CoVCA v1.0.0:"Land-population-economy" urban space collaborative simulation platform based on vector-based cellular automata model

Instruction Manual



UrbanComp

https://www.urbancomp.net/

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1. Product Description

1.1. Objects to use

CoVCA v1.0.0, the "land-population-economy" urban space collaborative simulation platform based on vector cellular automata model, integrates the density cellular automata and vector cellular automata models, and adopts the strategy of "hierarchical progressive" step-by-step dynamic driver update to conduct the "landpopulation-economy" multi-element space collaborative simulation. To provide help for practitioners and scientific research workers related to geographic information and urban planning.

1.2. Installation method

Click setup.exe or CoVCA_Setup.msi to install (the path cannot have Chinese characters and Spaces).

1.3. Interface display effect



1.4. Software control description

1.4.1. Menu bar

It consists of "File", "View", "DataProcessing", "UrbanVCA", "DensityCA",

"CoVCA" and "AboutUs".

 File
 View
 DataProcessing
 UrbanVCA
 DensityCA
 CoVCA
 AboutUs

 Image: Image

1.4.2. Toolbars

By "Open Vector File", "Open raster file", "Zoom in", "Zoom out", "Pan", "FullExtent", "Raster resample", "DLPS split", "Match land use data", "Vector to raster", "Normalize", "Calculate Pg", "UrbanVCA", "Initation Density State of Urban Development", "Calculate Overall Development Probability (Density)", "Continuitybased Mechanism CA", "Density Accuracy Evaluate", "Step-wise Synergetic Simulation VCA", "Step-wise Synergetic Simulation VCA (Multi-factor)" and "About us" several parts.

1.4.3. Data management module

This area is used to display the open data and perform some basic functions of GIS, in which the data is composed of "vector data" and "raster data", and the data that has been imported into the system is displayed under each module.



Right click on the data to be processed can open the basic GIS function module menu bar. Vector data includes four parts: "Scaling to layer", "Opening Property sheet", "Symbolization" and "Layer removal". Raster data includes three parts: "Scale to Layer", "Raster Symbolization" and "Layer Removal".

1.4.4. Data Visualization Area

This area is used to display vector files and raster files imported into the system, and also supports data display after operations such as classification. Here the raster image is symbolized to display.



1.4.5. Layer view

Select the four function keys at the top of the toolbar, "Zoom in", "Zoom out", "Move", "Zoom to current layer" to get a closer look at the current layer. \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc

Take "Zoom" button as an example. After clicking this button, the mouse pointer will turn into "Zoom" button. At this time, after clicking a certain position of the

image, hold down the left mouse button to drag and drop, you can select a certain rectangular area to zoom in, so as to observe more specific features of the area.



1.4.6. Exception prompt dialog box

This dialog box is used to prompt the status and cause of the current abnormal operation of the user in the system.



2. Data display function

2.1. Basic functions

2.1.1. Data file Import

Click Open Vector File in the File directory or the icon in the menu bar to open the Select vector file dialog box, the user can select the desired vector file to be added to the main interface for visualization. By selecting the vector file you want to open, you can import the file into the system for subsequent operations.

8 Open vector file	·	· · ·		×
← → ヾ ↑ 🖡 > 此	电脑 > 新加卷 (E:) > CoVCA >	~ ひ 在(CoVCA 中搜索	Q
组织 ▼ 新建文件夹				. 🔟 🚺
🧊 3D 对象 🔷	名称	修改日期	类型	大小 ^
🔿 A360 Drive	.vs	2023/12/17 14:29	文件夹	
📑 视频	📙 alglib-3.16.0.cpp.gpl	2024/1/24 18:33	文件夹	
▶ 图片	CoVCA	2024/10/7 14:51	文件夹	
🗐 文档	📕 eigen-3.3.7	2024/1/24 18:34	文件夹	
➡ 下载	📕 gdal2.0.2	2024/1/24 18:34	文件夹	
♪ 音乐	📜 Icons	2024/10/7 13:48	文件夹	
桌面	📙 libxml2	2024/6/13 20:30	文件夹	_
Windows-SSD (📙 log4cpp-1.1.4	2024/6/13 20:30	文件夹	
Data (Dr)	📙 opencv_x64	2024/1/24 18:34	文件夹	
	📙 proj-9.3.0	2024/6/13 19:19	文件夹	~
✓ 新加仓 (E:)	<			>
文件	名(N):	 ✓ *.sl 	пр	~
			打开(O)	取消

Click the Open Raster File in the File directory or the icon in the menu bar to open the dialog box of selecting raster file, and the user can select the required raster file to be added to the main interface for visualization. By selecting the raster file that needs to be opened, the file can be imported into the system for subsequent operations.

Sp Open raster file							
$\leftarrow \rightarrow \ \cdot \ \uparrow \ \ \cdot$	此电	脑 > 新加卷 (E:) > CoVCA	ٽ ~	在 CoVCA 中搜索	Q		
组织▼ 新建文件夹	1 1 1 1 1 1						
📑 视频	^	名称 个	修改日期	类型	大小 ^		
▶ 图片		.vs	2023/12/17 14:29	文件夹			
🖹 文档		📕 alglib-3.16.0.cpp.gpl	2024/1/24 18:33	文件夹			
➡ 下载		CoVCA	2024/10/7 14:51	文件夹			
♪ 音乐		📕 eigen-3.3.7	2024/1/24 18:34	文件夹			
■ 桌面		📕 gdal2.0.2	2024/1/24 18:34	文件夹			
🐛 Windows-SSD (Icons	2024/10/7 13:48	文件夹			
🕳 Data (D:)		libxml2	2024/6/13 20:30	文件夹			
新加卷 (F·)		📕 log4cpp-1.1.4	2024/6/13 20:30	文件夹			
Since (C)		opencv_x64	2024/1/24 18:34	文件夹			
🧼 网络		📕 proj-9.3.0	2024/6/13 19:19	文件夹	~		
	v -	<			>		
× لا	(件名	5(<u>N</u>):	~	remote sensing imag	e(*.tif *. ~		
				打开(<u>O</u>)	取消		

2.1.2. Vector data basic GIS function selection

Right click on the vector data layer that needs to be operated, after the right click, the menu interface will appear, including "Scale to layer", "Open property sheet", "Symbolization", "Remove layer" four functions.

2.1.2.1.Zoom to Layer

Click the "Scale to layer" option to display the current vector data layer as the layer range within the data visualization area.

2.1.2.2.Open the Properties sheet

Click "Open property sheet" option, you can jump to the property sheet interface, and the property sheet of the selected data will be displayed, and we can edit the property sheet of the data by clicking. As shown in the following picture:

	CoVCA				_	×
	DLMC	NewTypeID	Factor	Emission		^
1	city	NULL	NULL	NULL		
2	city	NULL	NULL	NULL		
3	city	NULL	NULL	NULL		
4	city	NULL	NULL	NULL		
5	garden	NULL	NULL	NULL		
6	garden	NULL	NULL	NULL		
7	city	NULL	NULL	NULL		
8	water	NULL	NULL	NULL		
9	city	NULL	NULL	NULL		
10	water	NULL	NULL	NULL		
11	city	NULL	NULL	NULL		
12	water	NULL	NULL	NULL		
13	city	NULL	NULL	NULL		~

2.1.2.3.symbolization

If the data of the current operation layer is vector data, click the "Edit vector symbol" option to open the vector layer symbol interface.

VectorSyr	mbolization			_		×
Property	Symbolization	Annotation				
Name: 20 Path: E: Storage: Geometry CRS: EPS Extent: Feature Field:DL New Fac Emi	15.shp /UrbanVCA_APP_v2. ESRI Shapefile 7:3 G:4326 - WGS 84 - ((1.94151e+06, 2. count: 126 MC TypeID tor ssion	1/data/2015.sl Geographic 59111e+06);(1	np .94356e+06,	2.5941	5e+06))	

The Property page displays the basic parameters of the selected layer, including the layer name, path, storage mode, geographic element type, reference system, coordinate range, element number, and all property field names.

