DESIGNING AN APPLICATION SOFTWARE FOR MODELING THE STRUCTURE AND GROWTH OF PLANTATION FORESTS

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SUMMARY

Application of plantation forest structure and growth modeling is developed by using Microsoft Visual C# professional in 2016, the overall objective is to automatic build the forest structural model in form of graphic as well as the growth model in form of mathematical equation from growth data of plantation forest. This application have some main functions: (1) Read and identify variables as input fields; (2) Build forest strucrural model as a 3- dimension model changes over time; (3) Draw vertical and horizontal profiles of forest; (4) Draw a graph that reflects the relationship between growth indicators and time; (5) Calculate the coverage, Canopy closure over time; (6) Develop the regression equation for the platation forest growth; (7) Export the output results to Microsoft Excel and Microsoft Word. After initial running, this application showed the results with high level of confidence, fast processing rate, great processing capacity. This application is installed and run independently on the personal computer. Hopefully, this apilication will contribute to support for research as well as forestry production.

Keywords: Forest structure, growth, modelling, plantation forest.

I. INTRODUCTION

In the research and practice of forestry production, the structure and growth modeling of plantation forest over time is always considered as a key task of forestry sector because forest growth change continuously over time. To illustrate the structure model of plantation forest visually and vividly as well as the dynamic growth of forest over time in form of 3-dimension, vertical and horizontal profiles of forest are always necessary for silviculture practice.

However, the traditional method as drawing directly on paper is wasted time, effort and money. Therefore, this subject is rarely implemented in research and practical production. On the other hand, the growth indicators always have close relationship with structural characteristics of forest stands and other environment factors under predetermined silvicultural rules. Hence, the growth model of plantation forest by using the mathematical equations is constructed by the experience foresters with specialized statistical software.

In practice, the constructions of

mathematical equations have not been widely applied. The application of structure and growth modeling of plantation forest is developed with the hope of contributing to overcome the limitation above and it has some specific objectives: (1) Read and identify variables as inputs fields; (2) Build forest strucrural model as a 3- dimension model fluctuates over time; (3) Draw a vertical and horizontal area of forest; (4) Draw a graph that reflects the relationship between growth indicators and time; (5) Calculate the coverage, Canopy closure over time; (6) Develop the regression equations for the platation forest growth; (7) Export the output results into Microsoft Excel and Microsoft Word.

II. METHODOLOGY

2.1. Study Approach

Forest growth is variable process. To manage forest effectively, foresters have to model status and development of forest growth to propose technical treatments. Therefore, if this process is illustrated by image of a visually, vividly, timely and obviously way, it is very useful and convenient for foresters. To

archive this requirement, structure and growth data of forest stands at present time as well as over time should be modeling into image by using graphic algorithms in computer. Forest structural factors and growth conditions are impact on the growth of plantation forest. These impacts are the relationship between growth of plantation forest and structural factors and environmental conditions in growing area. Hence, when modeling the relationship between growth of plantation forest and these factors, it needs to be modeling into 2 aspects – direct relationship and aggregate relationship by using a univariate and multivariate regression equations. In the reality, the growth of plantation forest is affected by all internal and external factors. The relationship between the plantation forest growth and all these factors is illustrated by a growth function. However, building this function is very difficult because it is too complicated. So people usually illustrate the growth of plantation forest with some factors that have huge impacts on plantation forest growth only by using mathematical equation, therefore, these equations are considered as the plantation forest growth model. The construction of these equation will satisfy the requirement of science research as well as practical production by programing method using regression equation in computer.

For modeling forest structure into image and building mathematical equation of plantation forest growth will be used widely, then these computer programs should be designed visual, easy to use, advanced automation features. These program will be packaged to an application software and then to install directly on personal computer.

2.2. Methods

- Building estimation database: based on the analysis of growth data of typical forest plantation in Binh Phuoc, established estimation datatbase for growth of a forest plot over time. This database includes some features such as tree age, trunk diameter, canopy diameter, tree height, canopy height, canopy cover, vegetation cover, vegetation density, length and width of sample plot, coordinate of sample plot, biomass, volume and so on.

- Building application development process: the appilation is developed in form of spiral sequence, includes some contents:

(1) Develop the idea: automatic graphic forest strucrure at the present time and the changes over time. Read and recognize variables automatically are the input fields. Change variables flexible by logarithmic and exponential functions by freely select coeficient and exponential factors. Building the regression equation from variables, that were read by the application, using the method of flexible selection of dependent and independent variables in regression equation. Output image of forest structure is the matrix of equations, regression equations and correlation coeficient.

