UNIVERSITY OF
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Planning your route: where to start?

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L. Sengupta, R. Mariescu-Istodor and P. Fränti, "Planning your route: where to start?"
Computational Brain & Behavior, 1 (3-4), 252-265, December 2018.

What is O-Mopsi?

Classical orienteering

Devices: Map and compass

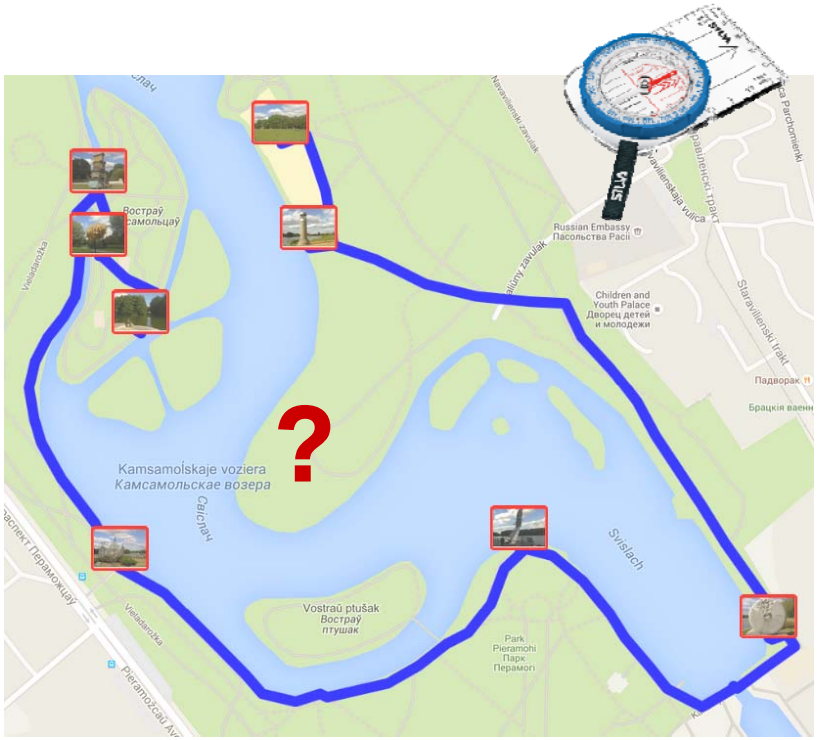
Targets brought to nature for the event

- Find all controls
- In **pre-defined** order
- Fastest wins

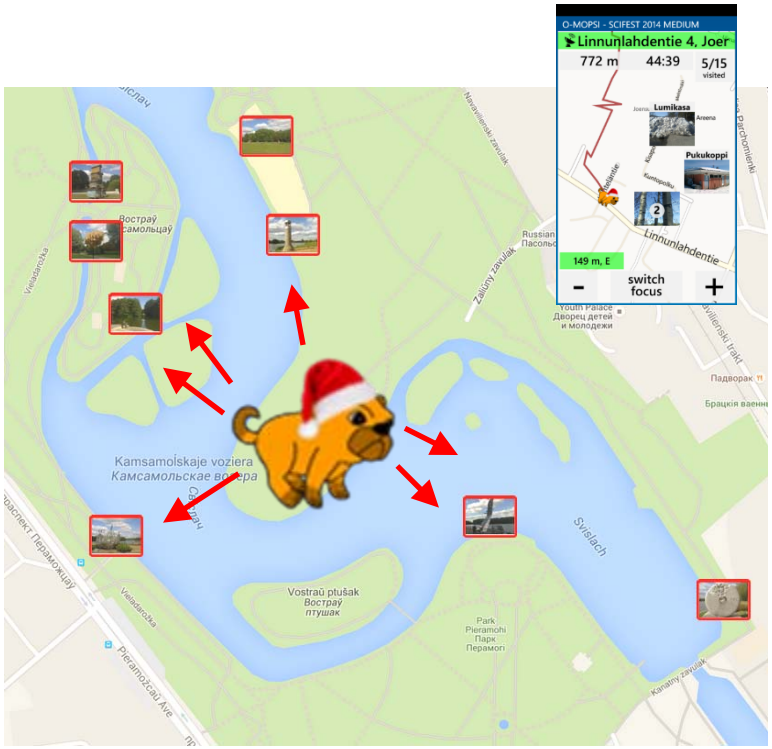
Mopsi orienteering (O-Mopsi)

Challenges of playing

Orienteering:
- Knowing your location
- Optimizing paths to targets



O-Mopsi:
- Finding best order
- Optimizing paths to targets



Winning the game

What matters

Order of visiting targets

- Travelling salesman problem (TSP)
- Human strategies: nearest neighbor, clustering
- Computer strategies: optimal, optimization

Where to start playing

- Remove longest edge from TSP?
- Blind selection
- Comparison of various heuristics

Navigating to targets

- Effects of routing

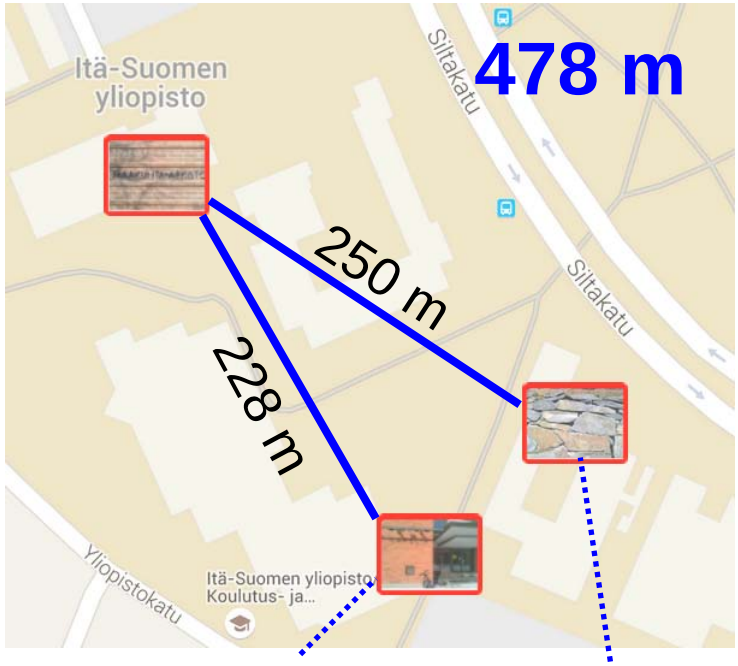
Order of targets

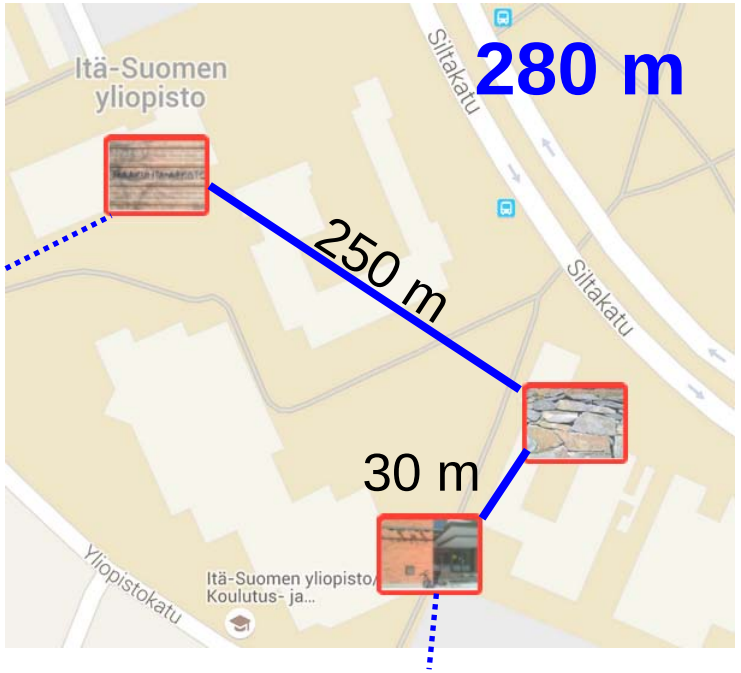
Bounding box


Bounding box
Player
Optimal tour
(2.9 km)
Terminal
point
Terminal
point
Holiday Linnunlahti
Joensuun kirkko
Koivuniemen koirapuisto
Jokiasema Ky
Hasanniemi
Pielisjoki
Länsikatu
Papinkatu
Kalastajankatu
Merimiehenkatu
Louhelankatu
Eteläkatu
Kirkkokatu
Kauppakatu
Malmikatu

Algorithmic problem

- Minimize total distance
- With N targets there are N! possible orders
- Variant of **travelling salesman problem** (TSP)

