neural network.

3. Experimental design

3.1 Data set

In order to accurately obtain the recognition situation of the network in the face of different types of pictures, this study used three completely different types of data sets, namely simpsons_dataset, animals_dataset and sewage dataset. Among them, simpsons are images captured by different animated characters of the Simpsons at different angles, animals are images collections of different living conditions of various animals in nature, and sewage datasets are images of abnormal working conditions of the water treatment process obtained from sewage treatment plants set.

The images of abnormal working conditions in the water treatment process are divided into six categories: foam, normal foam, normal working condition, scum, scum sludge, silt swelling, simpsons_dataset and animals_dataset are also divided into six categories in the above manner, and they are divided into 8:2 ratios respectively training set and test set.

In order to further improve the accuracy of the built convolutional neural network, this study also uses image processing software to segment the sample image, vertically flip left and right, random translation and other operations, so as to obtain additional training data with these image pairs of the pre-trained network performs secondary training to improve the accuracy of pre-recognition.

3.2 Training network

The next step is to use the pre-processed image to retrain the network. In the designed network, the freeze weights function is used to freeze these initial layers to suppress overfitting during training.

The gradient descent method is used to train the designed convolutional neural network. In addition, through experiments, the Mini Batch Size is adjusted to 100, which reduces the training time and improves accuracy. The relationship between Validation Frequency and Mini Batch Size is shown in Equation 1. In **Table 2**, and the setting values of other training parameters are given.

$$\text{ValidationFrequency}=\left\lfloor \frac{\text{numel(augimdsTrain.Files)}}{\text{MiniBatchSize}} \right\rfloor \quad (1)$$

Parameter	Setting
Initial Learn Rate	0.00006
Mini Batch Size	100
Max Epochs	6

Table 2. Network training parameter settings

3.3 Performance evaluation

This section calculates the accuracy, precision, recall, and F1-score of the network by introducing four indicators: TP (True Positive), TN (True Negative), FP (False Positive), and FN (False Negative).

Among them, precision refers to the proportion of samples that are positive in the positive prediction:

$$precision = \frac{TP}{TP + FP} \tag{2}$$

Recall is the proportion of samples that are predicted to be positive in the overall sample:

$$recall = \frac{TP}{TP + FN} \tag{3}$$

$$F1\text{-}score = 2\frac{precision \cdot recall}{precision + recall} \tag{4}$$

The Simpsons	accuracy	precision	recall	F1-score
Pre-IdentifyNet	95.83%	0.96	0.95	0.95
GoogleNet	79.67%	0.77	0.83	0.79
SqueezeNet	71.00%	0.76	0.70	0.72

Table 3. Performance comparison of different networks in the Simpsons

Animals dataset	accuracy	precision	recall	F1-score
Pre-IdentifyNet	94.79%	0.94	0.96	0.94
GoogleNet	80.62%	0.82	0.79	0.81
SqueezeNet	73.51%	0.74	0.75	0.74

Table 4. Performance comparison of different networks in animals dataset

Abnormal condition	accuracy	precision	recall	F1-score
Pre-IdentifyNet	96.31%	0.96	0.97	0.95
GoogleNet	79.67%	0.73	0.82	0.80
SqueezeNet	75.35%	0.77	0.76	0.76

Table 5. Performance comparison of different networks in abnormal condition image

In the same test environment, the Simpsons, animals, and sewage treatment abnormal working conditions datasets were used to train the Pre-IdentifyNet for many times, they are compared with the use of GoogleNet and SqueezeNet. The results are shown in **Tables 3~5**. It can be seen that the accuracy and F1-score of the design network are higher, which has achieved better results than GoogleNet and SqueezeNet. **Figure 2** shows the recognition effect of four randomly selected pictures in the sewage treatment dataset. The accuracy of using Pre-IdentifyNet is above 95%, which can effectively improve various performance indicators of image classification to achieve good experimental results.

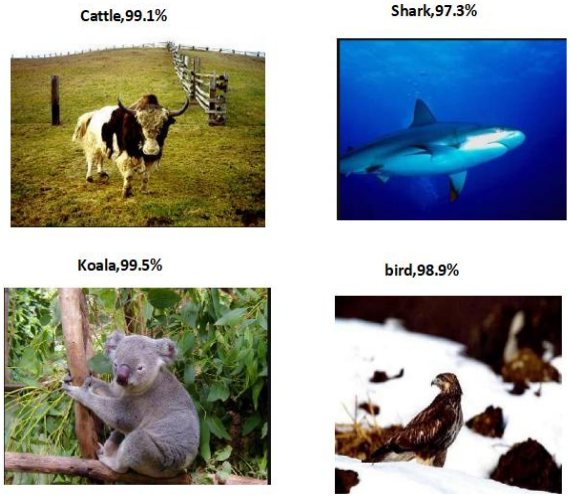

Figure 2. Animal recognition results.

