Design and Development of Analysis Tools of Uniform Angle Index

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ABSTRACT: Analysis Tools of Uniform Angle Index is of great importance to structure-based forest management, however, few convenient tools were developed for practical use. In order to facilitate calculating Uniform Angle Index of each tree and the mean value of uniform angle index of stand in forest, a tool was developed. Firstly, the distances from four closest neighboring trees to reference tree were separately computed with the formula of the distance. Secondly, four angles between the lines passing through the reference tree and other trees and x-axis were counted with the function Atan2 ( ) and the standard angles were determined in line with subtraction of the angles (θ). Thirdly, uniform angle index of each tree and the mean value of uniform angle index of stand in forest were computed. Testing results show that the tool can precisely calculate uniform angle index.
KEYWORD: Structure-based forest management; Uniform angle index; Excel VBA

1 INTRODUCTION

Forests can provide multiple services, including economic benefit, ecological benefit and social benefit. The global value of forest ecosystem goods and services has been estimated at $ 4.7 trillion annually (Hui & Klaus von Gadow, *et al.* 2007). The functions of a system are determined to a large extent by its structure. The spatial structure refers to the spatial relationships among different species in a forest community and the spatial arrangement of their attributes. The spatial pattern of trees is the integration of biological properties of the population, intraspecific and interspecific relationship and environmental conditions (Hui & Klaus von Gadow, *et al.* 2004). Author & Author 1987).

So far, more and more people have pay attention to trees' spatial pattern and more good methods have been presented. The common methods of analyzing trees' spatial pattern contain geo-statistics, nearest-neighbor method and the function of Ripley'S K(d). In 1999, Hui et al. proposed a structure parameter for describing distribution of forest tree position-uniform angle index and then have developed a forest management approach based on uniform angle index and other structure parameters (Hui & Klaus 1999).

Generally, the data which were collected from field survey were stored in Excel workbooks and Excel workbook itself has very powerful statistical analysis and charting function. Excel VBA programming language embedded in Excel can manipulate directly workbooks of Microsoft Excel (Zhao & Kang, *et al.* 2013). Therefore, it is feasible way to develop softwares with Excel VBA. VBA has been mostly preferred for systems development in recent years. Up to now, some DBMISs (data base management information systems), GISs (geographic information systems) (Zhou & Li, *et al.* 2006), DSSs (decision support systems) (Zhao & Lu, *et al.* 2011) and special software in regression analysis and charting (Tang & Zhao, *et al.* 2011; Zhao & Kang, *et al.* 2011; Zhao & Kang, *et al.* 2011; Wang 2009) have been developed.

The goal of this paper was to design and develop a tool that can calculate uniform Angle Index with VBA.

2 DESIGN OF ANALYSIS TOOLS OF UNIFORM ANGLE INDEX

2.1 *Basic Idea*

Four closest neighboring trees of a reference tree could be chosen in a stand. The included angle

between any two closest neighboring trees with the reference tree consist of a larger angle (β) and a smaller angle (α) and α and β equal to 360 (Figure1). αis usually described as the standard angles. Uniform angle index (W_i) is a ratio of the number of α (≤72°) to four. Wi can be expressed by the follow expression:

$$W_i = \frac{1}{4}\sum_{j=1}^{4} Z_{ij} \quad (1)$$

$$Z_{ij} = \begin{cases} 1, a \le 72 \\ 0, or \end{cases} \quad (2)$$

When W_{ij}=0, four closest neighboring trees around the reference tree are very unevenly distributed. When W_{ij}=1, four closest neighboring trees around the reference tree are extremely nonuniform distributed.

In order to develop a tool to calculate uniform angle index, two key points need be solved:

1. Four closest neighboring trees of a reference tree should be found out. According to the formula of the distance, the distances between the reference tree and the neighboring trees in a stand are separately calculated. Four closest neighboring trees are chosen by utilizing the function of minimum value transmission;

2. The standard angles are acquired. Firstly, the angles between the lines passing through the reference tree and each neighboring tree and x-axis are computed with the function Atan2 ( ). Moreover, the angles can be used to sort an array from lowest to highest with the function of minimum value transmission. Finally, the angles α are acquired by subtraction of the angles (θ) between the lines and x-axis (Figure 2) for example, $\alpha_1=\theta_2-\theta_1$.

