Solution performance and heuristics in closed and open versions of 2D Euclidean TSPs.

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Acknowledgements

Experiments reported here were designed and carried out in collaboration with Ed Chronicle and Tom Ormerod

Three of the experiments will be reported in a forthcoming article in the *Quarterly Journal of Experimental Psychology*.

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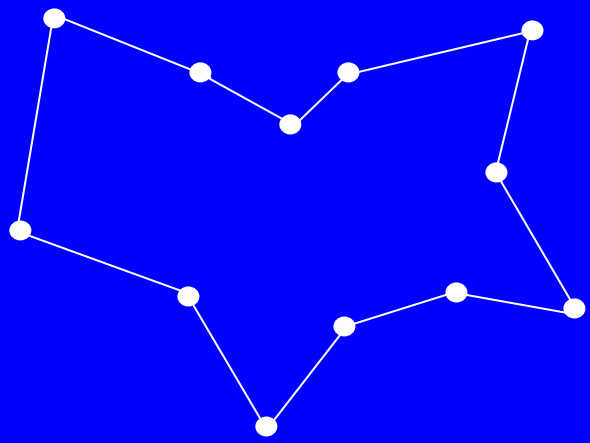
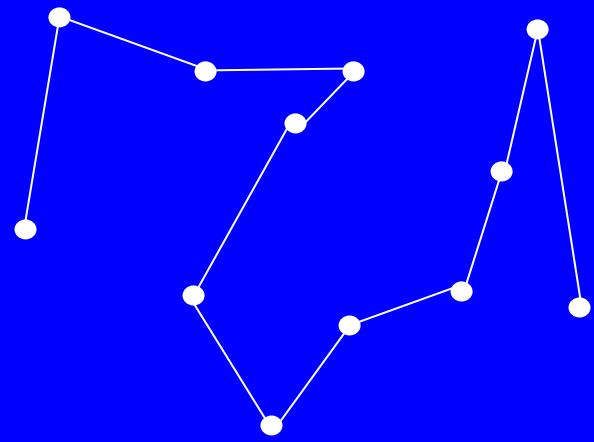
Four experiments compared performance of subjects on :

(a) Conventional closed tours, and;

(b) Open paths that required traversing the array from side to side





Motivation

Distinguish between competing approaches:

Global process
versus
Local process

Open versus closed paths

- Global process:

  Previously we suggested that E-TSPs are "easy" because of coincidence between task requirements and automatic perceptual tendencies

Open versus closed paths

- Specifically, the requirement to complete a circuit coincides with perception of boundary points as a contour around the array, which provides an effective cue.

Open versus closed paths

- Removing the circuit requirement would undo this connection, and may eliminate the usefulness of the boundary as a guide
- This suggests that “open” paths may be more difficult for people than “closed”paths

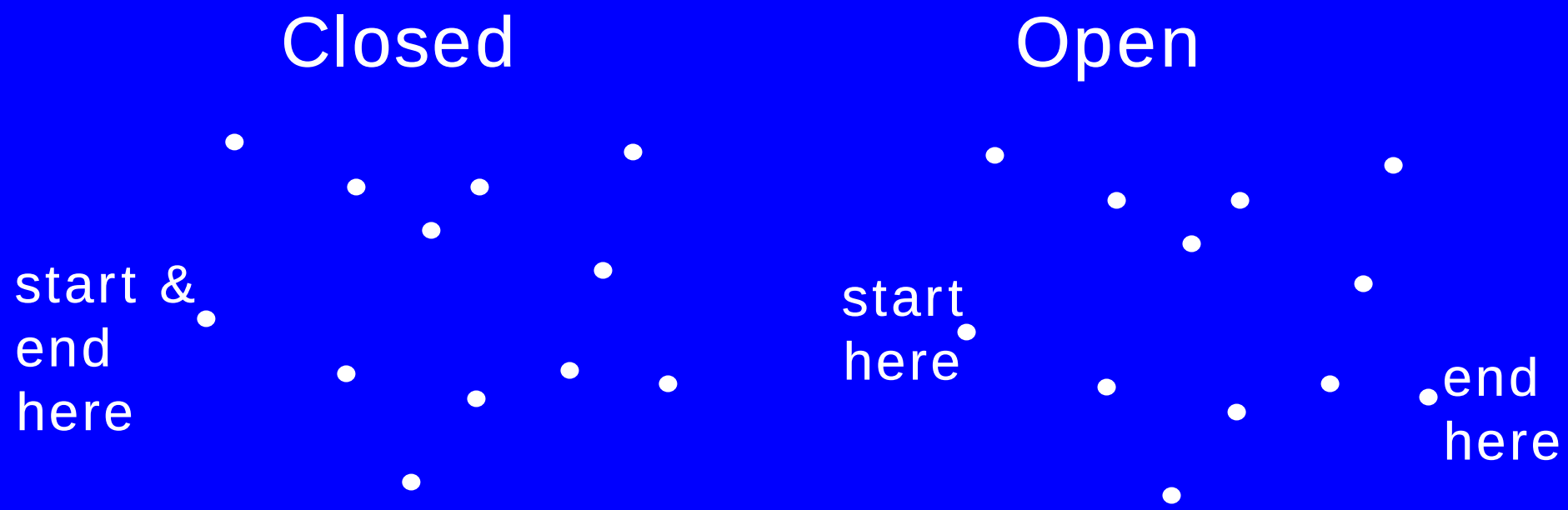
Open versus closed paths

- Global process view -- performance quality may differ between closed and open tours
- Local process view– performance quality should be the same on closed and open tours

Exp.1 : Open versus closed tours

- Stimuli : Twelve 12-point problems, six with 1 interior point, six with 6 interior points.

Exp.1 : Open versus closed paths stimuli



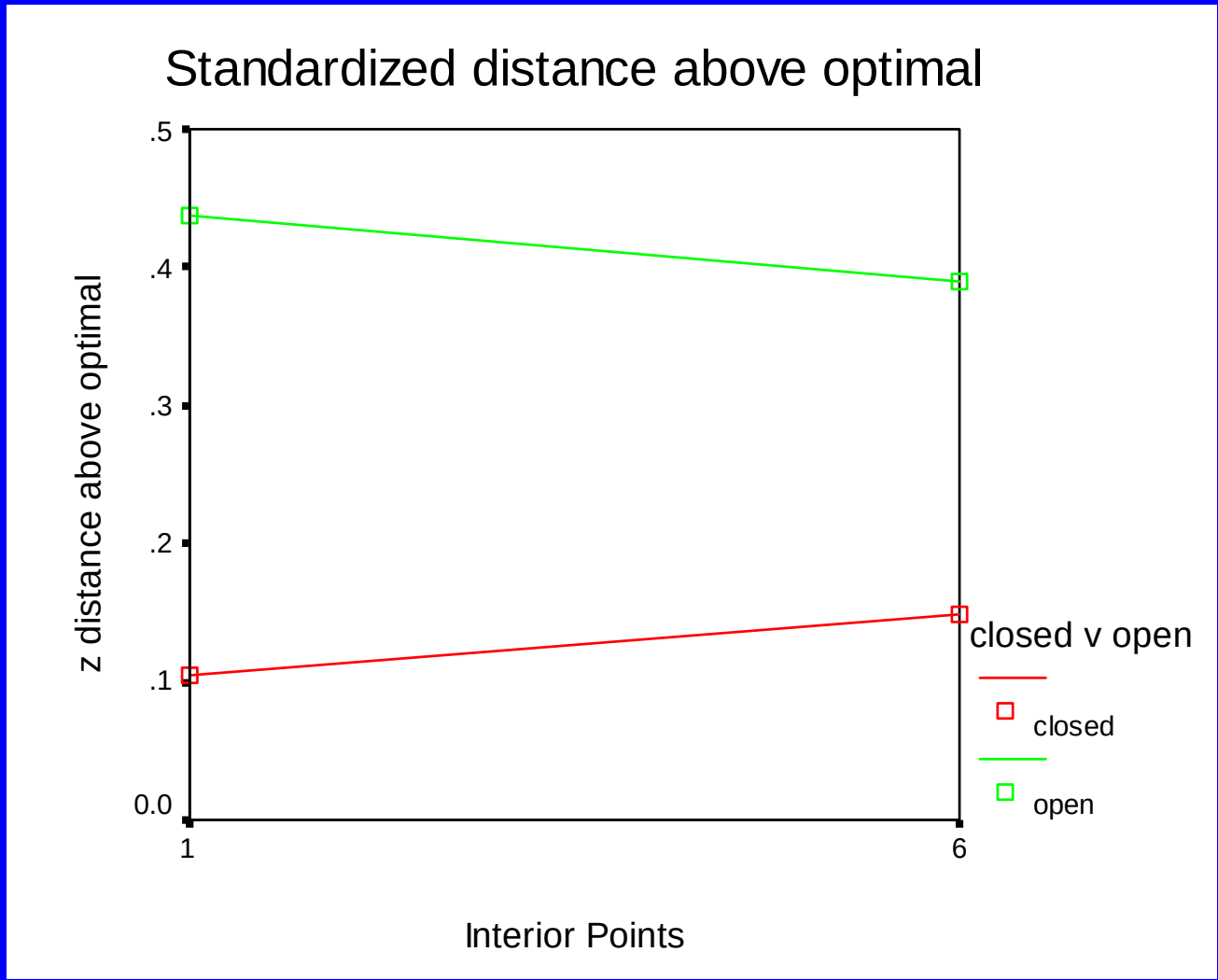
Exp.1 : Open versus closed tours stimuli

- The number of possible solutions =11!/2 for closed paths and 10! for open

- Closed paths have 5.5 times as many possible solutions as the open versions

Exp.1 : Results

	Path Type	
	Closed	Open
% of optimal solutions	52%	25%
PAO	3.20%	9.60%
zDAO	0.13	0.41


Standardized distance above optimal
z distance above optimal
.5
.4
.3
.2
.1
0.0
1
6
Interior Points
closed v open
closed
open

Conclusions

- An apparently trivial change in the task requirement, from closed to open path, affected solution quality

Conclusions

- Superior performance on closed versus open versions incompatible with a purely local process explanation

Conclusions

- Superior performance on closed versus open versions consistent with convex-hull hypothesis

Experiment 2

- Experiment 2 used 15 node problems.
- Problems were randomly generated until we found six each with 9 interior nodes
- The experiment used 96 subjects
- Half found open paths, half, closed tours

