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Implementation of Fuzzy Expert System to Detect Parkinson's Disease Based on Mobile

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Abstract
Parkinson's disease is a neurodegenerative disorder characterized by classic motor symptoms, namely bradykinesia, rigidity and tremor, where this disease attacks nerve cells gradually in the midbrain part which regulates the movement of the human body. This disease is one of the most common diseases found in old age with a prevalence of around 160 per 100,000 population. Among the general public knowledge about the disease Parkinson considered to be minimal, as a result many sufferers Parkinson which is not handled properly. Therefore, the authors built an application to detect and provide information on Parkinson's disease with Fuzzy Expert System. This application was built based on Android mobile to make it easier for users to operate it. In this research method Fuzzy Expert System aims to find out whether the patient has Parkinson's or not based on the input value of each symptom displayed. Symptom data were obtained from experts through interviews and appropriate literature. This system begins by entering the symptoms of Parkinson's disease that have been obtained from experts into the system. Symptoms included include: Tremor/vibration, Rigidity/Rigidity, Akinesia/Bradykinesia, Autonomic Dysfunction, Gait as if about to fall. After the symptoms are entered, the system will calculate the set Fuzzy, each symptom is divided into 2 (two) criteria/sets, namely: rarely, and often. After forming the set Fuzzy, the system will match the rule base obtained from the expert. The results of this system detection whether the user has Parkinson's disease or not. In building the system the author uses the waterfall method, which means sequential and systematic. The database used is the MySQL database. Testing this research using the Black Box Testing method. From the research that has been done, this system has succeeded in achieving a percentage value of 70% for accuracy results based on 20 trials from respondents, there are 6 experiments that are not in accordance with expert opinion. On testing usability obtaining a percentage of 40% for very good and 60% for good, with these results showing that the expert system that has been built can run well and is easy for users to use.

Keywords: Parkinson's Disease, Detecting, Fuzzy Expert System, Mobile
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1.0 INTRODUCTION

Parkinson's disease is a neurodegenerative disorder characterized by classic motor symptoms, namely bradykinesia, rigidity, and tremors (Gunawan et al., 2017). This disease attacks nerve cells gradually in the midbrain where the part regulates body movements. Symptoms of Parkinson's disease are the body feels weak or feels stiffer in part of the body, as well as tremors or fine shaking in one hand (Swandana et al., 2020). This disease is one of the most common diseases found in the elderly and rarely occurs under the age of 30 years. The prevalence of Parkinson's disease is about 160 per 100,000 population. Symptoms of this disease can appear at the age of 40 years with a peak in decade 6. This disease is mostly found in men when compared to women with a ratio of 3: 2. Overall, as life expectancy increases, the incidence of neurodegenerative diseases, including Parkinson's disease, will increase as high as possible.

Among the public, knowledge about Parkinson's is considered still minimal, as a result many sufferers. Parkinson's that wasn't handled well. Not a few Parkinson's patients are not handled properly because of the ignorance of the community, especially the patient's family about the knowledge of this disease how to treat and serve Parkinson's sufferers (Porsiana & Arimbawa, 2020).

Expert system is one branch of artificial intelligence that studies how to imitate the way an expert thinks in solving a problem, making decisions and drawing conclusions about a number of facts (Porsiana &; Arimbawa, 2020). In the expert system, there are several methods used to deal with uncertainty problems, including probability techniques, certainty factors, and fuzzy logic (Manik Prihatini, 2022). The author uses fuzzy expert system tracing for the decision-making process, because Fuzzy expert system has advantages, including being able to tolerate inaccurate data, being able to cooperate with conventional control techniques, being very flexible in processing knowledge to produce consequences, premises with conclusions or conditions with consequences so as to produce information that has accuracy to the end user or user. The general form of the fuzzy expert system is almost the same as the form of rule.

