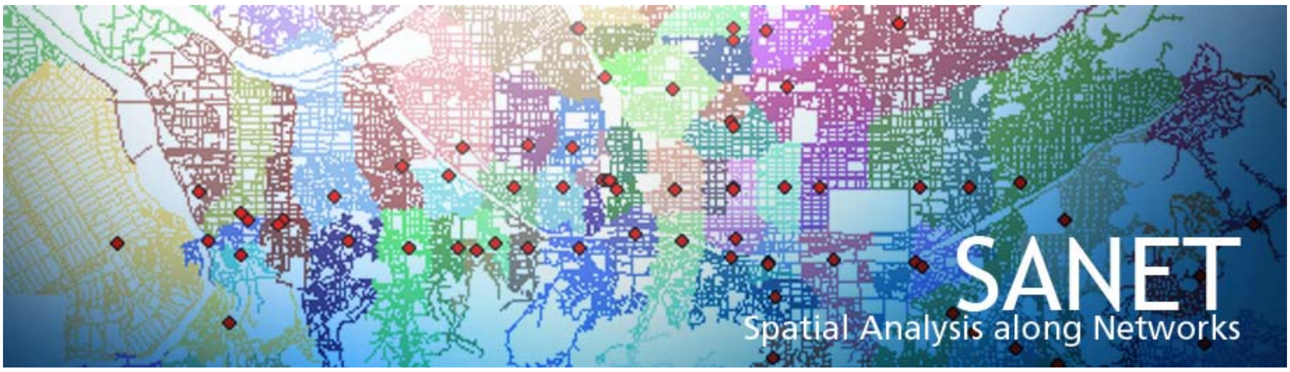
SANET:

Spatial Analysis along Networks

The manual for SANET V4.1 Beta runs on ArcGIS10 & ArcGIS10.1

(revised on 2013/2/9)

SANET TEAM



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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

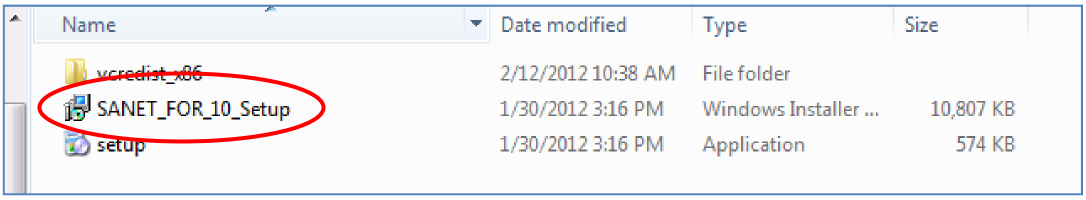
ESRI ArcGIS 10 is required.

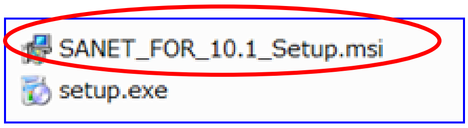
GNU R is preferably installed for the better performance of the results obtained.

2.2 How to install SANET and plug-in to ArcGIS

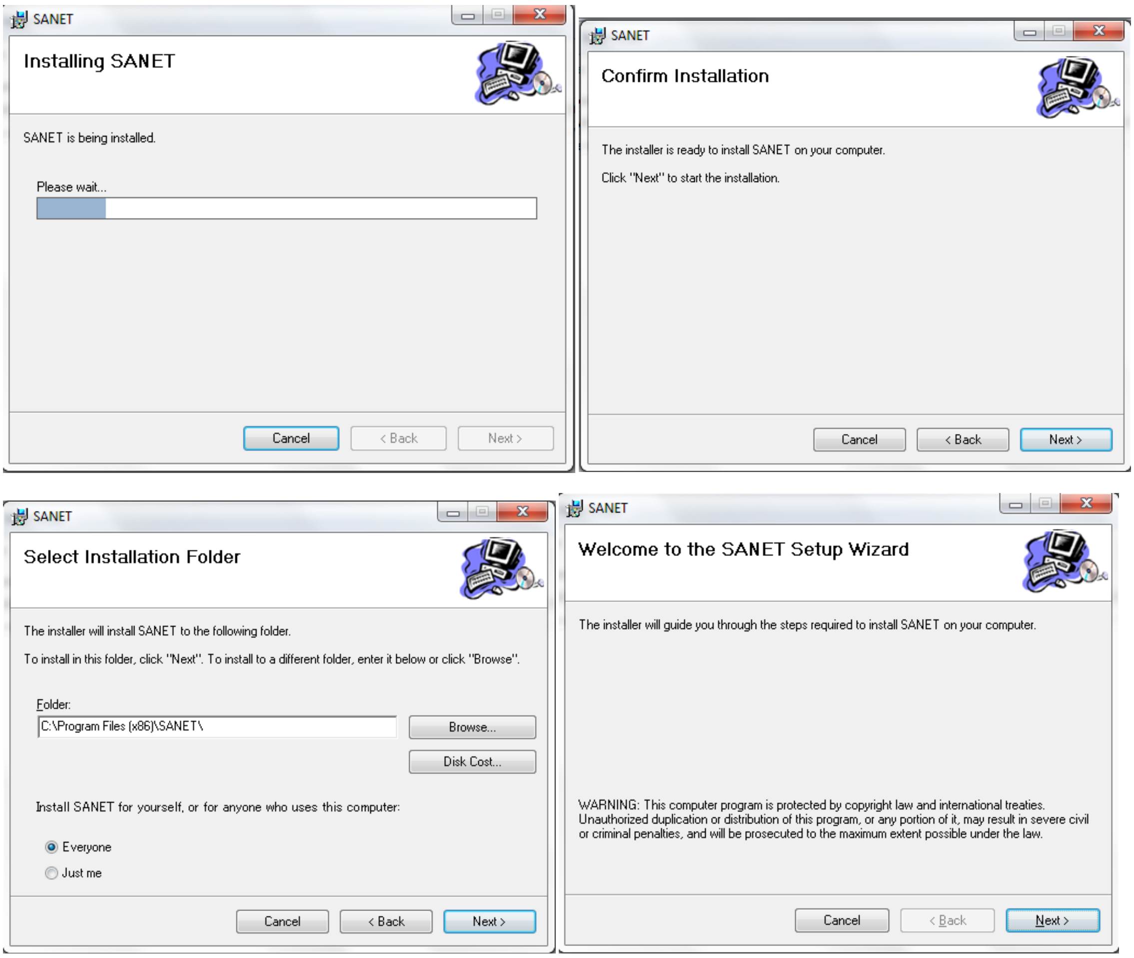
Firstly, download the SANET installer.

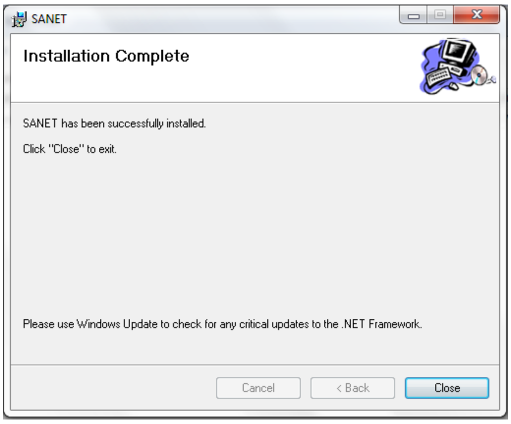
Secondly, double click the SANET_FOR_10_Setup file / SANET_FOR_10.1_Setup file/.



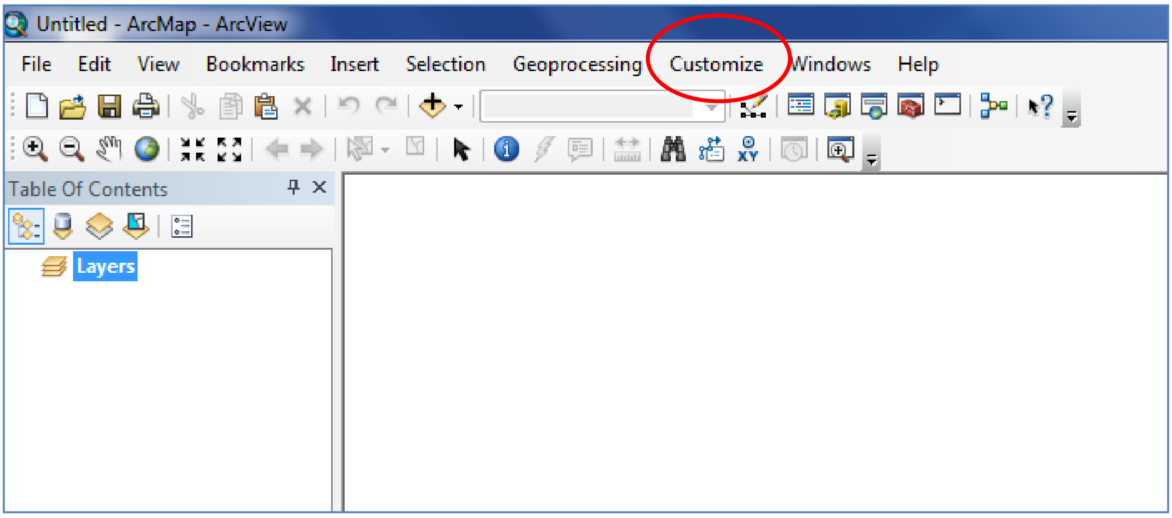


Once the installer is launched, it runs as below.

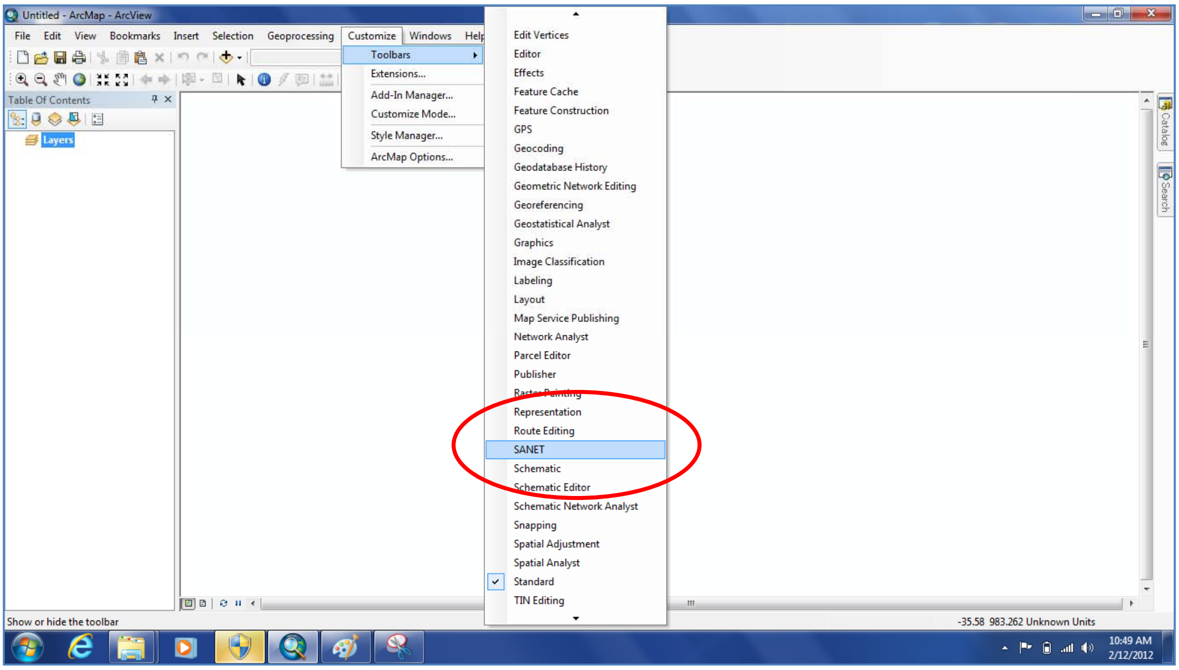




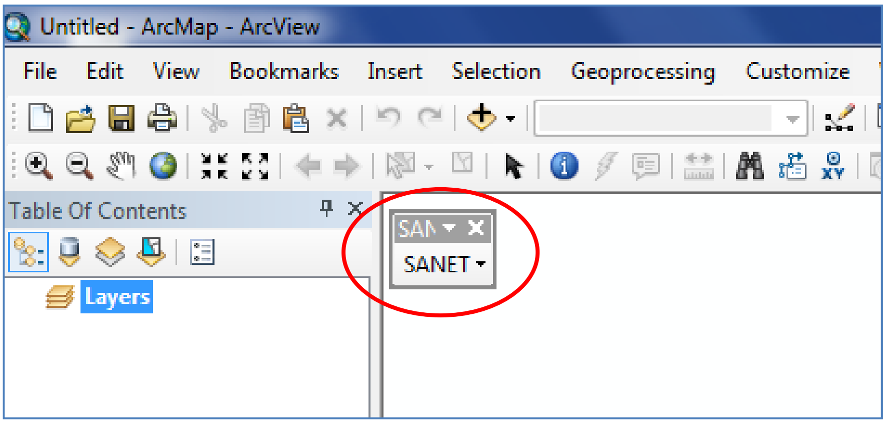
Thirdly, launch ArcGIS, and find 'Customize' on your menu bar.



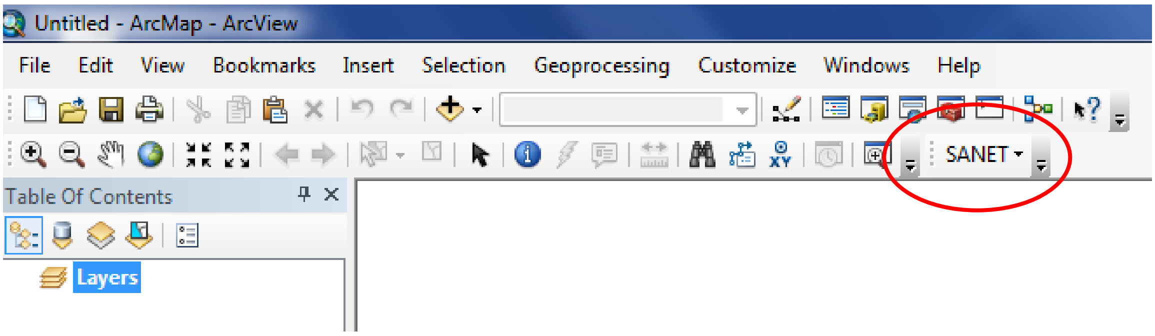
Click 'Customize' and you will find 'SANET' listed in the pull-down menu as below.



Click ‘SANET’ in the pull-down menu, then, SANET will appear on the following ArcMap window.



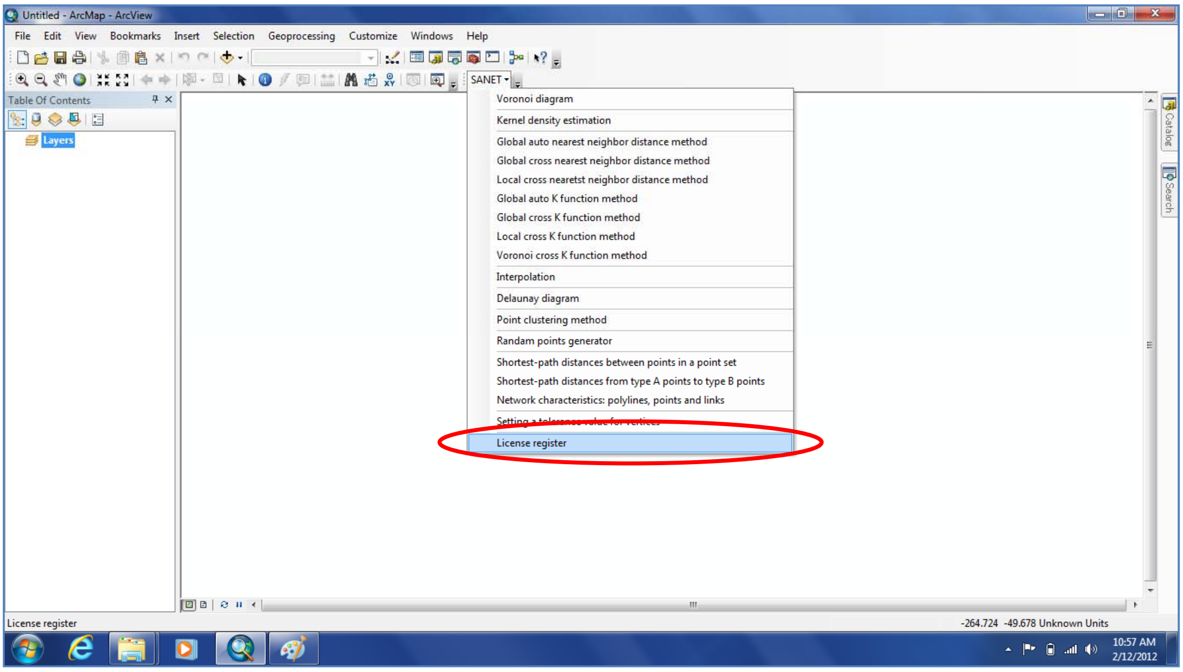
Just drag ‘SANET’ to place somewhere in the menu bar.



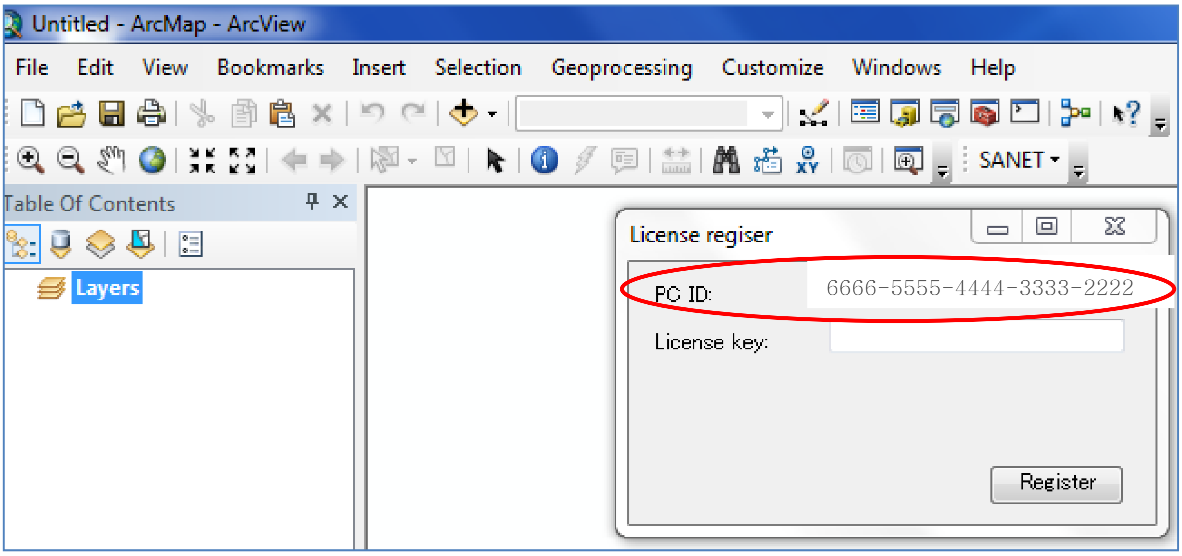
2.3 How to put license key to run SANET on your ArcGIS.

Make sure that ‘SANET’ sits in your menu bar.

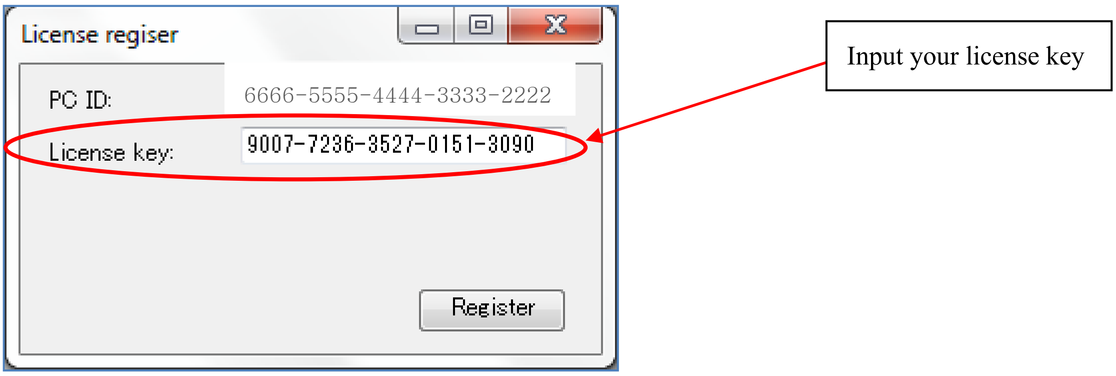
Firstly, click ‘SANET’ and find ‘license register’ at the bottom of the pull-down menu.