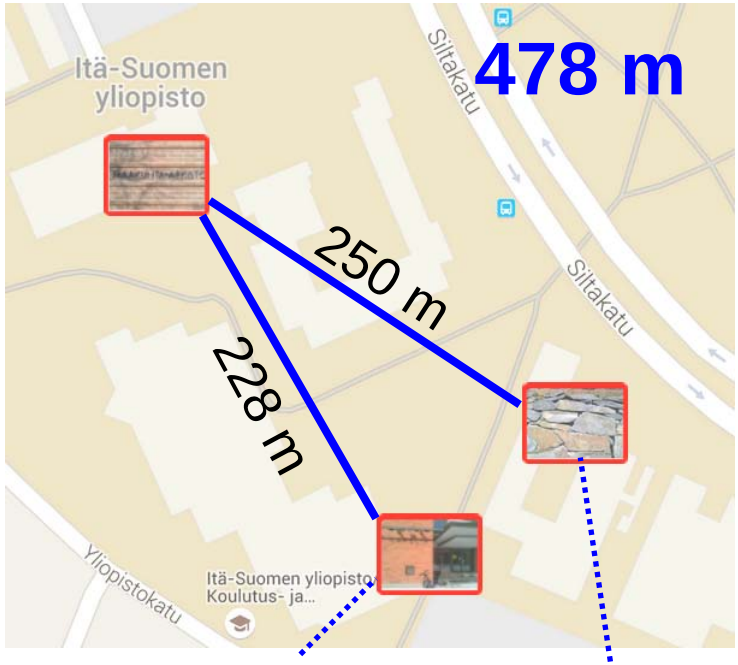


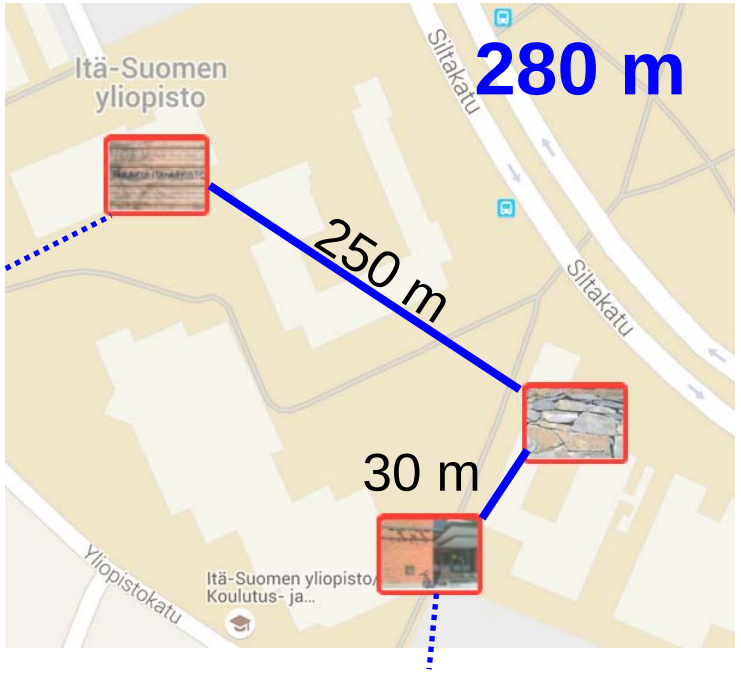


Algorithmic problem

N = 10 **N!= 3,628,800**

- Minimize total distance
- With N targets there are N! possible orders
- Variant of travelling salesman problem (TSP)





How much it matters?

- More targets, harder to solve
- Nearest target strategy
- 24% longer than optimal (on average)
- Median: 20%
- Minimum: 0.06%
- Maximum: 109%

Game	NT (km)	Opt. (km)	Diff.
Scifest 2014 short	1.14	0.97	17%
Helsinki downtown	4.97	4.08	22%

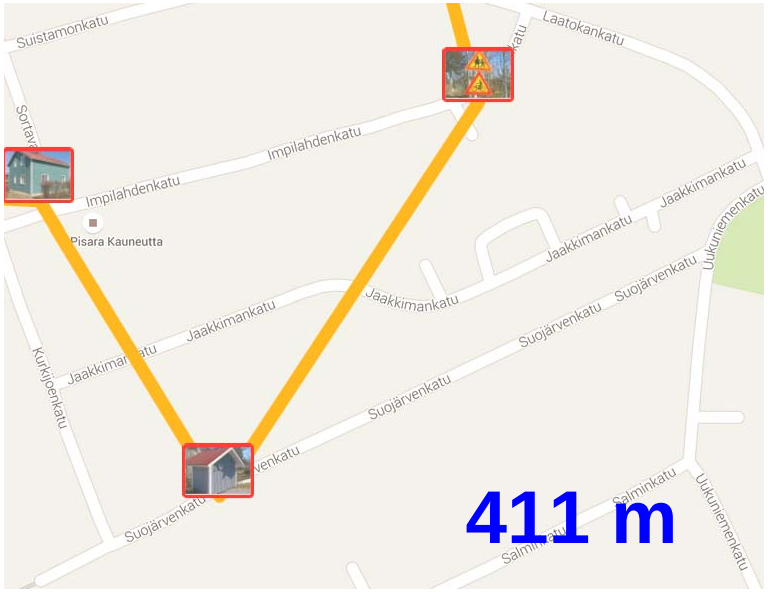
Navigating to the targets

Fastest route?

Routing vs. Bird's distance

- Buildings and small housing in city area
- Real distance on ~50% longer than bird's distance
- Can also affect the order of the targets

