# Pattern Tours, Part 3: Representing Tours

In order to deal with tours, both representations for understanding them and representations for creating and manipulating them are needed.

Graphical Representations

IThe first two articles on pattern tours [1-2] showed tours by lines drawn though the cells in the order of traversal. The beginning of a tour was shown in red and the end in green for two reasons: for ease in identifying these important locations and for establishing the direction of transversal.

This method works well for many tours in giving an overall impression of their geometries. Here is an example:
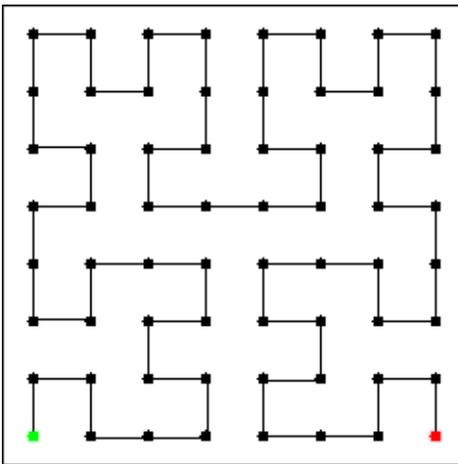

Grid lines may help identify specific locations:
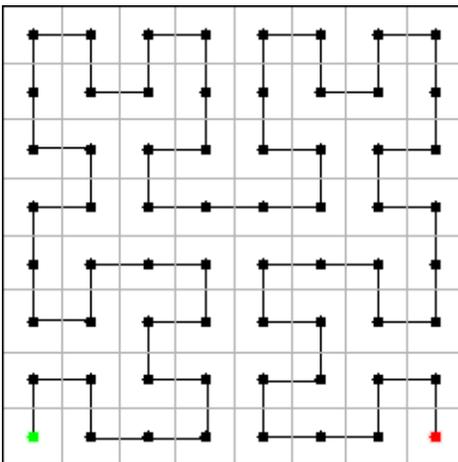
If, however, the tour is non-planar, line crossings may make the tour difficult to follow. And if the tour is chaotic and has many criss-crossing jumps, such a graphic representation may be a

useless jumble:
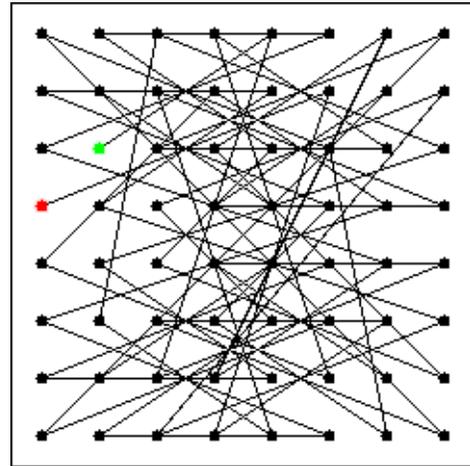
This representation also is ambiguous. There is no way to tell if a line through several cells includes all the cells on the line or jumps over some.

An alternative graphical method is to dispense with the lines and assign numbers to the cells that specify the order of traversal. Again, the ends can be highlighted by colors:

| 7	53	41	27	2	52	48	30
12	58	38	24	13	63	35	17
51	1	29	47	54	8	28	42
64	14	18	36	57	11	23	37
25	43	55	5	32	46	50	4
22	40	60	10	19	33	61	15
45	31	3	49	44	26	6	56
34	20	16	62	39	21	9	59

This numerical representation has the virtue of being precise and unambiguous. It may be difficult, however, to locate successive cells on a tour.

An alternative that is sometimes used is to overlay the line and numbered grid representations as in:
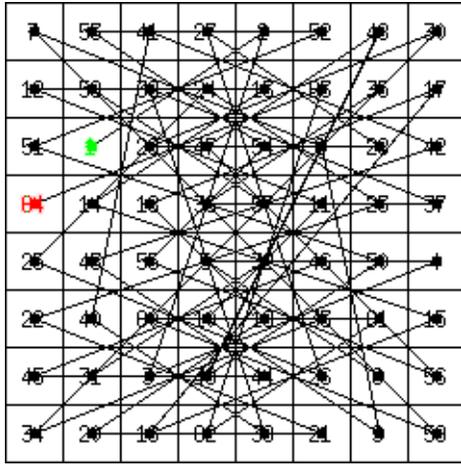
Except for small, simple tours, the result may be worse than either of the two forms separately. Both numbered grids and line drawings in situations are needed where a clear understanding of a tour is required. An example is:
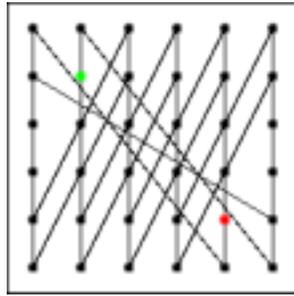

Data Representations

In order to write procedures for manipulating tours, data representations that a computer program can use are necessary. These are very different from the graphical representations that human beings find easy to understand.