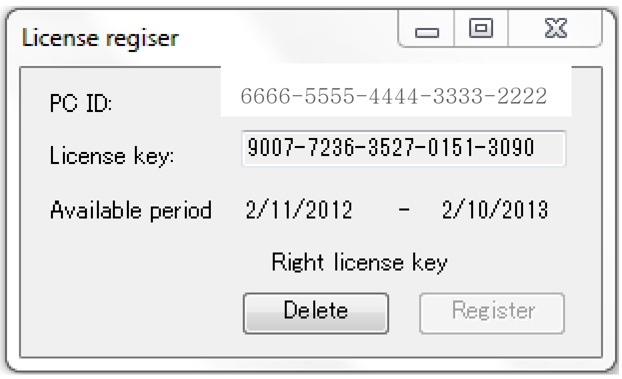
The license register window appears as below.
The numerals shown in the window is the PC ID which is requested to be filled in your registration form.



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.

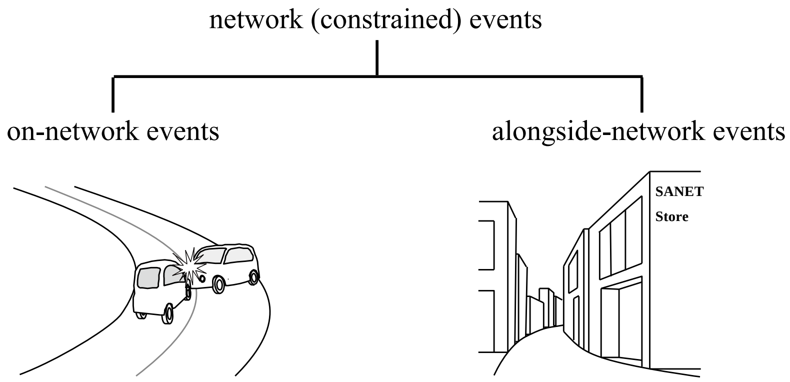


Enjoy SANET until your license expires.



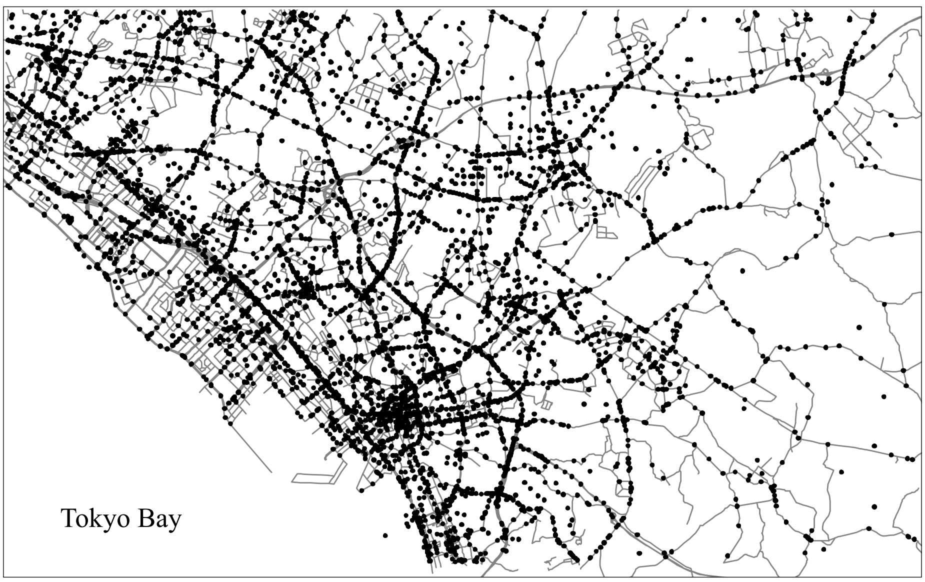
3. What is SANET?

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.



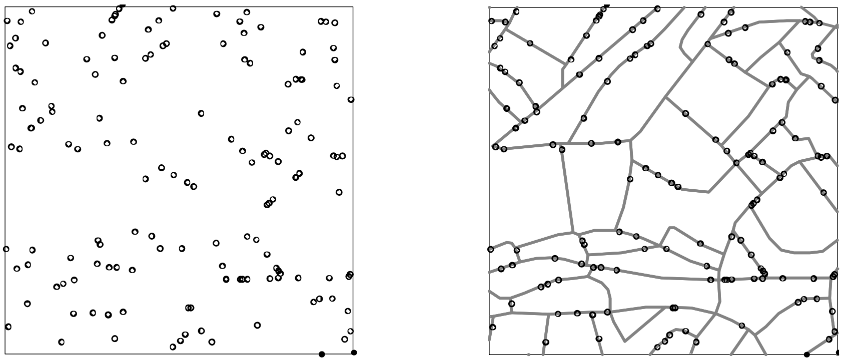
Source: Figure 1.2 in Okabe and Sugihara (2012). Sites of traffic accidents around Chiba station, Japan (private roads are not shown).

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.



(a) (b)

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

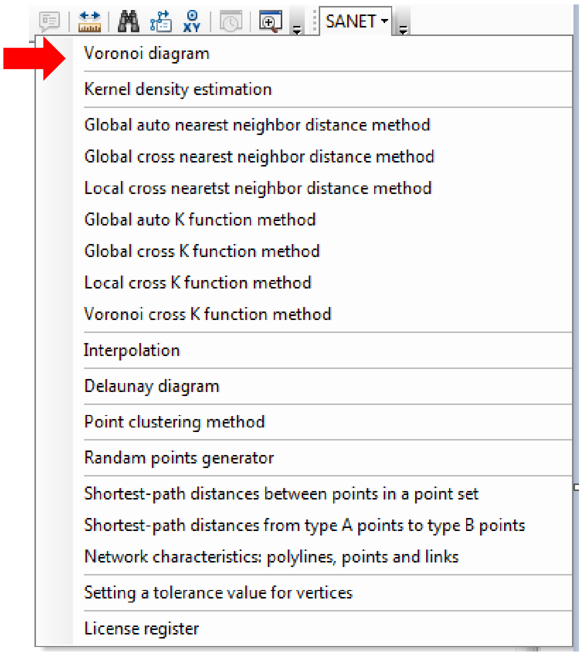
Tool 16: Network Characteristics: polylines, points and links

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.

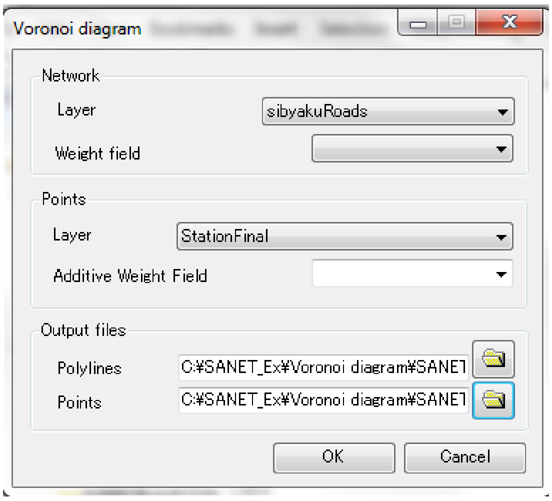
4.1 Tool 01: Voronoi diagrams

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.



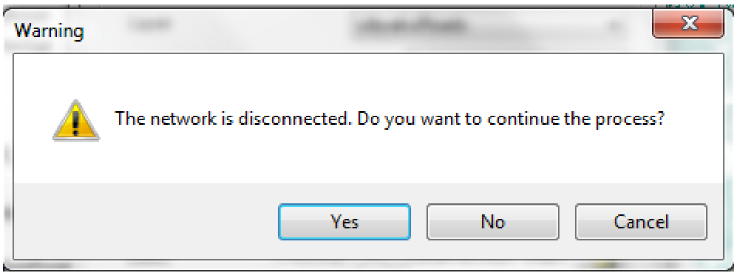
Choose ▼ the file of a network (e.g. SibyakuRoads: the street network in Shibuya ward, Tokyo).
Choose ▼ a set of points that generates Voronoi diagrams (e.g. StationFinal: 14 railways stations in Shibuya ward, Tokyo).
(Ignore "Weight field".)
If you use the ordinary Voronoi diagram, leave the 'Additively Weighted Field" blank.

If you use the additively weighted Voronoi diagram, choose ▼ the field of the file of the generation point set where weights are given.

Choose  the files where the output files are stored

Click “OK”.

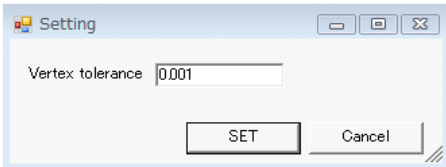
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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.

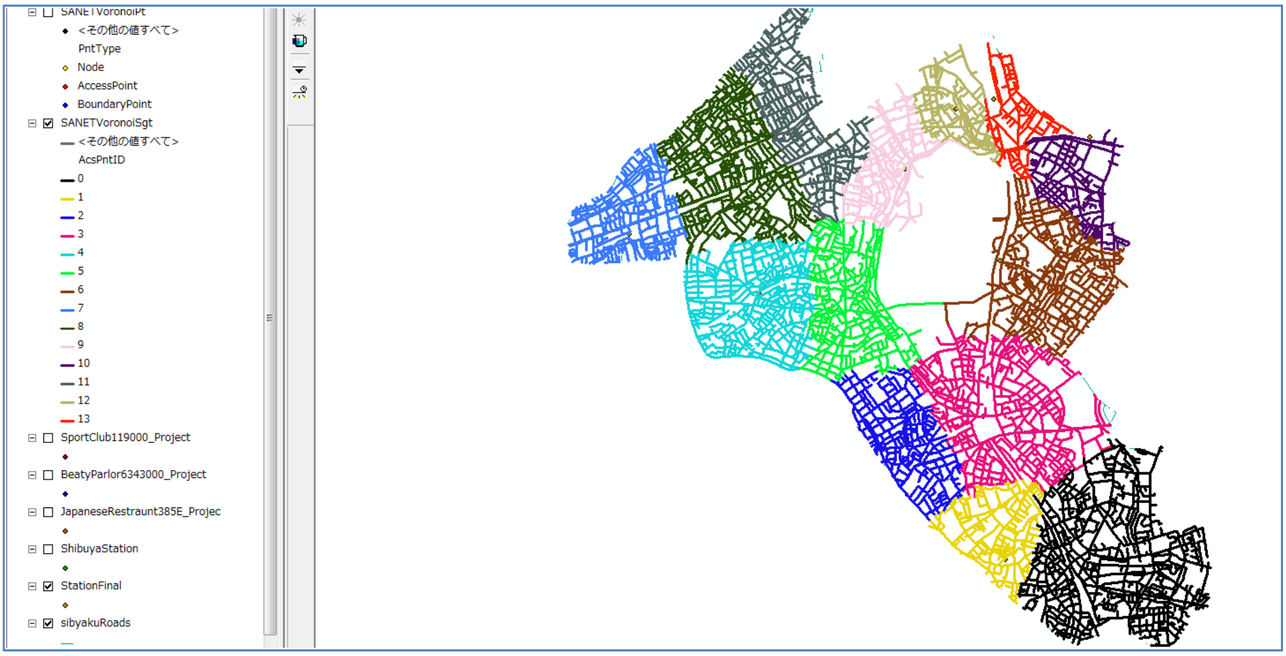
***

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.

属性: SANETVoronoiSgt

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
0	Polyline ZM	1E68DFC0	-14780.4	-35597	0	-14772.9	-35644.4	0	1E661530	1E661828	47.989686	47.989686	7
1	Polyline ZM	1E68DF50	-14786.4	-35566.6	0	-14780.4	-35597	0	1E661790	1E661530	30.986449	30.986449	7
2	Polyline ZM	1E68DEE0	-14801	-35493	0	-14786.4	-35566.6	0	1E6616F8	1E661790	75.034126	75.034126	7
3	Polyline ZM	1E68DE70	-14813.7	-35426.1	0	-14801	-35493	0	1E661660	1E6616F8	68.094787	68.094787	7
4	Polyline ZM	1E68DE00	-14817.717144	-35404.565476	0	-14813.7	-35426.1	0	1E6615C8	1E661660	21.906007	21.906007	7
5	Polyline ZM	1E68DD90	-14293.1	-35555.8	0	-14298.2	-35560.2	0	1E661498	1E661070	6.735726	6.735726	8
6	Polyline ZM	1E68DD20	-14298.2	-35560.2	0	-14329.7	-35574.3	0	1E661070	1E661368	34.511737	34.511737	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

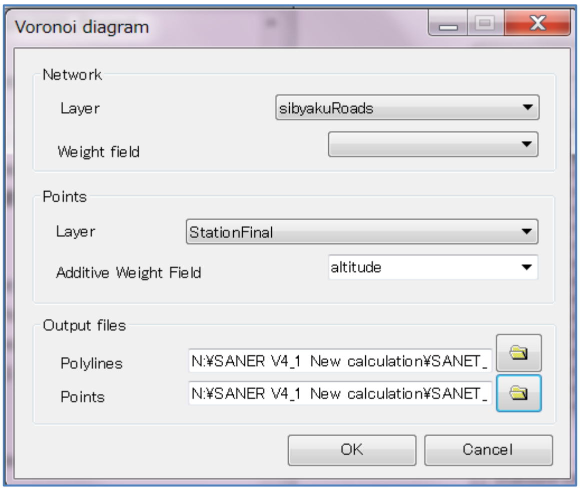
Do almost the same procedure except for the followings.

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

StationFinal

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	09LD37	P242	56	代官	224	渋谷区	13113	27
2	Point	323	09LD26	P242	45	神泉	115	渋谷区	13113	29
3	Point	336	09LD27	P242	46	渋谷	0	渋谷区	13113	14
4	Point	313	09LD26	P242	44	代々	336	渋谷区	13113	27
5	Point	315	09LD26	P242	44	代々	224	渋谷区	13113	25
6	Point	325	09LD27	P242	45	原宿	210	渋谷区	13113	32
7	Point	309	09LD26	P242	43	笹塚	588	渋谷区	13113	42
8	Point	312	09LD26	P242	44	幡ケ	448	渋谷区	13113	40
9	Point	212	09LD16	P242	31	参宮	378	渋谷区	13113	28
10	Point	222	09LD17	P242	32	千駄	406	渋谷区	13113	34
11	Point	211	09LD16	P242	31	初台	434	渋谷区	13113	39
12	Point	224	09LD17	P242	33	南新	462	渋谷区	13113	37
13	Point	221	09LD17	P242	32	代々	448	渋谷区	13113	35

Choose ▼ the weights.



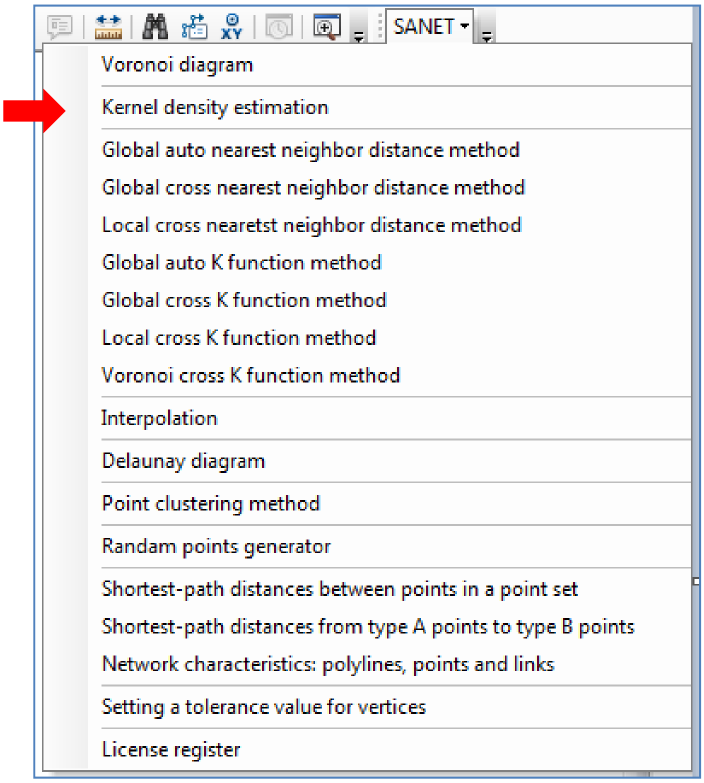
Reference

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.

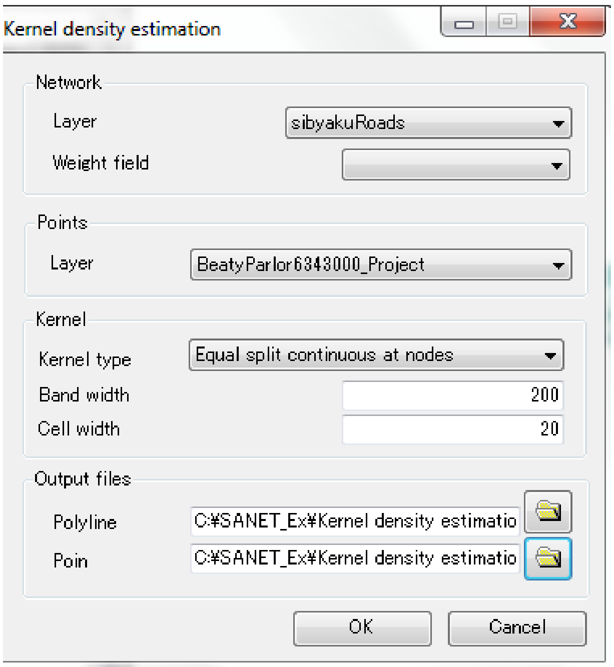
4.2 Tool 02: Kernel density estimation

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".



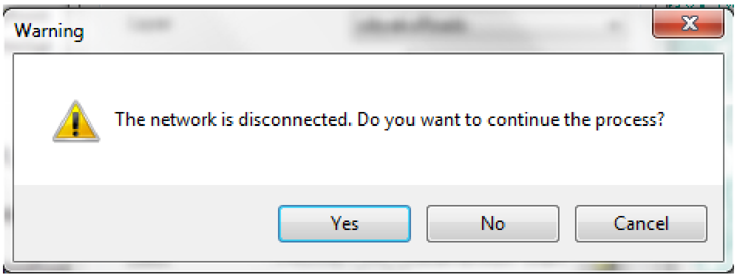
Then the following window appears.



