SANET:

Spatial Analysis along Networks

The manual for SANET V4.1 Beta runs on ArcGIS10 & ArcGIS10.1 (revised on 2013/2/9)

SANET TEAM



Tal	ole of	Contents	page
1.	Abo	ut SANET:	2
	1.1	Functions and Versions	
	1.2	Copyright	
	1.3	Use conditions	
	1.4	Citation in publication	
	1.5	Contact	
	1.6	I/O file formats	
2.	How	to install and plug-in SANET	4
	2.1	Hardware and Software requirements	
	2.2	How to install SANET and plug-in to your ArcGIS	
	2.3	How to put license key to run SANET on your ArcGIS.	
3.	Wha	t is SANET?	8
4.	Ana	lytical Tools	11
	4.1	Tool 01: Voronoi diagrams	12
	4.2	Tool 02: Kernel density estimation	16
	4.3	Tool 03: Global auto nearest neighbor distance method	21
	4.4	Tool 04: Global cross nearest neighbor distance method	27
	4.5	Tool 05: Local cross nearest neighbor distance method	(in preparation)
	4.6	Tool 06: Global auto K function method	33
	4.7	Tool 07: Global cross K function method	40
	4.8	Tool 08: Local cross K function method	47
	4.9	Tool 09: Global Voronoi cross K function method	54
	4.10	Tool 10: Interpolation	61
	4.11	Tool 11: Delaunay diagram	(in preparation)
	4.12	Tool 12: Point clustering method	66
	4.13	Tool 13: Random points generator	70
	4.14	Tool 14: Shortest path distance between points in a set of points	73
	4.15	Tool 15: Shortest path distance between A points to B points	77
	4.16	Tool 16: Network Characteristics: polylines, points and links	80

1. About SANET

1.1 Functions and Versions

SANET is the Plug-in Program which statistically analyzes spatial patterns of events that occur on/alongside networks.
SANET is developed by the SANET Team (Leader: Atsu Okabe).
SANET Version 3.1 is for ESRI ArcGIS Ver.9.1 & 9.2 with Windows XP.
SANET Version 4.0 Beta is for ESRI ArcGIS Ver.9.3 with Windows Vista and Windows XP.
SANET Version 4.1 Beta is for ESRI ArcGIS Ver.10 and ArcGIS Ver.10.1 with Windows 7, Vista and Windows XP.
Current version of SANET is Version 4.1 Beta and is a licensed program.

The effective license period for SANET Version 4.1 Beta is one year.

1.2 Copyright

The program is copyrighted by PASCO and is intended for the use of students, academic researchers, non-profit researchers and educators.

It can be distributed freely on educational and research purposes, but cannot be re-sold.

1.3 Use conditions

SANET Team distributes the program only to those who agree on the following conditions

- The user will use SANET for nonprofit purposes only.
- The authors will not bear responsibility for any trouble that the user may meet in the use of SANET.
- When the user uses SANET, he/she will report to the authors his/her name, affiliation, address and e-mail address.
- When the user publishes any results obtained by using SANET, he/she will explicitly state in the paper that he/she used SANET. Also, he/she will send a reprint of the paper to the authors.
- The authors appreciate the reports of users which help us discover and isolate bugs within SANET.

1.4 Citation in publication

SANET must be cited correctly in any papers or publication that use results obtained from SANET. Also it should be acknowledged the use of SANET, Spatial Analysis along Networks (Ver.4.1) developed by the SANET Team (leader: Atsu Okabe), Tokyo, Japan. In addition, in case any correspondence exists between a specific member, his/her name is most preferably being cited.

1.5 Contact

SANET team contact information is as follows.

Request for distribution of SANET Program and sending papers should contact to

Atsu Okabe [atsu@csis.u-tokyo.ac.jp]

Technical questions relating to the SANET software and manual should contact to Atsu Okabe [atsu@csis.u-tokyo.ac.jp]

1.6 I/O file types

The current Version is SANET Version 4.1 Beta

The SANET program inputs spatial data (e.g. accident incidence spots data, retail store location data) with ESRI SHAPEFILE.

The SANET program computes various spatial factors and gives results in forms of shapefiles, CSV file or R files for chart the result.

2. How to install and plug-in SANET

2.1 Hardware and Software requirements

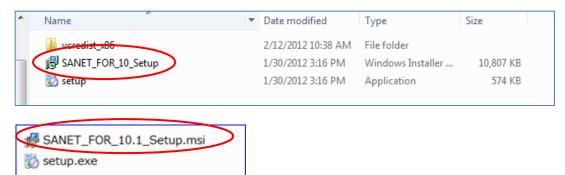
ESRI ArcGIS 10 is required.

GNU R is preferably installed for the better performance of the results obtained.

2.2 How to install SANET and plug-in to ArcGIS

Firstly, download the SANET installer.

Secondly, double click the SANET_FOR_10_Setup file / SANET_FOR_10.1_Setup file/.

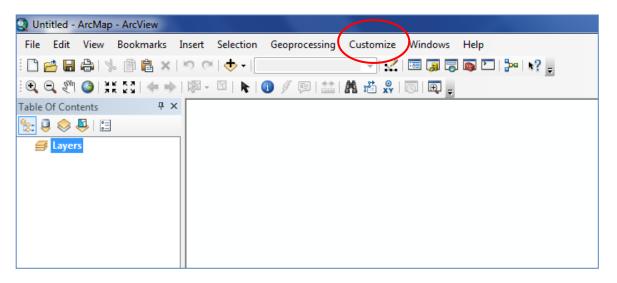


Once the installer is launched, it runs as below.

BANET		
Installing SANET		
		Confirm Installation
SANET is being installed.		The installer is ready to install SANET on your computer.
Please wait		Click "Next" to start the installation.
Cancel < Back	Next>	Cancel < Back Next>
谩 SANET		SANET
Select Installation Folder		Welcome to the SANET Setup Wizard
The installer will install SANET to the following folder.		The installer will guide you through the steps required to install SANET on your computer.
To install in this folder, click "Next". To install to a different folder, enter it below or click	« "Browse".	
Eolder:		
C:\Program Files (x86)\SANET\	owse	
Disk	< Cost	
Install SANET for yourself, or for anyone who uses this computer:		WARNING: This computer program is protected by copyright law and international treaties. Unauthorized duplication or distribution of this program, or any portion of it, may result in severe civil or criminal penalities, and villa be prosecuted to the maximum extent possible under the law.
Everyone		or enninear pervances, and will be prosecuted to the maximum extent possible under the law.
🔿 Just me		
Cancel < Back	Next >	Cancel < Back Next >

谩 SANET	
Installation Complete	
SANET has been successfully installed.	
Click "Close" to exit.	
Please use Windows Update to check for any critical updates to the .NET Fram	ework.
Cancel < Back	Close

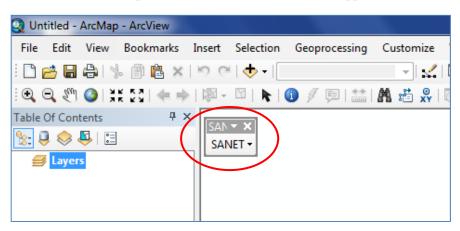
Thirdly, launch ArcGIS, and find 'Customize' on your menu bar.



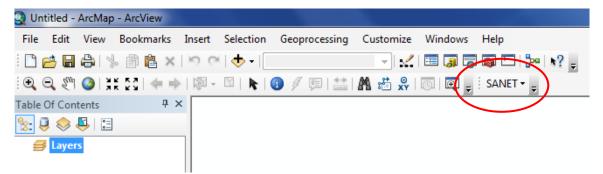
Click 'Customize' and you will find 'SANET' listed in the pull-down menu as below.

Q Untitled - ArcMap - ArcView		•	
File Edit View Bookmarks Insert Selection Geoprocessing	Customize Windows Help	Edit Vertices	
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	ArcMap Options	Geocoding	<
		Geodatabase History	-
		Geometric Network Editing	Ce ar
		Georeferencing	4
		Geostatistical Analyst	
		Graphics	
		Image Classification	
		Labeling	
		Layout	
		Map Service Publishing Network Analyst	
		Parcel Editor	E
		Publisher	
		Raster Printing	
		Representation	
		Route Editing	
		SANET	
		Schematic	
		Schematic Editor	
		Schematic Network Analyst	
		Snapping	
		Spatial Adjustment	
		Spatial Analyst	
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Show or hide the toolbar		•	-35.58 983.262 Unknown Units
			10.00.001
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Click 'SANET' in the pull-down menu, then, SANET will appear on the following ArcMap window.



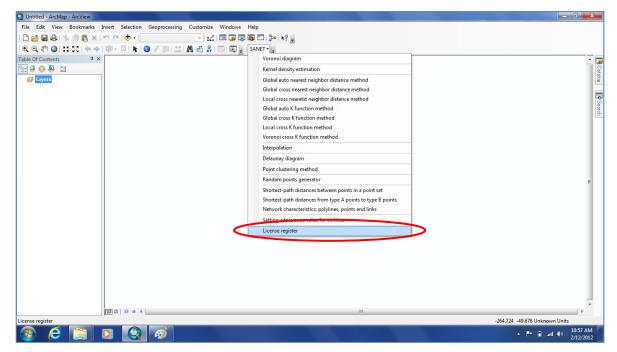
Just drag 'SANET' to place somewhere in the menu bar.



2.3 How to put license key to run SANET on your ArcGIS.

Make sure that 'SANET' sits in your menu bar.

Firstly, click 'SANET' and find 'license register' at the bottom of the pull-down menu.



The license register window appears as below.

The numerals shown in the window is the PC ID which is requested to be filled in your registration form.

🤰 Un	titled -	ArcMap	- ArcView								
File	Edit	View	Bookmarks	Insert	Selection	Geopr	ocessing	Customiz	ze Window	s Help	
	2 🖬		🖻 🛍 🗙	50	🔶 -			-	🖉 🖂 🔜	🗟 🖸 🖓	⊷ <u>*</u> ? ₌
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8: [) 😞	E 🕹					License r	regiser			23
	🖡 Layei						PC ID:	:	6666-555	5-4444-3333	3-2222
							Licens	se key:			
										Regis	ster

Download a registration form, fill up the form and e-mail it to the SANET contact person (see the section 1.5 above).

Having qualified as an eligible user, the license key will be sent to you via email.

Input your license key to your SANET License Register.

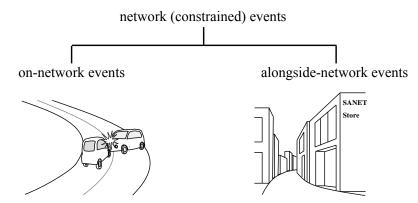
License regiser		Input your license key
PC ID:	6666-5555-4444-3333-2222	
License key:	9007-7236-3527-0151-3090	
	Register	
L		

Enjoy SANET until your license expires.

License regiser								
PC ID:	6666-5555-4444-3333-2222							
License key:	9007-7236-3527-0151-3090							
Available period	2/11/2012 - 2/10/2013							
	Right license key							
	Delete Register							

3. What is SANET?

In the real world, there are many and various kinds of network events. Those events may be classified into two types: the events occurring exactly on networks, termed *on-network events* and those occurring alongside networks, termed *alongside-networks* (Figure 1.1).

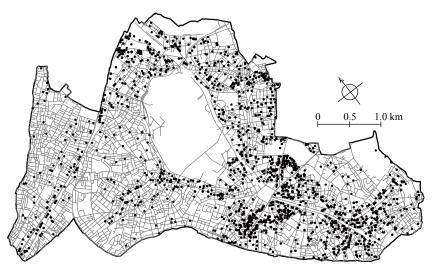


Source: Figure 1.1 in Okabe and Sugihara (to appear in 2012). Network (constrained) events consisting of on-network events and alongside-network events.

Typical examples of on-network events are: traffic accidents (shown in Figure 1.2), road-kills of animals, street crimes, beaver lodges in watercourses, leakages in gas pipe lines and river contamination. Alongside-network events include advertisement agencies (Figure 1.3), fast-food shops, convenience stores, fashionable boutiques and other kinds of facilities locating alongside streets in urbanized areas. Almost all facilities in urbanized areas are regarded as alongside-network events because their entrances are adjacent to streets.



Source: Figure 1.2 in Okabe and Sugihara (2012). Sites of traffic accidents around Chiba station, Japan (private roads are not shown).

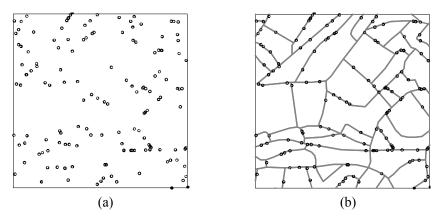


Source: Figure 1.3 in Okabe and Sugihara (2012). The distribution of advertisement agency sites (the black points) alongside streets (the gray line segments) in Shibuya ward, one of the subcentral districts in Tokyo.

Traditionally, network events are analyzed with spatial methods assuming Euclidean distance on a plane, referred to as *planar spatial analysis*. However, this assumption is difficult to accept in practice when analyzing network events, in particular, in urbanized areas, because Euclidean distances and their corresponding shortest-path distances are significantly different. As a matter of fact, an empirical examination shows that the difference is more than 20% when Euclidean distances are less than 400 meters.

Alternatively, network spatial analysis assumes the shortest-path distance on networks. This analysis potentially enables more practical investigation of network events than planar spatial analysis, but it requires heavy geometrical and topological computations. This difficulty hindered its development. To overcome this difficulty, SANET, a toolbox plugged in GIS, has been developed. Using this toolbox, application-oriented GIScientists, who are not always skilled in programming, can now easily perform network spatial analysis with detailed data (not spatially aggregated data, but such as objects in Figures 1.2 and 1.3).

Network spatial analysis is not only practical but also theoretically sound because it can avoid misleading statistical inference when network events are examined. A clear example is provided in Figure 1.4. Having observed the distribution of points in panel (a), nobody would consider that points are randomly distributed. This is true when a plane is assumed but this becomes false when a network is assumed. In fact, the points in panel (b) are randomly generated according to the uniform distribution over the network (the configuration of points in panel (a) and that in panel (b) is the same). This shows that planar spatial analysis is likely to lead to false conclusions when applied to network events.