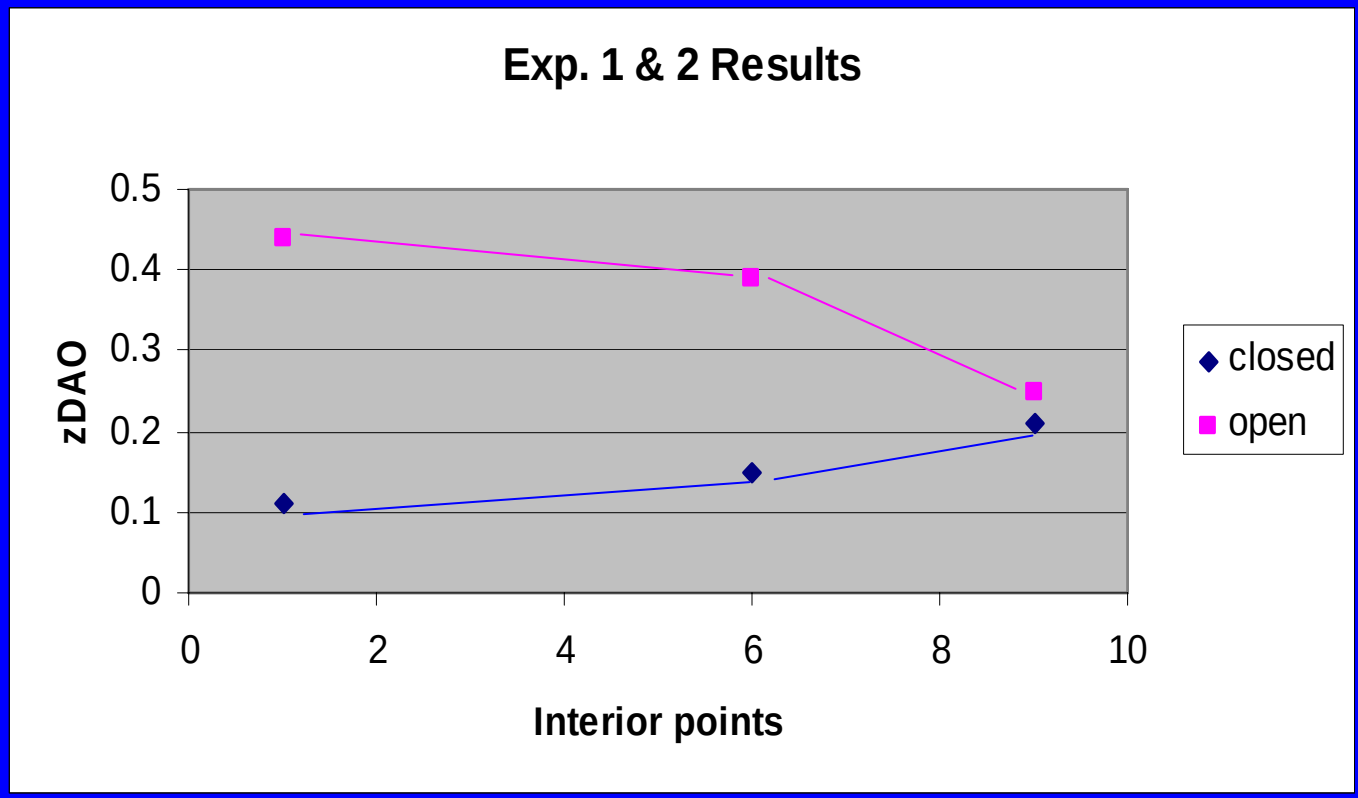
Experiment 2--Results

- No significant differences between performance on open tours and closed paths
- Mean standardized distances above optimal were .25 and .21 for the open and closed conditions, respectively
- Mean % above optimal were 6.1% and 4.1% for open and closed

Experiment 2--Results

- Compared to the Exp. 1 results, closed performance was poorer
- While open performance was better

Experiment 1 and 2--Results



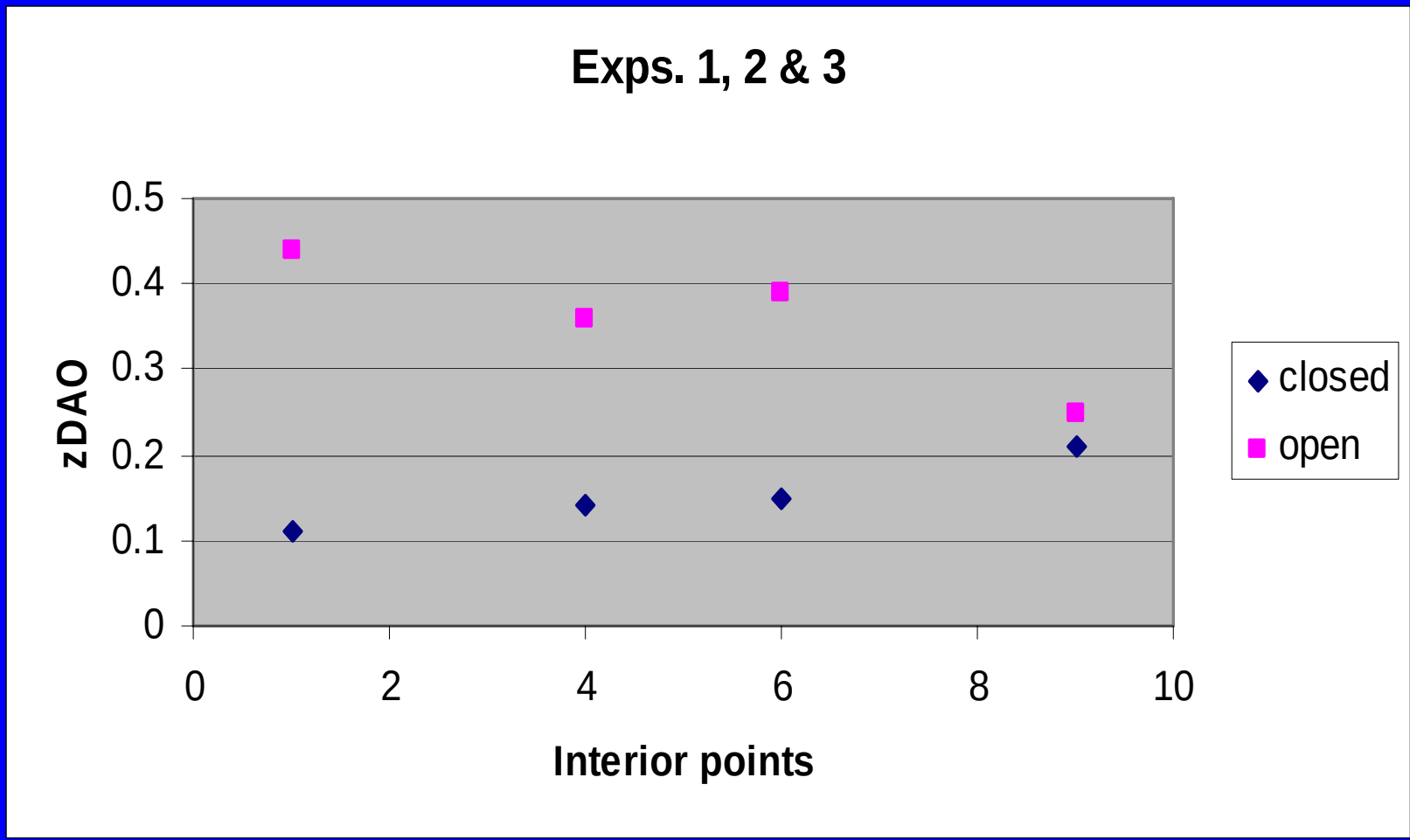
Experiment 3

- Experiment 3 again used 15 node instances.
- Problems were randomly generated until we found eight each with 4 interior nodes
- The experiment used 40 subjects
- Half found open paths, half, closed tours

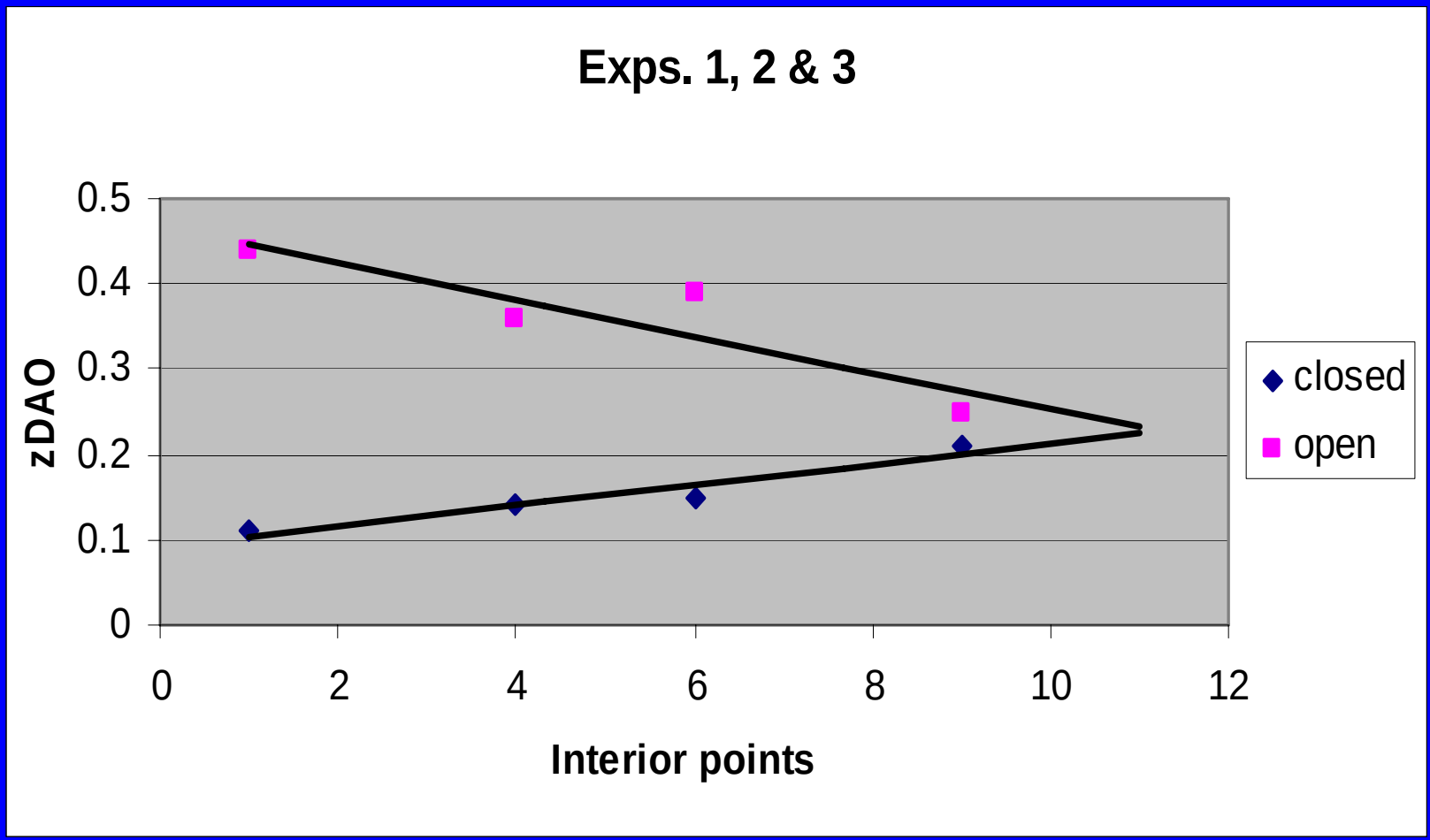
Experiment 3--Results

- Of the 290 scoreable solutions, 59 were optimal
- 43 of the optimal solutions occurred in the closed condition, 16 in the open
- zDAO averages were .14 for closed and .36 for open

