A PDA-BASED FEEDING EXPERT SYSTEM FOR INDOOR INTENSIVE CULTURING OF SOUTHERN FLOUNDER IN CHINA

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Abstract: This paper presents a research to develop and evaluate a PDA-based feeding support system for Indoor Intensive Culturing. Based on analysis of the feed fed The impact of various factors, the establishment of a knowledge base and fed feed the database, building a model of aquaculture feed formulation and decision-making model fed feed, feed formula to achieve the design, the volume of feeding, feeding time, feeding the number of decision-making and the knowledge base management functions of the three modules, which not only increased the number of aquaculture farms of the digital management level and reduced the cost of human resources, also for intensive aquaculture feedstuff fed policy-making to provide a new means of achieving.

Key words: PDA; intensive aquaculture; feeding; decision support system

1. INTRODUCTION

In China, the southern flounder supports valuable commercial and recreational fisheries throughout the geographic range it inhabits，which also plays a very important role in the intensive fish culturing factories and generating farmers' income (Roach J., 1987; James W.J., 1985; Jones,D.,1989). However, the traditional feeding ways can't meet its nutrient needs, supply good and enough fish for the present market and get a satisfactory economic interest for the farmers (Latin R.X, 1987; Stone N.D., 1987; Thieme R.H. Vadim Bulitko., 1997, 1999).

The cost of feed is usually the greatest operating cost in aquaculture, and may account for 40% or more of total operating costs in the southern flounder culturing system (Timmons and Losordo, 1994; Kuo, 1994). It has been estimated that over 60% of the feed placed into an aqua cultural system ends up as particulates (Masser, 1992). How to feed right is very important.

Some methods were developed to detect left over feed in order to stop feeding. Shepherd and Bromage (1988) estimated food waste by suspending a sheet below the sea cage during the feeding period, retrieving it after feeding, and counting the left over feed pellets. Juell (1991) and Juell et al. (1993) used hydroacoustic sensors to detect food pellets at 2.5 m depth in sea cages for feeding control. Foster et al. (1995) used an underwater camera and image analysis tool to detect and count left over pellets. Similar system is now commercially available for sea cage applications, sensors used including Doppler pellet sensor, CAS pellet sensor and camera sensor (Akvasmart, Norway). Kevin and Royann (2003) used the accuracy of a new machine-vision system for the identification of a feed wastage event and the response times are reported. Without using a feedback mechanism, Fast et al. (1997) used demand feeders and an automated data acquisition system to assess fish feeding rhythms. Acoustic and photoelectric sensors to detect turbidity of the effluent are also commercially available. Ultrasonic telemetric system was also used for automatic positioning of individual salmon in a sea cage (Juell and Westerberg, 1993).

Based on their previous study, this paper reports a research effort in applying southern flounder feeding in intensive culturing farming factories. It's developed by Agricultural Information Technology Institute of China Agricultural University and is a major outcome of an 863 Project funded by the National High Science and Technology Development Plan of the Peoples' Republic of China.

2. USERS' NEED FOR THE FEEDING SUPPORT SYSTEM

China is a large country but most aquaculture sites for southern flounder are scattered in seaside areas. Although fish farming is growing rapidly in recent years, the general level of farmers' skills and knowledge in fish farming is evidently low. An experiment is operated to demonstrate the fish output comparison between before and after users using the feeding machine, it is described as follows (Table 1).

Table 1 output comparison between before and after users using the feeding machine

	Before	After
Output of Southern flounder(kg)	480~500	550
Amount of Feeding stuff(kg)	8500	3700
Expenditure for Feeding stuff	1870	1628

Obviously, since the users use the feeding machine, not only the output of southern flounder has been distinctly increased, but also the cost has been saved a lot. At the same time, it reduces the labor expenditure. From the increasing economic interest, farmers can easily accept the feeding support system.

As a result of the emerging need for experts' help in fish feeding techniques, a feeding support system is going to be developed to help fish farmers with solutions to the problems they meet in practice.

3. SYSTEM FRAME AND FUNCTIONS

Based on users' needs analysis, a feeding support system is going to be developed and integrated to related Fish Expert. This support system mainly is comprised of seven sections, including knowledge base, inference engine, knowledge base management system, knowledge acquisition, explanation facility, interface and internet. The relation among them is as follows in Figure1.