In the fuzzy method, there are several inference processes, one of which is the inference system process to produce a final decision from the method, including Tsukamoto, Mamdani, Sugeno (Ferdiansyah &; Hidayat, 2018). This study uses Fuzzy Tsukamoto because it is intuitive and can provide responses based on qualitative, inaccurate, and ambiguous information. In this method, each rule is represented by a Fuzzy set with a membership function, which monton is also called fuzzification. As a result, the output of each rule is crisps based on the α predicate or minimum value of each rule and the z value. The final result is by defuzzifying in the form of a weighted average (Ferdiansyah &; Hidayat, 2018).

In a study conducted by Hani Nurhayati (2012) entitled Implementation of Fuzzy Expert System for Heart Disease Diagnosis. The study used a Fuzzy Expert system applied to the expert system to diagnose early symptoms of heart disease. The results of the study were in the form of heart diagnosis and treatment solutions with an accuracy of 70%. In a study conducted by Supardianto (2021) entitled Fuzzy Expert System to Help Early Diagnosis of Metabolic Syndrome. The study used the Fuzzy Expert System applied in diagnosing early metabolic syndrome, where the results of the study were in the form of decision making for early diagnosis of metabolic syndrome with an accuracy of 84%.

On the basis of the phenomena that occur, in this study the author designed an expert system to detect every symptom in mobile-based Parkinson's disease in order to make it easier for patients to detect the disease, and test the results of the accuracy of the Fuzzy Tsukamoto method with experts in detecting Parkinson's disease.

2.0 LITERATURE REVIEW

Expert System

Expert systems are a branch of artificial intelligence (Artificial Intelligence) and are a field of science that emerged along with the development of computer science today. This system is a computer system that can match or imitate the ability of an expert. This system works to adopt human knowledge to computers that combine the knowledge base with an inference system to replace the function of an expert in solving a problem (Syahrizal &; Haryati, 2018).

Fuzzy Logic

Fuzzy theory was first introduced by Dr. Lotfi Zadeh in 1965 from the University of California, developing a qualitative concept that has no precise boundaries, for example there is no clear or definite value which is the boundary between normal and low, normal or high (Harliana &; Rahim, 2017). Fuzzy logic is used as a way to map problems from input to corresponding output. The fuzzy set lies in the range 0. The membership value of a member x in a set A has two possibilities: one (1) means that an item is a member in a set, or zero (0) means that an item is not a member in a set. The membership of an element is expressed expressly in a set if that member is defined in that set.

Fuzzy Tsukamoto

In Tsukamoto's Fuzzy method, each consequence of the IF-Then Rule must be represented by a fuzzy set with a monotonous membership function as a result (fuzzification process). The inference output of each rule is given strictly (crisp) based on α-predicate. The final result was obtained using weighted average defuzzification (Harliana &; Rahim, 2017). In the inference process, Fuzzy Tsukamoto's method has several stages, namely:

1. Fuzzification
Fuzzification is the process of converting system inputs that have a firm or crisp value into fuzzy sets and determining their degree of membership in fuzzy sets.

2. Establishment of IF-Then Rules
The process to form a Rule that will be used in the form of IF – THEN stored in the fuzzy membership base.

3. Inference Engine

The process to convert fuzzy input into fuzzy output by fuzzifying each predefined Rule (IF-THEN Rule). Use the MIN implication function to get the alpha-predicate value of each rule. Then each alpha-predicate value is used to calculate the output of each Rule (z value).

4. Defuzzification
Converts the fuzzy output obtained from the inference engine into firm or crisp values. The final result is obtained using the weighting average equation using the average weight average method.

3.0 METHODOLOGY

Research Framework

In the research conducted by the author, there are several steps arranged for application design. The steps in question are in Figure 1.

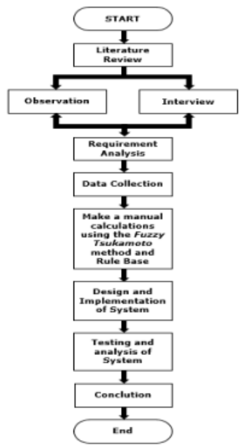

Figure 1. Research Framework

The initial stage of research began from collecting data on symptoms and criteria of Parkinson's disease through literature studies, observations, and interviews. then the symptom data and criteria obtained will be entered as a set of inputs and releases from the calculation process of the Fuzzy Tsukamoto method where the output is in the form of weighted flat. After making calculations, Fuzzy Tsukamoto continued to design and implement the system and conduct system testing and analysis.

