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Evaluation of the efficacy of an intelligent art therapy platform based on fuzzy logic algorithm for mental health intervention for children with hearing impairment

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Abstract The synergistic development of compulsory education and technology makes the education of children with special needs gradually receive extensive attention from the society, and how to help children with special needs realize effective mental health education has become a research hotspot. Starting from the factors affecting the mental health of children with hearing impairment, this paper constructs an intelligent art therapy platform for the mental health intervention of children with hearing impairment by combining art therapy and intelligent interaction design strategies. In this platform, the fuzzy logic algorithm is used to establish an intelligent retrieval model of painting information, which is combined with the vector space model to realize the keyword weighting, so as to improve the retrieval efficiency of children with hearing impairments on the information of art paintings. Then, a clinical experiment was designed based on the intelligent art therapy platform to reflect the feasibility of the application of the intelligent art therapy platform by comparing the mental health intervention effects of hearing-impaired children in the experimental group and the control group. The experiments showed that the average retrieval time of 500 documents by the fuzzy logic-based information retrieval method for paintings and artworks was 5.67 ms, and the scores of the experimental group were higher than those of the control group in the areas of auditory assessment, speech intelligibility, thematic dialogues, pictorial speech, auditory demonstration, and imitation of sentence length (P<0.05), and the scores of the experimental group in the areas of self-consciousness and social adaptability were significantly different than those of the control group before the intervention (P<0.05). The combination of intelligent technology and art therapy can provide new research findings for mental health intervention for children with hearing impairment.

Index Terms fuzzy logic algorithm, intelligent art therapy platform, hearing impaired children, mental health intervention

I. Introduction

Compared to normal children, children with hearing impairment have hearing deficits, which may make it more challenging for them to receive information from the outside world, leading to slower learning progress [1]. However, this also means that they are less exposed to external interference, have a purer inner world, tend to express themselves intuitively, and tend to have a higher degree of observational acuity [2]-[4]. Through the development of related art activities, they can firstly observe and feel the objects, improve their learning ability, and also improve their interpersonal skills through communication with teachers and other partners [5]-[7]. In this way, they can also cultivate an optimistic mindset and eliminate bad emotions in the continuous progress of related art skills [8]. Therefore, teachers should pay attention to the application of art activities in the intervention of children with hearing impairment, and promote the comprehensive growth of children with hearing impairment with the help of art activities [9].

In today's increasingly diversified learning subjects and participation methods of the intelligent platform, the further development of special teaching programs oriented to art therapy has become a necessity. Therefore, based on the cultural resources of the intelligent platform, art therapy for hearing-impaired children itself also contributes to the functional development of the intelligent platform [10], [11]. And in the intelligent platform environment, the use of its rich cultural content and art forms can reduce the psychological defenses of children with special needs and form authentic emotional expression [12], [13]. The intelligent art therapy platform can also promote the formation of positive social interaction and interaction between children with special needs and teachers, and use culture and art to calm their hearts [14], [15]. However, in the process of specific practice, teachers still generally lack a mature model to effectively utilize the intelligent art therapy platform to promote various aspects of children with hearing

impairment, and there is an urgent need to establish a mental health evaluation model for children with hearing impairment.

A large number of scholars have explored the role of art therapy methods in improving the self-efficacy and mental health of children with special needs, with a view to providing new ideas for the rehabilitation of children with special needs. Literature [16] introduced art therapy interventions into the school education process for children with special needs, which effectively improved the quality of life of the children, and at the same time, focused on improving their psycho-emotional and behavioral abilities. Literature [17] points out that children with special needs exhibit higher mental health risks compared to their healthy peers, and that the development of creative media-based art programs as a therapeutic tool has an important role to play in improving the physical and mental health of children with special needs. In the area of music therapy, literature [18] investigated the improvement of the psychological state of children with special needs by a music therapy method based on performance training, which achieved positive therapeutic results in children with autism as an example. Literature [19] shows that the educational environment has an important impact on the mental health of children with special needs, and the music therapy method improves the mental health of children with special needs and enhances the effect of education by arousing their physiological and psychological resonance. In terms of dance therapy, literature [20] outlined the positive effects of dance education as an alternative therapy on children's physiology and psychology, and found that dance exercise not only increases children's physical activity, but also serves as a medium of movement to improve their psychological state. Literature [21] examined the benefits of dance programs for children with special needs in terms of physical, cognitive, and psychosocial aspects; dance programs trained children with special needs in motor skills on the one hand, and improved their mental health and social cognition on the other. Regarding painting therapy, literature [22] analyzed the effectiveness of painting art therapy in addressing mental health disorders in children with special needs, and empirical investigations found that painting therapy was beneficial in relieving their anxiety and had sustainable therapeutic effects. Literature [23] proposed a mandala painting therapy that combines painting art and psychotherapy, pointing out that the therapy helps regulate the psychological state of children with special needs, while actively developing their cognitive and social skills, and providing effective assistance for the education of children with special needs. In summary, art therapy is a more intuitive intervention method, and the application of art therapy by teachers is not only in line with the actual emotional needs of children with special needs, but also contributes to the smooth development of psychological counseling, however, in the face of the special challenges of hearing-impaired children, relevant research needs to be further advanced.

This paper proposes an intelligent art therapy platform based on fuzzy logic algorithm, which mainly utilizes the fuzzy logic algorithm to transform the query demand for information about art paintings and drawings of hearing-impaired children in the intelligent art therapy platform into a fuzzy query expression form, including keywords and query conditions. Then the vector space model is introduced to sort the keywords' weights, so as to improve the efficiency of children with hearing impairment in retrieving information about art and painting works. In order to evaluate the effectiveness of the intelligent art therapy platform in intervening the mental health level of hearing-impaired children, this paper designs a clinical comparison experiment. It mainly analyzes the changes in auditory-verbal ability, self-awareness and social adaptability of hearing-impaired children under the intelligent art therapy platform.

