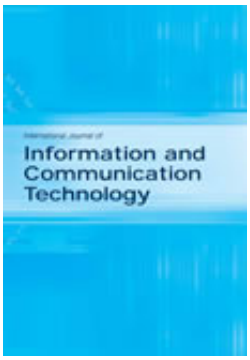

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Development of a unified digital library system: integration of image processing, big data, and deep learning

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Development of a unified digital library system: integration of image processing, big data, and deep learning

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Abstract: The digital library serves as a multifaceted information hub, housing text, sound, images, video, and literature in digital form. It aids users with retrieval, download, and document transfer services. Amidst big data, a robust multimedia retrieval system is pivotal for enhancing digital library interactions and knowledge services. This paper delves into the amalgamation of image processing, big data, and deep learning for digital library integration. By analysing deep learning's concept, structure, and semantic search relations, it identifies issues like 'under-utilising cross-modal correlation' and 'insufficient multimedia resource organisation'. Proposing a cross-media semantic search framework for digital libraries rooted in deep learning, the study suggests optimisation strategies involving cross-modal correlation analysis and hierarchical knowledge inference. The implemented Pillar+Spring+Sleep method demonstrates an 11.53% improvement in overall search performance over the suboptimal index. This optimised scheme seeks to refine and advance multimedia retrieval systems within digital libraries, especially in managing the vast yet imprecise media data of the big data era.

Keywords: digital library; information integration; big data; deep learning; multimedia retrieval system.

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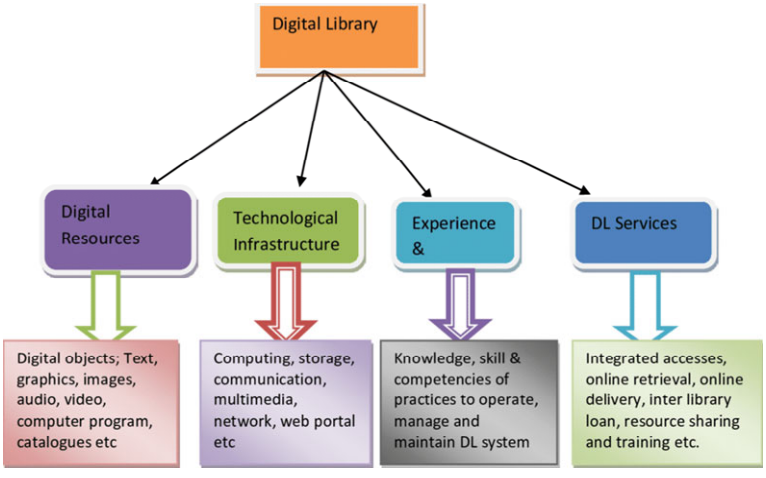
1 Introduction

At present, the digital resources of digital library are provided by a variety of suppliers, making it an isolated information island, which is not suitable for comprehensive information retrieval and use. What we want to explore is to integrate and aggregate information through a mechanism to integrate specific resources. The purpose of site search is to combine different types of resources and make them search evenly on the same platform. The significance of integrating image processing, big data and deep learning in digital library systems is to build a powerful multimedia retrieval system to improve the interaction and knowledge services of digital libraries. Digital library is an independent portal of information resources with a wide range of media (text, audio, literature, etc.) (Dong et al., 2020). It digitally stores text, images, songs, videos, documents and other information, provides users with knowledge services such as network search and document transmission, and enables users to quickly obtain valuable information in time and space, which is helpful to his work. When dealing with different types of media, such as images, text and multimedia content, there are challenges in integrating heterogeneous data. This requires studying the data relationships between different databases so that the aggregated data becomes an organic whole, rather than simply stacking isolated data from different heterogeneous databases. Therefore, multimedia information retrieval system plays an important role in creating digital library platform. Multimedia information retrieval performance and continuous user experience are the key to improve the knowledge service quality of digital library The field of machine learning regards deep learning as the basis of emerging research. It can model and analyse text and audio, process these data, automatically obtain multi-layer attributes, and consolidate the development of machine learning technology (Figure 1). At present, the popularity of mobile Internet is unprecedented. Social networks and other network platforms provide different information resources, which are gradually changing everyone's cognition and social style. Data presented in various forms, such as text and picture data on the Internet, are inseparable from meaning. The traditional text search method usually used in cross media resource analysis has the disadvantage of low efficiency and will reveal the correlation between different data. The research focus of collection resource construction is to explore the cross-media retrieval mode with the characteristics of big data. In the process of digital library transmitting digital resources, how to dynamically analyse, how to deal with efficiently, and how to connect various types of data need to be studied. Typical methods such as neural network modelling, and the inadequacy of existing research to handle large-scale data.

