The Design of Value Evaluation System Based on Fuzzy Comprehensive Method for Agricultural Science and Technology Achievements

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Abstract. Hierarchical analysis and comprehensive fuzzy evaluation are combined to evaluat the value of agricultural science and technology achievements (ASTA), based on the value evaluation index system. A Java based ASTA value valuation system was designed and developed. The system has multiple functions including storage, management of ASTA data and experts' information data, statistical analysis and evaluation of ASTA valuation. The application of the system shows that the system offer an automatic and simple data management tool for the management department, and also provides a reliable value authentication by the third party for ASTA holder.

Introduction

The current ASTA transformation ratio is an important indicator to measure the magnitude of transformation and also a pivotal factor of national economic growth, which mirrors the innovative nation. In the course of "11th five-year plan", the ASTA adaptation rate has been amplified significantly in China and has acquired the adaptation value of 41%, and that of agricultural enterprise has reached 47.24% [1]. However, the transformation rate of developed countries is about 65%-85% and the contribution rate of agricultural science and technology progress is about 60%-80% [2]. This is a significant gap as compared to the developed nations. A couple of factors restricting ASTA transformation in China. The root of the constraints is the lack of effective convergence between scientific research system and achievement transformation market and desperately needs the third party to act as liaison between the two sides. At this time, we need to have an independent and objective assessment of ASTA to avoid the blindness and randomness of the ASTA transaction, and also to protect the interests of the both sides to improve the success rate. So how to ensure the process of ASTA transaction through scientific, effective evaluation of agricultural science and technology achievements is a problematic study. This research has an important practical significance to accelerate the ASTA transformation, and promote the rational allocation of agricultural resources.

Scholars at home and abroad have conducted a lot of research on ASTA. Domestic research mainly focuses on the definition of ASTA, the connotations of the ASTA transformation, the ASTA transformation mechanism, and the existing problems in this field [3-6]. There is no specific concept of agricultural science and technology achievement transformation in the world, while the technology transfer [7-8] and technology extension [9] has been researched thoroughly. The existing research at home and abroad mainly focuses on the qualitative analysis and transfer and extension of a single technology. There is lack of adequate research on communication mode and platform which has universality and credibility. This model can provide ASTA the third party authoritative evaluation method, and build a trust between the two sides of supply and demand. At the same time, the network platform can solve the traditional assessment problems of high energy consumption and low time efficiency, and also to meet the needs of low cost and high efficiency for the both sides.

Combining the information technology with the evaluation model, we designed and developed the ASTA value assessment system which is a user friendly and efficient tool. The system realized the storage and management of expert and achievement data, statistical analysis, on line ASTA value evaluation, results visualization and other functions.

ASTA Valuation Assessment System

An evaluation system based on the ASTA evaluation model was designed to implement said method.

System Design Target. The online evaluation system for ASTA valuation is aimed to analyze the advantages and disadvantages of ASTA and provide service for both supply and demand during the transformation of ASTA. During designing process of the system, we followed the research of national and international researchers and integrated with the computer network technology. This system not only could be used to manage the complex evaluation model of ASTA value, but also can manage large-scale ASTA information and experts review information. So we can solve the problems of the former evaluation model, that restricted complexity, high error rate, and also the data processing time is too long. In addition, this research uses network technology to solve the problems of information exchange, data standards and so on. For the stated goal, this system take into account the technical factors, efficiency factors, market factors, and selected the evaluation indicators of ASTA. Then follow the technical feasibility, the manipulation and application principle, the system was designed to meet the demand of the agricultural research institutions and agricultural enterprises.

System Structure. Based on B/S mode, the system adopts the three layer system structure, including: display layer, business layer and data layer, as shown in Fig. 1. In terms to display layer, we use JSP technology in the browser to complete the ASTA data management, query, as well as the display of results and other functions, so as to achieve human-computer interaction. Business layer is the core and of the system and also known as Logical layer and also bridges the display layer and data layer. It uses the HTTP protocol to realize the interaction with the display layer. On the other hand, it interacts with data layer through JDBC using MySQL. The data layer provides data support for the whole system.

System Function Structure Design. According to the system's development goal, the system is mainly divided into 5 functional modules (as shown in Fig. 2).

Data Management Module. Accurate data is the basis for evaluating the value of ASTA, so it is necessary for this module to organize and manage all kinds of data to provide effective data operation. Moreover the module through the computer language processing data format make the interactive data in accordance with the rules of evaluation algorithm, on the other hand, through the way of manual intervention, control the authenticity and availability of data, such as abnormality of scientific technology technological achievements, and the activation of evaluation experts state, etc.