4.0 RESULTS AND DISCUSSION

Parkinson's Disease Symptom Data as a Fuzzy input variable

Table 1. Symptoms of Parkinson's Disease

Symptom Code	Symptoms
G1	Tremors/Vibrate
G2	Rigidity/ Stiffness
G3	Akinesia/ bradykinesia
G4	Autonomic dysfunction
G5	The style of the road is like about to fall

Define the Set of each input variable along with

Table 2. The set of each input variable

Symptom Variables	Set	Range of Values	Value Interval
Tremors/Vibrate	infrequently	0 - 2	0,2,5
	sometimes	2 - 8	2,5,8
	often	8 - 10	5,8,10
Rigidity/ Stiffness	infrequently	0 - 2	0,2,5
	sometimes	2 - 8	2,5,8
	often	8 - 10	5,8,10
Akinesia/bradykinesia	infrequently	0 - 2	0,2,5
	sometimes	2 - 8	2,5,8
	often	8 - 10	5,8,10
Autonomic dysfunction	infrequently	0 - 2	0,2,5
	sometimes	2 - 8	2,5,8
	often	8 - 10	5,8,10
The style of the road is like about to fall	infrequently	0 - 2	0,2,5
	sometimes	2 - 8	2,5,8
	often	8 - 10	5,8,10

Menentukan Variabel Output

Table 3. Output variables

Variable	Set	Ranges of Values	Value Interval
Parkinson	no	0 s/d 3	0,3,7
	Yes	7 s/d 10	3,7,10

Defining Rules

1. If G1 is Rare, G2 is Rare, G3 is Rare, G4 is Rare, and G5 Is Rare then No Parkinson's.
2. If G1 Sometimes, G2 Rare, G3 Rare, G4 Rare, and G5 Rare then No Parkinson's.
3. If G1 is Rare, G2 is Rare, G3 is Rare, G4 is Rare, and G5 Is Rare then No Parkinson's.
4. If G1 is Rare, G2 Sometimes, G3 Rare, G4 Rare, and G5 Rare then No Parkinson's.
5. If G1 Sometimes, G2 Sometimes, G3 Rarely, G4 Rarely, and G5 Rarely then No Parkinson's.
6. If G1 is Often, G2 Sometimes, G3 Rarely, G4 Rarely, and G5 Rarely then No Parkinson's.
7. If G1 is Rare, G2 is Rare, G3 is Rare, G4 is Rare, and G5 Is Rare then No Parkinson's.
8. If G1 Sometimes, G2 Often, G3 Rarely, G4 Rarely, and G5 Rarely then No Parkinson's.
9. If G1 is Often, G2 Is Often, G3 Is Rare, G4 Is Rare, and G5 Is Rare hence Parkinson's.

10. If G1 is Rare, G2 is Rare, G3 is Sometimes, G4 is Rare, and G5 Is Rare then No Parkinson's.

Dst... Until rule 243

Calculating Membership Value

In calculating a fuzzy membership value using the following formula:

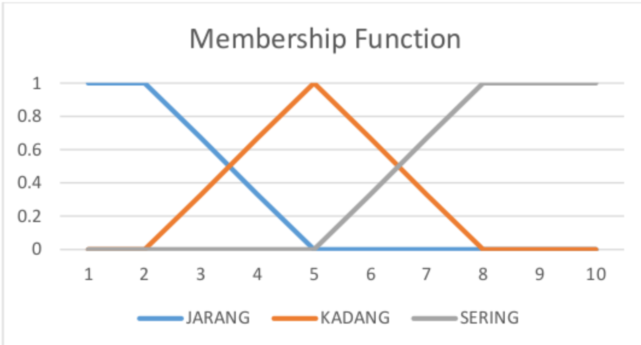

Figure 2. Membership function graph

$$\mu Jarang = \begin{cases} 1 & x \le 2 \\ \frac{5 - x}{5 - 2} & 2 \le x \le 5 \\ 0 & x \ge 5 \end{cases}$$