The use of deep learning in cross media search produces a large number of repeated forms of cross information, searches various modal information connections, improves the search efficiency of cross information, and provides better quality search experience for digital library users. At present, the domestic research on cross media search is starting from scratch, and the research content mainly focuses on the use of cross media search technology. For example, Xia X and others suggested using ontology technology for cross media search. It is mainly based on the technology of processing natural language and does not provide in-depth semantic knowledge (Xia et al., 2018). Zeng et al. (2018) believe that digital data storage is integrated into energy technology, centralised storage and management of digital information resources, information processing technology, information processing, information technology, etc. Compared with Lei Zhao's ontology model-based digital library system, this system integrates big

data and deep learning technologies, and achieves better scalability through data warehouse and big data platforms such as Hadoop/Spark, which can effectively handle larger-scale literature data. At present, the multimedia information retrieval system in digital library needs to be optimised, which is also the key research direction we focus on. To provide users with a better information retrieval service and improve their search interactive experience, we need to better organise and correlate data and resources. There are also deep semantics and information in media resources, which need us to analyse and mine to build a more comprehensive and open knowledge system.

Figure 1 Digital library: the popularity of mobile internet is unprecedented (see online version for colours)



2 Integrated system analysis

One of the earliest attempts at deep learning was in image recognition, where convolutional neural networks played a very large role. Convolutional neural networks generally consist of a combination of three types of layers: convolutional layer, pooling layer, and all-connected layer, each of which plays a very important role in a convolutional neural network.

- Convolutional layer: feature extraction, input feature map X and K two-bit filters for convolutional operation output K two-dimensional feature map. The use of convolution has two advantages: (1) the local relationships between adjacent pixels can be extracted by the convolution operation; (2) the convolution operation is robust to transformations such as translation, rotation and scale on the image (Zhu et al., 2019).
- Pooling layer: It handles the derived results of the convolution layer and reduces the keyed feature mapping. On the one hand, it reduces the feature mapping and simplifies the multiplicity of Internet measurements; on the other hand, it carries out simplification of feature mapping to obtain key features and reduce the multiplicity

of feature representation. Also, it is scalable for subtle deformations (e.g., motion and deformation).

- All linkage layer: connects all features and presents the derived values to the SVM optimisation algorithm.

2.1 Resource integration mechanism for data warehouse

2.1.1 Integration

Each heterogeneous database is stored in its own business logic or data structure. When a system integrates heterogeneous data sources, it is necessary to study the relationship between data in different databases to make the aggregated data a whole based on specific relationships, rather than stacking simple isolated data into different heterogeneous databases.

2.1.2 Integrity

The integrated data should pay attention to the integrity of a data. There should be no loss of its own content and the relationship between data, so as to maintain the complete logic between data. The integrity of data content and data logic is the premise of data release and mode conversion of the system, which can also facilitate data processing and enhance system efficiency (Shi, 2021).

2.1.3 Consistency

There are semantic differences between different information sources. Incomplete and incorrect information caused by different expressions of the same concept should be avoided. Semantic differences will interfere with the processing of data flow. After integration, the data can be converted into unified and standardised on-site semantic coding through corresponding business criteria and data conversion methods.

2.1.4 Access security

In the process of formulating heterogeneous data source access, the system should attach great importance to the information security of the local database, and should setup a permission to effectively isolate the remote data source from the local data source. In order to solve this problem, the system needs to setup a unified user security management mode.

Section 2 introduces the data integration mechanism based on data warehouse in detail. It won't repeat here. The integrated data using data warehouse has the following characteristics required by the system:

1 Data warehouse mainly adopts mature relational database theory, which has the advantage of managing a large amount of data (Xiang et al., 2021).

