Amino acids industry knowledge service platform*

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Abstract

Purpose: This paper introduces an amino acids industry knowledge service platform, which integrates industry data, science literature, and technology knowledge from patents.

Design/methodology/approach: From the perspective of knowledge organization, the amino acids industry knowledge service platform comprises a basic data layer, a knowledge representation layer, and a knowledge service layer. The platform integrates heterogeneous information sources by means of a multi-dimensional integration index. It enables users to find technology knowledge from patents by employing the semantic Theory of Inventive Problem Solving (TRIZ).

Findings: This paper constructs an integrated amino acids industry database, which offers a general service oriented to the public, and a technical innovation knowledge base, which offers a value-added service oriented to enterprises.

Research limitations: The technical innovation knowledge base only includes parts of amino acids technology knowledge, making it suitable to meet certain specific needs.

Practical implications: Semantic annotation of technical innovation knowledge from patents requires manual work by domain experts.

Originality/value: The amino acids industry knowledge service platform offers not only an integrated search service for amino acids industry information, but also a deep tech mining service for technical innovation knowledge of amino acids. It will offer a more personalized knowledge service in the future.

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Keywords  Knowledge service; Amino acids industry information; Multi-dimensional integration index; Semantic TRIZ

1 Introduction

Knowledge services are a new kind of information service to support the knowledge economy. They focus on solutions for specific user needs\cite{1,2}. Knowledge service platforms dynamically integrate related resources, helping users identify the precise information they need\cite{1,2}.

The knowledge service platform has become an important information infrastructure for science and technology innovation. The British National Knowledge Service (NKS) Platform, sponsored by the British Ministry of Health, was built in 2002. It was designed to promote the application of health knowledge to improve health care services by integrating and organizing health information\cite{3}.

In China, China National Knowledge Infrastructure (CNKI) established a series of knowledge service platforms, such as the printing and dyeing industry knowledge service platform\cite{4}, the pharmaceutical enterprises innovation and development knowledge service platform\cite{5}, the petroleum and petrochemical science and technology innovation knowledge service platform\cite{6}, and others. These knowledge service platforms are based on the information resources of CNKI, offering integrated domain knowledge services for government, enterprises, universities and research institutes. The knowledge cube disciplines service platform is a knowledge service platform created by the Chongqing VIP Information Company, a Chinese science and technology literature provider. This platform focuses on deep knowledge mining and context analysis, and offers highly accurate subject information services from detailed multi-dimensional knowledge bases\cite{7}.

There are some knowledge service platforms oriented to local specialty industries, such as the patent information service platform for industry development of Guangdong Province\cite{8}, the knowledge service platform of pillar industries in Gansu Province\cite{9}, and so on. These knowledge service platforms focus on the integration of different kinds of information resources. They have two disadvantages: One is the lack of integration of information; the other is the lack of deep mining and semantic association between the knowledge elements. Therefore, they are not sufficient to meet the needs of a deep and specialized knowledge service.

Amino acids are important raw materials for food, light chemicals, pharmaceuticals, and other fields\cite{10}. There are some problems in China’s amino acids industry, such as the lack of innovative varieties, loose contact between industry and research, low efficiency of technology transfer, and more\cite{11}. It is important to construct a knowledge service platform that integrates industry, science, and technology information, and offers specialized search services for development of the amino
acids industry. This paper introduces an Amino Acids Industry Knowledge Service Platform (AAIKS) that can help to enhance the level of information about amino acids research, development, and results transformation, promote the sharing of industry, education, and research resources, and enhance the international competitiveness of the industry by integration of all available resources.

2 Application environments

AAIKS is a Web system based on the Browser/Server service model. The details of application environments are introduced in the following sub-sections.

2.1 User environment

The client for users of the AAIKS is a general browser, such as IE or Chrome. The visual retrieval module needs to have a Flash plug-in installed.

2.2 System environment

The network environment of AAIKS is an IPV4 network, and the system must be deployed on a 64-bit server. AAIKS was developed in pure JAVA, which can be deployed in Windows or Linux systems with JAVA. The AAIKS database is based on Mysql, the index service of AAIKS is based on Solr, and Tomcat is used as the Web service container.