Source: Figure 1.4 in Okabe and Sugihara (2012). Point distributions: (a) nonrandomly distributed points on a bounded plane, (b) randomly distributed points on a network (note that the point distributions in (a) and (b) are the same).

As is noticed from the above discussion, tools in SANET are practically as well as theoretically useful for examining network events.

4. Analytical Tools

SANET Toolbox includes the following tools:

- Tool 01: Voronoi diagrams
- Tool 02: Kernel density estimation
- Tool 03: Global auto nearest neighbor distance method
- Tool 04: Global cross nearest neighbor distance method
- Tool 05: Local cross nearest neighbor distance method (in preparation)
- Tool 06: Global auto K function method
- Tool 07: Global cross K function method
- Tool 08: Local cross K function method
- Tool 09: Global Voronoi cross K function method
- Tool 10: Interpolation
- Tool 11: Delaunay diagram (in preparation)
- Tool 12: Point clustering method
- Tool 13: Random points generator
- Tool 14: Shortest path distance between points in a set of points
- Tool 15: Shortest path distance between A points to B points
- Tool 16: Network Characteristics: polylines, points and links

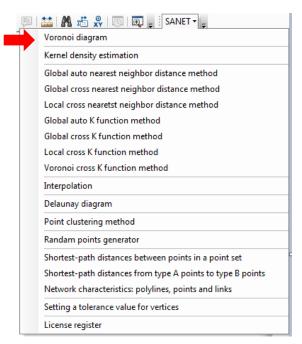
The following sections show how to operate these tools.

Note that each section is self-contained; therefore, the user can directly go to the section you want to read.

4.1 Tool 01: Voronoi diagrams

This tool generates the ordinary Voronoi diagram and the additively weighted Voronoi diagram for a given generator set of points placed on a given network. Details of this diagram are described in Chapter 4 of Okabe and Sugihara (2012).

Click the "Voronoi diagram" in the SANET menu.



Then the following window appears.

Network	
Layer	sibyakuRoads 🗸 🗸
Weight field	
Points	
Layer	StationFinal 🔹
Additive Weig	nt Field 🗸
Output files	
Polylines	C:¥SANET_Ex¥Voronoi diagram¥SANE1 🔤
Points	C:¥SANET_Ex¥Voronoi diagram¥SANE1 🗎
	OK Cancel

Choose ▼ the file of a network (e.g. SibyakuRoads: the street network in Shibuya ward, Tokyo).
Choose ▼ a set of points that generates Voronoi diagrams (e.g. StationFinal: 14 railways stations in Shibuya ward, Tokyo).

(Ignore "Weight field".)

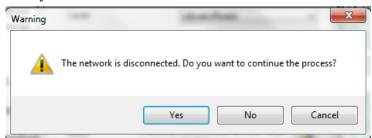
If you use the ordinary Voronoi diagram, leave the 'Additively Weighted Field" blank.

If you use the additively weighted Voronoi diagram, choose $\mathbf{\nabla}$ the field of the file of the generation point set where weights are given.

Choose is the files where the output files are stored

Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

	0	-												
Г	FID	Shape	SetiD	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
	3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7040	1 CBE71 70	59.827084	59.827084	0
	3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 OBE7208	1 CBE7 0D8	2.18119	2.18119	0
		Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879180311	0	1 CBE72 A0	1 CBE7338	24,085689	24.085689	20
	3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7040	6.705222	6.705222	0
- E	31.61	Polyline ZM	10BD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 OBE7 468	1 OBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting		
Vertex tolerance	0.001	
	SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

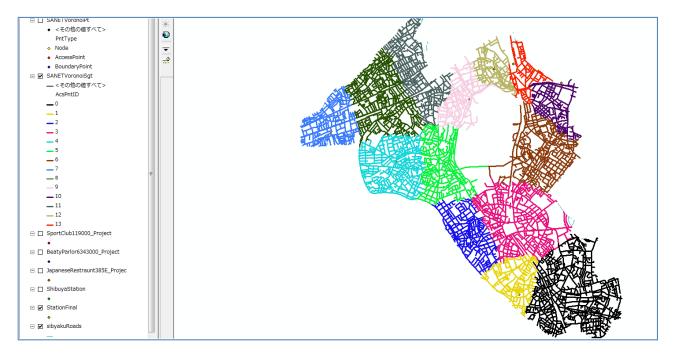
If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 14 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 12 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following files in the output

file and the following figure on the ArcMap.

SANETVoronoiPt.dbf	2/15/2012 9:34 PM	DBF File	1,783 KB
SANETVoronoiPt.shp	2/15/2012 9:34 PM	SHP File	538 KB
SANETVoronoiPt.shp.OKABEPC.5636.311	2/15/2012 9:34 PM	LOCK File	0 KB
SANETVoronoiPt.shx	2/15/2012 9:34 PM	SHX File	98 KB
SANETVoronoiSgt.dbf	2/15/2012 9:34 PM	DBF File	4,035 KB
SANETVoronoiSgt.shp	2/15/2012 9:34 PM	SHP File	2,190 KB
SANETVoronoiSgt.shp.OKABEPC.5636.31	2/15/2012 9:34 PM	LOCK File	0 KB
SANETVoronoiSgt.shx	2/15/2012 9:34 PM	SHX File	116 KB



The attribute table of the output is as follows.

III 属性: SANETVoronoiSgt														
FID	Shape	SetID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID	
	Polyline ZM	1 E68DFC0	-1 4780.4	-35597	0	-14772.9	-35644.4	0	1E661530	1E661828	47.989686	47.989686	7	
	Polyline ZM	1E68DF50	-1 4786.4	-35566.6	0	-14780.4	-35597	0	1E661790	1E661530	30,986449	30,986449	7	
2	Polyline ZM	1 E68DEE0	-1 4801	-35493	0	-1 4786.4	-35566.6	0	1E6616F8	1E661790	75.034126	75.034126	7	
3	Polyline ZM	1E68DE70	-1 481 3.7	-35426.1	0	-1 4801	-35493	0	1E661660	1E6616F8	68.094787	68.094787	7	
4	Polyline ZM	1E68DE00	-1 481 7 .71 71 44	-35404.565476	0	-1 481 3.7	-35426.1	0	1 E661 5 C8	1E661660	21.906007	21.906007	7	
5	Polyline ZM	1E68DD90	-1 4293.1	-35555.8	0	-1 4298.2	-35560.2	0	1 E661 498	1E661070	6.735726	6.735726	8	
6	Polyline ZM	1 E68DD20	-1 4298.2	-35560.2	0	-1 4329.7	-35574.3	0	1E661070	1E661368	34511737	34,511,737	8	

Shape: polylines

SgtID: link ID (a polyline ID).

FromX, FromY, From Z: from the node (x, y, z).

ToX,ToY, ToZ: to the node (x, y, z).

Length: the length of a link.

("Weight" is not used at present.)

AcsPntID: the Voronoi subnetwork ID to which a link belongs.

Additively weighted Voronoi diagram

Do almost the same procedure except for the followings.

Insert the values of weights in the attribute table of a point set, for example, altitudes as in the

following table.

٦	FID	Shape *	FID eki 23	FILEID	COD	ID	NAM	FID sibuya	NAME	JISCOD	altitude
•	0	Point	415	09LD37	P242	56	恵比	252	渋谷区	13113	17
	1	Point	414	C9LD37	P242	56	代官	224	渋谷区	13113	2
٦	2	Point	323	09LD26	P242	45	神泉	115	渋谷区	13113	2
	3	Point	336	09LD27	P242	46	渋谷	0	渋谷区	13113	1.
	4	Point	313	09LD26	P242	44	代々	336	渋谷区	13113	2
	5	Point	315	09LD26	P242	44	代々	224	渋谷区	13113	2
	6	Point	325	09LD27	P242	45	原宿	210	渋谷区	13113	3
	7	Point	309	09LD26	P242	43	笹塚	588	渋谷区	13113	4
	8	Point	312	09LD26	P242	44	幡ケ	448	渋谷区	13113	4
	9	Point	212	09LD16	P242	31	参宮	378	渋谷区	13113	2
	10	Point	222	09LD17	P242	32	千駄	406	渋谷区	13113	3
	11	Point	211	09LD16	P242	31	初台	434	渋谷区	13113	3
	12	Point	224	09LD17	P242	33	南新	462	渋谷区	13113	3
]	13	Point	221	09LD17	P242	32	代々	448	渋谷区	13113	3

Choose $\mathbf{\nabla}$ the weights.

Network	
Layer	sibyakuRoads 🔻
Weight field	•
Points	
Layer	StationFinal 🗸
Additive Weight	Field altitude 🗸
Output files	
Polylines	N:¥SANER V4_1 New calculation¥SANET_
Points	N:¥SANER V4_1 New calculation¥SANET_

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.

4.2 Tool 02: Kernel density estimation

For a given set of points on a given network, this tool estimates the density of points on the network. For details, see Chapter 9 and Section 12.2.5 in Okabe and Sugihara (2012)

Click "Kernel density estimation".

	🔛 🕂 🛱 🥋 🗔 🖳 🖕 SANET 🗸 🖕
	Voronoi diagram
	Kernel density estimation
ſ	Global auto nearest neighbor distance method
	Global cross nearest neighbor distance method
	Local cross nearetst neighbor distance method
	Global auto K function method
	Global cross K function method
	Local cross K function method
	Voronoi cross K function method
	Interpolation
	Delaunay diagram
	Point clustering method
	Randam points generator
	Shortest-path distances between points in a point set
	Shortest-path distances from type A points to type B points
	Network characteristics: polylines, points and links
	Setting a tolerance value for vertices
	License register

Then the following window appears.

Kernel density estima	ation 🗆 🗉 🗙
Network	
Layer	sibyakuRoads 👻
Weight field	
Points	
Layer	BeatyParlor6343000_Project 👻
Kernel	
Kernel type	Equal split continuous at nodes 🛛 👻
Band width	200
Cell width	20
Output files	
Polyline	C:¥SANET_Ex¥Kernel density estimatio
Poin	C¥SANET_Ex¥Kernel density estimatio 🔄
	OK Cancel

Choose ▼ the file of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo). (Ignore "Weight field".)

Choose ▼ the file a set of points (e.g., Beautyparlor6343000_Project: 894 beauty parlors in Shibuya ward, Tokyo).

Choose $\mathbf{\nabla}$ one of the two estimation methods:

"equal split continuous at nodes"

"equal split discontinuous at nodes".

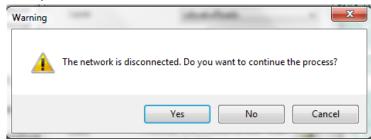
Fill in a band width and a cell width. Note that if you use a large band width and a small cell width, computation time becomes long. Try to use a fairly small band width and a large cell size satisfying that the former is larger than the latter. If the computation time is within your time allowance, change those values. Our experience says [band size]=10*[cell size].

We also note that you are supposed to use the same grid coordinates system as that of the network.

Choose is the output file where the resulting files are stored

Click "OK" .

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

_														
П	FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
	3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7040	1 CBE71 7 0	59.827084	59.827084	0
	3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
	3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 CBE7338	24.085689	24.085689	20
	3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
	3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29.500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

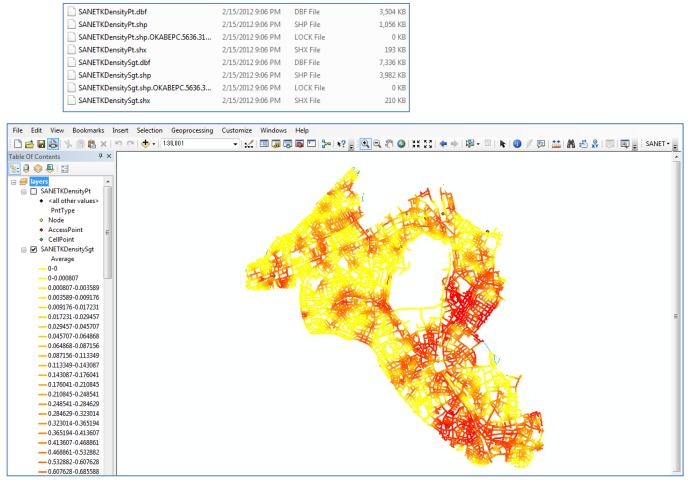
🖳 Setting	
Vertex tolerance 0.001	
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 894 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 1 minute and 10 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following files in the output file and one in the ArcMap window.

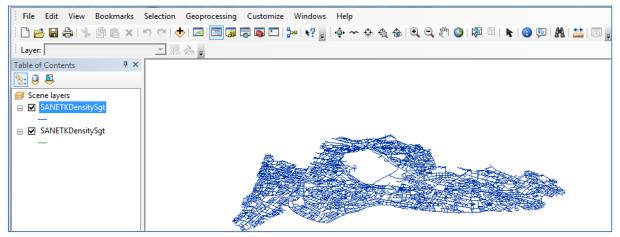


If you want to represent this figure in 3D, launch ArcScene.

Add data **SANETDensitySgt.shp**.

	। × । ∽ ⊂ । ♦
Layer	2 % A g
Table of Contents	* x
	Add Data 8
Scene layers	Look in: 🔁 CL'SANET_V4_1 English'SANET_ 🔹 🏠 🤯 🔯 🗐 🕶 🔛 🖽 🕤 😡
	SANETKDensityPt.shp

Do this TWICE, as seen below.



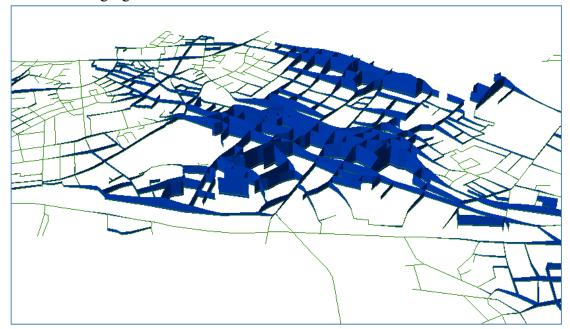
Left-click "SANETKDensitySgt" and choose ▼ "Properties" and next "Base hights".

