Visual Simulation Technique of Decision Making of Interactive Stand Management Methods

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***Abstract*-A technique platform was developed for adapting to forest intensive management by applying a variety of visual simulation techniques. Firstly, thirteen stand management relevant activities were customized and expressed graphically by using the WF. On the basis of the decision making activity of interactive stand management methods proposed in this study, the flow model for visual simulation of decision making of interactive stand management methods was customized by human-computer interaction. Secondly, statistics of stand structure characteristics and the stand state were simulated in 2D by using the GDI+ drawing technique. The stand scene was simulated in 3D by using the MOGRE technique. Finally, a case study of accretion cutting in a Chinese fir plantation was carried out to verify this method. The results showed that this method with operability, flexibility and visibility could be used to create stand management flow models, and that this method could simulate the decision making of methods in order to select a better method from a variety of methods according to the decision making criterion. This method can be applied in stand management practices, can run the better method by considering the specific stand management target, and can significantly improve the stand scientific management ability.**

Keywords-decision making; stand management methods; workflow; visual simulation

I. INTRODUCTION

The implementing of the correct forest management method plays a vital role in receiving expected forest benefits in the whole period of forest growth. The forest management activity and effect can be simulated visually by combining visual simulation techniques with forest management practices, which can improve the technology content of forest management and the cognition of forest management activities[1-2]. Based on the forest management theory, BWINPRO[3], SIBYLA[4], FORRUS-S software package[5], SVS and EnVision modules in LMS system[6-7], SSDMM[8] etc. and researchers such as Umeki et al[9], Hao[10], Li et al[11] have made the visual simulation of processes and effects of a variety of forest management measures possible by establishing models of forest management measures. The above results reflect the successful application of the visual simulation technique of forest management. But the existing methods focus on simulating a specific forest management method, so they lack comparison between different methods at the same time and cannot select a better method. When a stand meets the implementing conditions of management measures, the relevant measures should be carried out. But there are different methods in the same management measure and different methods will bring different effects. The selection of methods affects the quality of the management effect directly, so the decision making of management methods is very necessary. The method that is closer to stand management objective can be selected and the stand management ability can be truly advanced by using the decision making model. This process can meet the deeper demand for simulating management measures, and can adapt to forest intensive management.

In this study, a visual simulation method for selecting a better method from various stand management methods

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was proposed and the whole process of stand management was visually simulated by combining visual simulation techniques with forest management practices.

II. Materials and Methods

A. Test Plot

The Huangfengqiao state-owned forest farm in Youxian, Hunan, China was selected as the test area. This farm is located at 113°04′-113°43′E 27°04′-27°06′N. The highest elevation is 1,270.0 m and the lowest elevation is 115.0 m. The forest coverage rate reaches 90.07 %, average annual precipitation is 1,410.8 mm and the mean temperature is 17.8℃. A Chinese fir plantation with an area of 2,500 m^2 was selected as a test plot. There are 230 trees with an age of 18 years in this plot. The slope is 18.5^o from south to west and the elevation is 328.0 m. An electronic total station was used to get the relative coordinates of all the trees. The DBH (diameter at breast height), tree height, crown width etc. were measured. At the same time, the health indices of trees were recorded. At last, the survey data named as Standdata1 was stored in an Access database.

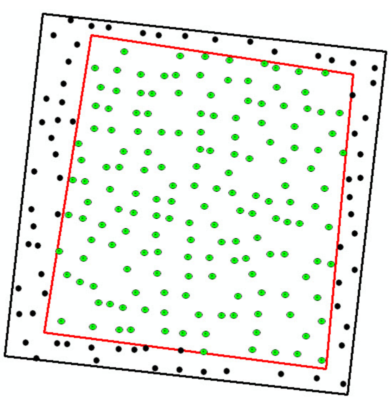


Figure 1. Schematic diagram of the core area of the plot

To avoid the edge effect, the trees were divided into trees in the core area and border trees. The core area with 161 trees is 1,799.0 m^2. The schematic diagram of the core area of the plot is shown in Figure 1. The outside black line is the plot boundary and the inside red line is the core area boundary. The trees in the core area were test objects and the other trees were only used as reference trees.