Bird distance

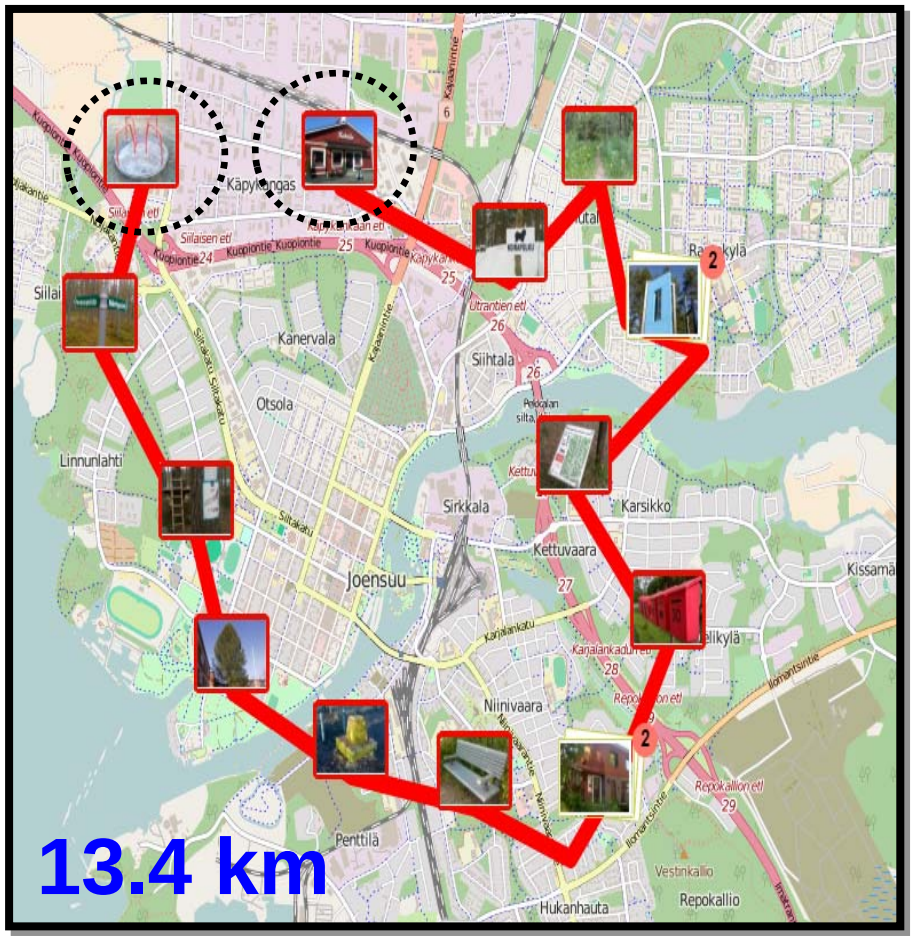


Routing

Effect of route network

Start point changes

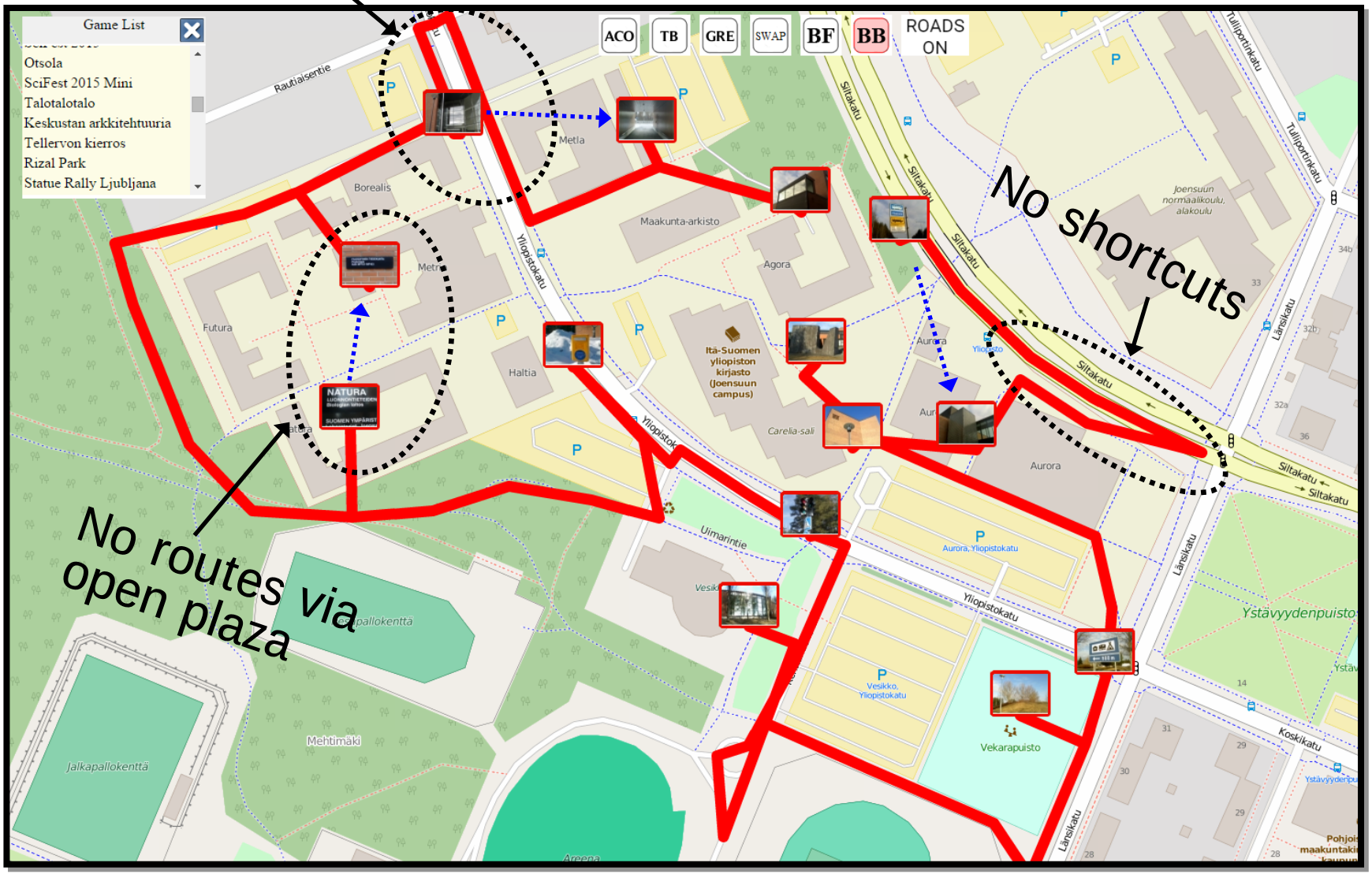
Bird distance



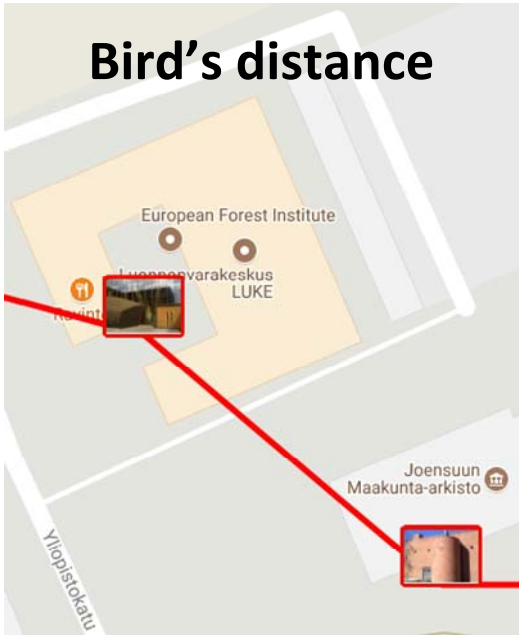
Routing

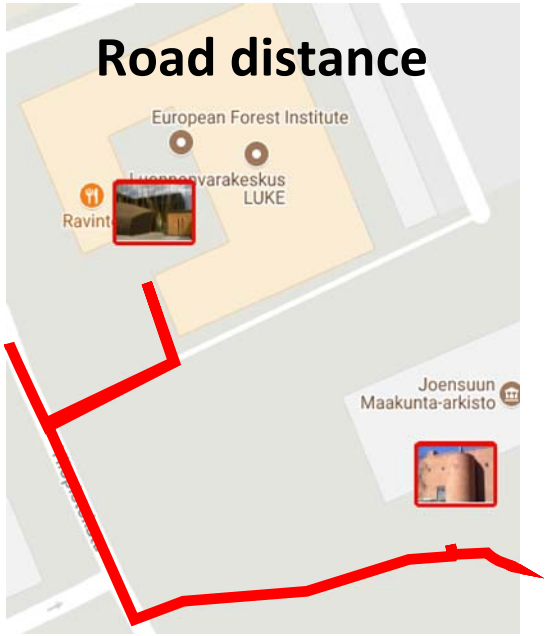
Limitations of routing

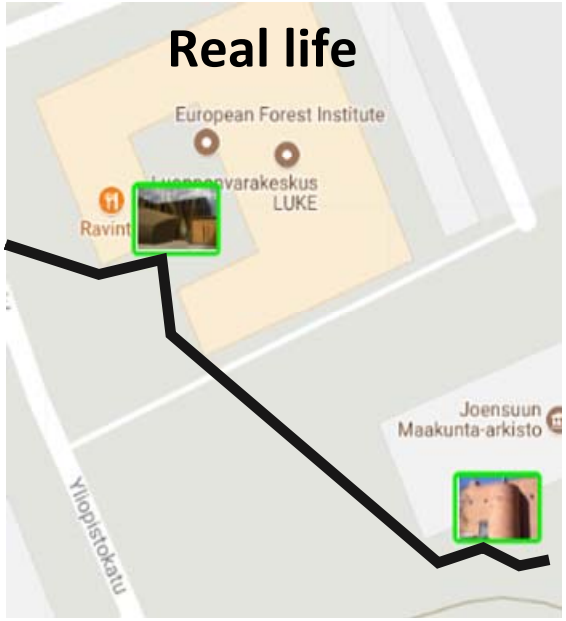
Limitations in street crossing

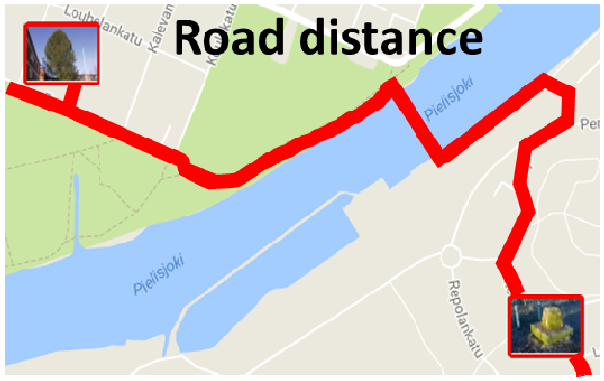


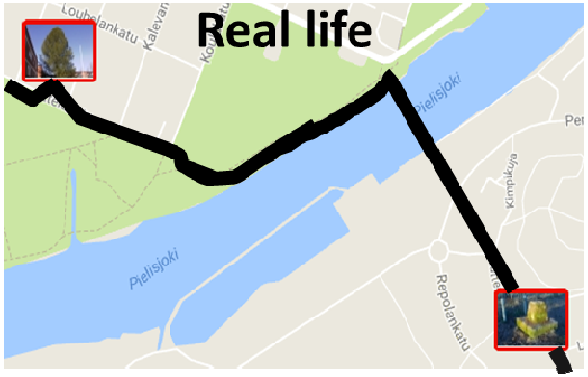
Examples of the limitations











Effect of transport mode

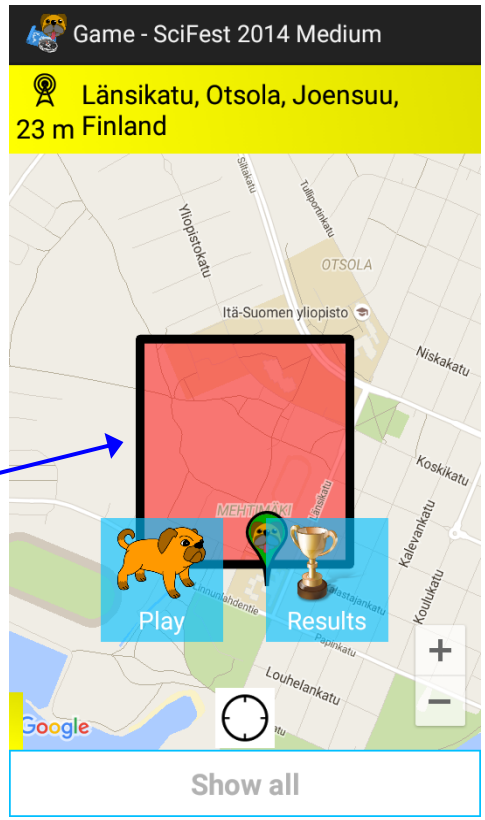
Effect of starting point

Where to start?

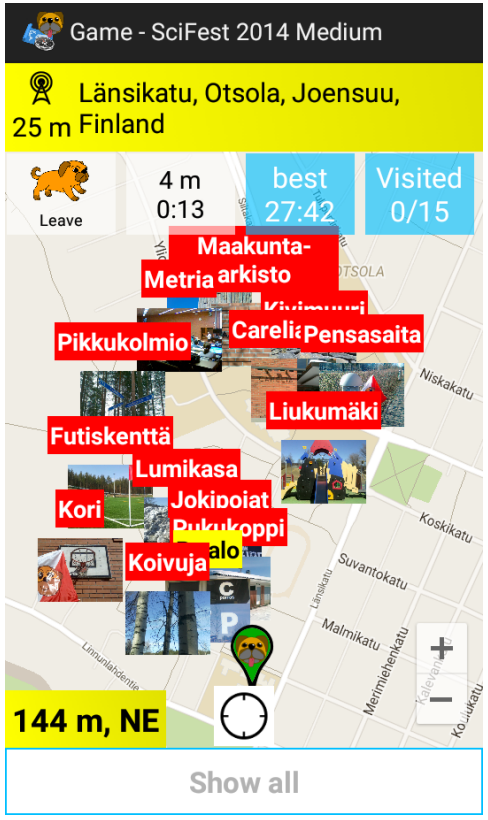
- Targets not visible before start
  (if known, can start at one target)
- No time for planning route
  (Time starts when game opens)
- Ony game area shown
  (bounding box)
- Start must be
  chosen blindly

