Optimization in Transport and Logistics

VU – ECTS: 3.0

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PART IV
Programming Exercise

RaceTrack

Background

- game “developed” in 1973
- paper and pencil game
- simple, yet physical reality

RaceTrack – Gaming Rules

Given

- track
- grass
- obstacles
- start position
- finish line

Goal

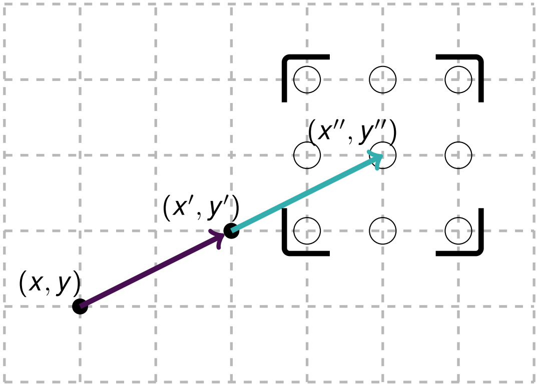
- Cross finish line as fast as possible (i.e., with the least number of moves)

RaceTrack – Gaming Rules II

Movements

- the next move is always dependent on the previous one
- mimicing physical reality
- only integer steps
- if on-track → acceleration, deceleration, and steering possible
- if off-track (grass) → slowing down
- if hitting an obstacle (or off-track (out of bounds)) → lost

RaceTrack – Gaming Rules III



always:

$x' + (x' - x) - 1 \leq x'' \leq x' + (x' - x) + 1$

$y' + (y' - y) - 1 \leq y'' \leq y' + (y' - y) + 1$

start speed: $\vec{x} = 0$, $\vec{y} = 0$

when on grass, in addition:

$(x' - x) \geq 2 \implies (x'' - x') - (x' - x) < 0$

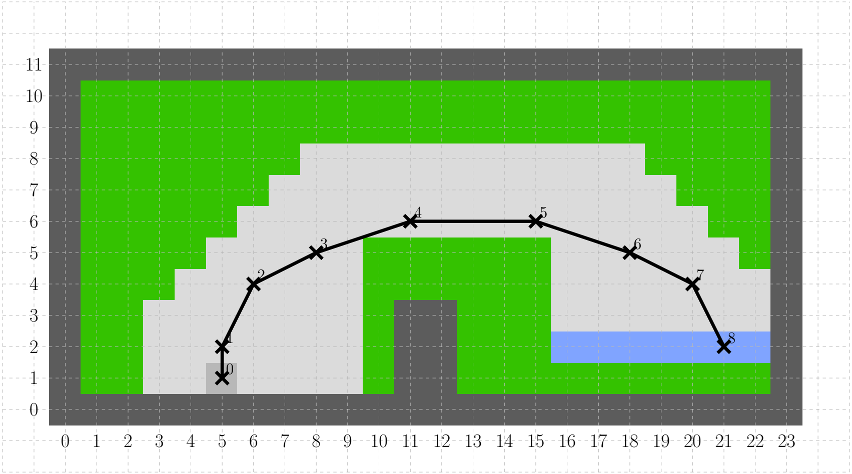
$(y' - y) \geq 2 \implies (y'' - y') - (y' - y) < 0$