Coordinate Lists

One data representation of a tour as a list of cell locations. For this, A systematic way of identifying locations on a grid is needed.

The dimensions of a grid in cells are given by two numbers, w for the width in cells and h:
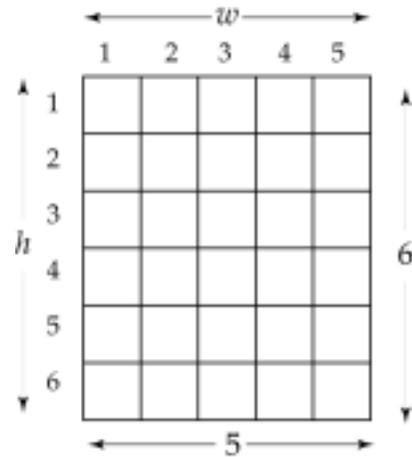
Rows and columns are numbered as indicated. The location of a cell is given by its coordinates, which is a pair (i, j) in which i is the column number of the cell and j is the row number of the cell. For example, in
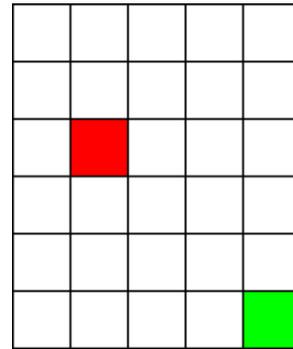
the coordinates of the red cell are $(2, 3)$ and the coordinates of the green cell are $(5, 6)$.

A tour then can be represented by a list of coordinates in the order of traversal. For example, the tour
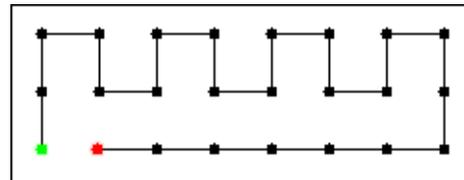
has the coordinate list

(1, 3), (1, 2), (1, 1), (2, 1), (2, 2), (3, 2), (3, 1), (4, 1), (4, 2), (5, 2), (5, 1), (6, 1), (6, 2), (7, 2), (7, 1), (8, 1), (8, 2), (8, 3), (7, 3), (6, 3), (5, 3), (4, 3), (3, 3), (2, 3)

To apply a band to a tour represented by a coordinate list, it is only necessary to pair the coordinate list with the band and place the colors of the band, in order, at the designated succession of

locations. For example, reducing the type size of the coordinate list for the tour above and drawing a band below it provide a complete specification for a pattern:

(1,3),(1,2),(1,1),(2,1),(2,2),(3,2),(3,1),(4,1),(4,2),(5,2),(5,1),(6,1),(6,2),(7,2),(7,1),(8,1),(8,2),(8,3),(7,3),(6,3),(5,3),(4,3),(3,3),(2,3)

The resulting pattern is:
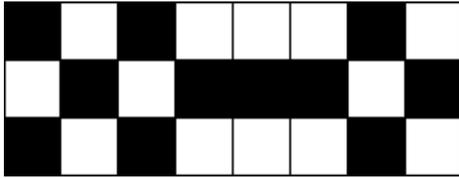
Navigational Representations

Methods for describing tours, which are particularly useful in some constructing some kinds of tours, use navigation rather than specific coordinates.