VectorSyn	nbolization	-		×
Property	Symbolization Annotation			
Setup Cor	rresponding Colors and Values for Each I	Land Use	Туре	
Classifi	cation		\sim	
Value	DLMC		\sim	
Label	DLMC		\sim	
Land Us	e Code Land Use Type Color Selection	n (Color	
	Classify Dele	te All	Cancel	

The Symbolization page classifies and renders a vector layer's elements. The "Category" drop-down box Classification can select the method that the current operation data needs to be symbolized, and the "Field value" drop-down box can select the field name that the current layer needs to be classified: Value OBJECTID The "Label" drop-down box can select the field that the current layer needs to be labeled:

If the "field value" drop-down box selects anon-numeric field, the following error pop-up window will popup, and ask the user tore-select the field value:



After adjusting the parameters, click the "classification" button, you cansymbolize the classification based on the current parameters. The classification results are shown in the picture below:

Ve	ctorSyr	mbolizatio	n		—		×
Prop	perty	Symboli	zation Annota	tion			
Setup Corresponding Colors and Values for Each Land Use Type							
C1	lassifi	cation					\sim
Va	lue	DLMC					\sim
La	bel	DLMC					\sim
	Land	Use Code	Land Use Type	Color Selection		Color	
1	city		city	Set Color			
2	garden	ı	garden	Set Color			
3	water		water	Set Color			
4	farmla	and	farmland	Set Color			
5	woodla	and	woodland	Set Color			
Classify Delete All							
Classify Delete All OK Cancel							

Click the "Delete all Classes" button to delete all the current classification effects and automatically empty the table content. Delete All However, if the user has been classified through the drop-down box to adjust the value of the category and label value, click the "category" button will re-initialize, complete thereclassification parameters setting.

After the classification, click the "Select color" property of each category, you can jump to the interface as shown in the following figure to modify the color of the category according to user needs:

Select the color of this label	×
Basic colors	
<u>C</u> ustom colors	Hug: 356 🗣 Red: 70 🗣 Sat: 189 🗣 Green: 18 🗣 Yal: 70 🗣 Blue: 21 🗣 Alpha channel: 255 🗣
Add to Custom Colors	HTML: #461215
	OK Cancel

After setting the relevant parameters, click the "OK" button to exit the "Layer

Properties" interface, and the original layer style after symbolic rendering will be



The Annotation page can display the corresponding fields on the elements.

VectorSymbolization				_		×
Property Symbolization	Anno	tation				
Annotation Text						
Annotation Field:						
DLMC						\sim
Annotation Style:						
Font		SimSun				^
Size		9				
Color						
Bold		0				
Italics		0				~
			ОК		Cance	1

Among them, the annotation field is used to select the field that needs to be

displayed.

Annotation Text	
Annotation Field:	
DLMC	\sim

Click Font to change the font.

Select Font			×
<u>F</u> ont AcadEref		Font style Regular	Size 9
AcadEref	^	Regular	6 ^
Agency FB			7
AIGDT			8
Algerian	~		9
<	>		10 🗸
Effects		Sample	
☐ Strikeout ☐ Underline		AaBb	YyZz
Wr <u>i</u> ting System Any	~		
		OK	Cancel

Click Color to change the font color.

Select the color of this label	×
Basic colors	
	Hu <u>e</u> : 184 🗭 <u>R</u> ed: 3 🖨
<u>C</u> ustom colors	<u>S</u> at: 245 ♥ <u>G</u> reen: 72 ♥
	Val: 77 ♥ Blue: 77 ♥ Alpha channel: 255 ♥
<u>A</u> dd to Custom Colors	<u>H</u> TML: #03484d
	OK Cancel

The effect is shown below:



2.1.2.4.Remove layer

Click the "Remove Layer" option to remove the selected vector data.

2.1.3. Raster data basic GIS function selection

Right click on the raster data layer that needs to be operated, after the right click, the menu interface will appear, including "Scale to layer", "symbolization", "Remove layer" three functions.

2.1.3.1.Zoom to Layer

Click the "Scale to layer" option to display the selected raster data layer in its full form in the data visualization area.

2.1.3.2.Symbolize

If the current layer data is raster data, click the "Edit raster symbol" option to open the raster layer symbolic interface.



The Property page displays the basic parameters of the selected layer, including the layer name, path, resolution, data storage type, range, number of bands, and the maximum and minimum values of pixels for each band.



The Symbolization page can count the frequencies of different bands within the user-specified pixel range.

	sterSyn	ıbolizatio	n			-		
Pro	perty	Symboli (Doubl	zation	Single-	band P	seudo Co	olor	
[opertre	Code	e crici	Conditio	n	(Color	
1	0		>	0				
2	0.25		>	0.25				
3	0.5		>	0.5				
4	0.75		>	0.75				
unt	per of (Categoris	15					

The single-band Pseudo Color page allows a pseudo-color display of a Single band. The user can set the Number of Categories in the Number of categories and click Color to change the color. The effect is as follows:



2.1.3.3.Remove layer

Click the "Remove Layer" option to remove the selected raster data.

3. Data Preprocessing

3.1. Data regularization - resampling

This function mainly resamples raster data to change the spatial resolution of the data. It should be noted that the data used by the model should maintain a uniform resolution.

Click the "data regularization-normalization" option to open the corresponding interface. The user adds the file to this interface and selects the base image for resampling to change the resolution.

resampling					-		×		
Add the file to this module, select the base image and change the resolution without changing the actual geographical range. (Note: Double click to identify the base file, select the file and press delete to remove it.) Pending Files									
Path Name	Data Type	Width	Height	Band Count	Finish				
Target Paras									
Width									
1							•		
Height									
1							*		
Output Path									
	Run								

The user clicks on the Insert raster file of Pending Files, and the table in Pending

Files displays basic information about the input data.

	Path	Name	Data Type	Width	Height	Band Count	Finish
1	D:/Experiment/	popu2000.tif	Float64	416	315	1	False
2	D:/Experiment/	popu2010.tif	Float64	416	315	1	False
3	D:/Experiment/	popu2020.tif	Float64	416	315	1	False

Set theresampled length and width in Target Params.

larget Params	
Width	
1000	÷
Height	
1000	•

Set the Output Path in Output Path and click run Output.

D:/Experiment/CoCA/Data Run

3.2. Data regularization - normalization

This function is mainly to normalize the spatially driven data set to form the raster data with the range value of $0\sim1$, which is convenient for the subsequent calculation of the overall development probability.

Click the "data regularization-normalization" option to open the corresponding interface. The user adds the single band raster data to this interface to normalize it.

[II] Normalize						-	×
Add files to this mod	ule to normalise	the various types of s	ingle band data. (Note: Select the	file and press the del	ete key to delete)	
Pending Files							
Path	Name	Data Type	Width	Height	Band Count	Finish	
Output Path							
			Ru	1			

The user clicks on the Insert raster file in Pending Files, and the table in Pending Files displays basic information about the input data.

Set the Output Path in Output Path and click run to output.

Output Path
D:/Experiment/CoCA/Data
...
Run

3.3. Vector plot handling - Dynamic plot splitting

This function is mainly used to subdivide vector plots again, for dividing large plots. Click on "DLPS split" to turn this feature on.