II. Intelligent art therapy platform for children with hearing impairment

The lack of speech and hearing makes the psychological development of children with hearing impairment not sound enough. In order to improve the psychological health of children with hearing impairment and enable them to integrate into normal social life, it is of great significance to improve the psychological health of children with hearing impairment through art education therapy. In order to improve the mental health of children with hearing impairment and enable them to integrate into normal social life, it is important to enhance the mental health of children with hearing impairment through art education therapy. The role of technology in art therapy is fully emphasized, and the introduction of an intelligent art therapy platform is used to assist children with hearing impairment in drawing therapy, so that children with hearing impairment can be guided to come into contact with their surroundings and the beautiful things in their lives, and be inspired to express and create beauty.

II. A. Relevant theoretical knowledge base

II. A. 1) Mental health of children with hearing impairment

Hearing impairment is a disability in which hearing is damaged or absent due to congenital genetics or acquired causes, also known as hearing loss, and can generally be categorized as deaf, hard of hearing, weak hearing, etc., depending on the degree of hearing loss. In addition, children aged 12 and above who are enrolled in schools are selected based on research needs and the children's own circumstances. Therefore, hearing-impaired children are

disabled people aged 12 to 18 years old who are attending school with impaired or missing hearing due to congenital or acquired reasons.

The psychological health of children with hearing impairment is affected by many factors, which can be said to be the result of a combination of multiple factors, including the internal characteristics of individuals and external influences [24]. Internal characteristics involve both physical and psychological aspects, and external factors are mainly family factors. Among them, internal factors play a dominant role, while external factors are centered on children with hearing impairment, and the study of the general environment that affects their growth, thus promoting the formation of internal characteristics, and the impact on individual development should not be underestimated. Therefore, in the education of children with hearing impairment, it is necessary to promote the positive role of internal factors on the basis of family education to help children with hearing impairment to improve their mental health, self-knowledge and acceptance of themselves.

II. A. 2) Manifestations of psychological problems in children with hearing impairment

The special physiological characteristics of hearing-impaired children lead to an imbalance in their psychological development and greater difficulties and psychological deviations in social cognition, learning and interpersonal communication. The psychological problems of these children mainly include the following aspects:

(1) Emotional problems. Due to their hearing defects, hearing-impaired children have difficulty in accurately recognizing changes in the outside world and lack correct cognition of external things, which is somewhat different from the development of normal children. Vision is an important part of hearing impaired children's cognition. In daily life, children usually concentrate on observing things in the outside world, and their performance is too quiet and focused, which easily creates a dull stereotype of the outside world and triggers discussions in the outside world, and even undesirable behaviors of pointing at the uninitiated crowd. Children's self-esteem is seriously damaged when they receive abnormal stares and comments from the outside world for a long period of time. In order to avoid external discussions, they become more reticent and develop the undesirable psychological problems of isolation and timidity. At the same time, this type of children are very observant, once they feel the external bad signals, they will produce anxiety and inferiority complex, which will have a serious impact on their own psychological development.

(2) Interpersonal communication disorder. Hearing impairment affects normal social and interpersonal interactions, resulting in poor communication skills, inability to smoothly integrate into peer groups, or even be talked about by others, resulting in low self-esteem and fear of the psychological state. Afraid of being rejected by the outside world, children usually choose to socialize with other children with hearing impairment, and in a long-term vicious circle, they are constantly alienated from normal children. In addition, in terms of learning, due to the physiological problems of this type of children, they cannot pronounce words well, have difficulty in understanding knowledge, and are unable to communicate normally with teachers or classmates. Moreover, they need to maintain concentration for a long time and are prone to nerve fatigue, which prevents them from mastering the classroom knowledge skillfully. The worsening of the learning difficulty problem will also cause children to lose their desire to learn, which will have a negative impact on their own development.

(3) Psychological Seeking Disorder. Due to their developmental deficiencies, children with hearing impairment are easily rejected by the outside world and their peers, and they are in a state of being despised by others for a long time, and they have more needs at the psychological level than normal children, and they are eager to be paid attention to and valued. As a result, they usually have a strong dependence on their families. If parents unconditionally meet the needs of their children in education, the children's dependence will deepen, which will have an impact on their personal development. At the same time, neglecting the child's needs too much can lead to stubbornness and capricious behavior.

II. A. 3) Advantages of using art therapy

Art therapy is a nonverbal psychotherapeutic method of treating patients through the interaction of the painter, the painting, and the therapist, with the creation of the painting as the mediator, and ultimately the treatment of the patient [25]. Studies have shown that the right brain is responsible for image thinking and processing activities related to nonverbal language, and the left brain is responsible for emotion, music, and art. There are differences in the division of labor between the right brain and the left brain, resulting in the need for individuals to deal with coping with emotional and affective trauma or psychological trauma in appropriate ways. The healing mechanism of action of the art of painting is shown in Figure 1. Painting art can present emotions and feelings in a visual way through symbols, which is conducive to dealing with emotional and affective trauma. Therefore, painting art has obvious effects on emotional control, and it is feasible and necessary to use it in mental health intervention for children with hearing impairment.

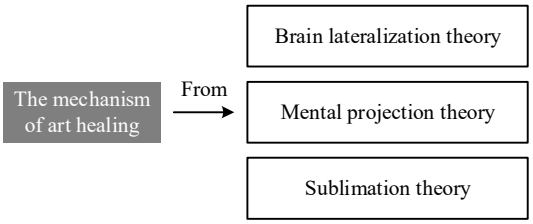

Figure 1: The healing mechanism of painting art

Traditional psychotherapy is mainly based on face-to-face interviews, in which children with hearing impairment are often defensive and resistant, unable to accurately describe the psychological problems they are experiencing, and the counseling teacher may easily miss the good opportunity to provide counseling. Painting art therapy can truly express the inner world of children with hearing impairment. The size of the painting, the weight of the lines, the color combination, and the setting of the composition all have specific representational meanings, which are all conveying the individual information of the children with hearing impairment. By interpreting the paintings of children with hearing impairment, the counseling teachers can understand the inner feelings and problems of children with hearing impairment, and give them timely assistance to promote their healthy growth.