Bounding box

Before start

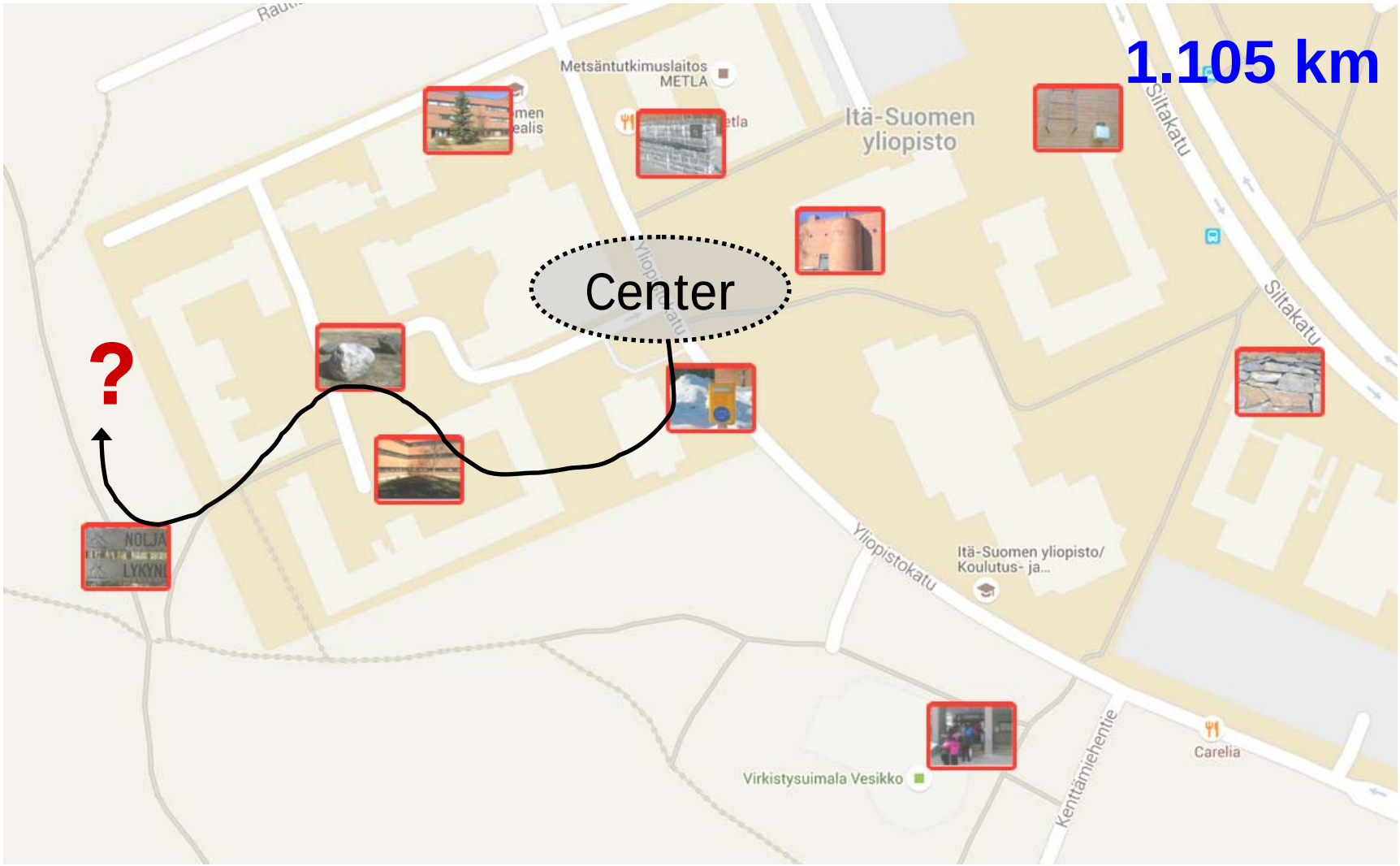


After start



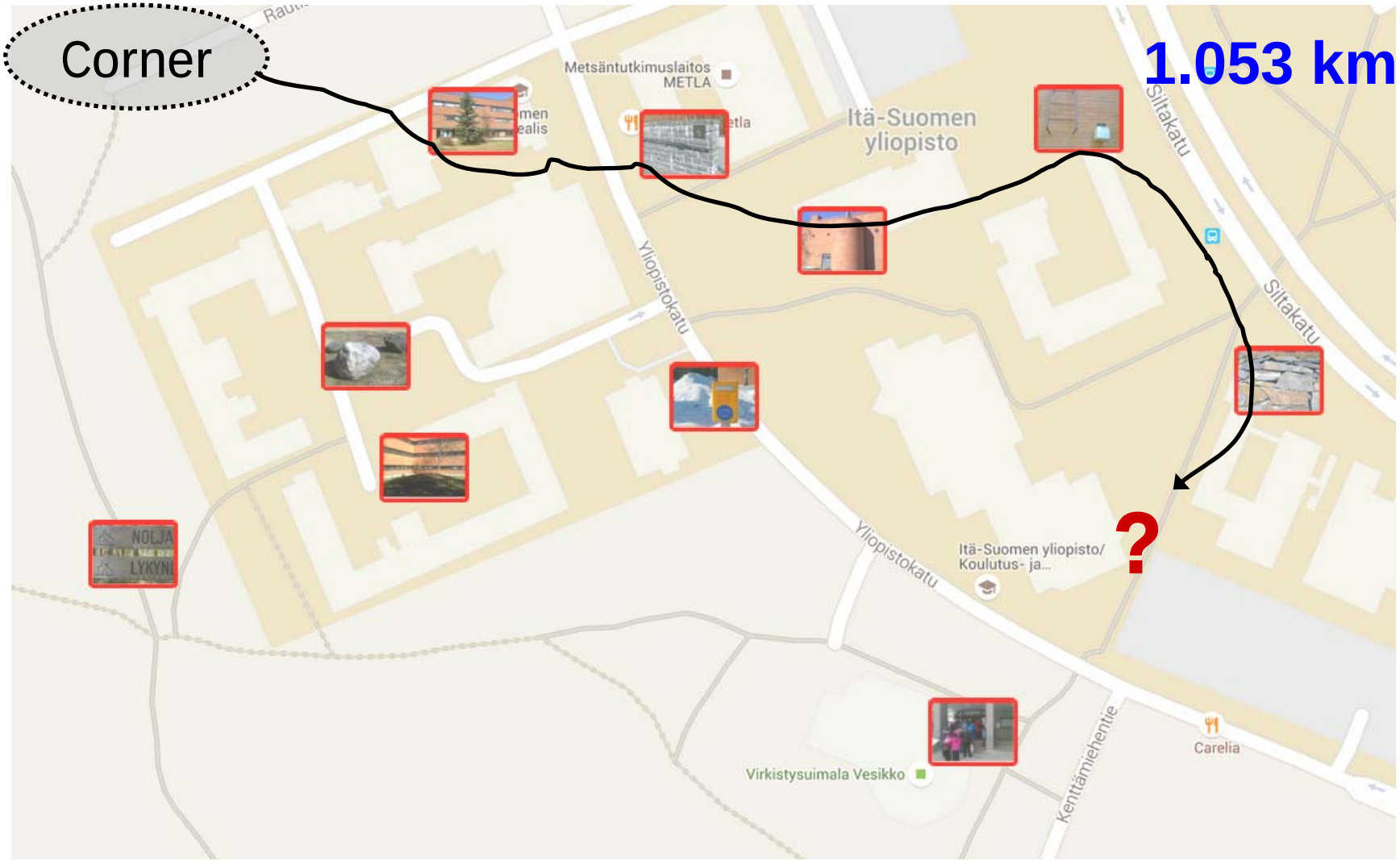
Start point strategy 1

Center of the area



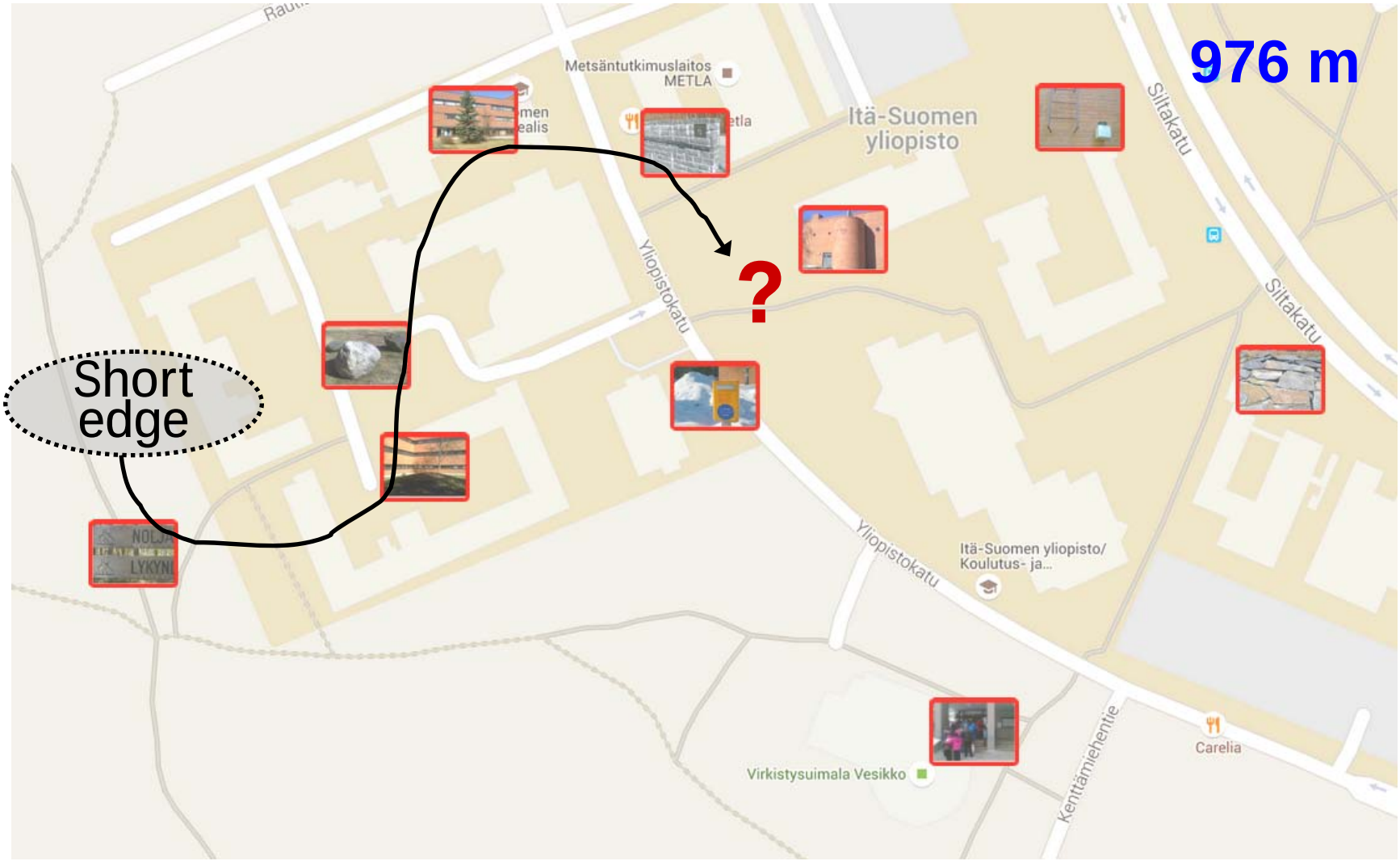
Start point strategy 2

Corner of the area



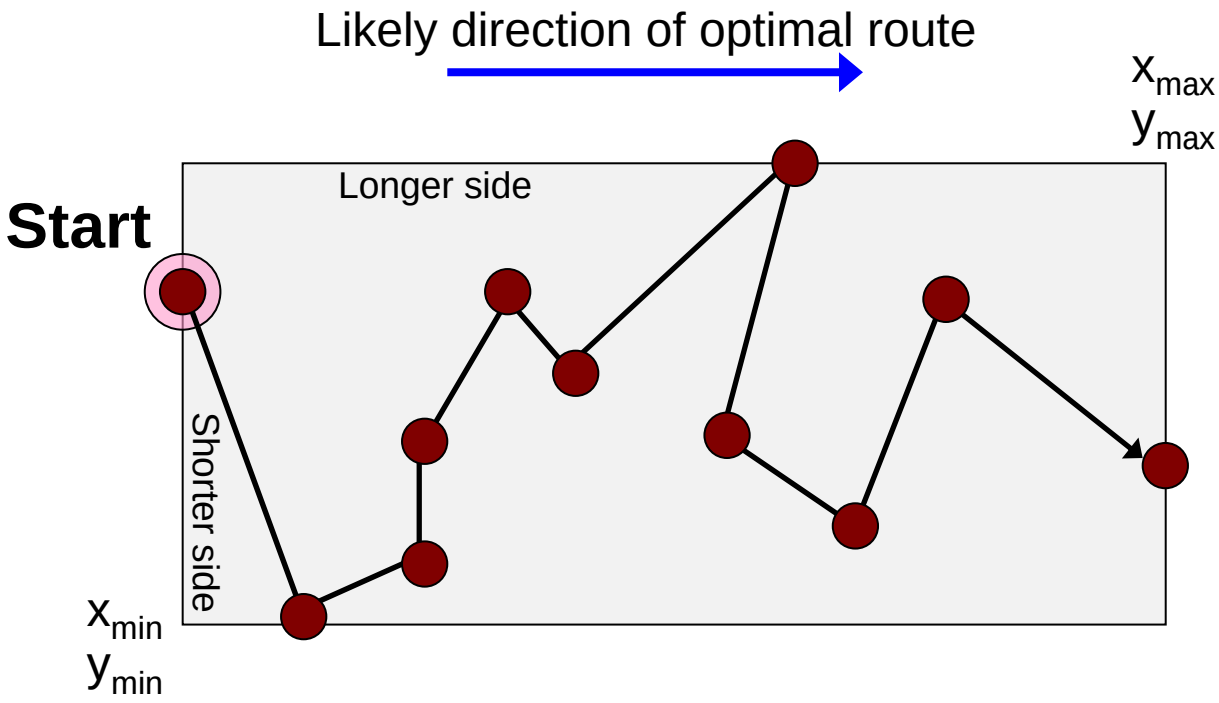
Start point strategy 3

Somewhere at the shorter edge



Start point matters

- Every side has at least one target
- Optimal order likely to go along longer side
  (rather than random zig zag)
- Heuristic: Start from the shorter side