B. Decision Making Activity of Management Methods Based on Workflow Foundation

WF (Windows Workflow Foundation) is a set of the programming model, engine and tool for developing application programs based on workflow on the Windows platform[12]. It faces developers and contains a lot of standard activities that cannot reflect the activities involved in forest management, so it needs to be extended to develop a professional simulation platform that is fit to the forest management research field.

The selection criterion must be determined before selecting a better method from various methods and making the decision. It needs to meet the requirements of management objectives and can be considered from many factors such as cutting volume, average DBH of remaining trees, stand crown density, mingling of remaining trees, etc. The decision making activity of management methods (differentManagementMethods) was self-defined by using the WF, and the above factors were packaged as its attributes. The effect is shown in Figure 2.

In Figure 2, the following features can be seen: (1) the decision making criterions (attributes) of this activity were listed in the region labeled as “1”, which contained stand crown density, cutting volume, average DBH of remaining trees and mingling of remaining trees; (2) the sequenceActiviy activity can be added to add different implement methods of the management measure by using the right mouse button in the area marked as “2” and the implement methods can be removed by using the right mouse button in the region labeled as “3”; (3) management measures (such as thinning1, thinning2 and thinning3) can be dropped into the area marked as “3” to create the specific implement method by dragging the activity in the region labeled as “5”.

Aiming at the requirements of the visual simulation technique of decision making of interactive stand management methods, a manager-oriented visual workflow designer (see the area marked as “4” in Figure 2), thirteen self-defined activities (see the region labeled as

"5" in Figure 2), workflow tracking services and a workflow runtime engine were created by using the WF. A professional visualization simulation workflow platform that enabled the interaction between forest managers and the forest management software was developed.

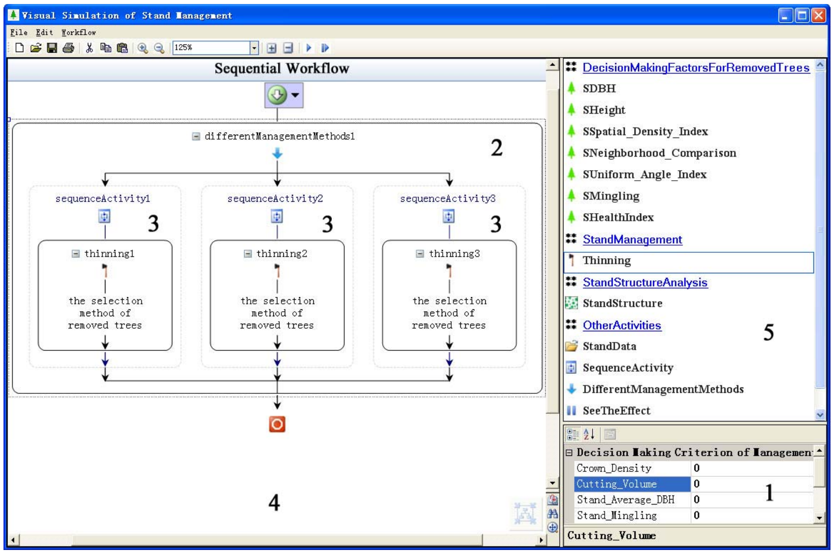


Figure 2. Decision making activity of management methods

C. *Implementation of the Decision Making Activity of Management Methods*

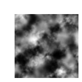
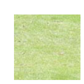
Firstly, acquire and record the decision making criterion by adding the tracking service of the decision making activity of management methods. Secondly, execute every management method in turn (sequenceActiviy1, sequenceActiviy2 and then sequenceActiviy3 in Figure 2) and select the removed trees of each management method. Finally, compare the effect of management method with the decision making criterion recorded and then select the method which is closer to the criterion as the management activity.

