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Research Article

Research on Fruit's 3D Solid Modeling and Simulation System

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Abstract: In this study, It takes the selection of tomato fruit appearance acquisition equipment as the key point, combined with the fruit shape extraction algorithm, discussing the establishment of the model of tomato. It is very necessary to design and simulate the life process and production process of tomato by using digital technology and constructing digital tomato technology system. At the same time, it explained the model's process design and function of the simulation system, based on the introduction of the morphological development of tomato. Tomato is one of the most common fruits and vegetables that are cultivated in the world.

Keywords: Digital technology, simulation system, tomato fruit appearance

INTRODUCTION

At present, as for the research of agriculture informationization, the research on technology system of digital plant has got more and more concern by the scholars (Cai *et al*., 2008). The digital plant is a kind of study by using the method of digital plant, which can provide technical support and information service for the plant geometric modeling, the simulation of plant life, the visualization calculation, the digital expression of plant life system, sharing the collaborative research experiment,as well as the integrated application achievements. Tomato is one of the most common fruits and vegetables that are cultivated in the world (Wang *et al*., 2012). It is necessary to design and simulate the life process and production process of tomato by using the digital technology and the construction of digital tomato technology system. It is a basic work to realize the three-dimensional visual modeling of tomato morphological structure, which is the basic work of the digital plant technology system.

There have been got many achievements on the the current domestic field in crops such as rice, wheat, maize organs as well as plant visualization simulation. Tomato is a typical horticultural crop, plus its morphological structure is more complex, the research on tomato model is mainly focused on the biomass production and distribution, which takes the yield as the target, such as Israel and the United States jointly developed the greenhouse tomato model TOMGRO as well as the model of TOMSIM established by the Netherlands and some other famous greenhouse tomato growth models (Heuvelink, 1996; Jones *et al*., 1991). The joint laboratory of China and France in the Automation Institute of China Academy of Sciences used the method of finite state automaton (Dong *et al*., 2006). At the same time, it took the tomato individual as the research object, so as to construct the model of the tomato structure, moreover, this model mainly studies the dynamic construction process of the plant and organs and the organ shape cab be simplified.

MATERIALS AND METHODS

In this study, the portable laser 3D scanner PCP-400 is widely used, this scanner is produced by Bowie Hengxin Company, using 3D Ca Mega three-dimensional optical scanning system, adopting the white light source that is harmless o the human body and the structure can be shown in the figure. The basic working principle of this three-dimensional optical scanning system is as follows: projecting the visible light grating fringe image to the measured object surface, through the lens of fretting, shooting objects in different parts with the raster image, by using CCD, it can input the fringe images into the computer, 3D image reverse software can calculate out the every bit of the surface of the object space coordinates (X, Y, Z) according to the fringe as well as the precise calculation of the shape change of the curvature by phase method and triangular method, so as to generate 3D output color information (R, G, B) with color point cloud data.

Fruit shape extraction algorithm of tomato: In view of the existing problems, such as large data volume, complex computation process and obvious feature extraction, in this study, it put forwards a kind of algorithm, combined with estimated segmentation,

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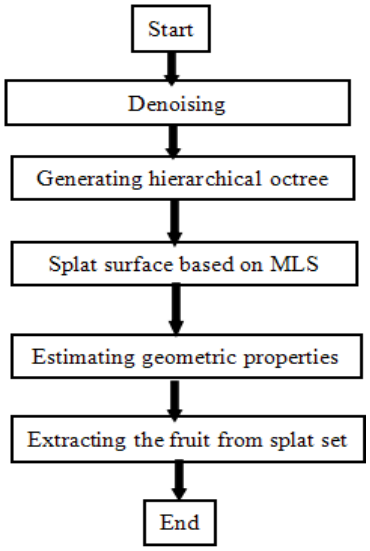

Fig. 1: Fruit shape extraction algorithm process of tomato

fitting, local features and recursive extraction as a whole from the point of "clean" after denoising in Set C to extract fruit geometry shape. First of all, in order to satisfy the accuracy and detail expression ability, the number of vector consistency and the law as the standard, it is necessary to make Set C have adaptive octree fine segmentation, so as to calculate the geometric characteristics for each unit; secondly, in order to simplify the data structure, better surface fitting for each department of the Ministry of regional, which will be converted to splat, by using the Moving Least Squares (MLS) instead of the traditional round or ellipse to fit splat; thirdly, based on the Principal Component Analysis (PCA) as well as the analysis of covariance method, each fruit splat vector change rate of curvature and geometric features can be estimated by the classical theory, for the next step of extraction; finally, the incremental algorithm is offered based on the Geometric Similarity Algorithm (GSA) recursively background to extract interesting fruit splats collection, the whole process can be shown in Fig. 1.

Establishment of tomato fruit model: Tomato as a kind of fruit, most of them are in oval shape, more structured, but the size of it is quite different, in the process of the establishment of the model, it should not only reflect the characteristics of the fruit, but also should have good controllability, which can make the model have good reusability. The fruit of tomato surface cab have the edges, in order to make the shape of the fruit more realistic, in view of the excellent properties of B spline surface, the B spline curve can be used to simulate tomato fruit. Using three-dimensional digital instrument to control the fruit surface, each column can have 17 points set, with 13 columns totally, by using B spline surface, it can reconstruct the tomato fruit.