Results for Exps. 1, 2 & 3



Results for Exps. 1, 2 & 3



Experiment 4

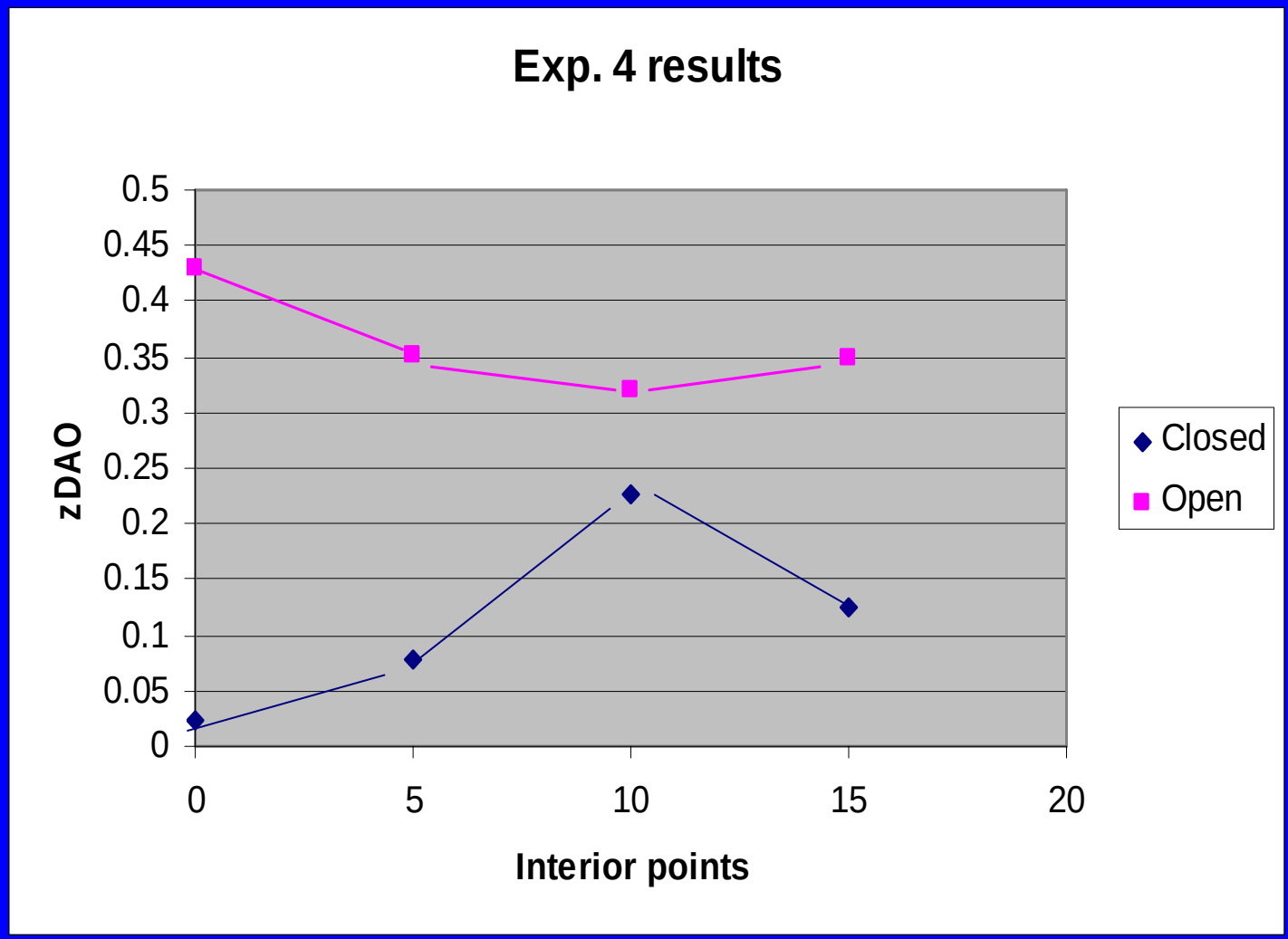
- Purpose was to test for these trends across a wider range of interior points, to see if they reach an asymptote, or intersect.
- The experiment used 20 node instances, two each of 0, 5, 10 and 15 interior points
- There were 83 participants, 42 in the Open condition and 41 in the closed

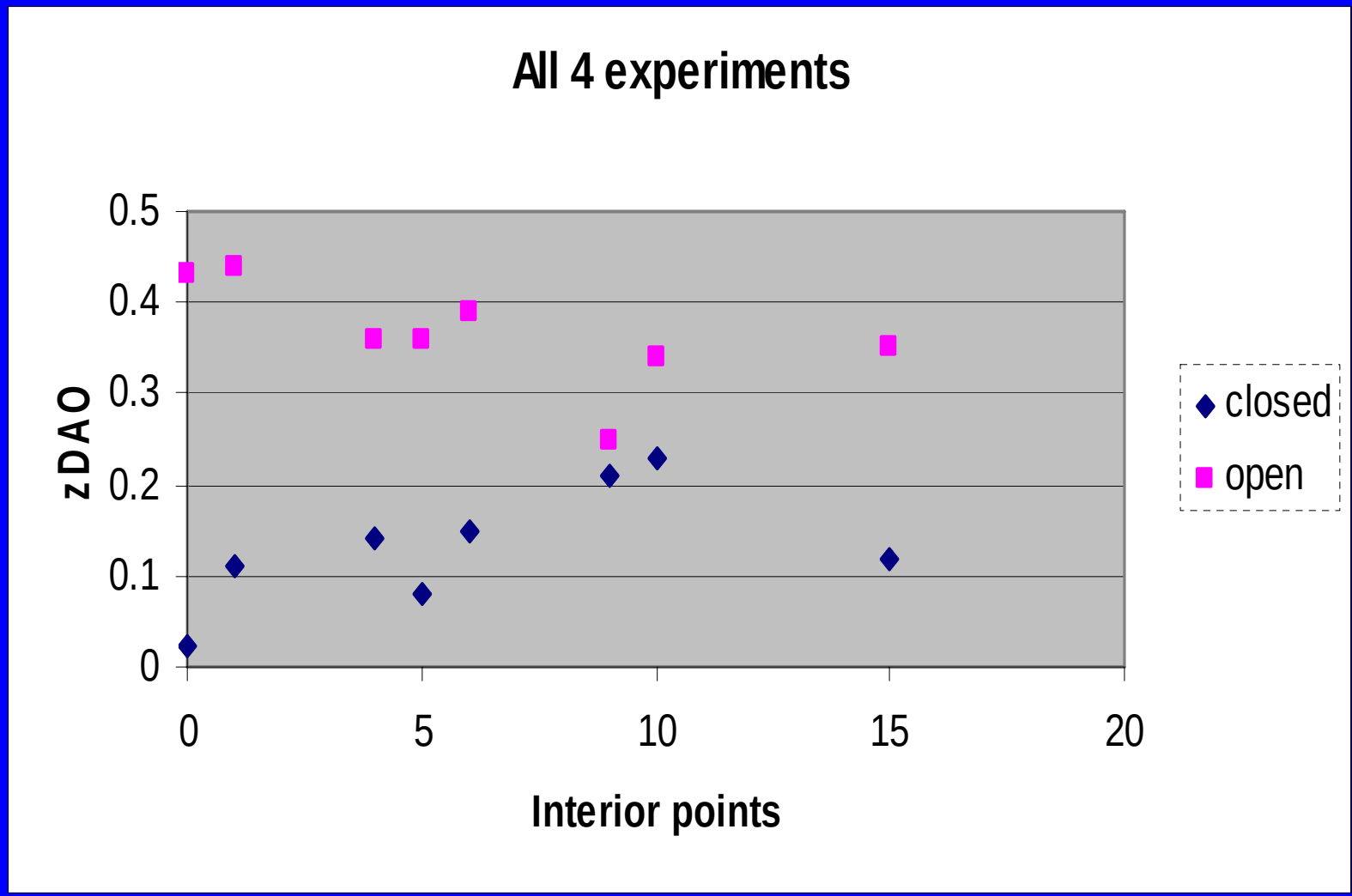
Experiment 4--Results

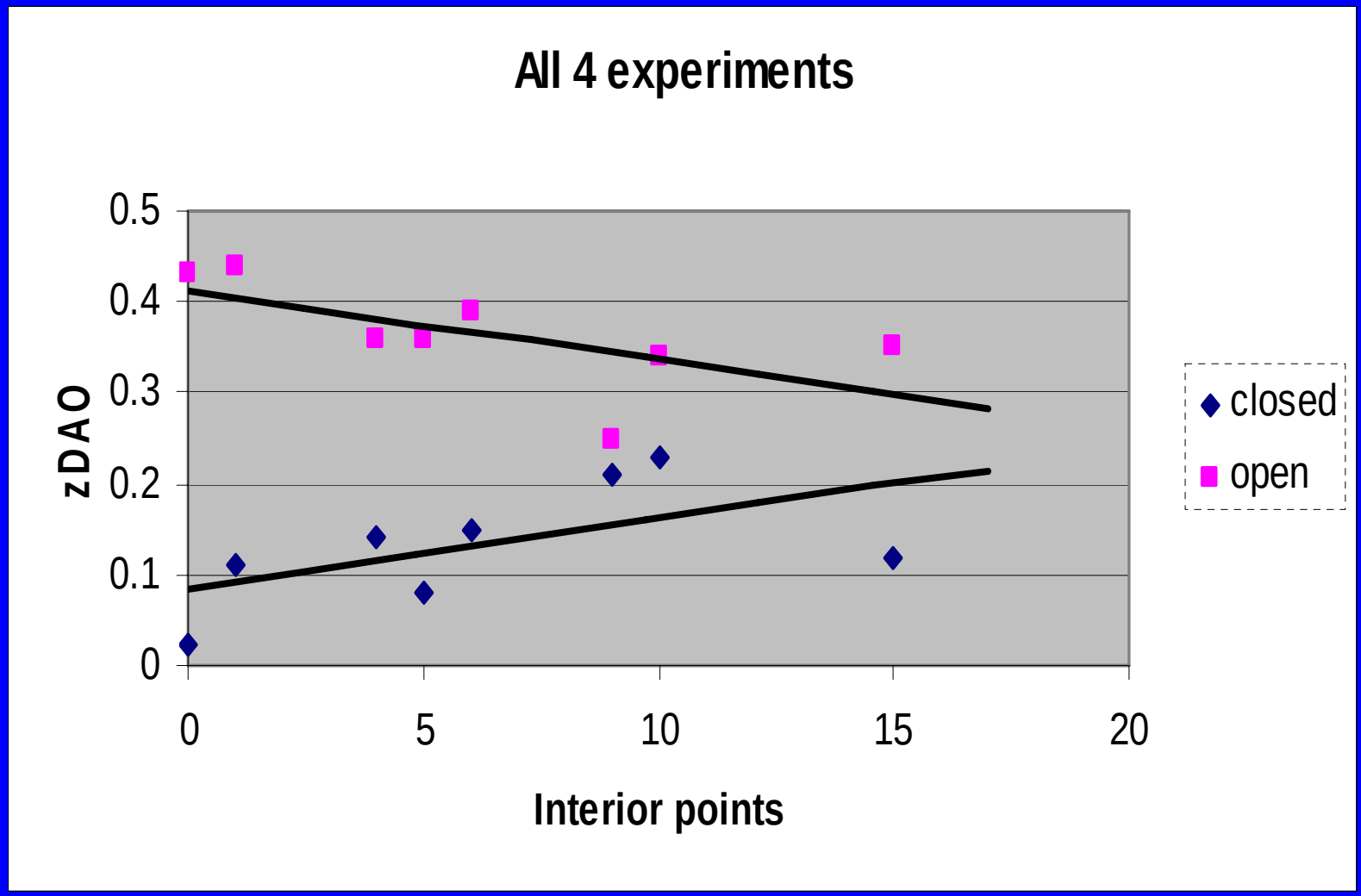
- The mean standardized distances above optimal were .36 and .11 for the open and closed conditions, respectively.
- In terms of percentage above optimal, the corresponding values were 10% and 3%