(2) Discuss with forestry experts about the ideas of application, complete concept and make an outline as functional diagram.

(3) Design the functional modules: the modules are designed to be simple, easy to use. Data processing programmer in the module must be highly automated as simple form. In the programming, graphic must be build under overall link, when a element change, the overall graphic changes as well. Programming regression function based on initial algorithms, matrix changing and solving the system of equations to find the coefficients of the regression equation.

(4) Connect the functional modules: functional modules were connected together in the overall scheme to make the application.

(5) Run tests, evaluate, package, install: (1) run the test, detect and adjust the application until satisfy the objectives; (2) creat an excel file and install software independently on other personal computer.

III. RESULTS AND DISCUSSION

3.1. Ideas construction and functional diagram of application

The idea to develop the modeling structure and growth application is illutrated in figure 1, plantation forest growth data is shown in form of Excel or Access format which is widely used. Microsoft Visual C# (C#) is easily read variables (data field names) of this kind of data for extracting and using. C# has abundant graphic functions for drawing stucture and growth diagram of plantation forest by age as well as two and three dimension. Having abundant of mathematical function system and programming structure, C# can change the variants, set the system of equations, matrices and build the regression equation favorably. Thus, this idea and algrorithms for developing software is derived from practical research and forestry production. Using the C# language to transform this idea into a computer program is absolutely capable.
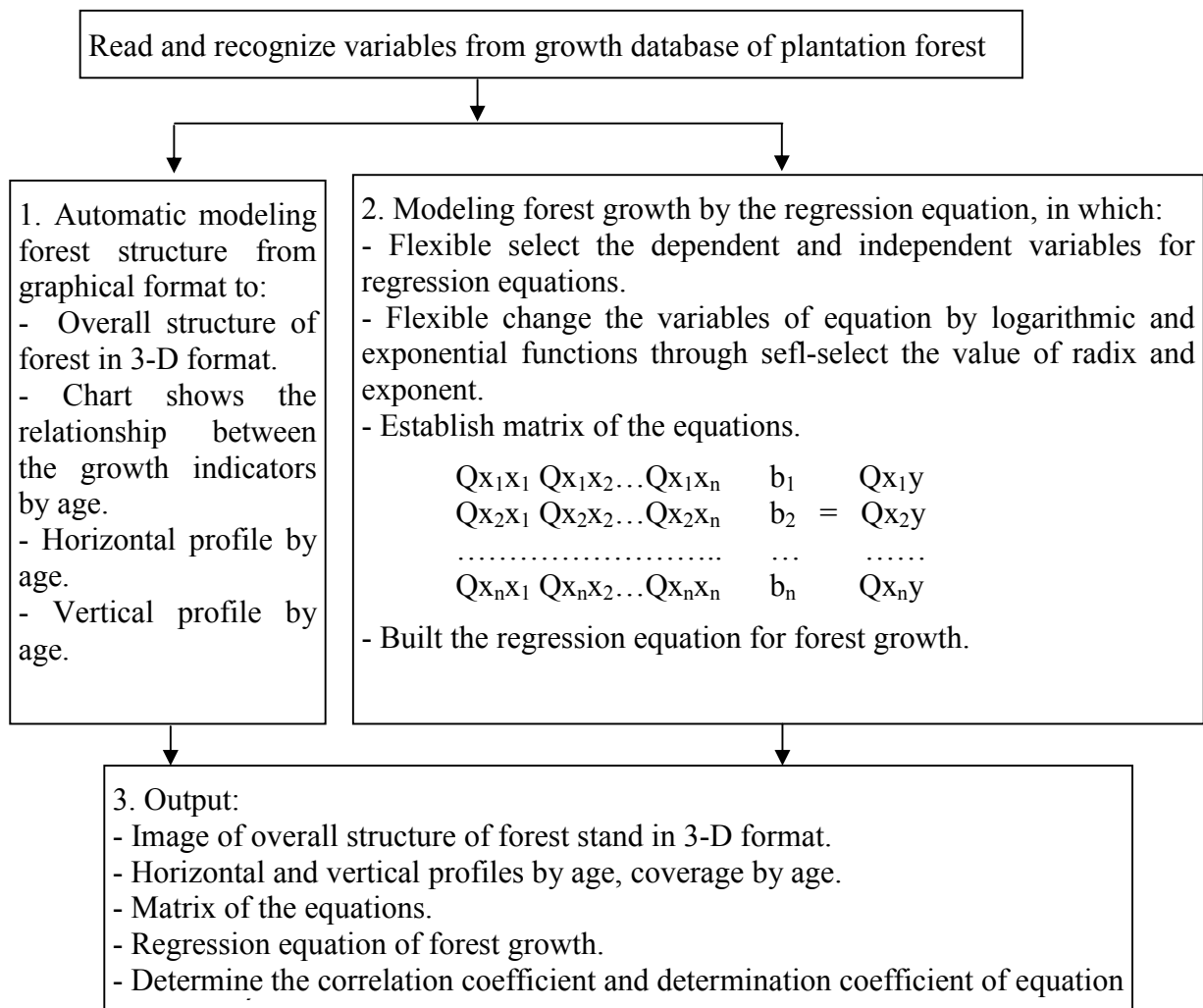
Read and recognize variables from growth database of plantation forest