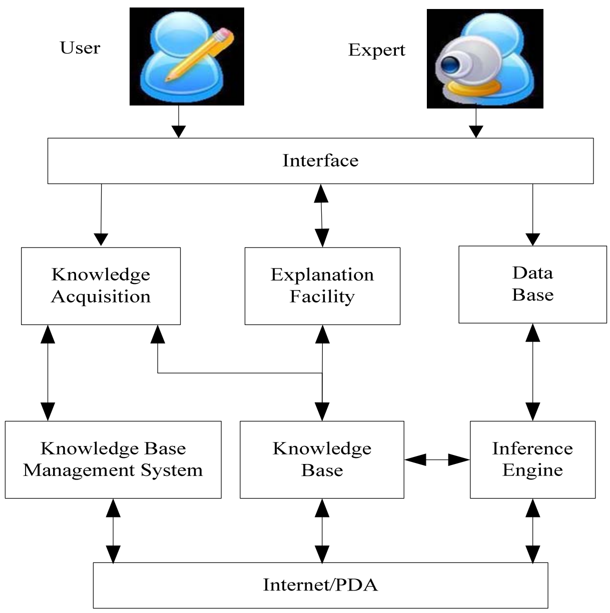

Figure 1. The structure of the feeding support system

4. SYSTEM COMPONENTS AND THE FEEDING PROCESS

In order to best meet the different needs of fish farmers, six feeding subsystems have been designed according to the different growing phases of southern flounder. They are a prophase fish fry feeding expert system, anaphase fish fry feeding expert system, post larval fish feeding expert system, juvenile fish feeding expert system; cultivate fish feeding expert system and adult fish feeding expert system.

4.1 Database structure and function modules

Six different subsystems are integrated in support system. It also contains a series of databases, which are needed for record-keeping and decision-making during the feeding process. For instance, typical databases include registration, user database, expert database, feedstuff database, fish database, etc. Every subsystem contains what kind of different function modules in the feeding expert system, which mainly have two modules: choosing feedstuff and feeding techniques. Choosing feed stuff needs to take four factors into consideration, which are respectively ingest habits, nutrients demand, feedstuff formula and make a feeding plan. The feeding techniques include domestication management, amount of bait, feeding methods, surplus feeding stuff.

4.2 Feeding process

For a particular fish species, assuming that it's in a growth phase, the total number of types of feed to be elected is *m*, the no. I feed is fixed as M_i, the Marxism and Minimum amount of the feed are respectively m_i^{max} and m_i^{min}.

There are *n* kinds of necessary nutritions, among which the no *j* nutrition is recorded as N_j, the Marxism and Minimum amount of the nutrition are respectively recorded as n_j^{max} and n_j^{min}, for each quantity unit of M_i, the percent of nutrition N_j is recorded as μ_{ij}, the price of feed M_i is recorded as c_i. The solution set of Formulation problem is in the form of a vector, according to the solution set, the daily feeding amount and the lowest cost of the feed can be easily got.

Suppose if the feed M_i's daily supply is x_i, then the function can de described as follows:

$$Z=\min\sum_{i=1}^{p} c_i x_i$$

Restraint of feedstuff use:

mimin≤xi≤mimax, i=1,2,…,u (1)

Nutrient intake bound:

$$n_j^{\min} \le \sum_{i=1}^{p} \mu_{ij} x_i \le n_j^{max}, j=1,2,\ldots,v \ (2)$$

Non-binding negative restraint for solution set:

$x_i \ge 0$, $i=1,2,\ldots,p$(3)

Using simplex method, the value of x_i can be easily got. So the quantity demanded of each feed is presented. Then the value of Z can be calculated out，which is the cost of formula in the condition of x_i.

Second, according to the value of Z and a which is the feeding coefficient that can be obtained from the database, the feeding quantity per time can be got through the calculation of the following function：

$N_1=a_1Z$，$N_2=a_2Z$，…，$N_q=a_qZ$ （N_q *and* a_q *mean for no.q's feeding quantity and feed coefficient*）.

5. SYSTEM IMPLEMENTATION

5.1 Platform Structure of System

The platform structure of PDA-based Feeding Expert System consists of knowledge engineer module, Serial conversion between the database module and expert system application module. Through knowledge engineers module, visualization of aquatic products to create a database of knowledge, rules and the yuan rules; then through the database of serial conversion component modules, will create a database simultaneously transformed into PDA; using the conversion of knowledge, according to the needs of users, the expert system application modules adopts a question-or-solving approach to decision-making experts, at last the conclusion can be obtained. The Platform Structure of System is shown in Figure 2.