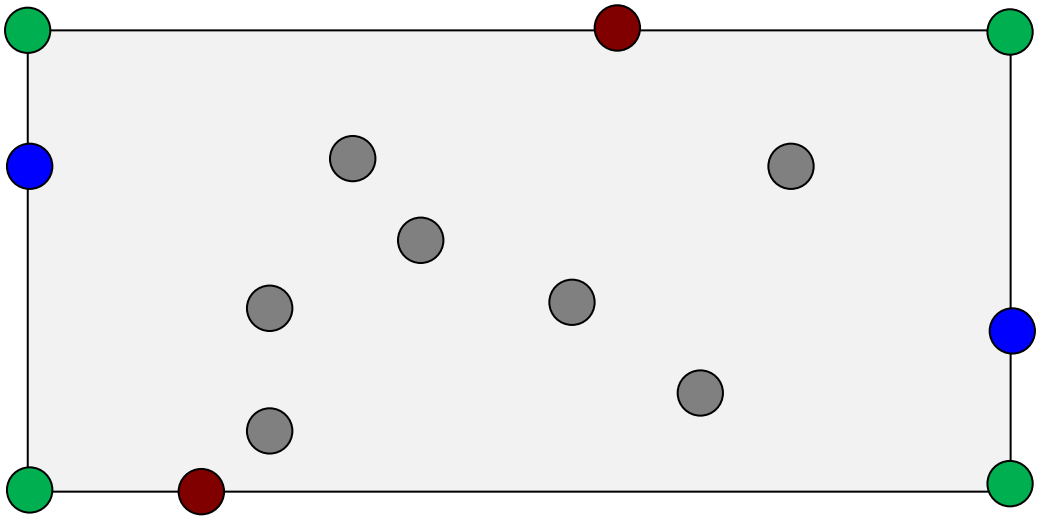


Start point statistics

according to target location

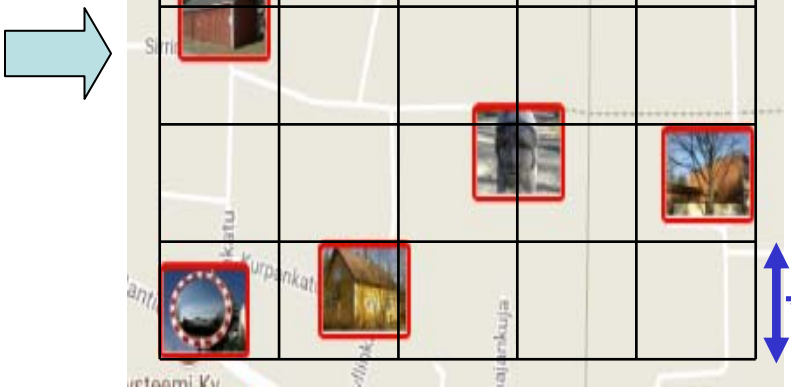
Optimal start point located:

- First/last target on corners: 42%
- First/last target along the long side: 22 %
- First/last target along the short side: 29 %
- Some other target: 7 %



Game area

Divided into 5x5 grid



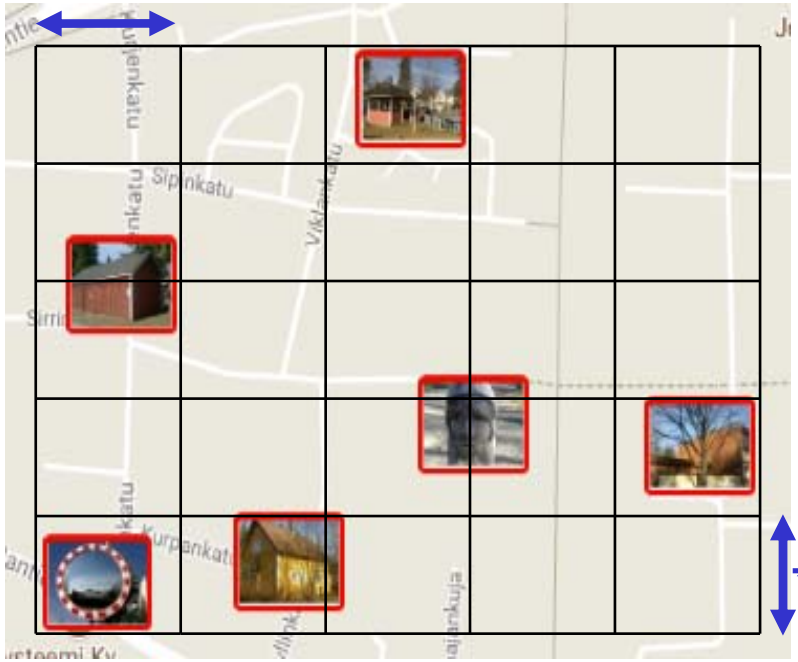
20% of
The width

20% of
the Height

Labeling grid cells

Corner, middle, long and short edge

20% of The width



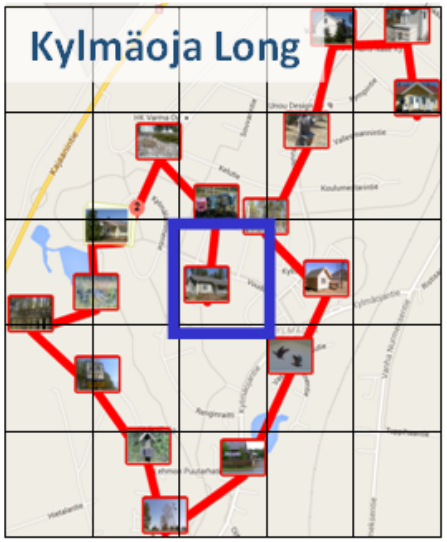
20% of the Height

Corner	Long edge	Corner
Short edge	Middle	Short edge
Corner	Long edge	Corner

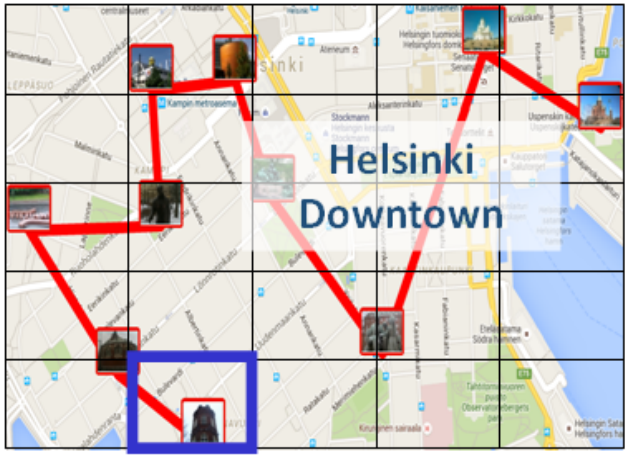
Start point examples

Corner

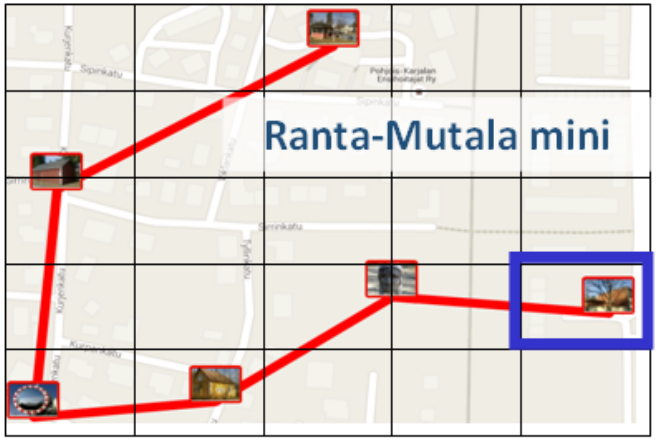
Middle



Long edge



Short edge



Start point statistics

according to grid

- Calculate optimal tour
- Divide the area into 20%×20% grid
- Locate the start and end points of the tour in the grid