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 ▼ 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  the output file where the resulting files are stored

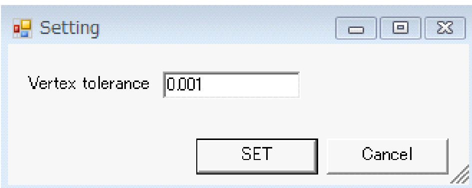
Click “OK” .
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



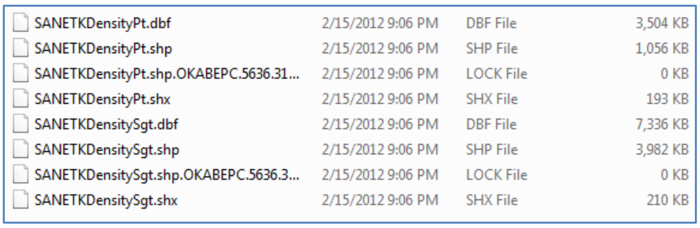
The “Vertex tolerance” means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed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

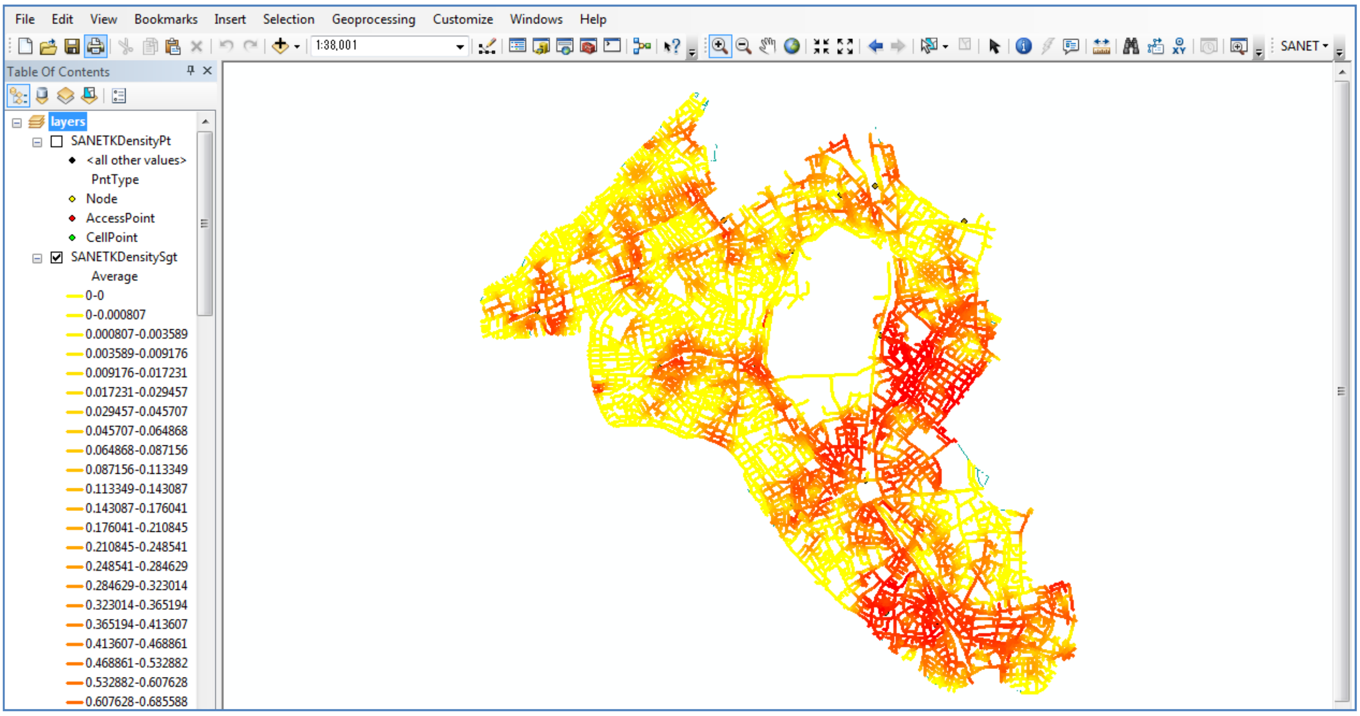
***

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).

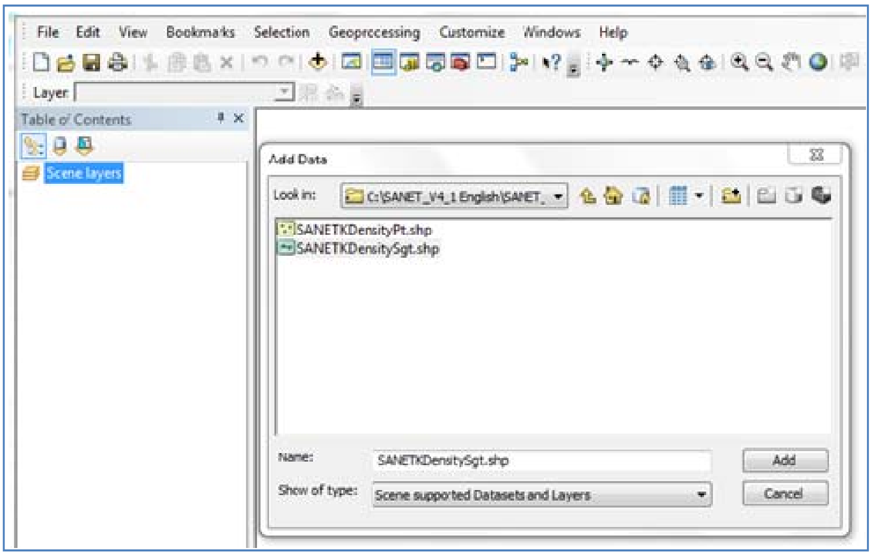
If you do not have any trouble such as memory overflows, you obtain the following files in the output file and one in the ArcMap window.



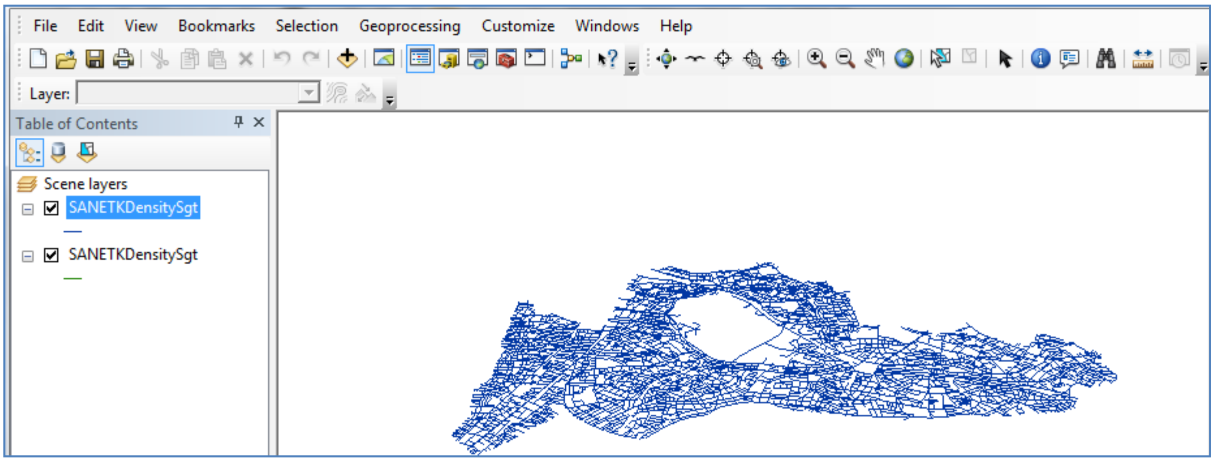


If you want to represent this figure in 3D, launch ArcScene.

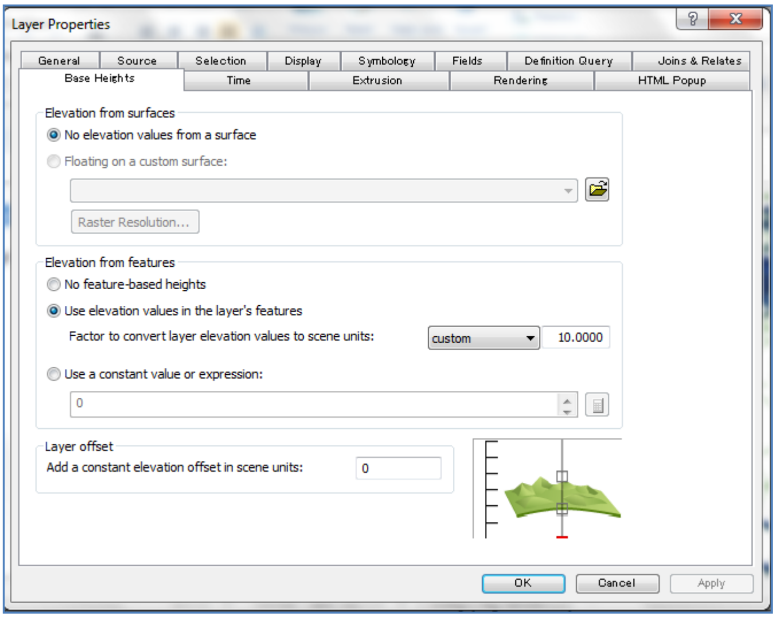
Add data  SANETDensitySgt.shp.



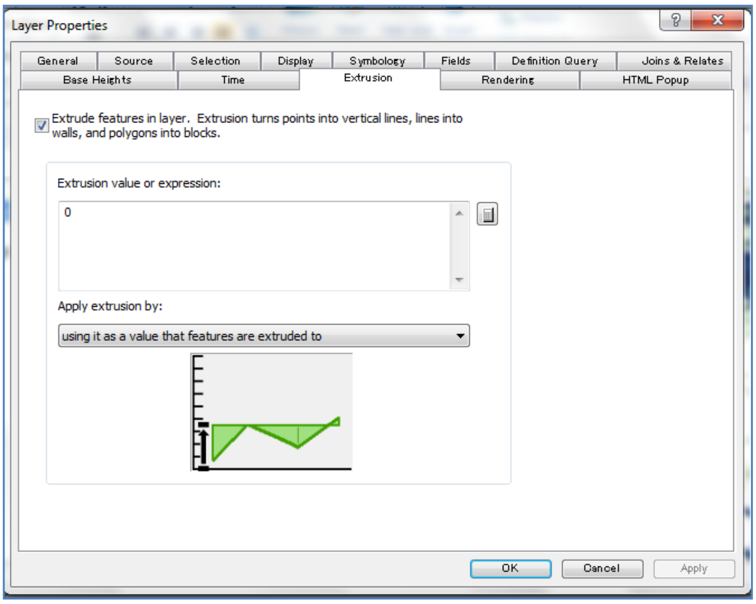
Do this TWICE, as seen below.



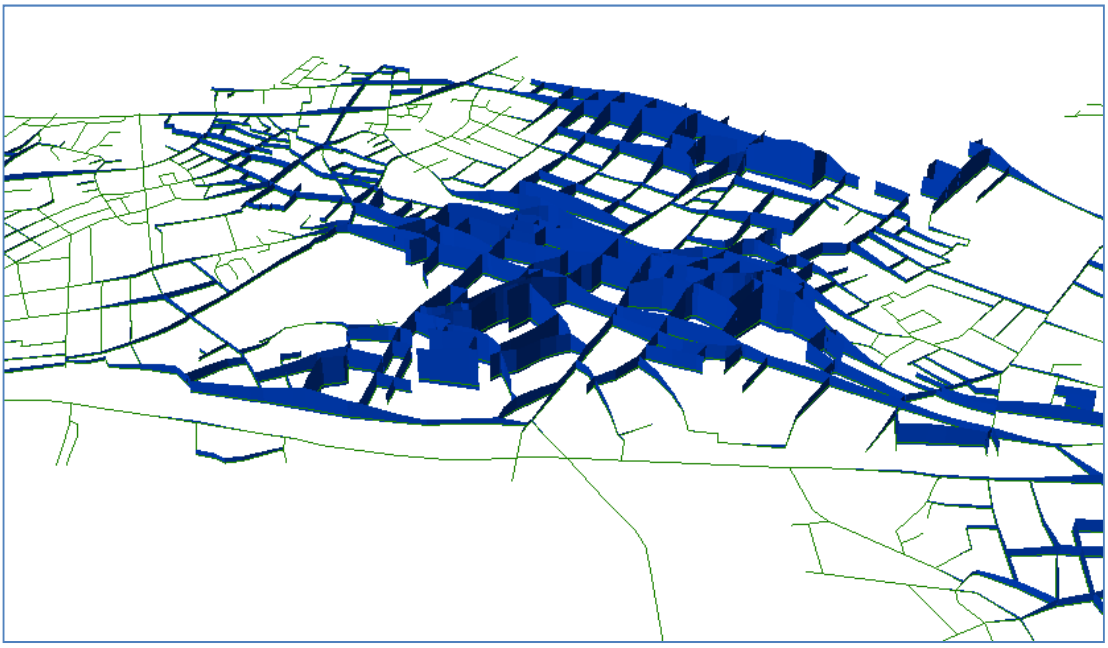
Left-click “SANETKDensitySgt” and choose ▼ “Properties” and next “Base hights”.



Choose ▼ "custom" and choose ▼ 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".



Then the following figure is obtained in the ArcScene window.



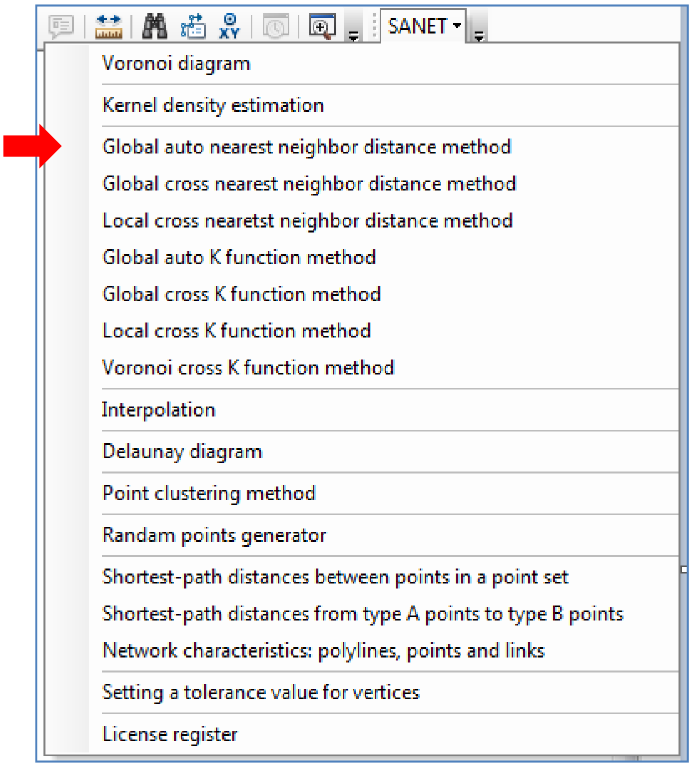
Reference

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.

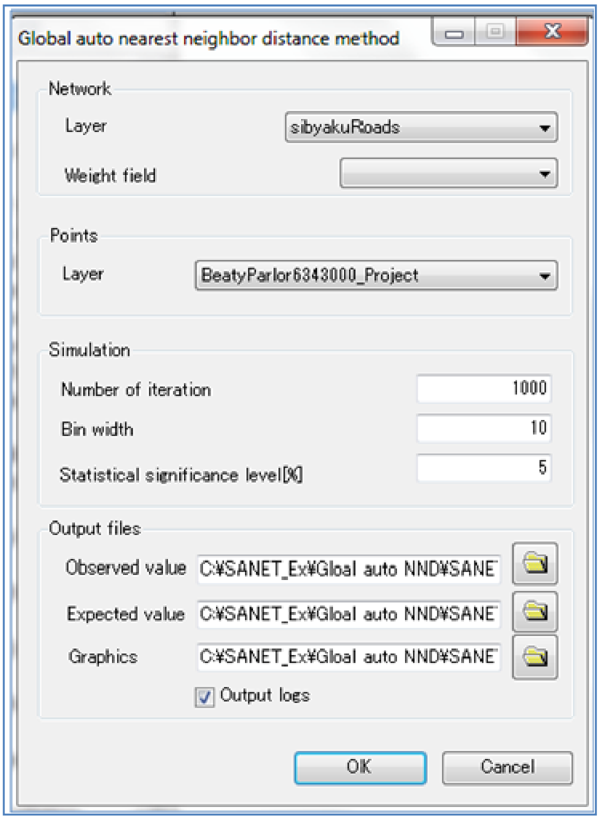
4.3 Tool 03: Global auto nearest neighbor distance method

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.

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



Then the following window appears.



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 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),

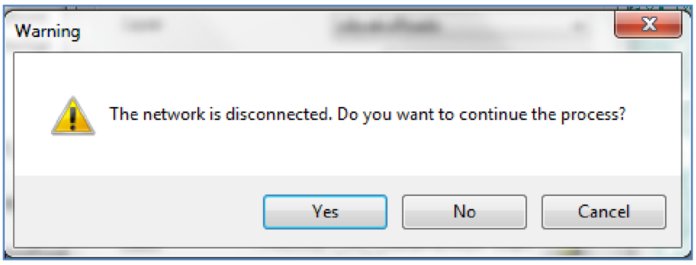
a bin width (a continuous distance is divided by the equal bin width; a default value is 10; in this case, the resulting intervals are 0-10, 10-20, 20-30,…..) , and one-sided statistical significance level (the default value is 5%).

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”.

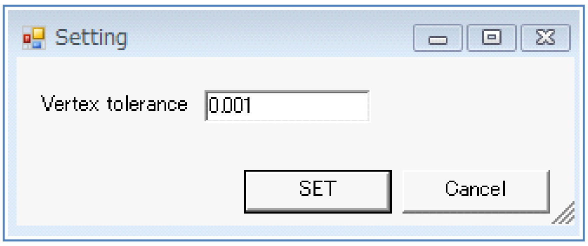
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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

	A	B	C
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

…

[illegible]	[illegible]	[illegible]	[illegible]
887	883	250	27.53011
888	884	178	2.295587
889	886	136	156.2032
890	887	0	100.0818
891	888	463	85.16306
892	890	207	45.82542
893	891	523	22.35403
894	892	42	10.47143
895	893	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

	A	B	C	D
1	Simulation	FromPntID	ToPntID	Distance
2	0	0	547	76.29765
3	0	1	161	72.11635
4	0	2	587	115.9444
5	0	3	363	117.9142
6	0	4	616	189.7447
7	0	5	637	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

…

894998	999	891	398	130.463
894999	999	892	471	67.7642
895000	999	893	516	106.882
895001	AVERAGE	86.24311		
895002				
895003	Lower	81.88646		
895004	Upper	88.27666		
895005	ALL AVERA	85.09293		
895006	VARIANCE	3.706896		

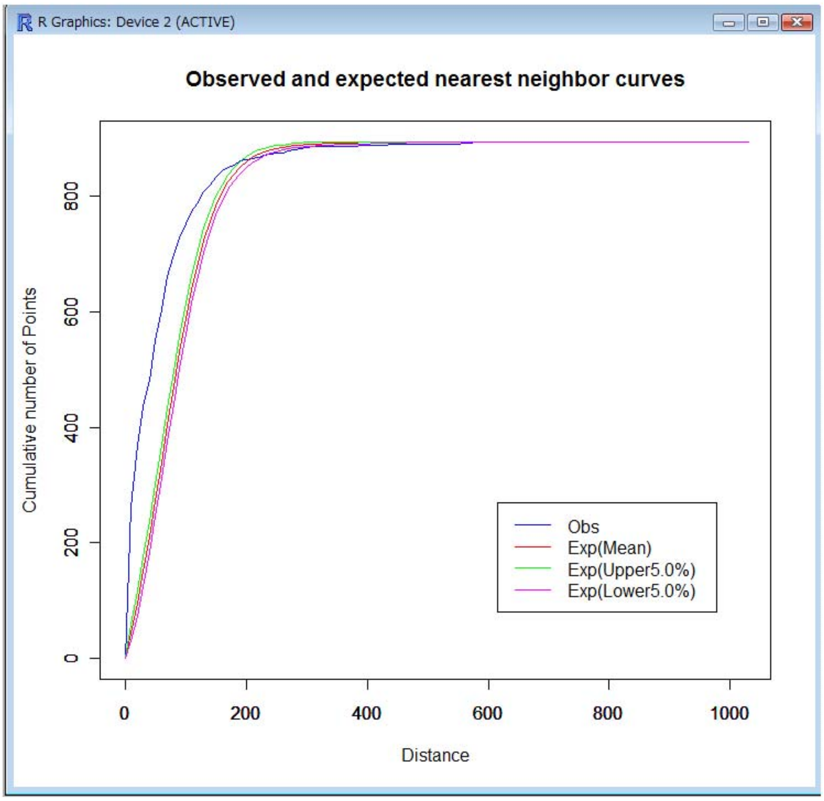
The first column indicates the *i*-th iteration of Monte Carlo simulation.
The second column indicates “from the *j*-th point” in a given point set.
Third column indicates “to its nearest neighbor point”.
The last column indicates the shortest-path distance between them.
The last row of the last (1000) 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.