General	Source	Selection	Display	Symbology	Fields	Definition Query	Joins & Relate
Base I	Heights	Time		Extrusion	R	endering	HTML Popup
Elevation	from surfaces						
No ele	evation values	from a surface					
🔵 Floati	ng on a custor	surface:					
						-	
		_					
Ras	ster Resolution						
Elevation	from features						
Licvation	non reatures						
No fea	ature-based be	sights					
	ature-based he	-					
O Use e	levation values	s in the layer's fe					
O Use e	levation values	-		e units: [custom	▼ 10.0000	
Use el Facto	levation values or to convert la	s in the layer's fe	alues to scen	e units:	custom	▼ 10.0000	
Use el Facto Use a	levation values or to convert la	s in the layer's fe ayer elevation va	alues to scen	e units: (custom		
Use el Facto	levation values or to convert la	s in the layer's fe ayer elevation va	alues to scen	e units: (custom	10.000010.0000	
 Use el Facto Use a 0 	levation values or to convert la constant value	s in the layer's fe ayer elevation va	alues to scen	e units: [
Use el Facto Use a O Layer offi	levation values or to convert la constant value set	s in the layer's fe ayer elevation va	alues to scen	e units: [custom		-
Use el Facto Use a O Layer offi	levation values or to convert la constant value set	s in the layer's fe ayer elevation va e or expression:	alues to scen				-
Use el Facto Use a O Layer offi	levation values or to convert la constant value set	s in the layer's fe ayer elevation va e or expression:	alues to scen				
Use el Facto Use a O Layer offi	levation values or to convert la constant value set	s in the layer's fe ayer elevation va e or expression:	alues to scen				-

Choose \bigvee "custom" and choose \bigvee a factor, say 10. Click "Extrusion" and apply extrusion or expression: using it as a value that Features are extrded to Click "apply" and "OK".

General	Source	Selection	Display	Symbology	Fields	Definition Query	Joins & Relate
Base H	leights	Time		Extrusion	Re	endering	HTML Popup
wais, a	features in lay d polygons int on value or ex	to blocks.	urns points in	ito vertical lines, lii	nes into		
	extrusion by:	at features are	extruded to		•		
Long .							

Then the following figure is obtained in the ArcScene window.



Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.3 Tool 03: Global auto nearest neighbor distance method

This tool tests the complete spatial randomness (CSR) hypothesis in terms of the shortest-path distance from every point in a given set of points placed on a given bounded network to its next nearest point in the set. Note that in the literature, the *global auto nearest neighbor distance method* is simply referred to as the *nearest neighborhood distance method*. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, or points follow the homogeneous binomial point process on the bounded network. A general description about the nearest neighbor distance method is provided in Chapter 5 in Okabe and Sugihara (2012); specifically, the global auto nearest neighbor distance method is shown in Section 5.1.2 and its application in Section 12.2.2.1.

🔛 🕅 🛍 🥋 | 💽 | 💽 📮 🗄 SANET 🗕 Voronoi diagram Kernel density estimation Global auto nearest neighbor distance method Global cross nearest neighbor distance method Local cross nearetst neighbor distance method Global auto K function method Global cross K function method Local cross K function method Voronoi cross K function method Interpolation Delaunay diagram Point clustering method Randam points generator Shortest-path distances between points in a point set Shortest-path distances from type A points to type B points Network characteristics: polylines, points and links Setting a tolerance value for vertices License register Then the following window appears.

Click the "Global auto nearest neighbor distance method" in the SANET menu.

Network				
Layer		sibyakuRoads		•
Weight field				+
Points				
Layer	BeatyPark	or6343000_Projec	st	Ŧ
Simulation				
Number of iterat	ion			1000
Bin width				10
Statistical signif	icance leve	IDK]		5
Output files				_
Observed value	C¥SANET	[_Ex¥Gloal auto I	ND¥SANE	
Expected value	C¥SANET	_Ex¥Gloal auto I	ND¥SANE	
Graphics	C:¥SANET	[_Ex¥Gloal auto I	ND¥SANE	
	V Output	logs		

Choose \checkmark the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo).

(Ignore "Weight field".)

Choose \checkmark the file name of a set of points (e.g., BeatyParLor6343000_Project: beauty parlors in Shibuya ward, Tolyo)

Fill in: the number of iterations for Monte Carlo simulation (a default values is 1000),

a bin width (a continuous distance is divided by the equal bin width; a default value is 10; in this case, the resulting intervals are 0-10, 10-20, 20-30,....), and one-sided statistical significance level (the default value is 5%).

Choose 🖻 the out file where the resulting files are stored

If you want to have intermediate data, check "Output logs", which may require much memory. Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.

Warning	×
1	The network is disconnected. Do you want to continue the process?
	Yes No Cancel

If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SetiD	FromX	FromY	FromZ	ΤοΧ	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 OBE71 70	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 OBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 OBE72 A0	1 OBE7338	24.085689	24.085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 OBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0,001	
SET	Cancel//

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 19 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

SANETExpectedValue.csv	2011/09/16 14:59	Microsoft Office Ex	20,452 KB
SANETGraphics.R	2011/09/16 14:59	R ファイル	9 KB
SANETObservedValue.csv	2011/09/16 14:59	Microsoft Office Ex	17 KB

The contents of the resulting files are as follows.

SANETObservedValue.csv

	А	В	С
1	FromPntID	ToPntID	Distance
2	0	355	61.15865
3	1	1	0
4	1	1	0
5	1	1	0
6	1	1	0
7	1	1	0
8	2	525	18.9316
9	3	874	209.942
10	4	882	30.00848
11	5	5	0
12	5	5	0

000		•	30.00010
887	883	250	27.53011
888	<mark>88</mark> 4	178	2.295587
889	<mark>88</mark> 6	136	156.2032
890	<mark>88</mark> 7	0	100.0818
891	888	463	85.16306
892	<mark>89</mark> 0	207	45.82542
<mark>8</mark> 93	891	523	22.35403
894	892	42	10.47143
<mark>8</mark> 95	<mark>89</mark> 3	135	55.12482
896	AVERAGE	52.71183	

The first column indicates "from the *i*-th point".

The second column indicates "to its nearest neighbor point".

Note that the same ID points mean different points are placed at the same location.

The last row "AVERAGE" indicates the average nearest neighbor distance.

Note that the same FromPtId (say, 1 1 1 1 1 in the above table) implies that those points are placed at the same location.

SANETExpectedValue.csv

	А	В	С	D
1	Simulation	FromPntID	ToPntID	Distance
2	0	0	<mark>547</mark>	76.29765
3	0	1	161	72.11635
4	0	2	58 7	115.9444
5	0	3	3 <mark>6</mark> 3	117.9142
6	0	4	616	189.7447
7	0	5	<mark>637</mark>	23.49545
8	0	6	399	41.54496
9	0	7	314	191.0143
10	0	8	576	117.5245
11	0	9	799	53.62011
12	0	10	115	28.80169
13	0	11	337	61.10231

Γ	051557	ددد	0.00	11.3	TE 311 TE
	894998	999	891	398	130.463
	894999	999	892	471	67.76424
	895000	999	893	516	106.882
1	895001	AVERAGE 9	86.243 1 1		
	895002				
	895003	Lower	81.88646		
	895004	Upper	88.27666		
	895005	ALL AVERA	85.09293		
ł	895006	VARIANCE	3.706896		

The first column indicates the *i*-th iteration of Monte Carlo simulation.

The second column indicates "from the *j*-th point" in a given point set.

Third column indicates "to its nearest neighbor point".

. . .

The last column indicates the shortest-path distance between them.

The last row of the last (1000) iteration (AVERAGE) indicates the average of the nearest neighbor distance for the *j*-th iteration.

At the end of this file,

"Lower" indicates the lower critical value for the one-sided significance level is 5 %

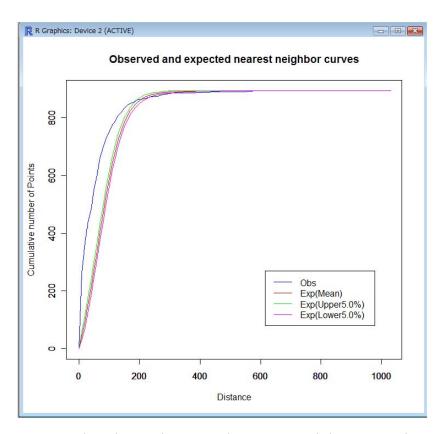
"Upper" indicates the upper critical value for the one-sided significance level is 5 %

"All average" indicates the average nearest neighbor distances for 1000 iterations.

The Clark-Evans index is given by AVERAGE in the table of SANETObservedValue.csv divided by ALL AVERAGE in the table of SANETExpectedValue.csv. In the above example, the value of the index is 52.71/85.09=0.62.

SANETGraphics.R.

Read the source code of this file with R, and then the following figure is obtained in the R window.



The curves are: the observed curve; the upper and lower envelop curves for the one-sided significance level 5%; and the expected curve under the CSR hypothesis. If the observed curve is in between the upper and lower envelop curves, we cannot reject the CSR hypothesis with 0.95 confidence level. In the above example, the observed curve is above the upper envelop curve for distances less than 170 m, and hence we reject the CSR hypothesis with 0.95 confidence level in that distance range.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.4 Tool 04: Global cross nearest neighbor distance method

This tool tests the complete spatial randomness (CSR) hypothesis in terms of the shortest-path distance from each point in a given set of type B points to its nearest point in a given set of type A points. In the literature, the *global cross nearest neighbor distance method* is sometimes referred to as the *conditional nearest neighborhood distance method*. In general, it is assumed that type B points are temporal, while type A points are stable over time; for instance, the former points are restaurants and the latter points are railway stations. This method tests the effect of railway stations on the distribution of restaurants in comparison with the CSR hypothesis. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, or points follow the homogeneous binomial point process on the bounded network. A general description about the nearest neighbor distance method is provided in Chapter 5 in Okabe and Sugihara (2012); specifically, the global cross nearest neighbor distance method is shown in Section 5.2.2 and its application in Section 12.2.2.2.

Click the "Global cross nearest neighbor distance method" in the SANET menu.

🔛 🕅 🛍 👷 💿 👰 🖕 🛛 SANET 🗕 🖕
Voronoi diagram
Kernel density estimation
Global auto nearest neighbor distance method
Global cross nearest neighbor distance method
Local cross nearetst neighbor distance method
Global auto K function method
Global cross K function method
Local cross K function method
Voronoi cross K function method
Interpolation
Delaunay diagram
Point clustering method
Randam points generator
Shortest-path distances between points in a point set
Shortest-path distances from type A points to type B points
Network characteristics: polylines, points and links
Setting a tolerance value for vertices
License register

Then the following window appears.

Network		
Layer	sibyakuRoads	-
Weight field		•
Type A points		
Layer	StationFinal	٦
Type B Points		
Layer	JapaneseRestraunt385E_Pro	ijec 🗸
Simulation		
Number of itera	tion	1000
Number of itera Bin width	tion	1000
Bin width		10
Bin width Statistical signi Output files		10
Bin width Statistical signi Output files Observed Valu	ficance level[%]	10 5 NND¥SAT
Bin width Statistical signi Output files Observed Valu	ficance level[%] e C:¥SANET_Ex¥Global cross	10 5 NND¥SAI

Choose ▼ the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo).

(Ignore "Weight field".)

Choose **▼**:

the file of type A points (e.g., StationFinal: 14 railway stations in Shibuya ward, Tokyo); and the file of type B points (e.g., JapanerseRestrant385E_Project: 426 Japanese restaurants in Shibuya ward, Tokyo).

Fill in:

- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a bin width (a continuous distance is divided by the equal bin width; a default value is 10; in this case, the resulting intervals are 0-10, 10-20, 20-30,....), and
- a statistical significance level (the default value is 5%; one-sided).

Choose \square the out file where the resulting files are stored. Click OK.

If the following window does not appear, the network is completely connected. Proceed to the next

step marked by *** below.

If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Cancel", the SANET do nothing. If you say "Y", the SANET chooses the largest connected network included in the give network. If you say "N", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

3157 Polyline ZM 1CBD942 -15319.4 -36351.1 0 -15317.6 -36410.9 0 1CBE7040 1CBE7170 59.827084 59 3158 Polyline ZM 1CBD949 -15317 -35867 0 -15319.1131.43 -35866.459429 0 1CBE7208 1CBE70D8 2.18119			59.827084	1 CBE71 70	10057040	0					FromX	SetID	Shape	FID
3158 Polyline ZM 1 CBD949 -15317 -35867 0 -15319,113143 -35866,459429 0 1 CBE7208 1 CBE70D8 2,18119					10007040	0	-36410.9	-15317.6	0	-36351.1	-15319.4	1 OBD942	Polyline ZM	3157
	8119	2.18119	2.18119	1 OBE7 0D8	1 OBE7208	0	-35866.459429	-15319.113143	0	-35867	-15317	1 CBD949	Polyline ZM	3158
3159 Polyline ZM 10BD950 -15322.730473 -35866.760873 0 -15343.367283 -35879.180311 0 10BE72A0 10BE738 24.085689 24	5689 2	24.085689	24.085689	1 OBE7338	1 CBE72 A0	0	-35879.180311	-15343.367283	0	-35866.760873	-15322.730473	1 CBD950	Polyline ZM	3159
3160 Polyline ZM 10BD957 -15313 -36349.1 0 -15319.4 -36351.1 0 10BE73D0 10BE7040 6.705222 6	5222	6.705222	6.705222	1 CBE7 040	1 CBE73D0	0	-36351.1	-15319.4	0	-36349.1	-15313	1 CBD957	Polyline ZM	3160
		29,500678		1 CBE73D0	1 CBE7 468	0	-36349.1		0			1 CBD95E	Polyline ZM	3161

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

💀 Setting	
Vertex tolerance 0.001	
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the threshold distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Y" in the warning window, the program begins to run.

Note that for 2 type A points and 47 type B points on the network consisting of 7858 links and 5905 nodes, the computational time was 1 minute and 38 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If the memory is enough, the following three files are obtained in the output file.