Experiment 4--Results

- Open performance was three times poorer than closed, a significant difference
- However, the difference depended on number of interior points


Exp. 4 results
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
zDAO
0
5
10
15
20
Interior points
Closed
Open


All 4 experiments
zDAO
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
Interior points
closed
open


All 4 experiments
zDAO
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
Interior points
closed
open

- We began by hypothesizing that human performance on closed tours would be better than on open paths.

- The hypothesis was strongly supported in instances with relatively few interior points, but the trends indicated that the difference disappears as interior points increase

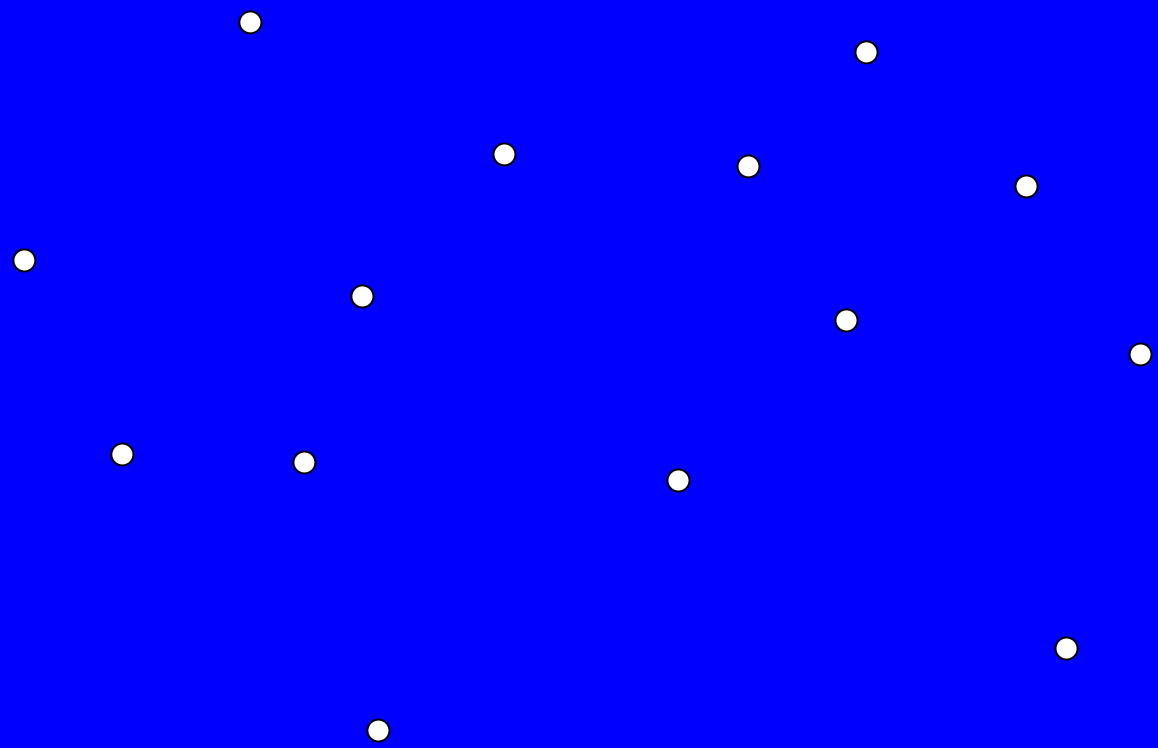
- These trends suggest that on instances with somewhere around 10 to 20 interior points, people will be equally good at closed tours and open paths

- This raises the question of what heuristics people use on open paths that are ineffective with few interior points but become more effective as interior points increase?

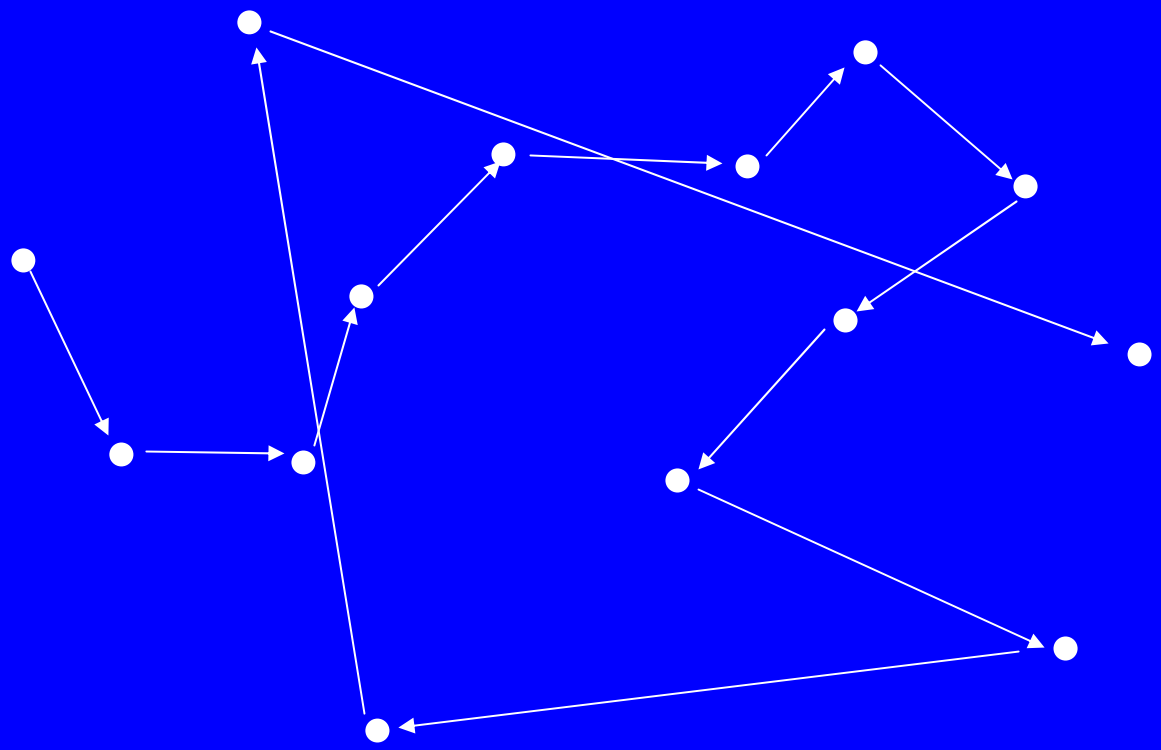
Three possibilities are illustrated below