For von Neumann paths, a list of compass points that specify the direction of one cell to the next is sufficient. Given the neighborhood labels in terms of compass points, as in
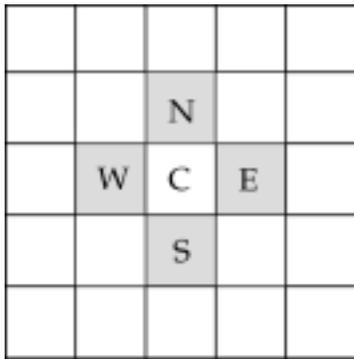
the cell following C can be indicated by a letter that corresponds to the direction of movement. For example, for the tour
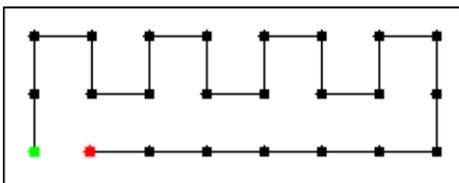
the sequence of directional moves is given by the string of letters

NNESENESENESENESSWWWWWW

Such a string and the location of the starting cell completely characterize von Neumann tours and in a much more compact way than coordinate lists.

As given above, direction strings are limited to von Neumann tours. There is, for example, no way to specify a diagonal move. The concept of direction string could be extended to include Moore tours by adding letters for the diagonal moves. A more general method, that can be used for all tours, is to provide a way for specifying passing over cells without including them on the tour. We'll use lowercase letters for this: nesw in addition to NESW. For example, the Moore tour
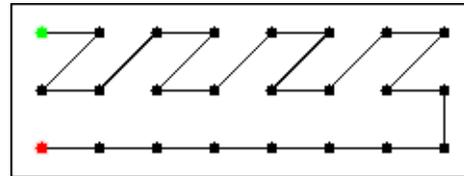
is described by the direction string

EsWEeNEEsWEeNEEsWEeNEsWES
WWWWWWW

Of course sW is equivalent to wS, and so on.

Using this navigational method, it is not necessary to specify the starting cell. Assuming the string starts at the upper-left corner, the first location on the tour can be reached by a string of nesw moves at the beginning.

Although this method is completely general, it is cumbersome for tours in which there are long jumps.

In cases of specialized neighborhoods, such as the knight's, a customized navigational system can be used. Here's the knight' neighborhood with the cells that can be reached lettered clockwise around the knight:
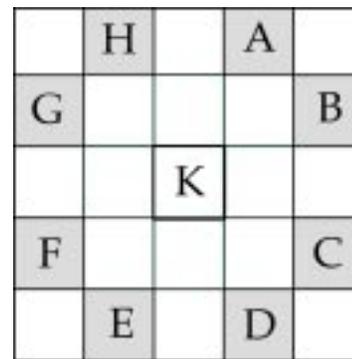
For this fragmentary tour
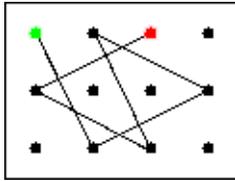
the navigational string is DBGDGB.

There are many possible navigational alternatives to these kinds of navigational strings. An attractive one is to use L-System notation in which the symbols used are interpreted to draw images [3]. Adapted to describing tours, these symbols are:

F   move forward, including cell on tour

f   move forward, not including cell on tour

+   turn right 90°

–   turn left 90°

The initial direction is east and that the starting point is the upper-left corner.

For example, the von Neumann tour shown earlier:

can be represented by the L-System string

+ffFF+F+F–F–F+F+F–F–F+F–F–F+FF+FFFFFF

The initial +ff gets to the first location on the tour.

The Moore tour shown earlier
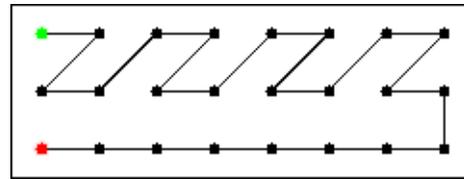
can be represented by

F+f+Ff–F+f+Ff–F+f+F+f–F+f+F++F+ fFFFFFF

Again, diagonal moves can be represented in different ways. For example, f–F produces the same result as –fF.

An advantage of using the L-System method is that there is a large body of knowledge associated with them. And this material includes some interesting tours.

References:

1. *Pattern Tours, Part 1: Basic Concepts*, Ralph E. Griswold, 2004:
   http://www.cs.arizona.edu/patterns/ weaving/webdocs/gre_dt01.pdf

2. *Pattern Tours, Part 2: Tour Basics*, Ralph E. Griswold, 2004:
   http://www.cs.arizona.edu/patterns/weaving/webdocs/gre_dt02.pdf

3. *Designing with L-Systems, Part 2: A Side Trip to Graphics*, Ralph E. Griswold, 2004:
   http://www.cs.arizona.edu/patterns/weaving/webdocs/gre_ls02.pdf

Ralph E. Griswold
Department of Computer Science
The University of Arizona
Tucson, Arizona

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