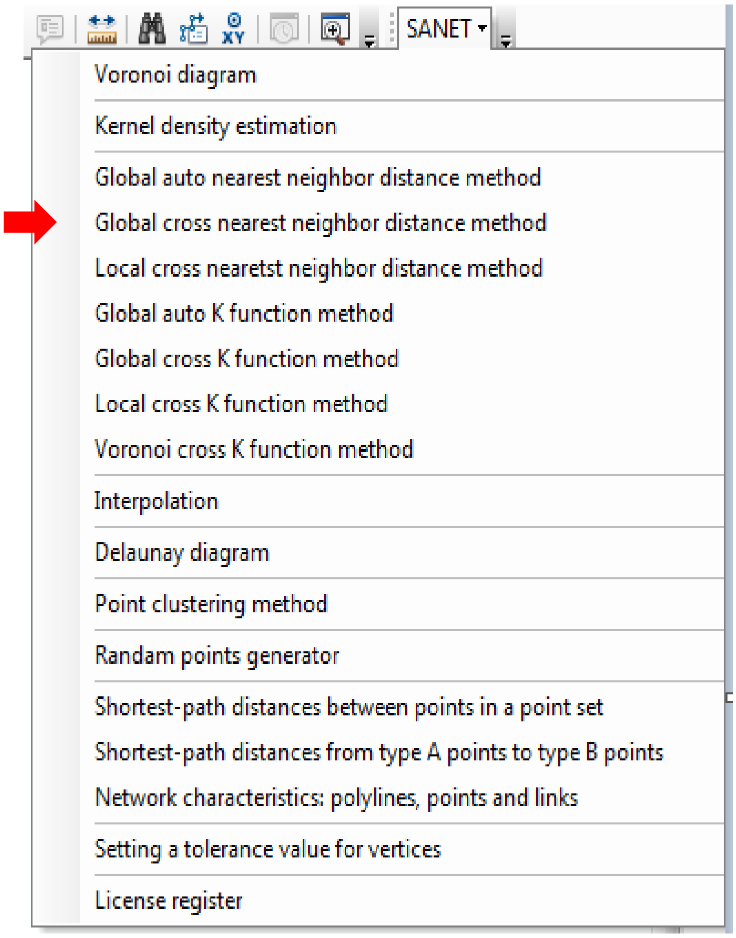
Reference

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.

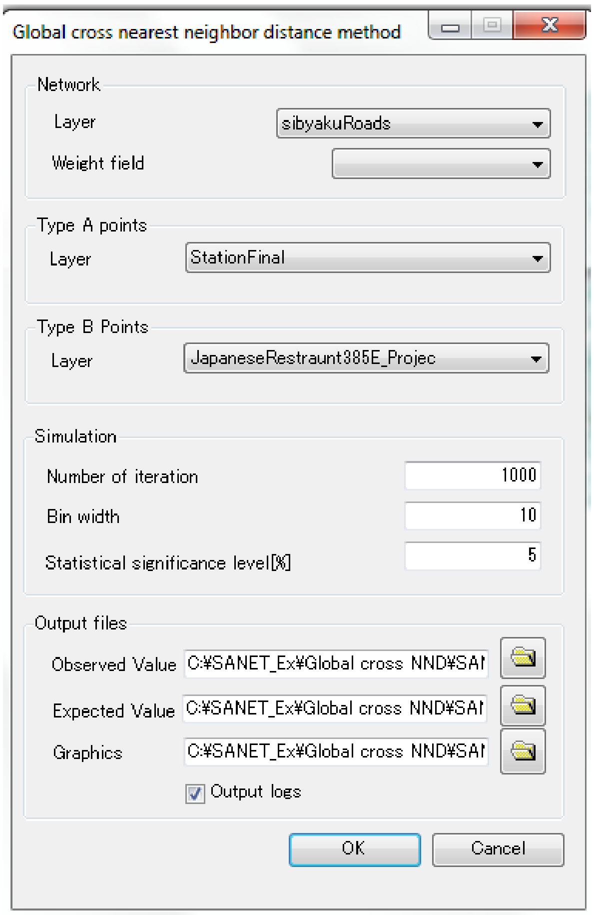
4.4 Tool 04: Global cross nearest neighbor distance method

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.



Then the following window appears.



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).

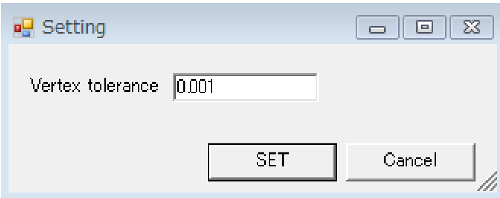
Choose  the out file where the resulting files are stored.
Click OK.

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.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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	Type	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

	A	B	C
1	TypeB	TypeA	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	5	599.0245
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:

	A	B	C	D
1	Simulatioı	TypeB	TypeA	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
9	0	5	5	541.1829
…				
422	0	420	5	515.2886
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	767.2001
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	423	0	1330.849
426999	999	424	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.

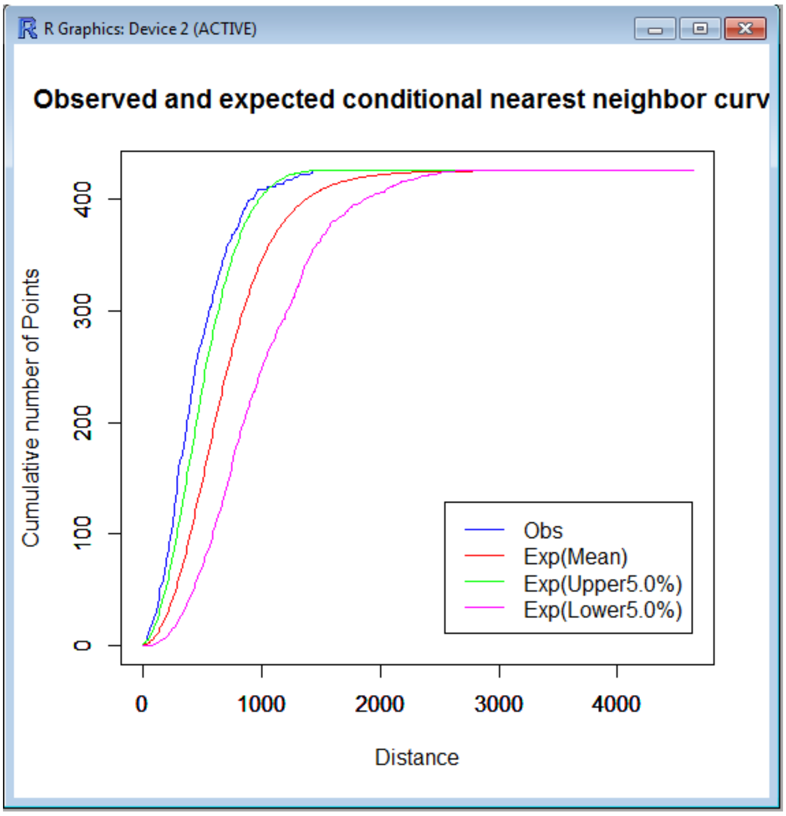
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	3
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3
5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	3
6	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3

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 × 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

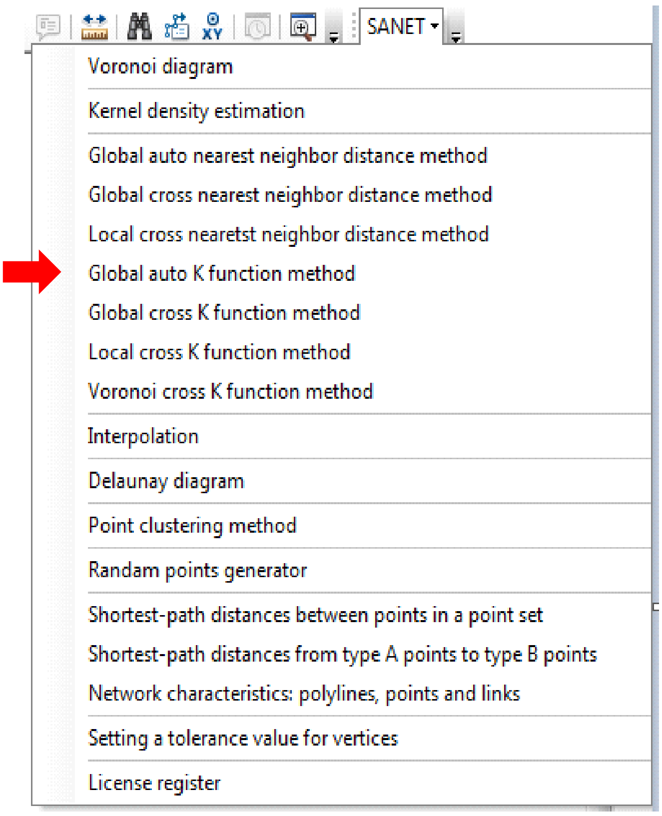
This tool tests the complete spatial randomness (CSR) hypothesis in terms of the number of points in a given point set satisfying that the shortest-path distance from every point to another point is less than a parametric shortest-path distance. The CSR hypothesis means that points are independently 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 $n(t \mid p_i)$ 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

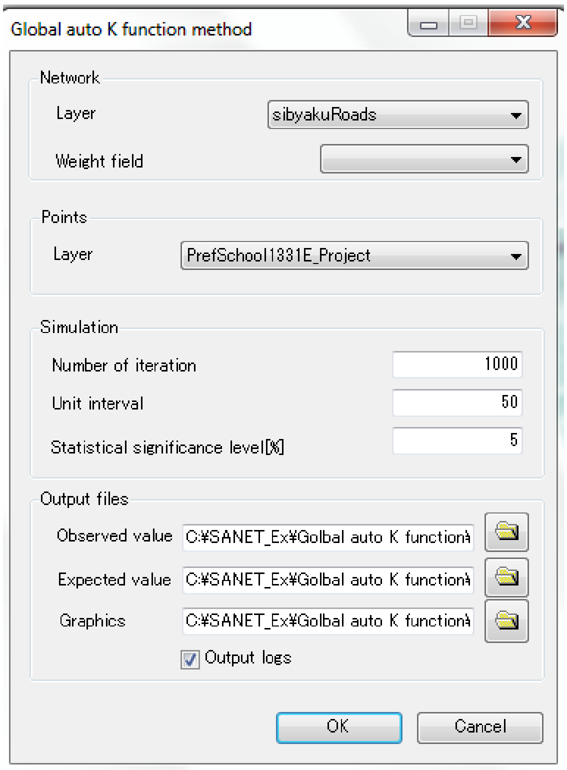
$$K(t) = \frac{1}{\rho} \frac{\sum_{i=1}^{n} n(t \mid p_i)}{n}.$$

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.



Then the following window appears.



Choose ▼ the file name of a network (e.g., sibyakuRoads in the above figure).
(Ignore "Weight field".)
Choose ▼ the file name of a set of points (e.g., PrefSchool1331E_Project).
Fill in:

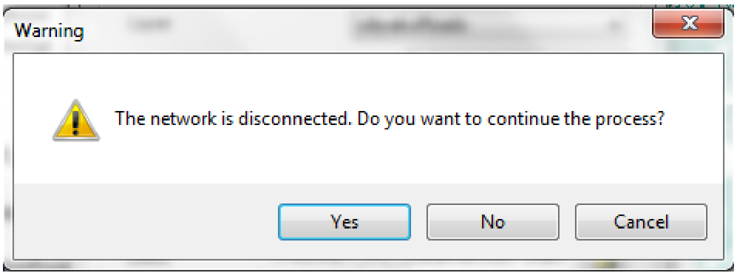
- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a unit interval (a continuous distance is divided by the equal unit interval; a default value is 10 but in the above example, 50 is used; in this case, the resulting intervals are 50, 100, 150,…..) , and
- a statistical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

Choose  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".

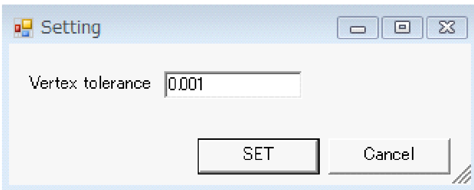
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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	Type	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

	A	B	C
1	FromPntID	ToPntID	Distance
2	0	1	1177.096
3	0	2	3615.931
4	0	3	2201.724
5	0	4	1864.719
6	0	5	723.519
7	0	6	1214.798
8	0	7	1393.547
9	0	8	4468.943
10	0	9	1975.764
11	0	9	1975.764

…

[illegible]	101	[illegible]	[illegible]
10295	101	91	1461.274
10296	101	92	1823.392
10297	101	93	1718.576
10298	101	94	1928.28
10299	101	95	1858.233
10300	101	96	2205.37
10301	101	98	2110.368
10302	101	99	1658.132
10303	101	100	1649.353
10304	AVERAGE	2809.084	

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.

	A	B	C	D	E	F	G	H	I	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	22
5	0	2	8	26	44	70	100	136	176	22
6	0	2	10	26	44	70	102	136	178	22
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	0	2	12	26	46	72	102	140	182	23

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

…

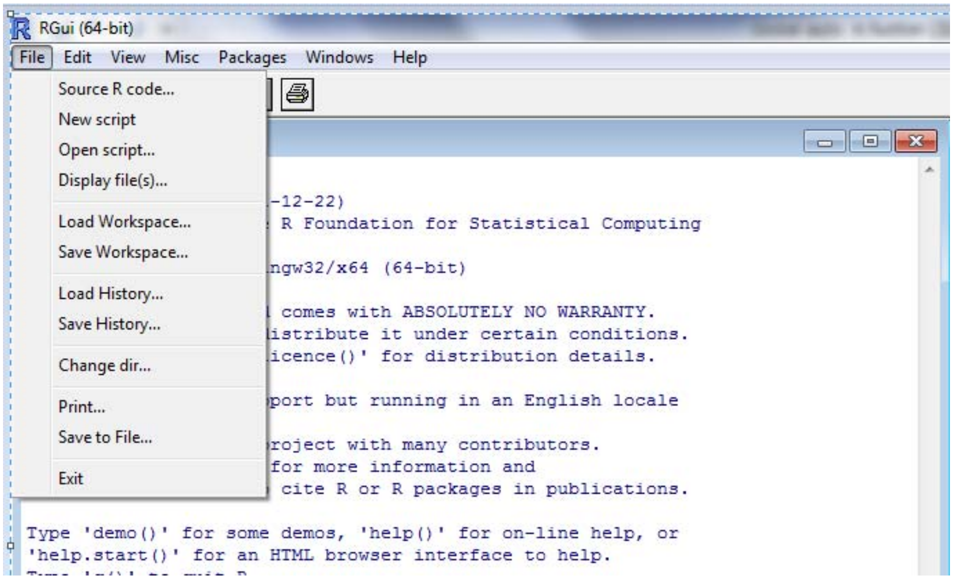
11294	0	101	90	4485.836
11295	0	101	91	3847.535
11296	0	101	92	1201.482
11297	0	101	93	209.2189
11298	0	101	94	3733.501
11299	0	101	95	4919.234
11300	0	101	96	2757.466
11301	0	101	97	190.2816
11302	0	101	98	5622.348
11303	0	101	99	1466.652
11304	0	101	100	3256.543
11305	1	0	1	685.3707
11306	1	0	2	2009.95
11307	1	0	3	1359.592
11308	1	0	4	903.1245

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

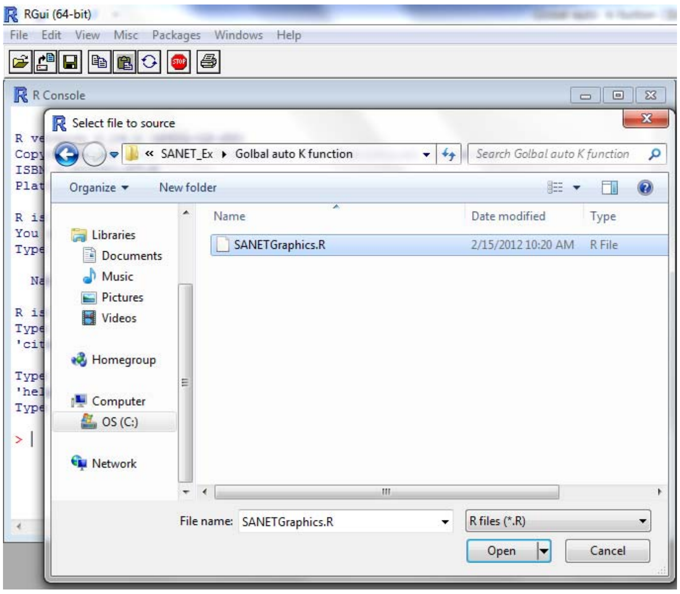
The second column indicates "from the *j*-th point" in the point set.
Third column indicates "to the *k*-th point in the point set.
For instance, the above table shows part of the output of the 0-th iteration, where the shortest-path distances are from the 0-th point to the *k*-th point (k =1, 2, …., 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.

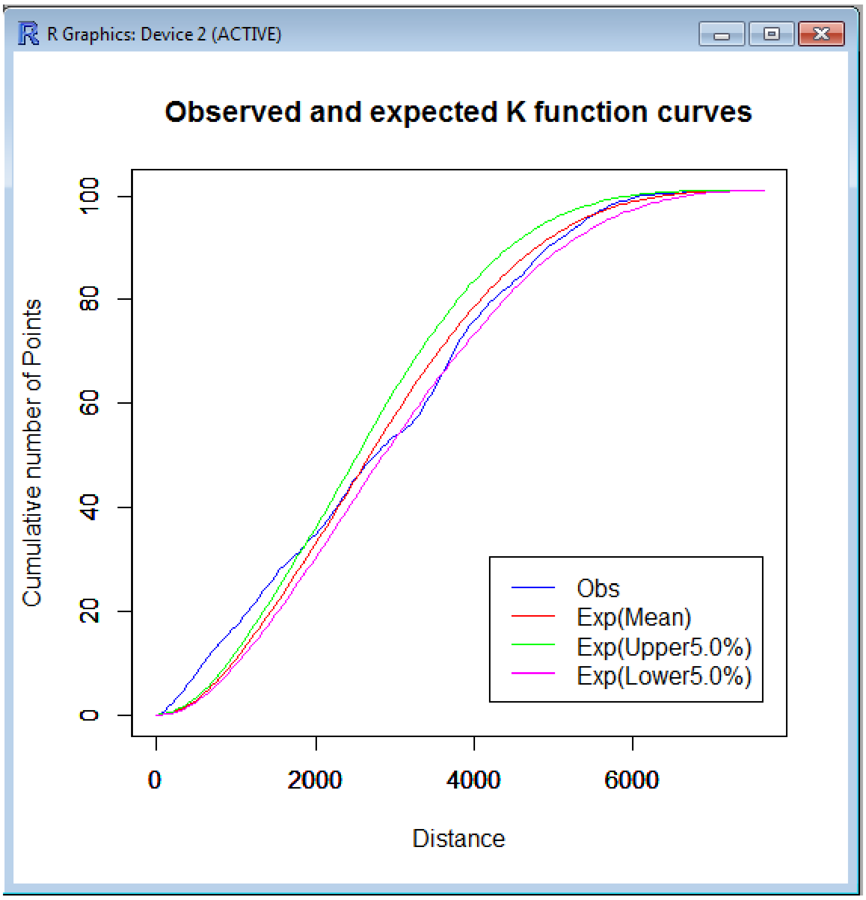
SANETGraphics.R

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

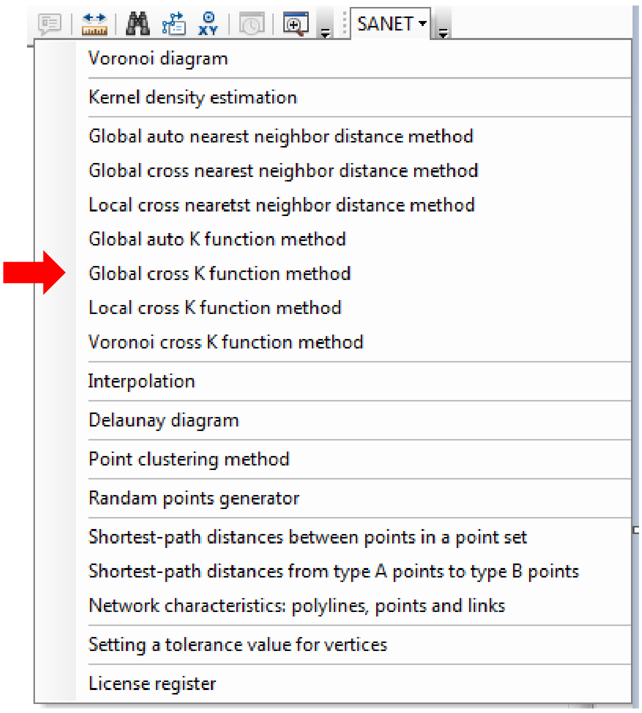
Given two sets of points, a set of type A points and that of type B points, placed on a given network, this tool tests the complete spatial randomness (CSR) hypothesis. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, 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 $n(t\,|\,p_{\mathrm{A}_i})$ 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

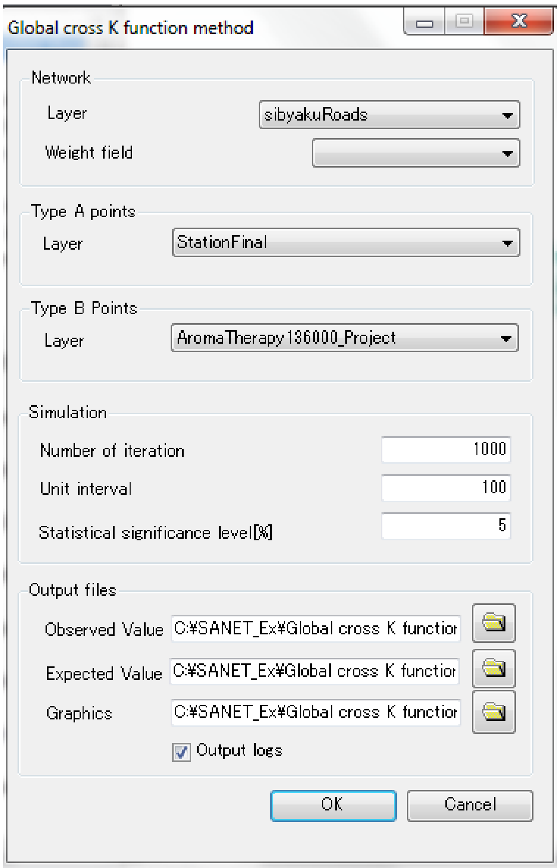
$$K_{\mathrm{AB}}(t\,|\,p_{\mathrm{A}_i}) = \frac{1}{\rho_{\mathrm{B}}} \frac{\sum_{i=1}^{n_{\mathrm{A}}} n(t\,|\,p_{\mathrm{A}_i})}{n_{\mathrm{A}}}.$$

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.