Name	Date modified	Туре	Size
SANETExpectedValue.csv	2/15/2012 5:07 PM	CSV File	9,193 KB
SANETGraphics.R	2/15/2012 5:07 PM	R File	35 KB
SANETObservedValue.csv	2/15/2012 5:07 PM	CSV File	8 KB

The contents of the resulting files are as follows.

SANETObservedValue.csv

	А	В	С
1	ТуреВ	ТуреА	Distance
2	0	0	402.5211
3	1	6	651.2611
4	2	3	356.1897
5	2	3	356.1897
6	3	3	257.5682
7	4	6	1259.22
8	5	0	198.1211
9	5	0	198.1211
10	5	0	198 1211
	••	•	
419	417	J	JJJ.024J
420	418	2	658.5335
421	419	0	115.4474
422	420	0	188.1468
423	421	6	1040.092
424	422	5	172.4938
425	423	2	91.30476
426	424	2	237.6965
427	425	8	201.5142
428	AVERAGE	443.4032	
429	VARIANCE	78120.46	

The first column indicates "from the *i*-th point in the type B point set".

The second column indicates "to its nearest neighbor point in the type A point set".

The third column indicates the shortest-path distance between those points.

The last row "AVERAGE" indicates the average nearest neighbor distance from all type B points to their nearest type A points.

SANETExpectedValue.csv

The first table is:

	А	В	С	D	
1	Simulatio	ТуреВ	ТуреА	Distance	
2	0	0	5	723.751	
3	0	1	0	400.2983	
4	0	2	8	906.1482	
5	0	2	8	906.1482	
6	0	3	8	807.5266	
7	0	4	11	546.4464	
8	0	5	5	541.1829	
٥	0	5	5/11 1000		
422	 U	420	S	515.2880	
423	0	421	0	673.7202	
424	0	422	13	671.23	
425	0	423	13	1012.224	
426	0	424	13	1264.507	
427	0	425	7	681.9401	
428	AVERAGE	631.2472			
429	1	0	9	598.2517	
430	1	1	3	1320.095	

426993	999		418		10	/6/.2001
426994	999		419		12	669.3463
426995	999		420		12	807.5009
426996	999		421		6	975.5073
426997	999		422		11	831.2312
426998	999	999			0	1330.849
426999	999	999			10	1342.123
427000	999		425		1	381.5659
427001	AVERAGE	671	.5471			
427002						
427003	Lower	525.	5831			
427004	Upper		931.	5585		

427005 ALL AVERAGE 696.2063 427006 ALL VARIANCE 19581.69

. . .

The first column indicates the *i*-th iteration of Monte Carlo simulation.

The second column indicates "from the *j*-th point of type B".

Third column indicates "to its nearest neighbor point of type A".

The last column indicates the shortest-path distance between those points.

The last row of the *i*-th iteration, AVERAGE, indicates the average distance of from each type B point to its nearest type A point.

At the bottom, ALL AVERAGE indicates the average of the average of AVERAGEs, and ALL

VARIANCE indicates the variance of AVERAGEs.

"Lower" and "Upper" indicate the lower and upper critical values for a given significance level, say, 5 % (one-sided).

These numbers indicate:

the lower critical value is 525.5381

the upper critical value is 931.5585

(the significance level is 5 %)

and the average of the average nearest neighbor distances for 1000 iterations is 696.2063

The Clark-Evans index is given by AVERAGE in the table of SANETObservedValue.csv (i.e., 443.4032 in this case) divided by the last ALL AVERAGE in the table of SANETExpectedValue.csv (696.2063); consequently, 0.64.

If the observed AVERAGE is outside the range "Lower" and "Upper", the CSR hypothesis is rejected with, say 95% confidence level.

This file has two tables.

The first one is as shown below.

	A	В	С	D	E	F	G	Н	Ι	J	К	L	M	N	0	Р	Q	R
1	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
2	0	0	0	0	0	Ó	0	0	Ó	0	0	0	0	0	1	1	2	2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	3
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3
5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	3
6	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3
7	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

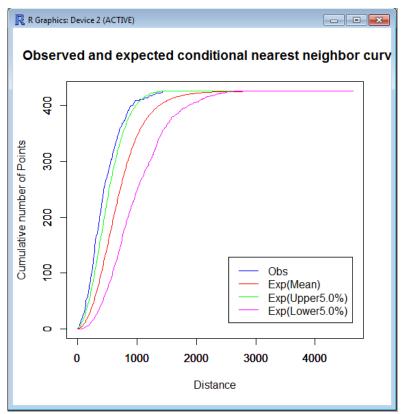
The first row indicates that the unit interval is 10 and the resulting intervals area 10, 20, 30, and so

on.

Each column indicates the numbers of points less than or equal to the distance given by the unit interval $\times i$ for 1000 Monte Carlo iterations, and those numbers are ordered from the smallest to the largest. For instance, 426 points (the number of Japanese restaurants in this case) are independently and identically generated according to the uniform distribution over the street network in Shibuya ward for 1000 times; then the type A points whose nearest neighbor type B points are less than or equal to 160 are 1, 1, 2, 2,..... (the number of these numbers is 1000).

SANETGraphics.R.

Run this file with R, and then the following figure is obtained in the R window.



The curves are: the observed curve; the upper and lower envelop curves for significance level 5%; and the expected curve under the CSR hypothesis. If the observed curve is in between the upper and lower envelop curves, we cannot reject the CSR hypothesis with 0.95 confidence level. In the above example, the observed curve is above the upper envelop curve for distances less than 900 m, and hence we reject the CSR hypothesis with 0.95 confidence level. The Japanese restaurants tend to cluster around stations in this region.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.

4.6 Tool 06: Global auto *K* function method

This tool tests the complete spatial randomness (CSR) hypothesis in terms of the number of points in a given point set satisfying that the shortest-path distance from every point to another point is less than a parametric shortest-path distance. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, or points follow the homogeneous binomial point process on the bounded network.

To state it explicitly, for a set of *n* points placed on a network, let $n(t | p_i)$ be the number of points

that are within shortest-path distance t from point p_i and ρ be the density of points on the network. Then the *K* function is given

$$K(t) = \frac{1}{\rho} \frac{\sum_{i=1}^{n} n(t \mid p_i)}{n}$$

In the literature, the *global auto* K *function method* is simply referred to as the K *function method*. A general review of the K function method is illustrated in Chapter 5 in Okabe and Sugihara (2012); specifically, the global auto K function method is described in Section 6.1.2, and its application in Section 12.2.3.1.

Click the "Global Auto K function Method" in the SANET menu.

Voronoi diagi	am
Kernel density	/ estimation
Global auto n	earest neighbor distance method
Global cross r	nearest neighbor distance method
Local cross ne	earetst neighbor distance method
Global auto K	function method
Global cross k	function method
Local cross K	function method
Voronoi cross	K function method
Interpolation	
Delaunay dia	gram
Point clusteri	ng method
Randam poin	ts generator
Shortest-path	distances between points in a point set
Shortest-path	distances from type A points to type B points
Network char	acteristics: polylines, points and links
Setting a tole	rance value for vertices

Then the following window appears.

Network				
Layer		sibyakuRoads		•
Weight field				•
Points				
Layer	PrefSchoo	011331E_Project		•
Simulation				
Number of iterati	ion			1000
Unit interval				50
Statistical signifi	icance leve	1[%]		5
Output files				_
Observed value	C:¥SANET	Γ_Ex¥Golbal auto	K function¥	
Expected value	C:¥SANET	Γ_Ex¥Golbal auto	K function¥	
Graphics	C:¥SANET	Γ_Ex¥Golbal auto	K function)	
	📝 Output	logs		

Choose $\mathbf{\nabla}$ the file name of a network (e.g., sibyakuRoads in the above figure).

(Ignore "Weight field".)

Choose \checkmark the file name of a set of points (e.g., PrefSchool1331E_Project). Fill in:

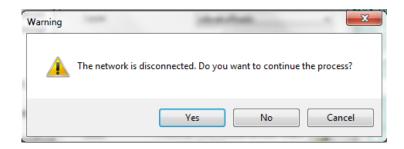
- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a unit interval (a continuous distance is divided by the equal unit interval; a default value is 10 but in the above example, 50 is used; in this case, the resulting intervals are 50, 100, 150,....), and
 - a statistical significance level (the default value is 5%).

Choose \square the out file where the resulting files are stored.

If you want to obtain intermediate files, check "Output log". Please note that the output file requires much memory; e.g., in the above case, as seen the output table, the memory amounts to 228MB; Excel cannot manage it; you may use Access.

Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SetiD	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 CBE71 7 0	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322730473	-35866.760873	0	-15343.367283	-35879180311	0	1 CBE72 A0	1 CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29.500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0.001	
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 102 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 9 minutes and 38 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

Name	Date modified	Туре	Size
SANETExpectedValue.csv	2/15/2012 10:20 AM	CSV File	228,382 KB
SANETGraphics.R	2/15/2012 10:20 AM	R File	14 KB
SANETObservedValue.csv	2/15/2012 10:20 AM	CSV File	188 KB

The contents of the resulting files are as follows.

SANETObservedValue.csv

		А		В		С	
1	Fr	omPntll	То	PntID	Di	stance	
2		0		1	1	177.096	
3		0		2	3	615.931	
4		0		3	2	201.724	
5		0		4	1	864.719	
6		0		5		723.519	
7		0		6	1	214.798	
8		0		7	1	393.547	
9		0		8	4	468.943	
10		0		9	1	975.764	
11		n		9	1	975 764	
102	54					1010.0.	
102	95	10	01		91	1461.2	74
102	96	10	01		92	1823.39	92
102	97	10	01		93	1718.57	76
102	98	10	01		94	1928.2	28
102	99	10	01		95	1858.23	33
103	00	10	01		96	2205.3	37
103	01	10	01		98	2110.30	58
103	02	10	01		99	1658.13	32
103	03	10	01	1	00	1649.3	53
103	04	AVERAG	θE	2809.0	84		

The first column indicates "from the *i*-th point".

The second column indicates "to the *j*-th point" $(i \neq j)$.

The third column indicates the shortest-path distance between those points.

The last row "AVERAGE" indicates the average of shortest-path distances between any pair of points.

SANETExpectedValue.csv

This file has two tables. The first one is as shown below.

	А	В	С	D	E	F	G	Н	1	J
1	50	100	150	200	250	300	350	400	450	50
2	0	2	4	16	40	60	94	122	164	20
3	0	2	8	24	40	68	96	122	168	22:
4	0	2	8	24	42	68	100	128	174	224
5	0	2	8	26	44	70	100	136	176	224
6	0	2	10	26	44	70	102	136	178	224
7	0	2	10	26	44	70	102	136	178	22
8	0	2	10	26	46	70	102	136	180	22
9	0	2	10	26	46	72	102	138	180	22
10	n	2	12	26	46	72	102	1/10	192	231

The first row indicates that the unit interval is 50 and the resulting intervals are 50, 100, 150, and so on.

Each column indicates the numbers of points within the distance given by the unit interval×i for 1000 Monte Carlo iterations, and those numbers are ordered from the smallest to the largest. For instance, 101 points (the number of preparatory schools in this case) are independently and identically generated according to the uniform distribution over the street network in Shibuya ward for 1000 times; then the points whose nearest neighbor points are within 150 are 4, 8, 8, (the number of these numbers is 1000, the number of iterations).

The second table is as shown below.

Note that the file size of this example was too large to use Excel; you are supposed to use, say Access.

1002	Simulatio	FromPntID	ToPntID	Distance
1003	0	0	1	3153.692
1004	0	0	2	2269.076
1005	0	0	3	3404.187
1006	0	0	4	2270.249
1007	0	0	5	2871.893
1008	0	0	6	1864.141
1009	0	0	7	3512.234
1010	0	0	8	1063.375
1011	0	0	9	1715 842
11294	4	0 10	1 9	4485.836
1129	5	0 10	1 9	3847.535
1129	6	0 10	1 9	1201.482
1129	7	0 10	1 9	3 209.2189
1129	8	0 10	1 9	4 3733.501
1129	9 (0 10	1 9	4919.234
1130	D	0 10	1 9	2757.466
1130	1 (0 10	1 9	190.2816
1130	2	0 10	1 9	5622.348
1130	3	0 10	1 9	9 1466.652
1130	4	0 10	1 10	3256.543
1130	5	1	0	1 685.3707
1130	6	1	0	2 2009.95
1130	7	1	0	3 1359.592
1130	R	1	n	/ 903 12/5

The first column indicates the *i*-th iteration of Monte Carlo simulation.

The second column indicates "from the *j*-th point" in the point set.

Third column indicates "to the *k*-th point in the point set.

For instance, the above table shows part of the output of the 0-th iteration, where the shortest-path distances are from the 0-th point to the *k*-th point (k = 1, 2, ..., 100).

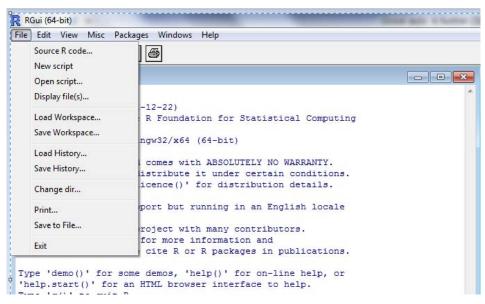
At the end of this file, AVERAGE appears, e.g., AVERAGE 2824.017907. This implies that the

average of the n(n-1) shortest-path distances between any pair of points in the point set.

SANETGraphics.R

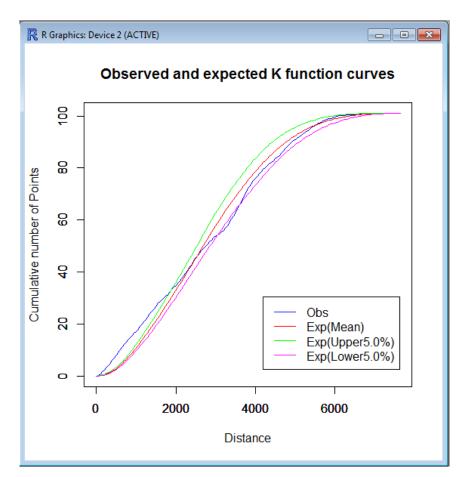
Open R program, and click "Files".

