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Design of Drug Information Visualization and Intelligent Recommendation Platform

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Abstract: *This study focuses on the current situation that the public's awareness of food and drug safety has significantly increased, but drug information is complicated and difficult to find. Aiming at the dilemma of drug recommendation and information extraction, an intelligent system based on the Django framework is designed. The system uses natural language processing technology to parse the user's condition description, combines collaborative filtering algorithm to implement personalized drug recommendations, and introduces a dynamic weighted hybrid model to optimize the recommendation logic to ensure the accuracy of the recommendation. Finally, the recommendation results are presented through visualization to help users efficiently screen suitable drugs. Compared with traditional recommendation systems, the solution proposed in this study shows higher personalization and medical recommendation accuracy, providing strong support for the public's safe use of drugs.*

Keywords: *Drug Information; Collaborative Filtering Algorithm; Natural Language Processing; Django Framework*

1. Introduction

With the development of society, the public's attention to food and drug safety continues to increase,and food and drug science popularization work is becoming more and more important. In terms of food science popularization, the Chinese Society of Food Science and Technology pointed out in 2024 that food safety and health are facing new challenges, and the focus of science popularization should shift from refuting rumors to improving the scientific literacy of the whole people, and it is necessary to strengthen the popularization of "new technologies and new knowledge" of food. In the field of drug science popularization, the State Food and Drug Administration actively carries out brand activities such as "National Safe Medication Month" and conducts science popularization through various means such as cooperation with platforms such as Baidu. However, according to the "National Food and Drug Science Popularization Status Survey (2017)", the public in my country has a strong awareness of food and drug safety, but relatively weak knowledge of drug safety. Ordinary people lack relevant medical knowledge about their own symptoms, and there are huge differences in everyone's symptoms and medication conditions. These all show that there is still a lot of room for improvement in food and drug science popularization work in terms of improving public awareness and promoting social co-governance. In this context, it is very important to make personalized medical recommendations. The development of drug information visualization and intelligent recommendation platform projects has important practical significance and facilitates users to understand medical care.

2. Overall system design

2.1 System Architecture

This system adopts a layered architecture design, uses the Django framework to build the Web service layer, and implements the interaction between browser user requests and backend logic through API interfaces. The business logic layer combines NLP technology to implement semantic analysis, combines collaborative filtering algorithms to perform dynamic weight matching, and implements the processing of real-time user requests. The data persistence layer implements structured storage based on the mysql database, establishes connections with the knowledge graph, and optimizes

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high-frequency access performance through the cache system. The front end uses echarts for data visualization and uses an integrated distributed log monitoring module to ensure system reliability. The system implements user attribute management, behavior analysis, intelligent decision-making and visualization through modular design. The specific process is shown in Figure 1:

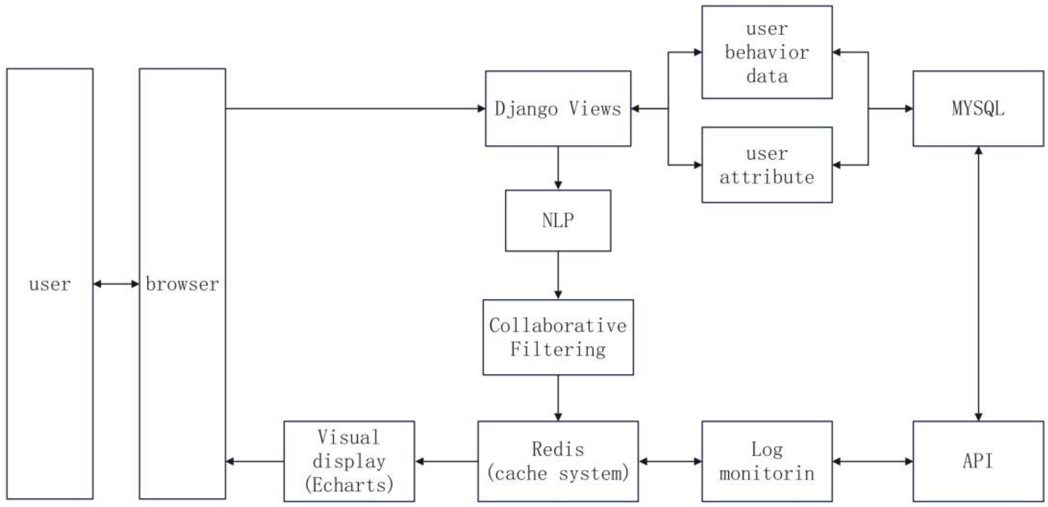

Figure 1 System overall architecture

2.1.1 Web Service Layer

The web service layer is the front-end display part of the system, which is built on the Django framework. The Django framework provides the system with powerful web development capabilities with its efficiency, stability and scalability. By designing a concise and clear user interface, users can easily enter the description of the condition, and the system will display the drug recommendation results and related information in an intuitive and friendly way. At the same time, the web service layer interacts with the back-end business logic layer through the API interface to realize data transmission and reception, ensuring that user requests are responded to and processed in a timely manner.

2.1.2 Business Logic Layer

The business logic layer is the core part of the system, responsible for processing user requests and generating corresponding recommendation results. In this layer, the natural language processing (NLP) technology is combined to perform semantic analysis on the description of the condition entered by the user. NLP technology can deeply understand the key information in the user's condition description, such as symptoms, medical history, allergy history, etc., and convert it into a data format that the system can recognize. Then, the collaborative filtering algorithm is combined for dynamic weight matching. The collaborative filtering algorithm calculates a personalized weight for each user by analyzing the user's historical behavior data and the preferences of similar users, thereby adjusting the calculation of the matching degree of drug recommendations. This dynamic weight matching method enables the system to accurately recommend the most suitable drugs according to the user's personalized needs.

2.1.3 Data persistence layer

The data persistence layer is responsible for the system's data storage and management, and implements structured storage based on the mysql database. The mysql database provides a stable data storage solution for the system with its good performance, reliability and ease of use. In this layer, the system's user data, drug information, historical recommendation records, etc. Are stored in an orderly manner. At the same time, in order to improve the relevance and digability of data, the system is connected to the knowledge graph. The knowledge graph can visualize the relationship between different data entities and provide richer information support for the system's intelligent decision-making. In addition, in order to optimize high-frequency access performance, the system also introduces a cache system. The cache system can temporarily store hot data in memory, reduce frequent access to the database, and thus improve the system's response speed.

2.1.4 Front-end visualization and system reliability assurance

The front end uses echarts for data visualization. Echarts is a powerful visualization library that can display the system's recommendation results and related data analysis in an intuitive and vivid chart format. Through echarts, users can clearly see the detailed information, applicable symptoms, dosage, etc. Of the recommended drugs, helping users to better understand and choose drugs. At the same time, the system integrates a distributed log monitoring module to ensure system reliability. The distributed log monitoring module can record various log information during the system operation in real time, including user operation logs, system error logs, performance monitoring logs, etc. By analyzing these logs, potential problems in the system can be discovered in a timely manner, optimized and repaired, and the stable operation of the system can be ensured.

2.1.5 Modular Design

The system implements multiple functional modules such as user attribute management, behavior analysis, intelligent decision-making and visualization through modular design. The user attribute management module is responsible for collecting and maintaining attribute data such as user personal information and health status, providing a basis for personalized recommendations. The behavior analysis module tracks and analyzes user operation behaviors to understand user preferences and demand changes. The intelligent decision-making module combines NLP technology and collaborative filtering algorithms to generate accurate drug recommendation plans based on user attributes and behavior analysis results. The visualization module uses tools such as echarts to display the recommendation results and related data analysis to users in an intuitive way. This modular design not only improves the development efficiency and maintainability of the system, but also enables the various functional modules to collaborate with each other to jointly achieve the system's intelligent medical recommendation goals.

2.2 Algorithm Design

2.2.1 Recommended calculation principle design

This system uses a dynamic weight model for calculation, and designs three scoring indicators: symptom and drug matching (SDM), user medication history fit (MHC), and personalized safety correction factor (PSF). Users can customize the proportion of these items. The recommended scoring formula is shown in the following formula:

$$RS = \alpha \cdot SDM + \beta \cdot MHC + \gamma \cdot PSF \tag{1}$$

In $\alpha + \beta + \gamma = 1$,default value $\alpha = 0.6$, $\beta = 0.3$, $\gamma = 0.1$ (Users can adjust according to their needs).