$$\mu Kadang = \begin{cases} 0 & x \le 2 \; dan \; x \ge 8 \\ \frac{x - 2}{5 - 2} & 2 \le x \le 5 \\ \frac{8 - x}{8 - 5} & 5 \le x \le 8 \end{cases}$$

$$\mu Sering = \begin{cases} 0 & x \le 5 \\ \frac{x - 5}{8 - 5} & 5 \le x \le 8 \\ 1 & x \ge 8 \end{cases}$$

Tsukamoto's Fuzzy Inference Process

In this process, find the values of α and z according to the rules specified as follows:

1. 1st Rule
   If G1 is Rare, G2 is Rare, G3 is Rare, G4 is Rare, and G5 Is Rare then No Parkinson's.

   $$\alpha - \text{predikat1} = \min \begin{pmatrix} \mu\text{Rare}(7);\ \mu\text{Rare}(7);\ \mu\text{Rare} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

   = min (0; 0; 0; 0; 0)
   = 0
   z1 = 7- (0 * (7-3)) = 7

2. 2nd Rule
   If G1 Sometimes, G2 Rare, G3 Rare, G4 Rare, and G5 Rare then No Parkinson's.

   $$\alpha - \text{predikat2} = \min \begin{pmatrix} \mu\text{Sometimes}(7);\ \mu\text{Rare}(7);\ \mu\text{Rare} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

   = min (0,33; 0; 0; 0; 0)
   = 0
   z2 = 7- (0 * (7-3)) = 7

3. 3rd Rule
   If G1 is Rare, G2 is Rare, G3 is Rare, G4 is Rare, and G5 Is Rare then No Parkinson's.

$$\alpha - \text{predikat3} = \min \begin{pmatrix} \mu\text{Rare}(7);\ \mu\text{Rare}(7);\ \mu\text{Rare} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

= min (0,67; 0; 0; 0; 0)
= 0
z3 = 7- (0 * (7-3)) = 7

4. 4th Rule
If G1 is Rare, G2 Sometimes, G3 Rare, G4 Rare, and G5 Rare
then No Parkinson's.

$$\alpha - \text{predikat4} = \min \begin{pmatrix} \mu\text{Rare}(7);\ \mu\text{Sometimes}(7);\ \mu\text{Rare} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

= min (0; 0,33; 0; 0; 0)
= 0
z4 = 7- (0 * (7-3)) = 7

5. 5th Rule
If G1 Sometimes, G2 Sometimes, G3 Rarely, G4 Rarely, and G5 Rarely
then No Parkinson's.

$$\alpha - \text{predikat5} = \min \begin{pmatrix} \mu\text{Sometimes}(7);\ \mu\text{Sometimes}(7);\ \mu\text{Rarely} \\ (6) \\ ;\ \mu\text{Rarely}(5);\ \mu\text{Rarely}(5) \end{pmatrix}$$

= min (0,33; 0,33; 0; 0; 0)
= 0
z5 = 7- (0 * (7-3)) = 7

6. 6th Rule
If G1 is Often, G2 Sometimes, G3 Rarely, G4 Rarely, and G5 Rarely
then No Parkinson's.

$$\alpha - \text{predikat6} = \min \begin{pmatrix} \mu\text{Often}(7);\ \mu\text{Sometimes}(7);\ \mu\text{Rarely} \\ (6) \\ ;\ \mu\text{Rarely}(5);\ \mu\text{Rarely}(5) \end{pmatrix}$$

= min (0,67; 0,33; 0; 0; 0)
= 0
z6 = 7- (0 * (7-3)) = 7

7. 7th Rule
G1 is Rare, G2 is Rare, G3 is Rare, G4 is Rare, and G5 Is Rare
then No Parkinson's.

