Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org
 Volume 25, Issues 5, pp. 3305–3313, DOI 10.12694/scpe.v25i5.3074

# THE APPLICATION OF DEEP LEARNING INTELLIGENT ROBOTS IN THE DESIGN AND IMPLEMENTATION OF INFORMATION RETRIEVAL SYSTEMS

YUQI MIAO*

**Abstract.** Traditional information retrieval algorithms ignore user needs and are unable to obtain user gaze coordinates and gaze times, resulting in low retrieval accuracy. The author proposes a new interactive information retrieval algorithm for this purpose. Divide eye tracking technology evaluation indicators, visually process eye movement information, obtain user gaze coordinates and gaze time, and calculate the influence coefficients of each gaze area and each point in the area. Weighted visual words are accumulated to get a visual word list with the weight of the associated area, and visual word list and Rocchio algorithm are combined to build a hidden Relevance feedback retrieval model in semantic space to judge information retrieval preferences. Intelligent robot is introduced, and Jensen Shannon divergence is used to calculate the Kullback–Leibler divergence distance between the probability distributions of document sets, calculate the similarity matching, and complete the interactive information retrieval. The simulation results prove that, due to the introduction of intelligent robot strategy in this method, the amount of irrelevant retrieval information is reduced by matching user needs and retrieval results. Therefore, the amount of messages generated by information retrieval is significantly lower than that of the two literature methods, without adding additional network load. The network system is in a stable operation state, and users can quickly grasp their own required information, and the retrieval speed is also improved to a certain extent. It is proved that the proposed algorithm has high retrieval accuracy, can effectively reduce network load and achieve high-quality human-computer interactive information retrieval.

**Key words:** Intelligent robots, Information retrieval, System design and implementation, eye tracking

## 1. Introduction.

Big data is actually a multi information fusion, through sorting and summarizing effective information, a large amount of effective data information is further processed and analyzed, and application information in the data is extracted, through extensive data processing, effective analysis can be conducted on various issues [1]. Big data has the following four characteristics: Firstly, there is a trend of diversification in data types, with uncertain data sources and a wide range of data types; Second, the storage space of Big data is very large, and the capacity often exceeds 10000GB; Third, Big data has high requirements for the authenticity of data, and it also needs data with a certain degree of real-time [2]. Fourth, the data structure of Big data is very complex, and a single storage mode cannot meet the needs of Big data. Gradually increasing and becoming more complex, artificial intelligence, as an emerging development discipline, cannot develop without the support of internet technology and communication devices [3]. Moreover, artificial intelligence can process information quickly and accurately, which humans cannot achieve. Artificial intelligence technology is also an extension and expansion of internet technology, especially in the application of artificial intelligence in information retrieval, which further increases the connection with the internet. However, there is also a certain mutual restriction relationship between artificial intelligence systems and the internet. In short, on the basis of Internet technology, AI technology can be effectively applied to information retrieval in the context of Big data [4].

After hundreds of years of research and exploration, artificial intelligence has also gained new characteristics and significance of the times. Given the rich scientific and technological knowledge contained in artificial intelligence technology, it is a very complex technical task and also involves psychology [5]. After completing the imitation of humans, artificial intelligence efficiently and accurately completes information retrieval work, greatly increasing work efficiency and social production efficiency. However, in the context of Big data, the work of artificial intelligence is becoming more and more difficult, and the technical characteristics of artificial intelligence should also make corresponding adjustments and changes to meet the current characteristics of the times.

*Hefei preschool education college (YuqiMiao7@126.com)

**2. References.** With the wide application of modern communication and network technologies such as network communication, Internet of Things technology and cloud computing technology, various structured and unstructured data resources have shown explosive growth, marking a new stage of the Big data era. And text data dominates all forms of information resources, with a large amount of data presented in the form of text [6]. As the main manifestation of internet information, massive amounts of text information have become a key research object in the fields of computer science and intelligence.Therefore, text processing technology is the key way to use information in the era of Big data, in which Text retrieval is an important foundation and premise of text processing technology. How to accurately and comprehensively retrieve the information required by readers in massive text information is the key issue and research hotspot of Text retrieval technology development [7].