II. B.Intelligent Art Therapy Platform

II. B. 1) Intelligent Interaction Design Strategy

In order to enable children with hearing impairment to have a better emotional experience in the process of mental health intervention, it is necessary to fully introduce interaction design strategies to help children with hearing impairment to establish touchpoints for contact between people and Internet products, fully emphasize the sense of user experience for children with hearing impairment, and consider the special physiological, psychological and behavioral characteristics of users.

The intelligent interaction design process for hearing-impaired children includes two basic interaction modes, i.e., the professional guidance interaction mode and the multi-role participation interaction mode, which are integrated into the intelligent art therapy platform to further enhance the ability of hearing-impaired children to perceive the art of painting, and also enable them to improve and exercise their language application skills in the application process.

(1) Introducing a new mental health intervention method to train with interactive dynamic presentation to solve the contradiction between two different subjects. We analyze and summarize the contradiction between the performance characteristics of the hearing impaired children, the actual needs of the participants and the goal of mental health intervention. The interactive dynamic video presentation increases the sensory experience of the hearing impaired children and improves the fun of the training process.

(2) Creative development of visual support methods for guiding the practice of drawing art. Based on the behavioral system characteristics and cognitive function characteristics of hearing-impaired children, we have explored the needs of user interaction product design, and proposed a painting art strategy that is dominated by hearing-impaired children, assisted by participants, and supported by sensory-perceptual integration and visual support. Through the excellent case study, the interactive effect highlighting the visual points and the visual expression form of cold-color interface are used to assist hearing-impaired children to carry out the practice of painting art.

II. B. 2) Art Therapy Platform Framework

Based on the intelligent interaction design strategy and combining multiple types of modern science and technology and cloud service platforms, this paper constructs an intelligent art therapy platform, the specific framework of which is shown in Fig. 2, which mainly consists of three modules: the personal image part, the collaborative drawing form and the collaborative drawing. Together digital coloring, together color coloring, together free painting three collaborative painting games unlock the painting process as a horizontal layer of the whole platform architecture, thus establishing a basic platform architecture. Each collaborative painting gallery contains graphics of various themes to choose from, and before painting the image will be selected or photographed AI-generated image, so as to choose the first perspective to substitute for painting.

The drawing theme function board is to display the pattern contained in each theme, when the user swipes left and right, it will display a different theme, and the theme will be continuously updated to ensure the sustainable drawing functionality of the product. The drawing process is the same for each collaborative drawing form, for example, “Color Together”, but different drawing forms will display different themes and patterns. For example, “Coloring Together” has a more complex gallery, “Coloring Together” has a simpler gallery, and “Free Drawing

Together" only provides simple basic shapes. The galleries in each format are differentiated by their complexity and simplicity, allowing children with hearing impairment to draw freely. The children's collaborative drawings are synchronized to form a single image, and each thematic feature panel has a small image to explain the content of the presentation, ensuring that the meaning is clear to the hearing impaired child.

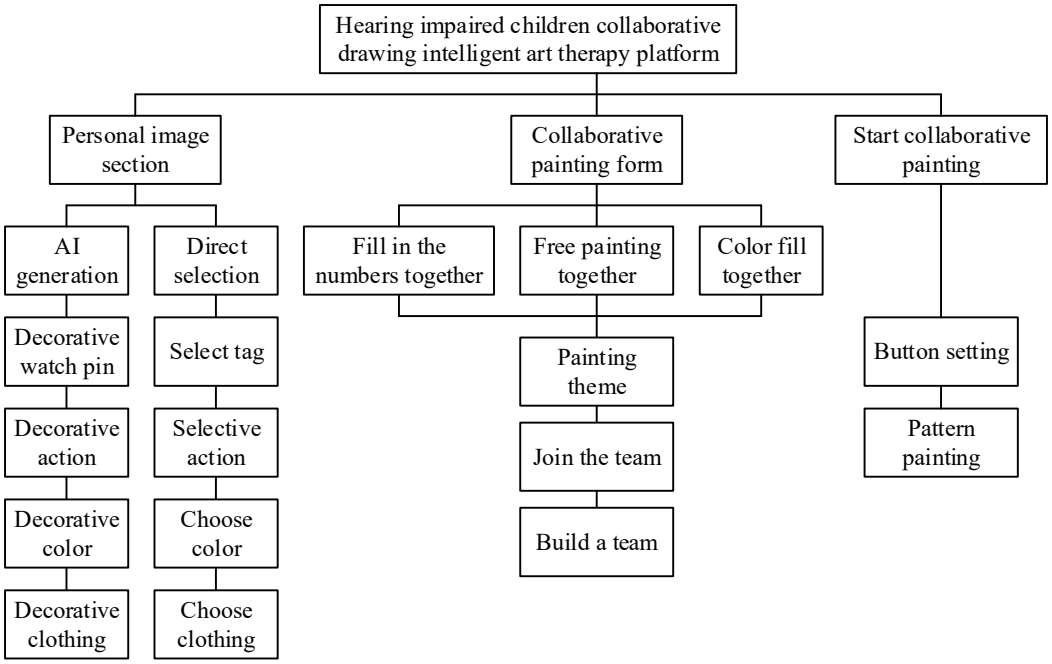

Figure 2: Smart art therapy platform

III. Intelligent retrieval of art therapy platforms under fuzzy logic

With the rapid development of science and technology, the use of intelligent art therapy platforms to assist children with hearing impairment in mental health interventions is an emerging approach. Relying on the intelligent platform to help children with hearing impairment understand the diversity of painting art, it promotes children with hearing impairment to generate the visual experience of discovering and creating beauty. This chapter further proposes a painting keyword retrieval method based on fuzzy logic algorithm to help children with hearing impairment to realize the retrieval of paintings in a fuzzy state, to better assist them to carry out the art of painting, and to provide support for the mental health intervention of children with hearing impairment.

III. A. Concepts related to fuzzy logic

III. A. 1) Fuzzy inference systems

Fuzzy theory uses the affiliation function to represent the fuzziness of things, that is, the degree of things to a certain set, different from the traditional set theory, the creation of fuzzy theory breaks through the traditional set theory between the elements and the set of the absolute subordinate relationship, so that the elements in the set of affiliation is more flexible, which does not require a complex computational model and the decision-making is similar to the way of thinking of the ordinary people, greatly simplifying the design process [26].