2.3 Service and management environment

AAIKS uses a multi-dimensional integrated index to integrate heterogeneous information sources, and TRIZ, to semantically annotate patent technology information, and various visualization techniques to display knowledge interactively. All services and managements of the AAIKS are operated through the Web.

3 Application design

3.1 Content of AAIKS

The aim of AAIKS is to integrate industry data resources, enable the mining of tacit knowledge, and promote the transfer of intellectual property. Its contents include three parts: 1) an amino acids industry database, 2) an amino acids academic database, and 3) an amino acids technological innovation knowledge base. The amino acids industrial database is the integration of amino acids industry data (such as standard industry data and economic data) and information (such as industry enterprises and projects). The amino acids academic database is the integration of amino acid science and technology literature resources. The amino acids technological innovation knowledge base is constructed based on the deep mining
of technological information from amino acids patents. The content of AAIKS is shown in Fig. 1.

![Diagram of Amino Acids Industry Knowledge Service Platform](image)

**Fig. 1 Content of AAIKS**

### 3.2 Framework of AAIKS

According to the content of the AAIKS, the platform is composed of a basic data layer, a knowledge organization layer, and a knowledge service layer, as shown in Fig. 2.

![Diagram of AAIKS Framework](image)

**Fig. 2 AAIKS framework**

#### 3.2.1 Basic data layer

The basic data layer includes two parts: Amino acids industry database and amino acids academic database. Its data is from commercial databases, such as Web of
Knowledge ISI, self-built databases and Internet open databases, such as the gene database of the National Center for Biotechnology Information (NCBI). The basic data layer uses methods such as metadata integration, standard interface acquisition, and RSS harvesting, to collect and integrate the heterogeneous information. It uses a traditional relational database to store the data collected. In addition to providing a single database search, the basic data layer is also the basic data source of the knowledge organization layer.

3.2.2 Knowledge organization layer

The knowledge organization layer includes two parts: The amino acids industry information multi-dimensional integration index, and the amino acid technical information semantic TRIZ index. The amino acids industry information multi-dimensional integration indexes are based on the unified metadata standard of the amino acid industry data and various information resources, and integrate heterogeneous information sources. The amino acids semantic TRIZ provides users with accurate, high-value-added knowledge by deep mining and linking technical information of amino acids patents.

3.2.3 Knowledge service layer

The knowledge service layer provides a uniform interface to the database of the basic data layer and the index of the knowledge organization layer. It is a service window for end users to browse and search data. In addition to traditional database retrieval, it also provides visual browsing, unified search, and other knowledge services.

3.3 Key technologies of AAIKS

From a technical point of view, the knowledge organization layer is the key research content of the AAIKS. The key technologies involved include the topic model, the multi-dimensional integration index, and semantic TRIZ, which are described below.

3.3.1 Topic model

In knowledge services, users often want to quickly obtain a comprehensive understanding on various topics related to amino acids. However, the amino acids information layers involved large and complex datasets. If you rely on manual classification of patent data, it will require much time and effort. Topic model is a series of approaches based on a probability model, which is used to detect hidden topics in documentation\textsuperscript{12}. We apply topic model to the secondary processing of amino acids information, extracting implicit and latent topics from a number of
types of amino acids information, and produce new knowledge. Specifically, we use a latent Dirichlet Allocation (LDA) model to generate new topics. LDA handles a document as probability distributions of a series of topics, and a topic is regarded as the probability distribution of a series of keywords. LDA has been widely used in scientific literature analysis and knowledge mining\cite{13,14}. It is an unsupervised machine learning technology and can automatically generate a series of topics based on document-words bags, without manual intervention by experts\cite{13,14}. The input to LDA is a document-keywords matrix; its output is a document-topic matrix. From these matrices, LDA can express distribution of amino acids in keyword space by computing topics’ distribution in keyword space, and information distribution in topic space. Similar information is found in each topic according to the content and number of keywords in every class, and this can help users quickly find what is interesting\cite{12}. We use the LDA module of the MALLET toolkit\cite{15} to handle amino acid papers, patents, and industrial information, to generate a series of appropriate topics. See an example in Table 1.