Then the following window appears.



Click "Source R code", move to the resulting output file, and open it.





The blue curve indicates the observed curve;

the red curve indicates the mean value under the CRS hypothesis;

the green and pink curves are, respectively, the upper and lower envelop curves under the CSR hypothesis.

Because the observed curve is above the upper envelop curve in the range 0-1700 m, we reject the CSR hypothesis with 0.95 confidence level; that is to say, preparatory schools tend to be clustered in that distance range.

Because the observed curve in the range 1700- is in between the upper and lower envelop curves, we cannot reject the CSR hypothesis.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.7 Tool 07: Global cross *K* function method

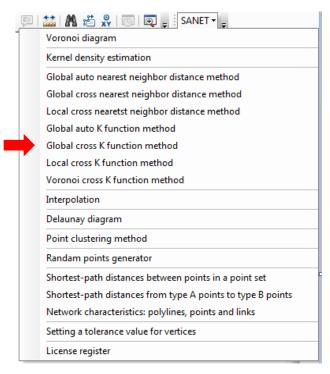
Given two sets of points, a set of type A points and that of type B points, placed on a given network, this tool tests the complete spatial randomness (CSR) hypothesis. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, or points follow the homogeneous binomial point process on the bounded network, implying that the configuration of type A points does not affect the distribution of type B points.

To state this test explicitly, consider a set of n_A type A points and that of n_B type B points, and let $n(t | p_{A_i})$ be the number of type B points that are within shortest-path distance t from the *i*-th type A point p_{A_i} , and ρ_B be the density of type A points on the network. Then the *local cross* K *function* is given by

$$K_{\rm AB}(t \mid p_{\rm A_i}) = \frac{1}{\rho_{\rm B}} \frac{\sum_{i=1}^{n_{\rm A}} n(t \mid p_{\rm A_i})}{n_{\rm A}}$$

In the literature, the *global cross* K *function method* is simply referred to as the *cross* K *function method*. A general review of the cross K function method is illustrated in Chapter 6 in Okabe and Sugihara (2012); specifically, the global cross K function method is described in Section 6.2.2, and its application in Section 12.2.3.2..

Click the "Global Cross K function Method" in the SANET menu.



Then the following window appears.

Network
Layer sibyakuRoads 🗸
Weight field
Type A points
Layer StationFinal 💌
Type B Points
Layer Aroma Therapy 136000_Project 🔹
Simulation
Number of iteration 1000
Unit interval 100
Statistical significance level[%] 5
Output files
Observed Value C:¥SANET_Ex¥Global cross K function
Expected Value C#SANET_Ex#Global cross K function
Graphics C#SANET_Ex#Global cross K function
☑ Output logs
OK Cancel

Choose ▼ the file name of a network (e.g., sibyakuRoas: the street network in Shibuya ward, Tokyo). (Ignore "Weight field".)

Choose ▼:

the file of type A points (e.g., StationFinal: 14 railway stations in Shibuya ward, Tokyo; type A points are supposed to be structural points)

the file of type B points (e.g., AromaTherapy136000_Project: 60 aromatherapy houses in Shibuya ward, Tokyo; type B points are supposed to be temporal points).

Fill in:

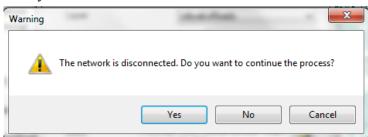
- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a unit interval (a continuous distance is divided by the equal unit interval; a default value is 10; in this case, the resulting intervals are 10, 20, 30,....; in the example, 100 was used), and
- a statistical significance level (the default value is 5%; one-sided).

Choose \square the out file where the resulting files are stored

If you want to obtain intermediate files, check "Output log". Please note that the output file requires much memory; e.g., in the above case, as seen in the output table, the memory amounts to 18MB; which may not be managed by Excel (in that case, use Access).

Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SgtID	FromX	FromY	FromZ	ΤοΧ	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7040	1 CBE71 70	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0.001]
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 14 type A points (railway stations) and 60 type B points (aromatherapy houses) on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 1 minute and 28 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

Name	Date modified	Туре	Size
SANETExpectedValue.csv	2/15/2012 1:26 PM	CSV File	18,235 KB
SANETGraphics.R	2/15/2012 1:26 PM	R File	7 KB
SANETObservedValue.csv	2/15/2012 1:26 PM	CSV File	15 KB

SANETObservedValue.csv

	Α	В	С
1	ТуреА	ТуреВ	Distance
2	0	0	2747.232
3	0	1	1709.677
4	0	2	5298.232
5	0	2	5298.232
6	0	3	4304.884
7	0	4	2949.158
8	0	5	1017.083
9	0	6	198.1211
10	0	7	102.6718
11	0	٩	/02 1562
	••	•	
001		40	241.2574
832	13	49	1117.766
833	13	50	3474.923
834	13	50	3474.923
835	13	53	3667.964
			3007.304
836	13	54	4771.345
836 837	13 13	54 55	4771.345
837	13	55	4771.345 975.4085
837 838	13 13	55 56	4771.345 975.4085 2911.993
837 838 839	13 13 13	55 56 57	4771.345 975.4085 2911.993 5063.5

The first column indicates "from the *i*-th point of type B".

The second column indicates "to the *j*-th point of type A".

The third column indicates the shortest-path distance between those points.

The last row "AVERAGE" indicates the average shortest-path distance.

SANETExpectedValue.csv

This file has two types of table.

The first table is as shown below.

	А	В	С	D	E	F	G	Н	1
1	100	200	300	400	500	600	700	800	90
2	0	0	2	7	11	21	33	44	5
3	0	0	2	7	13	22	34	45	6
4	0	0	2	7	13	23	35	45	6
5	0	0	2	7	13	24	35	46	6
6	0	0	3	8	14	25	36	46	6
7	0	0	3	8	15	25	36	47	6
8	0	0	3	8	15	25	36	47	6
9	0	0	3	8	15	25	36	47	6
10	0	•	2	0	10	26	26	40	6

The first row indicates that the unit interval is 100 and the resulting intervals are 100, 200, 300, and so on.

Each column indicates the numbers of points within the distance given by the unit interval×*i* for 1000 Monte Carlo iterations, and those numbers are ordered from the smallest to the largest. For instance, 60 points (the number of aromatherapy houses in this case) are independently and identically generated according to the uniform distribution over the street network in Shibuya ward for 1000 times; then the type A points whose nearest neighbor type B points are within 300 m are 2, 2, 2, 2, 3,..... (the number of these numbers is 1000).

The second table is as shown below.

1002	Simulatio	ТуреА	ТуреВ	Distance
1003	0	0	0	3014.686
1004	0	0	1	4524.108
1005	0	0	2	4481.116
1006	0	0	3	4984.59
1007	0	0	4	906.969
1008	0	0	5	386.0713
1009	0	0	6	4845.065
1010	0	0	7	5037.881
1011	n	n	Q	2105 511
 1833	0	13	50	2687.655
1834	0	13	51	578.8043
1835	0	13	52	3685.378
1836	0	13	53	3945.672
1837	0	13	54	2039.676
1838	0	13	55	5148.466
1839	0	13	56	2215.944
1840	0	13	57	5117.498
1841	0	13	58	3331.69
1842	0	13	59	3030.808
1843	1	0	C	1896.771
10//	1	0	1	4266 511

The first column indicates the *i*-th iteration of Monte Carlo simulation.

The second column indicates "from the *j*-th point of type B".

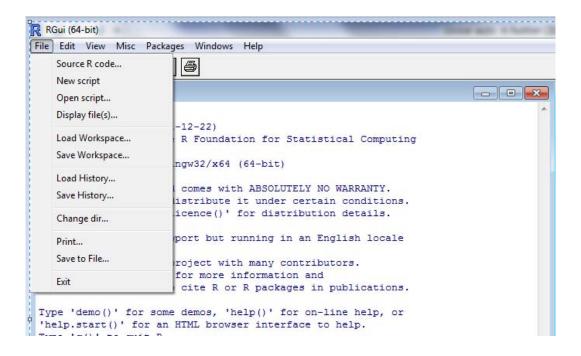
Third column indicates "to the *k*-th point of type A".

The last column indicates the shortest-path distance between those points.

SANETGraphics.R

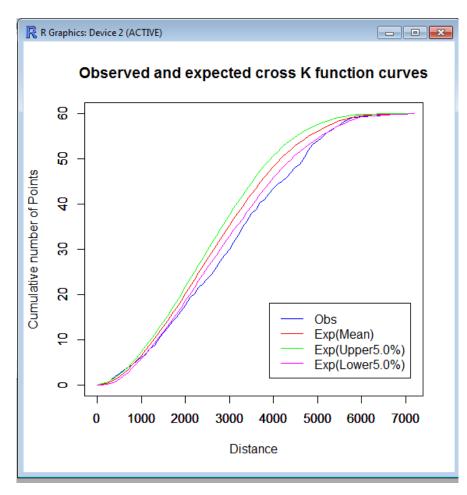
Launch R program, and click "Files".

Then the following window appears.



Click "Source R code", move to the resulting output file, and open it.





The blue curve indicates the observed curve;

the red curve indicates the mean value under the CRS hypothesis;

the green and pink curves are, respectively, the upper and lower envelop curves under the CSR hypothesis.

Because the observed curve is slightly above the upper envelope curve in the range 300-700 in, aromatherapy houses in this range fairly tends to cluster around stations. However, because in the rage 1200-, the observed curve is below the lower envelope curve, we can reject the CSR hypothesis with 0.95 confidence level in this range; that is to say, aromatherapy houses in this range tend to be dispersed from stations.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.

4.8 Tool 08: Local cross K function method

Given two sets of points, a set of type A points and that of type B points, placed on a given network, this tool tests the complete spatial randomness (CSR) hypothesis. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, or points follow the homogeneous binomial point process on the bounded network, implying that the configuration of type A points does not affect the distribution of type B points.

To state this test explicitly, consider a set of n_A type A points and that of n_B type B points, and let $n(t | p_{A_i})$ be the number of type B points that are within shortest-path distance t from the *i*-th type A point p_{A_i} , and ρ_B be the density of type A points on the network. Then the *local cross* K *function* is given by

$$K_{\rm AB}(t \mid p_{\rm A_i}) = \frac{1}{\rho_{\rm B}} n(t \mid p_{\rm A_i}).$$

A general review of the cross K function method is illustrated in Chapter 6 in Okabe and Sugihara (2012); specifically, the local cross K function method is described in Section 6.2.1, and its application in Section 12.2.3.4 (note that type A and type B are reversed in their book).

Click the	'Local	cross K	function me	thod' in th	e SANET menu.
-----------	--------	---------	-------------	-------------	---------------

🖹 🚵 🕂 😤 💽 👰 🖕 🤅 SANET 🗕 🖕
Voronoi diagram
Kernel density estimation
Global auto nearest neighbor distance method
Global cross nearest neighbor distance method
Local cross nearetst neighbor distance method
Global auto K function method
Global cross K function method
Local cross K function method
Voronoi cross K function method
Interpolation
Delaunay diagram
Point clustering method
Randam points generator
Shortest-path distances between points in a point set
Shortest-path distances from type A points to type B points
Network characteristics: polylines, points and links
Setting a tolerance value for vertices
License register

Then the following window appears.

Network	
Layer	sibyakuRoads 🔹
Weight field	
Гуре A points	
Layer	ShibHara 🔹
Type B points	
Layer	Church1787E_Project
imulation	
Number of itera	ation 1000
Unit interval	100
Statistical sign	ificance level[%] 5
Output files	
Observed Valu	e C:¥SANET_Ex¥Local cross K function
Expected Valu	e C:¥SANET_Ex¥Local cross K function
	C:¥SANET_Ex¥Local cross K function
Graphics	

Choose the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward in Tokyo).

(Ignore "Weight field".)

Choose

the file of type A point set (e.g., ShibuHara: Shibuya and Harajuku Stations in Shibuya ward, Tokyo; type A points are supposed to be structural points, such as railway stations).

the file of type B point set (e.g., Church1787_Project: 47 churches in Shibuya ward, Tokyo).

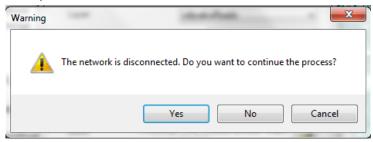
Recall that the local cross K function deals with the number of type B points (e.g., churches) within a parametric shortest-path distance from the *i*-th point in the type A point set (e.g., the Shibuya Station).

Fill in:

- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a unit interval (a continuous distance is divided by the equal unit interval; a default value is 10; in this case, the resulting intervals are 10, 20, 30,....; in the example, 100 was used), and
- a statistical significance level (the default value is 5%; one-sided).

Choose is the out file where the resulting files are stored. Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

Γ	FID	Shape	SetID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
	3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 CBE71 70	59.827084	59.827084	0
	3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE70D8	2.18119	2.18119	0
	3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 OBE7338	24.085689	24.085689	20
	3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 OBE73D0	1 CBE7 040	6.705222	6.705222	0
	3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0.001	
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 2 type A points and 47 type B points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 23 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

Also note that this computation requires much output space, and so your computer memory might

be overflowed. When you use the local cross K function, you are interested in particular type A points, and so you are supposed to use a small number of type A points. To shorten computational time, you may choose a long unit interval, say 100 (the default is 10).

If the memory is enough, the following files are obtained in the output file. The number of files is the number of A points multiplied by three. In the example, the number is six (two multiplied by three).

Name	Date modified	Туре	Size
SANETExpectedValue0.csv	2/15/2012 2:16 PM	CSV File	2,291 KB
SANETExpectedValue1.csv	2/15/2012 2:16 PM	CSV File	2,257 KB
SANETGraphics0.r	2/15/2012 2:16 PM	R File	38 KB
SANETGraphics1.r	2/15/2012 2:16 PM	R File	39 KB
SANETObservedValue0.csv	2/15/2012 2:16 PM	CSV File	1 KB
SANETObservedValue1.csv	2/15/2012 2:16 PM	CSV File	1 KB

SANETObservedValue.csv

1	А	В	С
1	ID	ToPntID	Distance
2	0	0	2992.523
3	0	1	1154.274
4	0	2	2381.217
5	0	3	2420.494
6	0	3	2420.494
7	0	4	1829.308
8	0	5	3219.903
٩	0	6	1200 /0/
	•	••	
42	U U	40	2272'210
43	0	41	3367.795
44	0	42	3382.072
45	0	43	2103.076
46	0	44	2091.224
47	0	45	652.6292
48	0	46	3482.345
49	AVERAGE	1821.108	

The first column indicates the *i*-th point in the type A point set (in the example, 0=Shibuya station).