Fuzzy inference system is a decision-making system designed by applying fuzzy theory, and its system design mainly involves four major modules, which are variable fuzzification, affiliation function, fuzzy rules and variable defuzzification.

(1) Variable fuzzification. Fuzzification of variables in fuzzy inference systems is the process of determining the affiliation function based on different fuzzy methods and calculating the fuzzy affiliation degree of each variable based on the designed affiliation function.

(2) Affiliation function. The affiliation function is used to describe the degree of affiliation of a variable in different fuzzy sets, and the degree of affiliation is obtained by mapping the element to the interval [0,1] through the affiliation function. It is specified as follows:

The triangular affiliation function expression is:

$$F(X,A,B,C)=\begin{cases}0 & X\le A\\ \dfrac{X-A}{B-A} & A\le X\le B\\ \dfrac{C-X}{C-B} & B\le X\le C\\ 0 & X\le C\end{cases} \tag{1}$$

where A,C are the horizontal coordinates of the two points on the base of the triangle and B is the horizontal coordinate of the vertex of the triangle.

The trapezoidal subordination function expression is:

$$F(X,A,B,C)=\begin{cases}0 & X\le A\\ \dfrac{X-A}{B-A} & A\le X\le B\\ 1 & B\le X\le C\\ \dfrac{D-X}{D-C} & C\le X\le D\\ 0 & X\ge D\end{cases} \tag{2}$$

where A,D are the horizontal coordinates of the two points at the bottom of the trapezoid and B,C are the horizontal coordinates of the two points at the top of the trapezoid.

The bell-shaped affiliation function expression is:

$$F(X,A,B,C)=\frac{1}{1+\left|\dfrac{X-C}{A}\right|^{2B}} \tag{3}$$

where A,B are taken as positive numbers and C is the horizontal coordinate of the center point of the curve.

The expression of S-type affiliation function is:

$$F(X,A,C)=\frac{1}{1+e^{-A(X-C)}} \tag{4}$$

where A positive or negative determines the image opening direction.

(3) Fuzzy rules. Fuzzy rules are the most important part of the fuzzy reasoning system, and the rationality of their design will directly affect the accuracy of the fuzzy reasoning results, and there can be one or more fuzzy rules, and the rules are presented through logical expressions, and the commonly used logical expressions of fuzzy rules are in the form of "If-Then", that is, the results can be inferred if the prerequisites are met [27]. Rule:

$$If\ x\ is\ A\ Then\ y\ is\ B \tag{5}$$

where x is the input, "$x\ is\ A$" is the judgment precondition, and "$y\ is\ B$" is the inference result. The form "$If-Then$" can also be rewritten in the following form, which is improved from input-output one-to-one form to input-output many-to-one form with the expression:

$$If\ x\ is\ A\ and\ y\ is\ B,Then\ z\ is\ C \tag{6}$$

Similarly the form "$If-Then$" can be replaced by the following expression:

$$If\ x\ is\ A\ or\ y\ is\ B,Then\ z\ is\ C \tag{7}$$

The final result is obtained by combining multiple operations.

(4) Defuzzification. For the last step of the fuzzy inference system, the values derived through the fuzzy rules are fuzzy values, which need to be converted into clear and specific values in order to output them. There are three commonly used defuzzification methods, which are the affiliation degree method, the center of gravity method and the center average method.

The central averaging method combines the center of gravity method and the degree of affiliation method, and the idea of taking the larger one is used in defuzzification, and when the fuzzy theory domain A is discrete, the calculation results are consistent with the center of gravity method. Namely:

$$y = \frac{\sum_{i=1}^{n} \mu_{\max}^{i}(x) \cdot x_i}{\sum_{i=1}^{n} \mu_{\max}^{i}(x)} \tag{8}$$

III. A. 2) Fuzzy logic algorithms

In classical set theory, the relationship between an element x and a set A can only be $x \in A$ or $x \notin A$. In fuzzy set theory, the affiliation of an element x with a set A is described using an affiliation function.

Let A be a subset of the domain U, i.e., $A \subseteq U$, then the affiliation function of the set A is a mapping from U to {0, 1}, i.e.:

$$\chi_A : U \to \{0,1\}, x \mapsto \chi_A(x) \tag{9}$$

Among them:

$$\chi_A(x) = \begin{cases} 1, & x \in A \\ 0, & x \notin A \end{cases}, \forall x \in U \tag{10}$$

Let μ be a set of fuzzy propositions such that $T : \mu \to [0,1]$ such that $T(P) = \alpha \in [0,1], \forall P \in \mu$, then $T(P)$ is said to be the truth-value of the fuzzy proposition P.

The fuzzy proposition $P \in \mu$ is of the form "$P : x \ is \ A$", where x is a variable, A is a fuzzy set corresponding to a certain fuzzy concept, and the truth value of the fuzzy proposition P is taken to be the degree of affiliation of the variable x to the fuzzy set A, i.e. $T(P) = A(x)$.

Fuzzy propositions such as "$P : x \ is \ A$" are called simple fuzzy propositions or atomic fuzzy propositions, and fuzzy propositions linked by propositional conjunctions (e.g., disjunctive $\vee$, cojunctive $\wedge$, implication $\rightarrow$, etc.) are called compound fuzzy propositions.

Fuzzy propositions are the basis of fuzzy reasoning, and the input and output of fuzzy reasoning are fuzzy propositions. The truth value of a fuzzy proposition corresponds to the degree of affiliation of a fuzzy set, which is a value on [0,1], so the truth value of the inference is related to the truth value of the inputs as well as to the truth value of the fuzzy proposition as a rule.

There are three main applications of fuzzy logic in information retrieval, i.e., representing documents and query contents, calculating keyword weights, and constructing ranking functions. Fuzzy logic in information retrieval mainly uses fuzzy propositions to represent documents and queries with ambiguity, and uses fuzzy reasoning to deal with the problem of judging and reasoning about uncertainty concepts in information retrieval.