Data Upload and Download Module. This module provides the users with their respective rights to upload and download functions. The system provide participating experts with the information download channel of scientific and technological achievements, and offer the supplier with scoring criteria and evaluation results certificate etc., and also provides the data output that covers all permissions for the system manager.

Value Evaluation Module. This module is the core function of the system, which can realize the quantitative evaluation of agricultural science and technology achievements, and the visualized output of the evaluation results.

Statistical Analysis Module. To facilitate the personnel management department analyzing achievements data and expert data in the system, this module provides a statistical analysis function, which can realize the visualization of statistical results and statistical analysis based on different attributes of data.

Users Management Module. Effective user management plays an important role in maintaining the security of the system and ensuring the integrity of the data. Therefore, the system administrator should carry out daily management for users with different privileges.

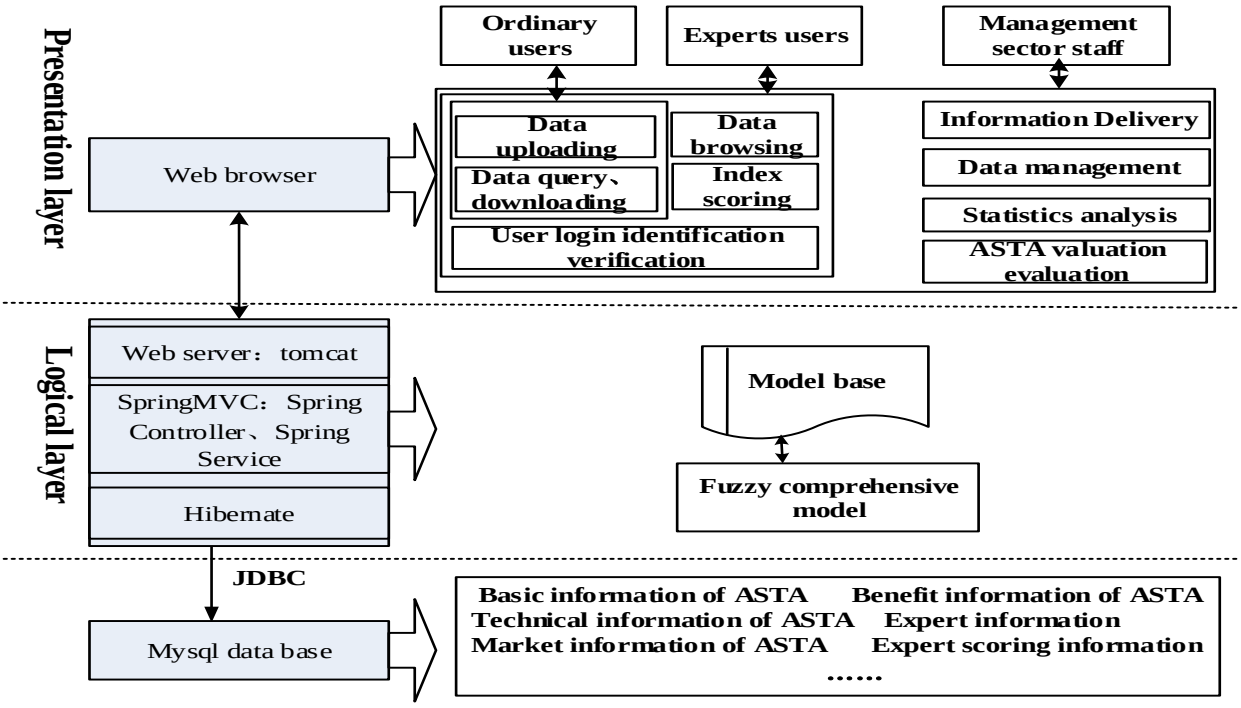

Figure 1. Web structure of the system.