The second column indicates the *j*-th point in the type B point set (e.g., churches).

The last column indicates the shortest-path distance between those points.

The last row indicates the average distance fom the *i*-th A point to evey B point (e.g., the average shortest-path from Shibuya station to the 47 churches is 1821 m).

SNAETExpectedValue.csv

This file has two tables. The first table is shown below.

		А		В		С			D	Τ
1	_	mulatio	ту	peA	ту	/peB		Di	stance	Τ.
2		0		C			0	1	1443.2	1
3		()	C	1		1	2	875.67	1
4	0)	C	1		2		2785.1	1
5		0		C			3	3	325.874	4
6	i -	()	C			4	1	1031.78	3
7		()	C			5	1	533.424	4
0		6		·			6	э,	755 07	2
2		U		U		40	J	50	0.8608	
3		0		0		41	1	14	95.888	
4		0		0		42	2	21	63.716	
5		0		0		43	3	21	72.226	
6		0		0		44		257.8137		
7		0		0		45	5	84	1.3883	
8		0	0			46		18	62.649	
9	AVI	ERAGE	19	88.712						
0		1		0		(n	28	10 533	
4/	995		999		U		2	11	308.40	050
47	996	9	99		0		4	42	2629.6	583
47	997	9	999		0		4	43	1764.0	055
47	998	9	999		0		4	14	4320.1	192
47	47999		999		0		4	45	1343.4	431
48	000	9	99		0		4	46	2469.0	002
48001		AVERA	GE	2171.2	34					
48	002	ALL AV	ER/	2264.7	85					

The first column indicates the *i*-th iteration of Monte Carlo simulation.

The second column indicates "from the *j*-th point of type A".

Third column indicates "to the *k*-th point of type B".

The last column indicates the shortest-path distance between those points.

The last row "AVERAGE" of each simulation indicates the average of those shortest-path distances (e.g., the 9th row is the average for the first (denoted by 0) simulation.

The last row of the last simulation (e.g., 999) indicates the average of the averages of all simulations.

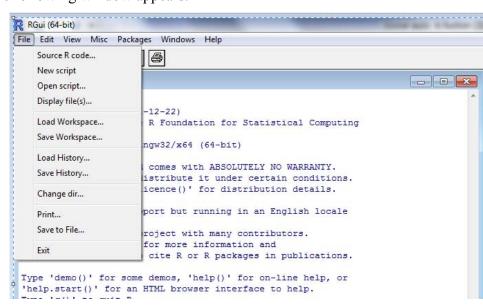
The second table is shown below.

48004	100	200	300	400	500	600	700	800	900	1000	1100
48005	0	0	0	0	0	0	0	0	0	1	1
48006	0	0	0	0	0	0	0	0	0	1	1
48007	0	0	0	0	0	0	0	0	1	1	1
48008	0	0	0	0	0	0	0	0	1	1	2
48009	0	0	0	0	0	0	0	0	1	1	2
48010	0	0	0	0	0	0	0	0	1	1	2
48011	0	0	0	0	0	0	0	1	1	1	2
10010	-	^	^	^	^	^	•				^

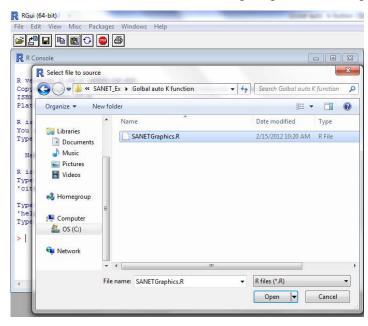
The row indicates intervals (with a chosen unit interval). For instance, 100, 200, 300, and so on. The column indicates the numbers of type B points within the unit interval $\times i$ for 1000 iterations, and those numbers are ordered from the smallest to the largest. For instance, in the 900 column, the numbers of the type A points within 900 are: 0, 0, 1, 1, ... (the number of these numbers is 1000) for 1000 iterations.

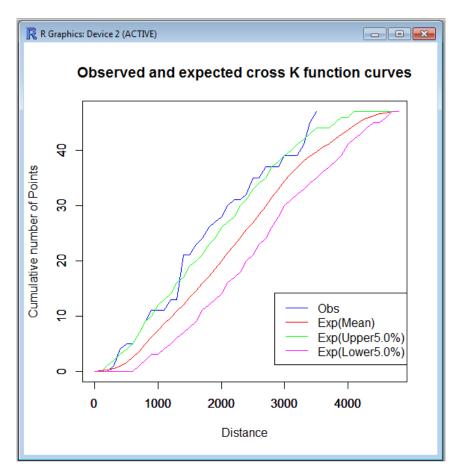
SANETGraphics.R

Open R program, and click "Files". Then the following window appears.



Click "Source R code", move to the resulting output file, and open it.





The blue curve indicates the observed curve;

the red curve indicates the mean value under the CRS hypothesis;

the green and pink curves are, respectively, the upper and lower envelop curves under the CSR hypothesis.

Because the observed curve is almost in between the upper and lower envelop curves, we cannot reject the CSR hypothesis with confidence level 0.95, implying that churches are almost randomly distributed independent of the location of Shibuya Station.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.

4.9 Tool 9: Global Voronoi cross *K* function method

Given two sets of points placed a network: a set of type A points (its number is n_A) and that of type B points (its number is n_B), this tool tests the complete spatial randomness (CSR) hypothesis in terms of the number of type A points that are within a parametric shortest-path distance *t* from their nearest type B points. To state it a little more explicitly, consider the shortest-path distance from every type A point to its nearest type B point. Note that if a type A point is placed in the Voronoi subnetwork of the *i*-th type B point, the nearest type B point from the type A point is the *i*-th type B point. The number of the resulting shortest-path distances is n_A . Next consider a function, K(t), that indicates the number of type A points satisfying that the associated shortest-path distances are less than *t*. The tool tests the CSR hypothesis with K(t).

Click the "Voronoi Cross K function Method" in the SANET menu.

	💷 💒 🥂 🏥 🧩 💽 👰 🖕 🤅 SANET 🗕 🖕
- 1	Voronoi diagram
	Kernel density estimation
	Global auto nearest neighbor distance method
	Global cross nearest neighbor distance method
	Local cross nearetst neighbor distance method
	Global auto K function method
	Global cross K function method
	Local cross K function method
	Voronoi cross K function method
	Interpolation
	Delaunay diagram
	Point clustering method
	Point clustering method Randam points generator
	Randam points generator
	Randam points generator Shortest-path distances between points in a point set
	Randam points generator Shortest-path distances between points in a point set Shortest-path distances from type A points to type B points

Then the following window appears.

Network				
Layer		sibyakuRoa	ds	-
Weight field				•
Type A points				
Layer	StationFi	nal		•
Гуре В Points				
Layer	AromaThe	erapy136000_P	roject	•
Simulation				
Number of iterati	ion			1000
Unit interval				10
Statistical signifi	icance leve	1[%]		5
Output files				
Observed Value	C:¥SANET	[_Ex¥Global V	oronoi cross K	
Expected Value	C:¥SANET	_Ex¥Global V	oronoi cross K	
Graphics	C:¥SANET	[_Ex¥Global V	oronoi cross K	
	👿 Output	logs	,	

Choose the file name of a network. (Ignore "Weight field".) Choose :

A: the file of a network

B: the file of type A points

C: the file of type B points.

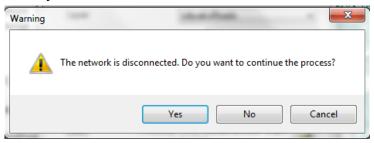
Fill in:

- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a unit interval (a continuous distance is divided by the equal unit interval; a default value is 10; in this case, the resulting intervals are 10, 20, 30,....), and
- a statistical significance level (the default value is 5%).

Choose is the out file where the resulting files are stored.

Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

Γ	FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
	3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7040	1 CBE71 70	59.827084	59.827084	0
	3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
	3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879180311	0	1 CBE72 A0	1 CBE7 338	24,085689	24.085689	20
	3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
	3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0
_	1								-					-

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0.001	
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 14 A points (railway stations) and 60 B points (aromatherapy houses) and the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 20 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

Name	Date modified	Туре	Size
SANETExpectedValue.csv	2/15/2012 3:39 PM	CSV File	1,724 KB
SANETGraphics.R	2/15/2012 3:39 PM	R File	15 KB
SANETObservedValue.csv	2/15/2012 3:39 PM	CSV File	2 KB

SANETObservedValue.csv

	el veu val	uc.csv	
1	A	В	С
1	FromPntI	ToPntID	Distance
2	0	5	1017.083
3	0	6	198.1211
4	0	7	102.6718
5	0	10	990.8497
6	0	19	508.2919
7	0	24	737.6131
8	0	28	381.3677
9	0	29	209.3339
10) 0	33	1412.544
11	. 0	34	367.108
12	2 0	35	878.7134
13	0	35	878.7134
14	ا	35	878.7134
15	5 0	36	482.9371
16	5 O	37	1244.961
17	/ 0	39	109.9994
18	3 0	54	96.08572
19	0	57	948.8333
20) 1	9	371.6719
01	1	20	216 6126
/114	•••		LIVI BY
49	0	10	1181.08
50	6	21	327.2924
51	6	25	663.1421
52	6	32	316.4162
53	6	46	592.588
54	6	58	842.506
55	7	2	544.9863
56	7	2	544.9863
57	9	3	181.2362
58	10	49	431.9056
59	12	55	747.0642
60	13	43	302.3762
61	13	48	241.2374
62	AVERAGE	537.6749	
1	AVENAGE		41 .4

The first column indicates "from the *i*-th point of type A".

The second column indicates "to the *j*-th point of type B".

The third column indicates the shortest-path distance between those points.

The last row "AVERAGE" indicates the average distance.

The this example shows that the B points whose nearest A point is 0 is 5, 6, 7, ..., 59; those whose nearest A point is 7 is 2 and 2 (the same number means that two points coincide.

SANETExpectedValue.csv

This file has two types of table. The first one is as shown below.

	А	В	С	D		Z	AA	AB	AC	
1	10	20	30	4(.50	260	270	280	290	
2	0	0	0	(0	1	1	1	1	
3	0	0	0	(1	1	1	1	1	
4	0	0	0	(1	1	1	1	2	
5	0	0	0	(1	1	1	2	2	
6	0	0	0	(1	1	1	2	2	

The row indicates bin lengths. For instance, 10 means the bin length is 0-10; 20 means the bin length is 10-20; and so on.

The column indicates the numbers of points in the *i*-th bin for 1000 iterations, and those numbers are ordered from the smallest to the largest.

The second one is as shown below.

	А	В	С	D
1002	Simulation	FromPntID	ToPntID	Distance
1003	0	0	25	687.9144
1004	0	0	28	881.7677
1005	0	0	29	203.4705
1006	0	0	30	619.1696
1007	0	0	35	1169.918
1008	0	0	38	444.6335
1009	0	0	42	1720.276
1010	0	0	46	610.92
1011	0	0	55	643.8385
1012	0	0	57	444.1414
1013	0	1	4	634.5605
1014	0	1	5	333.1973
1015	٥	2	19	283 2386
1058	0	12	6	184.8686
1059	0	12	48	494.9826
1060	0	12	51	542.7399
1061	0	13	14	676.445
1062	0	13	47	349.9294
1063	1	0	21	1187.758
1064	1	0	26	1742.78
1005	4	•	- 14	000 0500
60993	999	11	21	149.4309
60994	999	11	36	799.0819
60995	i 999	11	45	438.0622
60996	i 999		5	789.6203
60997			11	407.5989
60998	999	12	13	413.0629
60999	999	12	25	232.3713
61000	999	12	56	586.314
61001	. 999	12	59	386.1213
61002	999	13	33	782.3956
61003	AVERAGE	601.13352		

The first column indicates the *i*-th iteration of Monte Carlo simulation.

The second column indicates "from the *j*-th point of type A".

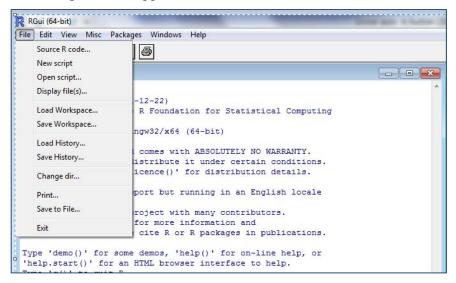
Third column indicates "to the *k*-th point of type B".

The last column indicates the shortest-path distance between those points.

SANETGraphics.R

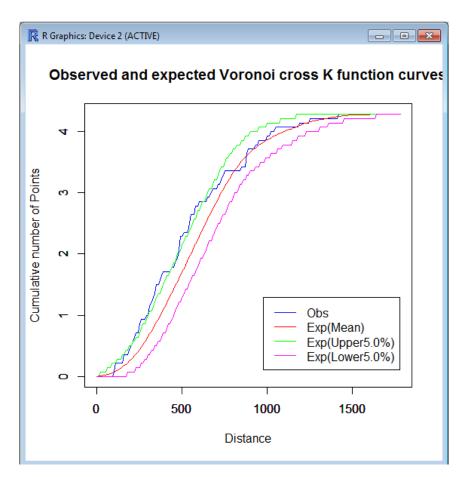
Launch R program, and click "Files".

Then the following window appears.



Click "Source R code", move to the resulting output file, and open it.

Console		
R Select file to source		✓ 4→ Search Golbal auto K function
	ANET_Ex Golbal auto K function w folder	 ✓ 4→ Search Golbal auto K function IIII ▼ □
	 Name 	Date modified Type
Cibraries	SANETGraphics.R	2/15/2012 10:20 AM R File
Music		
Videos		
🍓 Homegroup		
🛀 Computer	Ξ	
🏭 OS (C:)		
辑 Network		
	+ (



The blue curve indicates the observed curve;

the red curve indicates the mean value under the CRS hypothesis;

the green and pink curves are, respectively, the upper and lower envelop curves under the CSR hypothesis.