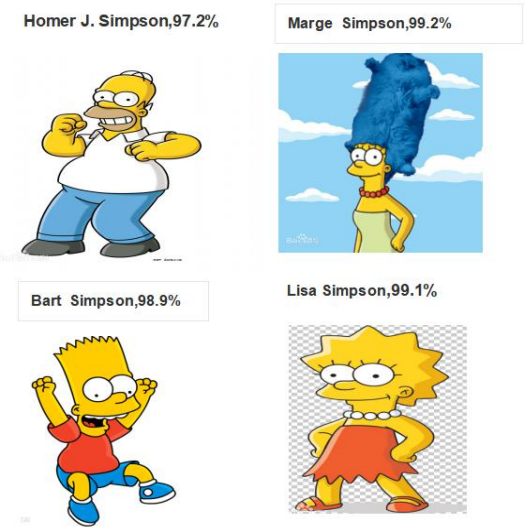

Figure 3. Simpson's recognition results.

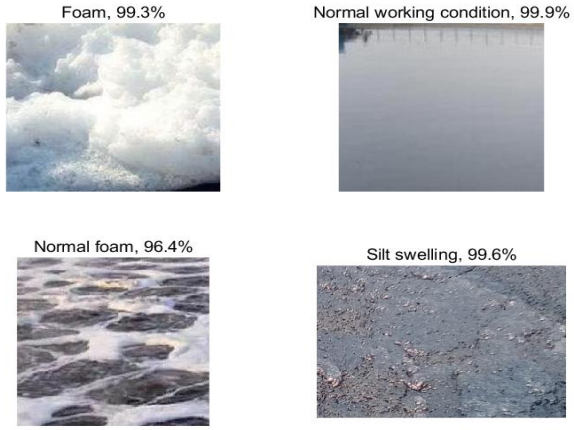

Figure 4. Identification results of abnormal sewage conditions.

4. In conclusion

Based on SqueezeNet's fire module and GoogleNet's inception, this paper constructs an improved convolutional neural network---Pre-IdentifyNet, which is used to identify animals, cartoon images of the Simpson family, and abnormal working conditions in sewage. During the training process, an attempt is made to gradually approach and determine a series of parameter values such as the learning rate, the number of iterations, and the size of the small batch. On the sample dataset, training results superior to the original network are obtained.

In addition to identifying abnormal conditions in wastewater treatment, the Pre-IdentifyNet designed in this study can also be applied in various fields such as image recognition, item classification, and behavior recognition, pose estimation, and other fields.

In the following research, further researches need to be focused on, including improving the accuracy of the network and the ability of network feature extraction by constructing a more scientific and reasonable structure, further optimizing relevant network parameters to simplify the network structure, and trying to optimize the Pre-IdentifyNet network used in more scenarios.

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Universe Scientific Publishing

ORIGINAL ARTICLE

A Multi-objective Particle Swarm Optimization Algorithm Based on Reverse Learning

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Abstract: In order to solve the contradiction between population diversity and convergence in particle swarm optimization algorithm, in this paper, a particle swarm optimization algorithm with reverse learning is proposed. On this basis, the values of learning factor and constraint factor parameters are modified, and the linear decreasing weight strategy was adopted. By modifying the learning factor and the constraint factor, the algorithm improves the particle optimization ability. It balances the global search and local search of the particle, and the convergence speed is improved by using the inertia weight. When it is detected that the algorithm falls into the local optimal region, the position information of these poor particles is used to guide some particles to reverse learning at a faster flight speed, and the particles are quickly pulled out of the local optimal region. The reverse learning process can not only improve the diversity of particle population, but also ensure the global detection ability of the algorithm. Experimental results show that, compared with the basic MOPSO algorithm, this algorithm has fast convergence speed and high solution accuracy in function optimization.