D. *Stand Scene Rendering Based on the MOGRE*

There are many classes that can be used to rapidly construct a stand 3D scene in the MOGRE (Managed Object-Oriented Graphics Rendering Engine)[13]. Stand scene rendering elements in this study are shown in table 1.

A stand 3D virtual scene which was used to visually simulated stand real-time state was rapidly built by using C# programming language, the stand survey data table which contained single tree's information and relative coordinates of all the trees and the MOGRE which was used to organize elements such as the elements listed in table 1, environment illumination, camera, viewport, etc.

Table 1. Stand scene rendering elements

Name	Format	Dimension	Specific expression
Entity (tree model)	mesh		
Terrain (elevation map)	png	513×513	
Terrain texture	bmp	255×255	
Skybox	jpg	256×256	

III. PROCESS AND RESULTS

A. *Flow Model for Visual Simulation of Decision Making of Interactive Stand Management Methods*

The forest management plan of this forest farm pointed out that a plantation at the age of 16-18 should be thinned.

In this example, the plantation with an age of 18 should be carried out accretion cutting according to the plan. In addition, the removed trees were selected by using the quantitative method - tree removal model based on the weight - to avoid the emergence of various thinning results and improve the thinning efficiency.

In the manager-oriented visual workflow designer, a flow model for visual simulation of decision making of interactive stand management methods was created by dragging activities from the toolbox and defining attributes of each activity. According to the management requests, managers are free to customize the workflow by human-computer interaction. In this study, the model is shown in Figure 3.

The setting of activity attributes is shown in Table 2.

As shown in Figure 3 and Table 2, (1) cutting volume accounted for 20% of the total volume of trees in the core area, which was the decision making criterion; (2) in the thinning1 activity, the DBH index and the spatial density index were decision making factors for removing trees and in the thinning2 activity, the tree height index and the uniform angle index were used to remove trees. The selection methods for removing trees were different, but they all met the accretion cutting target.

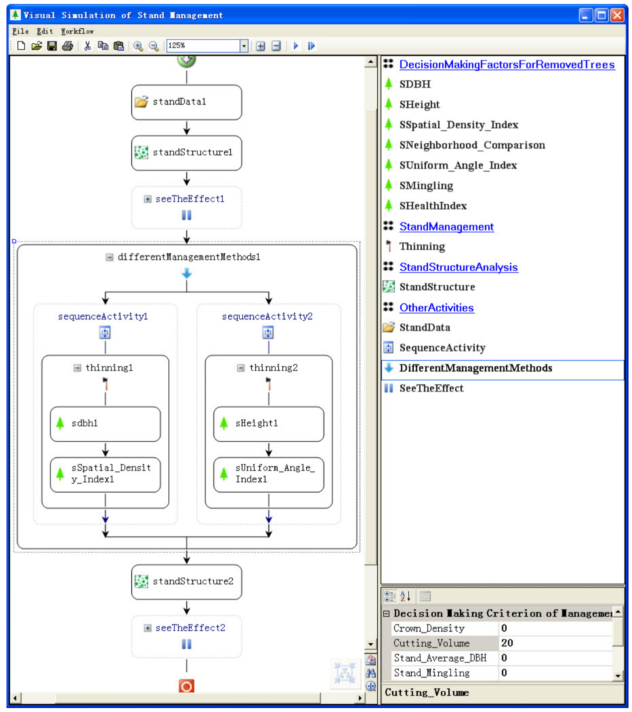


Figure 3. Flow model for visual simulation of decision making of interactive stand management methods

Table 2. Setting of the activity attributes

No.	Activity name	Attribute	Attribute value
1	standData1	Database name	Temp
		Table name	Standdata1
		Origin	Plantation
		Elevation	328.0 m
		Slope	18.5
		Aspect	Southwest
2	standStructure1	DBH distribution	True
		Height distribution	True
		Uniform angle index	True
		Neighborhood comparison	True
		Mingling	False
		Spatial density index	True
		Volume	True
3	seeTheEffect1	Show 2D	True