1. Automatic modeling forest structure from graphical format to:
- Overall structure of forest in 3-D format.
- Chart shows the relationship between the growth indicators by age.
- Horizontal profile by age.
- Vertical profile by age.

2. Modeling forest growth by the regression equation, in which:
- Flexible select the dependent and independent variables for regression equations.
- Flexible change the variables of equation by logarithmic and exponential functions through sefl-select the value of radix and exponent.
- Establish matrix of the equations.

$$\begin{array}{lll} Qx_1x_1\ Qx_1x_2\ldots Qx_1x_n & b_1 & Qx_1y \\ Qx_2x_1\ Qx_2x_2\ldots Qx_2x_n & b_2\ = & Qx_2y \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. & \ldots & \ldots\ldots \\ Qx_nx_1\ Qx_nx_2\ldots Qx_nx_n & b_n & Qx_ny \end{array}$$

- Built the regression equation for forest growth.

3. Output:
- Image of overall structure of forest stand in 3-D format.
- Horizontal and vertical profiles by age, coverage by age.
- Matrix of the equations.
- Regression equation of forest growth.
- Determine the correlation coefficient and determination coefficient of equation

Figure 1. Idea construction diagram of the development plantation forest structure and growth model

From ideas analyzing, overall function diagram of modeling structure and growth of plataion forest application were built and illustrated in figure 2. This application have 8

function modules which are arranged into 3 groups. In which, 3 modules is in graphic format and 1 modules is in regression equation format.

Table 2. The function diagram of modeling structure and growth of plantation forest appilation

Introduction and objectives	Plantation forest modeling	Guidance
Introduction	Three - dimension structure	Install
Objectives	Vertical structure	Using
	Horizontal structural	
	Regression equation	

3.2. Database and functional of application

a) Database: The estimation database of growth in a sample plot represents for forest stand by age as illustrated in figure 2 including: (1) the basic parameters such as width and length of sample plot, rows and column distance (meter); (2) some parameters of platation forest growth such as tree height, DBH, canopy height, canopy diameter (meter), diameter (centimeter), canopy (1/10); coverage of vegetation (%).

Tuoi	Hvn	Hdc	Dk	Dt	Ht	Dtt	Tche	Tbi	F	V	Hang	Cay	Ngang	Doc
1	2.5	2.0	4.0	0.5	0.5	0.000	0.05	55	0.5	0.0000	6	6	40	
2	3.5	3.0	5.0	0.7	0.0	0.004	0.15	50	0.5	0.0001	6	6	40	
3	5.5	3.0	6.0	2.5	2.5	0.012	0.25	45	0.5	0.0004	6	6	40	

Figure 2. Plantation forest growth database

b) Function: The basic functions of the appilation include:

- *Build 3D model of platation forest structure:* from the parameters of size and coordinates of samples plot, row and column distance, canopy diameter, DBH, tree height, canopy height by age in plantation forest growth database, program will automatically build 3D model of the forest structure changes with age, it is illustrated in figure 3.
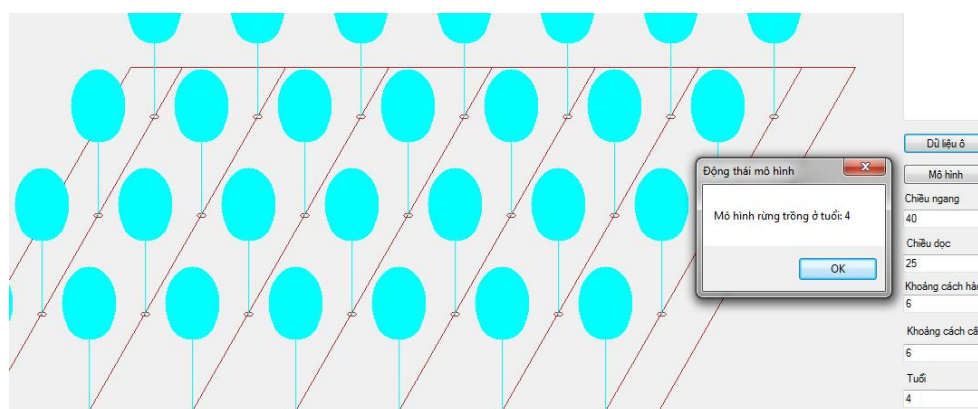
Figure 3. 3 dimension model of platation forest structure by age