Keywords: Particle Swarm Algorithm; MOPSO; PSO; Test Ctions

1. Introduction

Particle swarm optimization was proposed by Kennedy, *et al* in 1997. It was first applied to single-objective optimization problems, which showed good performance. However, most of the optimization problems in real life are multi-objective optimization problems. Particle swarm optimization algorithm has the advantages of fast search speed, high efficiency and simple algorithm, so it is widely applied to the optimization of multi-objective problems. Therefore, a large number of multi-objective particle swarm optimization algorithms are proposed. In order to improve the diversity of the population and the convergence of the algorithm, Liu Ming, *et al*[1] proposed a multi-objective particle swarm optimization algorithm based on the regular competitive learning mechanism, which combined the multi-objective particle swarm optimization algorithm with the competitive learning mechanism to maintain the diversity of the population, effectively improving the convergence of the algorithm; Chen, *et al*[2] proposed a multi-objective decomposition particle swarm optimization algorithm (D-CLMOPSO) based on comprehensive learning strategy, which was used to solve multi-objective problems to avoid premature convergence. The archiving mechanism is used to store the non-dominant solution and polynomial variation in the optimization process to avoid the algorithm falling into the local optimal, but it may not converge to the complete Pareto front when dealing with complex multimodal problems; Li, *et al*[3]

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proposed a multi-objective particle swarm optimization algorithm (SSlMOPSO) using the quadratic reinforcement learning strategy. By using the speed-free multi-objective particle swarm framework and integrating the decomposition strategy into the multi-objective particle swarm algorithm, the two-time reinforcement learning of particles can be realized to enhance the algorithm's ability to jump out of local optimal. It also improves the diversity of the population.

Thus, a large number of outstanding scholars on the improved multi-objective particle swarm optimization algorithm get the excellent achievements, but the multi-objective particle swarm optimization (PSO) algorithm is easy to fall into local optimum and precocious defect still haven't been solved well, thus improving population diversity and convergence algorithm is still an area worthy of study. In view of the prematurity of particle swarm optimization algorithm, reverse learning strategy was introduced into MOPSO algorithm in this paper to improve the searching ability of the algorithm.

2. Basic theory

2.1 Basic particle swarm optimization

The standard PSO algorithm is a random search algorithm derived from the bird foraging model, that is, if there is only one piece of food in a certain area, the optimal strategy is to find the area around the bird closest to the food. In this problem, there is a bird of space position corresponding to the problem of the solution, and the bird is called the "particles". Each "particle" has its own velocity and position (decided to birds flying direction and distance), all the particles "have" in each iteration a adaptive value is determined by the function of optimization, then all particles with the optimal particle in all within the scope of the search the solution space. During each iteration, the particle updates itself by tracking two extremes. An extremum is an individual extremum, the optimal solution is found by the particle itself. The other extreme is the optimal solution of the whole particle population, which is called the global extreme. The particle then updates its position and velocity through individual extremum and global extremum. The updating formula of position and speed is as follows:

$$v_{id}^{k+1} = v_{id}^{k} + c_1 rand_1^k\left(pbest_{id}^k - x_{id}^k\right) + c_2 rand_2^k\left(gbest_{id}^k - x_{id}^k\right) \quad (1)$$

$$x_i d^{(k+1)} = x_i d^k + v_i d^k \quad (2)$$

Type: v_{id}^k is the d-dimensional velocity of particle I in the KTH iteration, $v_{id}^k \in [-v_{max}, v_{max}]$; c1, c2 is the acceleration factor (or learning factor), $rand_1^k$ 、$rand_2^k$ is the random number between$^{[0,1]}$ in the KTH iteration, x_{id}^k is the d-dimensional position of particle I in the KTH iteration, $pbest_{id}$ is the position of the individual extremum of particle I in the DTH dimension, $gbest_d$ is the global optimal value of the whole particle population.

C1 and c2 represent learning factors and the learning ability of particles to their own historical and population optimal locations. When c1 = 0 and c2 ≠ 0, the algorithm has strong global convergence ability, but it is easy to fall into local optimal. When c1 ≠ 0, c2 = 0, the global convergence rate of the algorithm is slow. So by constantly changing their values, we can find the most suitable result.

Inertia weight is used to describe the influence of the particle velocity on the current generation, value is larger, the global optimization ability is strong, the local optimization ability is weak; on the contrary, local optimization ability will be gradually strengthened. In order to achieve a balance between search speed and precision, the algorithm generally has a higher global search capability in the early stage and a stronger local search capability in the later stage. Therefore, dynamic can get better optimization results than fixed values.