2.2.2 Detailed mathematical logic of each dimension

1) Symptom-drug matching (SDM)

Calculation process: first extract the symptom text, then perform TF-IDF vectorization, then perform knowledge graph retrieval, and finally complete the calculation of semantic similarity. The mathematical formula is shown below:

$$SDM(d,s) = \sum_{i=1}^{n} (tf - id(s_i) * sim(s_i, d_i) * w_{path}) \tag{2}$$

In, s_i is the ith symptom keyword, d_i is the therapeutic suitability of candidate drug d,The path weight from symptoms to drugs in the knowledge graph (based on clinical strength).

2) Medication History Compliance (MHC)

The time decay weighted model is shown in the following formula:

$$MHC(d) = \frac{\sum_{k=1}^{m} \delta^{t_k} * I(d = d_k)}{\sum_{k=1}^{m} \delta^{t_k}} \tag{3}$$

In, d_k represents the kth medication in history, t_j Represents the time from now (months), σ=0.9

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(attenuation factor) I() represents the indicator function (1 when the current drug is consistent with the history).

Data enhancement is shown in the following formula:

$$MHC'(d) = MHC(d) + 0.2 * \sum_{d' \in N(d)} MHC(d') \tag{4}$$

Where N(d) represents the set of drugs that have synergistic effects with d (from drugbank[1]).

3) Personalized correction (PSF)

The multi-dimensional security check is shown in the following formula:

$$PSF(d) = \prod_{i=1}^{p} \left(1 - Risk_i(d)\right) \tag{5}$$

Risk factors include contraindications and drug interactions, which are shown in the following formula:

a) Taboo Conflict:

$$Risk_1 = \begin{cases} 1| & taboos \\ 0| & No\ taboos \end{cases} \tag{6}$$

b) Drug Interactions:

$$Risk_3 = \sum DDI\ SEVERITY\ |\ 0.3 \tag{7}$$

4) Key mathematical principles

Using TF-IDF weighted optimization algorithm[2]As shown in the following formula:

$$Accuracy = \frac{Num}{Tr} \tag{8}$$

Time decay function[3](Exponential decay) is shown in the following formula:

$$\delta^{\tau} = e^{|\frac{t}{\tau}}, \tau = 6Y\,Half\ life\ of\ 6\ mont|sY \tag{9}$$

5) Verification indicators

a) Recommendation accuracy:

$$Accuracy = \frac{Num}{Tr} \tag{10}$$

b) Risk control rate:

$$Safety=1-Accuracy \tag{11}$$

c) Personalization Index:

$$Personalization = 1\ |\ \frac{S}{R} \tag{12}$$

2.3 System Function Design

This project takes "drug information association" and "personalized recommendation" as the core, and carefully constructs seven functional modules. These modules work together to realize the intelligent medical recommendation function of the system.

2.3.1 User registration and login module

This is the first barrier of system security protection, providing strict identity authentication and

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sophisticated permission management. Users can complete the registration process by setting username, password, email verification, mobile phone number verification and other methods to ensure the authenticity and uniqueness of the user's identity. At the same time, the module assigns corresponding permissions to different types of users (such as ordinary patients, professional doctors, etc.), strictly controls data access rights, ensures the security of user privacy data, prevents unauthorized access and data leakage risks, and lays a solid foundation for the safe operation of the entire system.

2.3.2 Drug Information Visualization Module

This module is dedicated to presenting complex drug information to users in the form of intuitive and easy-to-understand charts. Various charts are used to display drug properties, such as drug ingredient pie charts, drug dosage form bar charts, drug applicable symptom radar charts, etc., to provide a detailed introduction to the overall overview of the drug database, including drug type distribution, quantity statistics of various drugs, etc. Users can clearly see the characteristics and differences of different drugs, so as to better understand and choose drugs, and improve users' understanding of drugs and the accuracy of their choices.