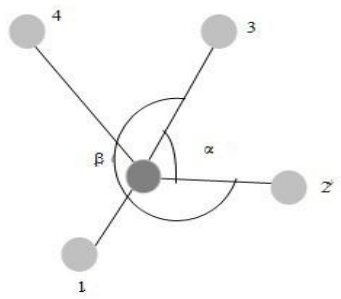

Figure1. Schematic plot of the included angle between any two closest neighboring trees with the reference tree

2.2 *Operation flow of Analysis Tools of Uniform Angle Index*

The distances from four closest neighboring trees to reference tree were separately computed with the formula of the distance. Four closest distances are chosen by utilizing the function of minimum value transmission. Moreover, four angles between the lines passing through the reference tree and other trees and x-axis were counted with the function Atan2 ( ) (Figure6a) and can be used to sort an array from lowest to highest with the function of minimum value transmission (Figure6a). Subsequently, the standard angles were chosen in line with subtraction of the angles (θ) between the lines and x-axis. The number of αthat are greater than 72 degree were counted and Wi of each reference tree was acquired according to the formula of uniform angle index (Figure6c).

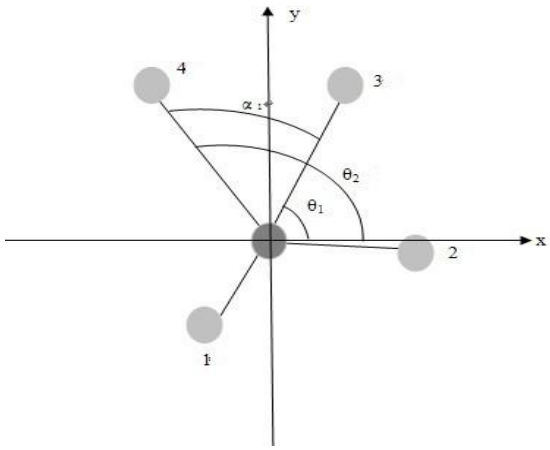

Figure2. Schematic plot of the standard angle acquired by subtraction of the angles (θ)

2.3 *Development of Analysis Tools of Uniform Angle Index*

Generally, when systems are developed by using VBA, fields and format of sheets and main modules should be separately designed in the framework of the systems flow charts. Sheets are mainly used for storing initial data and processed data. Modules are mainly engaged to implement the all functions of the systems or tools.

Analysis Tools of Uniform Angle Index contained two EXCEL sheet, toolbars and abundant program codes embedded in Excel workbook. Toolbars in EXCEL are convenient for computing uniform angle index. Excel sheets were used as database, where data were processed and stored.

2.3.1 *The design of sheets*

Operating environment of the Analysis Tools of Uniform Angle Index is EXCEL. There were two sheets: “Primitive data” and “Mean value of UAI” (Figure5). The two sheets were used for storing initial data and processed data, respectively. The sheet of “Primitive data” insist of four fields: “Tree

Number”,” Tree species”,” coordinate(x or y)”,” Uniform Angle Index”. Data of the first three fields were collected by foresters, and the last one was computed by related module of the tool. The sheet of “Mean value of UAI” was used to store the mean value of uniform angle index of stand (Figure4).