Fig. 2: Tomato fruit model

Given $(M+1) \times (n+1)$ a control points, $d_{i,j}$ ($i = 0, 1,..., m$, $j = 0, 1,..., n$), as well as the number of the array and parameters u, v, which is k, l, 2 node vector $U = (u_0, u1,\ldots,u_{m+k+1})$ and $V = (v_0, v_1,\ldots,v_{m+1+1})$, then we can define B spline surface with $k \times l$:

$$p(u, v) = \sum_{i=0}^{m}\sum_{j=0}^{n} d_{i,j} N_{i,k}(u)\, N_{j,l}(v) \quad (1)$$

$$(u_k \le u \le u_{m+1},\ v_l \le v \le v_{n+1}) \quad (2)$$

Among them, both $N_{i,k}(u)$ ($i = 0, 1,\ldots, m$) and $N_{j,l}(v)$ ($j = 0, 1, \ldots, n$) are the basis function of B spline.

In the formula, the double subscript of $N_{i,k}(u)$, the second subscript k cab stand for the number of times, while the first subscript i can stand for symbols, which regulates 0/0 = 0, tomato fruit similar to the oval, the surface is flat but with the fruit edges. By using 3D scanner FASTSCAN pen according the order to get the fruit surface with 17×13 points, so as to form a grid control, according to the above formula of B spline curved surface data, the surface data of tomato fruit can be calculated out, then by using B spline surface technology, it can construct tomato fruit geometric model, so as to get the fruit, which can be shown as in Fig. 2.

Plant morphology development of tomato: According to the physiological characteristics of tomato, the simulation growth and development process of the plant can be characterized by the number of internodes, namely, Plastochron index, which can represent the physiological age of the plant. Therefore, it should be analyzed from the angle of plant morphology. Firstly, it should be involved in the concept of Sympodium: in general, for normal growth and development of the unlimited growth form of tomato plant, it should be composed of a set of continuous shafts, among them, the first shaft is composed by 7 stems with a bouquet, the other shafts are composed by 3 stems with a bouquet; moreover, one bouquet can bloom 5-12 flowers, with 3-12 fruits in the end. It can be clearly seen from the above that each Sympodium can be used to characterize the physiological parameters of the plant.

The characteristic parameters of each organ of the plant can be known as age class and the set if all age class can be composed of the whole plant growth and

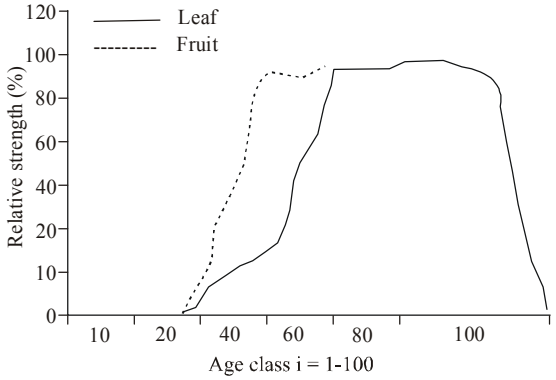

Fig. 3: Age class of plant

development process, which can be shown in Fig. 3. Among them, the growth of the plant refers to the variation of the parameters in the age class, which can also be called as Residence Time. It can times the age is the whole plant physiological age; The growth of plant refers to s the transformation between the age class, therefore the growth rate of plant organs can determine the conversion rate among the age class. Changing (reducing or extending) the Residence Time of age class can change the physiological age of the plant, as well as the growth rate of the plant organs, which can realize the adjustment and control of plant physiological cycles.

RESULTS AND DISCUSSION

"Virtual" image. This part is mainly about the integration of the system design and 3D virtual reality technology. But in this study, due to the limitation of time and technology, so far, the research results have not realized 3D virtual in the real sense. The content mainly includes the crop growth and development of the "virtual" image and "virtual" module state circulating as well as the "virtual" picture frames, photo album module and modern greenhouse image module. Among them, the "virtual" dynamic cycle used VB drawing function, Time: control and circulation function can have schematic simulation for the tomato growth and development process, while the "virtual" picture frames are on the basis of the image library building related material by using Picture control to cycle the images, so as to realize the dynamic display of the tomato growth and development process. Album module can be regarded as the verification of model experiment and the integration of the photos show, which also can be regarded as an extension of the auxiliary function. Modern greenhouse image module can also use VB graphics function to realize the modern greenhouse structure with "virtual" display picture.

Program code can completely use MS Visual Basic6.0 programming language to carry on the design, which can avoid the data transmission error due to the mixed language programming, complicated program debugging as well as some other defects, at the same time, it can take full advantages of the characteristics of VB with the object-oriented programming and the advantage of powerful function, so as to form the dynamic simulation system of tomato growth (Jones *et al*., 1999).

Data input and output module. This module can achieve the database file by setting up the proper interface channel. As for the input, it can mainly include environment, physiological parameters of varieties, greenhouse cultivation and management, as well as some other parameters, through the module, it can call the relevant database files, input data, parameters and variable values; as for output part, it mainly include the generation of simulation of the database file and chart output, output data variables are mainly including interval index, the number of leaves, fruit fresh weight, photosynthesis rate and so on (Marcelis *et al*., 1998).

Plant morphological development module. This module is mainly based on the theory of ecological physiology, on the basis of analyzing he tomatoes physiological characteristics, it can determine the number of leaf, stem section, flowering number and fruit bearing number, leaf area index and the related net weight, as well as the temporal variation function and other time functions through dividing them into age class. At the same time, through simulation calculation, it can get the dynamic changes of various organs quantity, weight equivalent during the process of plant growth and development.

CONCLUSION

This system adopts the programming technology based on Windows, since the interface is friendly, the function is strong, it can realize real-time viewing and chart display not only through the simulation data results, so as to realize data fast browse, edit and analysis; which can also use VB multi-class control, AIP function and graphic images as well as the other technologies, to realize the image "virtual" simulation for the tomato growth and development process, as well as greenhouse facilities.

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