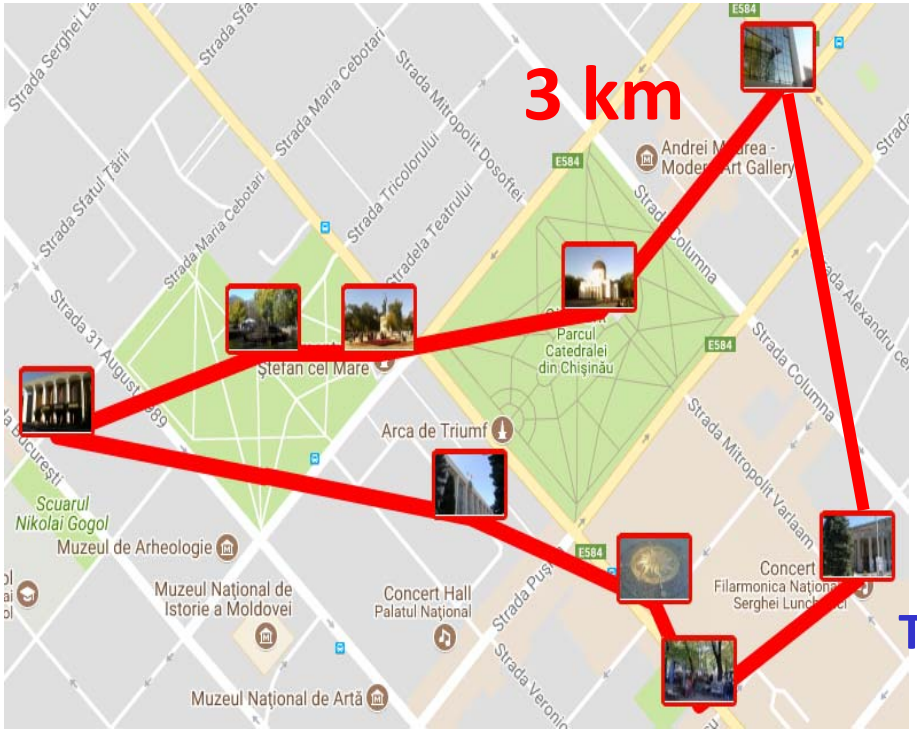
Longer side

8	3	4	4	13
5	1	1	1	5
6	1	0	1	4
4	1	0	1	6
14	2	1	3	11

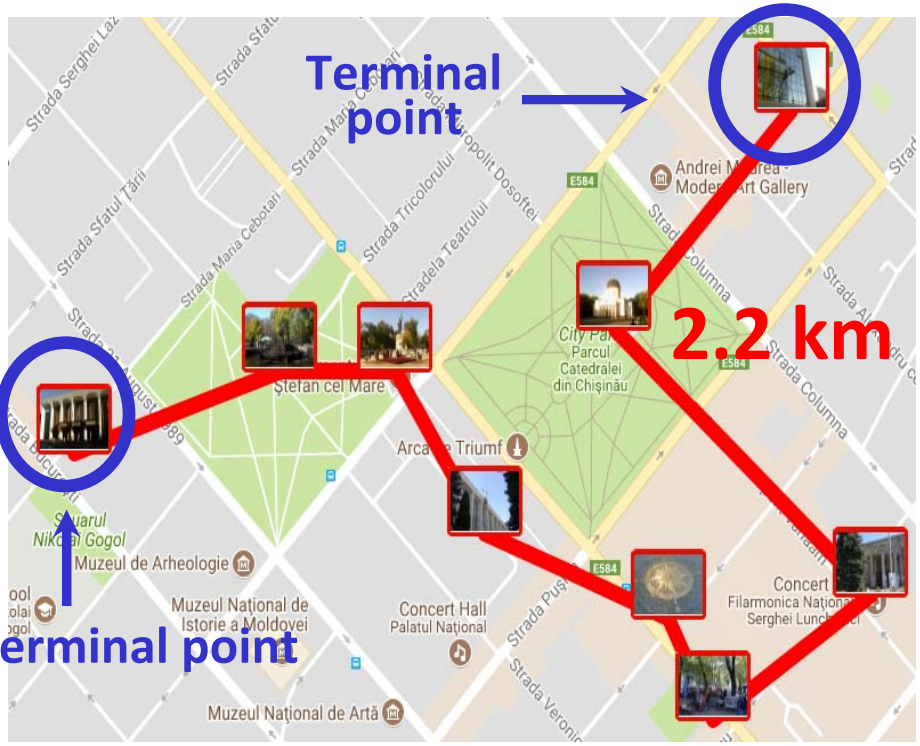
Shorter side

Optimal tour

Closed-loop case

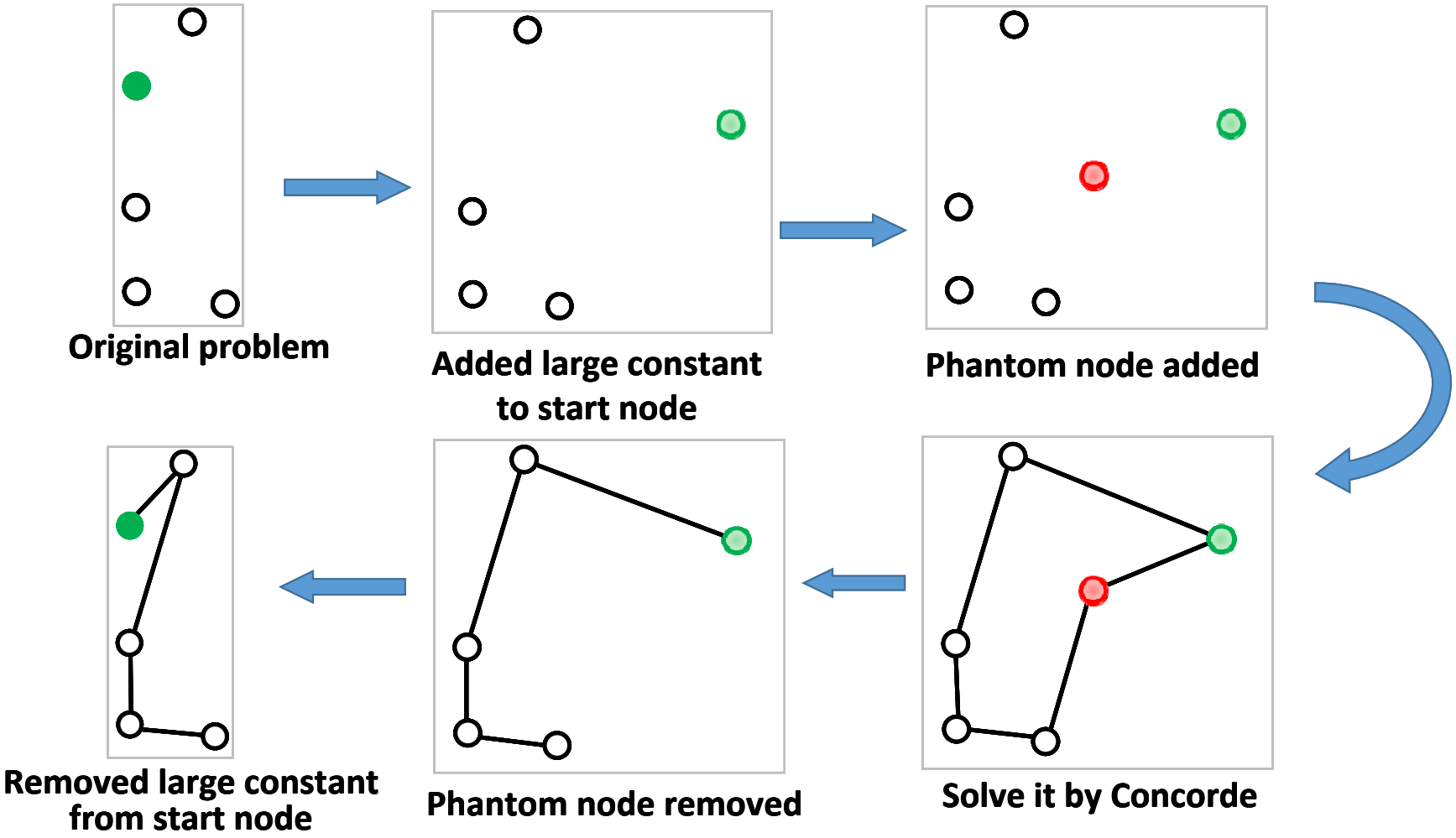


Open-loop case



Solving the optimal tour

Using Concorde algorithm



Optimum vs. player's choice

Optimum order

Player's route

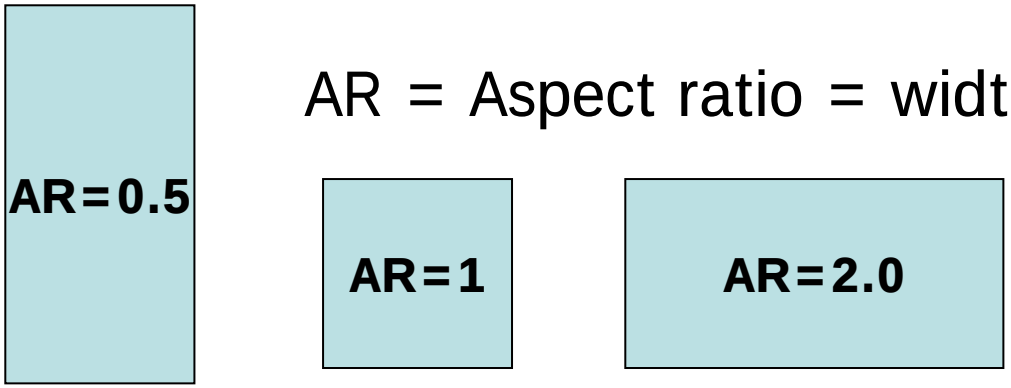
Optimum order from player's start

Worst cell to choose start

Computer performance

Location of terminal points

	Low AR<0.8	Medium AR=0.8-1.2	High AR>1.2
Corner	48%	46%	45%
Short edge	31%	21%	37%
Long edge	17%	23%	16%
Middle	4%	10%	2%



AR = Aspect ratio = width/height

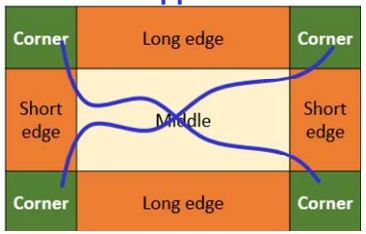
Human performance

Average performance

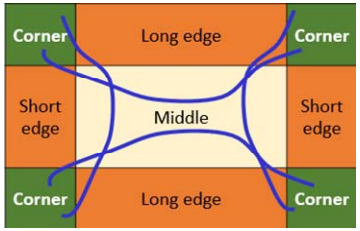
	Probability to find best	Gap to best
Random	3%	8%
Middle	9%	9%
Any corner	32%	7%
Any short edge	23%	6%