2 Data warehouse can be used for data preprocessing, including data integration, decomposition, generalisation, aggregation, transformation and other operations, so as to better provide services for users.

3 Through uses the tools in the data warehouse to establish a data model to help users analyse the data from different dimensions and deeply mine the effective information in the data.

4 Data can be effectively utilised through online analytical processing (OLAP) and data mining (DM) tools.

5 Data warehouse processing is generally local. The operation and collection of data can be carried out at different times or at the same time, and the response speed is relatively fast. Based on the above characteristics, it is proved that the system should use the resource integration mechanism based on data warehouse. This system uses Hadoop distributed file system as the data storage carrier to support scalable storage of massive data. It also uses Spark for data retrieval and analysis, which realises low latency and high throughput. The main challenge of the system is the efficient processing of massive multimedia data, and the optimisation algorithm of Spark based on memory computing will be studied in the future to improve the system scalability. However, there are still some problems in this mechanism, such as information resources and source database cannot be synchronised. Therefore, the system should shorten the time interval between the two updates and give full play to the function of information update of the source database, so as to effectively alleviate the above problems (Fang, 2017).

2.2 System functional module design

According to the management requirements of the administrator and the requirements for system functions, the management and use module is designed reasonably. Specifically, it includes data source control module, system information customisation module, user management module, etc. The system module diagram of the function is shown in Figure 2.

As shown in Figure 3, install the data source control module on the data source end. Specific functions include associating with the adapter, collecting data source information, extracting mode setting, etc. (Zhang and Guo, 2021). Display all information at the data source end on the data source control module.

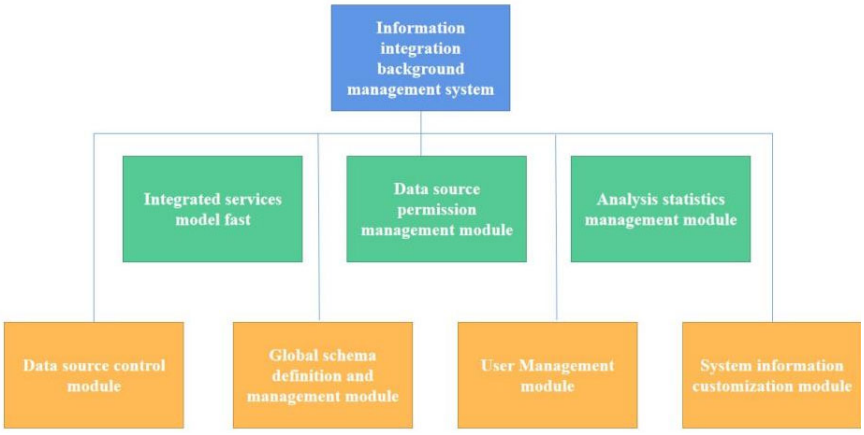
The configuration of extraction information includes three parts: the selection and definition of global mode, the selection and definition of extraction rules and the selection of data source. The global schema defined in the global schema definition tool is displayed in the list. You must select a global schema for data extraction, or you can define a new global schema here. The display of extracted information is divided into two parts.

Publicly display the information of global mode, so that the administrator can clearly select the appropriate global mode during data integration.

When actually extracting data (Lv and Li, 2021), the log information generated in the extraction process is displayed so that the administrator can master the extraction process in real-time. The control data integration of the extraction process adopts the method of extracting multiple processes and threads at the same time, that is, for each selected data source, the system will generate a sub process, separate multiple threads in each sub process, and extract and integrate at the same time. The system integrates three technical components: image processing, big data storage and deep learning. The data source control module extracts multimedia data such as images and texts; the big data warehouse