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:

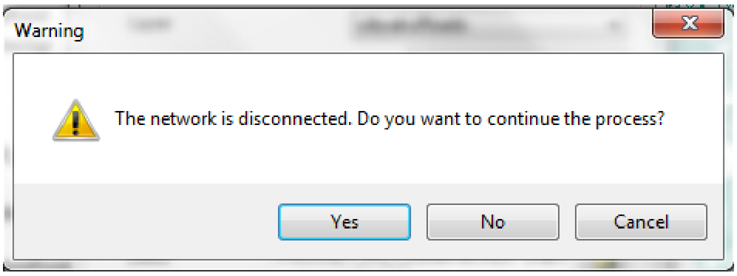
- the number of iterations for Monte Carlo simulation (a default values is 1000),
- a unit interval (a continuous distance is divided by the equal unit interval; a default value is 10; in this case, the resulting intervals are 10, 20, 30,…..; in the example, 100 was used) , and
- a statistical significance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

Choose  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”.

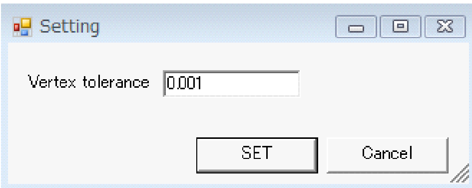
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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	Type	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

	A	B	C
1	TypeA	TypeB	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	9	402.1562

…

831	13	48	241.2574
832	13	49	1117.766
833	13	50	3474.923
834	13	50	3474.923
835	13	53	3667.964
836	13	54	4771.345
837	13	55	975.4085
838	13	56	2911.993
839	13	57	5063.5
840	13	58	2232.531
841	13	59	3694.626
842	AVERAGE	2994.976	

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.

	A	B	C	D	E	F	G	H	I
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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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	TypeA	TypeB	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	0	0	8	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	0	1896.771
1844	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".

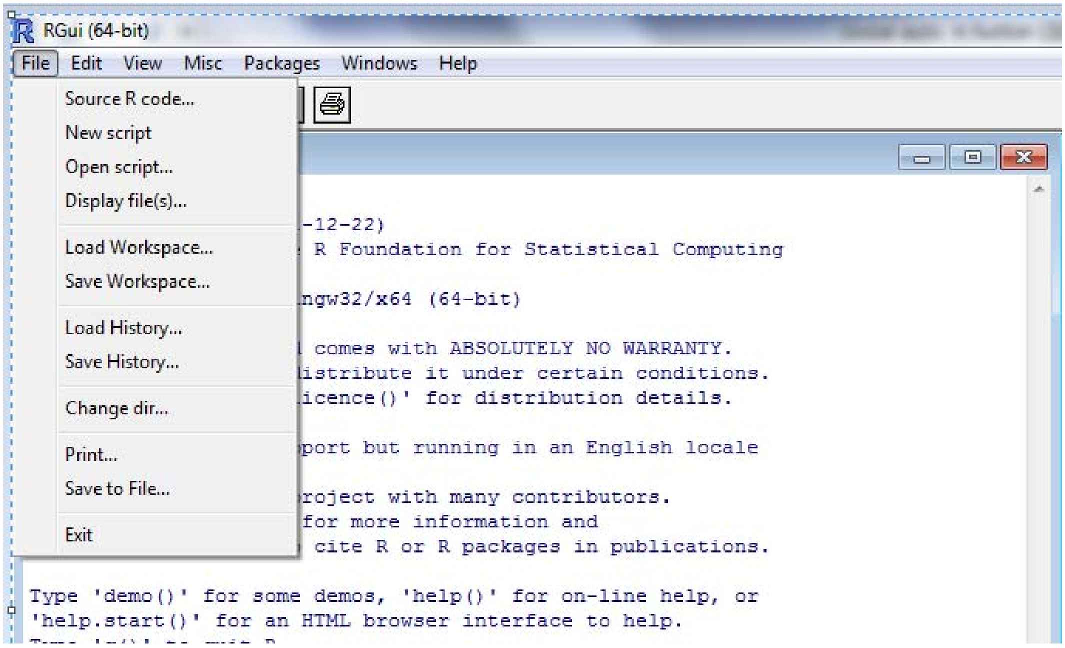
Third column indicates "to the *k*-th point of type A".

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

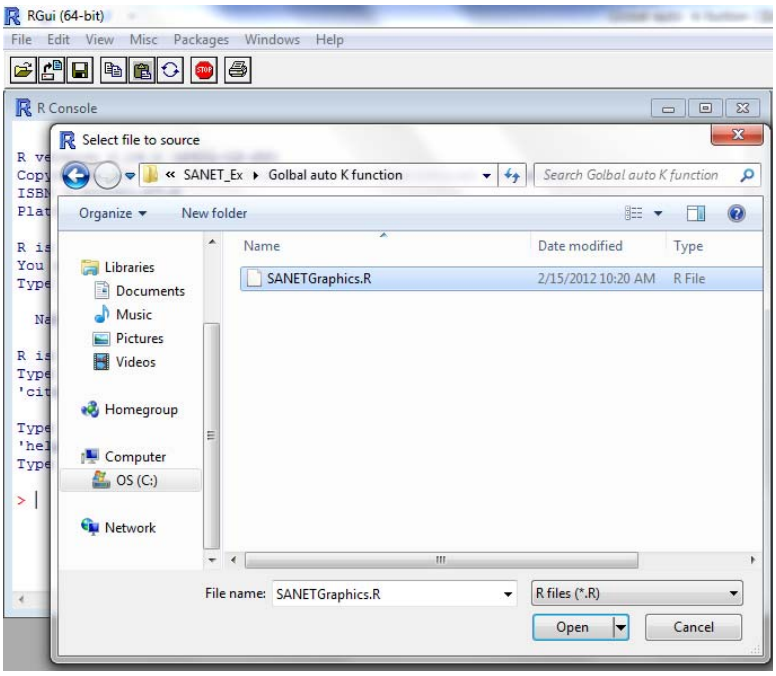
SANETGraphics.R

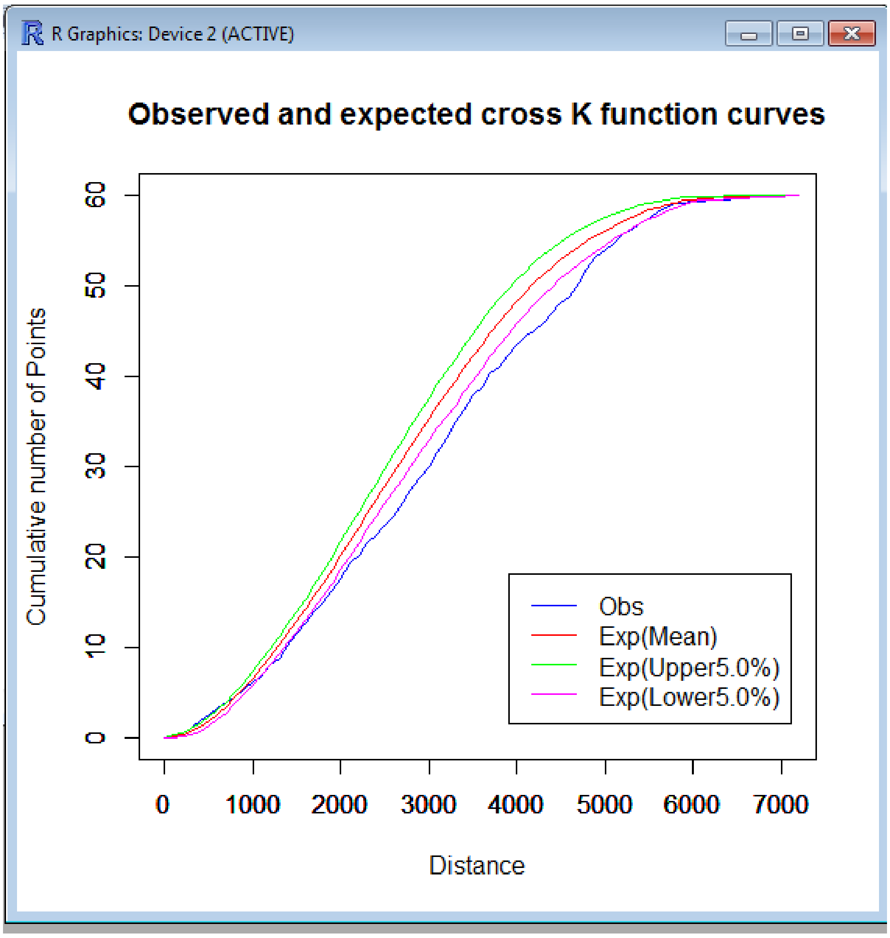
Launch R program, and click "Files".

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

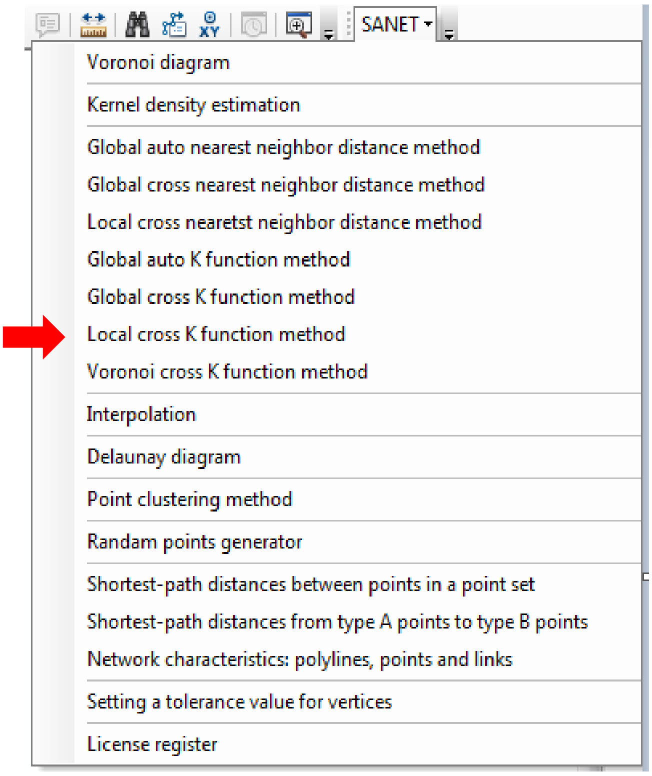
Given two sets of points, a set of type A points and that of type B points, placed on a given network, this tool tests the complete spatial randomness (CSR) hypothesis. The CSR hypothesis means that points are independently and identically distributed according to the uniform distribution over the network, 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 $n(t \mid p_{\mathrm{A}_i})$ 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

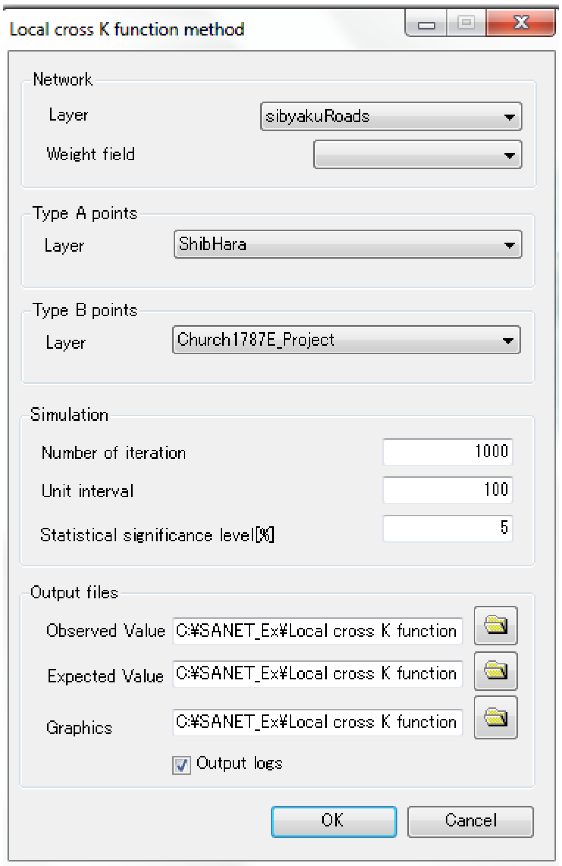
$$K_{\mathrm{AB}}(t \mid p_{\mathrm{A}_i}) = \frac{1}{\rho_{\mathrm{B}}} n(t \mid p_{\mathrm{A}_i}).$$

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 method' in the SANET menu.



Then the following window appears.



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).

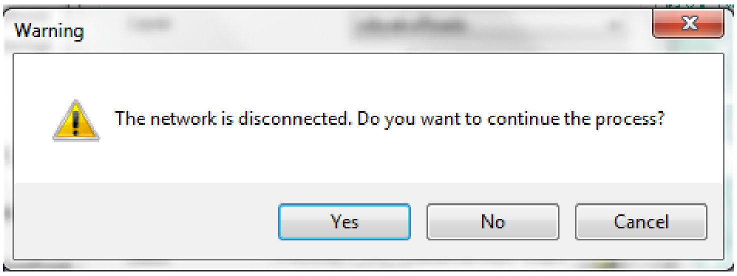
Recall that the local cross *K* function deals with the number of type B points (e.g., churches) within a parametric shortest-path distance from the *i*-th point in the type A point set (e.g., the Shibuya Station).

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 the out file where the resulting files are stored.
Click “OK”.

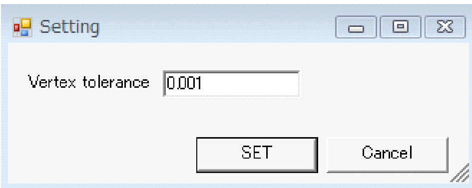
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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	Type	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

	A	B	C
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
…			
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.

	A	B	C	D
1	Simulatio	TypeA	TypeB	Distance
2	0	0	0	1443.21
3	0	0	1	2875.671
4	0	0	2	2785.1
5	0	0	3	3325.874
6	0	0	4	1031.78
7	0	0	5	1633.424
8	0	0	6	3255.872

…

2	0	0	40	500.8608
3	0	0	41	1495.888
4	0	0	42	2163.716
5	0	0	43	2172.226
6	0	0	44	257.8137
7	0	0	45	841.3883
8	0	0	46	1862.649
9	AVERAGE	1988.712		
0	1	0	0	2810.533

…

47995	999	0	41	368.4656
47996	999	0	42	2629.683
47997	999	0	43	1764.055
47998	999	0	44	4320.192
47999	999	0	45	1343.431
48000	999	0	46	2469.002
48001	AVERAGE	2171.234		
48002	ALL AVER/	2264.785		

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 9^{th} 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

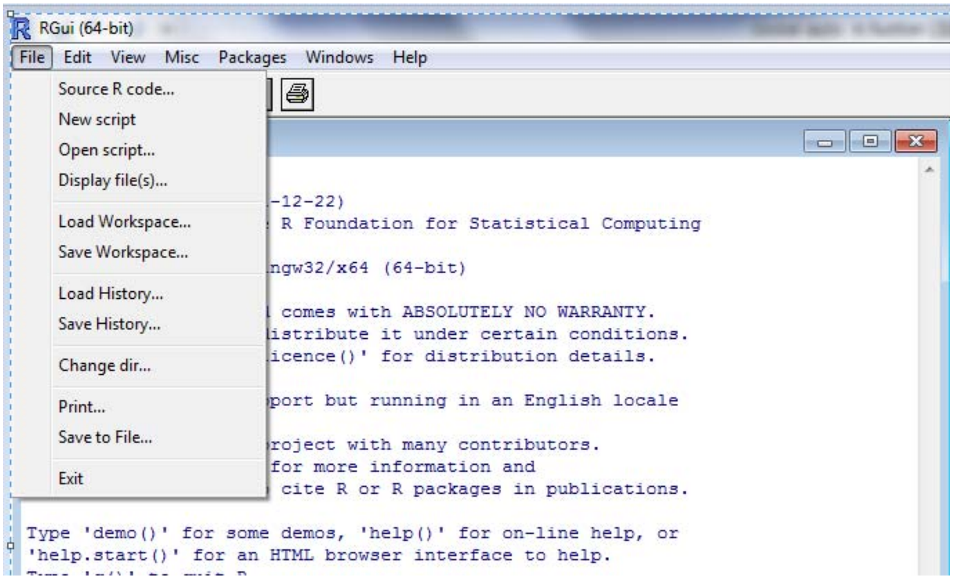
The row indicates intervals (with a chosen unit interval). For instance, 100, 200, 300, and so on.
The column indicates the numbers of type B points within the unit interval $\times i$ for 1000 iterations, and those numbers are ordered from the smallest to the largest.

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.

