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# RAEDSS: An integrated decision support system for regional agricultural economy in China

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ABSTRACT

Recent advances in artificial intelligence, particularly in the field of multi-agent system theory and techniques, offer great promises in the development of decision support systems. This paper designs an agent-based regional agricultural economy decision support system (RAEDSS) to deal with complex decision problems. It introduces the architecture of the system, including interface agents, management agents, functional agents, model agents, information agents and knowledge agents and their interactions. Since dynamic analysis, evaluation, forecast, optimization and decision of regional agricultural economy are the central task of RAEDSS, this paper gives a detailed discussion on the decision processes and internal mechanisms in the system. Meanwhile, agent-based modeling is introduced to simulate and evaluate policy impact on rural development in different scenarios as an important part in RAEDSS. The simulation result shows that this agent-based agricultural development model is able to perform regeneration and is able to produce likely-to-occur projections of reality. The related issue such as building an agent based on the theory of classifier systems is also surveyed.



## 1. Introduction

In recent years, more and more artificial intelligence technologies have been incorporated into decision support system (DSS) design frameworks in order to request intelligent problem-solving mechanisms and improve the decision-making processes and therefore to obtain a more powerful decision support. In addition, the development of distributed artificial intelligence frameworks provides a new methodology to solve problems for complex systems by dividing them into a number of agents which can cooperate to solve the problem using their own knowledge, goals, skills and plans.

To improve the mechanism of problem solving more and more artificial intelligence technologies and, especially multi-agent systems (MASs) are being applied in the exploitation of DSS. Research into agents and the development of related technology [1–3] has grown dramatically since the 1980s as domains suitable for their applications have emerged. Multi-agent systems (MASs) have been applied broadly to a variety of industrial problems [4], from electronic commerce [5,6], to supply chain management [7]. However, most multi-agent applications are still in the early phases of development and few standards have been widely accepted. Bentham [8] has developed an agent-based system to assist with decisions related to crop production, and [9] have created a multi-agent expert system to aid farmers with the selection of appropriate hybrids. Berger et al. proposed multi-agent systems as a modeling approach well suited for capturing the complexity of constraints as well as the diversity in which they appear at the farm household level, and illustrated how they may assist policymakers in prioritizing and targeting alternative policy interventions especially in less-favored areas [10]. Lobianco and Esposti [11] developed the Regional Multi-Agent Simulator (RegMAS) for long-term simulations of the effects of policies on agricultural

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systems. It is an open-source spatially explicit multi-agent model framework. In the dairy industry, a simple multi-agent system for heifer management was then developed as a proof of concept, in order to explore practical aspects related to an actual implementation of the technology [12].

This paper presents a number of perspectives on our ongoing work in developing agent-based regional agricultural economy decision-support system (RAEDSS), which is a decision-support framework that can be of use in supplying decision-enabling information in a number of economic domains for regional management. The paper is organized as follows. Section 2 discusses the basic concept of agents and multi-agent system. Section 3 presents the framework of the proposed agent-based decision support system. Section 4 introduces the developing system and mechanism. Section 5 gives a detailed discussion of agent-based modeling in policy simulation of rural and agricultural development in different scenarios. Section 6 concludes the paper.

## 2. Agent and multi-agent system

Before proceeding any further, it is important to gain an understanding of exactly what is an agent-based system. The concept of agent is now being broadly used not only as a model for computer programming units displaying certain kind of characteristic but also in a more abstract and general way, as a new metaphor for the analysis, specification, and implementation of complex software systems. Generally speaking, an agent has the following properties:

- autonomy: agents operate without the direct intervention of humans or others;
- reactivity: agents perceive their environment and respond in a timely fashion to changes that occur;
- pro-activeness: agents are able to exhibit goal-directed behaviors by taking the initiative;
- co-operability: agents co-operate with other agents toward the achievement of certain objectives.
- social ability: agents interact with other agents and typically have the ability to engage in social activities in order to achieve their goals.
- adaptability: the ability of an agent to modify its behaviors over time in response to changing.

In addition to these necessary conditions sketched out above, a number of other potentially desirable characteristics have been proposed. These include: knowledge, belief, intention, and obligation [13]. Some AI researchers have gone further, and considered emotional agents [14].

Although, in many cases, agents can run separately to solve a particular problem of their own, it often happens that an AI system made of several different agents has to be designed to cope with a complex problem involving either distributed data, information, knowledge, or control. A multi-agent system can therefore be defined as a collection of, possibly heterogeneous, computational entities, having their own problem-solving capabilities and which are able to communicate and interact with other agents in order to reach an overall goal. It may also be the case that a MAS is seen as a system revealing a king of synergy that would not be expected from the simple sum of its component agents. This synergy is an emergent property of the system as a whole.

## 3. System overview

The proposed agent-based decision support system consists of three basic modules-task decomposition and assignment module, problem solving and decision-making module that consists several functional agents including economic evaluation agent, economic forecast agent, economic optimization agent, economic analysis agent and economic decision agent take charge in the decision support function of this system, information and resources support module which has three types of agent to provide related data, information and knowledge that functional agents need. Particularly, the management agent in task decomposition and assignment module is a key of the system which provides functions of task planning and coordinating for the RAEDSS. These modules implicitly guide users to follow systematic decision procedures to structure a problem, collect information, develop a model, and analyze a decision step by step. Additionally, the input/output interface provides an interactive mechanism for communication between users at the client sides and the other components of the system. The database manages the domain knowledge embodied in the system. The overall developed system infrastructure was based on object-oriented and agent technology. Fig. 1 shows the system architecture of the RAEDSS.

These agents mentioned above reside at distinct physical computing servers so that each acts independently and the system workload balanced. Furthermore, every agent can communicate with other agents to smooth out the decision process. When an agent conducts a decision-support activity, it consults the knowledge base and the database located in various sectors of the information center. Besides, such an agent framework allows decision-makers such as remote individuals, and regional management or company sectors to access easily to each of the agents. In particular, the system is developed on an intranet client–server structure, using Windows XP Server with SQL Server and Internet Information Server.

## 4. Agents system and structure

### *4.1. Functions of agents*

1. Management Agent

Management Agent is a key to the whole system which has several important functions as follows: (1) administer the other agents in the RAEDSS; (2) decompose, plan and coordinate the tasks according to the user's request; (3) activate

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