

Simulation and Implementation of Photosynthetic process based on MIS

Tang Jianjun¹, Qian Zhaopeng¹ and He Huojiao²

¹College of Computer & Information Engineering, Jiangxi Agricultural University, Nanchang, China

²College of Software, Jiangxi Agricultural University, Nanchang, China

email: tangjjl@163.com

Abstract. Photosynthesis is the result of long-term evolution and development of solar energy to the process can be fixed. "Photosynthesis" is a process of evolution and developed over a long period that can fix solar energy, which will give a good inspiration to energy field, material field, and even economical field. In this article, computer programming ideas and MIS theory were applied to simulate the process of plant photosynthesis, and it can reproduce the process of plant photosynthesis appropriately.

Keywords- Simulation; Photosynthesis; Computer programming; MIS

1. Introduction

Since 1960th, DeWit (1965, Wageningen University) and DuCan (1967, Florida University, America) have published interception of canopy light and canopy photosynthesis model. In these models, relationship between crop growth and yield formation process, the quantitative ecological factors was studied based on systematic theory and crop physiology. And the ecology and physiology of crop growth process were summarized as a simple mathematical expression. With presented by Netherlands, American, the former Soviet Union, three style of crop model have formed: the Netherlands focused on the biological mechanisms, the former Soviet Union focused on the treatment of mathematical and physical aspects, and the United States stressed on the practicality of the model, they constructed the models with the principles such as convenient, simple and stable[1]. As the crop photosynthesis mechanism is featured with very complex, many influence factors, and some of the process mechanism is still vague, its process is difficult to be simulated. In this article, a new method of plant photosynthesis simulation was put forward, and in this method, information system development ideas and method was applied based on the predecessor research results[2-4]

2. Overview of Model

In this article, the simulation of a biochemical reaction and physiological of photosynthesis process is described. The model is designed to abstract the specific physic-chemistry structure into biochemical structure. It means the place of biochemical reactions is compiled into a system of process implementation, and all kinds of biochemical reactions and functional structures is described with specific computer programs. The variety of reaction products and reactants are regarded as parameters which delivered between functions. Especially, the influence of the environmental factors of plant photosynthesis can be abstracted into a function controlled by changing the amount of parameters. The environmental function is regarded as the input devices receiving the changes outside. Every reaction is abstracted into subsystems process, and the reaction product will appear after being called in the database from output system which is output device.

In order to reduce the coupling between several modules, parameters are used to communicate each other within the system. Every module implements their biochemical reactions alone to improve the system's

aggregate. And the biochemical reaction equations are applied as main line for reaction progress simulation. To simplify the call of program between the modules, the data between modules is delivered through database which is as the buffer (it's also called data pool, shown as Figure 1)

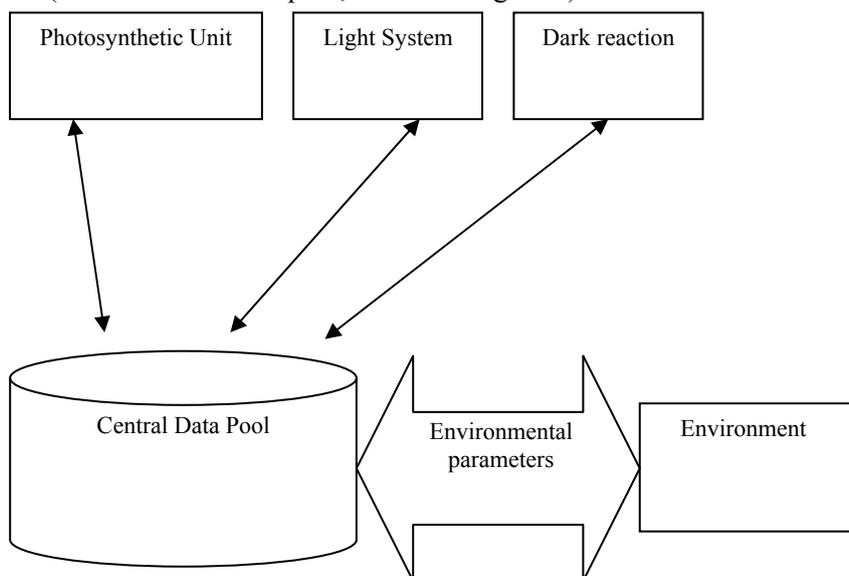


Figure 1. System architecture model diagram

3. Design of Model

3.1. Photosynthetic Unit

Photosynthetic unit contains two functional modules as follows: I is the light harvesting pigment and II is the reaction center pigment. In this module, the process of light energy accepting and the process of energy of light-electrical transforming are simulated.