Xu, Y provide a method for manufacturing magnetic nanorobots, which is an intelligent robot system updated from traditional autonomous experimental platforms. Nanorobots synthesized by robots have uniformly sized samples, which can significantly reduce time costs [8]. Rahimi, T introduced a new topology structure of the proposed converter, which has the following advantages: (i) the topology structure of the converter is based on traditional boost and buck boost converters, which leads to its simplicity; (ii) The voltage gain of the converter provides a higher value through the lower value of the duty cycle; (iii) Due to the use of efficient traditional topology in its structure, the efficiency of the converter remains high for a large duty cycle interval; (iv) In addition to the increase in voltage gain, the current/voltage stress of semiconductors remains at a relatively low level; (v) The continuous input current of the converter reduces the current stress of the capacitor in the input filter [9]. Zeinoddini Meymand, H designed and implemented a speed control controller for permanent magnet synchronous motors based on an intelligent neural network. Firstly, an accurate mathematical model of permanent magnet synchronous motor was presented, and then, by designing a controller, we applied the challenge of wind turbine simulation. The designed controller was first implemented on the Arm Cortex-M microcontroller and tested on laboratory PMSM [10]. In order to solve the application problems of the traditional methods mentioned above, the author proposes an interactive information retrieval algorithm based on intelligent robots. Combining eye tracking technology, divide eye tracking technology evaluation indicators, visually process eye movement information, and obtain user gaze coordinates and gaze time. And the author first creates four eye movement evaluation indicators: gaze, scanning, pupil dilation, and scanning path.

**3. Interactive Information Retrieval.** Incorporating user behavior into the retrieval system can effectively achieve human-machine interaction for information retrieval. At present, Relevance feedback has two modes: explicit Relevance feedback and implicit Relevance feedback. Displaying Relevance feedback requires users to make a lot of preparations and inform users of the impact of their behavior on information retrieval in advance; In the implicit Relevance feedback mode, users do not need to consider the impact of their own behavior on the search results, but only need to pay attention to whether the search behavior meets their own needs, which can greatly reduce the workload of users, and the accuracy of the search results is also high [11].

**3.1. Classification of eye tracking feature indicators.** Eye trackers are tools for implementing eye tracking technology, which can be classified into three types: Helmet mounted eye trackers, desktop eye trackers, and eyeglass eye trackers. Eye tracking is divided into four categories: Gaze, scanning, pupil dilation, and scanning path. Gazing indicates the length of time the eyes stay at a fixed point; Scanning refers to the rapid movement or delay of the eyes between fixation points; Pupil dilation is used to describe the level of interest of users when browsing information; The scanning path is a trajectory formed by the rapid movement of both eyes between fixation points [12].

**3.2. Implicit Relevance feedback of search page.** Use multiple circles to describe the range of fixation points, with the diameter of the circle indicating the fixation time and the connecting line indicating the fixation trajectory. For each user's interest region, the region's fixation time is represented as

$$FD(i) = \sum_{e \in AOI(i)} T(e) \tag{3.1}$$

In the formula, e represents a fixation event, T (e) is the user's fixation time for event e, and i is the index of the region of interest (AOI). The corresponding coordinates of the fixation point in the region of interest are

$$\begin{aligned} FiA_x(j) = F_x(j) - AOI_{x1}(i), F(j) \in AOI(i) \\ FiA_y(j) = F_y(j) - AOI_{y1}(i), F(j) \in AOI(i) \end{aligned} \tag{3.2}$$

In the formula, $AOI_{x1}(i)$ represents the x-coordinate of the upper left corner of the region of interest, and $AOI_{y1}(i)$ represents the y-coordinate of the upper left corner of the region of interest. The influence area of each user's fixation point is

$$\begin{cases} FiA_x(j) - r \leqslant IA_x(j) \leqslant FiA_x(j) + r \\ FiA_y(j) - r \leqslant IA_y(j) \leqslant FiA_y(j) + r \end{cases} \tag{3.3}$$

In the equation, r is the radius of influence. The calculation process is as follows

$$r = p \cdot F_{time}(j) \tag{3.4}$$

In the formula, p represents the regulatory factor, and $F_{time}(j)$ represents the fixation time of the fixation point.