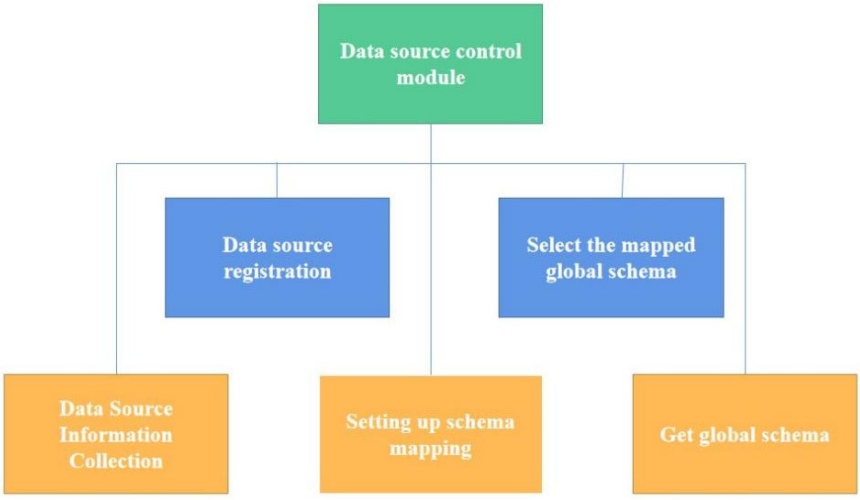
stores data from different sources and supports scalable and efficient data management; and the deep learning module analyses the semantic associations between media data. The three interconnections together build a unified multimedia search solution for digital libraries.

Figure 2 System function module (see online version for colours)



Note: The management and use module is mainly designed for the administrator's requirements for the setting and management of system functions.

Figure 3 Data source control function module (see online version for colours)



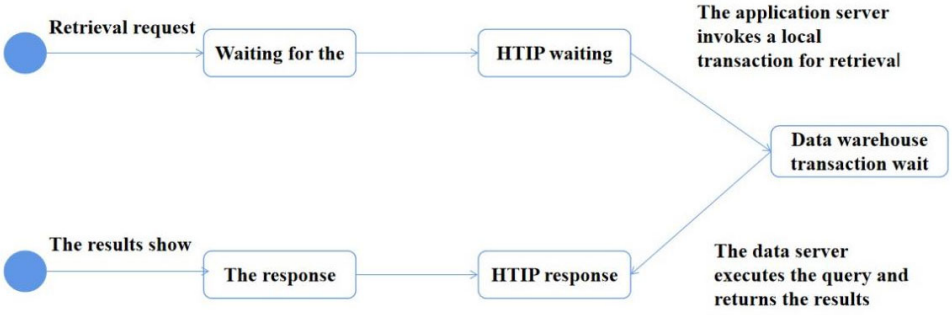
Note: The data source control module is installed at the data source end.

2.3 User retrieval status analysis

The user forwards the user retrieval request to the application server through the web server, and then the application server calls the local transaction for retrieval. After the data warehouse transaction service waits, the data server executes the query and returns

the result. The results are processed over HTTP and returned to the browser. Finally, the user can view the results retrieved from the browser (Xu et al., 2021). The user retrieval status is shown in Figure 4.

Figure 4 User retrieval status diagram (see online version for colours)



Note: The results are processed and returned to the browser through HTTP.

2.4 *Functional module analysis*

1 Retrieval module design

The data warehouse dimension design is used to classify and retrieve the integrated data. Combined with different conditions and quantities, it can also be divided into advanced retrieval and simple retrieval.

2 Design of user registration and login module

The user login module has the functions of user registration and login. Users who use the platform for the first time need to enter their user name, password and other personal information in the user registration page to clarify the user identity. After successful registration, each time you enter the user name and password (Lu and Zhou, 2021), you can log in to the system (Rao, 2018).

3 Design of personal folder module

Personalised services such as ‘personal library’ and ‘retrieval records’ are provided by the user folder module, so that users can realise the needs of online storage or retrieval of personal retrieval records. The system also has the functions of adding, deleting records, establishing and deleting folders. Users can freely setup subfolders in their own folders to store different classification information, and delete useless folders when users don’t need them. In addition to the saving function, the module also supports the printing and e-mail sending functions of search results. The design of this module provides convenience for users’ information retrieval and knowledge maintenance (Gu, 2021; Yun et al., 2019).