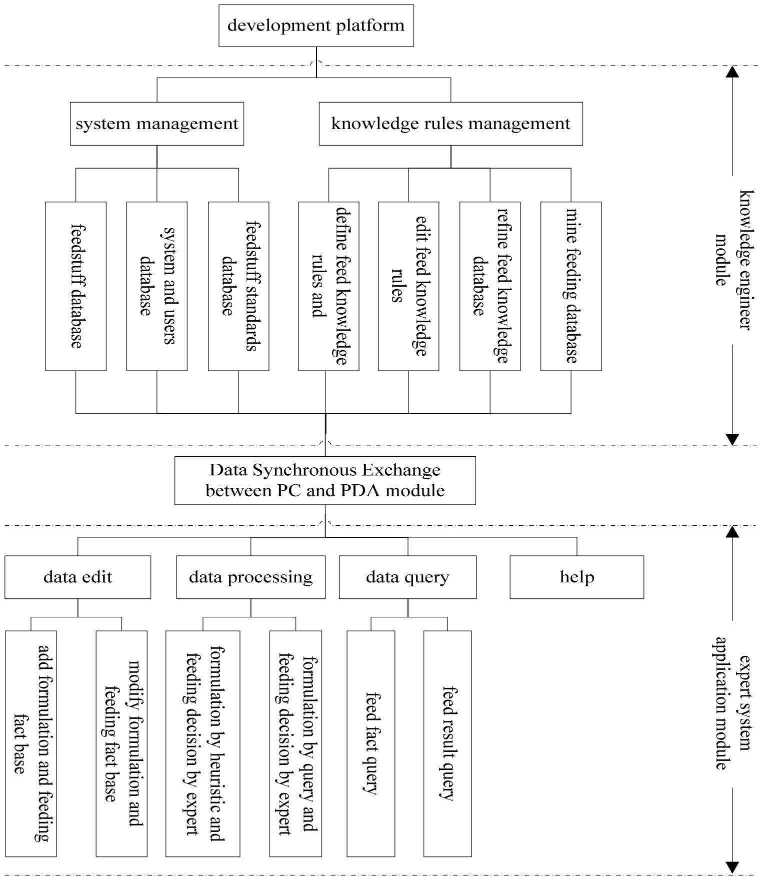

Figure 2. Platform Structure of System

5.2 Implementation

In Visual Studio 2005 environment, based on data management using C# and MsSQL Server 2005 CE, MsSQL Server 2005 for the desk PC database, a model of feeding formula, feeding model and user interface design were established; a PDA-based intensive aquaculture feed fed expert system was developed. The PDA is from Hewlett Packard (HP) company, the type is iPAQ 5965 with the system Windows Mobile 5.0 (version: 437809-012), processor SAMSUNG S3C2440 400Mhz. The feeding input interface and feeding expert system are shown in Figure3 and Figure4:

Fig 3. Input interface of system

Fig.4. Output interface of system

6. RESULTS AND DISCUSSION

This paper reports a research in developing and testing a feeding support system in aquaculture. The development process adopted a user-centered approach and users (fish farmers) were consulted regularly during each stage of development. As a result, the system components and its major functions are derived from users' suggestions and needs. For example, the system was initially a feeding support system. Based on the need for real expert support, a feeding support system was developed and integrated into the expert system. Further improvement and testing are still being undertaken alongside the collection of more feedback from users.

Reduction of labor requirements represents an advantage of the system. It is expected that when personnel are more familiar with the system, the labor requirements may decrease further.

The research demonstrates the possibility and potential benefits of using the Internet to facilitate feeding support in aquaculture. As the performance of an expert system is limited by its knowledge, an ES is unlikely to perform as well as a real expert. It is hoped that the improvement and new development of networks and the rapidly decreased cost of IT equipment will eliminate the bottleneck in the future, thus the feeding support systems will be more practical and beneficial to end users.

7. CONCLUSIONS

The feeding support system presented provides a tool to enhance the management of southern flounder cultivation. When connected with monitoring systems currently available in the market the system shows potential to serve as a management system for intensive cultivation. Further improvement of the system will be possible by incorporating components such as controllers that could follow the potential fluctuations of the actual requirements from the estimated ones and adapt the feeding tables accordingly.

The system has emerged as a result of the use of a PDA-based feeding expert system. It helps to overcome the limitations and enhance the functionality of traditional ESs. This research used this pilot system as a research vehicle to experiment in applying, and to evaluate the usability of the system with potential users. Feedback collected from the demonstration and evaluation of the system has provided valuable insights into the issues related to the development and implementation of feeding support system in aquaculture in China.

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