Set a fixation threshold t, if the fixation time of a user's interest area is higher than t, the information relative to this area is considered as related information, and vice versa is considered as unrelated images. Express the measurement criteria for evaluating user interest as

$$M(i) = \begin{cases} 1, if FD(i) \geqslant t \\ 0, if FD(i) < t \end{cases} \tag{3.5}$$

According to the user's fixation time for different information, if the information correlation degree h (i) is specified, the coupling relationship between fixation time and correlation degree is

$$k(i) = \frac{FD(i)}{\sum_{M(i)=1} FD(i)} \tag{3.6}$$

Based on the above information, a fixation point influence area can be obtained, and the size of this influence area is proportional to the fixation time. Record the influence coefficients of each point in the affected area as

$$IF(x,y) = e\frac{-((x - F_x)^2 + (y - F_y)^2)}{2\delta^2} \tag{3.7}$$

Based on the initial search results viewed by the user, calculate the influence coefficients of each fixation point's influence area and each point in the area. Extracting visual words from each region, weighting and accumulating visual words, can obtain a visual word list that covers all associated regions and includes weights. The visual word list is the expression form of semantic space

$$word = \sum_{i \in FiA} word(i) \cdot IF \tag{3.8}$$

In order to obtain more accurate user retrieval preferences, relevant information is reordered, and the reordering process can be seen as the process of forming a visual word list of user retrieval intentions, as shown in Figure 3.1. If there are M related regions, the initial visual word list for each related region is

$$G(i) = (w_1, w_2, ..., w_c) \tag{3.9}$$

In the equation, G(j) represents the visual vocabulary, and $w_n$ represents the vocabulary in the vocabulary [13]. The weight WA (i) of each region of interest is

$$WA(i) = \frac{FD(i)}{\sum_i FD(i)} \tag{3.10}$$

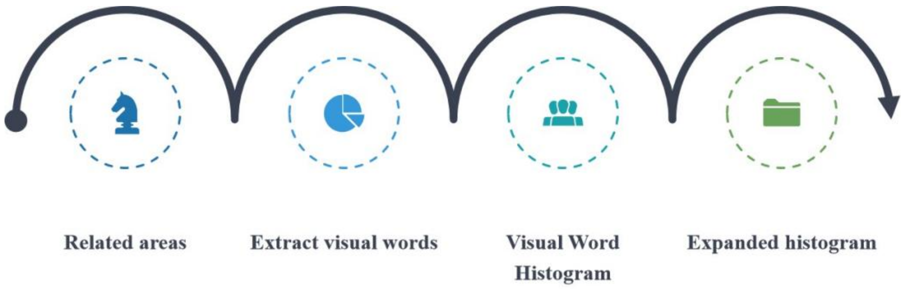


Fig. 3.1: Step of the implicit correlation feedback algorithm on the retrieval page

The improved visual word list for the relevant areas is

$$G^e(i) = (w_1^e, w_2^e, ..., w_i^e, ..., w_c^e) \tag{3.11}$$

where

$$w_i^e = WA(n) \cdot F_{time}(m) \cdot IF \tag{3.12}$$

In the formula, WA(n) represents the range of interest of the relevant region, and $F_{time}(m)$ represents the corresponding fixation time of the relevant region. The expanded search visual word histogram $H_i^e$ is

$$H_i^e = \sum_{i=0}^{M-1} G^e(j) \tag{3.13}$$

After using the above process to obtain new visual words, the Rocchio algorithm is integrated, and the implicit Relevance feedback retrieval model in semantic space is recorded as

$$\overrightarrow{q} = \alpha\overrightarrow{q_0} + \beta\frac{1}{|D_r|}\sum_{\overrightarrow{d_j}\in|D_r|}\overrightarrow{d_j} - \gamma\frac{1}{|D_{nr}|}\sum_{\overrightarrow{d_j}\in|D_{nr|}}\overrightarrow{d_j} \tag{3.14}$$

In the formula, $\overrightarrow{q_0}$ represents the user's initial search vector, $D_r$, $D_{nr}$ represent the set of known related and unrelated search contents, and $\alpha, \beta, \gamma$ is the corresponding weight [14]. During information retrieval, the system needs to interact with users for many times, that is, it has multiple pages of implicit Relevance feedback feedback, each feedback will generate a corresponding retrieval strategy, introduce new information vectors into the original retrieval vector, and eliminate+irrelevant vectors, thus improving Equation 3.14 to

$$\overrightarrow{q_{m+1}} = \alpha\overrightarrow{q_m} + \beta\frac{1}{|D_r|}\sum_{\overrightarrow{d_j}\in|D_r|}\overrightarrow{d_j} - \gamma\frac{1}{|D_{nr}|}\sum_{\overrightarrow{d_j}\in|D_{nr|}}\overrightarrow{d_j} \tag{3.15}$$

The search vector $\overrightarrow{q_{m+1}}$ in Equation 3.15 is determined by the search vector $\overrightarrow{q_m}$ during the m-th search and the related and unrelated search content vectors fed back in the macro results of this search.

