Research on Water-Fertilizer Integrated Technology Based On Neural Network Prediction and Fuzzy Control

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Abstract. Water-fertilizer integrated technology based on neural network prediction control and fuzzy control combines fertilization with irrigation precisely. Water-soluble solid or liquid fertilizers are mixed together by irrigation equipment, which can be precisely transported to crop roots and greatly improved fertilization and irrigation efficiency. Through the neural network prediction control and fuzzy control, the dynamic management control system of time-varying nonlinear models can be set up to achieve more accurate control. This paper will elaborate the definition of neural network prediction and fuzzy control, the development history and current statues of water-fertilizer integration, the control on irrigation amount, the control on fertilizer amount and the ratio of fertilizer solution, the control on mixed system of fertilizer solution, and the application effect of water-fertilizer integration under the neural network prediction and fuzzy control, to gradually explain how to carry out research on water-fertilizer integration based on neural network prediction and fuzzy control.

1. Introduction
Water-fertilizer integrated technology based on neural network prediction and fuzzy control is a new type of agricultural technology based on accurate drip irrigation of irrigation and fertilization. In order to achieve this technology, the neural network prediction control and fuzzy control need to be studied in depth. The control on irrigation amount, fertilizers amount, the ratio of fertilizer solution, and mixing system of fertilizer solution are guaranteed by two kinds of control methods. To achieve accurate irrigation and fertilization, the control on irrigation amount, fertilizer amount and the fertilizer ratio can be carried out by the neural network prediction control, while the control on mixing system of fertilizer solution needs to be carried out by the fuzzy control of the neural network.

2. The definition of neural network prediction and fuzzy control
2.1. The definition and form of neural network
Artificial neural network is a network computing system composed of large numbers of interconnected simple neurons. As one of the most important elements of intelligent control technology, artificial neural network control is based on the research of contemporary neurology. Artificial neural network reflects the characteristics of the human brain, which is an important means to simulate artificial intelligence. The machine developed on artificial neural network can produce specific function, which is of crucial importance to the participation of some complex computational work. It is not merely a calculation method but also a cognitive method. In contrology, the importance of artificial neural network is self-evident. With the gradual development of artificial neural network, its theoretical
foundation and scientific research continue to become mature. Artificial neural network has been applied in various control fields, such as the prediction control and fuzzy control in this article.

2.2. The definition of prediction control
Prediction control is striving to overcome various uncertainties to achieve the desired goal by establishing different models to control the object under the influence of various uncertainties.

![Figure 1. The structure of prediction control.](image)

With the addition of prediction control of artificial neural network, the ability of prediction control has been greatly improved. The complex computing and cognitive abilities of prediction control such as self-learning ability, optimization ability and memory ability play a strong security for solving complex problems in agriculture protection. In essence, the prediction control based on artificial neural network still cannot get out of the range of prediction control. However, by means of function approximation, not only the previous linear change, but also the nonlinear changes can be handled, which means a qualitative leap of its ability.

With \( r_j \) as control weight coefficient, we can get

\[
\Delta u(k + j - 1) = u(k + j - 1) - u(k + j - 2).
\]

Since \( J / \Delta u = 0 \), we can know the result of \( \Delta u(k + j - 1) \). The calculation procedure can be summarized as follows (\( j = 1, 2, \ldots P \)): (1) Input the expectation value in reference to trajectory formula \( y_d(k + j) \); (2) Output \( y^*(k) \) and \( y_p(k + j) \); (3) Calculate the error value: \( e(k + j) = y_d(k + j) - y_p(k + j) \); (4) \( \Delta u(k + j - 1) \) is obtained by \( \min J(P, L, r) \). With \( u(k) \) as the first control signal and go to step (2), loop back and forth.