No.	Activity name	Attribute	Attribute value
		Show 3D	True
		Show stand structure	True
		Show volume comparison	False
		Crown density	Null
4	differentManagementMethod1	Cutting volume	20.0%
		Average DBH	Null
		Mingling	Null
		Thinning intensity	30.0%
5	thinning1	Lighting cutting	False
		Accretion cutting	True
		Sanitation cutting	False
6	sdbh1	DBH weight	0.6
7	sSpatial_Density_Index1	Spatial density index weight	0.4
		Thinning intensity	30.0%
8	thinning2	Lighting cutting	False
		Accretion cutting	True
		Sanitation cutting	False
9	sHeight1	Height weight	0.7
10	sUniform_Angle_Index1	Uniform angle index weight	0.3
11	standStructure2	The same as standStructure1	The same as standStructure1
		Show 2D	True
12	seeTheEffect2	Show 3D	True
		Show stand structure	True
		Show volume comparison	True

B. Simulation Process and Effect

The flow model for visual simulation of decision making of interactive stand management methods would execute in the order of declaration. First of all, the standDate1 activity was executed to read the stand survey data (Standdata1). Next, the standStructure1 activity and the seeTheEffect1 activity were run. At this time, the workflow was suspended and statistics of stand structure characteristics and the stand view in 2D and 3D were shown. The effects are displayed in Figure 4 and 5.

When the workflow was awakened, the differentManagementMethod1 activity was run. The decision making criterion that cutting volume (7.13m^3) accounted for 20% of the total volume of trees in the core area was recorded. Next, the thinning1 activity and the thinning2 activity were executed in turn. The cutting volumes of two cutting activities were compared with the criterion respectively. The results showed that 48 trees were removed in each method, the cutting volume was 6.38m^3 in the thinning1 activity and the cutting volume was 7.11m^3 in the thinning2 activity. The latter method was closer to the decision making criterion, so the thinning2 activity was selected as the better method.

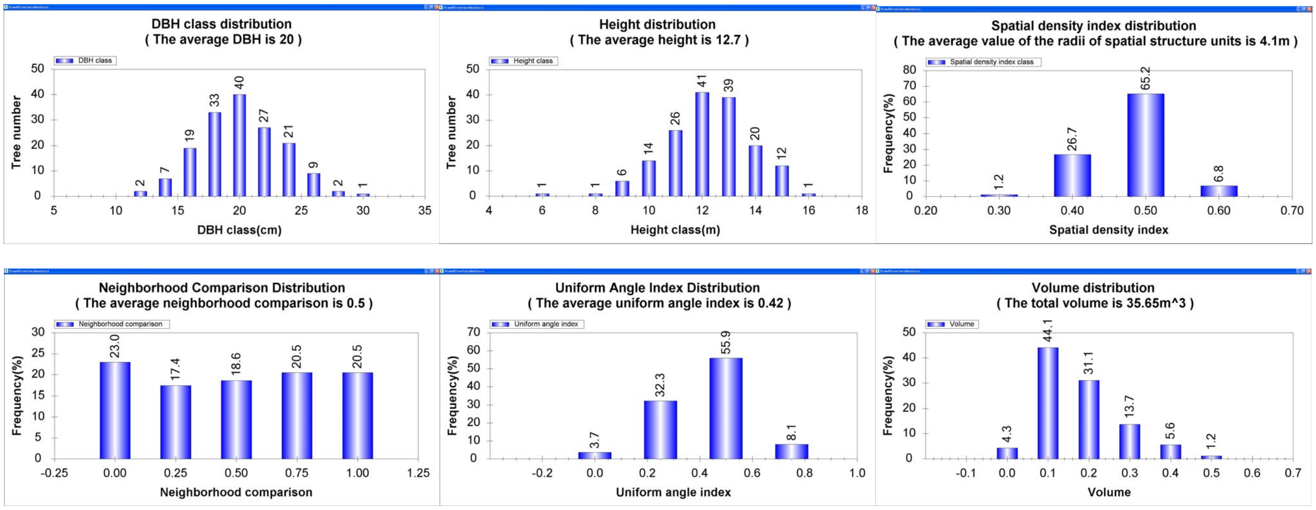


Figure 4. Statistics of stand structure characteristics (age: 18, before cutting)