<table>
<thead>
<tr>
<th>Semantic tags</th>
<th>Including keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acid</td>
<td>Amino acid; Nitrogen; Volatile compounds; Lipid oxidation; Fatty acids; Amino acid composition; Dissolved amino acid</td>
</tr>
<tr>
<td>Gene</td>
<td>Gene; Genome comparison; DNA binding; DNA sequence; Nucleotides; Genomic DNA; Gene-Expression; Mutations</td>
</tr>
<tr>
<td>Food processing</td>
<td>Food processing; Nutrient stability; Foal meat; Food analysis; Food composition; Extraction; Emulsification; Carbohydrate</td>
</tr>
<tr>
<td>Protein</td>
<td>Protein surface; Protein evolution; Protein structure; Dietary protein; Macro-nutrient; Protein descriptor; Nucleocapsid protein</td>
</tr>
<tr>
<td>Enzyme</td>
<td>Enzyme; Dehydrogenase; Thermophilic enzyme; Enzyme activity; Enzyme immobilization; Threonine aldolase; Enzyme aggregates</td>
</tr>
</tbody>
</table>

3.3.2 Multi-dimensional integration index

The basic data layer contains structured data, but it has the characteristics of heterogeneity and distribution. Therefore, it is necessary to hide these differences and provide users with a unified knowledge retrieval model. A multi-dimensional index is a technique of multi-level and multi-facet indexing for complex data. It can be used to integrate heterogeneous information sources and provide a unified interface; such an approach has been widely used in information integration systems\cite{16,17}. Therefore, AAIKS uses a multi-dimensional integrated index to integrate and index the database of the basic data layer.
In particular, the multi-dimensional integration index is based on Apache Solr, which indexes and integrates the metadata of heterogeneous information sources[16]. The indexed fields include resource type, resource title, author, inventor, institutions, applicant, type of agency, publishing year, source, keywords, IPC classification, standard level, amino acid variety, name of bacterium, and technology topic. Depending on the data sources, a corresponding index update mechanism is adopted, such as weekly, monthly, or yearly update.

3.3.3 Semantic TRIZ

Patent documents are the most important information sources for amino acid innovation. They contain rich technical information, but the information is hidden in unstructured text, which is difficult to search directly. Semantic TRIZ is a tool for mining and organizing patent technology information. It is a semantic extension of the contradiction and innovation principle of classical TRIZ, which can be considered a special kind of knowledge organization system[17,18]. AAIKS uses semantic TRIZ to extract, organize, and represent technical information from amino acids patent documents.

From the TRIZ point of view, patent technology information can be summarized as technical problems (Problem), technical solutions (Solution), technical functions (Function) and technical effects (Effect)[17,18]. Specific to the amino acid domain, AAIKS indexes technology information from strain construction technology, separation and extraction technology, gene regulation mechanism, acid production performance and other aspects of the study of amino acids, and organizes them using ontology.

Referencing the amino acids ontology of the National Center for Biomedical Ontology (NCBO)[19] and the opinions of some experts, a schema of amino acids semantic TRIZ was made. Some of its important concepts are shown in Table 2; some relationships between the concepts are shown in Table 3. The schema of amino acids semantic TRIZ is shown in Fig. 3. Once the schema was designed, technology information mined from patents was mapped onto the schema. The D2RQ mapping language[20] is used to map the data.

Semantic TRIZ is used to reveal the technology information hidden in amino acids patents, and link it with other data, such as genetic data. It can help users quickly grasp the technical tools behind amino acid patents, achieve their technical effect, and conduct bypass design to avoid patent infringement.