LanduseDLPS	_		\times
DLPS Parameters			
Input data before DLPS spliting:			
Output data after DLPS spliting:			
Field name of land use type after reclassi	ficati	on	
			\sim
W	1		
Max iteration	1		-
Statistical Threshold Custom	Three	shold	
Max parcel area	0		•
Run DLPS			
Info		6	×

First, we need to select the vector land use file path to be split, and the vector land use data saving path after splitting

······································	
DLPS Parameters	
Input data before DLPS spliting:	
Output data after DLPS spliting:	

Through the "Input fileselection" button, we can select the vector file through the

vector fileselection dialog box, as shown in the picture below:

Select data before DLPS slpiting ×							
← → 、 ↑ 📜 > 此	CoVCA 中搜索	م					
组织▼ 新建文件夹			s •				
🧊 3D 对象 🔷 ^		修改日期	类型	大小 ^			
🔊 A360 Drive	.vs	2023/12/17 14:29	文件夹				
📑 视频	📕 alglib-3.16.0.cpp.gpl	2024/1/24 18:33	文件夹				
▶ 图片	CoVCA	2024/10/7 14:51	文件夹				
🗐 文档	📕 eigen-3.3.7	2024/1/24 18:34	文件夹				
➡ 下载	📕 gdal2.0.2	2024/1/24 18:34	文件夹				
♪ 音乐	Icons	2024/10/7 13:48	文件夹				
- 桌面	libxml2	2024/6/13 20:30	文件夹				
Windows-SSD (📕 log4cpp-1.1.4	2024/6/13 20:30	文件夹				
Data (Dr)	opencv_x64	2024/1/24 18:34	文件夹				
	📕 proj-9.3.0	2024/6/13 19:19	文件夹	~			
→ 新加倍 (E:)	<			>			
文件:	名(N):	∽ shį	o(*.shp)	~			
			打开(O)	取消			

Then, the user needs to set the land splitting parameters, including the number of land splitting iterations, the maximum land volume threshold, and the field name of the land use type after reclassification. Among them, the maximum land area threshold function is: if the land area exceeds the threshold value, it will split. If it is set to "0", the system will automatically set the threshold value to the average land area according to the current data. The setting interface of dynamic plot splitting parameters is shown in the following figure:

Field	l name	of	land	use	type	after	recla	assifi	cation-	
										~
Max it	eratic	'n							1	▲ ▼

In addition, when the maximum plot area threshold is 0, the system will split the plots whose area is greater than "average plot area +n*dStd".Allowable product parameter (*n*) of standard deviation of area and standard deviation of mean area. Set as follows (default is 3):

Statistical Threshold	Custom Threshold
Allowable multiply of standard parcel area and average parcel	deviation between 3

After the above parameters are set, the user clicks the "Run DLPS" button to split.

Run DLPS

In addition, the user can observe the function running in the log status bar.



3.4. Vector plot processing - Plot matching

This function is used to match the vector plot data of two years, so as to merge them into the same vector data, which is convenient for the subsequent urban vector plot simulation operation.

Click on "Land use data Matching" in "Data Preprocessing" in the menu bar. You will get the following interface.

LanduseMatch	-	×
Land use data to be matched		
Land use data before change		
Field name of land use type		~
Land use data after change		
Field name of land use type		~
Output the data after matching		
Match		
Info		8 ×

First, the user needs to enter the land use data before and after the land use change, and the field name containing the numeric code of the land use type. By clicking the button, the user can select the land use data in the pop-up dialog box, and the system will automatically identify all the field names of the property list of the current data.

The user can select the field name with the numeric code of land use type from the drop-down list.

Land use data to be matched	
Land use data before change	
Field name of land use type	
	\sim
Land use data after change	
Field name of land use type	
	\sim

Once this is done, the user needs to set the path to save the matched land use data.

Output	the	data	after	matching -		

Click the "Match" button again, and the system will automatically run the land use data matching function.

Match

The exported land use data will automatically generate fields: ID, before, simulated, after, Pr, area, centerX, centerY, Pg0, Pg1... Pgn, N0, N1... Nn. Their respective stands for: Plot ID Serial number, land use type before land use change, land use type after land use change simulation, land use type after land use change, limiting factor, land area, land centroid coordinate X, land centroid coordinate Y, the overall development probability of land development into type 0 land use type, the overall development probability of land use type 1 land use type.... The overall development probability of the plot developing into the NTH land use type, the plot subject to the neighborhood effect of the 0th land use type, the plot subject to the neighborhood effect of the 1st land use type... The land parcel is subject to the neighborhood effect of the NTH land type. The data automatically generates a list of properties, as shown below: <u>ID before simulated after Pr area centerX centerY Pg0 N0</u>

	ID	before	simulated	after	Pr	area	centerX	centerY	Pg0	N0
1	0	0	-1	-1	1	320	1941906	2593809	0	0
2	0	0	-1	0	1	2370	1942066	2593915	0	0
3	1	0	-1	-1	1	165	1941806	2593585	0	0
4	1	0	-1	-1	1	584	1941728	2593597	0	0
5	2	0	-1	-1	1	8	1941548	2593469	0	0
6	2	0	-1	-1	1	з	1941637.	2593598	0	0
7	2	0	-1	0	1	46	1941601.	2593573	0	0
8	3	0	-1	-1	1	417	1941864.	2593748	0	0

(Image courtesy QGIS)

In addition, users can observe the status of the function running in the log status



3.5. Vector block processing - Vector data to raster

bar.

This function is mainly used to convert vector plots to raster processing, which is convenient for subsequent collaborative simulation operations.

Click "Vector to raster" in "Data Preprocessing" to open the function, as shown:

	VectorT	oRaster	_		×
	ShpFile				
	Input shp	data to convert to raste	r data		
				• • •	
	-Pactor na	ramotore			
	Calaat ab				
	Select th	e ileia which to convert	Proto		
	Select th	le output data type			
	rasterCel	ISize(m)	0.00000	-	
	Output Pa	th			
				•••	
		R	un		
Select Shp D	ata File				×
← → ∽ ↑	📙 > 此电脑	> 新加卷 (E:) > CoVCA >	v 0	在CoVCA中	搜索 タ
组织▼ 新建	建文件夹				
	^ 4		修改日期	类型	大小 ^
A360 Dri	ive		2022/12/17 14:2	0 +++++	
📑 视频		alglib-3.16.0 cpp.gpl	2023/12/17 14:2	9 又14天 文仕李	
▶ 图片			2024/10/7 14:51	文件夹	
🖹 文档		eigen-3.3.7	2024/1/24 18:34	文件夹	
↓下载		dal2.0.2	2024/1/24 18:34	文件夹	
▶ 音乐		lcons	2024/10/7 13:48	文件夹	
		libxml2	2024/6/13 20:30	文件夹	
		log4cpp-1.1.4	2024/6/13 20:30	文件夹	
Window:	s-SSD ('	opencv_x64	2024/1/24 18:34	文件夹	
🥌 Data (D:)		Proj-9.3.0	2024/6/13 19:19	文件夹	
🧹 新加卷 (E	:) ~ <				>
	文件名(N):	~	*.shp	~
				±T#(0)	取治
				1JT(U)	+X/F

Subsequently, select "Field", "Data Type (float, etc.)", and "raster Size" for which

you want to turn the raster.

Raster parameters	
Select the field which to convert	TypeID ~
Select the output data type	Byte ~
rasterCellSize(m)	0.000000

Click the "run" button to perform the vector-to-raster operation.

In the blank status bar below, you can see the corresponding operation and

running status.

[Info]start [Info]Finish!

4. Vector plot simulation function based on UrbanVCA

4.1. Overall development probability calculation module

4.1.1. Function selection

Click on the menu bar "UrbanVCA" and select "Calculating Pg" from the menu that pops up.



We can also Calculating the total development probability by calculating the

"Calculating Pg"	button in the	toolbar, as	shown ir	1 the follow	ving figure:	

00			/				
) LandusePgs				-	-		\times
Pgs Compute	Pgs Visualiza	tion					
Spatial auxi	liary variable	s (.tif)					
		Images	Path		7		
Setting para	neters						
Data after ma	atching (.shp)						_
Mining method	d of overall p	robability of	development (Pg)				~
Nanuolii Pores			Number of hidden lavers:	20			
OOB ratio:	0.30		Number of restarts:	10			•
Number of tre	ees: 90		Number of folds in k-fold	cross-valida	tion:	10	¥
Output / Inpu	ut Pg text data	a (.csv)					
Output Pg data	(.shp)						
			Calculate			-	
Into						6	×
L							

4.1.2. Calculating the total development probability

. . .

First of all, the spatial auxiliary variables in Tiff format need to be imported.