2.3.3 Drug search module

In order to meet the diverse search needs of users, the drug search module supports multi-dimensional search functions based on keywords, symptoms or diseases. Combined with advanced semantic analysis technology, the system can deeply understand the semantic information of the search terms entered by users, automatically identify synonyms, near synonyms and related concepts, thereby improving the accuracy of queries. For example, when a user enters "heart palpitations", the system can simultaneously retrieve drug information related to "heart palpitations", ensuring that users can quickly and accurately find the drugs they need, improving search efficiency and user experience.

2.3.4 Drug Information Management Module

This module is mainly responsible for the addition, deletion, modification and query of drug data, which is a key link to ensure the accuracy and timeliness of drug data. System administrators can quickly and easily add new drug information through a friendly management interface, including drug name, ingredients, indications, usage and dosage, manufacturer and other details; delete expired or incorrect drug data; modify and update drug information in a timely manner when it changes, such as drug packaging updates, indication extensions, etc.; and query detailed drug information at any time to conduct data analysis and management decisions to ensure the integrity and reliability of drug data.

2.3.5 Medical Knowledge Association Engine Module

As one of the core modules of the system, the medical knowledge association engine module uses cutting-edge knowledge graph technology to build a huge three-layer association network of symptoms, diseases and drugs. The system integrates a large amount of medical literature, clinical guidelines and actual case data to associate various symptoms with possible corresponding diseases, and then connects diseases with applicable drugs to form a structured and semantic knowledge graph. This not only provides a solid logical support for the recommendation algorithm, enabling the system to recommend drugs based on a rigorous medical knowledge system, but also assists doctors in disease diagnosis and treatment plan formulation, improving the quality and safety of medical services.

2.3.6 User Interaction Module

The user interaction module is a bridge between the system and the user, and uses natural language processing technology to parse the symptom description and other information entered by the user. The system can accurately understand the semantics expressed by the user, extract key symptom information, and combine the user's previous medication history to comprehensively analyze the user's condition and needs, thereby forming an accurate personalized recommendation plan. During the interaction process, the module will also adjust the recommendation results in a timely manner based on user feedback, continuously optimize the recommendation effect, and enhance the interactivity and trust between users and the system.

2.3.7 Intelligent Recommendation Module

The intelligent recommendation module uses a carefully designed dynamic weight model to generate drug recommendations. The model comprehensively considers information from multiple dimensions, such as drug effectiveness, safety, user preferences, price factors, and drug inventory, and dynamically adjusts the weights of each dimension according to different user needs and scenarios. For

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example, for users with allergies, the safety weight will be appropriately increased; for price-sensitive users, the price weight will be increased accordingly. In this way, the system can provide each user with a drug recommendation plan that best meets their personalized needs, thereby improving user satisfaction and acceptance of the recommendation results.

2.3.8 Recommendation Result Visualization Module

Finally, the recommendation result visualization module presents the drug recommendation results generated by the intelligent recommendation module to the user in an interactive interface. The interface clearly displays the priority ranking of drugs, and reasonably sorts them according to factors such as the degree of match between the drug and the user's condition and the efficacy, so that users can quickly locate the most suitable drug for themselves. At the same time, the module will also provide detailed risk warnings, including important information such as possible side effects, contraindications, and drug interactions of drugs, to help users fully understand the risks of drugs. In addition, the basis for recommending drugs is displayed based on the traceability function, such as relevant medical research literature, clinical trial data, etc., to enhance the credibility and transparency of the recommendation results, so that users can use the recommended drugs with confidence.