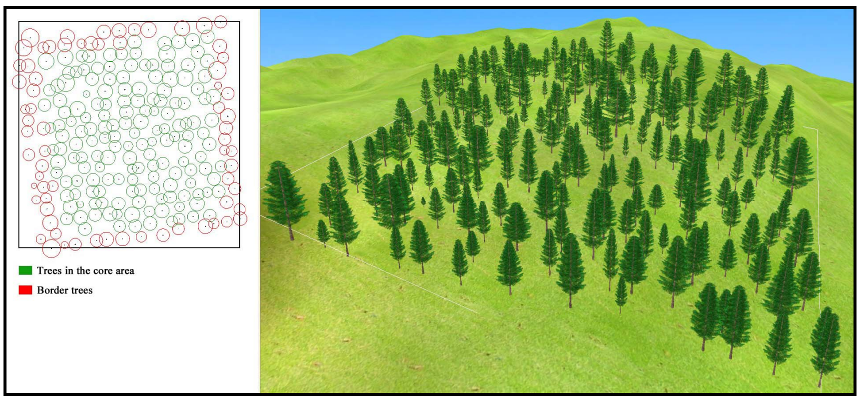


Figure 5. Stand view in 2D and 3D (age: 18, before cutting)

When the standStructure2 activity and the seeTheEffect2 activity were run, the workflow was suspended and statistics of stand structure characteristics, comparison between cutting volume and remaining volume and the stand view in 2D and 3D after cutting were displayed. The effects are shown in Figure 6, 7 and 8.

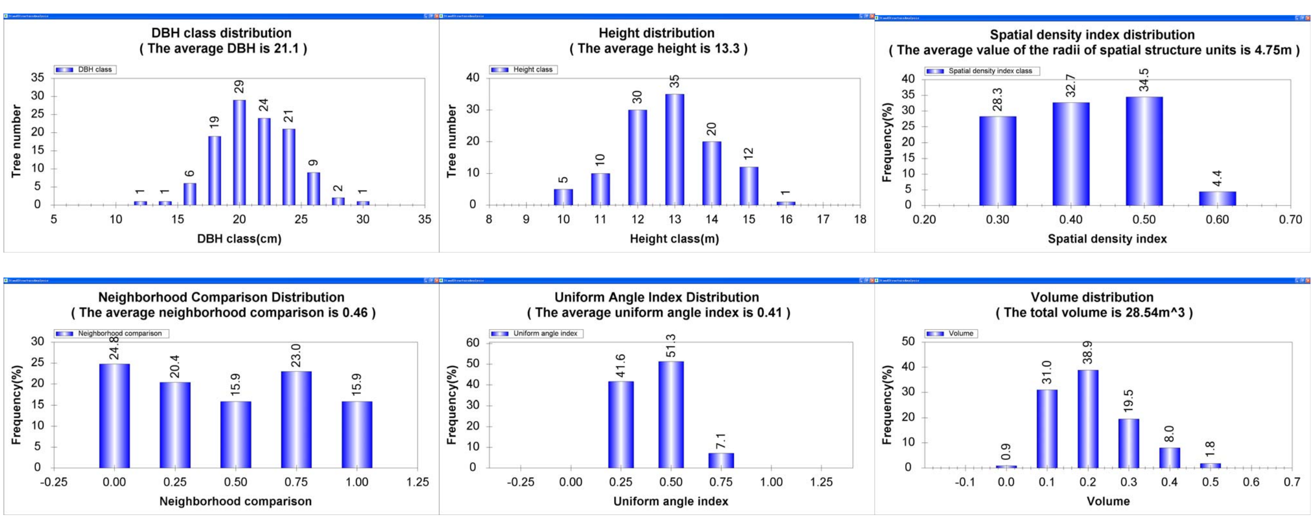


Figure 6. Statistics of stand structure characteristics (age: 18, after cutting)