Users can select multiple spatial auxiliary variables in the pop-up dialog box by

clicking the button, as shown in the following figure: Spatial auxiliary variables (.tif)

	Tillages Facti	
1	D:/geodata/LC08_L1TP_123039_20191020_20191030_01_T1/ LC08_L1TP_123039_20191020_20191030_01_T1_B1.TIF	
2	D:/geodata/LC08_L1TP_123039_20191020_20191030_01_T1/ LC08_L1TP_123039_20191020_20191030_01_T1_B2.TIF	
3	D:/geodata/LC08_L1TP_123039_20191020_20191030_01_T1/ LC08_L1TP_123039_20191020_20191030_01_T1_B3.TIF	

Then, the user needs to import the land use data matching data file (see 3.4 for

details), as shown below:

Setting parameters

Data after matching (.shp)

Then, users can choose random forest, neural network, logistic regression and

other machine learning models according to their needs, or directly import Pg files

from outside:

Random Forest	\sim
Random Forest	
Neural Network	
Logistic Regression	- 1
Existing Pg text data	

If the user chooses the machine learning model, the parameters of the model can

be set, and the trained Pg file saving path can be selected:

00B ratio:	0.30	Number of hidden layers: 20 Number of restarts: 10	
Number of trees:	90	Number of folds in k-fold cross-validation: 10	
Output / Input Pg te	xt data <mark>(.</mark> csv)		

If the user chooses to import the Pg file directly, there is no need to import the spatial auxiliary variables. Note that Pg is in.csv format and each line is formatted as: "Pg0,Pg1... Pgn,ID ", where the ID of each plot is the value corresponding to the "ID" field in the generated attribute list of the land use data (the format can be referred to the trained Pg file above). Users need to import the path where the Pg file is located in the following figure:

Output / Input Pg text data (.csv)

After the above Settings, set the storage path of the total development probability

. . .

. . .

data file, and then click the "Calculation" button, as shown in the following picture: $_{\tt Output\ Pg\ data\ (.shp)}$

-	-	-	
Ca	lci	ula	te

The software also provides the overall development probability visualization

function. After the calculation is complete, the user can make the observation in the

"Pgs Visualization", as shown below:

es Compute Pes Visualization		
elect the Pg to convert to the current land use type		~
The Derite convert to the surgest land use type. Papers [0, 1]	5	~
me rg to convert to the current fand use type. Range. [0, 1]	L.	^

Select the overall probability of developing into land Type i in the drop-down list

box as follows:

Select the Pg to convert to the current land use type					
Pg0	\sim				
Pg0					
Pg1					
Pg2					
Pg3					
Pg4					

Then, the software will automatically display the visual dynamic effect diagram of the overall development probability on the right side of the interface, and the redder the color, the greater the probability value. As shown in the following picture:

Select the Pg to convert to the current land use type

Pg0



Users can also observe the function running in the log status bar.

28

Info

8 ×

Pg0	Pg1	Pg2	Pg3	Pg4
0.08889	0.27778	0.13333	0.12222	0.18889
0.13333	0.07778	0.11111	0.34444	0.27778
0.14444	0.15556	0.22222	0.40000	0.23333
0.14444	NULL	0.21111	0.17778	0.11111
0.02222	0.12222	0.08889	0.41111	0.17778
0.08889	0.27778	0.06667	0.38889	0.08889
0.07778	0.20000	0.07778	0.43333	0.16667
0.42222	0.12222	0.13333	0.33333	0.22222
0.06667	0.15556	0.35556	0.07778	0.30000

Of course, users can skip this module and directly modify the Pg field in the property list of land use data after matching.

(Photo courtesy of QGIS)

4.2. UrbanVCA analog module

4.2.1. Feature selection

Click on the menu bar "UrbanVCA" and select "UrbanVCA" from the menu that pops up.



We can also open the UrbanVCA model simulation function by clicking

"UrbanVCA" button in the toolbar, as shown in the following picture:

VC/	A Paras	Accuracy Evaluation		
Parameter settings —				
Data after calculatio	ng Pg (.shp)			
Neighborhood radius:		600.00		
Iteration times:		1		
Restricted developmen	nt data (.shp) (Optional)			
Land use deve	lopment needs (area)	Conversation rules		
Default	O Portion	O Total		
Info: The values in	the table represent the a	area of land use change from column t	o row.	
Info: The values in Dutput Simulation / F	the table represent the a Prediction dataset	area of land use change from column t	o row.	
Info: The values in Dutput Simulation / R	the table represent the a Prediction dataset	rea of land use change from column t	o row.	
Info: The values in Dutput Simulation / F	the table represent the a	nrea of land use change from column to Run	o row.	
Info: The values in Dutput Simulation / F	the table represent the a	nrea of land use change from column to Run	o row.	5
Info: The values in Dutput Simulation / R	the table represent the a Prediction dataset	nrea of land use change from column to Run	o row.	5
Info: The values in Dutput Simulation / F	the table represent the a	nrea of land use change from column to Run	o row.	5
Info: The values in Dutput Simulation / F	the table represent the a Prediction dataset	nrea of land use change from column to Run	o row.	57
Info: The values in Dutput Simulation / F	the table represent the a	nrea of land use change from column to Run	o row.	5
Info: The values in Output Simulation / F	the table represent the a	nrea of land use change from column to	o row.	57

4.2.2. UrbanVCA model simulation

First, the user needs to import the total development probability calculation file

(see 4.1.2 for details) and set the neighborhood radius value and the number of

iterations as follows: Data after calculating Pg (.shp) Neighborhood radius: Iteration times: 1 After completion, the system will automatically count and display the area size

Land use development needs (area) Conversation rules							
Default		⊖ Porti	on	⊖ Total			
	Type 0	Type 1	Type 2	Type 3	Type 4	^	
Type 0	0.000	13871571.440	10241911.247	919757.837	7609403.378	32	
Type 1	29088066.285	0.000	185780.324	37428.183	2531932.370	31	
Type 2	48791157.864	1165600.783	0.000	108944.163	3643784.605	53	
Type 3	11942178.038	523300.357	102978.473	0.000	1178870.347	19 >	

of conversion between various land use types, as shown below:

Each value of the table in the figure represents the area of the land use type corresponding to that column to the land use type corresponding to that row, regardless of the fact that the land use type has not changed.

The user can then set the restricted development area as needed, and by importing the. SHP file of the restricted area in the figure below, the system will automatically prohibit the development of the block located within the restricted area (this feature is optional, not necessary). Restricted development data (.shp) (Optional)

The user can then set the land use change area as shown in the image. If "Default" is selected, it means that the system adopts the statistical result of the imported overall development probability calculation file; If "Portion" is selected, it means that the conversion area between various types of land use can be modified artificially, and the system adopts the modified value; If "Total" is selected, it means that the development area of various land use types can be artificially modified, and the system adopts the artificially modified value.

Default

O Portion

O Total

. . .

Land use development needs (area) Conversation rules									
🔵 Defai	ılt			Portion	n	ОТ	Total		
		Туре 0	Туре	e 1	Type 2	Туре 3		Type 4	^
Type 0		0.000	1387157	1.440	10241911.247	919757.8	37 76	509403.378	32
Type 1	29	088066.285	0.00	00	185780.324	37428.18	83 25	31932.370	31
Type 2	48	791157.864	116560	0.783	0.000	108944.1	63 36	543784.605	52
Type 3	11	942178.038	523300).357	102978.473	0.000	11	78870.347	13 ~
<									>
Land us	e de	velopment nee	eds (area)	Conve	ersation rules				
🔿 Defa	ult		(O Portio	n	\odot	Total		
		Type 1		Type 2	Туре 3	Ту	pe 4	Total	^
Type 0		13871571.4	40 102	41911.24	7 919757.83	76094	103.378	32642643	
								52042045.3	902
Type 1	5	0.000	18:	5780.324	37428.18	3 25319	932.370	31843207.1	162
Type 1 Type 2	35 54	0.000 1165600.78	18:	5780.324 0.000	37428.18	3 25319 53 36437	932.370 784.605	31843207.1 53709487.4	162 115

At the sametime, users can click "Conversation rules" to set the land use conversion rules. By double-clicking the median value of the table, they can set

	Type 0	Type 1	Type 2	Type 3	Type 4
Type 0	/	True	True	True	True
Type 1	True	/	True	True	True
Type 2	True	True	/	True	True
Type 3	True	False	True	/	True
Type 4	True	True	True	True	/

whether there is conversion between land use types. Land use development needs (area) Conversation rules

Each value of the table in the figure represents the change of the land use type corresponding to the column to the land use type corresponding to the row, regardless of the unchanged land use type.