Because the observed curve is slightly above the upper envelope curve in the range 300-700 in, aromatherapy houses in this range fairly tends to cluster around stations. However, because in the rage 1200-, the observed curve is below the lower envelope curve, we can reject the CSR hypothesis with 0.95 confidence level in this range; that is to say, aromatherapy houses in this range tend to be dispersed from stations.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.

4.10 Tool 10: Interpolation

For a given set of known attributes values at sample points on a given network, this tool interpolates unknown attribute values at arbitrary points on the network using the inverse distance weighting method. Stated explicitly, the tool predicts the value \hat{z}_0 at p_0 as the weighted average of the

known attribute z_j values at the points p_j of a neighborhood $P_N(p_0)$ of p_0 , i.e.:

$$\hat{z}_0 = \sum_{p_i \in P_{\mathcal{N}}(p_0)} w_i \, z_i$$

where the weight w_i is given by:

$$w_{i} = \frac{d_{S}(p_{0}, p_{i})^{-\alpha}}{\sum_{p_{j} \in P_{N}} d_{S}(p_{0}, p_{j})^{-\alpha}}$$

where α is a positive predetermined parameter. For details, see Chapter 9 and Section 12.2.5 in Okabe and Sugihara (2012).

Click "Interpolation".

ū	📩 🥂 📸 👷 💿 🗊 🖕 🗄 SANET 🗕 🖕
۷	'oronoi diagram
K	Cernel density estimation
G	ilobal auto nearest neighbor distance method
G	lobal cross nearest neighbor distance method
L	ocal cross nearetst neighbor distance method
G	lobal auto K function method
G	ilobal cross K function method
L	ocal cross K function method
۷	oronoi cross K function method
Ir	nterpolation
D)elaunay diagram
P	oint clustering method
R	landam points generator
S	hortest-path distances between points in a point set
S	hortest-path distances from type A points to type B points
Ν	letwork characteristics: polylines, points and links
S	etting a tolerance value for vertices
	icense register

Then the following window appears.

Network		
Layer	sibyakuRoads	•
Observed Points		
Layer St	onFinal	-
Observed value field	altitude	•
Interpolation		
Interpolation Type	Inverse distance weighted	d me 👻
Band width		
Cell width		10
Value of ramda		:
Number of sample po	s	ł
Output files		_
Polylines C	ANET_Ex¥Interpolation¥SANETInt	
Points CS	ANET_Ex¥Interpolation¥SANETInt	

Choose ▼ the file of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo). (Ignore "Weight field".)

Choose $\mathbf{\nabla}$ the file a set of points at which their attribute values are known (e.g., StationFinal: 14 railway stations in Shibuya ward, Tokyo, where their altitudes are known).

Choose $\mathbf{\nabla}$ the field in which weights are given.

Choose ▼ "Inverse distance weighting method".

Fill in

• cell width (This determines the resolution of the resulting figure; default is 10, but might

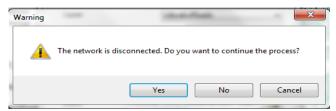
require much memory; you may start a larger value, say 100).

- value of α , say 1-3.
- number of points in the neighborhood $P_{\rm N}(p_0)$, say 3-6.

Choose is the output file where the resulting files are stored

Click "OK" .

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FIE) Shape	SetID	FromX	FromY	FromZ	ΤοΧ	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
315	7 Polyline ZM	1 OBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 CBE71 70	59.827084	59.827084	0
315	3 Polyline ZM	1 CBD949	-15317	-35867	0	-15319113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
315	9 Polyline ZM	1 OBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 CBE7338	24.085689	24.085689	20
316) Polyline ZM	1 OBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
316	Polyline ZM	1 OBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0
_					0			0					

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0.001	
SET	Cancel

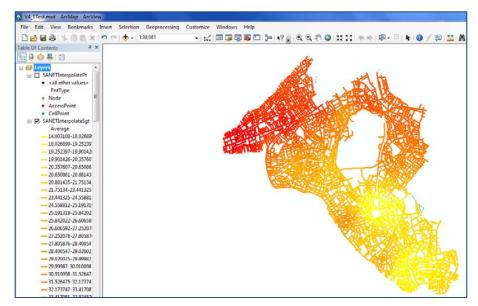
The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 14 sample points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 4 minutes and 40 seconds in the case of cell width 10; 20 seconds in the case of 100) using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following six files in the output file and one figure in the ArcMap window.

Name	Date modified	Туре	Size
SANETInterpolatePt.dbf	2/19/2012 9:02 PM	DBF File	6,140 KB
SANETInterpolatePt.shp	2/19/2012 9:02 PM	SHP File	1,851 KB
SANETInterpolatePt.shx	2/19/2012 9:02 PM	SHX File	337 KB
SANETInterpolateSgt.dbf	2/19/2012 9:01 PM	DBF File	12,391 KB
SANETInterpolateSgt.shp	2/19/2012 9:01 PM	SHP File	6,727 KB
SANETInterpolateSgt.shx	2/19/2012 9:01 PM	SHX File	355 KB



If you want to represent this figure in 3D, launch ArcScene.

Add data **SANETInterpolateSgt.shp**.

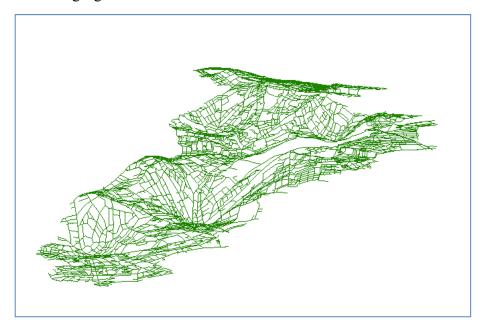
Add Data						x
Look in: 📔	C:\SANET_Ex\Interpolation	ኅ 🏠	i	- 🖴	60	4
SANETInte	rpolatePt.shp rpolateSgt.shp					
Name:	SANETInterpolateSgt.shp				Add	
Show of type:	Scene supported Datasets and Lay	/ers		•	Cancel	

Left-click "SANETKDensitySgt" and choose ▼ "Properties" and next "Base hights". Check "No elevation from surface".

Choose \bigvee "custom" and choose \bigvee a factor, say 50. Click "apply" and "OK".

General	Source	Selection	Display	Symbology	Fields	Definition G	luery	Joins & Relate:
Base H	Heights	Time		Extrusion	R	endering		HTML Popup
Elevation	from surfaces							
No ele	vation values	from a surface						
Floatir	ng on a custom	n surface:						
	-					_	2	
						×.		
Ras	ter Resolution							
Elevation	from features							
🔘 No fea	ature-based he	eights						
_		eights s in the layer's fe	atures					
O Use el	evation values	s in the layer's fe		e units:	custom	▼ 50.00	000	
O Use el	evation values	-		e units: (custom	▼ 50.00	000	
Use el Facto	evation values or to convert la	s in the layer's fe		e units: (custom	▼ 50.00	000	
Use el Facto Use a	evation values or to convert la	s in the layer's fe ayer elevation va		e units: (custom	▼ 50.00		
Use el Facto	evation values or to convert la	s in the layer's fe ayer elevation va		e units: (custom		000	
 Use el Facto Use a 0 	evation values or to convert la constant value	s in the layer's fe ayer elevation va		e units: [custom			
 Use el Facto Use a Use a Layer off: 	evation values or to convert la constant value set	s in the layer's fe ayer elevation va	lues to scene		custom			
 Use el Facto Use a Use a Layer off: 	evation values or to convert la constant value set	s in the layer's fe ayer elevation va e or expression:	lues to scene	e units: [
 Use el Facto Use a Use a Layer off: 	evation values or to convert la constant value set	s in the layer's fe ayer elevation va e or expression:	lues to scene					

Then the following figure is obtained in the ArcScene window.



Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.12 Tool 12: Point clustering method

This tool clusters points in a given point set on a given network by the closest-pair clustering method. For details, see Sections 8.1.2.1 and 12.2.4 in Okabe and Sugihara (2012).

Click the "Point clustering method" in the SANET menu.

🔛 🕂 📸 🥋 💽 ਦ 🖕 🗄 SANET 🗕 🖕							
Voronoi diagram							
Kernel density estimation							
Global auto nearest neighbor distance method							
Global cross nearest neighbor distance method							
Local cross nearetst neighbor distance method							
Global auto K function method							
Global cross K function method							
Local cross K function method							
Voronoi cross K function method							
Interpolation							
Delaunay diagram							
Point clustering method							
Randam points generator							
Shortest-path distances between points in a point set							
Shortest-path distances from type A points to type B points							
Network characteristics: polylines, points and links							
Setting a tolerance value for vertices							
License register							

Then the following window appears.

oint clustering me	thod 🗖 🗖 💌 🗙
Network	
Layer	sibyakuRoads 🔹
Weight field	▼
Points	
Layer	SportClub119000_Project
Output file File name	C¥SANET_Ex¥Point clustering methoda
	OK Cancel

Choose \checkmark the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo).

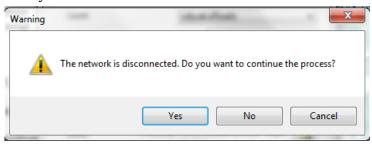
(Ignore "Weight field".)

Choose ▼ the file name of a set of points (e.g., SportClub119000_Project: 21 sports club houses in Shibuya ward, Tokyo).

Choose is the output file where the resulting files are stored

Click "OK" .

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SetID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7040	1 CBE71 70	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0
								-					_

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🛃 Setting		
Vertex tolerance 0.001		
	SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 21 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 3 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following "SANETClustering.R" file in the output file.

] SANETClustering.R	2/15/2012 9:23 PM	R File	7 KB
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Launch R program, and click "Files".

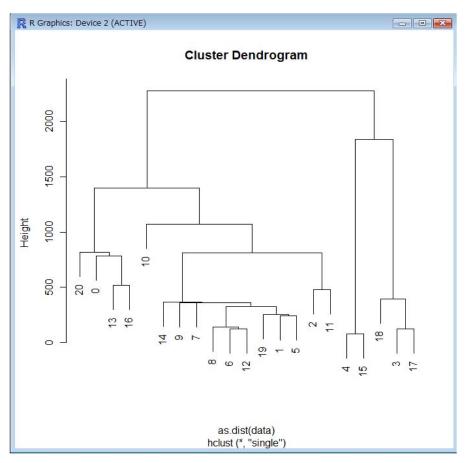
Then the following window appears.

Edit View Misc Packages Windows Help							
Source R code							
New script							
Open script							
Display file(s)	-12-22)						
Load Workspace	R Foundation for Statistical Computing						
1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -	K roundation for Statistical computing						
Save Workspace	ngw32/x64 (64-bit)						
Load History							
-	comes with ABSOLUTELY NO WARRANTY.						
Save History	listribute it under certain conditions.						
Change dir	<pre>icence()' for distribution details.</pre>						
Print	port but running in an English locale						
Save to File	roject with many contributors.						
	for more information and						
Exit	cite R or R packages in publications.						

Click "Source R code", move to the resulting output file, and open it.

Select file to source Organize New folder Image: Search Golbal auto K function Organize New folder Image: Search Golbal auto K function Ibiaraites Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function Image: Search Golbal auto K function <t< th=""><th></th><th></th><th></th></t<>			
Organize ▼ New folder Ibitraries Name Date modified Type Ibitraries SANETGraphics.R Duble Videos Wideos Videos Homegroup E Computer E	select file to source		
Libraries Libraries SANETGraphics.R Date modified Type SANETGraphics.R 2/15/2012 10-20 AM R File Nusic File Videos Homegroup Computer Computer Computer	3 • 1 « SA	NET_Ex Golbal auto K function	👻 🐓 Search Golbal auto K funct
Name Date modified Type Date modified Type SANETGraphics.R 2/15/2012 10:20 AM R File Music Pictures Videos Homegroup Computer Computer	Organize 👻 Ne	ew folder	8≡ ▼ 🗍
Documents Music Pictures Videos Homegroup Computer Conjunt			Date modified Type
Music Pictures Videos Homegroup Computer Computer		SANETGraphics.R	2/15/2012 10:20 AM R Fil
	🛃 Videos 🔣 Homegroup	E	

Then the following dendrogram is obtained.



Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.13 Tool 13: Random points generation

This tool generates random points on a given network according to the uniform distribution over the network. The resulting points are a realization of the complete spatial randomness (CSR) often used for a null-hypothesis. For details, see Sections 2.4.2 3.4.5 and 12.1.4 in Okabe and Sugihara (2012).

Click the "Random points generation" in the SANET menu.

	🔛 🕅 😤 👷 💽 👰 🖕 🤅 SANET 🗕 🖕								
1	Voronoi diagram								
	Kernel density estimation								
	Global auto nearest neighbor distance method								
	Global cross nearest neighbor distance method								
	Local cross nearetst neighbor distance method								
	Global auto K function method								
	Global cross K function method								
	Local cross K function method								
	Voronoi cross K function method								
	Interpolation								
	Delaunay diagram								
	Point clustering method								
	Randam points generator								
	Shortest-path distances between points in a point set								
	Shortest-path distances from type A points to type B points								
	Network characteristics: polylines, points and links								
	Setting a tolerance value for vertices								
	License register								

Then the following window appears.

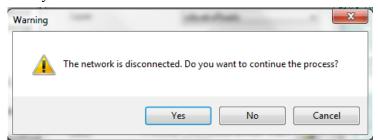
Random points generator	
Network Layer	SANETVoronoiSgt 🗸
Number of random points Output file	500
File name C¥SAN	ET_Ex¥Random points generati
	OK Cancel

Choose the file name of a network (e.g., sibyakuRoas: the street network in Shibuya ward, Tokyo).

Fill in the number of random points, say 500.