3.2. Light System

Light System includes twelve subsystems as follows: I – photoelectric conversion, II - selected electronic transmission, III - noncyclic electron transfer pathway, IV - photosystem II, V - Cytb6-ft complexus, VI - photosystem I, VII - water oxidation kinds of models (water photolysis), VIII - cyclic electron transfer pathway, IX - pseudocyclic electron transfer pathway, X - photosynthetic phosphorylation, XI - cycle cyclic photophosphorylation, XII - noncyclic photophosphorylation.

In energy conversion of LtoE, its functions are to select the pathway of electron transferring (firstly, noncyclic electron transfer pathway III; next pseudocyclic electron transfer pathway IX; and then cyclic electron transfer pathway VIII). Among these, each of the systems will call the corresponding function body respectively. And then it will transfer the electron to where it needs by the called function. After the parameters are transferred into systems IV, or V, or VI, it will lead to the systems' running by itself. Parameters of the reaction products, including energy, water parameters are stored in the database and transferred to VII system at the same time which will trigger this system's running. Then the system will call the environmental parameters from the center data pool, which would simulate water oxidation bell reaction and store the oxide parameters into the database. The parameters of light energy are converted into electrical energy parameters thought system I and transferred into system X, XI, XII which will cause the program of photophosphorylation to run. System calls the parameters from database and simulates the process of photophosphorylation according to specific physiological conditions. After the reactions, the products NADP^+ parameters will be stored into database.

3.3. Dark Reaction

The main function of this module is to choose the way of the carbon cycle. After decision by the conditional, the corresponding command will pass to the subsystem. If the condition is C_3 , C_3 function in chloroplast stroma file will be called; if the condition is C_4 , C_4 function in mesophyll cell file will be called; and if the condition is CAM, the CAM function in CMA file will be called.

3.4. Chloroplast Stroma

This module is a functional subsystem belongs to the dark reaction, which includes three sub functions: I – C_3 pathway, II – the fixation of CO_2 , III – reduction of CO_2 .

3.5. Mesophyll

This module simulates C_4 pathway biological function. The parameters deliver into the Calvin cycle pathway in bundle sheath cells module is its products such as malate and aspartic-acid, and will be stored into database.

3.6. Bundle Sheath Cells

This module will choose the corresponding reaction pathway according to the different reaction conditions, including three subsystems: I - malic acid pathway, II - aspartic acid pathway, and III-vascular Calvin cycle, which refer to the conversion of CO_2 , the simulation of aspartate pathway reaction and the process of providing energy, and the process of synthesizing the organic molecules parameters and storing for the display of system to be called, respectively.

3.7. CAM Way

This module includes three functions: I - selected state mode, II - day state mode, and III - night-state mode. The process is as follows: CO_2 , PEP parameters and ATP energy parameters are transferred out from the library, and assigned to the specified variable. Malic acid parameters are stored into parameter database. Malic acid parameters be assigned to the specified variable, and will be judged. If it belongs to PCK type, the parameters of CO_2 and 3-PGA will be produced in the OAA reaction, and the energy comes from the reaction of CO_2 and RuBP which will produce 3-PGA, and the terminated products starch polysaccharides would be stored into database. Else if it belongs to NAD(P)-ME type, the energy comes from the reaction of Pyr which will produce 3-PGA, the malic acid will react into CO_2 and Pyr, and then the products synthesize starch polysaccharides and will be stored into database. [5,6]

3.8. Environment

In this system, there are eight subsystems to simulate the environmental variable and input these parameters into the database, which we call it as center data pool. The subsystems are as follows: I - pH value, II - temperature, III- water, IV - trace elements, V – CO_2 concentration and volume parameters, VI - enzyme, VII - photorespiration, VIII - reactants library. These environmental parameters will be stored into database directly, and will be called from the database when it's needed. (System architecture is shown in Figure 2)