- Nearest neighbor
- Raster scan
- Convex hull

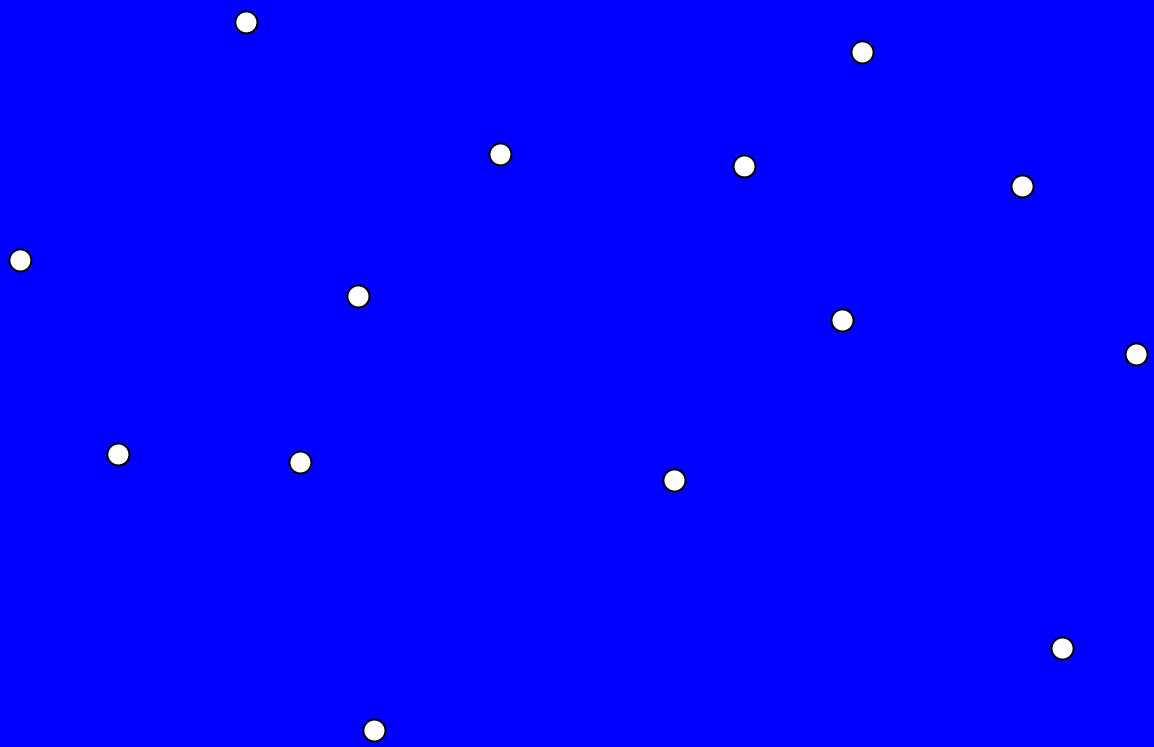
Nearest neighbor



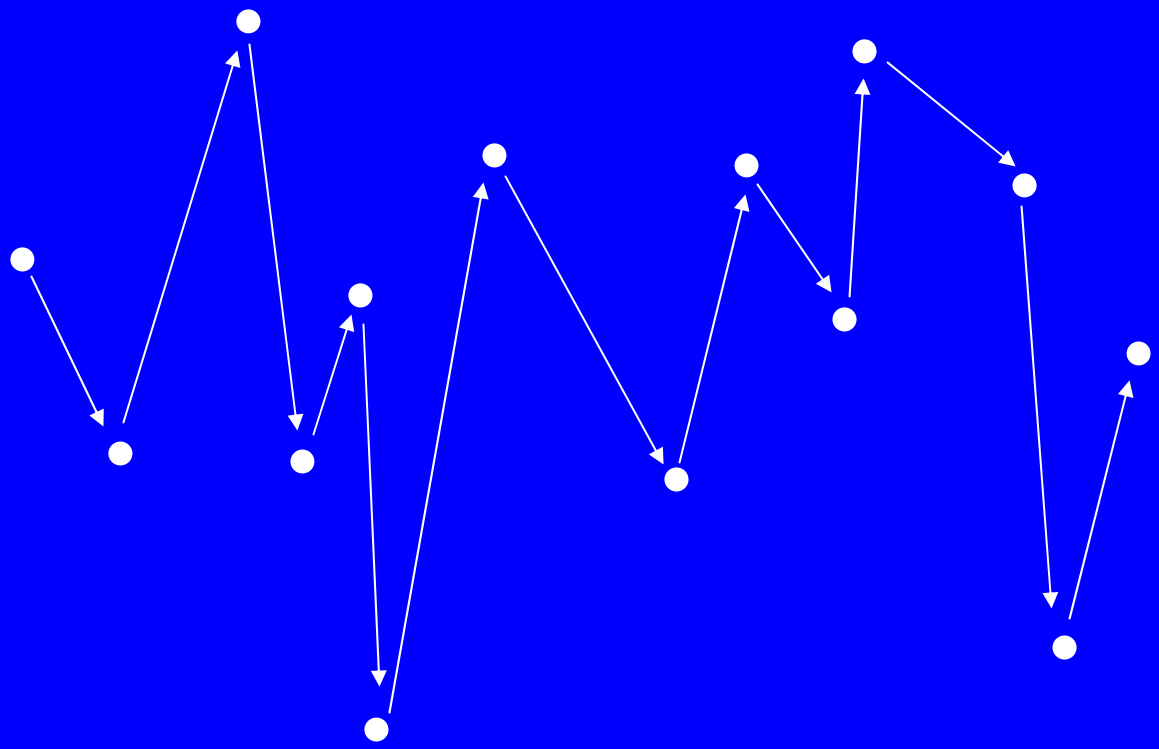
Nearest neighbor



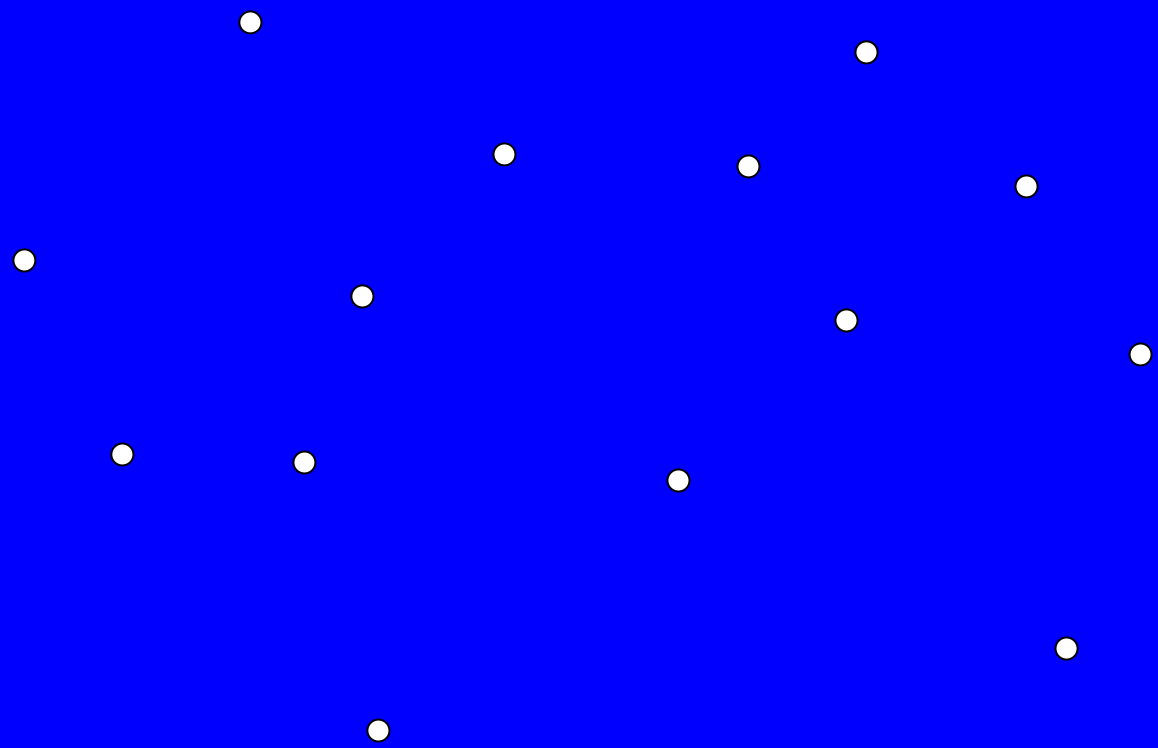
Raster scan



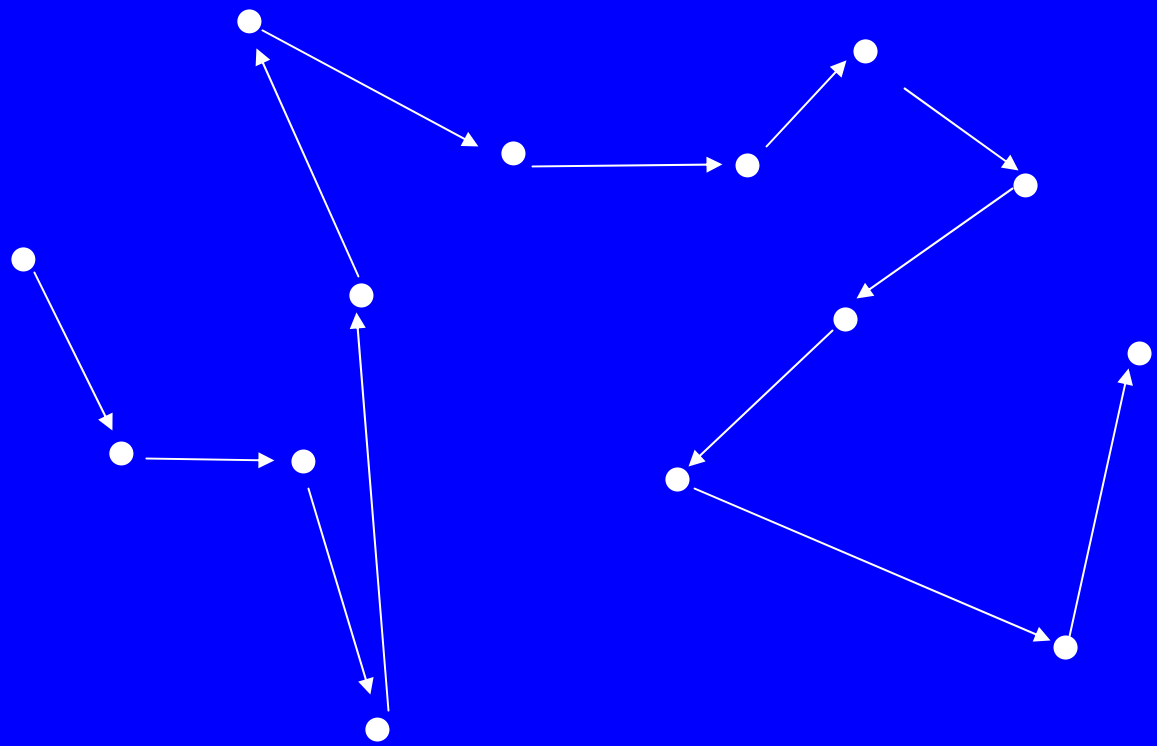