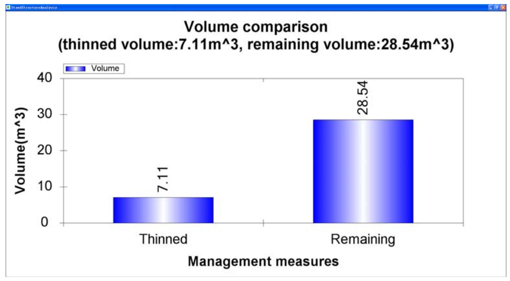


Figure 7. Comparison between cutting volume and remaining volume

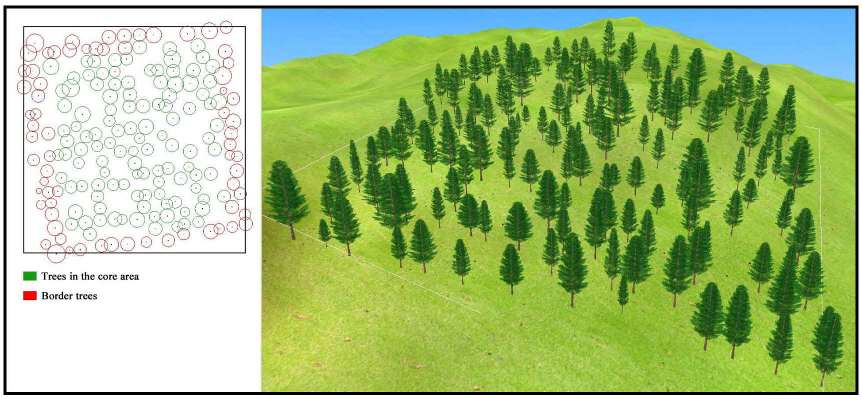


Figure 8. Stand view in 2D and 3D (age: 18, after cutting)

Stand structure characteristics before and after cutting were shown in Table 3.

Table 3. Stand structure characteristics before and after cutting

Stand structure characteristics	Before accretion cutting	After accretion cutting
Average DBH	20.0cm	21.1cm
Average tree height	12.7m	13.3m
Average radius of stand spatial structure units	4.10m	4.75m
Neighborhood comparison	0.5	0.46
Uniform angle index	0.42	0.41
Total volume	35.65m^3	28.54m^3

It can be found that the accretion cutting selected could improve growth environment and achieve the optimization and adjustment of stand structure from Figure 4, Figure 6 and Table 3.

The whole simulation process showed that this method could select a better method from various methods and make method decision under defining the decision making criterion of management methods.

IV. Conclusion and Discussion

The model for decision making of interactive stand management methods is the further expansion of visual simulation models for stand management measures. This model not only can customize stand management measures, but also can bring higher demands on the specific implementing methods of stand management measures and provide visual simulation platform to the establishment of flow models of stand management by using this method. Based on the WF, MOGRE and GDI+ drawing technique, the more reasonable stand management measure with a better method can be run by customizing the decision making criterion and creating the decision making model. The accretion cutting in a test plot was taken as an example. The cutting volume was defined as the decision making criterion and then a better accretion cutting method was selected from two methods. This approach is closer to requirements of stand management practices, can be easily used to stand management practices, can adapt to forest intensive management, and can significantly improve stand management efficiency and ability.

According to different forest management objectives, more decision making criterions can be added to the decision making activity of management methods, such as stand average height, neighborhood comparison, uniform angle index and stand volume or ecological benefits, to maximize applicability and comprehensiveness of this platform.

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