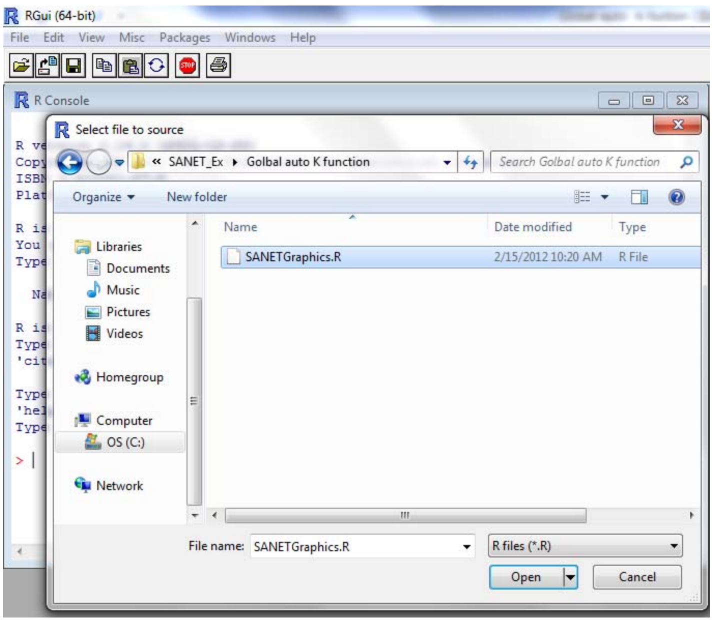
SANETGraphics.R

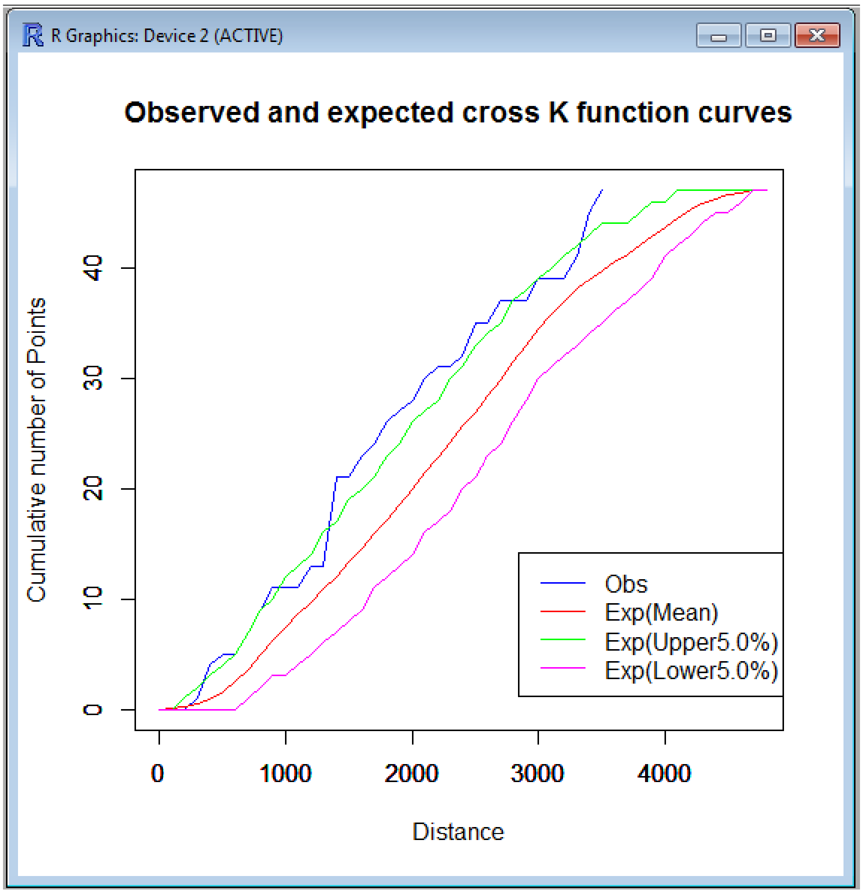
Open R program, and click “Files”.

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.

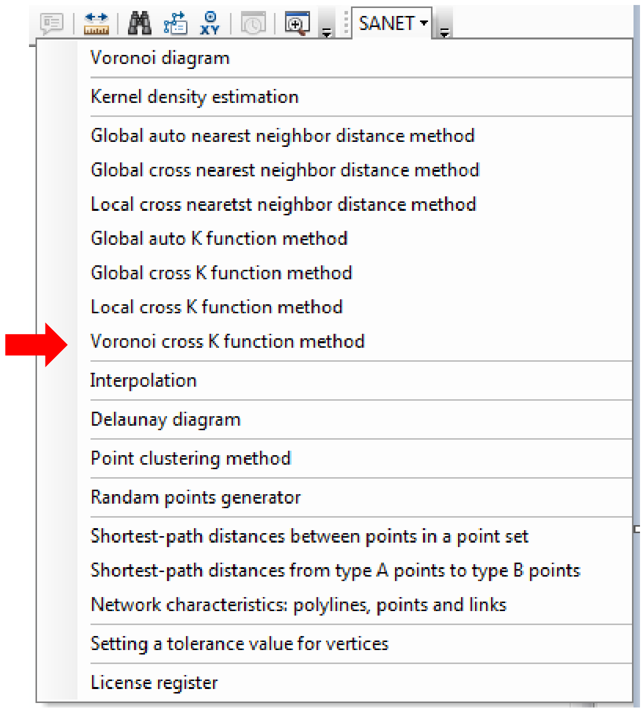
Reference

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.

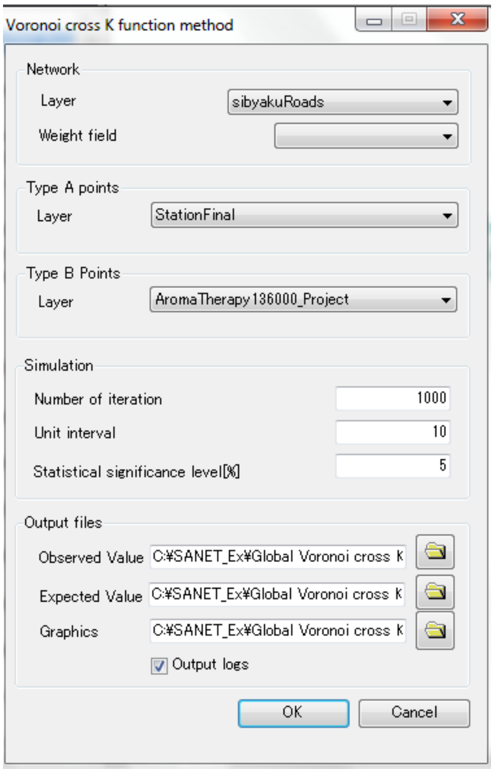
4.9 Tool 9: Global Voronoi cross *K* function method

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.



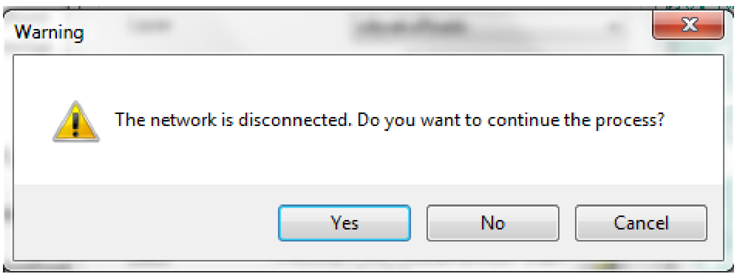
Then the following window appears.



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%).

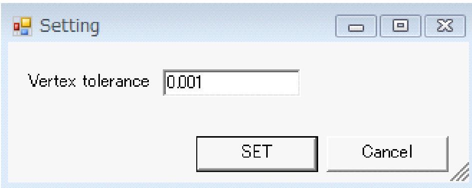
Choose the out file where the resulting files are stored.
Click "OK".
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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.

FID	Shape	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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	Type	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

	A	B	C
1	FromPntII	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	0	35	878.7134
13	0	35	878.7134
14	0	35	878.7134
15	0	36	482.9371
16	0	37	1244.961
17	0	39	109.9994
18	0	54	96.08572
19	0	57	948.8333
20	1	9	371.6719
21	1	[illegible]	[illegible]
…			
49	6	16	1181.68
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	

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.

	A	B	C	D	…		Z	AA	AB	AC	AD
1	10	20	30	4[illegible]		[illegible]50	260	270	280	290	30[illegible]
2	0	0	0	[illegible]		0	1	1	1	1	[illegible]
3	0	0	0	[illegible]		1	1	1	1	1	[illegible]
4	0	0	0	[illegible]		1	1	1	1	2	[illegible]
5	0	0	0	[illegible]		1	1	1	2	2	[illegible]
6	0	0	0	[illegible]	…	1	1	1	2	2	[illegible]

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.

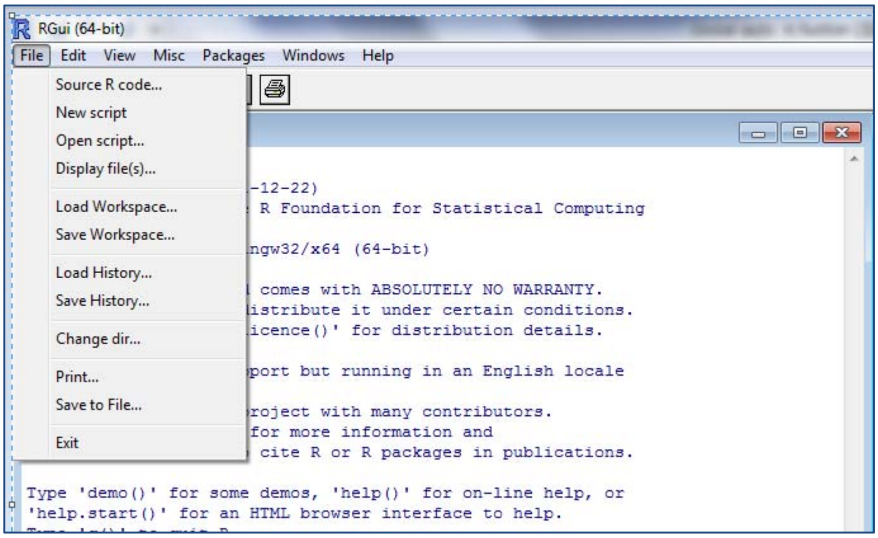
	A	B	C	D
1002	Simulation	FromPntID	ToPntID	Distance
1003	0	0	25	687.9144
1004	0	0	28	881.7677
1005	0	0	29	203.4705
1006	0	0	30	619.1696
1007	0	0	35	1169.918
1008	0	0	38	444.6335
1009	0	0	42	1720.276
1010	0	0	46	610.92
1011	0	0	55	643.8385
1012	0	0	57	444.1414
1013	0	1	4	634.5605
1014	0	1	5	333.1973
1015	0	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
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	…			
60993	999	11	21	149.4309
60994	999	11	36	799.0819
60995	999	11	45	438.0622
60996	999	12	5	789.6203
60997	999	12	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.

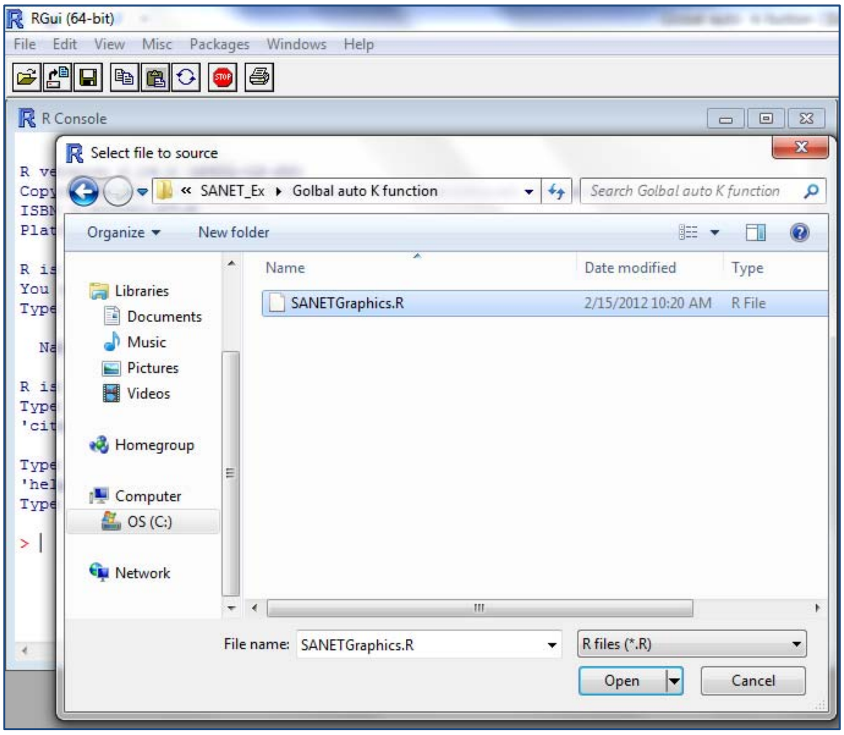
SANETGraphics.R

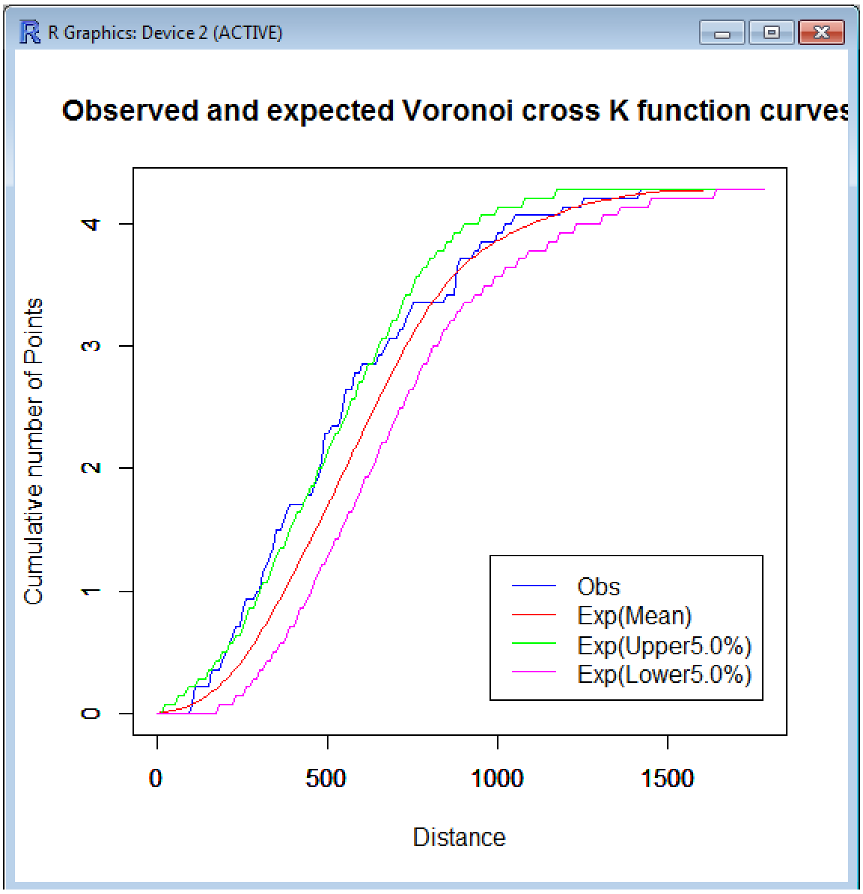
Launch R program, and click “Files”.

Then the following window appears.



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





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 $P_{\mathrm{N}}(p_0)$ of p_0, i.e.:

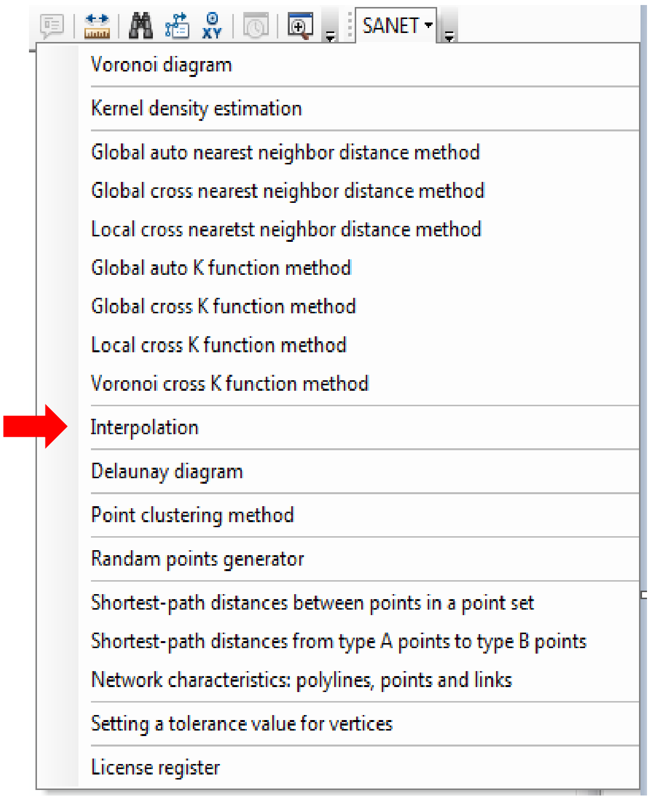
$$\hat{z}_0 = \sum_{p_i \in P_{\mathrm{N}}(p_0)} w_i z_i ,$$

where the weight w_i is given by:

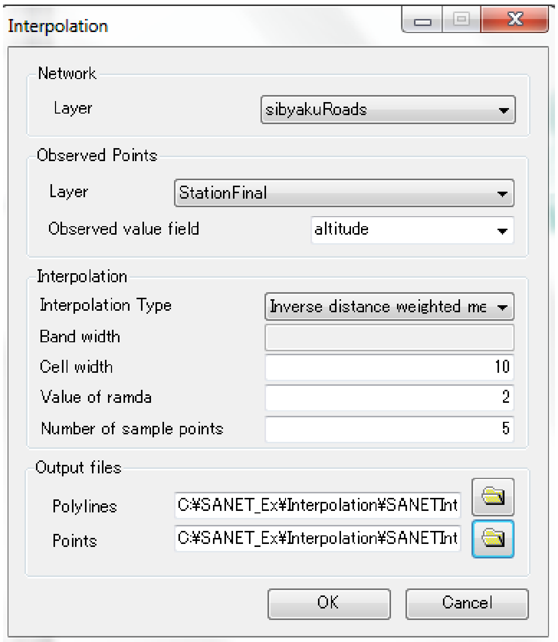
$$w_i = \frac{d_{\mathrm{S}}(p_0, p_i)^{-\alpha}}{\sum_{p_j \in P_{\mathrm{N}}} d_{\mathrm{S}}(p_0, p_j)^{-\alpha}} ,$$

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

Click "Interpolation".



Then the following window appears.



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 at which their attribute values are known (e.g., StationFinal: 14 railway stations in Shibuya ward, Tokyo, where their altitudes are known).

Choose ▼ the field in which weights are given.

Choose ▼ "Inverse distance weighting method".

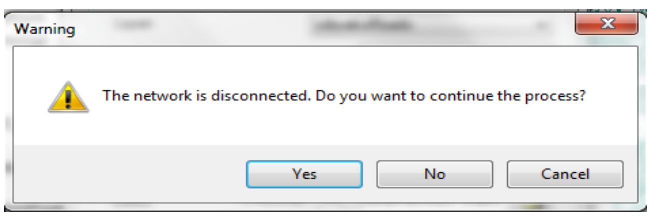
Fill in

- 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 $P_N(p_0)$, say 3-6.

Choose  the output file where the resulting files are stored

Click "OK" .

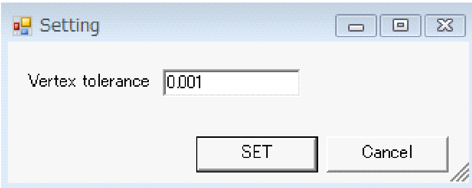
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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.

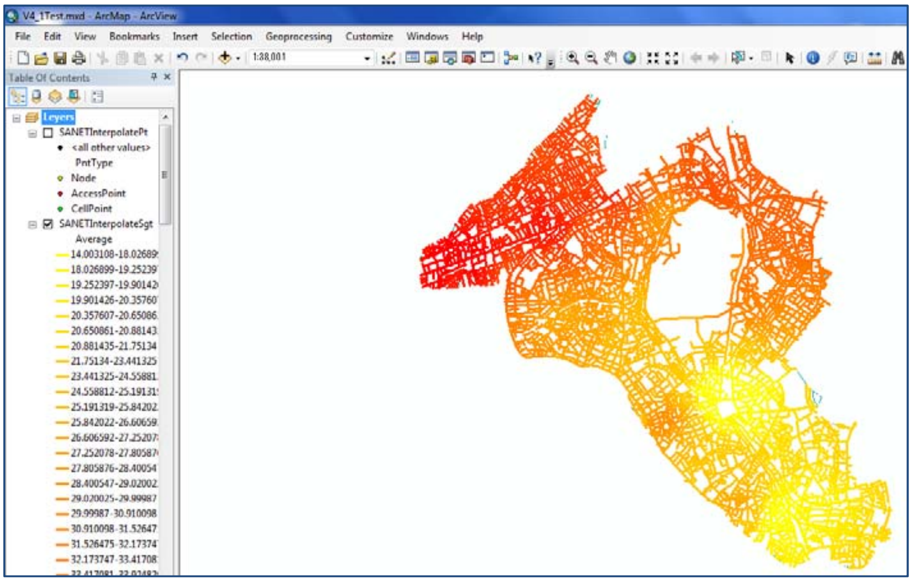
***

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).