After setting the above parameters, the user selects the path of the folder where the simulation results are saved and exported, and clicks the "Run" button to start the operation.

```
Output Simulation / Prediction dataset
```

Note: The result file contains the land use simulation data (.shp) and corresponding accuracy evaluation (.txt). For the land use simulation data, the simulated field can be viewed after the user opens the attribute list, which represents the simulated land use type of each land plot (see 3.4 for the meanings of the fields in the attribute list). In addition, the user can observe the operation of the function in the log status bar.



After the model simulation is completed, the Accuracy Evaluation results of each iteration will be displayed in the "accuracy evaluation" table. Users can also click "Export accuracy table" button to export the accuracy evaluation results. As shown in the following picture:



5. Simulate the continuous change of urban elements based on DensityCA model

5.1. Calculate the initial density state of urban development

Click on the menu bar "DensityCA" and select "Initialization Density State of Urban Development" from the menu that pops up. So CoVCA



We can also open the function module of calculating the initial Density State of

Urban Development by clicking the button of "Initialization Density State of Urban

Initialisation Density State of Urban Development – – × Land Use Data Previous land-use data Subsequent land-use data Classification of Urban Land and Non-urban Land Index Pixel value Urban Land Output Path Output Path Image: State St	Development" in the toolbar, a	as shown in the following J	picture:		
Land Use Data Previous land-use data Subsequent land-use data Classification of Urban Land and Non-urban Land Index Pixel value Urban Land Urban Land Output Path Run	Initialisation Density State of Urba	n Development	_		
Previous land-use data	Land Use Data				
Subsequent land-use data	Previous land-use data				
Subsequent land-use data Classification of Urban Land and Non-urban Land Index Pixel value Urban Land Output Path Run					
Classification of Urban Land Index Pixel value Urban Land Urban Land Output Path	Subsequent land-use data				
Index Pixel value Urban Land	Classification of Urban Land and Non-urba	n Land			
Output Path	Index	Pixel value	Urban Lan	1	
Output Path					
Output Path					
Output Path					
Output Path					
Output Path					
Output Path					
Output Path					
Run	Output Path				
Run					
		Run			

First, click on the right buttons of Previous land-use data and Subsequent land-

use data respectively. In the subsequent folder	selection dialo	og box, select th	e path for
storing Land data before and after the change.		The following	is shown:
Previous land-use data			
Subsequent land-use data			

In order to divide the original data into "Urban - Non-urban" Land, you can set whether it is urban Land by double-clicking "Urban Land" corresponding to the land type in "Classification of Urban Land and non-urban Land", as follows:

Classification of Urban Land and Non-urban Land
Index Pixel value

	Index	Pixel value	Urban Land
1	1	2	True
2	2	1	True
3	3	3	True
4	4	4	True

Finally, click the button in "Output Path", select the result saving path in the popup dialog box, and the result will be. Output in Tif format.

Click the "Run" button to start performing the city Development Initial density status calculation function.

5.2. Calculate the overall density development probability of the city

Run

Click on the menu bar "Density CA" and select "Calculate Overall Development Probability (Density)" from the menu that pops up.



We can also open the function module of calculating Overall Development

Probability (Density) by clicking the button of "Calculate Overall Development Probability (Density)" in the toolbar, as shown in the following figure:

Calculate Overall Development Probability		- 🗆 X
	Subsequent Land-use Samples	
	Land Use Data	
	C - 27	Dete Miles
	Set INC	DJata value
	Driving Data (Select and press the delete key to delete)	
	Input Samples I	Path
	Related Params Mining method of overall development probability	
	random forest	~
	Sampling rule	
	Uniform Sampling O Random Sampling	Manual Sampling Stationary Sampling
	Sampling Rate (1/1000)	300
	Sample file data (Polygon vector data)	
	Sample file data (Point data)	
	RF-based Params NN-based Params	
	Decision Trees Number	80
	Output Pg Path	
	С	Convert

First of all, click the button in "Land Use Data", the system will automatically popup a dialog box, the user needs to select the initial density state data of urban development obtained in the previous step.

Then, after clicking the button in "Driving Data", the system will automatically popup a dialog box, in which the user needs to select the data set of driving factors to be trained.

e delete key to delete)	
Input Samples Path	
1	ne delete key to delete) Input Samples Path

After completion, select the Mining method of overall development probability

from the drop-down box of "Mining Method of overall development probability",

which is random forest model by default. It looks like this:



Then, in "Sampling rule" select regular sampling, random sampling, manual

sampling, Static sampling, as follows:

Samping rule			
 Uniform Sampling 	○ Random Sampling	O Manual Sampling	O Stationary Sampling

If Sampling is random, set the Sampling Rate size by "Sampling Rate", as

follows:

Sampling Rate (1/1000)	300	

If Sampling is manual, import the specified sampling area.shp File via "Sampling

```
File data (Polygon vector data)", as shown below:
Sample file data (Polygon vector data)
```

Where, the data format of the specified sampling area.shp file is polygon surface

data under the same projection area range.

If the Sampling is static, it is necessary to import the specified sampling pixel

location File through "Sampling File data (Point data)", as shown below: Sample file data (Point data)

Where, the data format of the specified sampling pixel location file is: "row number, column number," and the sample data is shown as follows:

12,	132,
123,	141,
142,	124,
88,	616,
686,	919,

Then, according to the mining method of overall development probability selected above, model parameters are set in "RF-based Params" or "NN-based

P	arams", as follows:			
	RF-based Params NN-based Params			
	Decision Trees Number		80	÷
	Finally, click the button		in "Output Pg Path" and select the stora	age
lo	ocation of the overall development	ent probal	bility file in the pop-up dialog box, as	



Click "OK", the system will start mining the overall development probability Pg,

and display the function execution status in the left Log.

5.3. Simulate the continuous change of urban elements

Click on the menu bar "Density CA" and select "Continuity based Mechanism



We can also open the simulation module of urban element Continuity change through the button of "Continuity-based Mechanism CA" in the toolbar, as shown in the following figure:



First, we need to set the number of iteration rounds of this simulation through the input box of iteration rounds, which represents the number of iterations of this simulation

Then, click the right button of "Density Data", "Density Data (Reference)", "Density State Data", "Pg File Path" and "Constrain File Path" successively.

In the pop-up dialog box for folder selection, select the path for storing the real density data before the change, the path for storing thereal land data after the change, the path for storing the initial density data before the city change, the path for storing the Pg file and the path for storing the restricted development file in turn. The following is shown:

Density Data
Density Data (Reference)
Density State Data (1: non-urban, 2: urban)
Pg File Path
Constrain File Path

The "Constrain File Path" function restricts the development of a specific area, and the path can be empty. If necessary, it should be noted that the data format must be: only GByte raster data of 0 and 1 is contained in the same projection range. 0 indicates no development land, 1 indicates development land.

Then we need to choose the relevant parameters needed for the model simulation. Set the Neighborhood Size to the right of "Neighborhood Size";

Neighborhood Size 3 Set the Density Demand on the right of "density demand". In the simulation experiment, the model will automatically calculate the total demand according to the density data put in, and the relevant value should be

manually modified if the experiment is to predict the future year.