**3.3. Interactive Information Retrieval Algorithm Based on Requirements Mining .** It can be seen from the implicit Relevance feedback model of equation (15) that each improvement of retrieval method is obtained on the premise of Relevance feedback of the previous retrieval results [15]. Requirement mining refers to starting from the real needs of users, the system judges their needs, and obtains the information they need. From content structure - spatial navigation construction - information content presentation, this series is expressed in an interactive logical form, as shown in Figure 3.2.

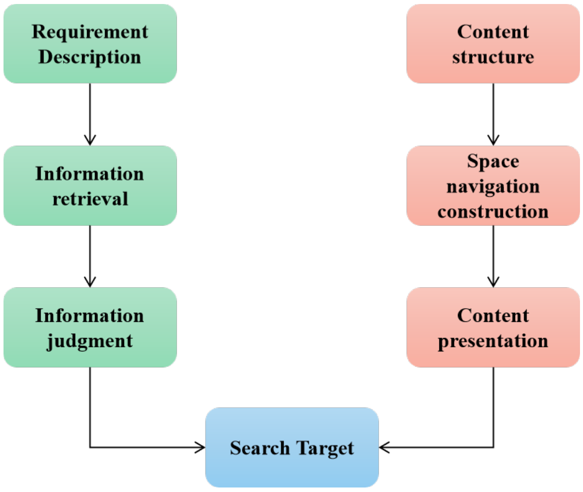


Fig. 3.2: Interactive information retrieval logical relationship

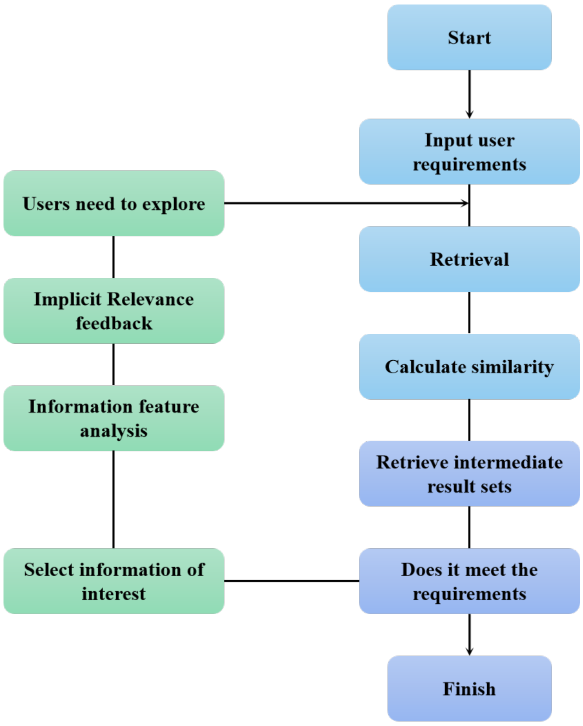


Fig. 3.3: Interactive information retrieval process based on demand mining

We introduce requirements mining conditions and design an interactive information retrieval process as shown in Figure 3.3.

In interactive retrieval systems, information retrieval refers to the similarity matching between retrieval vectors that describe information requirements and different document vectors within the system.

Currently, the cosine of the vector angle is widely used. The calculation formula for measuring the similarity between two documents using this method is:

$$cos(P,Q)=\frac{P\times Q}{|P|\times|Q|}=\frac{\sum\limits_{i=1}^{n}freq(w_i|P)freq(w_i|Q)}{\sqrt{\sum\limits_{i=1}^{n}freq(w_i|P)^2}\times\sqrt{\sum\limits_{i=1}^{n}freq(w_i|Q)^2}} \tag{3.16}$$

In the formula, P and Q represent the vectors of two documents in sequence, $freq(w_i|P), freq(w_i|Q)$ represents the component in the vector, which is the frequency at which the user retrieves terms within this document.