Most common optimal patterns

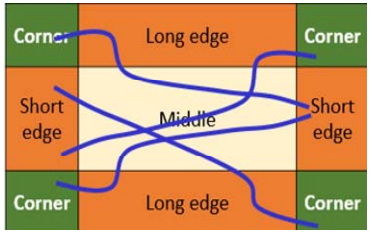
Corner to opposite corner



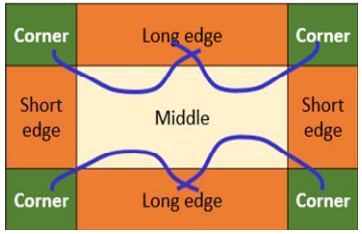
Corner to same side corner



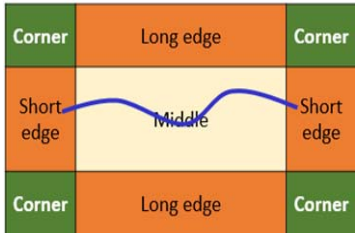
Corner to opposite short edge



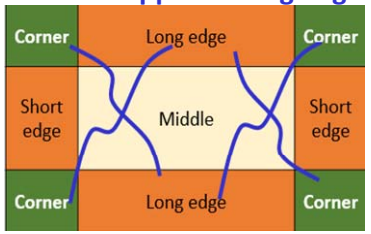
Corner to adjacent long edge



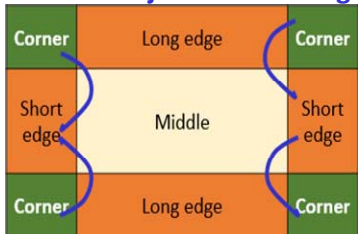
Short edge to short edge



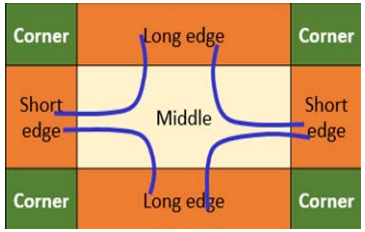
Corner to opposite long edge



Corner to adjacent short edge



Long edge to short edge



Corner to…

- opposite corner
- opposite short edge
- opposite long edge

45%

Corner to…

- same side corner
- adjacent long edge
- adjacent short edge

30%

Short edge to…

- short edge
- long edge

17%

Human performance

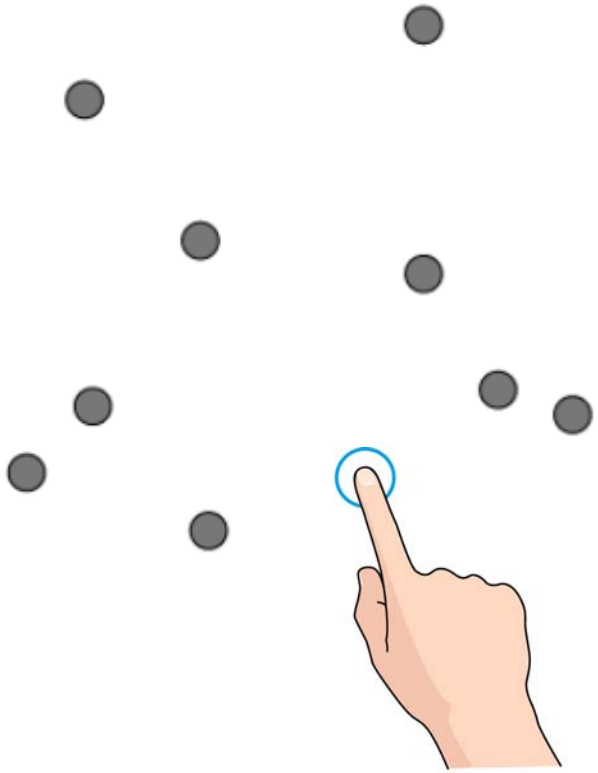
Experimental setup

Visible task

- Student volunteers (30)
- Design and Analysis of Algorithms course

- Player selects only start point
- Concorde algorithm solves the rest of the tour

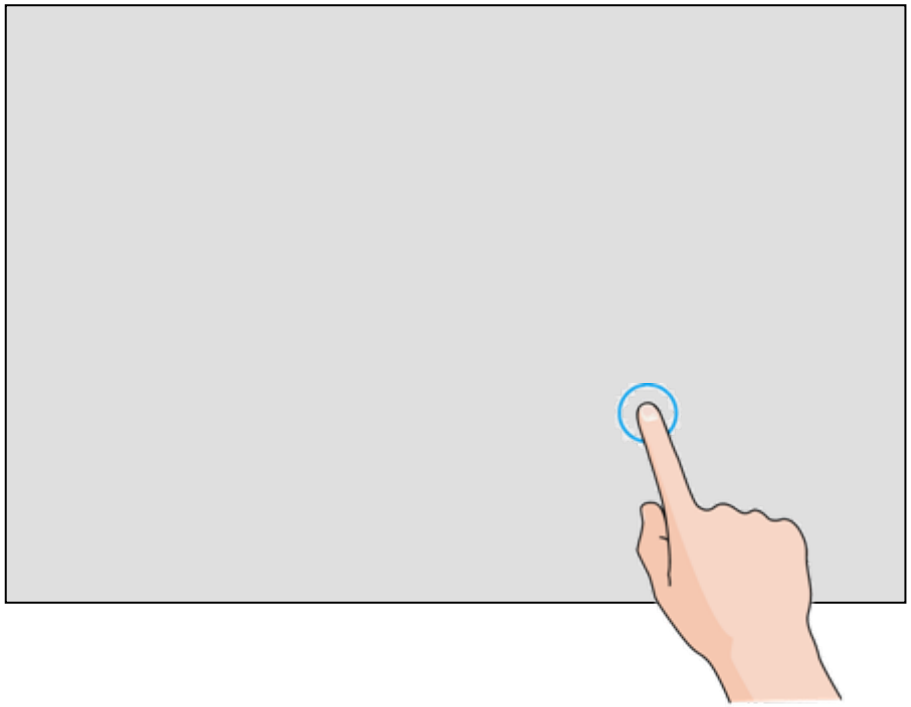
- Calculate the **gap** between the resulting tour and the optimum



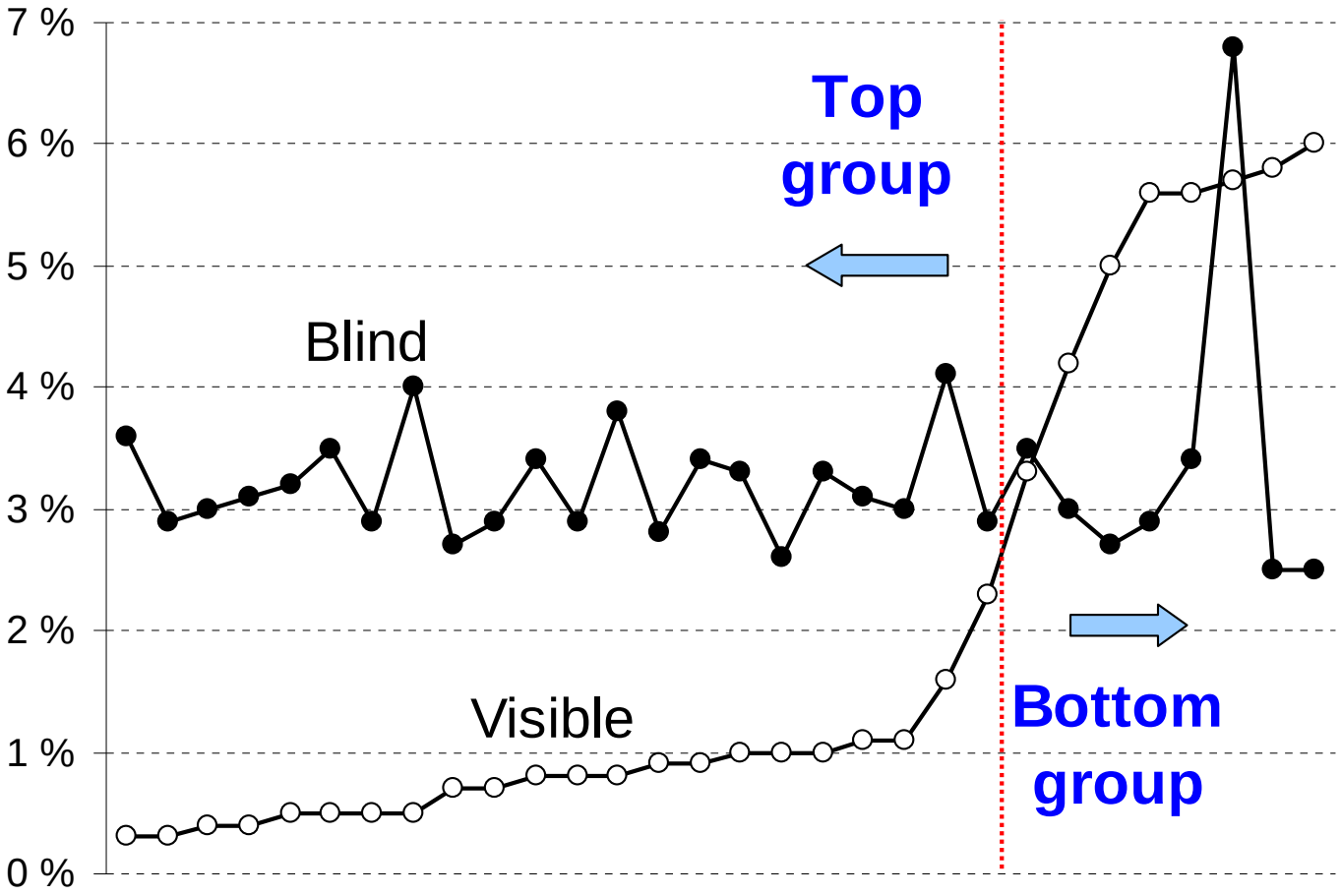
Experimental setup

Blind task

- Player sees only the bounding box!
- Otherwise the same test setup
- Significantly more challenging