Density Demand 100000.00 Cell Radius (km) 1 The user clicks the button to the right of "City Bourder Path" and selects the vector boundary data of the experimental research area in the pop-up dialog box (it is better to have the data divided by the boundaries of districts and counties). It is shown below:

City Bourder	Path	

An example of boundary data is as follows:



After the above parameters are set, if you need to customize the display symbols of different plots, you can click the "Use Default Symbolization Plan" check box to

use the custom symbolization plan. Set Symbolic Scheme Click the "Set

Symbolic Scheme" button to enter the following interface to set the plot symbol and

Set Symbolic Scheme

partition display:

Pro	operties of Density (Doub)	le click to change)			
	Density Code	Value	Colo	r	
1	0.0636995	> 0.0636995			
2	23712.1	> 23712.1			
3	47424.1	> 47424.1			
4	71136.1	> 71136.1			
5	94848.1	> 94848.1			

Click the color of each category, you can jump to the interface as shown in the following picture to modify the color of the category according to user needs, click the value of each category, you can switch the value of each color segment point, and

need to add or delete categories can be completed through the bottom category setting

box:

Select the color of this label	×
Basic colors	
Custom colors	Hue: 200 Red: 0 Sat: 255 Green: 170 Val: 255 Blue: 255 Alpha channel: 255 HTML: #00aaff OK Cancel

Also very important point, this model supports the display of partition data, through the "partition statistical analysis" module, including the selection of partition plane data, partition annotation fields and color Settings, the method is similar to the above.

Sp	atial Heterogeneity Analysis		
urtitio	on File Path		
:/Exp	periment/CoCA/dwq-data/da	ata/SpatialData/GBA_bourder_city.sh	ıp
ibel I	Field		
)BJE	CTID	the stick to show and	
	ernes of Farmion The (Dou	bie click to change)	
	Index	Name	Color
1	1	200	
2	2	202	
3	3	203	
4	4	205	
5	5	206	
6	6	209	
7	7	210	
8	8	216	
9	9	217	
10	10	370	

Click the "OK" button, you can complete the setting of custom symbolization.

OK. To facilitate subsequent research, click the button in the "Output File Path of Simulation Result" function, and select the saving path of simulation results in the pop-up dialog box

Output File Path of Simulation	Result

Click the button "Export Parameter File", you can save and export all parameter Settings of the current interface in XML file format Export Parameter File (.xml)

Finally, click the button "Run" in the simulation interface to simulate the continuous change of urban elements automatically, as shown in the following picture:



The urban element change chart module in the upper left corner can display each area through scaling, and the line chart of density change below it corresponds to the density change in the simulation process.



The accuracy evaluation index module located in the middle of the system shows the changes of each accuracy index in this simulation, and the accuracy evaluation index change line chart below corresponds to the changes of each accuracy index in this simulation (under the partition statistical setting, the calculation unit is each plane partition rather than the grid).



In addition, we also provide a Log output interface for checking the relevant output. The Log output interface of the urban element density change simulation module is shown in the following figure:

^

5.4. Accuracy evaluation

Click on the menu bar "Density CA" and select "Precision Validation (Density)" from the menu that pops up.



We can also open the Precision evaluation function module by clicking

"Precision Validation (Density)" button in the toolbar, as shown in the following

C		
† 1	oure	•
11	guic.	•

densityAccuracy	/EvaluateV2				_	×
Density Data Evaluation Model Normal Real Density Data		O Partitioned	l			
Administrative division	ns data(vector type)					
Accuracy	MCE	PAGE	MAE			
1 dui	MOL	RNDL	MAL			
<			>			
			Ca	lculate		

First, click the button to the right of "Real Density Data" and select the path of storing real data in the dialog box of folderselection that pops up.

as follows:

Real Density Data	
D:/Experiment/CoCA/dwq-data/data/PopulationDatas/popu2000.tif	

Then, click the button on the right of "Accuracy" to import the land data to be assessed for accuracy in the pop-up dialog box, as shown below:

	Path	MSE	RMSE	MAE	MAPE	SMAPE
1	D:/Experiment/	5173621.544	2274.560	537.877	60.175	67.086
2	D:/Experiment/	4956253.915	2226.265	529.056	59.942	66.724
3	D:/Experiment/	4956253.915	2226.265	529.056	59.942	66.724
4	D:/Experiment/	4956253.915	2226.265	529.056	59.942	66.724
5	D:/Experiment/	4956253.915	2226.265	529.056	59.942	66.724
6	D:/Experiment/	4956253.915	2226.265	529.056	59.942	66.724
7	D:/Experiment/	4956253.915	2226.265	529.056	59.942	66.724

If the user needs to perform partition statistics, please select the "partition statistics" mode, and select the partition data for calculation through the select file dialog box.

Density Data		
Evaluation Model		
🔿 Normal	 Partitioned 	
Real Density Data		
D:/Experiment/CoCA/dwq-data/data/F	PopulationDatas/popu2010.tif	
Administrative divisions data(vector ty	/pe)	

When finished, click the "Run" button to start the precision evaluation function

Run

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6. Simulate the vector land-population-economycollaborative development module based on the CoVCAmodel

6.1. Urban single element (real vector land) simulation

This function is mainly used for the simulation of urban vector plots. This module integrates the three functions of UrbanVCA: land matching, calculating the overall development probability, and starting the cellular automata for simulation, so that it can directly complete all the basic simulation operations of UrbanVCA in this module.

We can also open the Simulation module of urban single elements (real vector plots) by clicking the button of "Step-wise Synergetic Simulation VCA" in the toolbar, as shown in the picture below:



 \times

CoVCA v1.0.0 Instruction Manual

inulation Result	Accuracy Evaluation	Basic Params
	Iteration FoM PA	UA Internal Iterations 10 Land-use Data
		Field name of land use type
		Land-use Data (Reference)
		Field range of land use time
		Field liame of faild use type
		Pg Exception Paras
		NULL
		VCA Model Paras
		NULL
		Output File Path of Simulation Res
	<	Run
ange Curve of Various Land Parcels	Change Curve of the Accuracy Indices	Output Info
000 T		
800	_ 0. 8 -	
500 3		
400 -	A A C	
200	- 0. 2	
	0 200 400 600 800 1, Iteration	000

First, you need to set the number of iterations through the internal iteration number input box Internal Iterations 10 -

Then, click the buttons on the right of "land-use Data" and "land-use Data (Reference)" respectively. In the pop-up dialog box for folder selection, select the path for storing real Land use Data before the change and the path for storing real Land use Data after the change. The following is shown:

Land-use Data
Field name of land use type
×
Land-use Data (Reference)
Field name of land use type
¥
×

Also, select the plot field in this vector plot data (note the use of English).

Land-use	Data
cationBa	seData1/2014.shn
-Field n	ame of land use type
	ame of failu use type
TypeID TypeID ORIG_FID ORIG_FIC AREA_1 GYRATE PARA FRAC CIRCLE NCA CAI	
ECON	× 1
Next, we need to set the part	ameters of the global development probability model
by clicking the "Pg Excavation P	Paras" button and the parameter setting
Pg Excavation Paras	and the parameter setting
NULL	
sub-interface	of the global development
probability calculation module w	ill automatically popup, as shown below:
setPgModelParas	-
Land use data to be matched	Pgs Compute
Land use data before change E:/CarbonWCA/ClassificationEaseData1/2014 shn	Spatial auxiliary variables (.tif)
Field name of land use type	Images Path
TypeID	
ssificationBaseData1/2014_Reclassification.shp	Setting parameters
Field name of land use type	Mining method of overall probability of development (Pg) Random Forest
TypeID ~	00B ratio: 0.30 € Number of hidden layers: 20 €
Output the data after matching	Number of trees: 90
	Output / Input Pg text data (.csv)
	Output Pg data (.shp)
	OK
lafa	

In the Pg parameter setting sub-interface, "Land use data before change", "Field name of land use type", "Land use data after change", and "Field name of land use type (after) is automatically set based on the parameters on the previous interface and cannot be modified externally. The following information is displayed:

Land use data to be matched
Land use data before change
E:/CarbonVCA/ClassificationBaseData1/2014.shp
Field name of land use type
TypeID \vee
Land use data after change
ssificationBaseData1/2014_Reclassification.shp
Field name of land use type
TypeID 🗸

Then, in the Output the data after matching module, click the button to select the

output plot r	natching
	Output the data after matching

In the Pgs Compute module on the right, it is the calculation parameter setting of

the overall development probability.