However, in practical calculations, it has been found that the vector angle cosine method has a high computational complexity and cannot achieve fast retrieval targets. For this reason, the Jensen Shannon divergence method is used to compensate for its shortcomings. Calculate the Kullback–Leibler divergence distance between the probability distributions of two document sets, and determine the similarity between documents [16]. If the Kullback–Leibler divergence distance is shorter, the document similarity is greater, and vice versa. The derivation formula for Jensen Shannon divergence is

$$D_{js}=(P||Q)=\frac{1}{2}D_{KL}(P||R)+\frac{1}{2}D_{KL}(Q||R) \tag{3.17}$$

$$R=\frac{1}{2}(P+Q) \tag{3.18}$$

where, $D_{KL}$ represents the Kullback–Leibler divergence of P and Q probability distribution.

$$O=(o_1,o_2,...,o_n) \tag{3.19}$$

According to the Kullback–Leibler divergence theorem, design a probability vector o as in Equation 3.19, then the information entropy of the vector is

$$H(O)=-\sum_{i=1}^{n}o_i\cdot lgo_i \tag{3.20}$$

Regarding the vocabulary set $W=\{w_1,w_2,...,w_n\}, o_i$ can be used as , and the number of occurrences in the document, then

$$o_i=\frac{freq(w_i|o)}{\sum\limits_{i=1}^{n}freq(w_i|o)} \tag{3.21}$$

If information entropy is used to describe Jensen Shannon divergence, Equation 3.17 can be transformed into

$$D_{js}(P||Q)=H(R)-\frac{1}{2}(H(P(w_i))+H(Q(w_i))) \tag{3.22}$$

In the formula, H is the information entropy function, and R is the composite vector of P and Q. The author fully integrates the two strategies of implicit Relevance feedback and demand mining under eye tracking technology, calculates the matching degree of user needs and retrieval results by using Equation 3.22, and completes the intelligence and accuracy of information retrieval while effectively tracking user retrieval preferences.

**3.4. Search engines.** The fundamental idea of an intelligent search robot system is to combine two major internet applications, information retrieval and instant messaging. The most important and common manifestation for information retrieval is search engines, according to the intelligent search robot designed by the author, it also uses search engines to achieve the search characteristics of the system. In this section, we first provide a brief overview of search engines [17].

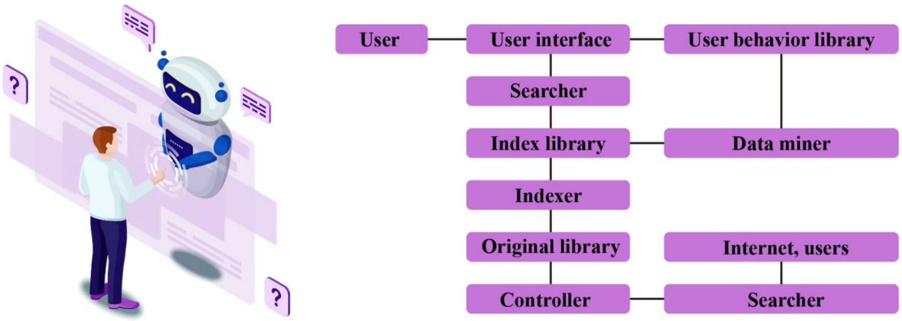


Fig. 3.4: Search engine architecture

Modern large-scale high-quality search engines generally use a three stage working mode for information collection, information processing, and query services.

Information gathering: Each independent search engine has an information gathering program, which is a web crawler for search engines. Web crawlers continuously crawl web pages along hyperlinks. In theory, starting from a certain range of web pages, they can collect the vast majority of web pages. In addition to web crawlers, users can also input information through robots for the search of this system.

Information processing: Search engines need to do a lot of processing work after collecting information in order to provide retrieval services. The most important thing is to extract keywords and establish index files. It should be pointed out that the processing of Chinese also requires the execution of Chinese word segmentation.

According to the above requirements and workflow, the architecture of the search engine is roughly shown in Figure 3.4.

**4. Simulation research.** In order to detect the true information retrieval performance of the proposed algorithm, simulation analysis was conducted, and traditional method 1 and traditional method 2 were compared. Using recall and precision indicators to measure the quality of a retrieval algorithm, recall represents the ratio of the number of relevant documents retrieved to the total number of relevant documents in the system document library, highlighting the comprehensiveness of the retrieval algorithm [18]. The calculation formula is

$$\text{Recall rate} = \frac{\text{Retrieved similar documents}}{\text{All detailed documents in the database}} \tag{4.1}$$

The precision ratio represents the ratio of the number of relevant documents retrieved to the total number of documents retrieved, highlighting the correctness of the retrieval algorithm. The calculation formula is

$$\text{Accuracy} = \frac{\text{Retrieved similar documents}}{\text{Retrieve all documents obtained}} \tag{4.2}$$

The comparison of recall and precision of the three methods is shown in Figure 4.1.

