Mathcad Community Challenge September 2025:
Djikstra's Algorithm Inspired Programming Challenge

using Prime 11 Express **Alan Stevens**

Challenge 1: Known Points

For the provided points, write a program to calculate the shortest path from the first node (5,5) to all other nodes, always choosing the shortest path from the current node.

Feel free to use Mathcad's random number generator functions to make your own points instead. You can also start from a different point of your choosing if you so desire.

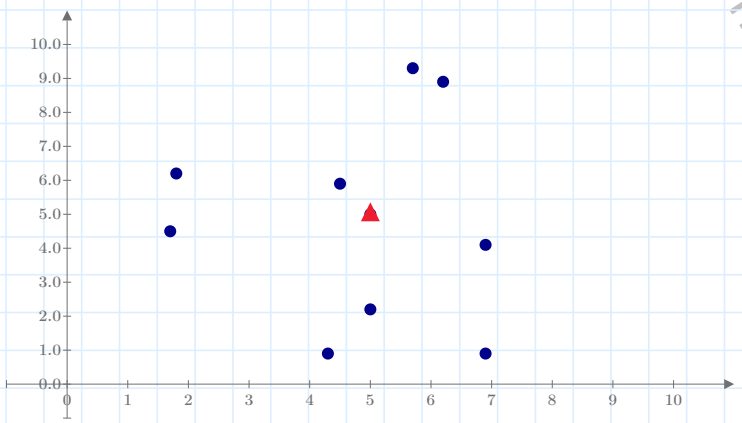
Generate random data points (but fix the start point)

$n := 10$ $Nodes_{0,0} := 5.0$ $Nodes_{0,1} := 5.0$

$i := 1 .. n-1$ $Nodes_{i,0} := \frac{\text{floor}(\text{rnd}(n) \cdot n)}{n}$ $Nodes_{i,1} := \frac{\text{floor}(\text{rnd}(n) \cdot n)}{n}$

$$Nodes = \begin{bmatrix} 5.0 & 5.0 \\ 6.9 & 0.9 \\ 4.3 & 0.9 \\ 5.7 & 9.3 \\ 6.2 & 8.9 \\ 5.0 & 2.2 \\ 6.9 & 4.1 \\ 1.8 & 6.2 \\ 1.7 & 4.5 \\ 4.5 & 5.9 \end{bmatrix}$$

Plot points (use red triangle for starting point)



Construct the following functions:

Given a matrix, P, of node coordinates, calculate each of their radial distances from the 'origin'.
The 'origin' will be the current node from which distances are being calculated.

$$fnR(P) := \sqrt{\left(P^{\langle 0 \rangle}\right)^2 + \left(P^{\langle 1 \rangle}\right)^2}$$

Augment P with a third column that contains the above distances and sort the resulting matrix based on those distances.

$$srt(P) := \mathrm{csort}\left(\mathrm{augment}\left(P^{\langle 0 \rangle}, P^{\langle 1 \rangle}, fnR(P)\right), 2\right)$$

Generate a vector of values that counts from the current start row to the last row

$$fn(start) := start\,..\,n-1$$

Calculate the appropriate node order and distances

Unfortunately, in the Express version of Prime the standard programming facility is unavailable, and nested iterative loops use the wrong logic for what is required here, so I've resorted to a cumbersome 'handraulic' set of repetitive statements. This is feasible, if ugly, for 10 nodes, but would be infeasible for many more.

The C matrix below collects the current node values in order, together with the distances from their 'origin'.

The set of remaining node coordinates are then offset by the those of the current node (P - C), and the result augmented by their distances and sorted in order of distance smallest to largest).

