Université Libre de Bruxelles

INFO-F420

Computational Geometry

Project Proposal : Mirror reflections

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October 2022

1 Introduction

This small 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

The project will introduce the readers to the ray-tracing subject, by explaining its utilities and difficulties. Then, we will vulgarize our main reference while showcasing our deep understanding of the subject. We could also compare this algorithm with other algorithms of higher complexity, like the simple "bound-and-bounce" algorithm (compute every bounce).

We plan to implement this algorithm as an interactive website allowing to explore the algorithm proposed in the article which runs in $O(n^2 logN + log^2 N)$.
Additionally, we might try to create a small puzzle game based on this algorithm. A classic idea would be to implement small laser game (e.g. Laser Chess[3]) in which we need to put mirrors to lead an initial ray to a final destination.

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.

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

[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.