$(x' - x) = 1 \implies (x'' - x') - (x' - x) \leq 0$

$(y' - y) = 1 \implies (y'' - y') - (y' - y) \leq 0$

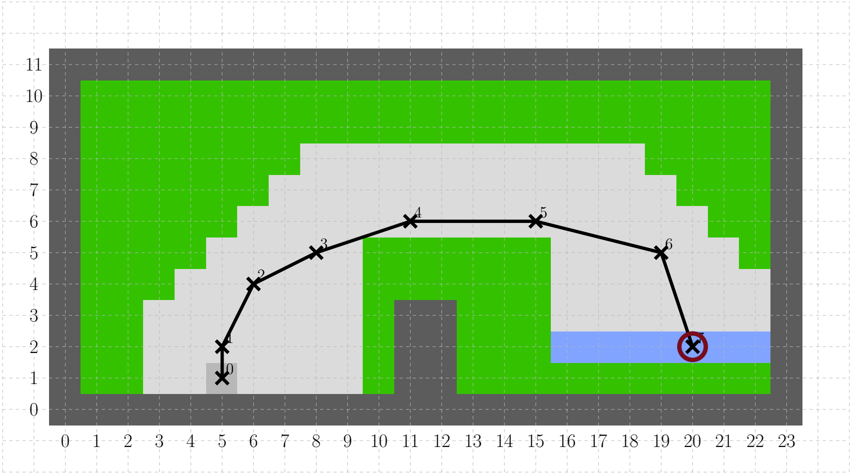
RaceTrack – Example I

all fine



RaceTrack – Example II

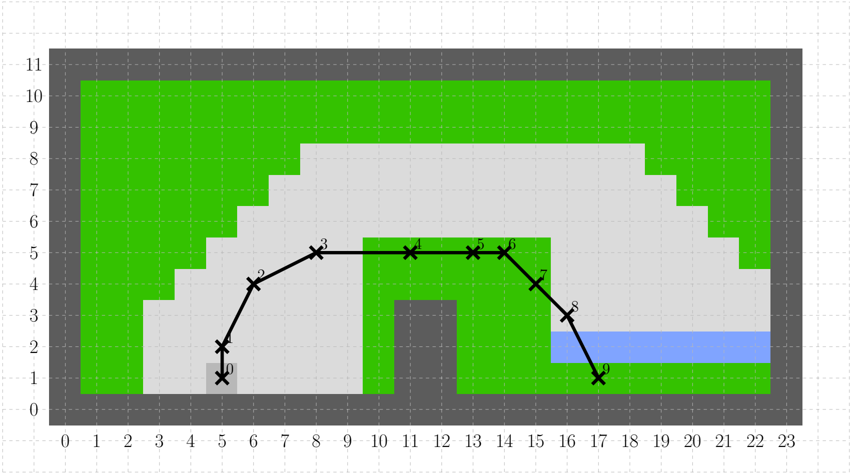
wrong speed (move 7)



Programming Exercise

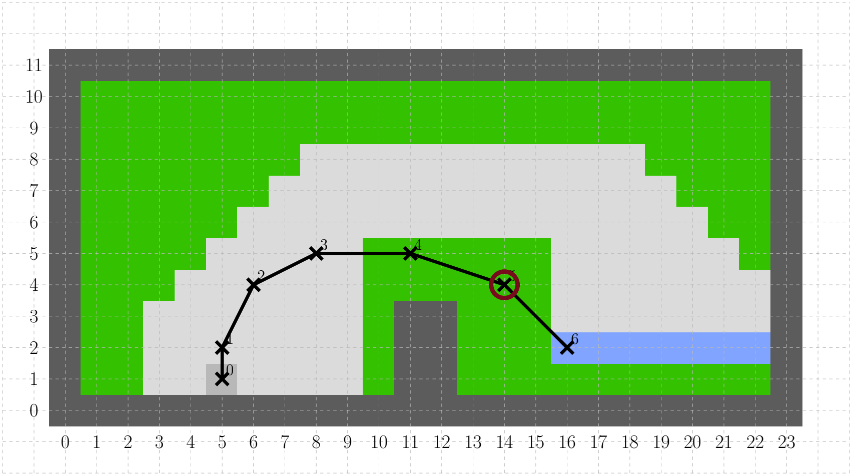
RaceTrack – Example III

all fine (slowing down in grass)



RaceTrack – Example IV

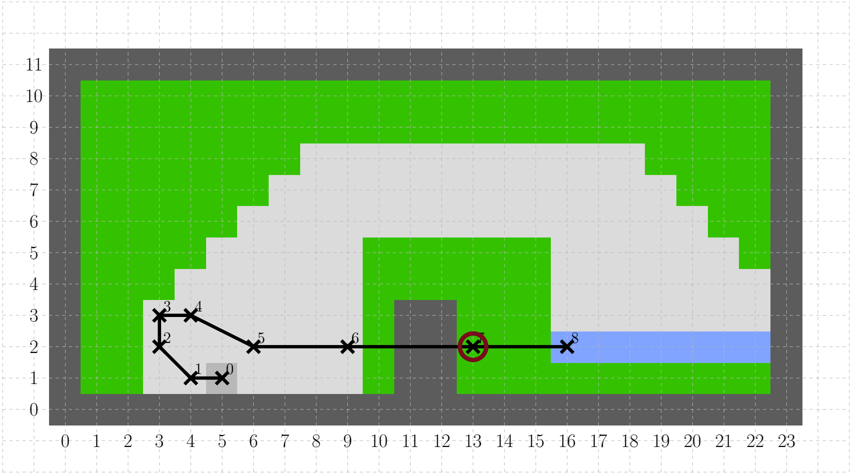
wrong speed in grass



Programming Exercise

RaceTrack – Example V

hitting an obstacle (move 7)