Raster scan



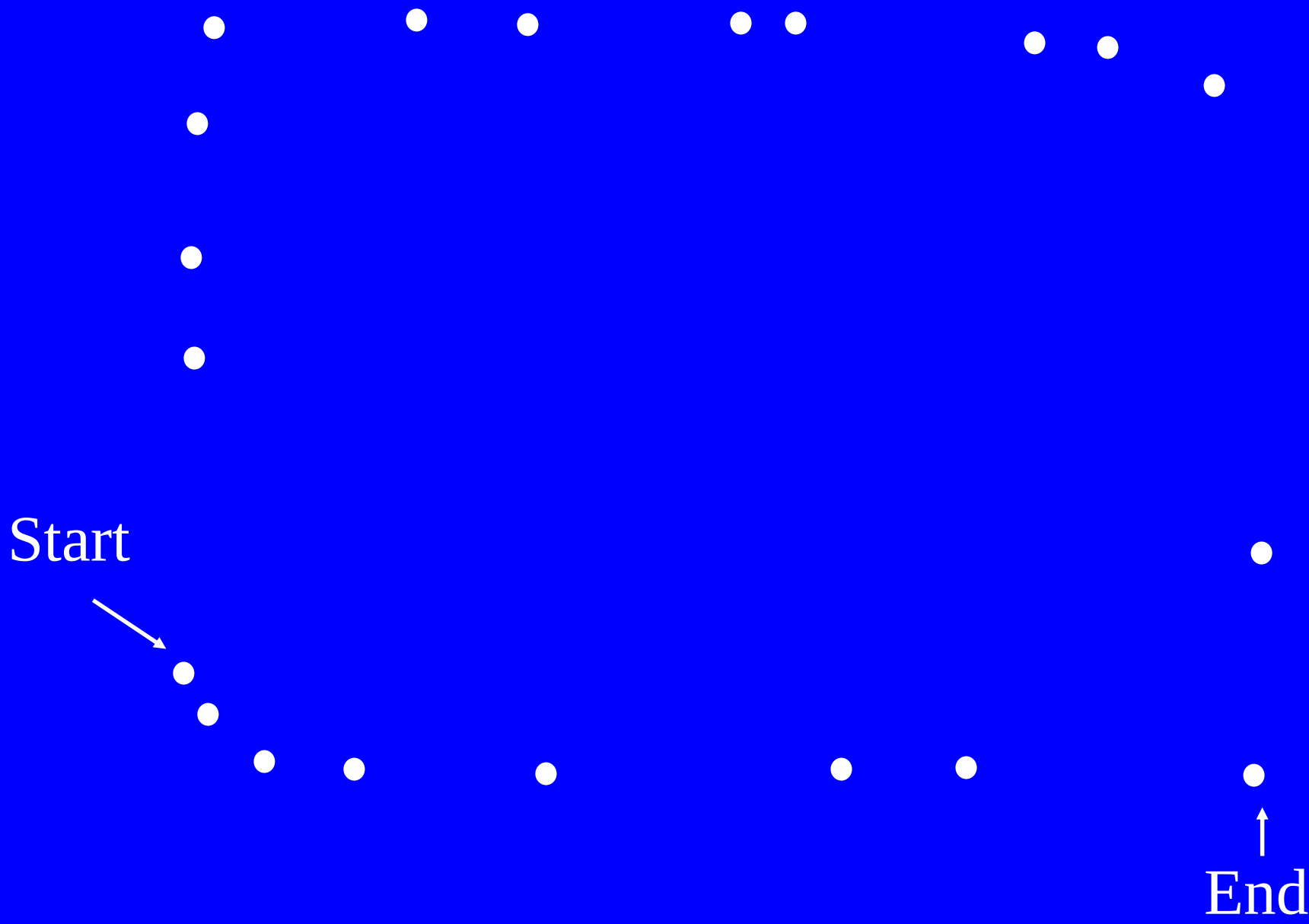
Convex hull



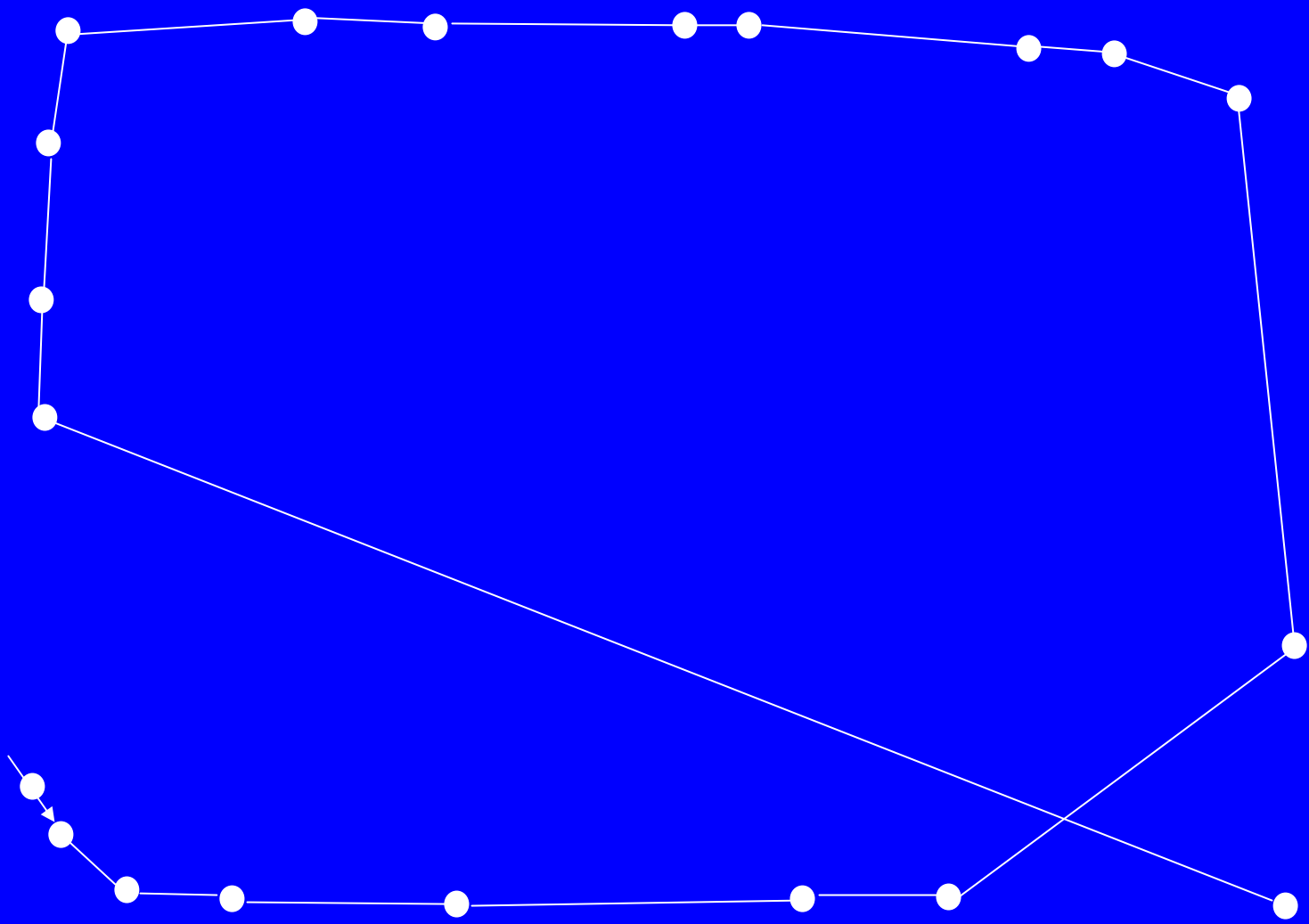
Convex hull



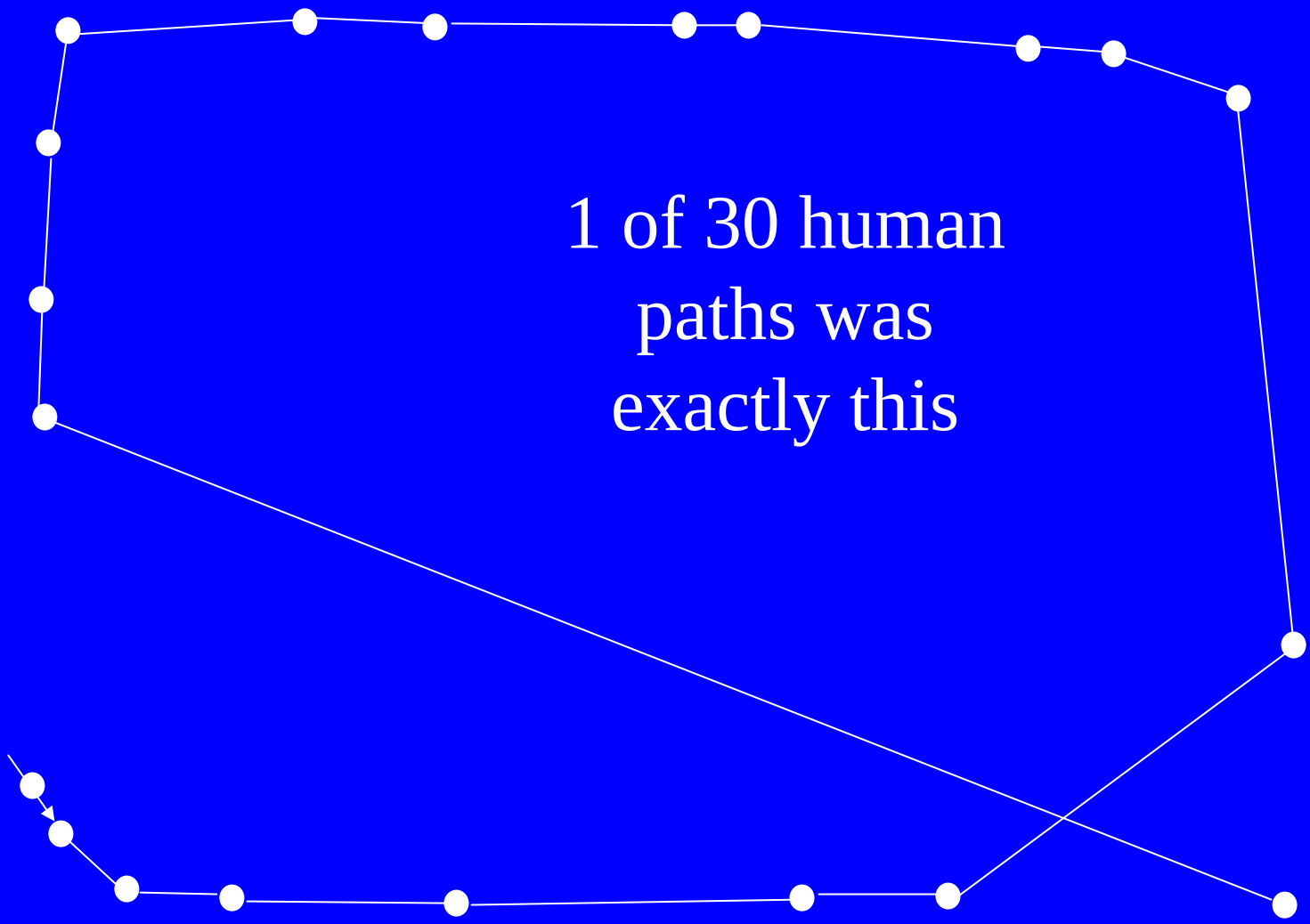
The following slides illustrate these procedures on an instance from Exp. 4