From Figure 4.1, it can be seen that when the recall rate is between 20% and 60%, the traditional method 1 and method 2 exhibit significant precision jitter. However, this method outperforms the other two methods in terms of precision as the recall rate gradually increases. This is because this method uses eye tracking technology to timely capture user retrieval preferences, and this interactive strategy can maximize the accuracy of information retrieval [19].

The message volume of the information retrieval process is the average message volume that meets each retrieval request. This indicator is used to verify the stability of the method's operation, thereby reflecting the efficiency of the method's retrieval. The comparison results of message volume simulation for the three methods of information retrieval process are shown in Figure 4.2.

Therefore, the amount of messages triggered by information retrieval is significantly lower than that of the two literature methods, without adding additional network load. The network system is in a stable operation

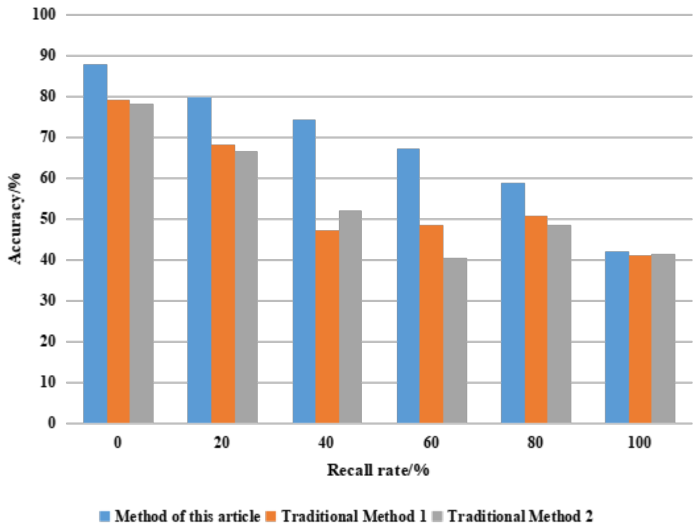


Fig. 4.1: Compare the recall and precision of the three methods

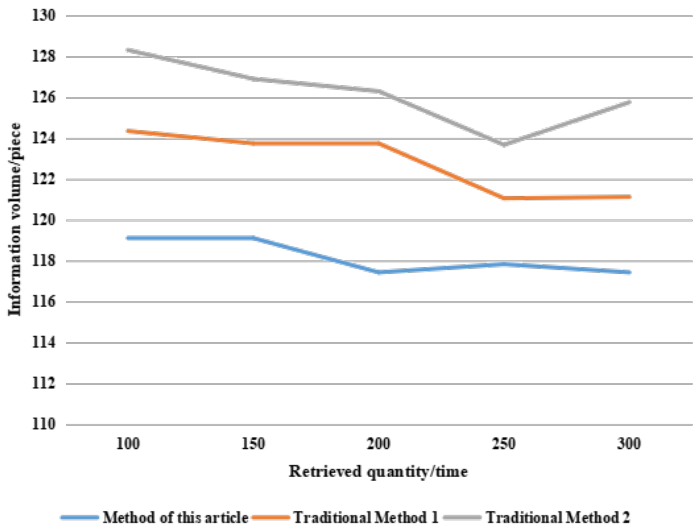


Fig. 4.2: Comparison of the message volume of the information retrieval process

state, and users can quickly grasp their own required information, and the retrieval speed is also improved to a certain extent [20].

**5. Conclusion.** In order to effectively improve the accuracy of interactive information retrieval and provide users with a better service experience, this study combines the theory of human gaze behavior and proposes a new interactive information retrieval algorithm. This method can concentrate on presenting cognitive features in the process of information retrieval, evaluate users' actual retrieval needs, and ultimately present an ideal human-machine interactive retrieval mode, bringing new exploration ideas for future research in the field of interactive information retrieval.

**6. Acknowledgement.** The study was supported by the Education Department of Anhui Province“The Case of ideological and political education in the course of information retrieval”, project number hytyldsr21)”

REFERENCES


[1] Varlamov, O. (2021). ”brains” for robots: application of the mivar expert systems for implementation of autonomous intelligent robots. Big Data Research, 25(ahead-of-print), 100241.