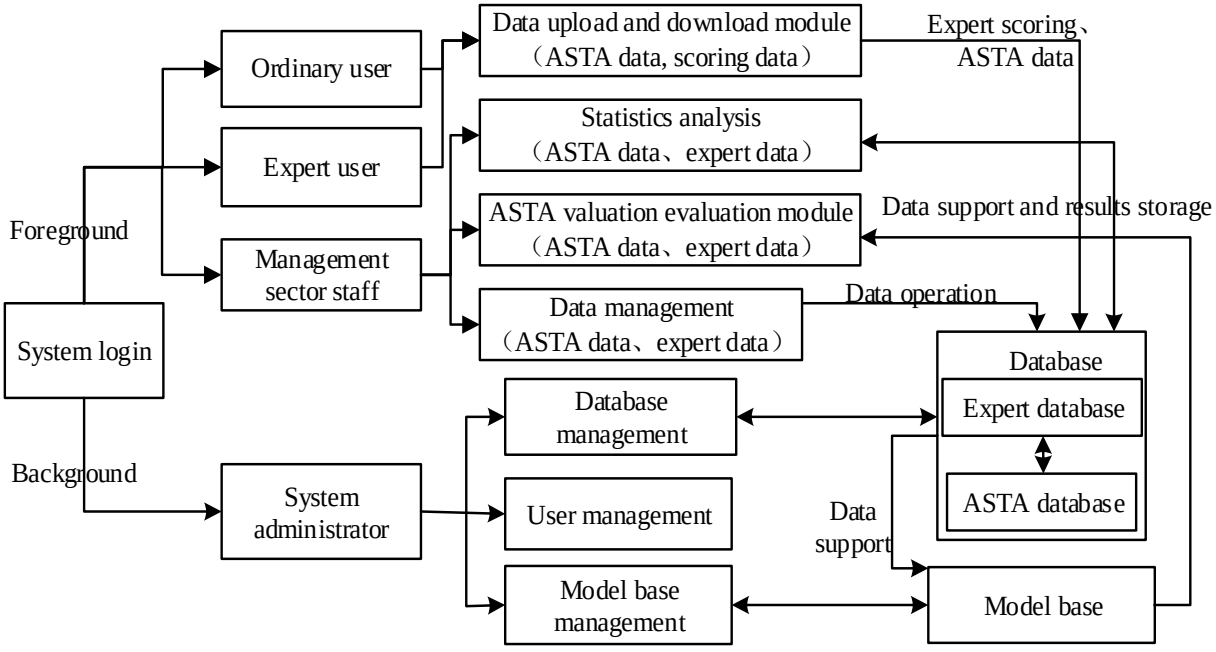

Figure 2. Function module structure of system

Fuzzy Comprehensive Evaluation Model of ASTA Valuation. *The establishment of index system an example.*ASTA has the characteristics of the wide variety and large differences between classes. Thus, we take a single ASTA as the research object. The technical characteristics and income status of ASTA not only affects its own value, but also the external market factors have a great impact on the value. In addition, the evaluation index is the foundation and basis for the evaluation of ASTA, whose quality has a direct impact on the reliability and validity of the evaluation results. Through the study, analysis of the literature and the current regulations, we realized that many of the indicators constitute a hierarchical system. In view of above statement, we have developed a 3 level evaluation index system (shown in Table 1 below) to assess the valuation

of ASTA, following the principles of general, systematic, typical, concise, scientific, comparable, actionable, quantifiable and comprehensive principles.

Table 1 Index system for ASTA evaluation

First-level index	Second-level index	Third-level index	
Technical index	Technology Level	Technology innovation	Intellectual property rights
		Mature technology	Technical standard level
		development potential	applicability of the Technology
		difficulty of technology application	Advanced level of the technology
		Completeness of technical description	Ability to provide complementary technology
	Technical risk	Longevity risk	
		Technical personnel availability risk	
		The risk for easy to be faked	
Benefit index	Economic benefits	Cost profit ratio	
		Payback period	
	Eco efficiency	Environmental impact	
		Utilization of resources	
Market index	Market environment	Market demand	
		Market cycle	
		Recognized degree	
		Market competition ability	
		Promotion prospects	

ATSA value evaluation model.There are many methods such as neural network method [10-11], data envelopment analysis [12], principal component analysis [13], fuzzy comprehensive evaluation [14], analytic hierarchy process [15] and so on. Neural network method has high adaptability, but requires a large number of training samples. Similar to the neural network method, the principal component analysis also requires a large number of sample data. The data envelopment analysis method can be used to deal with multi input and output indexes, which is more appropriate for the evaluation of the comparative effectiveness of the decision making units. As a systematic engineering method, the analytic hierarchy process is easily influenced by the subjective consciousness, but it can be used to analyze the qualitative problem quantitatively. Compared with other methods, the foremost feature of the comprehensive fuzzy method is that it is apposite for the evaluation of the object with the characteristics of "explicit connotation, fuzzy extension ".