4 Application effect

AAIKS provides two different levels of service. One for the public—is called “the amino acids industry information data service.” It is free. The other for
Table 2  Some concepts of the amino acids semantic TRIZ ontology

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>CLASS</td>
<td>Technical problems in patents</td>
</tr>
<tr>
<td>StrainImprovement</td>
<td>SubCLASS</td>
<td>Technology of improving strain, subclass of Problem</td>
</tr>
<tr>
<td>Solution</td>
<td>CLASS</td>
<td>Technical solutions in patents</td>
</tr>
<tr>
<td>GeneRegulation</td>
<td>SubCLASS</td>
<td>Technology of regulating gene, subclass of Solution</td>
</tr>
<tr>
<td>GeneUp-Regulation</td>
<td>SubCLASS</td>
<td>Technology of up-regulating gene, subclass of GeneRegulation</td>
</tr>
<tr>
<td>GeneDown-Regulation</td>
<td>SubCLASS</td>
<td>Technology of down-regulating gene, subclass of GeneRegulation</td>
</tr>
<tr>
<td>Extraction</td>
<td>SubCLASS</td>
<td>Technology of extracting amino acids, subclass of Solution</td>
</tr>
<tr>
<td>IonExchange</td>
<td>SubCLASS</td>
<td>Technique of ion exchange, subclass of Extraction</td>
</tr>
<tr>
<td>MembraneSeparation</td>
<td>SubCLASS</td>
<td>Technique of membrane separation, subclass of Extraction</td>
</tr>
<tr>
<td>Adsorption</td>
<td>SubCLASS</td>
<td>Technique of adsorption, subclass of Extraction</td>
</tr>
<tr>
<td>Precipitation</td>
<td>SubCLASS</td>
<td>Technique of precipitation, subclass of Extraction</td>
</tr>
<tr>
<td>Production</td>
<td>SubCLASS</td>
<td>Technology of producing amino acids, subclass of Solution</td>
</tr>
<tr>
<td>Fermentation</td>
<td>SubCLASS</td>
<td>Technique of fermentation, subclass of Production</td>
</tr>
<tr>
<td>MicrobialEnzymes</td>
<td>SubCLASS</td>
<td>Technique of using microbial enzymes, subclass of Production</td>
</tr>
<tr>
<td>ProteinHydrolysis</td>
<td>SubCLASS</td>
<td>Technique of protein hydrolysis, subclass of Production</td>
</tr>
<tr>
<td>Function</td>
<td>CLASS</td>
<td>Technical functions in patents</td>
</tr>
<tr>
<td>FunctionofGene</td>
<td>SubCLASS</td>
<td>Functions of gene, subclass of Function</td>
</tr>
<tr>
<td>EnzymeActivityDecreased</td>
<td>SubCLASS</td>
<td>Activity of enzyme is decreased, subclass of FunctionofGene</td>
</tr>
<tr>
<td>EnzymeActivityIncreased</td>
<td>SubCLASS</td>
<td>Activity of enzyme is increased, subclass of FunctionofGene</td>
</tr>
<tr>
<td>Effect</td>
<td>CLASS</td>
<td>Technical effects in patents</td>
</tr>
<tr>
<td>ImproveProductionofAcid</td>
<td>SubCLASS</td>
<td>Improving production of amino acids, subclass of Effect</td>
</tr>
<tr>
<td>AvoidUnexpectedEffect</td>
<td>SubCLASS</td>
<td>Avoiding unexpected effect of amino acids, subclass of Effect</td>
</tr>
<tr>
<td>SimplifyProcess</td>
<td>SubCLASS</td>
<td>Simplifying process of producing amino acids, subclass of Effect</td>
</tr>
<tr>
<td>ReduceCost</td>
<td>SubCLASS</td>
<td>Reducing cost of producing amino acids, subclass of Effect</td>
</tr>
<tr>
<td>AminoAcid</td>
<td>CLASS</td>
<td>Amino acid</td>
</tr>
<tr>
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<td>SubCLASS</td>
<td>Glutamate, subclass of AminoAcid</td>
</tr>
<tr>
<td>Threonine</td>
<td>SubCLASS</td>
<td>Threonine, subclass of AminoAcid</td>
</tr>
<tr>
<td>Strain</td>
<td>CLASS</td>
<td>Strain</td>
</tr>
<tr>
<td>BacillusBrevis</td>
<td>SubCLASS</td>
<td>Bacillus Brevis, subclass of Strain</td>
</tr>
<tr>
<td>CoryneBacterium</td>
<td>SubCLASS</td>
<td>Coryne Bacterium, subclass of Strain</td>
</tr>
<tr>
<td>Enzyme</td>
<td>CLASS</td>
<td>Enzyme</td>
</tr>
<tr>
<td>Ketoglutarimidehydrogenase</td>
<td>SubCLASS</td>
<td>Keto glutarimide hydrogenase, subclass of Enzyme</td>
</tr>
<tr>
<td>Patent</td>
<td>CLASS</td>
<td>Patent</td>
</tr>
<tr>
<td>Assignee</td>
<td>CLASS</td>
<td>Assignee</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
enterprises—is called “the amino acid technology innovation knowledge service,” and it is a value-added service, augmented by manual services from experts.