Figure3. User interface of analysis tools of uniform angle index

	A	B	C	D	E
1	Tree Number	Tree species	X	Y	Uniform Angle Index
2	1	korean pine	3.491892036	10.74693863	0.75
3	2	spruce	1.055737479	10.04467114	0.5
4	3	korean pine	10.15064721	4.733324531	0.75
5	4	korean pine	10.07492029	2.141490415	0.25
6	5	spruce	7.046597295	2.84701011	0.25
7	6	korean pine	6.472135955	4.702282018	0.75
8	7	korean pine	1.790222027	7.180188374	0.5
9	8	korean pine	-3.02476091	6.201678919	0.75
10	9	spruce	-5.79652964	5.21921873	0.5
11	10	spruce	-9.20898768	3.351797405	0.5
12	11	spruce	-6.12229515	3.975864956	0.5
13	12	spruce	1.830314894	4.110954559	0.5
14	13	korean pine	5.450217201	1.983716831	0.25
15	14	tilia	6.475265538	0.566512328	0.5
16	15	tilia	8.932807369	1.736361858	0.25
17	16	korean pine	10.17515331	-0.71151603	0.5
18	17	korean pine	10.36836457	-2.20386392	0.5
19	18	korean pine	6.861160524	-2.77208879	0.5
20	19	korean pine	5.479191667	-1.57113293	0.25
21	20	tilia	3.099527855	0.05410246	0.75
22	21	tilia	0	2.7	0.25
23	22	spruce	-1.60199763	3.774069899	0.25
24	23	tilia	-4.09576022	2.867882182	0.5
25	24	tilia	-10.0811991	3.27558014	0.75
26	25	马尾松	-7.11135605	1.126328148	0.5
27	26	马尾松	-5.67311145	1.953408927	0
28	27	马尾松	-0.48220826	0.988673451	0.25
29	28	马尾松	3.547605621	-1.36179821	0.25

Figure4. The sheets of Analysis Tools of Uniform Angle Index

Figure5. The names of analysis tools of uniform angle index

2.3.2 *The design of user interface*

Firstly, a commandbar was defined and established, then controls commandbarpopup were added with the method “add ( )”. Finally, dropdown menus were acquired by applying “add ( )” method of controls commandbarpopup to msocontrolbutton. The system includes two dropdown menus: “Data management” and “Calculating Uniform Angle Index” (Figure 3). The codes were as flow:

```
Public Sub addpopupbar()
Set cmbnewbar = CommandBars.Add(Name:="Analysis Tools of Uniform Angle Index ")
With cmbnewbar
Set mbtn = .Controls.Add(msoControlPopup)
With mbtn
.Caption = "Data Management"
Set ctlbtn = .Controls.Add
  With ctlbtn
  .Caption = "Open File"
  .OnAction = "Open File"
  End With
Set ct1btn = .Controls.Add
  With ct1btn
  .Caption = "Save File"
  .OnAction = "Save File"
  End With
   Set ct1btn = .Controls.Add
With ct1btn
  .Caption = "Delete Data"
  .OnAction = "Delete Data"
 End With
 End With
 .Visible = True
 Set mbtn1 = .Controls.Add(msoControlPopup)
 With mbtn1
 .Caption = "Calculating Uniform Angle Index"
 Set ctlbtn1 = .Controls.Add
 With ctlbtn1
 .Caption = "Calculating Uniform Angle Index"
 .OnAction = "Calculating Uniform Angle Index"
 End With
 .Visible = True
 End With
 .Visible = True
 End With
 End Sub
```

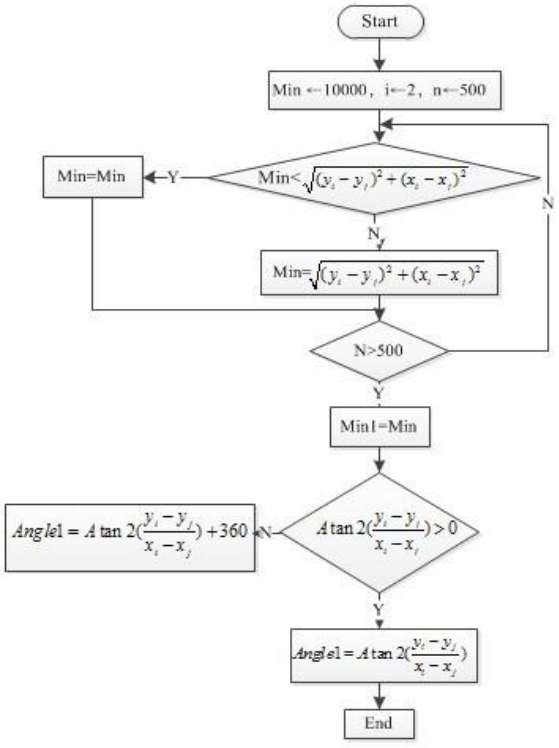

Figure6a. Flow chart of analysis tools of uniform angle index

2.3.3 *The design of main modules*

The main modules were divided into there part: the module of computing four closest distances, the module of calculating the standards angles and the module of counting uniform angle index of each tree and the mean value of uniform angle index of stand in forest.