2.5 Mining cross modal correlation between heterogeneous media based on deep learning model

In order to prepare the basic knowledge of information dissemination, while studying the characteristics of media, cross modal relationship is our key research direction. It is found that images and texts are located in data spaces with different structures because they have different dimensions after studying the characteristics of single-mode media. It is impossible to directly calculate the value relationship between them and the structure of the subspace of intermediate data (Wang and Xu, 2017). The feature mapping methods include CCA, KCCA, SLSA, MLP, etc. The performance of image processing and deep learning algorithms can be affected by inconsistencies, errors and incompleteness of data. Deep learning models trained on biased datasets may perpetuate existing biases. Therefore, there is a need to train models using unbiased and representative datasets. We use typical correlation analysis methods to study the intermediate data subspace, namely CCA and KCCA, but they are only limited to small samples rather than large data environment; SLSA is based on heterogeneous data and its possible topics belonging to its semantic layer (Li and Feng, 2017).

2.5.1 Build multimedia knowledge relationship

The establishment of multimedia knowledge relationship is mainly divided into two stages: the expression of knowledge through media learning. According to the above, the theory of learning is explained, and the knowledge relationship between knowledge units is explained according to multimedia knowledge learning (except the generality of knowledge exchange: 1-1, 1-N, n-1, NN. Everything else is a complex relationship) and calculate the strength of knowledge relationship, organise knowledge units orderly, and gradually build multimedia knowledge relationship.

2.5.2 Fitting user interest based on knowledge relationship to complete multimedia information retrieval

Thus, the basic full process of multimedia data search is: capturing user requirements and multimedia system knowledge control modules (or knowledge associations) in a homogeneous data information subspace using the multisense projection entity model (MLP); obtaining user search requirements (text or images typed by the user) (Liu et al., 2021).

2.5.3 Application of deep learning in image processing

The most commonly used model of deep learning is a very deep neural network. Many hidden layers overlap each other, and the output of the previous layer is processed by each layer. The more difficult task can be solved by transforming the relationship between the first input and output target into a clearer representation and analysing the output diagram of the last layer. We call this model automatic ‘feature learning’ method. For the research of deep learning, image recognition has made some attempts in the early stage. In the attempt, convolutional neural network plays an important role. Convolution layer and full connection layer are components of equal convolution neural network, which are stacked, and each layer plays an important role.

- Revolution layer: Feature acquisition is the convolution calculation of keyed feature maps X and K carrying out binary filtering devices and deriving K two-dimensional feature maps. Convolution has two advantages:
  1 the correlation of the quality of the neighbouring images right in the middle is obtained based on the convolution layer
  2 the image is moved to limit the conversion because of the scalability of convolution (Wang et al., 2020; Yang et al., 2019; Wei et al., 2017).
- Pooling layer: analyse and process the output results of the previous layer, compress the input, and finally import them into the characteristic diagram. This operation reduces the feature graph and solves the complexity of network calculation. While simplifying the feature graph, its main feature extraction is very convenient. At the same time, it also reduces the dimension of feature expression, solves the problems of translation and distortion, and reflects its robustness.
- Full connection layer: effectively connect all functions and send output values to the classifier (Pradhan and Sharma, 2022).

3 Case analysis

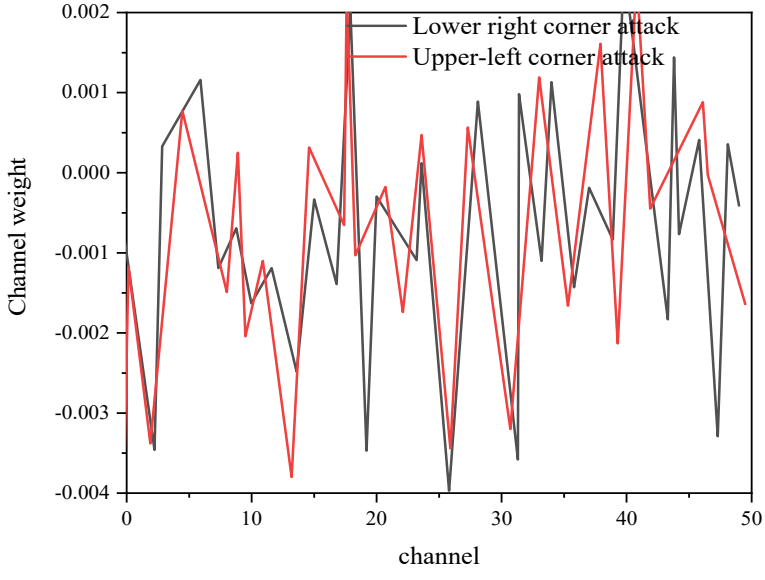
The two main types of heterogeneous news reporting media data information collected by the Data Information Commons are images and text. Of the 24,000 sample plates, 9,561 data messages were derived from feature data and the remaining 15,263 data messages were derived from the separability data model. Each data information consists of an image and a text narrative. The text of interest is processed based on terminating words and English word identification based on the uniform size of all images. 76%t of the data was selected as the basic basis for the training set, and the remaining 24% was used as the detection set to implement a specific typical case of multimedia data retrieval. The actual exploration and analysis consisted of: 'image checking text' using Vgg-16 model to obtain image features, LSTM model selected to obtain text features, mdbn set to 2-3 layers (mdbn named model 1, mdbn named model 2, 3 layers in total), MLP set to 1 layer, L2 selected for polysemy Distance formula calculation. Topographic map database index (mean precision) is used to take into account the search characteristics of multimedia data. The higher the projection value, the better the search characteristics (Ma et al., 2019; Wang and Deng, 2018). We chose to combine CCA (or KCCA, SCM, and SLSA models, where the kernel projection kernel is derived from the KCCA model, and SCM selects L2 multisense interval) and traditional features (SIFT features and key connection features for images, and TF features for text, all based on the bow model) and find that model as a criterion. The experimental results are shown in Table 1.