Choose the output file where the resulting files are stored Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SetID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 CBE71 7 0	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 OBE72 A0	1 OBE7338	24.085689	24.085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 OBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting		
Vertex tolerance 0.001		
	SET	Cancel

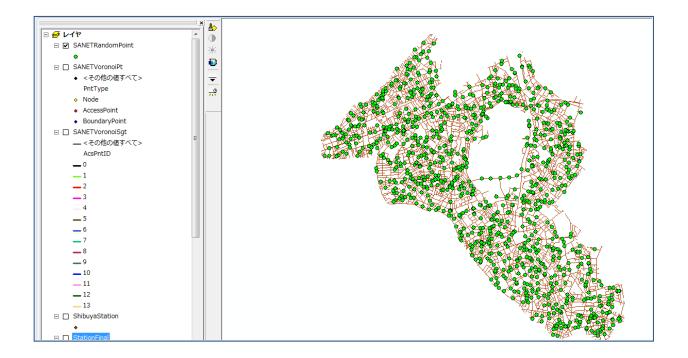
The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 500 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 3 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following files in the output file and the following figure on the ArcMap window.

36 KB	DBF File	2/15/2012 9:54 PM	SANETRandomPoint.dbf
22 KB	SHP File	2/15/2012 9:54 PM	SANETRandomPoint.shp
0 KB	LOCK File	2/15/2012 9:54 PM	SANETRandomPoint.shp.OKABEPC.6620
5 KB	SHX File	2/15/2012 9:54 PM	SANETRandomPoint.shx



Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.14 Tool14: Shortest-path distances between points in a set of points

This tool computes the shortest-path distances between any pair of points in a given set of points placed on a given network. For details, see Section 12.1.3 in Okabe and Sugihara (2012).

Click the "Shortest-path distance between points in a point set" in the SANET menu.

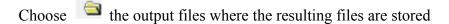
	🛗 🕂 🛱 🧩 🗔 🗐 💭 🖕 SANET 🗕 🖕
-	Voronoi diagram
	Kernel density estimation
	Global auto nearest neighbor distance method
	Global cross nearest neighbor distance method
	Local cross nearetst neighbor distance method
	Global auto K function method
	Global cross K function method
	Local cross K function method
	Voronoi cross K function method
	Interpolation
	Delaunay diagram
	Point clustering method
	Randam points generator
	Shortest-path distances between points in a point set
	Shortest-path distances from type A points to type B points
	Network characteristics: polylines, points and links
	Setting a tolerance value for vertices
	License register

Then the following window appears.

_		
Sł	ortest path distar	nces between points in a poin 🗖 📄 🔀
Γ	Network	
	Layer	sibyakuRoads 👻
	Weight field	•
	Points Layer	BeatyParlor6343000_Project
	Output file	
	File name	C:¥SANET_Ex¥Shortest path distances
		OK Cancel

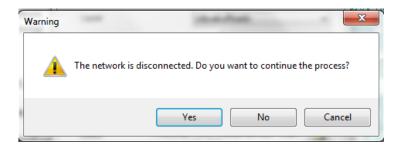
Choose ▼ the file name of a network (e.g., sibyakuRoad: the street network in Shibuya ward, Tokyo). (Ignore "Weight field".)

Choose ▼ the file name of a set of points (e.g., BeautyParlor6343000_Project: 894 beauty parlors in Shibuya ward, Tokyo)



Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 CBE71 7 0	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 CBE7338	24,085689	24,085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting		
Vertex tolerance 0.001		
	SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 894 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 10 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

SANETB2B.csv	2/15/2012 8:27 PM	CSV File	16,009 KB
--------------	-------------------	----------	-----------

The contents of the file are as follows.

		А		В		С
1	Fro	romPntID T		PntID	Distance	
2		0		1	26	13.53
3		0		176	26	13.53
4		0		361	26	13.53
5		0		411	26	13.53
6		0		746	26	13.53
7		0		2	322	.7458
8		0		3	117	0.477
9		0		4	757	.0587
10	10 0			5	227	2 831
7983	000		22	88	5 27	49.405
7983		893		88		43.403 93.696
		893		88		93.194
798340 798341		89		89		46.054
798342		89		89		97.865
798343		89	-	89		83.727
7983	344	AVERAGE		2287.40	3	

The first column indicates "from the *i*-th point of the point set".

The second column indicates "to the *j*-th point of the point set".

The last column indicates the shortest-path distance between those points.

For instance, the shortest-path distance from the 0th point to the first point is 2613.53, and so forth.

AVERAGE of the last row shows the average of all the distances.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.

4.15 Tool 15: Shortest -path distances from type A points to type B points

This tool computes the shortest-path distance from each point in a given set of type A points to each point in a given set of type B points, where those points are on a given network. For details, see Section 12.1.3 in Okabe and Sugihara (2012).

Click the "Shortest-path distances between type A points and type B points" in the SANET menu.

Ģ	🗉 💒 👫 🍰 🧩 🗔 👰 🖕 🤅 SANET 🗕 🖕
1	Voronoi diagram
	Kernel density estimation
	Global auto nearest neighbor distance method
	Global cross nearest neighbor distance method
	Local cross nearetst neighbor distance method
	Global auto K function method
	Global cross K function method
	Local cross K function method
	Voronoi cross K function method
	Interpolation
	Delaunay diagram
	Point clustering method
	Randam points generator
	Shortest-path distances between points in a point set
	Shortest-path distances from type A points to type B points
	Network characteristics: polylines, points and links
	Setting a tolerance value for vertices
	License register

Then the following window appears.

Network	
Layer	sibyakuRoads 🔹
Weight field	
Type A points	
Layer	StationFinal
Type B points	
Layer	SportClub119000_Project
Output file	
File name	C:¥SANET_Ex¥Shortest-path distance

Choose ▼ the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward,

Tokyo).

(Ignore "Weight field".)

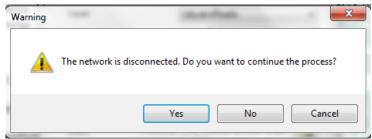
Choose ▼ the file name of a set of type A points (e.g., SportClub119000_Project: 21 sports clubs in Shibuya ward, Tokyo).

Choose $\mathbf{\nabla}$ the file name of a set of type B points (e.g., StationFinal: 14 railway stations in Shibuay ward, Tokyo).

Choose is the output file where the resulting files are stored

Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7 040	1 CBE71 70	59.827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1 CBE7208	1 CBE7 0D8	2.18119	2.18119	0
3159	Polyline ZM	1 CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1 CBE72 A0	1 CBE7338	24.085689	24,085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7 040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.5	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0
								-					-

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting	
Vertex tolerance 0.001	
SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

Note that for 14 type A points and 60 type B points the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 3 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

SANETB2NB.csv	2/15/2012 8:51 PM	CSV File	6 KB
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The contests are as follows.

	А	В	С
1	ТуреА	ТуреВ	Distance
2	0	0	543.7987
3	0	1	1769.024
4	0	2	1313.781
5	0	3	4915.878
6	0	4	4620.97
7	0	5	1827.256
8	0	6	1794.785
9	0	7	2171.715
10	0	8	1904.252
11	0	9	2057.844
12	0	10	2974.168
13	0	11	1056.179
14	0	12	1845.425
15	0	13	1189.021
16	0	14	2054.242
17	0	15	4586.658
18	0	16	977.3025
19	0	17	4910.633
20	0	18	5222.263
21	0	19	2080.229
22	0	20	1624.59
23	1	0	1152.225
24	1	1	1659.147
25	1	2	911 5542

The first column indicates "from the *i*-th point of the type A point set.

The second column indicates "to the *j*-th point of the type B point set.

The last column indicates the shortest-path distance between those points.

For instance, the shortest-path distance from the 0th sport club to the 0th station is 543.7987.

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis Along Networks: Statistical and Computational Methods*, Chichester: JonWiley, a volume in the Wiley series of Statistics in Practice.

4.16 Tool 16: Network characteristics: polylines, points and links

This tool shows the characteristics of polylines, points and links forming a given network.

Click the "Network characteristics: polylines, points and links" in the SANET menu.

5	🔛 🎢 📸 🥋 🗔 👰 🖕 🤅 SANET 🗕 🖕
	Voronoi diagram
	Kernel density estimation
	Global auto nearest neighbor distance method
	Global cross nearest neighbor distance method
	Local cross nearetst neighbor distance method
	Global auto K function method
	Global cross K function method
	Local cross K function method
	Voronoi cross K function method
	Interpolation
	Delaunay diagram
	Point clustering method
	Randam points generator
	Shortest-path distances between points in a point set
	Shortest-path distances from type A points to type B points
-	Network characteristics: polylines, points and links
	Setting a tolerance value for vertices
	License register

Then the following window appears.

Network	
Layer	sibyakuRoads 🗸 🗸
Weight field	
Output files	
Polvlines	C:¥SANET_Ex¥Netwrok characteristi
Points	C:¥SANET_Ex¥Netwrok characteristi
Links	C:¥SANET_Ex¥Netwrok characteristii 🔄

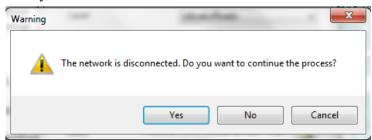
Choose $\mathbf{\nabla}$ the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo).

(Ignore "Weight field".)

Choose is the output file where the resulting files are stored

Click "OK".

If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



If this window appears, the given network is not completely connected. If you say "Cancel", the SANET do nothing. If you say "Yes", the SANET chooses the largest connected network included in the give network. If you say "No", the SANET indicates disconnected parts by color on the "Warning" map of ArcMap; its attribute table shows disconnected links by numbers on the AcsPntID column of the "Warning" map.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1 CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1 CBE7040	1 CBE71 70	59,827084	59.827084	0
3158	Polyline ZM	1 CBD949	-15317	-35867	0	-15319,113143	-35866,459429	0	1 CBE7208	1 CBE7 0D8	2,18119	2,18119	0
3159	Polyline ZM	1 CBD950	-15322,730473	-35866,760873	0	-15343,367283	-35879180311	0	1 CBE72 A0	1 CBE7338	24,085689	24,085689	20
3160	Polyline ZM	1 CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1 CBE73D0	1 CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1 CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1 CBE7 468	1 CBE73D0	29,500678	29,500678	0

If you think that the disconnected parts should be connected, click "Setting" in the SANET menu. Then the following window appears.

🖳 Setting		
Vertex tolerance 0.001		
	SET	Cancel

The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed to connect disconnected parts using tools in ArcGIS.

If the network is completely connected or if you click "Yes" in the warning window, the program

begins to run.

Note that for the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 3 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

If you do not have any trouble such as memory overflows, you obtain the following three files.

Name	Date modified	Туре	Size
SANETNetworkLink.csv	2/15/2012 8:15 PM	CSV File	836 KB
SANETNetworkPt.csv	2/15/2012 8:15 PM	CSV File	476 KB
SANETNetworkSgt.csv	2/15/2012 8:15 PM	CSV File	425 KB

SANETNetworkLink.csv

📳 S	SANETNetworkLink.csv					
	A	В	С	D		
1	PntID	SgtID	AdjacentPntID	FromToFlg		
2	6A835F78	21590478	6A8360A8	From		
3	6A835F78	21590408	6A835DB0	То		
4	6A835F78	2158E798	6A837E58	То		
5	6A835F78	2158E4F8	6A838150	From		
6	6A8360A8	21590478	6A835F78	То		
7	6A8360A8	22395260	7D4AB808	From		
8	6A835DB0	21590408	6A835F78	From		
9	6A835DB0	21590398	6A836010	То		
10	6A835DB0	2158E878	6A837F88	То		
11	6A836010	21590398	6A835DB0	From		
12	6A836010	21590328	6A835EE0	То		
13	6A836010	2158E728	6A838020	То		
14	6A835EE0	21590328	6A836010	From		
15	6A835EE0	215902B8	6A835D18	То		
16	6 A835 FE0	21591048	6A840650	Fmm		

This table shows that:

SgtID: line segment ID;

PntID and AdjacentPntID are end nodes of a line segment;

FromToFlg:

From: from PntID to AdjacentPntID;

To: from AdjacentPntID to PntID.

SANETNetworkPnt.csv

SANETNetworkPt.csv						
	A	В	С	D		
1	PntID	Х	Y	Z		
2	6A835F78	-14780.4	-35597	0		
3	6A8360A8	-14772.9	-35644.4	0		
4	6A835DB0	-14786.4	-35566.6	0		
5	6A836010	-1 4801	-35493	0		
6	6A835EE0	-14813.7	-35426.1	0		
- 7	6A835D18	-14817.7	-35404.6	0		
8	6A835C80	-14293.1	-35555.8	0		
9	6A835E48	-14298.2	-35560.2	0		
10	6A835B50	-14329.7	-35574.3	0		
11	6A835BE8	-14386.1	-35599.7	0		
12	6A835AB8	-14402	-35606	0		
13	6A835988	-14489.4	-35644.4	0		
14	6A8358F0	-15071	-35591.4	0		

This table shows that the (x, y, z) coordinates of a point specified by PntId. **SANETNetworkSgtID.csv**

🔊 Si	SANETNetworkSgt.csv							
	A	В	С	D				
1	SgtID	FID	Length	Weight				
2	21590478	0	47.98969	47.98969				
3	21590408	1	30.98645	30.98645				
4	21590398	2	75.03413	75.03413				
5	21590328	3	68.09479	68.09479				
6	215902B8	4	21.90601	21.90601				
7	21590248	5	6.735726	6.735726				
8	21 5901 D8	6	34.51174	34.51174				
9	21590168	7	61.85564	61.85564				
10	215900F8	7	17.10263	17.10263				
11	21590088	8	95.46371	95.46371				
12	21590018	9	11.71405	11.71405				
13	2158FFA8	9	8.306437	8.306437				
14	2158FF38	10	36.20387	36.20387				
15	2158FEC8	11	26.49623	26.49623				
16	2158FE58	11	1.369284	1.369284				
17	2158FDE8	12	3.312099	3.312099				
10	01 FOED70	10	0.000264	0.000264				

This table shows that the length of a link specified by SgtID. (Ignore FID and Weight.)

Reference

Okabe, A. and K. Sugihara (2012) *Spatial Analysis along Networks: Statistical and Computational Methods*, Chichester: John Wiley, a volume in the Wiley series of Statistics in Practice.