$P := Nodes$

$i := fn(0)$	$C^{\widehat{0}} := P^{\widehat{0}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{0}}$	$P := srt(P)$
$i := fn(1)$	$C^{\widehat{1}} := P^{\widehat{1}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{1}}$	$P := srt(P)$
$i := fn(2)$	$C^{\widehat{2}} := P^{\widehat{2}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{2}}$	$P := srt(P)$
$i := fn(3)$	$C^{\widehat{3}} := P^{\widehat{3}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{3}}$	$P := srt(P)$
$i := fn(4)$	$C^{\widehat{4}} := P^{\widehat{4}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{4}}$	$P := srt(P)$
$i := fn(5)$	$C^{\widehat{5}} := P^{\widehat{5}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{5}}$	$P := srt(P)$
$i := fn(6)$	$C^{\widehat{6}} := P^{\widehat{6}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{6}}$	$P := srt(P)$
$i := fn(7)$	$C^{\widehat{7}} := P^{\widehat{7}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{7}}$	$P := srt(P)$
$i := fn(8)$	$C^{\widehat{8}} := P^{\widehat{8}}$	$P^{\widehat{i}} := P^{\widehat{i}} - C^{\widehat{8}}$	$P := srt(P)$
	$C^{\widehat{9}} := P^{\widehat{9}}$		

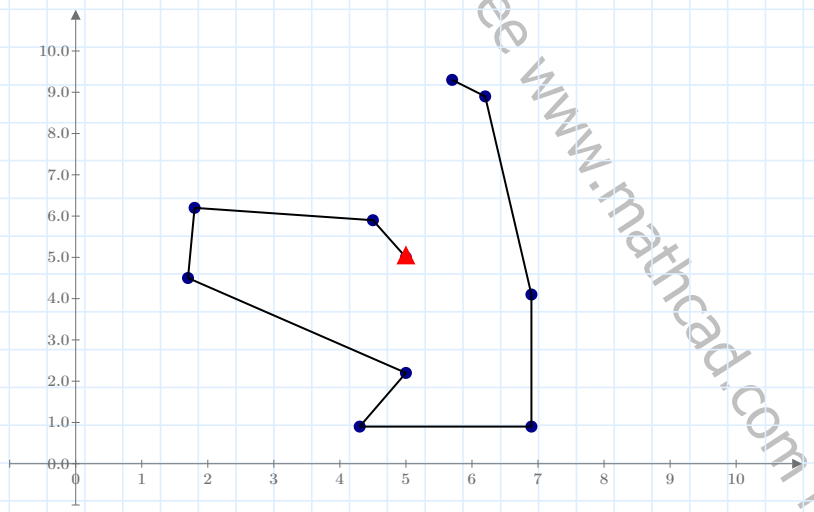
Reconstruct the absolute coordinates of the nodes, now in order, while simultaneously calculating the cumulatve distance along the path from start node to last (matrix K).

$\overset{\frown}{K^{0}} := \overset{\frown}{C^{0}} \qquad j := 1 .. n-1 \qquad \overset{\frown}{K^{j}} := \overset{\frown}{C^{j}} + \overset{\frown}{K^{j-1}}$

$$K = \begin{bmatrix} 5 & 5 & 0 \\ 4.5 & 5.9 & 1.03 \\ 1.8 & 6.2 & 3.746 \\ 1.7 & 4.5 & 5.449 \\ 5 & 2.2 & 9.472 \\ 4.3 & 0.9 & 10.948 \\ 6.9 & 0.9 & 13.548 \\ 6.9 & 4.1 & 16.748 \\ 6.2 & 8.9 & 21.599 \\ 5.7 & 9.3 & 22.239 \end{bmatrix} \qquad Total\_distance := K_{n-1,2} = 22.239$$

Challenge 2: Graphing

Create a Chart Component or XY Plot that graphs this path.



Challenge 3: Advanced Inputs

Incorporate advanced input controls to allow the user to change quantities such as the number of points or generate new points / path.

Not possible in Prime Express.

Challenge 4: 3D

Can you write a program that performs the same calculation, but for points in 3D instead of 2D?

It would be a trivial matter to add a third column to the C and P matrices above to represent z-axis coordinates, and to use a similar logic. However, this would suffer from the same limitations in Prime Express of absence of programming facilities. Prime Express also has no 3D plotting.