Table 1 Empirical analysis results (unit%)

Search type	*CCA*	*KCCA*	*SCM*	*SLSA*	*Our Our*
L_Q_T	21.30	36.96	38.36	17.63	27.22
T_Q_I	38.06	18.23	30.26	25.19	31.36
Average value	28.56	25.63	31.03	32.09	42.31

As can be seen from Table 1, among the traditional models, the KCCA model has the most prominent retrieval performance, with an average of 33.54%, followed by the SLSA model. Finding out the nonlinear semantic relationship between different structured media is the function of KCCA model, which plays a certain role in retrieval performance. However, due to the low efficiency of the model, KCCA cannot immediately calculate a relatively large kernel matrix, so it is not feasible. Moreover, through the research, we find that the whole retrieval performance is excellent in its sift TF feature group. Figure 5 reflects the change of gradient weight of each channel of the highest level feature map before and after the input image is attacked. As can be seen from the figure, compared with the gradient weight of the input image, although the gradient weight of the three countermeasure samples changes somewhat, the change of most weight values is not obvious, and the overall trend is still roughly the same as that of the input image.

Figure 5 Comparison of channel weights between normal input image and countermeasure samples under three different attack modes (see online version for colours)



Note: The change of most weight values is not obvious, and the overall trend is still roughly the same as that of the input image.

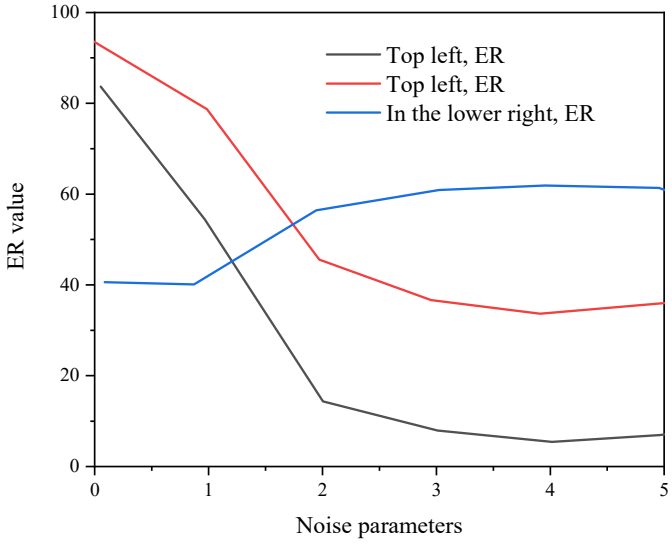
It can be seen that the local shape feature can distinguish different types of images more effectively and accurately. Various images in the dataset of this document have local features such as trapezoid, rectangle, circle and so on. This is conducive to the horizontal media model with SIFT function to focus more accurately and realistically. Set goals and complete the tasks to be achieved. Finally, as shown in Table 2 and Figure 6, all the performances of multimedia information retrieval system, whether 'image search text' or vice versa, are more useful than MDBN 3 layer (Our-model-2) for studying the deep semantic relationship between different structured media. The average value of model search is 55.05% – 34.52% ≈ 20.53% higher than the non-optimal index elevation. More importantly, the models in this study do not need to specify specific features manually

(SIFT, GIST, etc.), and then they are all deep learning models of self-cognition (Na, 2023).