RaceTrack – Example Va

Obstacles

Hitting an obstacle

an obstacle is hit whenever

- either the end or the starting point (or both) are inside of the obstacle
- the line segment between two positions cross an obstacle

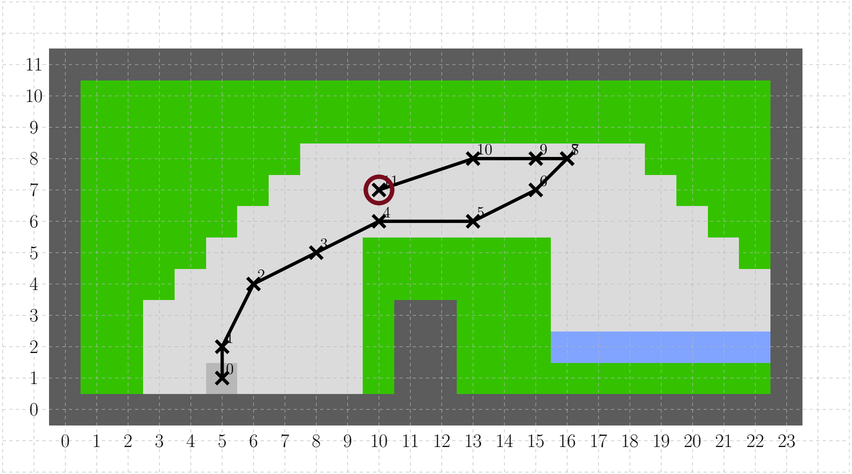
Definition of obstacles

an obstacle is defined as

- the rectangle [-0.5;+0.5] around
- the center position specified in the input file
- on both axis

RaceTrack – Example VI

did not finish



Now, let’s have a game.

RaceTrack – Programming Exercise I

file formats

Input Format

- text file
- character based matrix / raster
  - T .. track
  - S .. start
  - F .. finish
  - O .. obstacle
  - G .. grass

Output Format

- text file (csv)
- each line one coordinate (i.e., x, y; e.g., $3, 4$)

RaceTrack – Programming Exercise II

Visualisation and Validation Script

Requirements

- Perl
- assumes correct file formats
- checks on correctness of moves
- highlight errors
- (do not judge me on the programming style ;)

- call `./visualise.pl <trackFile> <tripFile> <outputFile>`
- call `pdflatex <outputFile>`
- (tested on Ubuntu)

RaceTrack – Programming Exercise III

- Solve RaceTrack
  - only minimize number of moves
- Implement a **construction heuristic**
  - present **May 13, 2025.**
- Implement a **metaheuristic-based approach**
  - present **June 6, 2025**
- Alone or in groups of up to three
  - you have to be able to explain your approach in detail

RaceTrack – Programming Exercise IV

- Presentation
  - briefly describe the method you used
  - explain any required adaption from the literature
  - solve provided benchmark instances
  - prepare result tables (best, avg, dev, runtime) and system specs for comparison
- Programming Language
  - up to you
- Provided Material
  - problem description (see slides above)
  - benchmark instances (more to come; you are also invited to submit your own race tracks)
  - solution visualiser/validator (Perl and PDFLaTeX required)

Literature

- Gardner, M.: Mathematical games—Sim, Chomp and Race Track: new games for the intellect (and not for Lady Luck). Scientific American 228(1), 108–115 (1973)
- Holzer, M., McKenzie, P. (2010). The Computational Complexity of RACETRACK . In: Boldi, P., Gargano, L. (eds) Fun with Algorithms. FUN 2010. Lecture Notes in Computer Science, vol 6099. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-13122-6_26
- Tarandi, A., Olsson, R. (2011). A genetic algorithm in the game racetrack. Degree Project in Computer Science, First Level. KTH, Sweden.
- Michael A. Bekos, Till Bruckdorfer, Henry Förster, Michael Kaufmann, Simon Poschenrieder, Thomas Stüber, Algorithms and insights for RaceTrack, Theoretical Computer Science, Volume 748, 2018, Pages 2-16, https://doi.org/10.1016/j.tcs.2018.04.028.
- Wikipedia: https://de.wikipedia.org/wiki/Racetrack