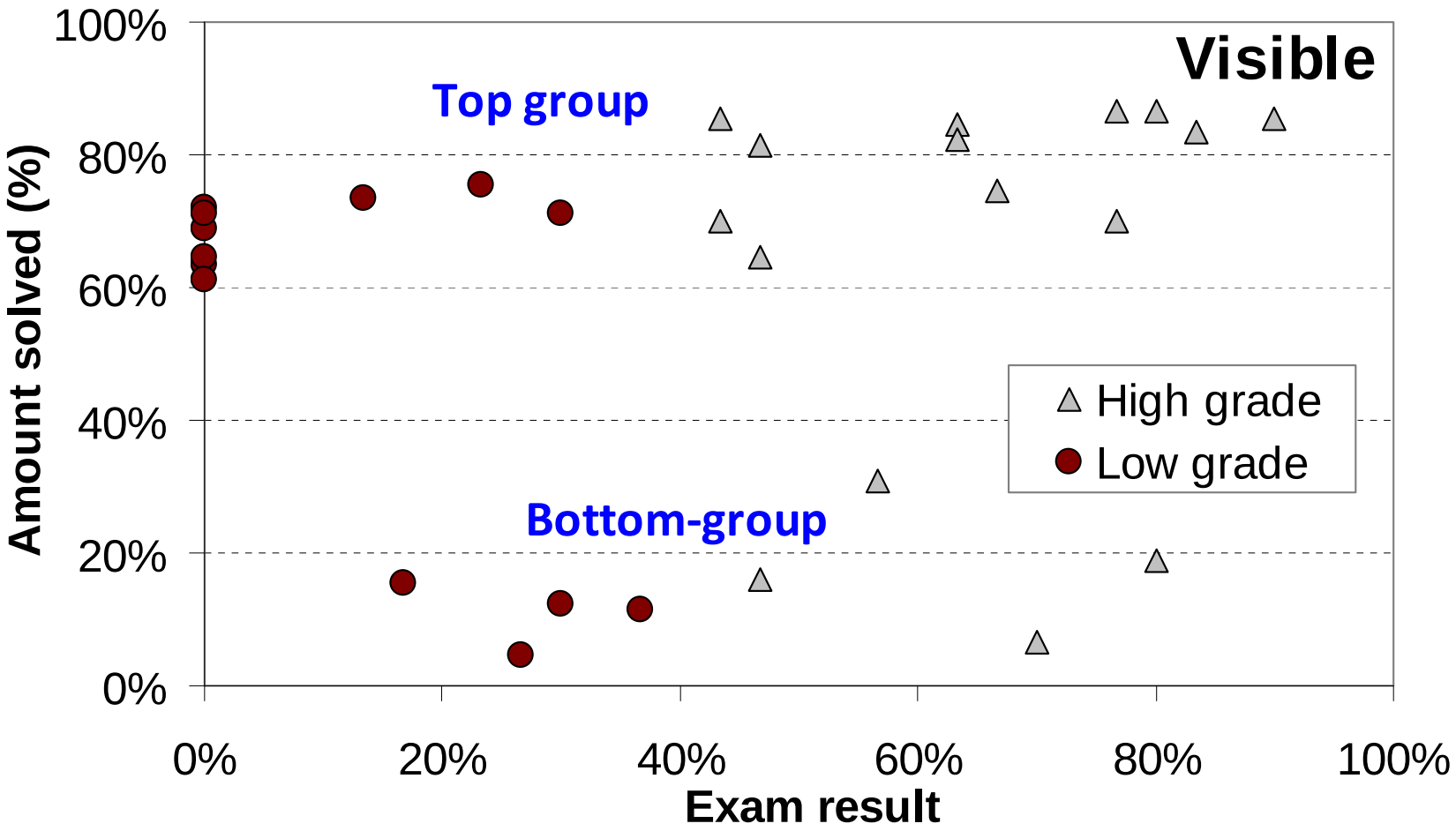


Human performance (gap)



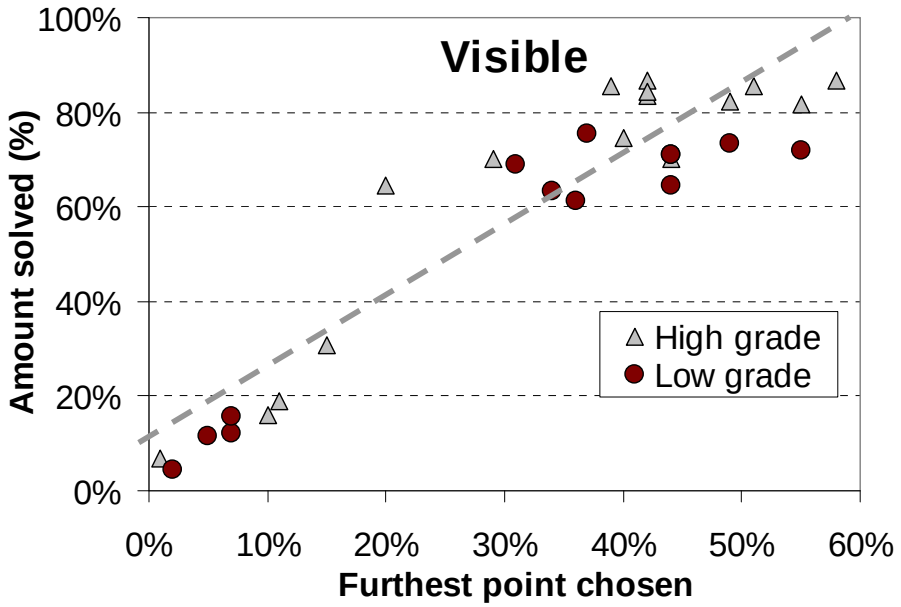
Correlation to study results

Design and Analysis of Algorithms

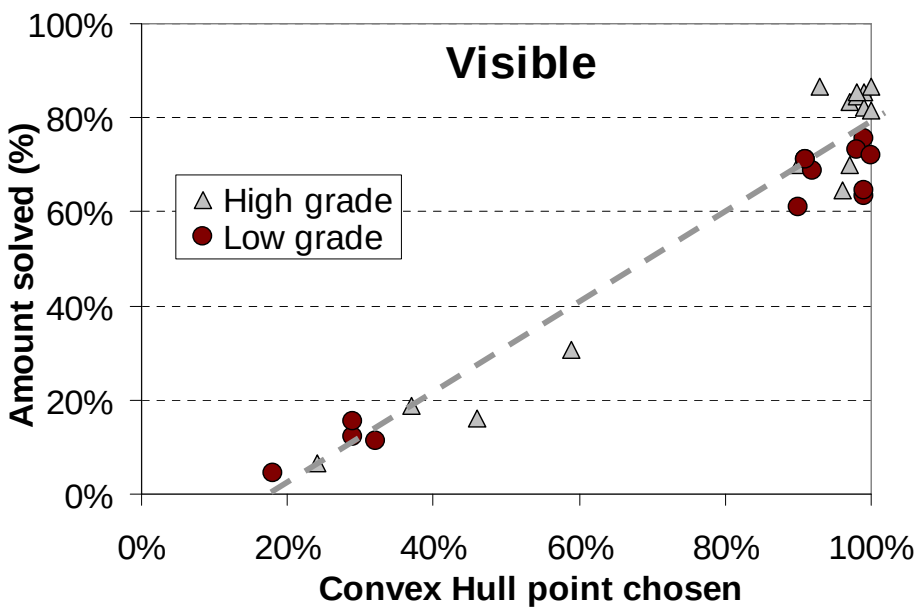


Effect of playing strategy

Furthest point strategy



Points on convex hull

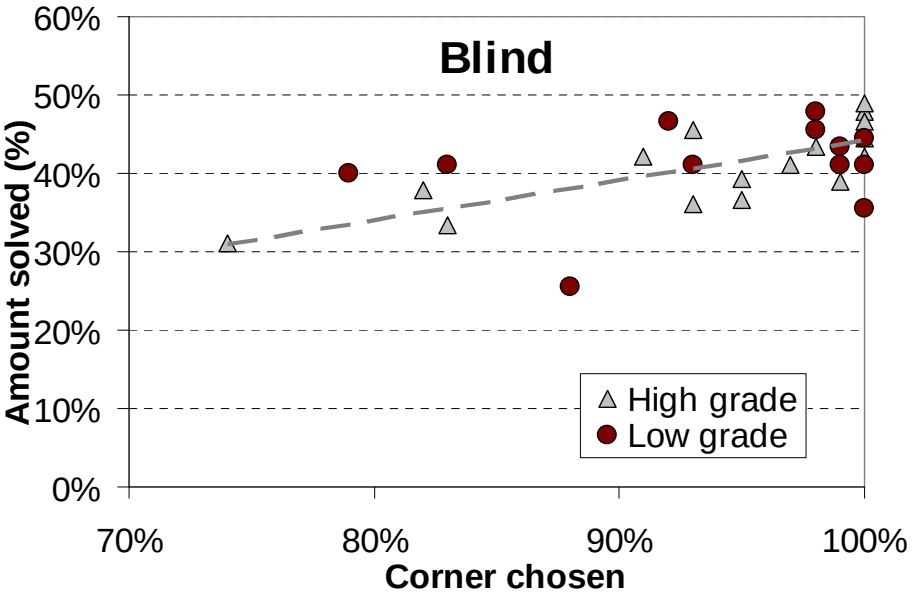


Summary of affecting factors

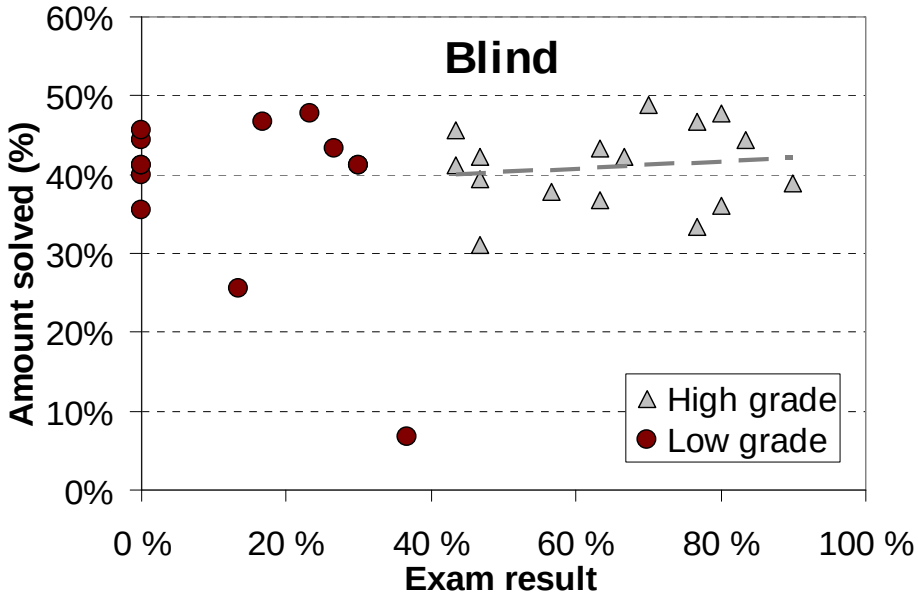
Affecting factor:	All	Top group
Convex hull	**0.97**	0.38
Furthest point	**0.93**	0.53
Course performance	0.11	**0.72**

Blind performance

Corner point strategy



Exam result



What did we learn?

Conclusions

- Selecting the start point surprisingly tricky
- Best human strategies:

  Visible: Furthest points and convex hull

  Blind: Corner!
- Best computer strategy (blind):

  Shortest edge