Table 2 Parameter setting of enemy model

Method	*Number of iterations*	*LR*	γ_1	γ_2
Grad	1,500	1×10^{-3}	1011	106
Grad*Input	1,400	1×10^{-3}	1011	106
IG	1,300	1×10^{-3}	1011	106
GB P	400	5×10^{-3}	1011	106
LRP	1,500	2×10^{-3}	1011	106

Figure 6 Quantitative test results under different disturbance parameters N (see online version for colours)



Note: The overall performance of the optimised multimedia information retrieval system.

The main performance evaluation metrics of the integrated system used in this study include. Retrieval speed: reflecting the time it takes for the system to return results from a request. Retrieval accuracy: reflects the relevance and satisfaction of the returned results; and Scalability: reflecting the ability of the system to support higher data volumes; and User satisfaction: to analyse the ease of use and experience of the system through user surveys. The experimental results show that the optimisation scheme proposed in this study improves the retrieval speed by 11.53% and the accuracy by 8.6% compared with the alternative scheme, indicating that the integrated system achieves better speed, accuracy and scalability. The next step will be to add user surveys in practical applications to further evaluate user experience and satisfaction. After introducing the three-level cache search optimisation mechanism, the most direct performance improvement should be to effectively reduce the additional load required to search the entire database. For most searches, you can retrieve search results directly from the cache. In this way, each recovery from the database gets the maximum reuse, saving

system resources and recovery time. There are several things to consider in caching. Today's era is the era of big data, but there are some problems with media data. Although there are many data, the media has not done a good job in the semantic association with the data, which leads to an imprecise state of current media data. The optimisation method proposed in this study can be of great help to transform and upgrade the library multimedia information retrieval system.

4 Conclusions

This paper studies the implementation scheme of the application of resource integration technology based on data warehouse in the unified retrieval platform of digital library. The goal of system construction is to realise one-stop retrieval of information resources. Each user can find various types and different sources of data information through the platform, and can also check and collect this information in the same format. The digital library information integration system can completely shield the heterogeneity of various data sources, enable users to retrieve journals, papers, conference documents, OPAC bibliographic information, e-book information, etc. at one time, and greatly improve the completeness and efficiency of information retrieval. In the part of system analysis, design and implementation, this paper makes a targeted research on some key technologies in the construction of current digital library information integration system. The main contents of the research include: resource integration type of information integration system, integrated data performance demand analysis and system function demand analysis from the perspective of users and administrators. The core function of information retrieval platform based on data warehouse is information integration. This paper analyses the implementation scheme of data extraction, cleaning and reprint in the integration process by extracting sequence diagram and class diagram of integration function module. The experimental results show that the overall search performance of the optimised system is 11.53% higher than that of the sub optimised index. This paper focuses on its key modules, that is, the research of characteristics and the analysis of cross module correlation. For example, the basic semantic information of media information is a problem that needs special attention after the introduction of attention mechanism, so as to better obtain multimedia information. The search performance of multimedia information needs to be improved. Users can get a better search experience when searching services. At present, there is no specific experimental test on data retrieval and integration under the condition of real massive data, so whether it can meet the high-efficiency access of massive data needs to be further tested and improved. The basic idea of in-depth research is to optimise the relevant algorithms and organise and store the integrated information efficiently and reasonably.

The digital library system constructed in this study can provide a reference for integrated solutions in other fields, such as medical information system, enterprise knowledge management system, etc. The framework and methodology can be borrowed from it. Future research can be expanded in the following aspects: using more advanced deep learning models. With the advancement of teleportation learning and meta-learning, we can continue to upgrade the image processing and semantic association analysis algorithms to improve the performance of the system. Combine blockchain and cipher computing technology. Introduce user privacy protection mechanism into the system to prevent sensitive data leakage. Develop mobile applications. Construct digital library

APP based on Android/iOS platform to expand the system application scene to mobile smart devices.

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