The amino acids industry information data service provides searching and browsing of amino acids industry standards data, economic data, news, organizations, research projects, and other information, without manual services. Its Web interface is shown in Fig. 4.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Some relationships between the concepts of the amino acids semantic TRIZ ontology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Domain</td>
</tr>
<tr>
<td>hasProblem</td>
<td>Patent</td>
</tr>
<tr>
<td>hasSolution</td>
<td>Patent</td>
</tr>
<tr>
<td>hasFunction</td>
<td>Patent</td>
</tr>
<tr>
<td>hasEffect</td>
<td>Patent</td>
</tr>
<tr>
<td>includeAminoAcid</td>
<td>Patent</td>
</tr>
<tr>
<td>includeStrain</td>
<td>Patent</td>
</tr>
<tr>
<td>includeEnzyme</td>
<td>Patent</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>

![Fig. 3 Part of the schema of the amino acids semantic TRIZ ontology](image)
The amino acid technology innovation knowledge service includes access to the amino acids academic database and amino acids technological innovation knowledge base. It also offers manual services from experts. The amino acids technological innovation knowledge base contains 3,406 amino acids patents, which are annotated by experts, based on semantic TRIZ, and also offers six amino acids information analysis reports, written by experts. Its Web interface is shown in Fig. 5.

5 Conclusion

AAIKS is a platform for the project of “Research and Application of Intellectual Property Development Strategy of Amino Acids Industry”. There are two innovations in the application and service. One is that AAIKS integrates amino acid industry
data, such as standards data and economic data, with other information resources, such as enterprises and projects, which can provide users with a one-stop amino acid industry information search service. AAIKS also cooperates with the practical work of the project, taking into account specific needs of users, and offers a semantic TRIZ for amino acids patents, which helps reveal the technology information behind acids patents and constitutes an amino acids technological innovation knowledge base; this has been applied to practical research jobs.

In the future, we will utilize the data resources of AAIKS to offer customized knowledge services, as well as a combination of online and offline services to meet the actual needs of users. In the process of serving customers, the content of AAIKS will be gradually enriched. This project represents another focus to integrate information source and offer a wide variety of knowledge products.

Author contributions

Y. Wen (weny@clas.ac.cn, corresponding author) and H. G. Fu (fu_hongguang@hotmail.com) designed and performed the research, and wrote and revised the manuscript. S. Fang (fangs@clas.ac.cn) proposed the research question. Q. G. Li (li_qg@tib.cas.cn), C. J. Liu (liucj@clas.ac.cn), Y. Xu (yuanx@clas.ac.cn), and N. Yang (yangn@clas.ac.cn) designed and implemented the knowledge organization layer, the knowledge service layer and the basic data layer of AAIKS, respectively. X. Zhang (zhangx@clas.ac.cn) contributed to the research proposal and was in charge of integrating heterogeneous information sources. Y. X. Zhu (zhuyx@clas.ac.cn) Y. X. Zhu (zhuyx@clas.ac.cn) and C. J. Ding (dingcj@clas.ac.cn) cleaned and analyzed amino acids semantic TRIZ data.

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