III. B. Fuzzy logic based retrieval model

III. B. 1) Intelligent Search Model

In order to help hearing-impaired children retrieve the required drawing graphics on the intelligent art therapy platform, this paper designs a fuzzy logic-based information intelligent retrieval method, the specific architecture of which is shown in Fig. 3. A fuzzy logic-based retrieval model is designed under this retrieval method. The model should be able to accurately represent the user's query needs and match with the information in the database. The following steps are used to construct the retrieval model:

Step1 Query expression. Transform the user's query requirements into fuzzy query expressions, including keywords and query conditions. The keywords are the focus of the user query, while the query conditions are used to constrain the specific requirements of the query, such as time range, data type, etc.

Step2 Fuzzy set definition. Define the corresponding fuzzy sets for keywords and query conditions, and choose suitable affiliation functions to describe their affiliation degrees. Common affiliation functions include triangular affiliation function, Gaussian affiliation function and so on.

Step3 Fuzzy matching degree calculation. According to the fuzzy set and the affiliation function, calculate the fuzzy matching degree between each data item in the database and the keywords and query conditions. Fuzzy similarity measures can be used, such as fuzzy intersection, fuzzy concatenation and so on.

Step4 Sorting and filtering. Sort the data items in the database according to the fuzzy matching degree, and put the data items that match the query requirements most in the front.

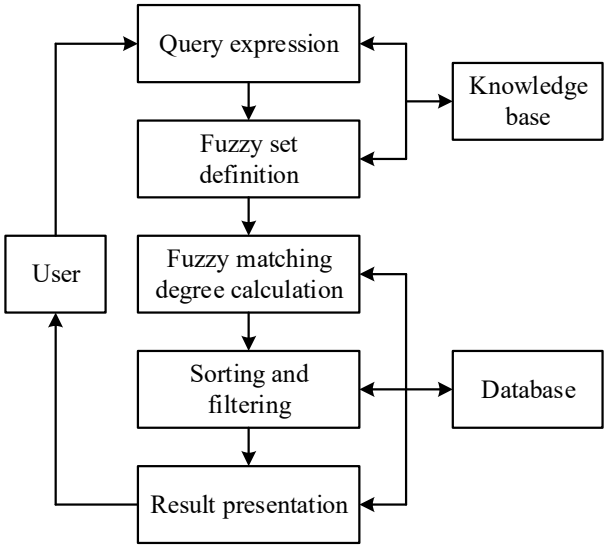

Figure 3: Intelligent information retrieval based on fuzzy logic

III. B. 2) Ranking of keyword weights

To sort documents (which can be viewed as a tuple of relations), the information retrieval system computes each sequence related to the query (a sequence of keywords provided by the user) and gives a similarity value score for both. In this paper, the vector space model is utilized for weight ranking of keywords.

The calculation method of vector space model is adopted, and a keyword in the query sequence is noted as k, the document vector is D, and the query vector is Q. The similarity value $Sim(Q,D)$ of the retrieved document and the query vector is calculated (this value is used as the basis for the query result ranking) is expressed as:

$$Sim(Q,D)=\sum_{k\in Q,D} weight(k,Q)*weight(k,D) \tag{11}$$

The computation of $weight(k,Q)$ is relatively simple, the weight of a keyword in the query is either 1 or 0. If the keyword appears in the query, the weight is 1, otherwise it is 0. The weight of keyword k in document D can be expressed as:

$$weight(k,D)=\frac{ntf}{ndl}*idf \tag{12}$$

Among them:

$$ntf=1+\ln(1+\ln(tf)) \tag{13}$$

$$idf=1n\frac{N}{df+1} \tag{14}$$

$$ndl=(1-s)+s*\frac{dl}{avgdl} \tag{15}$$

The size of the weight of word k in document D is determined by the following 3 factors:

(1) Word frequency (tf): the number of times the word k appears in the document D. Obviously, the more frequently the word appears in a document, the greater its weight.

(2) Document frequency (df): document frequency, the number of times a document D containing a certain feature word k appears in the test set. Its expression indicates that the inverse document frequency (idf) weighting method is used to normalize df.

(3) Document length (dl): a text is measured in terms of the number of bytes or the number of feature words contained in the text. Expressions are normalized to enable the reduction of the weight of the feature value k in long texts (where $avgall$ is the average document length and s is a constant, usually taking the value of 0.25).

III. C. Fuzzy Logic Intelligent Retrieval Validation

III. C. 1) Retrieval time for different methods

In order to verify the effectiveness of the proposed algorithm, the experiment uses a large-scale painting database, in which each piece of painting works as the title of the file with its painting content, and the database covers 20 kinds of data in a total of 10,000 files, the database training set of each file are categorized. The experimental hardware and software environment with Intel Core i5-7500 Windows 10 operating system, using Python language programming.

Under the same experimental conditions, the information retrieval methods based on the region-growth coupled multiple classifiers and keyword-based Trie trees and the method of this paper are selected for comparison experiments. Select 50~500 files sequentially, and the size of the selected files are all between 1~50KB. The number of retrieval keywords is 1200, the retrieval request is composed through 20 keywords, each keyword possesses a weight value from 2 to 6, and the user needs to return 10 files. Regarding the retrieval time of the three methods for detecting different number of files is shown in Fig. 4.

From the figure, it can be seen that in the initial stage (the number of retrieved documents is less than 50), the retrieval time of this paper's method is more similar to that of the region-growth-coupled multi-classifier and keyword Trie-tree-based information retrieval methods. Along with the rise of the number of documents, the retrieval time of the two literature methods shows roughly linear growth, but the retrieval time of this paper's method is lower than that of both literature methods. The average retrieval time of the fuzzy logic-based information retrieval method for paintings and artworks to retrieve 500 documents is 5.67ms, which is 57.78% and 68.99% lower than the average retrieval time of the region-growth-coupled multi-classifier and keyword Trie-tree-based information retrieval methods, respectively. This is because the method proposed in this paper utilizes the fuzzy logic algorithm to transform the information query demand of children with hearing impairment for art paintings into fuzzy query expression, and describes its affiliation degree by Gaussian affiliation function, and then establishes the fuzzy matching degree between the data items and the keywords and query conditions through the vector space model and fuzzy similarity method, which effectively reduces the number of relevance calculations and significantly improves the art paintings information retrieval efficiency.