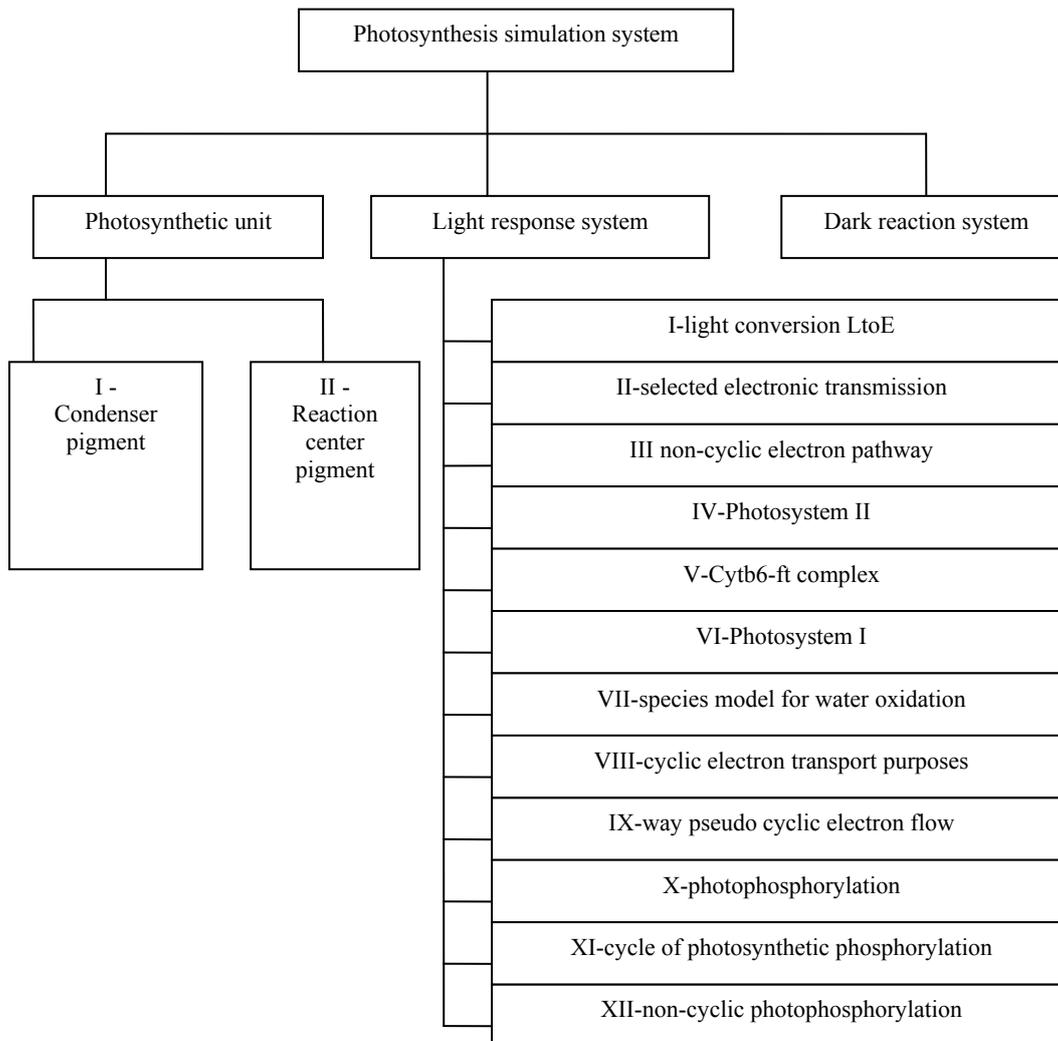


Figure 2. System structure diagram

4. System Implementation

This system is run under PHP + MySQL, and the platform of operation system is window XP/Vista/7.0.

5. Summary

In this system, a viewpoint that uses the information management system theory to simulate the process of photosynthesis was proposed. The products flow was regarded as information flow, the database as the data pool, which could solve the problem that system may cause confusions because the parameters delivered among various subsystems. The method we proposed to restore the model of the photosynthesis process gives another way to study the simulation of system. Honestly to say we can use formulas and equations to describe the process, and we can also describe the process in algorithm architecture system.

6. Acknowledgment

This research was funded by National Natural Science Foundation of China (contact No. 60963013) and Jiangxi Natural Science Foundation (contact No. 2007GQN0197). Thanks for the support from the Key Laboratory of Agricultural Information Technology in Jiangxi Colleges.

7. References

[1] Liu Tiemei, Xie Guosheng, Agricultural Systems Analysis and Simulation[M], Science Press, 2010

- [2] Xin-GuangZhu, ricdeturler, and tephenP.Long, Optimizing the Distribution of Resources between Enzymes of Carbon Metabolism Can Dramatically Increase Photosynthetic Rate : A Numerical Simulation Using an Evolutionary Algorithm[J], *Plant Physiology*, 2007, Vol.145:13–526
- [3] Fan Yiji, Simulation of Photosynthesis [J], *Chemistry*, 1978, (5): 9-14
- [4] Zhang Qi, Chen Yanli, Yang Xiuli, et al., The Current Situation and Developing Trend of Photosynthetic Model Compounds [J], *Journal of Qufu Normal University [J]*, 2001, 26 (1):76-79
- [5] Meng Fanjing, Liu Daohong, Su Yeyu. *Plant Physiology and Biochemistry [M]*, China Agriculture Press, 1992
- [6] Yu shuwen, Tang Zhangcheng. *Plant Physiology and Molecular Biology (Second Edition) [M]*, Science Press, 1998