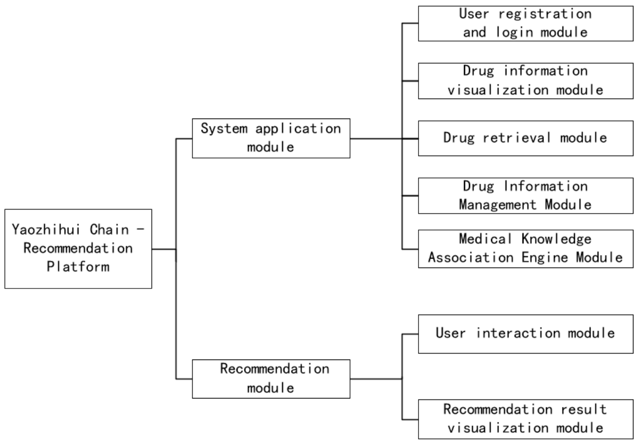

Figure 2 System functional modules

These seven functional modules achieve efficient data intercommunication and collaboration through the API interface within the system. The user registration and login module provides user identity information and permission verification services for other modules; the drug information visualization module, drug search module and drug information management module together constitute the basic support framework of drug data, providing rich drug data resources for the intelligent recommendation module; the medical knowledge association engine module provides medical knowledge logic support for the intelligent recommendation module and the user interaction module; the user interaction module collects user input information and passes it to the intelligent recommendation module, and at the same time feeds back the recommendation results to the user; the recommendation result visualization module displays the complex calculation results of the intelligent recommendation module to the user in an intuitive and easy-to-understand form. They are closely connected and completely constitute a powerful, efficient and intelligent medical recommendation system, providing users with comprehensive and personalized medical drug recommendation services. The system functional module diagram is shown in Figure 2.

2.4 Database Design

This system adopts a hybrid architecture of relational database and knowledge graph. The core data tables (users, drugs, symptoms) store basic information and map them with the entity relationships of the knowledge graph. The treatment intensity, evidence source and dynamic weight of the symptom and drug association path are recorded, and the symptom table and drug table are associated by foreign keys. The knowledge graph realizes efficient association query through the graph database, with "symptoms and drugs" as nodes and "treatment relationship" as edges, stores multi-dimensional medical logic, supports complex path retrieval, and finally dynamically integrates the JSON field of the relational database with the graph query results to realize the semantic association and calculation required for accurate recommendation. The system ER diagram is shown in Figure 3.

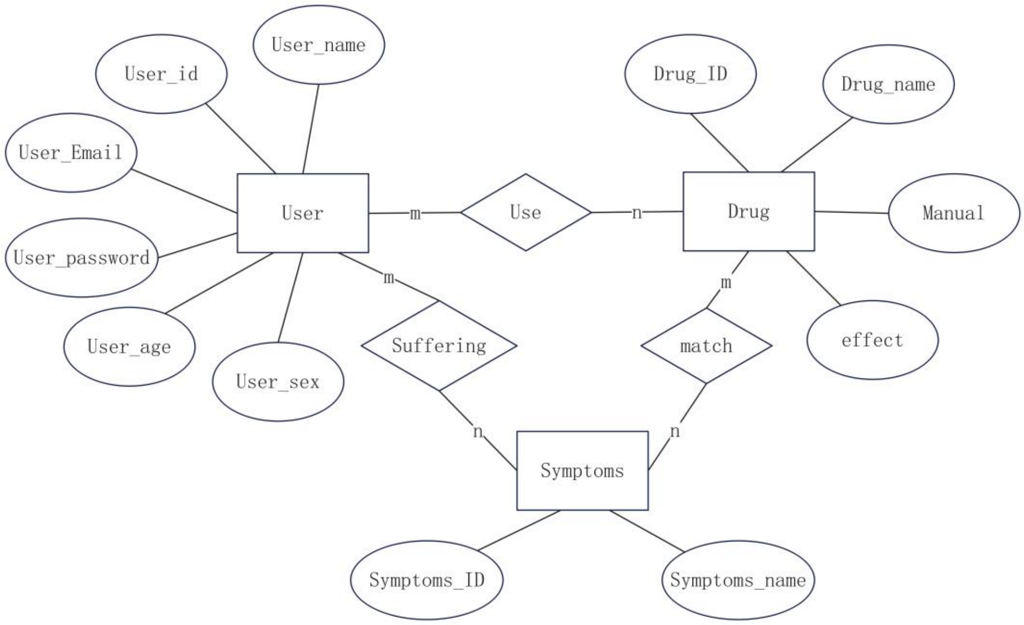

Figure 3 System ER diagram

3. System Implementation

3.1 Environment Construction

The system is built as a web application based on the Django framework. Users enter symptom descriptions through the front-end form, and the back-end uses NLP technology to extract symptom entities. Combined with the Neo4j knowledge graph and the mysql user medication history database, a list of recommended drugs is generated in real time through a dynamic weight algorithm. After the recommendation results are verified for security (contraindication screening, drug interaction detection),the drug priority, risk warnings, and recommendation basis traceability are displayed in an interactive visual interface. The front-end uses Bootstrap+echarts to achieve responsive layout and data charts, and the back-end optimizes query performance through Redis cache. The entire process data is encrypted (HTTPS+AES) and strictly follows medical privacy protection specifications, forming a complete closed loop from symptom input to medication recommendations.