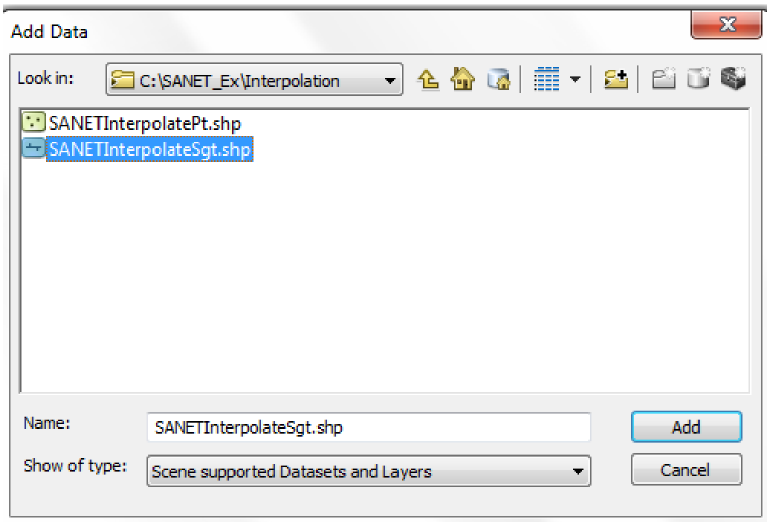
If you do not have any trouble such as memory overflows, you obtain the following six files in the output file and one figure in the ArcMap window.

Name	Date modified	Type	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

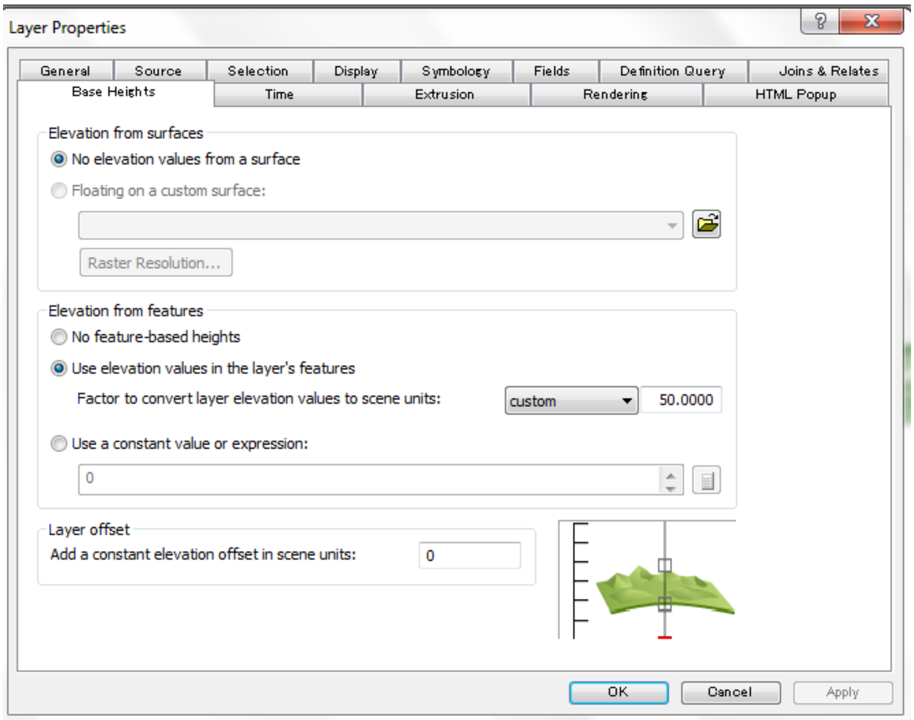


If you want to represent this figure in 3D, launch ArcScene.

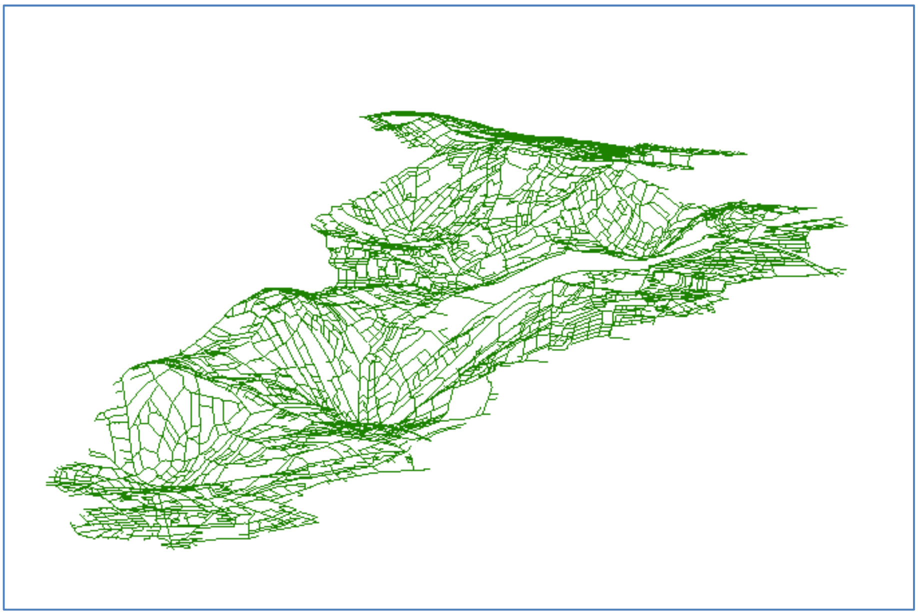
Add data  SANETInterpolateSgt.shp.



Left-click “SANETKDensitySgt” and choose ▼ “Properties” and next “Base hights”.
Check “No elevation from surface”.
Choose ▼ “custom” and choose ▼ a factor, say 50.
Click "apply" and "OK".



Then the following figure is obtained in the ArcScene window.



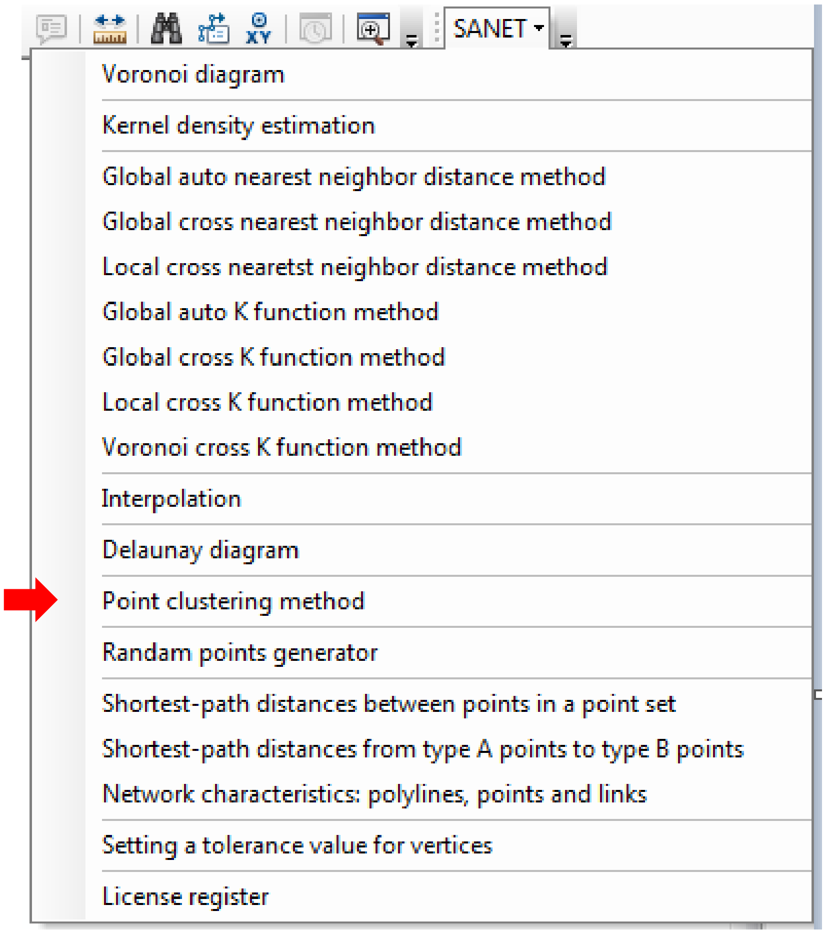
Reference

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.

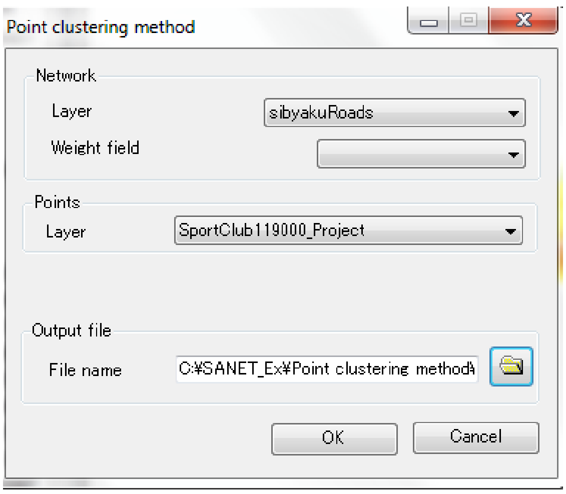
4.12 Tool 12: Point clustering method

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.



Then the following window appears.

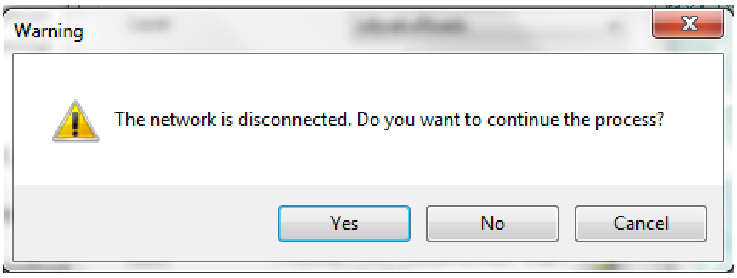


Choose ▼ the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo).
(Ignore “Weight field”.)
Choose ▼ the file name of a set of points (e.g., SportClub119000_Project: 21 sports club houses in Shibuya ward, Tokyo).

Choose  the output file where the resulting files are stored

Click “OK” .

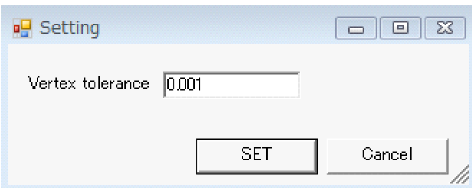
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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.

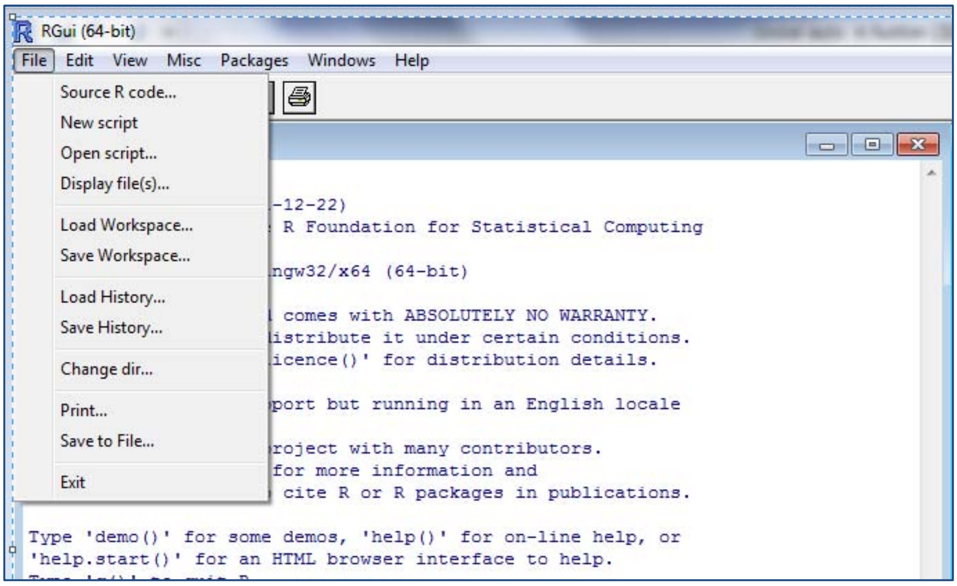
***

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

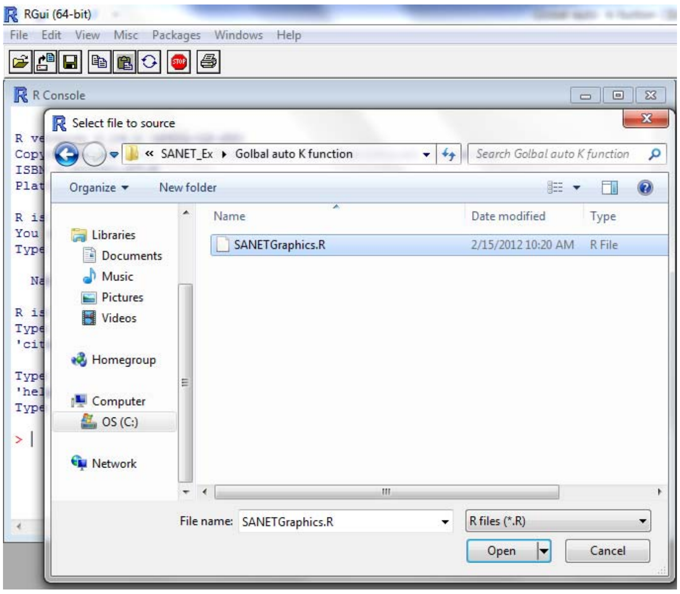
Note that for 21 points on the street network in Shibuya, Tokyo consisting of 7858 links and 5905 nodes, the computational time was 3 seconds using the machine: Intel (R) Core (TM) i7-2670QM, CPU 2.20GHz, Memory 8GB, 64-bit (Dell XPS L502X).

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

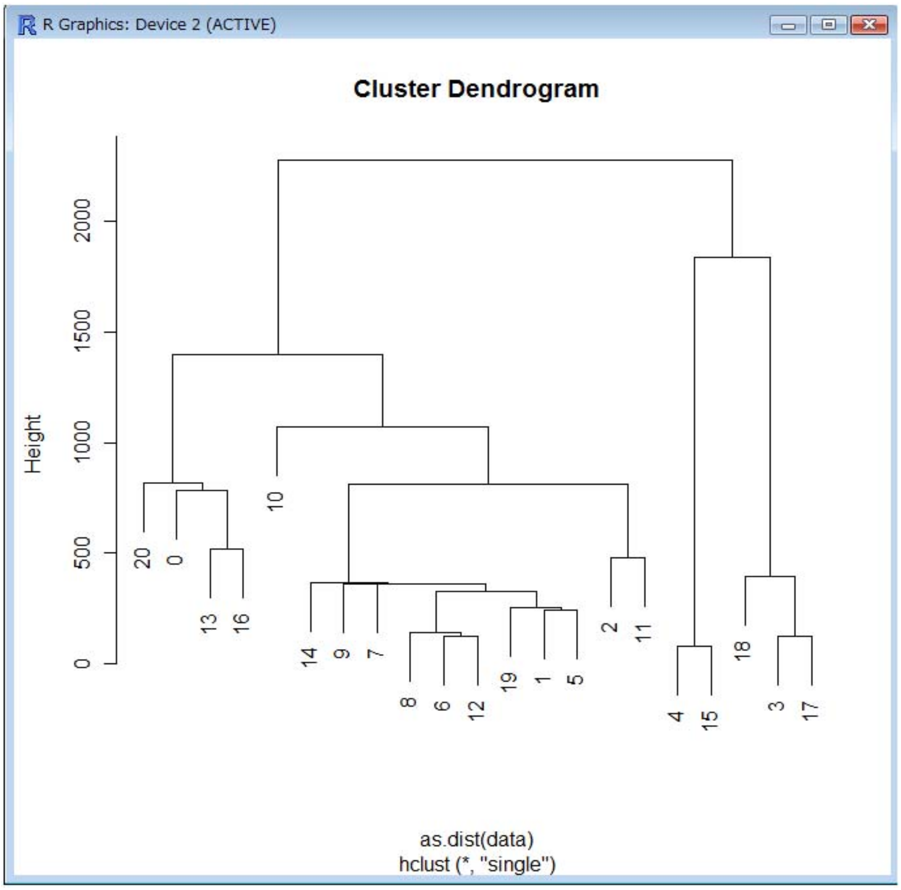
Launch R program, and click “Files”.
Then the following window appears.



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



Then the following dendrogram is obtained.



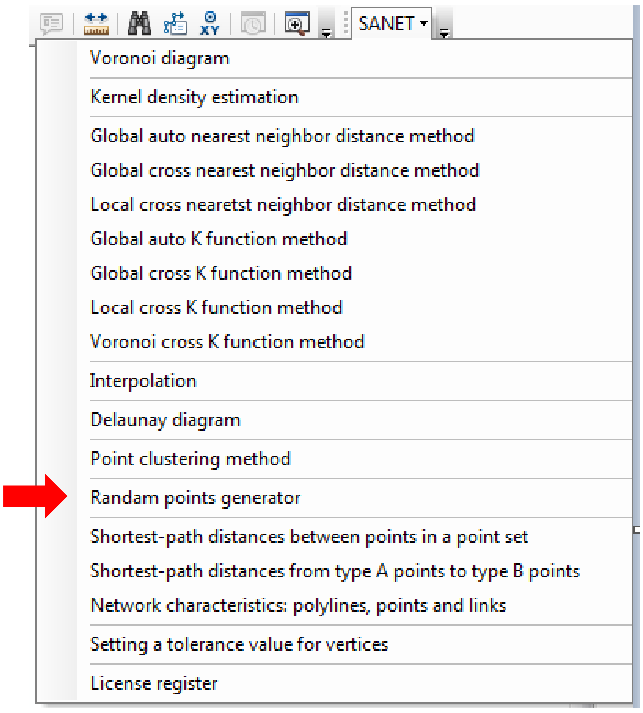
Reference

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.

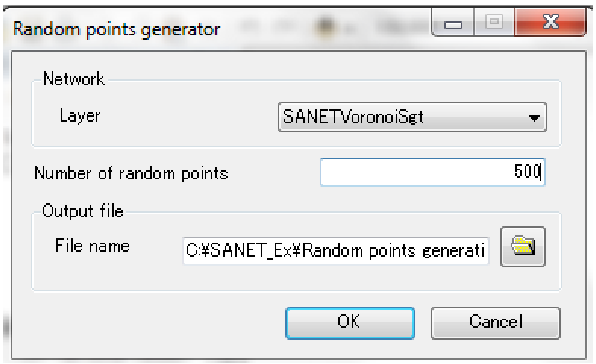
4.13 Tool 13: Random points generation

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.



Then the following window appears.



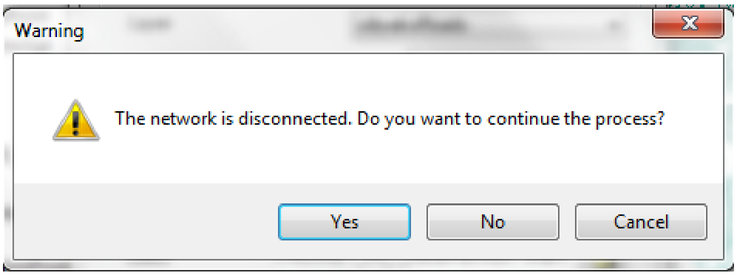
Choose ▼ the file name of a network (e.g., sibyakuRoas: the street network in Shibuya ward, Tokyo).

Fill in the number of random points, say 500.

Choose  the output file where the resulting files are stored

Click "OK".