2.3. The definition of fuzzy control
Fuzzy neural network is the same as artificial neural network prediction control, which is the combination of fuzzy control and artificial neural network. It not only has the advantages of artificial neural network but also has the advantages of fuzzy control. Fuzzy neural network has learning ability, associative ability from neural network and information identification and control ability from fuzzy control. Fuzzy neural network shows a long-term agricultural application prospect in simulating intelligent behavior and dealing with the non-linear complicated problems. Fuzzy controller includes four important parts: (1) fuzzification; (2) rule base; (3) fuzzy reasoning; (4) Defuzzification. Firstly, we choose the input quantity and turn it into the fuzzy quantity by fuzzification, then determine the membership grade, then establish the rule base according to the experience. Through the control rules, the decision based on the realistic theory are obtained. Finally fuzzy quantity is output and transformed to accurate quantity. Among them, defuzzification consists of three methods, that is, the centroid method, the area method and the height method. These three methods reason and check the
control rule, and the final result will be the precise output under the control of the system. Fuzzy control simplifies complexity of design system, reduces the dependence on accurate mathematical model, and multiple features of variable relation are described by the practical experience instead of complete mathematical modeling and the use of control valves. It is not only a language controller for convenient man-machine conversation, but also a non-linear controller which easy to control and operate. Fuzzy control has a relatively good robustness and fault tolerance. For this difficulty, domestic and foreign scholars show no fear. With continuous research, a large number of structural models and learning algorithms continue to be created. Due to different needs, the structural model to be established and the learning algorithm are also different. Requirements of the partial structural model and learning algorithm are relatively simple, while requirements of the other structural model and learning algorithm are relatively complicated. Next, I will compare the excitation functions of several fuzzy neural networks, show in Table 1.

| Model name | BP FNN | ANFIS | B Spline FNN | SFNN | FCMAC | RBF FNN | wavelet FNN |
|------------|--------|-------|--------------|------|-------|---------|-------------|
| Excitation function | Sigmoid | Sigmoid | B Spline base | Sigmoid | B Spline base | Gaussian base | Sigmoid |

Although the models and functions are different, they are all in the range of three basic forms: hybrid fuzzy neural network, logical fuzzy neural network and arithmetic fuzzy neural network. The organic combination of different basic forms can play a complementary effect.

3. the development history and current statues of water-fertilizer integrated technology

3.1. The definition of water-fertilizer integration
Water-fertilizer integrated technology means dissolving soluble fertilizers in water while irrigating through underground or above ground pipelines, fertilizing and irrigating simultaneously. Irrigation can meet the water requirements of crops, and fertilization can meet the nutrient needs of crops. Simultaneous irrigation and fertilization can satisfy water requirements and nutrient needs of the crops at the same time, which result in substantial increase of production efficiency and conservation of water resources. Compared with the traditional irrigation methods, drip irrigation technology of water-fertilizer integrated technology can reduce evaporation and leaching loss of fertilizer and fertilizer can be directly reach the crop roots. The utilization rate of fertilizer increases to 30 to 50 percent, while the utilization rate of water can increases to 40 to 60 percent. The intelligent management of water-fertilizer integrated technology can also reduce the labor input significantly. In addition, the output of crops increases by 20 to 50 percent, or even doubled.
Figure 2. The histogram of the main crop application area of water-fertilizer integrated technology in China's in recent years.

The water-fertilizer integrated technology is the key technology in developing modern and intelligent agriculture. It is environmental friendly and resources saved. It is the primary technology of contemporary agriculture.

3.2. The development status of water-fertilizer integrated technology
The development of water-fertilizer integrated technology in our country can be traced back to the drip irrigation equipment in Mexico in 1974, when insufficient production of technology required the introduction of a large amount of foreign technology and equipment. Nowadays, through the development of nearly 40 years, our country has developed two water-fertilizer integrated technologies independently, such as various irrigation technologies and fertilization machine. Among them, drip irrigation technology under plastic film of cotton in Xinjiang is famous around the world, which has reached the international advanced level. The northeast, northwest, north and south areas are not far behind. They began the widespread use of water-fertilizer integrated technology to improve plantation efficiency. The Central Government started investing in water-fertilizer integrated technology projects in 10 provinces across the country in 2002 with a total of one billion yuan. The area of demonstration zone is more than 20 million mu, which contains more than 20 different kinds of crops, including corn, wheat, potato and cotton. In the three years from 2010 to 2012, the extensive promotion of water-fertilizer integrated technology has rapidly expanded from more than 23 million mu in 10 years to more than 3,000 mu.