	Images	Path		
Setting parameters				
Mining method of ov	verall probability of	f development (Pg)		
Random Forest				\sim
00B ratio:	0. 30	Number of hidden layers:	20	-
		Number of restarts:	10	
Number of trees:	90	Number of folds in k-fold	cross-validation: 10	•
Output / Input Pg ·	text data (.csv)			
ıtput Pg data (.shp))			
	·			

First, you need to add the spatial auxiliary variable (.tif), click the button to add



When this is done, the software can automatically recognize these spatial

auxiliary variables.



Then, the algorithm, algorithm parameters, and the output of the csv file are set (see 4.1.2).

Random Forest	· · · · · · · · · · · · · · · · · · ·	
OOB ratio: Number of trees:	0.30 90	Number of hidden layers: 20 Number of restarts: 10 Number of folds in k-fold cross-validation: 10
Output / Input Pg	text data (.csv)	

Output Pg data (.shp)

...

Click "OK"

OK

"And select the location of the output".xml "model parameter file to complete the final

Pg calculation setu	p.			
Select Project Save Path				×
← → ~ ↑ 📕 > 此時	1脑 > 新加卷 (E:) > CoVCA >	✓ ひ 在(CoVCA 中搜索	ρ
组织 ▼ 新建文件夹				?
文档 个	名称 ^	修改日期	类型 大小	^
➡ 下载	.vs	2023/12/17 14:29	文件夹	
♪ 音乐	alglib-3.16.0.cpp.gpl	2024/1/24 18:33	文件夹	
三 桌面	CoVCA	2024/10/7 17:06	文件夹	
💺 Windows-SSD (📕 eigen-3.3.7	2024/1/24 18:34	文件夹	
🧼 Data (D:)	📕 gdal2.0.2	2024/1/24 18:34	文件夹	
、 新加卷 (E:)	📙 Icons	2024/10/7 13:48	文件夹	
	📙 libxml2	2024/6/13 20:30	文件夹	
♥ 网络	📙 log4cpp-1.1.4	2024/6/13 20:30	文件夹	\sim
¥ ·	<		1	*
文件名(N):				\sim
保存类型(T): xml(*.>	(ml)			\sim
▲ 陶荷文件本			保存(S) 取消	
	information	×		
	Pg model p	oaras set successfully!		
	Y	'es No		
	Pg Excavation Para WCA/UrbanVCA/data,	s /Pg. xml		

In the status bar below, you can view the status and operation of the current run.

Next, we need to set the parameters of the VCA Model, (note that it is necessary

to complete the setting of Pg before setting VCA) Click the button in "VCA Model VCA Model Paras

. . .

Params", NULL

Info

the system will automatically popup

đΧ

the sub-interface of setting parameters of the VCA model, as shown below:

Land use development needs (area) C	onversation rules
Default O Portion	🔾 Total
Type 0 Type 1 Type 2 Type 3	Type 4 Total ^
Type 0 0.000 41964.912 131693.070 292914.430) 14981.458 481553.8 [°]
Type 1 8300.926 0.000 49.412 21149.687	3741.346 33241.37
Type 2 32173.765 12664.378 0.000 84625.247	0.000 129463.3
Type 3 0.000 79655.874 53325.435 0.000	50400.828 183382.1. →
Info: The values in the table represent the area of land use change	from column to row.
ОК	
	6
	anVCA/UrbanVCA/data/Pg.shp.
24 IO OF IT. TO.II // DEC IMIG GEE GALA AILEI CAICUIALINS IS E./OID	anvon/ of banvon/ da ca/1 5. shp.

The first is to load the Pg file, where the software has automatically read the Pg file in the previous step (users do not need to add it themselves).

Data after calculating Pg (.shp)	
E:/UrbanVCA/UrbanVCA/data/Pg.shp	

Subsequently, the user needs to set the field radius (see 4.2.2), and the number of

iterations has been set according to the first step.						
Neighborhood radius:	600.00	•				
Iteration times:	10	A V				

The user can set the vector data of the restricted development area below (none

can be left unadded).

	/	
Restricted development	data (.shp)	(Optional)

						•••
An	d set the app	ropriate restri	ctions (see 4	.2.2).		
]	Land use develo	pment needs (are	a)	Conv	ersation rules	
🔘 Defau	lt	O Por	rtion	0	Total	
	Type 0	Type 1	Type 2	Type 3	Type 4	Total ^
Type 0	0.000	41964.912	131693.070	292914.430	14981.458	481553.8 [.]
Type 1	8300.926	0.000	49.412	21149.687	3741.346	33241.37
Type 2	32173.765	12664.378	0.000	84625.247	0.000	129463.3
Type 3	0.000	79655.874	53325.435	0.000	50400.828	183382.1
<						>

Info: The values in the table represent the area of land use change from column to row.

Finally, click "OK" to complete the operation.

OK

After setting up the Pg and VCA models, select the folder directory where you want to output the results.

```
Output File Path of Simulation Result
```

Run

Click the "run" button to start running the module.

After the program is finished, the system will display the last land use type chart, the accuracy evaluation index of each round of iteration, the line chart of the change number of different types of land and the line chart of the change of each accuracy evaluation index, as shown in the following figure:



The land use type chart module in the upper left corner can display each area by scaling and traversing, and the line chart of the change number of different types of land plots below corresponds to the change situation of each type of land plots in this simulation.



The accuracy evaluation index module located in the middle of the system shows the changes of each accuracy index in this simulation, and the accuracy evaluation index change line chart below corresponds to the changes of each accuracy index in this simulation.



In addition, we also provide a Log output interface for checking the relevant

output, as shown in the following figure:

```
2024-10-07-17:45:25 >> Set land use
data before change E:/UrbanVCA/
UrbanVCA/data/2015.shp.
2024-10-07-17:45:26 >> Set land use
data after change E:/UrbanVCA/
UrbanVCA/data/2018.shp.
2024-10-07-17:54:10 >> Start...
2024-10-07-17:54:12 >> Finish (1.44
second)
```

6.2. Urban multi-factor collaborative change simulation

Click on the menu bar "CoVCA" and select "Step-wise Synergetic Simulation

VCA (Multi-factor)" from the menu that pops up.

 ensityCA
 CoVCA
 AboutUs

 Image: Step-wise Synergetic Simulation VCA
 Image: Step-wise Synergetic Simulation VCA (Multi-factor)

We can also open the urban Multi-factor collaborative Simulation change module by clicking the button of "Step-wise Synergetic Simulation VCA (Multi-factor)" in the toolbar, as shown in the picture below:



First of all, the number of iterations of each collaboration should be set through the internal iteration input box; Iteration Rounds 10 😨 Set the number of collaboration through the external collaboration number input box setting.

-

Internal Iterations 10

We can Add and Delete sub-VCA models by "add" and "delete". By doubleclicking sub-VCAmodel parameter table, model switching, VCA parameter setting, Pg parameter setting and symbolic display can be achieved, as shown in the following figure:



The second part is the parameter setting of each sub-VCA model, which is similar to the previous content. Next, the specific design methods of UrbanVCA and DensityCA will be introduced respectively.

UrbanVCA:

First, double-click the red NULL corresponding to UrbanVCA in the "Pg Paras" column, and the following Pg setting interface will popup.