The module of computing four closest distances was designed to compute the four closest distances from four closest neighboring trees to reference tree with the function of minimum value transmission. The main codes calculating the first closest distances were as follow:

```
Worksheets("Primitive data "). Activate
For xi = 2 To RowNumber
      t = 1000
            For yj = 2 To RowNumber
                  If yj <> xi Then
                        If t < ((Cells(xi, 3).Value - Cells(yj,
3).Value) ^ 2 + (Cells(xi, 4).Value - Cells(yj, 4).Value) ^ 2) ^
0.5 And t > 0 Then
                        t = t
                        Else
                        t = ((Cells(xi, 3).Value - Cells(yj, 3).Value)
^ 2 + (Cells(xi, 4).Value - Cells(yj, 4).Value) ^ 2) ^ 0.5
                        End If
                  End If
            Next yj
            t1 = t
t = 1000
Next xi
```

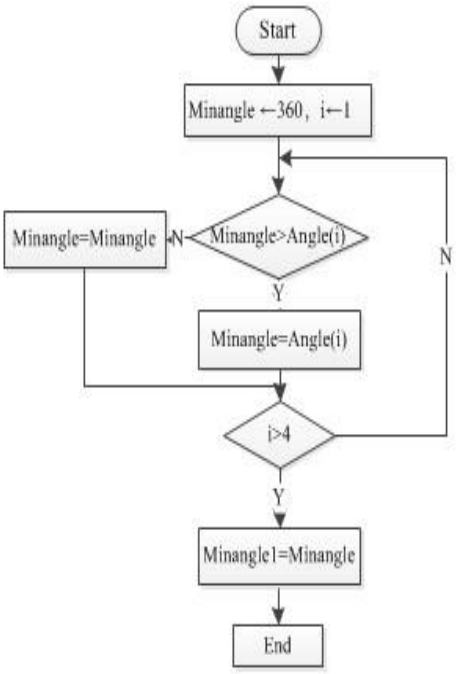

Figure6b. Flow chart of analysis tools of uniform angle index

The integrated module of calculating the standards angle involved process of computing the angles (θ), ranking the angles and counting the standards angle. The main codes were as follow:

```
For yj = 2 To RowNumber
          If yj <> xi Then
                If ((Cells(xi, 3).Value - Cells(yj, 3).Value) ^ 2 +
(Cells(xi, 4).Value - Cells(yj, 4).Value) ^ 2) ^ 0.5 = t1 Then
                      If Cells(yj, 3).Value = Cells(xi, 3).Value
Then
                            If Cells(yj, 4).Value > Cells(xi,
4).Value Then
                                  angle1 = 90
                            Else
                                  angle1 = 270
                            End If
                      Else
hudu=Application.WorksheetFunction.Atan2((Cells(yj,3).Valu
e - Cells(xi, 3).Value), (Cells(yj, 4).Value - Cells(xi, 4).Value))
                            angle =
Application.WorksheetFunction.Degrees(hudu)
                                  If angle > 0 Then
                                  angle1 = angle
                                  Else
                                  angle1 = angle + 360
                                  End If
                      End If
                End If
Next yj
          angle(1) = angle1
                angle(2) = angle2
                angle(3) = angle3
                angle(4) = angle4
                minangle = 360
          For i = 1 To 4
                If angle(i) < minangle Then
                      minangle = angle(i)
                End If
           Next i
                Minangle(1)= minangle
          For j=1 to 3
                If   Minangle(j+1)-Minangle(j)<180   then
                includedangle (j) = Minangle(j+1)-Minangle(j)
                Else
                includedangle (j)=360-( Minangle(j+1)-
Minangle(j))
                End If
                If   Minangle(4)-Minangle(1)<180   then
                includedangle (4) = Minangle(4)-Minangle(1)
                Else
                includedangle (4)=360-( Minangle(4)-
Minangle(1))
          Next j
```