3.2 Data collection and processing

First, visit the drugbank official website to obtain free data download permissions, download the XML or CSV file, parse the file, and then build a local medical knowledge graph, perform data modeling, and create drug nodes, disease nodes, and the relationships between them.

The data collection of this study is based on the drugbank open database[4]First, we registered on the official website to obtain permissions, and used the Python requests library to automatically download structured data files. In the data preprocessing stage, pandas was used to parse the core fields of CSV, and beautifulsoup was used to extract XML molecular structure information. After the data cleaning process, by deleting records with a completeness of less than 80%, mapping mesh terminology standardization, and resolving conflicts based on FDA information, we finally constructed a structured data set containing 12,783 drugs and 56,420 interaction relationships. The quality verification adopted a triple mechanism: rule-based drug interaction conflict detection, manual comparison of 200 random samples with Micromedex, and ATC code coverage verification (up to 98.7%) to ensure data reliability and integrity.

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3.3 System Implementation

For user input processing and symptom extraction, the medical field NLP model is loaded first, and then the symptom entity recognition is performed and standardized mapping is performed to ICD-11. Next, the knowledge graph query and symptom matching degree calculation are performed, and Neo4j query is performed.[5], and then connect with the project, and realize the calculation of the user's medication compatibility. Next, the recommended drugs are safety checked. If successful, the results are visualized and output. If failed, contraindicated drugs are marked. The specific process is shown in Figure 4.

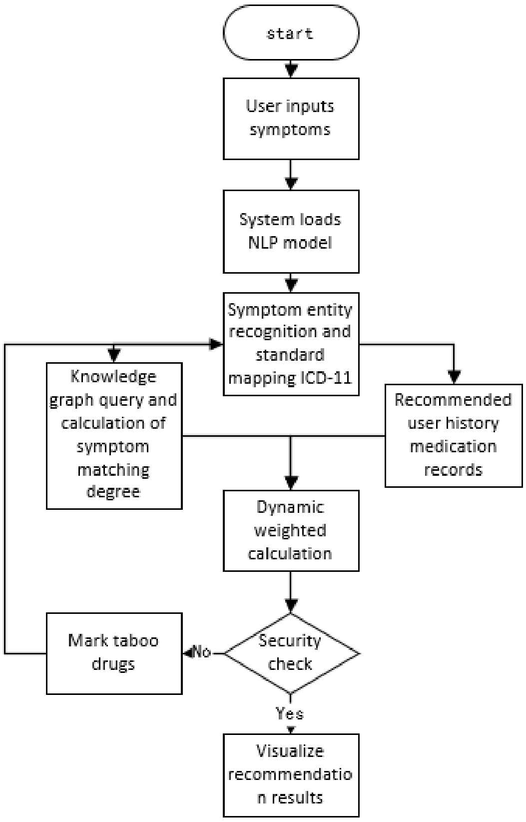

Figure 4 Program flow chart

4. Conclusion

This study proposes an innovative architecture based on dynamic weight fusion and medical knowledge graph to meet the accuracy and safety requirements of the drug recommendation system. A multi-layer symptom-drug association network was constructed, and accurate semantic analysis of symptoms was achieved through natural language processing and ICD-11 standardization. A dynamic weight recommendation model was designed to break through the limitations of traditional static rules, take into account personalization and evidence-based medicine logic, and establish a multiple security verification mechanism. Through the hybrid architecture of knowledge graph and relational database, efficient reasoning of complex medical relationships is achieved, and interpretable recommendation results are output to enhance clinical credibility; the localized deployment solution strictly protects data privacy. This achievement provides a safe and reliable drug decision support tool for smart medical care, especially for primary medical scenarios. It has important social value in reducing misdiagnosis rates and optimizing resource allocation, and provides an innovative paradigm for the implementation of artificial intelligence-assisted diagnosis and treatment systems.

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