Start
End

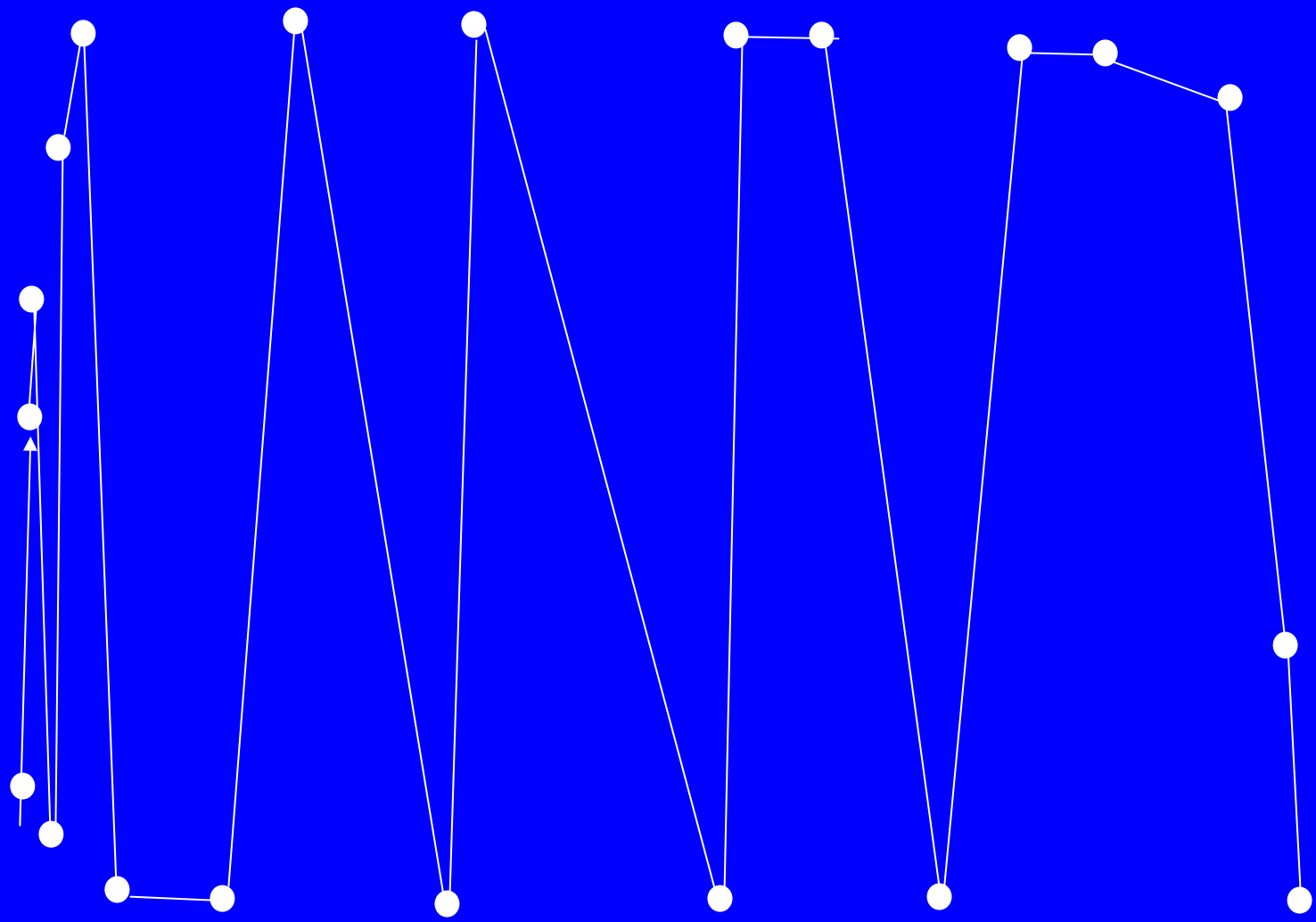
Nearest neighbor



Nearest neighbor



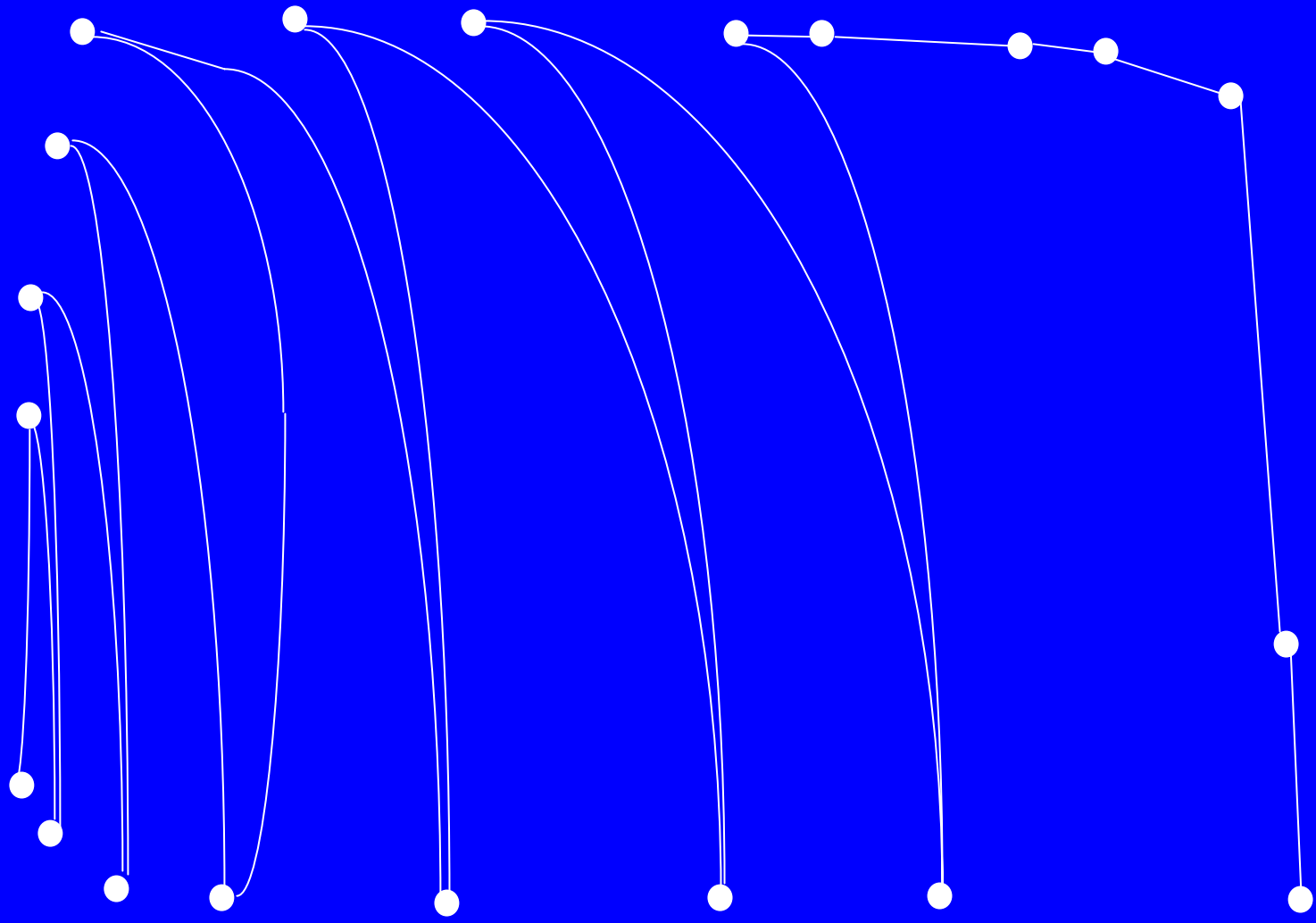
Raster scan



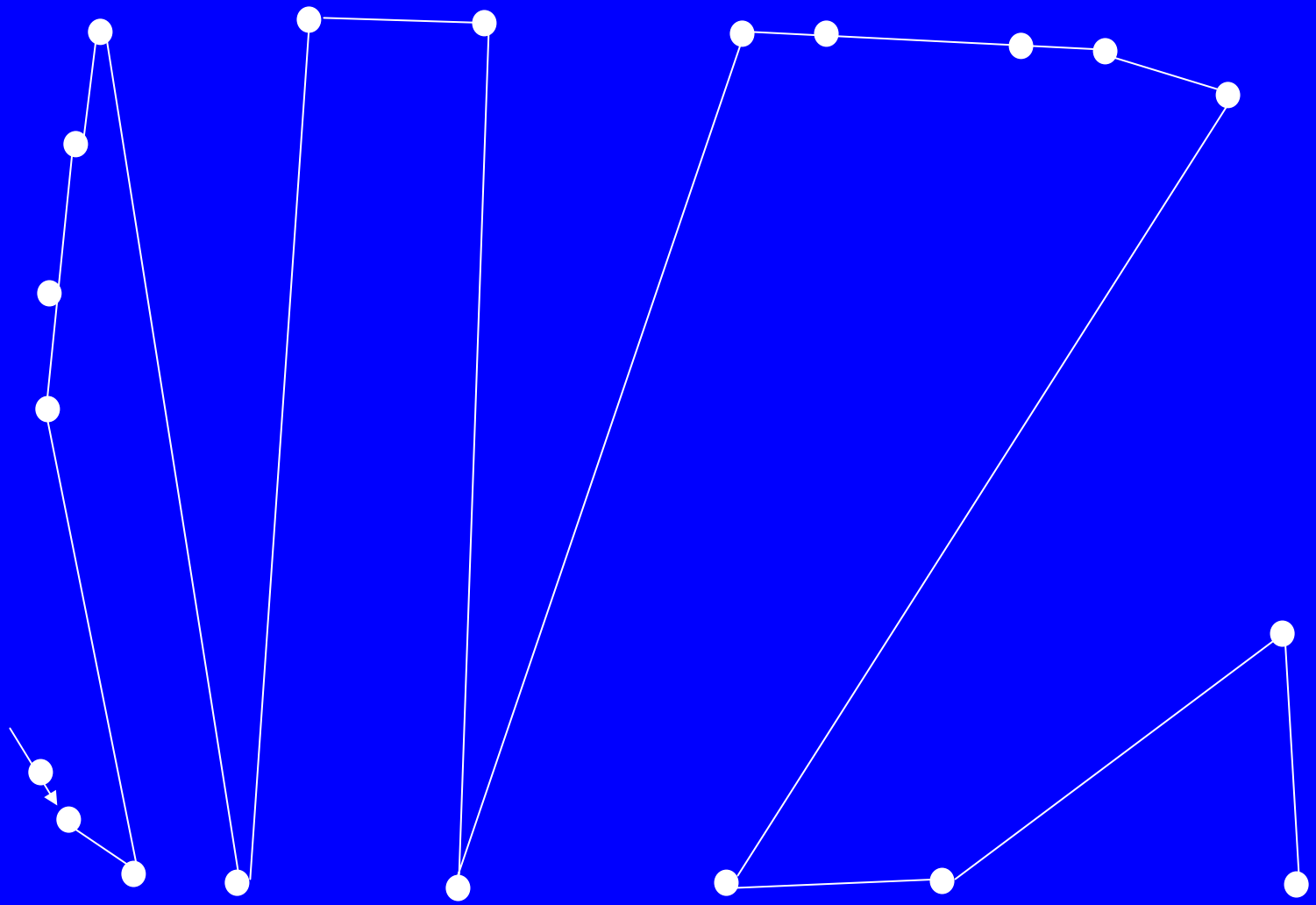
Raster scan

While no observed paths were exactly like this, some were similar

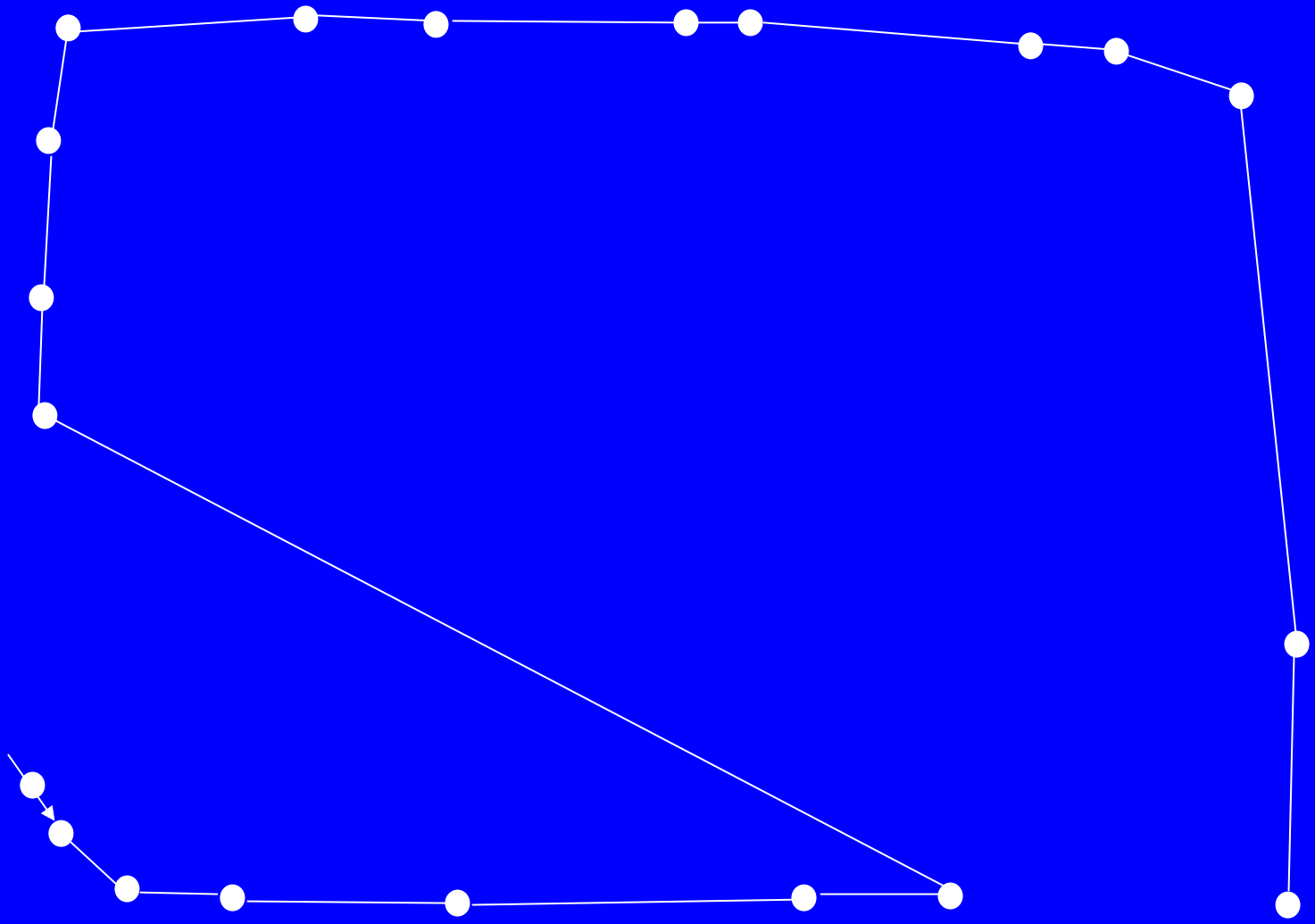