According to the characteristics of ATSA, that personality significantly, the multi-target, multi-level and index have the characteristics of fuzziness, we adopt comprehensive fuzzy evaluation method and combine with the thought of hierarchical analysis to assess the value of ATSA synthetically. So that we can make full use of the hierarchy structure for index system and fuzzy judgment of qualitative indicators. The detailed steps of ATSA value evaluation model are as follows:

The first step is to set up the evaluation factor set and the evaluation set. In this study, the factor set U is defined as:

$$U = \{u_1, u_2, \cdots, u_i, \cdots, u_n\} \tag{1}$$

As the three level index system was adopted in this study, u_{i} contains sub factors u_{ij} and u_{ij} contains sub factors u_{ijt}.The expressions are as follows.

$$u_{\mathrm{i}} = \{u_{i1}, u_{i2}, \cdots, u_{\mathrm{ij}}, \cdots, u_{im}\} \tag{2}$$

$$u_{\mathrm{ij}} = \{u_{ij1}, u_{ij2}, \cdots, u_{\mathrm{ijt}}, \cdots, u_{ijm}\} \tag{3}$$

In the formula, u_{i} indicates the i factor in the first level corresponding to the i index in the first level, i=1,2,…, n. u_{ij} indicates the j factor in the first second level and belongs to the first class evaluation factors of I, j=1,2,…, m.

At the same time, each factor set corresponds to a set of *V*, which is defined as:

V= {excellent, good, general, poor, very poor} (4)

The second step is to construct the fuzzy judgment matrix and determine the weight of the factors. Based on the value evaluation index system, we designed the questionnaire of expert opinion, and then invited the experts to score the relative importance of the index, and finally established the judgment matrix *R*.

$$R = \begin{bmatrix} r_{11} \cdots \mathrm{r}_{1i} \cdots r_{1n} \\ \vdots \quad \ddots \quad \vdots \\ r_{j1} \cdots r_{ji} \cdots r_{jn} \\ \vdots \quad \ddots \quad \vdots \\ r_{n1} \cdots r_{ni} \cdots r_{nn} \end{bmatrix} \tag{5}$$

In formula (5), r_{ji} refers to the importance of *i* relative to *j* when *i* and *j* are secondary indicators under the same high level indicators.

After the determination of judgment matrix, we used the analytic hierarchy process (AHP) to determine the index weight vector for all the levels. In order to ensure the consistency of the results, we took on the matrix theory as the foundation to test the consistency of the judgment matrix. When the inequality, $CR = CI/RI < 0.1$, is established, we consider that the matrix has good consistency, otherwise we need to adjust the judgment matrix.*CR* can be obtained by the following formula:

$$CR = (\lambda_{\max} - n)/(n-1) \tag{6}$$

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(RW)_i}{W_i} \tag{7}$$

$\lambda_{\max}$ is the particular characteristic of the judgment matrix. n indicates the order of the matrix. RI is the average random consistency.

The final step is to carry out a comprehensive fuzzy evaluation. The evaluation starts from the third layer index to the upper layer by layer. The membership degree of the third layer index A to the evaluation set v_{k} is $\delta_{ijk} = \frac{z_{ijk}}{N}$, z_{ijk} is the number that whose evaluation is v_{k} in factors set of u_{ij} ,and there are N experts to participate in the evaluation. So the comprehensive fuzzy evaluation of the third layer is

$$A_{ij} = W_{\mathrm{ij}} \times \left\lfloor \delta_{ijk} \right\rfloor_{n\times n} \tag{8}$$

n is the number of three level indicators who belongs to the same second level indicator, and W_{ij} is the weight vector of u_{ij} . $\left\lfloor \delta_{ijk} \right\rfloor_{n\times n}$ is the membership degree matrix of the three level indexes. In the same way, we can deduce the fuzzy evaluation of the first level and the two level indicators.

System Development and Application

System Development. In order to realize the demand of ASTA value assessment system, the software that supports the system includes Server2008 Windows operating system, Server2005 SQL database, and component library and so on. We used Java programming language to compile the background, while JSP and jQuery technology were used to meet the needs of different users by achieving the visualization of the system. The login interface of the system is indicated in Fig. 3.

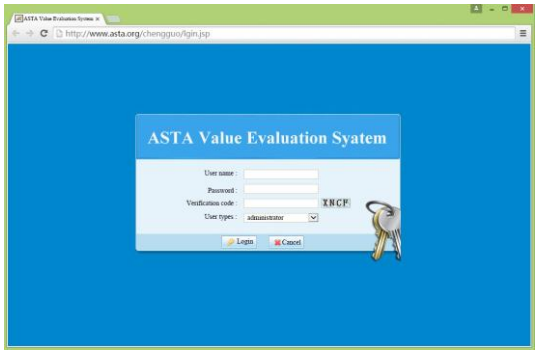

Figure 3. System login interface

System Application. From the perspective of effectiveness and efficiency of resource use, the achievements holder needs to submit the results of the summary, innovation and other related materials, through the audit by the rear of the value assessment.