$$\alpha - \text{predikat7} = \min \begin{pmatrix} \mu\text{Rare}(7);\ \mu\text{Rare}(7);\ \mu\text{Rare} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

= min (0; 0,67; 0; 0; 0)
= 0
z7 = 7- (0 * (7-3)) = 7

8. 8^{th} Rule
If G1 Sometimes, G2 Often, G3 Rarely, G4 Rarely, and G5 Rarely
then No Parkinson's.

$$\alpha - \text{predikat8} = \min \begin{pmatrix} \mu\text{Sometimes}(7);\ \mu\text{Often}(7);\ \mu\text{Rarely} \\ (6) \\ ;\ \mu\text{Rarely}(5);\ \mu\text{Rarely}(5) \end{pmatrix}$$

= min (0,33; 0,67; 0; 0; 0)
= 0
z8 = 7- (0 * (7-3)) = 7

9. 9^{th} Rule
If G1 is Often, G2 Is Often, G3 Is Rare, G4 Is Rare, and G5 Is Rare hence Parkinson's.

$$\alpha - \text{predikat9} = \min \begin{pmatrix} \mu\text{Often}(7);\ \mu\text{Often}(7);\ \mu\text{Rare} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

= min (0,67; 0,67; 0; 0; 0)
= 0
z9 = (0 * (7-3)) + 3 = 3

10. Aturan ke-10
If G1 is Rare, G2 is Rare, G3 is Sometimes, G4 is Rare, and G5 Is Rare
then No Parkinson's.

$$\alpha - \text{predikat10} = \min \begin{pmatrix} \mu\text{Rare}(7);\ \mu\text{Rare}(7);\ \mu\text{Sometimes} \\ (6) \\ ;\ \mu\text{Rare}(5);\ \mu\text{Rare}(5) \end{pmatrix}$$

= min (0; 0; 0,67; 0; 0)
= 0
z10 = 7 - (0 * (7-3)) = 7

Dst... Until rule 243

Defuzzification

$$WA = \frac{a1 * z1 \ + \ a2 * z2 \ + \ a3 * z3 \ + \ \dots . + a32 * z32}{a1 \ + \ a2 \ + \ a3 \ + \cdots + a32}$$

$$WA = \frac{\begin{array}{c}
(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*3)+(0*7)+(0*7)+(0*7)+(0*7) \\
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+(0,33*5,68)+(0,33*4,32)+(0*3)+(0,33*4,32)+(0,33*4,32)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7)+(0*7) \\
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\end{array}}{\begin{array}{c}
(0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0+0 \\
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+0+0+0+0+0\ 0+0+0)
\end{array}}$$

$$WA = \frac{15{,}58}{2{,}98}$$

$$WA = 5{,}23$$

The results of the calculation of the fuzzy method with tsukamoto's inference in the defuzzification process obtained a Weight Average figure of 5.23, where the number is in the **YES Parkinson's** interval.

The test results carried out in this study are testing the accuracy of the results between the system and experts.