[2] Guo, J. (2021). Research on the application of intelligent robots in explosive crime scenes. International Journal of System Assurance Engineering and Management, 14(2), 626-634.

[3] Hosono, K., Maki, A., Watanabe, Y., Takada, H., & Sato, K. (2021). Implementation and evaluation of load balancing mechanism with multiple edge server cooperation for dynamic map system. IEEE Transactions on Intelligent Transportation Systems, PP(99), 1-11.

[4] Zhu, L. (2021). Research on the design and application of ideological and political education platform in colleges and universities based on moodle. Journal of Intelligent and Fuzzy Systems,98(3), 1-8.

[5] Bian, L., Zhang, J., Cui, Q., Chen, X., & Wang, S. (2021). Research on the realization and application of intelligent iot platform for electrical equipment under industrial internet. Journal of Physics: Conference Series, 1982(1), 012078.

[6] Wei, H. H., Zhang, Y., Sun, X., Chen, J., & Li, S. (2023). Intelligent robots and human–robot collaboration in the construction industry: a review. Journal of Intelligent Construction, 18(8),9180002-9180002.

[7] Santhanaraj, K. K., Ramya, M. M., & Dinakaran, D. (2021). A survey of assistive robots and systems for elderly care. Journal of Enabling Technologies, ahead-of-print(ahead-of-print),97(1),974-976.

[8] Xu, Y., Gao, Y., Liu, R., Li, J., & Zhu, X. (2021). Robots built robots: nanorobots customized by intelligent robot. Crystal Growth & Design,84(5),749-754.

[9] Rahimi, T., Islam, M. R., Gholizadeh, H., Mahdizadeh, S., & Afjei, E. (2021). Design and implementation of a high step-up dc-dc converter based on the conventional boost and buck-boost converters with high value of the efficiency suitable for renewable application. Sustainability, 13(5),99-103.

[10] Zeinoddini-Meymand, H., Kamel, S., & Khan, B. (2022). Design and implementation of a novel intelligent strategy for the permanent magnet synchronous motor emulation. Complexity, 74(8),941-946.

[11] Wisniewski, R. (2021). Design of petri net-based cyber-physical systems oriented on the implementation in field programmable gate arrays. Energies, 14(7),87-89.

[12] Lv, X., & Li, M. (2021). Application and research of the intelligent management system based on internet of things technology in the era of big data. Mobile Information Systems, 2021(16), 1-6.

[13] Jia, J., & He, Y. (2021). The design, implementation and pilot application of an intelligent online proctoring system for online exams. Interactive Technology and Smart Education, ahead-of-print(ahead-of-print),47(7),58-61.

[14] Yang, Y., Xie, Y., Liu, J., Jiang, P., & Chen, Y. (2023). Self-pumping actuation module and its application in untethered soft robots. Journal of Intelligent & Robotic Systems, 108(2),854-865.

[15] C, J. H. A., & B, B. P. (2022). Study the path planning of intelligent robots and the application of blockchain technology. Energy Reports, 8(7), 5235-5245.

[16] A, L. F., A, X. L., A, C. G., & B, B. J. (2021). Path control of panoramic visual recognition for intelligent robots based-edge computing. Computer Communications,987(1),45-49.

[17] Zhou, L., Wang, F., Wang, N., & Yuan, T. (2021). Application of industrial robots in automated production lines under the background of intelligent manufacturing. Journal of Physics: Conference Series, 1992(4), 042050.

[18] Zhao, M., Mao, Y., Hen, Q., & Zhou, Y. (2021). Research on problems and countermeasures in the application of substation intelligent inspection system. Journal of Physics: Conference Series, 1983(1), 012084 (7pp).

[19] Kandlhofer, M., Steinbauer, G., Lassnig, J., Menzinger, M., & Szalay, I. (2021). Edlris: a european driving license for robots and intelligent systems. KI - Künstliche Intelligenz,74(3),98-103.

[20] Yang, R., Mo, Q., Li, Y., Liu, Y., & Hu, R. (2021). Application of 3d vision intelligent calibration and imaging technology for industrial robots. Journal of Physics: Conference Series, 2082(1), 012004.


*Edited by:* B. Nagaraj M.E
*Special issue on:* Deep Learning-Based Advanced Research Trends in Scalable Computing
*Received:* Dec 25, 2023
*Accepted:* Mar 18, 2024