ASTA Value Assessment. Achievements holders need to upload the relevant certification materials of indicators, and have to provide supporting data for the expert scoring in order to ensure the authenticity of the results, the expert scoring interface as shown in Fig. 4. The system automatically calls the model. The model bases and carries on the comprehensive fuzzy evaluation, then under the control of the department manager, the evaluation results will be communicated to the achievements holder in a visual way. As shown in Fig. 5, a corn seed value assessment score: 4.616, corresponding comment: generally, these results indicate that the comprehensive level of the seed is general considering technical, market and benefit three aspects. Due to the comprehensive consideration in this study, it is not completely accurate to represent the progressiveness of the new seed varieties.

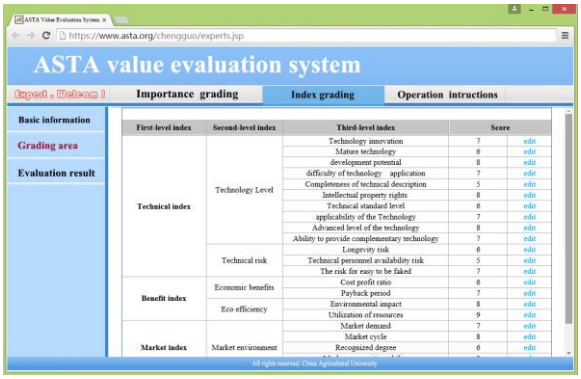

Figure 4. Grading by experts

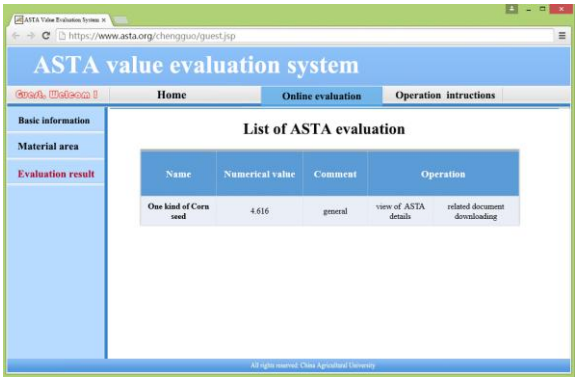

Figure 5. Query results

Statistical Analysis. The second function of this system is to carry on statistical analysis of ASTA. The system stores the panel data from 2010 to 2014 of achievements and relevant experts' information who participated in the value assessment, providing data support for manage personnel to master the achievements and assign experts. The statistical information of panel data of agricultural scientific and technological achievements can be obtained by the statistical analysis module. As shown in Fig. 6 for the calendar year is the chart of evaluation results distribution and proportion of the achievements number. In 2010-2014, the number of agricultural scientific and

technological achievements showed growing trend. The number of ASTA in 2014 was 75, of which were 5 times in 2010. On the assessment results, the proportion of the results for excellent and good showed a rapid growth trend. From the view of the number, results for the highest number of good results, accounting for 57.33% of the total, and the proportion of poor and very poor was 0%. On the whole, the overall level of the 2014 eligible results is good, but there are still 9.33% of the results only in the current average.

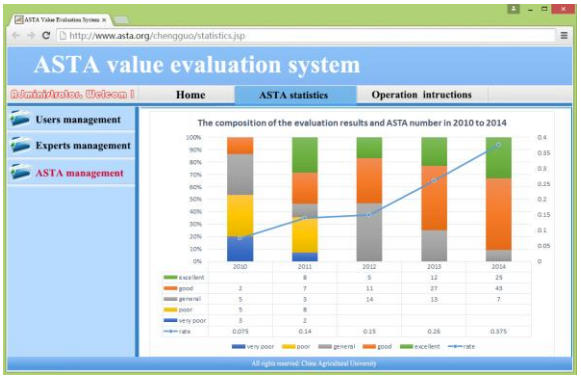

Figure 6. Schematic diagram of statistical analysis

Conclusion

This study realized the storage and management of agricultural scientific and technological achievements and Web technology based expert data. At the same time, combined with fuzzy comprehensive evaluation model, we realized the comprehensive fuzzy evaluation and statistical analysis of agricultural scientific and technological achievements. The ASTA value assessment system is committed to the fuzzy evaluation, to a certain extent, and promote the transformation of ASTA.

The core of this study is to assess the value of ASTA. Considering the technology, the benefit and the market factors, we constructed the three level index systems to carry out the comprehensive evaluation of ASTA, which provides the reference for the transformation of ASTA.

There are a huge differences between similar or the same kind of ASTA. This systematic study focuses on the value evaluation of individual ASTA based on the field expert scoring, while the differences between similar or the same kind ASTA have not been further comparative studied. Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

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