No	Nama	JK	Umur	G1	G2	G3	G4	G5	Defuzzifikasi	Hasil Pakar	Hasil Sistem	KESESUAIAN
1	Bambang Septiono	L	62 Thn	9	6	4	6	5	4,77	Parkinson	Tidak Parkinson	Tidak Sesuai
2	Ferry Budiono	L	65 Thn	8	5	8	6	6	4,87	Parkinson	Tidak Parkinson	Tidak Sesuai
3	Hendrik Widjaja	L	56 Thn	8	6	6	2	2	4,32	Parkinson	Tidak Parkinson	Tidak Sesuai
4	Anna Rosita	P	68 Thn	8	7	7	5	3	4,93	Parkinson	Tidak Parkinson	Tidak Sesuai
5	Juliana Ong	P	53 Thn	4	4	1	1	1	5,13	Tidak Parkinson	Parkinson	Tidak Sesuai
6	Lianawati	P	59 Thn	7	2	6	2	2	4,86	Parkinson	Tidak Parkinson	Tidak Sesuai
7	Budianto	L	58 Thn	7	7	6	5	5	5,23	Parkinson	Parkinson	Sesuai
8	Doni	L	52 Thn	4	2	4	5	3	5,37	Parkinson	Parkinson	Sesuai
9	Sumardi	L	66 Thn	7	5	8	8	8	5,68	Parkinson	Parkinson	Sesuai
10	Suherman	L	47 Thn	4	2	1	4	2	5,13	Parkinson	Parkinson	Sesuai
11	Jefri Christian	L	42 Thn	9	7	3	3	7	5,12	Parkinson	Parkinson	Sesuai
12	Sufianto	L	68 Thn	5	8	8	6	6	4,87	Tidak Parkinson	Tidak Parkinson	Sesuai
13	Widianto	L	36 Thn	5	4	6	2	8	5,13	Parkinson	Parkinson	Sesuai
14	Dewi	P	45 Thn	4	2	2	1	1	4,77	Tidak Parkinson	Tidak Parkinson	Sesuai
15	Elvi Halim Purnamasari	P	65 Thn	9	5	7	5	3	5,41	Parkinson	Parkinson	Sesuai
16	Linda Lunardi	P	35 Thn	6	3	4	2	2	5,37	Parkinson	Parkinson	Sesuai
17	Natalie	P	33 Thn	4	2	2	3	1	5,13	Parkinson	Parkinson	Sesuai
18	Ng Nie	P	58 Thn	2	4	1	1	1	4,77	Tidak Parkinson	Tidak Parkinson	Sesuai
19	Nosariwati	P	53 Thn	5	1	1	1	1	3	Tidak Parkinson	Tidak Parkinson	Sesuai
20	Shanty	P	44 Thn	6	2	2	1	1	4,77	Tidak Parkinson	Tidak Parkinson	Sesuai

Figure 3. Results Accuracy testing between the system and experts

Based on the comparison of data in the table above, data can be taken that many data tested 20 data, corresponding Test Results = 14 data, which do not match = 6 data, so the accuracy value is

$$\frac{Tesing\ Accordingly}{Total\ data} \times 100\%$$

$$\frac{14}{20} \times 100\% = 70\%$$

Implementation of System

This stage is the stage where the results of interface design that have been implemented into programs created using Android Studio for users.

1. Home Page

   The following is a view of the home page of application users that can be accessed through the mobile app.

Figure 4. Home Page

2. Examination Form

On the examination form, users can do an examination to check whether the person concerned suffers from Parkinson's or not.

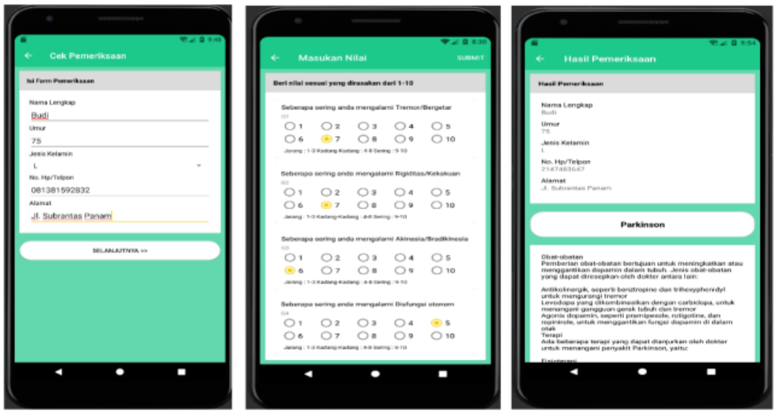

Figure 5. Examination Form

3. Performing Information Search Page
   On the information search page is a page that displays Parkinson's-related information in the form of reading articles that can be read by the public.

Figure 6. Performing Information Search Page

5.0 CONCLUSION

Based on the discussion and description above, the conclusions that can be drawn from this study are as follows: This system can help the public in detecting Parkinson's disease through mobile devices that have been designed, whose detection process uses the calculation of Tsukamoto's Fuzzy inference method based on the symptoms felt by system users. Search results with this method have an accuracy rate of 70% compared to results from experts.

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