The module of calculating uniform angle index contained two sub-modules: counting uniform angle index of each tree and calculating the mean value of uniform angle index of stand in forest. The main codes were as follow:

```
                For i = 1 To 4
                      If   jiajiaoji(i) > 72 Or jiajiaoji(i) = 72 Then
                            n = n + 1
                      End If
                Next i
          If n = 4 Then
                            wi = 0
                      End If
                      If n = 3 Then
                         wi = 0.25
                      End If
                      If n = 2 Then
                         wi = 0.5
                      End If
                      If n = 1 Then
                         wi = 0.75
                      End If
                      If   n = 0 Then
                         wi = 1
```

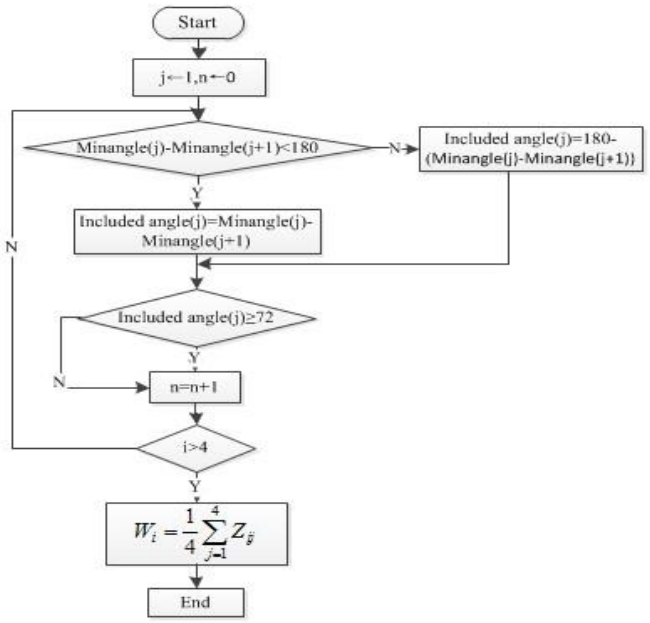

Figure6c. Flow chart of analysis tools of uniform angle index

```
        End If
            Next yj
    '        swi = swi + wi
            Cells(xi, 5).Value = wi
    For xi = 2 To RowNumber
                If ((Cells(xi, 3).Value) ^ 2 + (Cells(xi, 3).Value)
^ 2) ^ 0.5 <= 10.29 Then
                    If   Cells(xi, 5).Value = 0 Then
                        n0 = n0 + 1
                    End If
                    If   Cells(xi, 5).Value = 0.25 Then
                         n025 = n025 + 1
                    End If
                    If   Cells(xi, 5).Value = 0.5 Then
                        n05 = n05 + 1
                    End If
                    If   Cells(xi, 5).Value = 0.75 Then
                        n075 = n075 + 1
                    End If
                    If   Cells(xi, 5).Value = 1 Then
                        n100 = n100 + 1
                    End If
                    ntotal = ntotal + 1
                    stotalu = stotalu +Cells(xi, 5).Value
                End If
            Next xi
```

3 CONCLUSION

The Analysis Tools of Uniform Angle Index has been developed by utilizing Excel VBA programming language.

Excel VBA programming language has many merits. Firstly, development environment and operating environment of Excel VBA are EXCEL.

Hence, the programming language can recall expediently and directly data in Excel. Moreover, due to no requirement of development of database module, workload of programming is greatly reduced. Furthermore, Excel workbook itself has very powerful statistical analysis and charting function, which can be implemented by VBA. Finally, it is easy to learn.

4 ACKNOWLEDGEMENTS

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