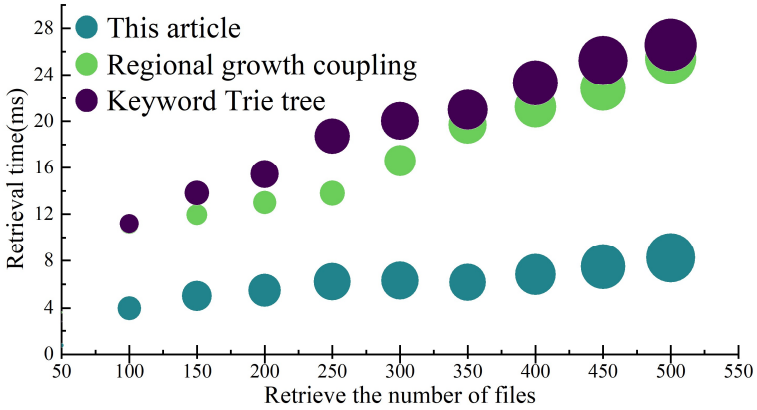

Figure 4: Comparison of retrieval time of different methods.

III. C. 2) Search accuracy of intelligent searching

In order to further verify the effectiveness of this paper's method, the retrieval of art painting information is carried out by this paper's method in the intelligent art therapy platform established in this paper. PROPHET, Binary Optimization and Epidemic are chosen as the comparison methods of this paper's algorithms, and the detection rate is used as the evaluation index to verify the detection rate of key information retrieval of art paintings under different algorithms. Figure 5 shows the accuracy of key information retrieval under different algorithms.

As can be seen from the figure, with the gradual increase in the volume of retrieved files, the key information retrieval rate of the four retrieval methods is also rising, and the intelligent retrieval method based on the fuzzy logic algorithm in this paper has the largest increase in the rate of retrieval, and after the volume of retrieved files is more than 16MB, the key information retrieval rate stabilizes at about 95%. Compared with PROPHET, Binary Optimization and Epidemic algorithm, it is 29.55, 11.29 and 21.91 percentage points higher respectively. The algorithm in this paper has a high keyword information retrieval rate, and the matching performance of data features is better, showing greater superiority compared with traditional methods. Relying on the application of fuzzy logic algorithm in the intelligent art therapy platform, the index optimization of art painting information is realized, and the

retrieval ability of art painting information is improved, so that hearing-impaired children can have access to more diversified painting information in the process of art painting, and new technical support is provided for the mental health intervention of hearing-impaired children.

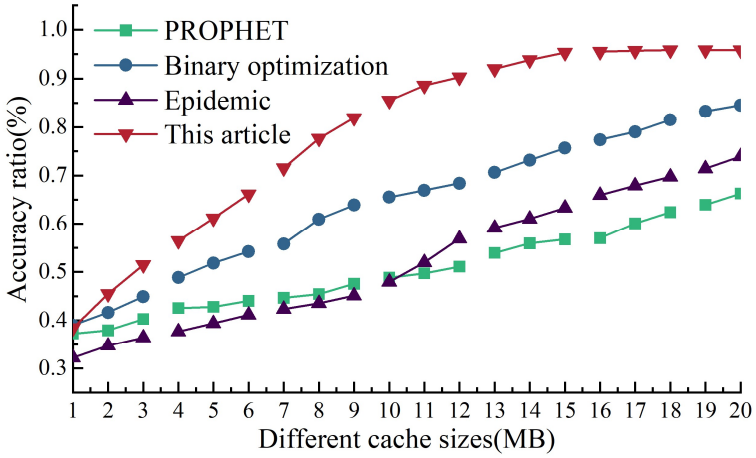

Figure 5: Comparison of accuracy of key information index

IV. Intelligent Art Therapy Platform for Mental Health Interventions

Hearing-impaired children have hearing deficits that can make it more challenging for them to receive information from the outside world, which can slow down their learning process. However, this also means that they are less exposed to external interference, have a purer inner world, tend to express themselves intuitively, and often have a higher degree of observational acuity. Therefore, in the process of mental health intervention, teachers can help create a more relaxed and free environment for children with hearing impairment by applying the Intelligent Art Therapy platform, in order to better support the psychological and emotional development of children with hearing impairment.

IV. A. Subjects and Methods

IV. A. 1) Experimental Objects

In order to verify the positive effect of the intelligent art therapy platform based on fuzzy logic algorithm on the mental health intervention for hearing impaired children, this paper selects some hearing impaired children from T Deaf School to carry out clinical validation analysis. The age of the selected hearing impaired children is about 12 to 18 years old, and the students under this age stage are changing in all aspects of their body and mind. This is coupled with the fact that they all have varying degrees of hearing loss and are prone to mood swings, and it is essential to intervene in their mental health level during this period.

Fifty hearing-impaired children were randomly selected from T Deaf School and divided into an experimental group (EG) and a control group (CG) according to the random sampling method, with 25 children in each group. There was no statistically significant difference in the comparison of gender, age, and grading of hearing impairment between the two groups of hearing impaired children (P>0.05).

IV. A. 2) Experimental methods

Before the experiment, the Social Adaptation Scale (SHS) and the Self-Awareness Scale (SAS) were distributed to the parents and teachers of the children in the experimental group and the control group for measurement and evaluation. The Social Adaptation Scale (SHS) mainly includes dealing with peer relationships, self-management, study skills, obedience skills and willingness to express (SHS1~SHS5). The Children's Self-Awareness Scale (SA) mainly examines behavior, intelligence, physical appearance, anxiety, conformity, happiness, etc. (SA1~SA6), with higher scores indicating better performance. The two scales were still distributed at the end of the experiment as a way to understand the effect of the intervention.

Pre-experiment, the first week of the pre-experiment, to observe the acceptance of the experimental method of the experimental subjects, listen to the teacher's organization and management of the experimental process, guidance and other aspects of the problems and suggestions, and according to the feedback to amend the intervention program. If the pre-experiment is successful, the first week of the experiment will be included in the formal experiment.