And use data before change iteld name of land use type and use data after change iteld name of land use type Number of land use type Number of trees: 90 Number of folds in k-fold cross-validation: 10 Output / Input Pg text data (.csv) Output Pg data (.shp)	setrgmodelParas	- L X
rield nase of land use type Images Path Setting paraseters Number of local probability of development (Pg) Number of restarts: 10 OUTput the data after matching Output Pg data (.stp) Output Pg data (.stp)	Land use data to be matched Land use data before change	Pgs Compute Spatial auxiliary variables (.tif)
And use data after change Setting parameters Hining method of overall probability of development (Fg) Kandom Forest OUB ratio: Number of hidden layers: OB ratio: Number of restarts: OUTput / Input Pg text data (.csv) Output / g data (.shp) () () () () () () () () () (Field name of land use type	Images Path
Tield name of land use type Iming method of overall probability of development (Pg) Random Forest 00 Dutput the data after matching Iming method of overall probability of development (Pg) Number of trest: 00 Number of restarts: 10 Output / Input Pg text data (.csv) Iming method of overall probability of development (Pg) Output / g data (.shp) Iming method of overall probability of development (Pg) fo 0%	Land use data after change	Setting parameters
butput the data after matching 00B ratio: 0.30 Number of hidden layers: 20 00B ratio: 10 Number of restarts: 10 0 00B ratio: 00B ratio: 00B ratio: 00B ratio: 10 00B ratio: 10 00 00C 00C 00C 00C 00C 00C 00C 00C 0	Field name of land use type	Mining method of overall probability of development (Pg) Random Forest ~
in output Pg data (.shp)	Output the data after matching	OOB ratio: 0.30 Number of hidden layers: 20 20 Number of trees: 90 Number of restarts: 10 20 Number of trees: 90 Number of folds in k-fold cross-validation: 10 20 Output / Input Fg text data (.csv)
fo		Output Pg data (.shp)
fo		OK
	nfo	e >

For the specific Settings of this part, see 4.1.2. Fill it in the order from left to right and from top to bottom.

setPgModelParas	- 0
Land use data to be matched	Pgs Compute
Land use data before change	Spatial auxiliary variables (.tif)
E:/CoVCA/CoVCA/data/test 2009.shp	Images Path
Field name of land use type	E:/CoVCA/CoVCA/data/4/27_29_81_86_808_862_normalize_gongchang.tif
OBJECTID	<pre>E:/CoVCA/CoVCA/data/4/27_29_81_86_808_862_normalize_gongjiao.tif</pre>
and use data after change	E:/CoVCA/CoVCA/data/4/27_29_81_86_808_862_normalize_gongyuan.tif
E:/CoVCA/CoVCA/data/test_2014.shp	E:/CoVCA/CoVCA/data/4/27_29_81_86_808_862_normalize_osm.tif
field name of land use type	E:/CoVCA/CoVCA/data/4/27_29_81_86_808_862_normalize_shangchang.tif
OBJECTID	
utput the data after matching	Catting parameters
	Wining mathed of organil probability of devalopment (Pg)
	Randon Romest
	00B ratio: 0.30 Number of hidden layers: 20
	Number of trees: 90
C:/CoVCA/CoVCA/data/matching.shp	wunder of folds in k-fold cross-validation: 10
	E:/CoVCA/CoVCA/data/4/Pg.csv
	Output Pg data (. snp)
	E:/COVCA/COVCA/data/4/Pg. snp
	OK
fo	6
2024-10-09-18:01:37 >> Set land use data before 2024-10-09-18:01:39 >> Set land use data before 2024-10-09-18:01:43 >> Set land use data after 2024-10-09-18:01:55 >> Set Pg (.csy) text data	e change E:/CoVCA/CoVCA/data/test_2009.shp. e change E:/CoVCA/CoVCA/data/test_2014.shp. matching E:/CoVCA/CoVCA/data/matching.shp. E:/CoVCA/CoVCA/data/Amatching.shp. E:/CoVCA/CoVCA/data/AMAtching.shp.
2024-10-09-18:01:58 >> Set Pg (.shp) data E:/Co	oVCA/CoVCA/data/4/Pg.shp.

After clicking "OK", a window will popup to set the xml file, the user needs to

choose the location of the file to save, click the "Save" button in the lower right

corner.						
Select Project Save	Path					\times
← → ~ ↑ 📕 «	新加卷 (E:) > CoVCA >	CoVCA > data > 4	~	ひ 在4中搜索		2
组织▼ 新建文件夹	1				-	?
 ◇ A360 Drive 翻 视频 ◎ 图片 ○ 文档 ◆ 下载 ♪ 音乐 ■ 桌面 ٤ Windows-SSD (~ Data (D:) ~ 新加卷 (E:) 	res	CA.xml	CAPG.xml	Pg.xml		
文件名(N): Pg	g.xml					~
★仔头型(1): XII ▲ 隐藏文件夹	m(*.xm)			保存(S)	取消	

Then you can find that the "Pg Paras" section has been setup, as shown in the picture.

UrbanVCA E:/CoVCA/ NULL	JLL

Double click the red "NULL" button under "VCA Paras" again, you can open the interface of setting cellular automata in the UrbanVCA section. As shown in the

age.							
setVCAM	odelParas				-	- 🗆	
arameter	settings						
ata after	calculating Pa	g (.shp)					
E:/CoVCA/C	CoVCA/data/4/Pg	. shp					
eighborho	ood radius:		600	. 00			[
teration	times:		10				
estricted	l development da	ata (.shp) (Opti	onal)				
т	and use develor	mont noods (ana	a)	Com	remaction mules		•
Dafaul	anu use ueveror	O Real	a)	Conv	versation rules		
	Type 0	Type 1	Type 2	Type 3	Total		
Type 0	0.000	0.000	0.000	0.000	0.000		
турео	10000	0.000	0.000	0.000	4.000 4.00		
Type 1	16993.163	0.000	0.000	0.000	16993.163		
Type 2	6514.901	0.000	0.000	0.000	6514.901		
Type 3	0.000	2806.890	4934.887	0.000	7741.777		
Info: The	e values in the	table represent	the area of la	and use change fr	com column to ro	Ψ.	
							8
:02 4 -10-0	9–19:43:54 >> S	et land use data	after calcula	ting Pg E:/CoVCA,	′CoVCA∕data/4/Pg	. shp.	

See 4.2.2 for the Settings of this section. The Pg file and the number of iterations have been set. The user only needs to set the radius of the domain and the restrictions below, and click "OK" to complete the setting of this module.

	Туре	Pg Paras	VCA Paras
1	UrbanVCA	E:/CoVCA/	E:/CoVCA/

DensityCA:

Double click UrbanVCA under "Type" to switch to DensityCA

Step-wise Model Paras

Туре	Pg Paras	VCA Paras
1 DensityCA	NULL	NULL
	Ada	d Delete

As above, double click on the red "NULL" under "Pg Paras" to open the setting screen for the overall development probability of density CA.

setCAPgModelParas		_		\times
Land Use Data				
Driving Data (Select and press the delet	e key to delete)			
Inpu	t Samples Path			
Poloted Percent				
Mining method of overall development m	rohahility			
random forest				\sim
Sampling rule				
🖲 Uniform Sampling	🔘 Random Sampling			
Sampling Rate (1/1000)	300			
RF-based Paras NN-based Paras				
Decision Trees Number	80		-	+
				1
		OK	Canc	el

The Settings of this part are detailed in 5.1 and 5.2, which will not be repeated here. After the setting is complete, click "OK" and double click the red button under

"VCA paras" to open the setting section of cellular automata in Density CA.

setDensityModelParas			- 0	×
Basic Parans			Attenuation Factor	
Iteration Rounds	10	* *		
Densty Data				
Density Data (Reference)				
Density State Data (1: non-urba	n, 2: urban)			
City Bourder File Path			1	
Constrain File Path				
Neighborhood Size	3	-		
Density Demand	100000.00	=		
Cell Radius (km)	1	÷		
Attenuation Factor	0.005	÷		
			0K Cance	1

See 5.3 for the Settings of this part, and do not go into details here.

After all Settings are completed, the user needs to select the folder directory of output results and click "..." Button, select the folder directory. Click the "Run" button at the end, and it is ready to run.

Output File Path of Simulation Result					
Run					

(The data used here is only for simulation, users need to prepare their own data.)

The running result is shown as follows:



7. About Us

Click AboutUs on the menu bar, and choose AboutUs from the menu that is displayed.



We can also access information About the R&D team by clicking the "About Us"

R button in the toolbar, as shown below:



8. Copyright Notice

CoVCA v1.0.0: "Land-population-economy" urban space collaborative simulation platform based on vector cellular automata model

CoVCA v1.0.0 was developed by the following laboratories: UrbanComp: Location Intelligence and Urban Perception Research Group Faculty of Geography and Information Engineering China University of Geosciences (Wuhan) Website: <u>https://www.urbancomp.net/</u>

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