The most common method is to change the weight of inertia by linear decline. The formula is as follows:

$$\omega = \omega_{max} - (\omega_{max} - \omega_{min}) \times \frac{it}{MaxIt} \quad (3)$$

Where, ω_{max}、ω_{min} are the maximum and minimum values of inertia weight respectively, MaxIt is the maximum number of iterations, and it is the current number of iterations.

Because of the change of inertia weight of linear decrease only considers the change of iteration number, this method cannot deal with complex and nonlinear problems well. Therefore, factors such as particle distribution can be considered on this basis.

2.2 MOPSO

MOPSO is a PSO-based multi-objective

optimization algorithm, which generally includes optimization of two or more functional objectives with constraints between objective functions. MOPSO can be described mathematically:

$$\begin{aligned} &\min f(x) = (f_1(x), f_2(x), \cdots, f_m(x)) \\ &g_j(x) < 0, j = 1,2,\cdots,A \\ &h_k(x) = 0, k = 1,2,\cdots,B \\ &x_d^{min} < x_d < x_d^{max}, d = 1,2,\cdots,D \\ &\text{s.t. } 0 \le x_i \le 1, i = 1,2,\cdots,D \end{aligned}$$

Where, M is the number of objective functions, $f_i(x)$ is the ith objective function, and $g_j(x)$、$h_k(x)$ are the constraints of the kthand jth inequalities. A and B are the sum of$g_j(x)$、$h_k(x)$constraints, respectively. x_d^{min}、x_d^{max} are the upper and lower limits of the d-dimensional positions of particles respectively.

3. Inverse learning

3.1 Definitions

The concept of reverse learning was first proposed by Tizhoosh[4] in 2005. By finding the reverse solution of a feasible solution of a problem, and comparing the original feasible solution with its reverse solution, a better solution is selected as the optimal learning strategy for the next generation of individuals. In reverse learning, the definition of reverse point and reverse learning optimization[5] is as follows:

Reverse point: Assuming $x = x_1, x_2, \cdots, x_D$ is any point in the d-dimensional space, and$x_1, x_2, \cdots, x_D \in R, x_i \in [a_i, b_i]$, then the global reverse point corresponding to x is defined as $ox = (ox_1, ox_2, \cdots, ox_D)$, where

$$ox_i = a_i + b_i - x_i \quad (4)$$

Back learning optimization[5]: Suppose $x = (x_1, x_2, \cdots, x_D)$ is any point in d-dimensional space, and its global reverse point is defined as

$$ox = (ox_1, ox_2, \cdots, ox_D) \quad (5)$$

For the problem of minimization, if $f(ox) < f(x)$, then $x = ox$, which is called backward learning optimization.

3.2 Reverse solution

Back learning can expand the search range of the population. Under a certain probability, solving the generated particles, generating reverse solutions and comparing them to better find the optimal solution are crucial. Generating the reverse solution can be explained as follows:

Let the current particle be $X_{i,j}$, and the corresponding inverse solution

$$X_{i,j}^* = k(a_j + b_j) - X_{i,j} \quad (6)$$

Where $a_j = \min(X_{i,j}), b_j = \max(X_{i,j}), i = 1,2,...,NP, j = 1,2,3,...,D, X_{i,j} \in [a_j, b_j]$, NP is the number of generated particles, D is the number of dimensions, and $k \in [0,1]$ is the generalization coefficient, which is used to generate different inverse solutions.

Algorithm 1: The Framework of Multi-Objective Particle Swarm Algorithm

Input: nPop, Population size; MaxIt, maximum iterations; c1、c2, Learning factor

Output: The best solution for the task.

```
Initialize the population
Calculate fitness function
Update the best individual
Identify the leader
Archive and create grid
for it=1:MaxIt
    for i=1:nPop
        Get the leader
        If rand>gl
            Use formula (1) (2) to update the particle position and velocity
            Calculate fitness value
        End
        If rand<gl
            Get population speed and position
            Calculate a_j、b_j
            Use formula (6) to obtain a new position
            Position update, calculate fitness value
            Calculate the fitness value and optimal selection before and after the reverse solution respectively
        End
        Apply mutations, solve updates
    End
    Screening and archiving based on dominance
    Update grid
End
```

4. Experimental simulation and result analysis

4.1 Test function

In Matlab2019 environment, the four test functions of ZDT1, ZDT2, ZDT3, ZDT6 in **Table 1** are simulated and verified. The next step is to compare the Pareto obtained in Matlab2019 with the improved optimization algorithm in this paper with the Pareto obtained in Matlab2019 with the basic MOPSO algorithm.

