Université Libre de Bruxelles

INFO-F420

Computational Geometry

Project Proposal : Mirror reflections

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1 Introduction

This short project proposal report was made in the context of the INFO-F420 *Computational Geometry course* at Université libre de Bruxelles.

Our group will work on the ray tracing topic, and in particular on studying the article *Reflections in an Octagonal Mirror Maze*[1] [Epp22a] by D. Eppstein.
It can be summarized by the following result cited from the above's paper: "*Suppose we are given an environment, described as a collection of line segments, each side of which may be marked as reflective or non-reflective, with integer endpoints, an integer position for the start of a light ray, and an integer vector describing the initial direction of the light ray. Then in time polynomial in the number of segments and in the number of bits needed to specify the integers of the input, we can determine whether the reflected ray is eventually absorbed or escapes to infinity. If it is absorbed, we can determine where it is absorbed, what direction it comes from when it is absorbed, and how many bounces it makes before this happens. If it escapes to infinity, we can determine its eventual escape path, and how many bounces it takes before reaching this path. The time bound for these algorithms is* $O(n^2 logN + log^2 N)$.".

In short, its idea is mainly based on the *iterated integer interval exchange transformation*[2] [Epp21] by reducing the problem into a "discrete one-dimensional system".

2 Planned work

Our work will be organized as follows.

- We will introduce the readers to the ray-tracing subject, by explaining its applications and difficulties.
- We intend to popularize the main reference and its underlying aspects whilst demonstrating our deep understanding of the subject throughout.
- The above paper's result will be compared to other articles, methods and algorithms in the domain notably in terms of their main ideas and their complexity.
- We plan to implement the proposed method as an interactive website application, allowing users to explore and experiment with the algorithm.
- Additionally, we might create a small puzzle game employing the studied methods. For instance, we could implement a small laser game as *Laser Chess™* [3] where we need to put mirrors to lead an initial ray to a final destination, or just come up with an idea of our own.

2.1 Work distribution

Despite this being a group project, the workload will *a priori* not be distributed; all group members will collaborate on every part of the project, mainly by following a sort of pair programming technique.

[1] https://arxiv.org/abs/2206.11413
[2] https://arxiv.org/abs/2112.11607
[3] https://www.thinkfun.com/products/laser-chess/

3 Additional comments

3.1 Bibliography

The below bibliography (references) section is given as a starting point and does not yet explicitly include every article that will be analysed during the project.

References

[Ben73] Charles H. Bennett. "Logical reversibility of computation". In: *Ibm Journal of Research and Development* 17 (1973), pp. 525–532.

[RTY94] John H. Reif, J. Doug Tygar, and A. Yoshida. "Computability and complexity of ray tracing". In: *Discrete & Computational Geometry* 11 (1994), pp. 265–288.

[Gho+11] Subir Kumar Ghosh et al. "Algorithms for computing diffuse reflection paths in polygons". In: *The Visual Computer* 28 (2011), pp. 1229–1237.

[Epp21] David Eppstein. "The Complexity of Iterated Reversible Computation". In: *ArXiv* abs/2112.11607 (2021).

[Epp22a] David Eppstein. "Reflections in an octagonal mirror maze". In: *ArXiv* abs/2206.11413 (2022).

[Epp22b] David Eppstein. *Slides for Reflections in an octagonal mirror maze*. https://www.ics.uci.edu/~eppstein/pubs/Epp-CCCG-22c.pdf. 2022.