Formal experiments, to ensure that the experimental environment is safe and free, to be accompanied by the subjects in an inclusive, holding attitude, and gradually establish a relationship of trust with the subjects, according to the design of the experimental program, to give guidance. The subjects in the experimental group were free to choose how to respond to the instructions, so that they could conduct drawing art therapy with the help of the intelligent art therapy platform in a free and safe environment. The control group followed the traditional mental health intervention methods.

For the experimental group of hearing-impaired children, the implementation of the content mainly includes:

(1) Warm-up exercises to familiarize the children with the experimental environment, familiarize them with the operation of the intelligent art therapy platform, the therapist should establish a trusting relationship with them, stimulate their interest, and help to reduce the children's sensitivity to the experience of painting art therapy, so that the children can relax and devote themselves to the therapy, and express their thoughts and emotions as much as possible.

(2) The process of creating different kinds of portraits and self-symbols allows the children's attention to regulate to themselves, their appearance, body type and attitudes.

(3) Painting different scenarios to explore children's feelings and emotional health states.

(4) Children's spontaneous drawings give them the opportunity to express their problems, feelings, spaces, expectations, and concerns.

In the course of the clinical trial, the auditory verbal ability of the hearing impaired children was evaluated, mainly including imitation of sentence length, looking at pictures and talking, subject dialog, auditory assessment, speech clarity, listening demonstration, etc. The higher the score of each index indicates the more advanced auditory verbal ability. And the statistics of speech function improvement were conducted according to their recovery, which was reflected by the total effective rate. In addition, the middle ear analyzer recorder hearing curve was also utilized and its hearing threshold threshold was objectively assessed.

The data collected from the hearing impaired children were analyzed descriptively, Pearson's correlation analysis, independent samples t-test, one-way ANOVA, correlation analysis and stepwise regression analysis by SPSS, and $P<0.05$ indicated statistical significance.

IV. B. Statistical results and analysis

IV. B. 1) Auditory Verbal Ability Score

Based on the data after the clinical experiment, the SPSS software was input to carry out statistical analysis, and the results of the comparison of the auditory-linguistic ability scores of the hearing impaired children in the experimental group and the control group before and after the intervention were obtained as shown in Table 1, with * in the table denoting $P<0.05$. It can be seen from the table that, after the implementation of mental health interventions based on the Intelligent Art Therapy platform, the auditory assessment, speech intelligibility, thematic conversation, looking at the pictures, and speaking of hearing impaired children in the experimental group were higher than those in the control group ($P<0.05$), Listening Demonstration, and Imitation Sentence Length were scored higher than those of the control group ($P<0.05$).

Table 1: Auditory speech ability score

Index	EG	CG	*t*	*P*
Auditory evaluation	14.18±0.64	10.48±0.73	28.416	0.005*
Speech articulation	2.73±0.12	1.51±0.08	58.322	0.002*
Thematic dialogue	4.36±0.48	3.27±0.29	13.503	0.000*
Look at pictures and speak	5.38±0.74	2.43±0.05	26.278	0.000*
Listening demonstration	21.89±2.17	18.34±1.14	9.137	0.001*
Imitative sentence length	19.65±2.03	16.23±1.27	9.856	0.000*

Table 2 shows the results of the comparison of the total effective rate after the intervention of the two groups, the total effective rate of the experimental group of children with hearing impairment reached 92%, significantly higher than the control group of 72%, as analyzed by the rank-sum test, there is a difference between the different effects.

Table 3 shows the changes in the types of hearing curves in the two groups after the intervention, and the difference between the different types of hearing curve types was statistically significant compared to the control group ($P<0.05$).

Table 2: Comparison of total effective rate after intervention

Group	Recovery	Remarkable	Turn better	Ineffective	Total effective rate
EG	13	5	3	2	23(92.00%)
CG	8	7	2	1	18(72.00%)
z	-6.749				
P	0.005*				

Table 3: Hearing curve type changes

Group	Flat descent type	Low frequency descent type	High frequency descent type	Total deafness type
EG	16(64.00%)	6(24.00%)	3(12.00%)	0(0.00%)
CG	4(16.00%)	8(32.00%)	13(52.00%)	0(0.00%)
z	-4.168			
P	0.024*			

Table 4 shows the results of the comparison of the hearing threshold thresholds of the two groups of hearing impaired children after the intervention. The hearing thresholds of hearing impaired children in the experimental group were significantly higher than those of the control group at 400, 800, 1600, and 3200 Hz frequency stimulation after intervention (P<0.05).

Table 4: Comparison of hearing threshold after intervention

Group	400Hz	800Hz	1600Hz	3200Hz
EG	78.46±21.28	83.28±11.29	88.91±22.37	76.38±12.64
CG	16.35±2.71	13.53±3.62	18.26±3.05	14.87±2.16
z	17.816	38.629	19.534	30.472
P	0.005*	0.001*	0.000*	0.003*

Hearing impairment is a general term for the loss of auditory function in the human ear, in which functional hearing impairment is correlated with the mental and psychological conditions of the body. Many children with hearing impairment have the same intellectual level and language potential as normal people, but they are unable to communicate with others, which affects the development of their psychological traits, so it is valuable to provide effective mental health interventions for children with hearing impairment. The fuzzy logic-based intelligent art therapy platform provides a new paradigm for mental health intervention for children with hearing impairment, and its introduction of drawing art therapy helps children with hearing impairment better discover and create beauty, realizes positive communication among children with hearing impairment, and improves their auditory-verbal ability. This study shows that mental health interventions based on the intelligent art therapy platform can improve the overall prognosis of the children and enhance their auditory verbal ability.

Children with hearing impairment have the same needs for knowledge, skills, attitudes, emotions, and abilities as hearing children during their development. Therefore, the intervention for hearing impaired children should be based on the theory of potential development, and make full use of visual, expression, gesture and other silent language to assist in language intervention. Mechanistically, the establishment of the mental health intervention program combined with the Intelligent Art Therapy platform provided the intervention team and family members with effective intervention strategies, and developed measures that were compatible with the characteristics of the disease and the intervention needs of children with hearing impairment, so that the parents improved their ability to implement the interventions, and therefore were able to improve the disease control effect and improve the hearing of the children.