- *Draw horizontal profile of forest by age:* from the parameters of size of sample plot, rows and column distance, canopy diameter by age, program will draw a horizontal profile, and also calculate coverage, cown-time and crow-rate as illustrated in figure 4.
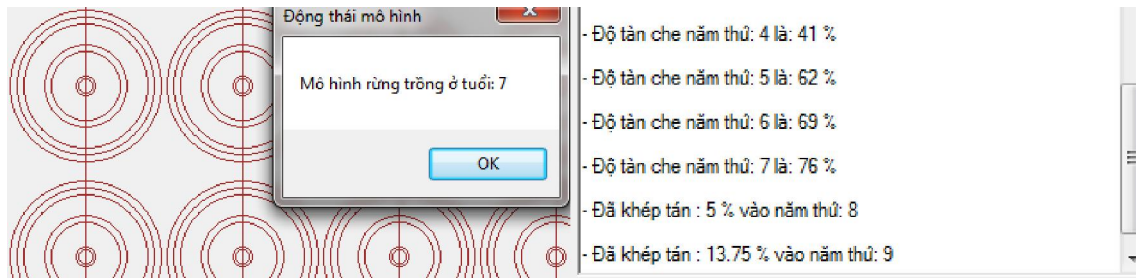
Figure 4. Horizontal profile of plantation forest by age

- *Draw vertical profile of forest by age*: Also from the parameters of growth, structure of forest by age as described in above, the program will draw a vertical profile and the graph of growth indicators over time (figure 5).
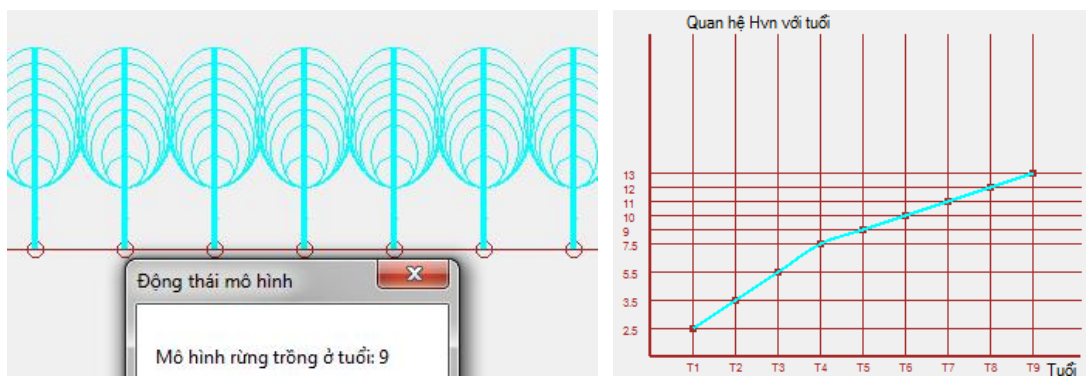