name	
ZDT1	$f_1(x) = x_1$ $f_2(x) = g(x)\left[1 - \sqrt{f_1(x)/g(x)}\right]$ $g(x) = 1 + \frac{9(\sum_{i=2}^{n} x_i)}{(n-1)}, x = (x_1,\cdots,x_2)^T \in [0,1]^n$
ZDT2	$f_1(x) = x_1$ $f_2(x) = g(x)\left[1 - \left(\frac{f_1(x)}{g(x)}\right)^2\right]$ $g(x) = 1 + \frac{9(\sum_{i=2}^{n} x_i)}{(n-1)}, x = (x_1,\cdots,x_2)^T \in [0,1]^n$
ZDT3	$f_1(x) = x_1$ $f_2(x) = g(x)\left[1 - g\left(\frac{f_1(x)}{g(x)}\right) - g\left(\frac{f_1(x)}{g(x)}\right)\sin(10\pi x_1)\right]$ $g(x) = 1 + \frac{9(\sum_{i=2}^{n} x_i)}{(n-1)}, x = (x_1,\cdots,x_2)^T \in [0,1]^n$

ZDT6	$\min f_1(x_1) = 1 - \exp(-4x_1 \sin^6(6\pi x_1))$ $\min f_2(x) = g(1 - (f_1/g)^2)$ $g(x) = 1 + 9\left(\left(\sum_{i=2}^{m} x_i/(m-1)\right)^{0.25}\right)$ $s.t.0 \le x_i \le 1, i = 1,2,\cdots,10$

4.2 Simulation analysis

Take the population size nPop = 10, the maximum number of iterations MaxIt = 50, c1 = 1.41, c2 = 2, gl = 0.01 for simulation experiments. The simulation results are as follows:

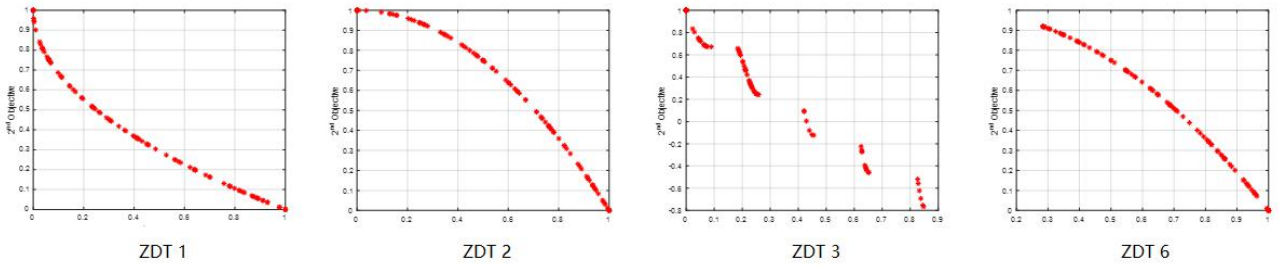

Figure 1. Multi-objective particle swarm optimization operation curve.

The ideal pareto front curve obtained by ZDT1 simulation is concave; the ideal pareto front curve obtained by ZDT2 and ZDT6 is convex; the ideal pareto front curve obtained by ZDT3 is discontinuous. The simulation results of ZDT1, ZDT2, ZDT3, and ZDT6 can all obtain a pareto front with good effect, and the stability of the curves obtained by ZDT3 and ZDT6 has been significantly improved.

5. Conclusion

In order to alleviate the contradiction between the convergence speed of the MOPSO algorithm and the "premature" problem, and to further improve its optimization performance, this paper proposes a particle swarm optimization algorithm with reverse learning. Value is modified and a linear decreasing weight strategy is used. The algorithm adjusted the inertial weights, learning factors, and constraint factors to balance the search ability of particles, and it improves the convergence speed; when the algorithm appeared "precocious", it started the reverse learning process. In this process, some particles used their worst individual history. The combined force of the solution and multiple worst solutions of the initial population escapes the local optimum to improve the diversity of the population; after the backward learning is over, the algorithm enters the normal iterative optimization process again. Compared with the basic MOPSO algorithm on the test function, the simulation results show that the algorithm proposed in this paper has stronger global and local optimization capabilities, faster convergence speed, and better stability of the obtained non-dominated solution. However, the improvement of the performance of the algorithm proposed in this paper is not very large. What should do next is continuing to study the MOPSO algorithm to improve the performance of the algorithm.

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