IV. B. 2) Analysis of social adaptability

Relying on the Intelligent Art Therapy platform, it gives children with hearing impairment more colorful intervention programs, promotes better adjustment of their mental health, and provides support for stabilizing the self-awareness of children with hearing impairment. In addition, the development of self-awareness will, to a certain extent, promote the social adaptability of children with hearing impairment, so that they can better establish themselves in society and help them cope with possible social prejudice.

Based on the post-intervention data, data from the Social Adaptive Ability Scale and the Self-Awareness Scale were collected, and correlation analysis was used to explore the correlation between social adaptive ability and self-awareness of hearing impaired children. Table 5 shows the results of correlation analysis between social adaptive ability and self-consciousness of hearing impaired students, where *,** denotes $P<0.05$ and $P<0.01$, respectively.

As can be seen from the table, self-consciousness and social adaptability of hearing impaired children showed a positive correlation at the 1% level (r=0.331, $P<0.01$), and the anxiety dimension of self-consciousness was also positively correlated with social adaptability (r=0.314, $P<0.01$). Using linear stepwise regression analysis with self-awareness and its anxiety dimension as independent variables and social adjustment ability as dependent variable, it was found that self-awareness entered as a predictor and the regression equation was statistically significant ($F=8.492$, $P<0.01$), and its overall explanation of the total social adjustment ability score reached 12.87%. This shows that the mental health intervention method for hearing impaired children based on intelligent art therapy can enhance the self-awareness of hearing impaired children, which leads to the improvement of their social adaptive ability.

Table 5: Spoon correlation analysis results

-	SA	SA1	SA2	SA3	SA4	SA5	SA6
Total	0.331**	0.183	0.161	0.045	0.314**	0.227	-0.123
SHS1	0.028	-0.023	0.134	0.017	0.012	0.195	-0.023
SHS2	0.135	0.079	-0.032	-0.062	0.095	0.143	-0.114
SHS3	0.187	0.172	0.021	-0.026	0.204	0.023	-0.141
SHS4	0.286*	0.053	0.163	0.158	0.247*	0.065	0.128
SHS5	0.314**	0.215	0.157	0.034	0.341**	0.203	-0.159

In order to further analyze the effect of mental health intervention based on intelligent art therapy on enhancing the social adaptive ability of children with hearing impairment, independent samples t-tests were conducted on the social adaptive ability and the scores of each dimension of children with hearing impairment in the experimental group before and after the intervention. Table 6 shows the test results before and after the intervention.

As can be seen from the table, before the mental health intervention, the total score of social adaptive ability of hearing impaired children in the experimental group was 5.62±8.45, while after the mental health intervention based on the intelligent art therapy platform, their total score of social adaptive ability reached 33.63±4.32, and there was a statistically significant difference ($t=-7.518$, $P<0.01$). There was also a statistically significant difference in the scores of the dimensions of social adjustment ability of the hearing-impaired children in the experimental group ($P<0.01$).

Table 6: Test results before and after intervention

-	Before	After	*t*	*P*
Total	5.62±8.45	33.63±4.32	-7.518	0.000*
SHS1	0.29±2.18	6.74±1.57	-8.421	0.002*
SHS2	0.54±2.17	8.42±1.38	-6.785	0.001*
SHS3	0.35±3.61	6.31±2.42	-6.492	0.000*
SHS4	2.23±2.54	4.58±1.71	-4.774	0.005*
SHS5	2.21±2.38	7.63±3.52	-5.814	0.003*

The effectiveness of mental health interventions relying on the Intelligent Art Therapy platform stems from the following effects:

(1) Self-expression and communication. First of all, drawing therapy itself is a non-verbal way of self-expression through drawing, and this way for the speech impaired people, in order to facilitate their expression and communication at the same time can be very good to eliminate their defenses, so as to facilitate accurate diagnosis and counseling of psychological counselors. Furthermore, drawing therapy expresses the repressed emotions and thoughts in the subconscious mind of the individual through drawing, so that they can be felt and recognized by the individual. For example, many hearing impaired students repeatedly draw their ears and mouths, which to some extent reflects their desire for compensation, wishing to have the same ears as normal children. In the group sharing session, the counselor raised this phenomenon, and after a short silence, the hearing impaired students finally expressed in sign language, “I actually envy them for being able to hear sounds and make sounds”. It can be seen

that the drawing art therapy for hearing impaired students is conducive to the expression of their deeper thoughts and desires, as well as effective communication with the counselor.

(2) Self-awareness. The mental health intervention on the platform of drawing art therapy includes several sessions of drawing creation, work presentation, and member sharing, which will further strengthen the individual's knowledge of themselves, from the unconscious presentation of the creative process to the epiphany of acceptance in the process of discussion and reaction of group members.

(3) Group Role. The form of mental health intervention carried out on the platform of painting art therapy is group-based, which is more likely to produce group cohesion, which will be conducive to the formation of a mutually supportive and accepting atmosphere, which is conducive to the members to let go of their defenses, to express themselves freely and to encourage and support each other.

V. Conclusion

The application of fuzzy logic-based intelligent art therapy platform in mental health intervention for children with hearing impairment involves multidisciplinary knowledge and fields such as psychology and special education, and the intervention effects achieved vary depending on the type of children with hearing impairment. This paper verifies the intervention effect of the Intelligent Art Therapy platform through mental health intervention clinical experiments, and provides a new theoretical basis for improving the mental health of children with hearing impairment.

Although this study has achieved certain results, there are still certain shortcomings, namely, the number of experimental samples selected is small and the experimental time is relatively short, the overall experimental results may lack a certain degree of generalizability. In the future research, based on the problems encountered by scholars in the use of painting art therapy, we should do a more in-depth analysis, and deepen the research basis to strengthen the application of the intervention of painting art therapy in the mental health neighborhood of children with hearing impairment.

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