Figure 5. vertical profile and growth graph of plantation forest by age

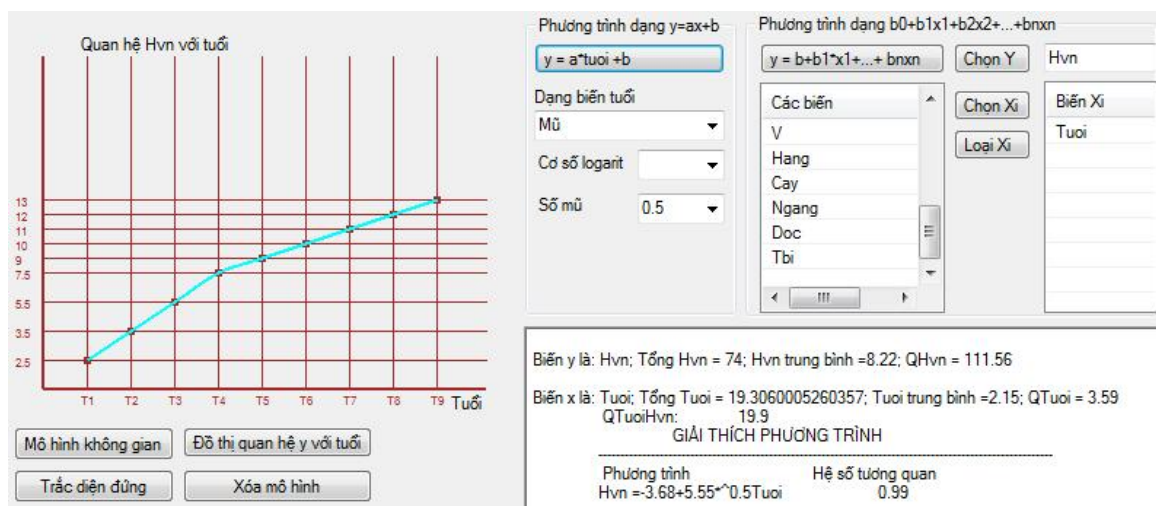- *Establish univariate regression equation with y in form of y = a+bx*:

Figure 6. Establish univariate regression equation of forest growth

Databased of platation forest by age is entered, program will automatically read, recognize and export the name list of fields. The name of fields is variable to build regression equation. From the list of variables, choose the dependent variable (y) and independent variable (x). To choose the equation reflects better the relationship

between components (variables), conducting transform dependent variable (x) into logarithmic or exponential format with optional radix and exponent. The result of establishment univariate regression equation:

$y = a + bx$ is illustrated in figure 6.

- *Establish multivariate regression equation with y in form of $y = b_0 + b_1x_1 + b_2x_2 + ... + b_nx_n$:*

Figure 7. Establish multivariate regression equation of forest growth

Same as regression variable equation $y = a + bx$, program allows optional choose dependent variable (y), optional and transform independent variables (xi). After choosing, program will build regression equation in form of $y = b_0 + b_1x_1 + b_2x_2 + ... + b_nx_n$. The results is described in figure 7, it is clearly inform which is depende or independent variables, basic satatistic parameters, matrices, the process of transform matrix, coefficient value of equation and multivariate regression equation.

IV. CONCLUSION

- Application has modeled the plantation forest structure over time in the form of three-dimensional, horizontal profile and vertical profile.

- Application has flexible identified variables (field name), transform variables as logarithm and exponential functions.

- Application has flexible chosen dependent and independent variables and built univariable and multivariable regression equations of plantation forest.

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NGHIÊN CỨU PHÁT TRIỂN PHẦN MỀM MÔ HÌNH HÓA CẤU TRÚC VÀ SINH TRƯỞNG RỪNG TRỒNG

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TÓM TẮT

Ứng dụng mô hình hóa cấu trúc và sinh trưởng rừng trồng được phát triển bằng Microsoft Visual C# professional vào năm 2016 với mục tiêu tổng quát là từ số liệu sinh trưởng rừng trồng sẽ tự động hóa xây dựng được các mô hình cấu trúc rừng ở dạng đồ họa cũng như các mô hình sinh trưởng dạng phương trình toán học. Ứng dụng có những chức năng cơ bản: (1) Đọc và nhận biết các biến số là các trường dữ liệu đầu vào. (2) Xây dựng mô hình cấu trúc rừng ở dạng không gian 3 chiều biến động thời gian theo. (3) Vẽ trắc diện đứng, trắc diện ngang của rừng. (4) Vẽ đồ thị phản ánh mối quan hệ giữa các chỉ tiêu sinh trưởng với thời gian. (5) Tính độ che phủ, tỷ lệ khép tán theo thời gian sinh trưởng. (6) Xây dựng các phương trình hồi quy về sinh trưởng của rừng trồng. (6) Xuất kết quả đầu ra ở dạng Excel, Word. Bước đầu chạy thực nghiệm, kiểm tra cho thấy phần mềm cho kết quả chính xác, tốc độ xử lý nhanh, dung lượng xử lý lớn. Đây là ứng dụng được cài đặt và chạy độc lập trên các máy tính cá nhân. Hy vọng, ứng dụng sẽ góp phần hỗ trợ cho công tác nghiên cứu cũng như trong sản xuất lâm nghiệp.

Từ khóa: Cấu trúc rừng, mô hình hóa, rừng trồng, sinh trưởng.