Raster scan



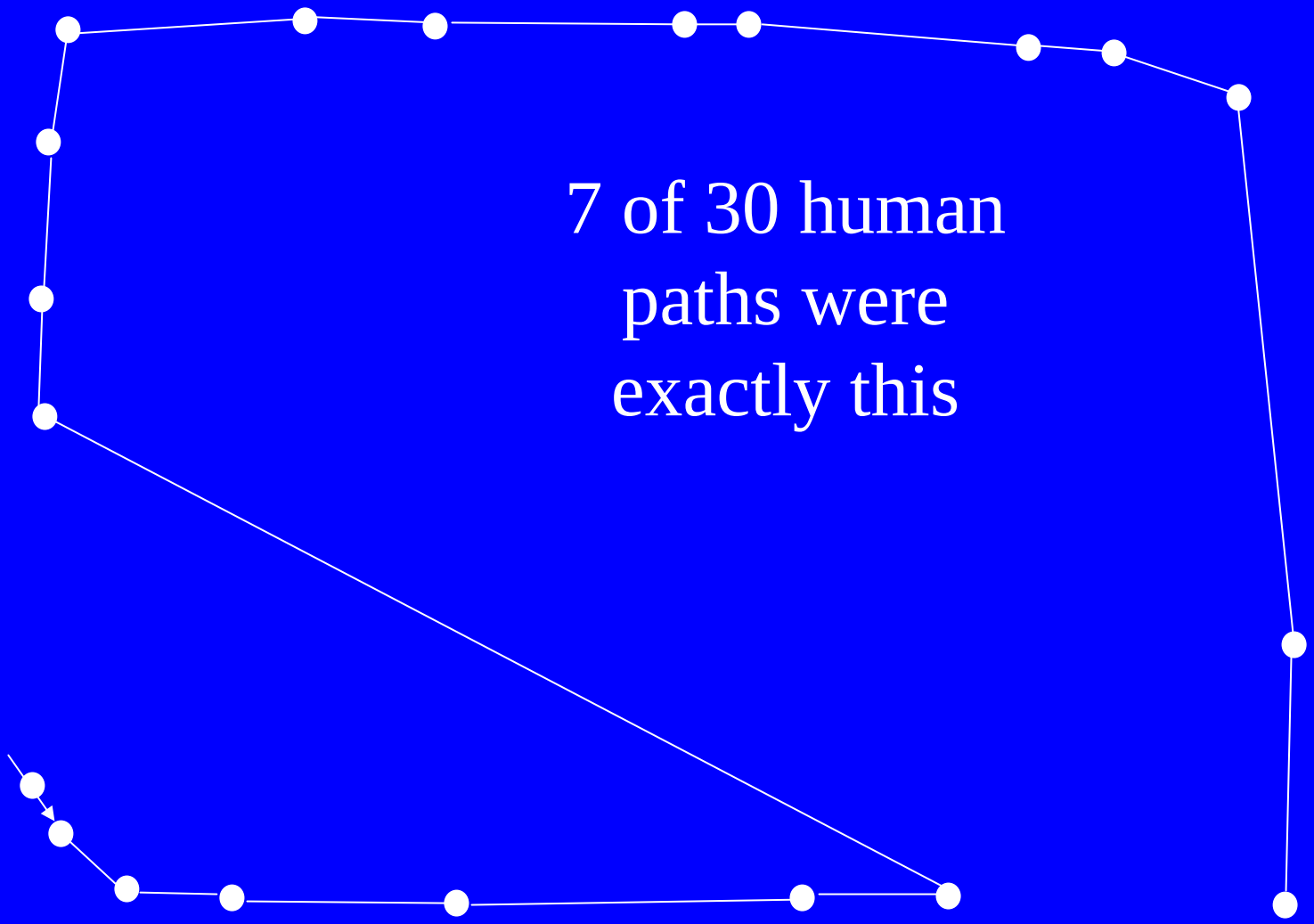
Raster scan



Convex hull



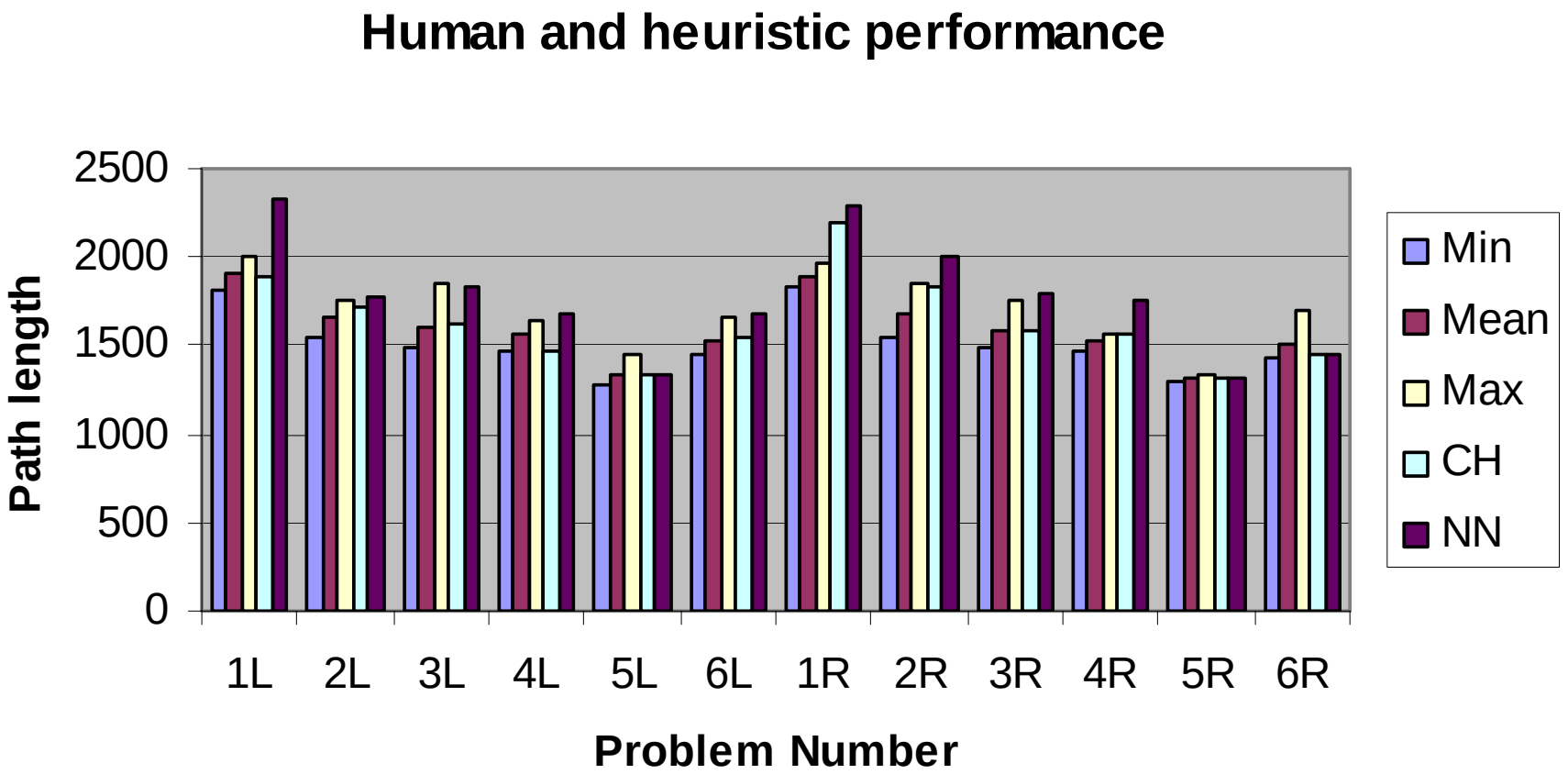
Convex hull



7 of 30 human paths were exactly this

Finally, a quantitative comparison with data from Exp. 2

Heuristic and human open path lengths



Thank
You