4. The control on irrigation amount, fertilizer amount and ratio of fertilizer solution, and the mixed system of fertilizer solution
4.1. The control on irrigation amount
Since the total amount of water used for irrigation is proportional to the irrigation time, it can be considered as a linear function. However, due to the different weather conditions, the total amount of water that needs to be irrigated daily is not constant, which convert the linear function to a non-linear function. When facing impact of the uncertainties from changing weather, artificial neural network prediction control should be the introduced. Through the establishment of weather - irrigation total model and the single-chip microcomputer to control the valve switch, the impact of weather factors is strive to overcome to achieve the desired water-saving irrigation goals when the control object is under the influence of the weather uncertainty.
4.2. The control on fertilizer amount and the ratio of fertilizer solution
Fertilization control is composed of control on fertilizer amount and the ratio of fertilizer solution. Fertilizer amount is also proportional to irrigation time by a linear function. Relatively accurate fertilizer amount and ratio of fertilizer solution can be obtained by sequential control. However, the main objective of drip irrigation technology is to save resources, whether water or fertilizer, so we should also consider the impact of the weather on the irrigation amount in order to achieve precise control on ratio of fertilizer solution without waste of fertilizers. At this point we still need to introduce artificial neural network prediction control means, relying on control of the microcontroller on valve switch to control the fertilizer amount.

4.3. The control on mixed system of fertilizer solution
There is a non-linear function when the fertilizer liquid is in the mixing tank, and the control valve switch has only two states. Therefore, the whole system at this time has the uncertainty and cannot determine whether it is real-time or has the risk of delay or lag, which is difficult to define by traditional methods. So at this time we need to introduce artificial neural network fuzzy control method.

After the integration of control rules and decision-making means, the fuzzy neural network is used to fuzzy control, and then the amount is input. After the fuzzification of input amount, observing the membership grade of the output amount, the final judgment is carried out according to different membership grade. At the same time, the conclusion can be drawn as a part of fuzzy control according to the actual on-site experience, and express it as a fuzzy control statement in computer language. After multiple fuzzification procedures, the fuzzified output is obtained and processed precisely, and the control instruction is output finally.

5. The Application Effect of water-fertilizer integrated technology Based on Neural Network Prediction and Fuzzy Control
Through the drip irrigation under plastic film, the application of neural network prediction and fuzzy control on water-fertilizer integrated technology can achieve the control on irrigation amount, the amount fertilizers amount and the ratio of fertilizer solution, and the mixture of fertilizer solution, which result in the following results.

(2) Water and fertilizers are mixed and then delivered accurately to the plants roots, resulting in reduced loss of nutrients due to reduced volatility and nutrient loss from excessive watering, resulting in a much higher rate of fertilizer utilization. The precise control can save 40 to 50 percent fertilizer over traditional watering methods.

(3) With advanced drip irrigation technology and equipment, a substantial reduction in labor costs has been achieved. The amount of work that was done previously by a few dozen persons has been reduced to a workload easily accomplished by a few people in a short period of time, which save the funds for agricultural units and improve business efficiency.

(4) Because fertilizer solution is a liquid fertilizer, it is more easily absorbed by plants roots than solid fertilizers, which not only reduces soil damage to the crop area, but also promotes the improvement of plant quality and yield.

(5) The precise control on fertilizer amount and the ratio of fertilization solution can prevent fertilizer solution from infiltrating deep soil causing groundwater pollution, and avoid soil degradation.

6. Conclusion
As a large agricultural country, China consumes a large amount of irrigation water and fertilizer. From the perspective of resource control, great efforts to develop a water-fertilizer integrated technology based on neural network prediction and fuzzy control can reduce irrigation water and the waste of chemical fertilizers, save the production resources, reduces the production costs and improves the
efficiency of agricultural products enterprises. From the view of sustainable development, drip irrigation technology can directly transport the fertilizer solution to the plants roots to prevent the soil degradation and the contamination of deep groundwater with chemical reagents, and prevent the waste of soil and water in the whole area, which is of great importance to respond to the call of sustainable development. To enhance the benefit in the small direction, the research on water-fertilizer integrated technology improves efficiency in minor terms and benefits our country in major terms. Thus the research on water-fertilizer integrated technology shows the contemporary benefits and the credit centuries.

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