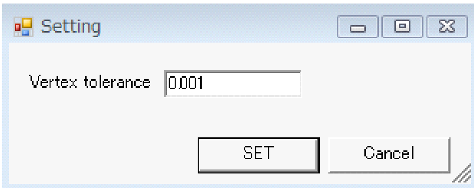
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



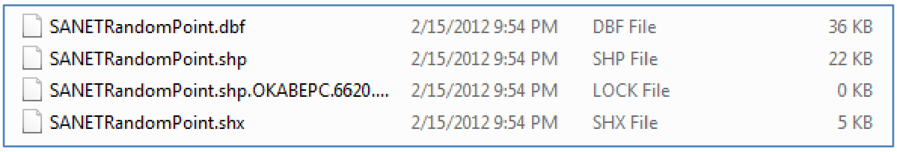
The "Vertex tolerance" means that if the distance between two nodes (vertexes) is less than 0.001 (the unit depends on the scale of the map you are using), then two vertices are regarded as the same. You change the tolerance distance and try again. If your network is still disconnected, you are supposed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

***

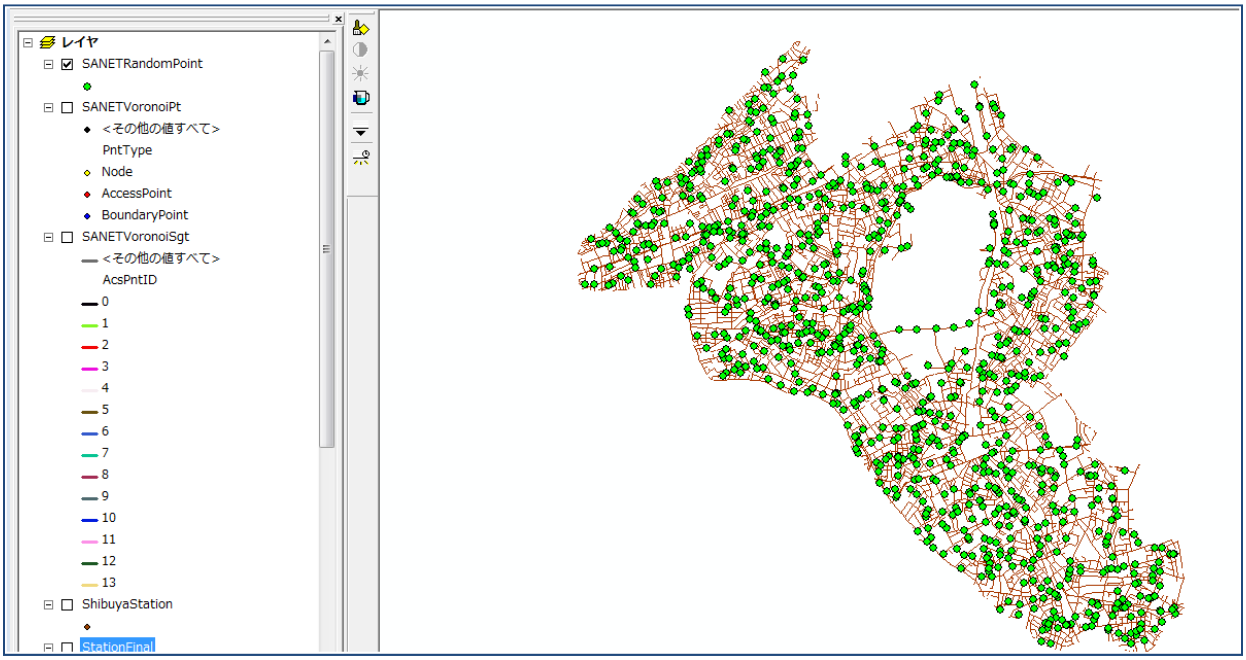
If the network is completely connected or if you click "Yes" in the warning window, the program begins to run.

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.



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



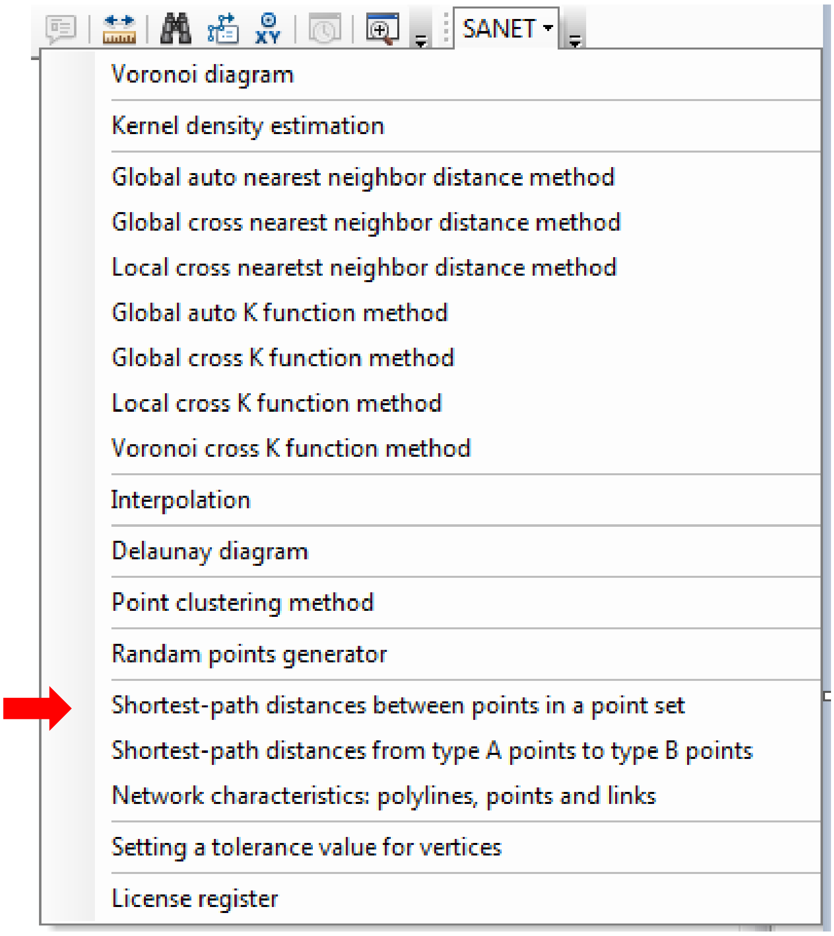
Reference

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.

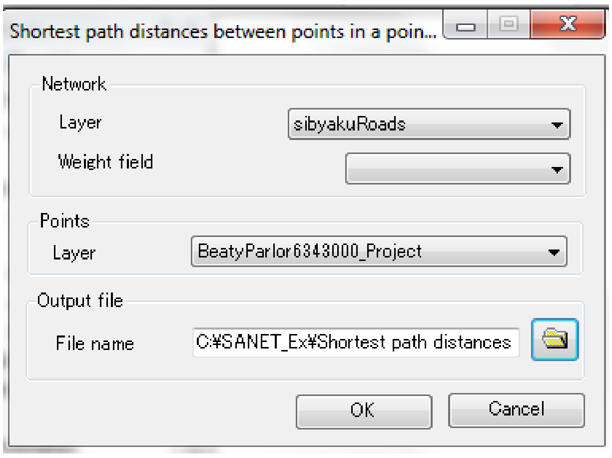
4.14 Tool14: Shortest-path distances between points in a set of points

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.



Then the following window appears.

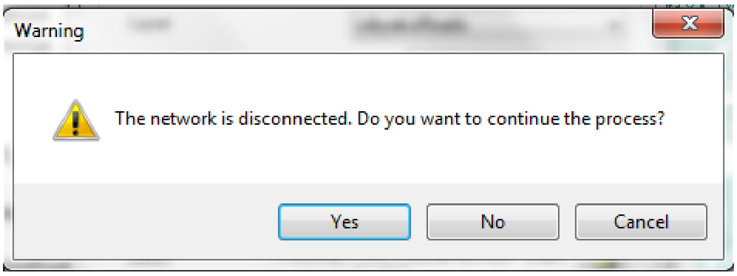


Choose ▼ the file name of a network (e.g., sibyakuRoad: the street network in Shibuya ward, Tokyo). (Ignore “Weight field”.)
Choose ▼ the file name of a set of points (e.g., BeautyParlor6343000_Project: 894 beauty parlors in Shibuya ward, Tokyo)

Choose  the output files where the resulting files are stored

Click “OK”.

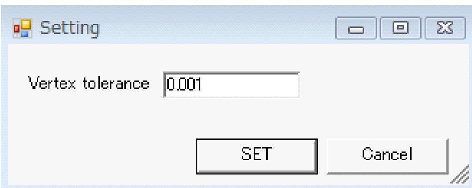
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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.

	A	B	C
1	FromPntID	ToPntID	Distance
2	0	1	2613.53
3	0	176	2613.53
4	0	361	2613.53
5	0	411	2613.53
6	0	746	2613.53
7	0	2	322.7458
8	0	3	1170.477
9	0	4	757.0587
10	0	5	2372.831
…			
798338	893	886	2749.405
798339	893	887	2893.696
798340	893	888	1793.194
798341	893	890	1146.054
798342	893	891	2697.865
798343	893	892	3183.727
798344	AVERAGE	2287.403	

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 0^{th} point to the first point is 2613.53, and so forth.

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

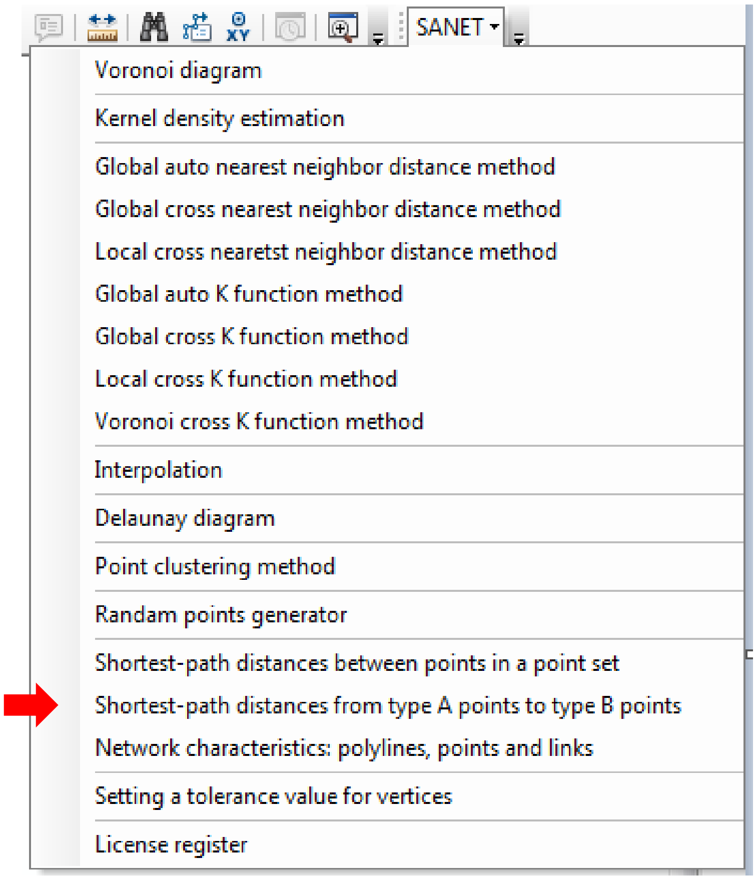
Reference

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.

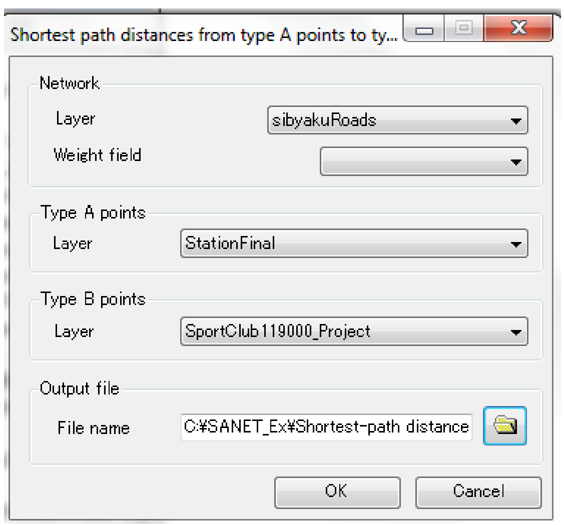
4.15 Tool 15: Shortest -path distances from type A points to type B points

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.



Then the following window appears.

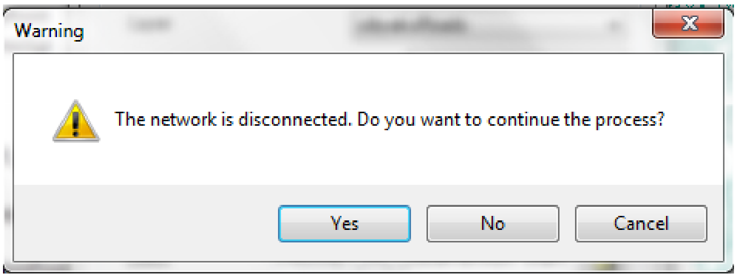


Choose ▼ the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward,

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 ▼ the file name of a set of type B points (e.g., StationFinal: 14 railway stations in Shibuay ward, Tokyo).

Choose  the output file where the resulting files are stored

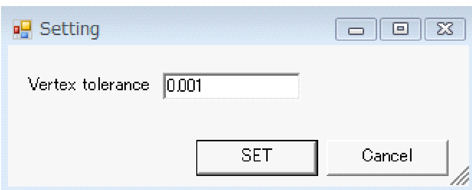
Click “OK”.
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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

The contests are as follows.

	A	B	C
1	TypeA	TypeB	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 0^{th} sport club to the 0^{th} station is 543.7987.

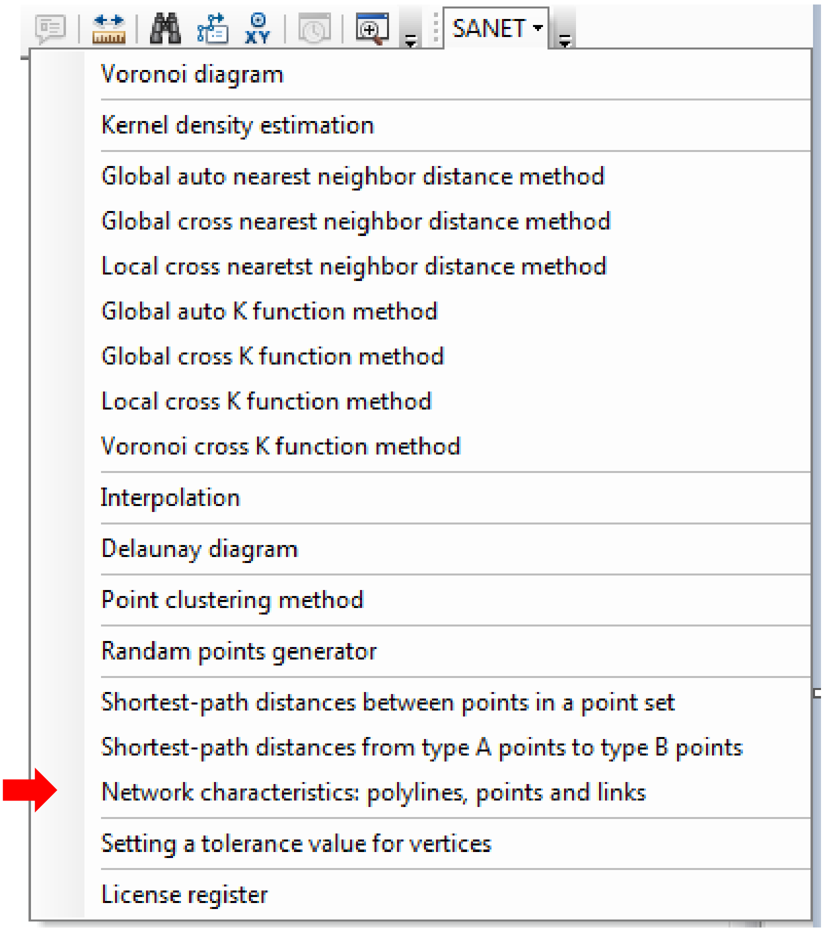
Reference

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.

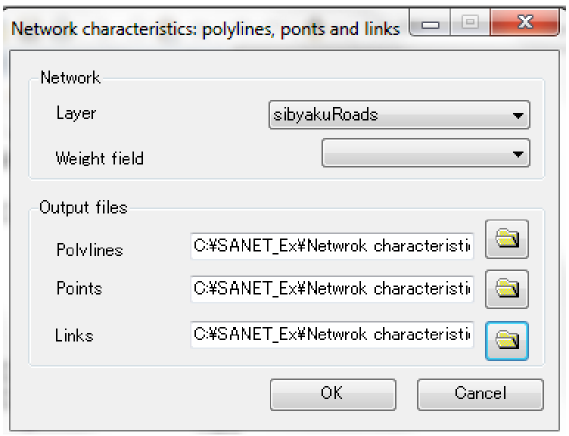
4.16 Tool 16: Network characteristics: polylines, points and links

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.



Then the following window appears.



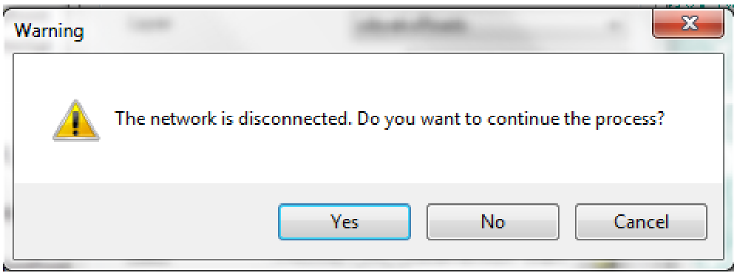
Choose ▼ the file name of a network (e.g., sibyakuRoads: the street network in Shibuya ward, Tokyo).

(Ignore "Weight field".)

Choose  the output file where the resulting files are stored

Click “OK”.

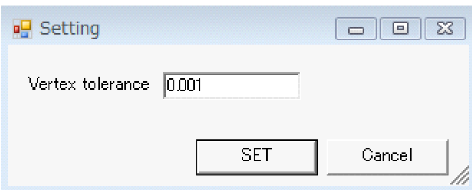
If the following window does not appear, the network is completely connected. Proceed to the next step marked by *** below.



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	SgtID	FromX	FromY	FromZ	ToX	ToY	ToZ	FromPntID	ToPntID	Length	Weight	AcsPntID
3157	Polyline ZM	1CBD942	-15319.4	-36351.1	0	-15317.6	-36410.9	0	1CBE7040	1CBE7170	59.827084	59.827084	0
3158	Polyline ZM	1CBD949	-15317	-35867	0	-15319.113143	-35866.459429	0	1CBE7208	1CBE70D8	2.18119	2.18119	0
3159	Polyline ZM	1CBD950	-15322.730473	-35866.760873	0	-15343.367283	-35879.180311	0	1CBE72A0	1CBE7338	24.085689	24.085689	20
3160	Polyline ZM	1CBD957	-15313	-36349.1	0	-15319.4	-36351.1	0	1CBE73D0	1CBE7040	6.705222	6.705222	0
3161	Polyline ZM	1CBD95E	-15312.8	-36319.6	0	-15313	-36349.1	0	1CBE7468	1CBE73D0	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.



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	Type	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

SANETNetworkLink.csv

	A	B	C	D
1	PntID	SgtID	AdjacentPntID	FromToFlg
2	6A835F78	21590478	6A8360A8	From
3	6A835F78	21590408	6A835DB0	To
4	6A835F78	2158E798	6A837E58	To
5	6A835F78	2158E4F8	6A838150	From
6	6A8360A8	21590478	6A835F78	To
7	6A8360A8	22395260	7D4AB808	From
8	6A835DB0	21590408	6A835F78	From
9	6A835DB0	21590398	6A836010	To
10	6A835DB0	2158E878	6A837F88	To
11	6A836010	21590398	6A835DB0	From
12	6A836010	21590328	6A835EE0	To
13	6A836010	2158E728	6A838020	To
14	6A835EE0	21590328	6A836010	From
15	6A835EE0	215902B8	6A835D18	To
16	6A835EE0	21591048	6A840650	From

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	B	C	D
1	PntID	X	Y	Z
2	6A835F78	-14780.4	-35597	0
3	6A8360A8	-14772.9	-35644.4	0
4	6A835DB0	-14786.4	-35566.6	0
5	6A836010	-14801	-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

SANETNetworkSgt.csv

	A	B	C	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	215901D8	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

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.