Computer Graphics and Computational Geometry
Project Report

Art Gallery Problem with Streetlight Placement

Group Details

Group ID: **23**
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Problem Statement

We aim to solve the classical Art Gallery Problem (AGP). Given a simple polygon with n vertices:

- **Input:** A simple polygon represented using a DCEL.
- **Goal:** Place the minimum number of vertex guards so that all interior points are visible.
- **Variants considered:** Vertex guards (primary), extended to streetlight placement.
- **Assumptions:** Polygons are simple, no holes, vertices in general position.

Extension: As an application, we map guards to streetlights in urban layouts. Vertices represent possible poles, and guards correspond to minimum streetlights ensuring coverage.

System Description and Features

Core Approach

- Polygon generation and validation via DCEL.
- Decomposition using trapezoidalisation and monotone partitioning.
- Triangulation of monotone polygons.
- Three-coloring of triangulation to select minimum vertex guards.

Extra Features

- Interactive GUI to step through each stage.
- Support for polygons of varying sizes.
- Streetlight placement extension for real-world analogy.

Screenshots for Sample Polygon

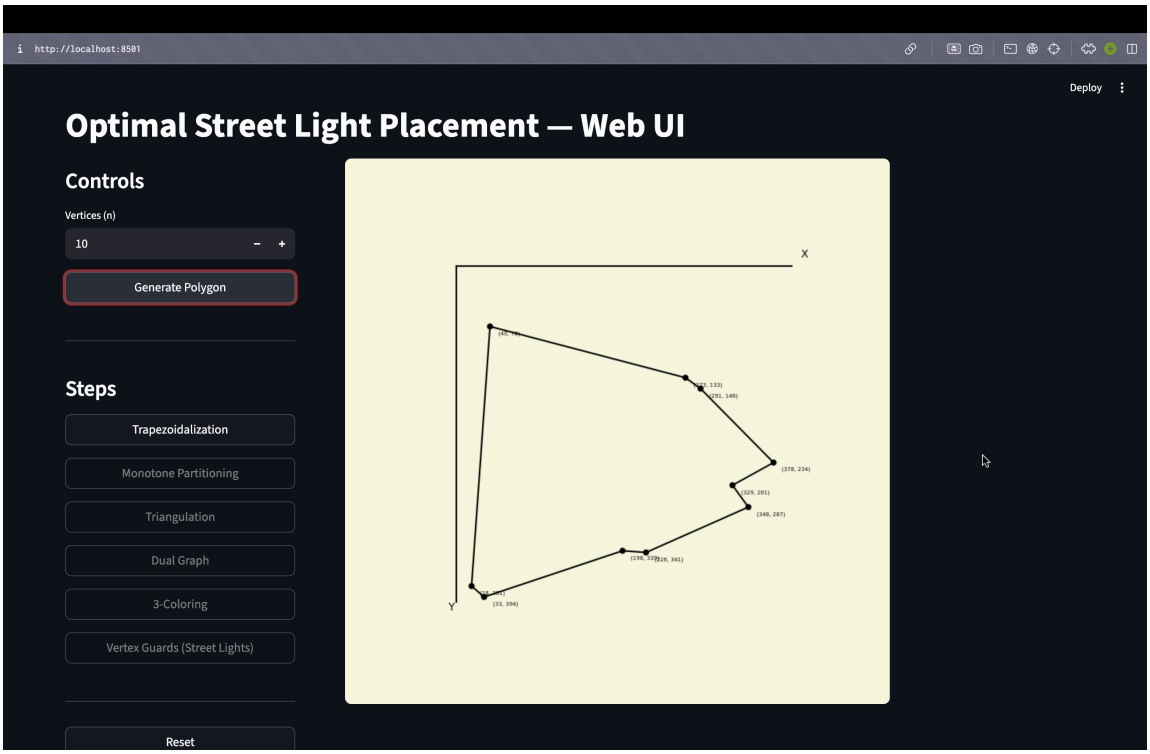

Figure 1: Polygon Generation

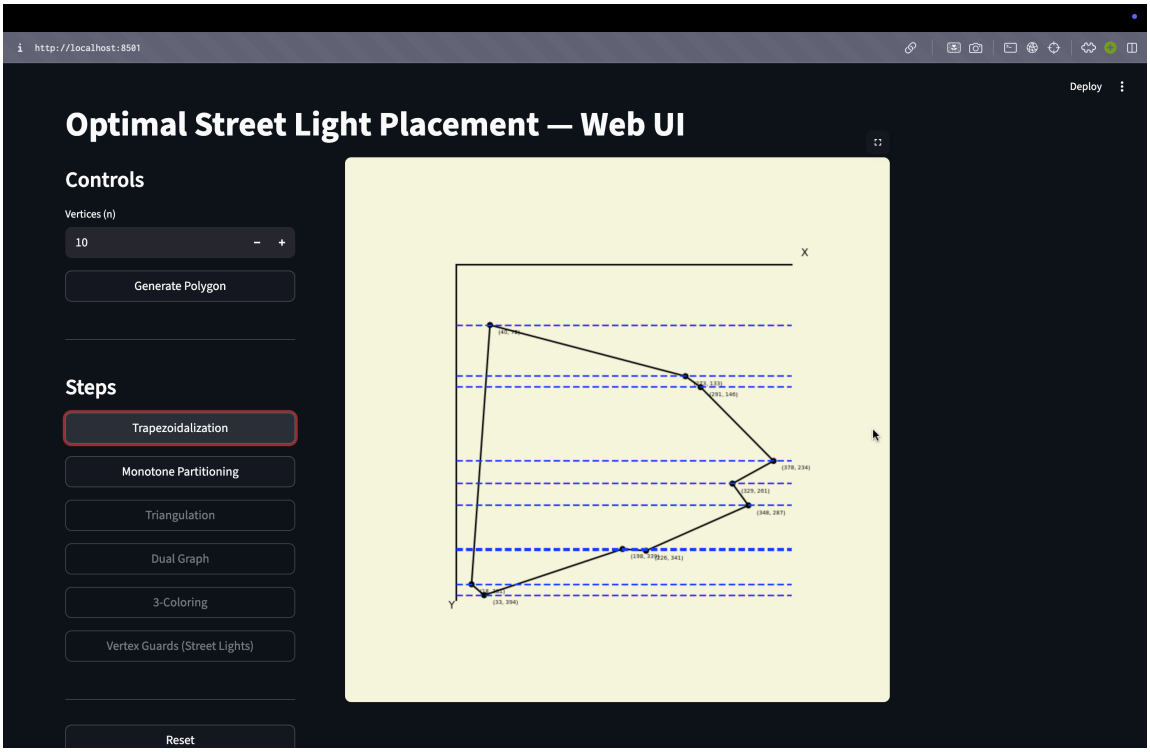

Figure 2: Trapezoidalisation

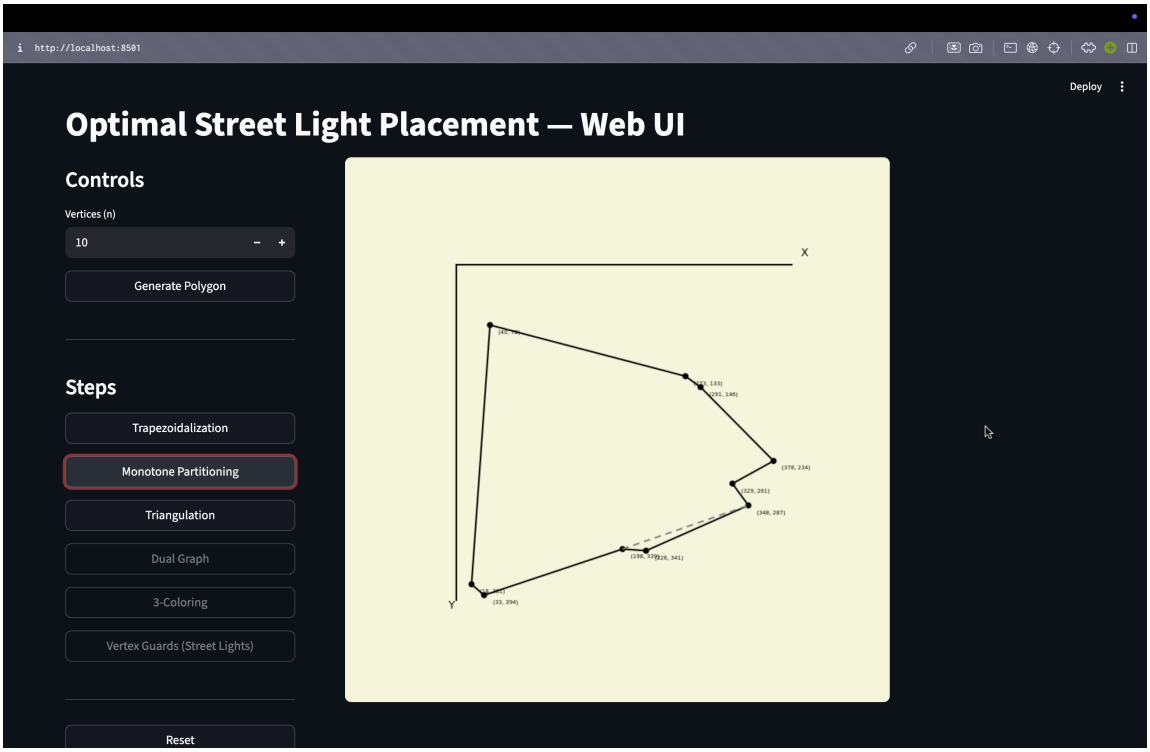

Figure 3: Monotone Partition

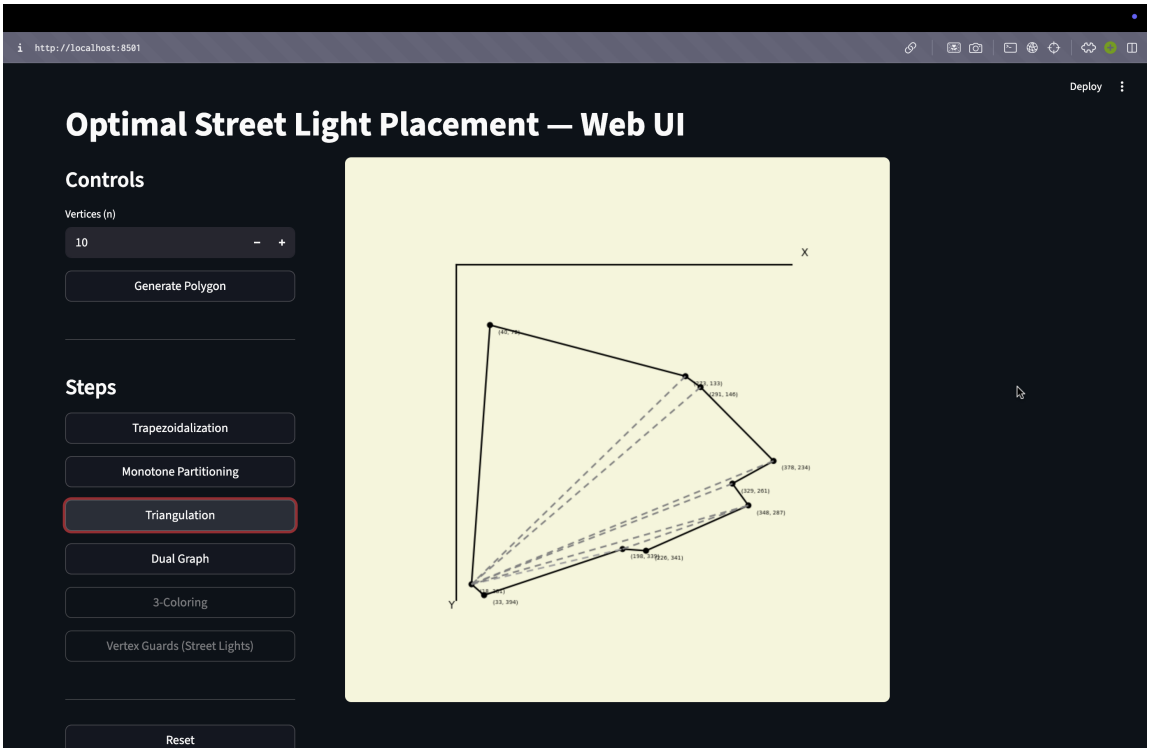

Figure 4: Triangulation

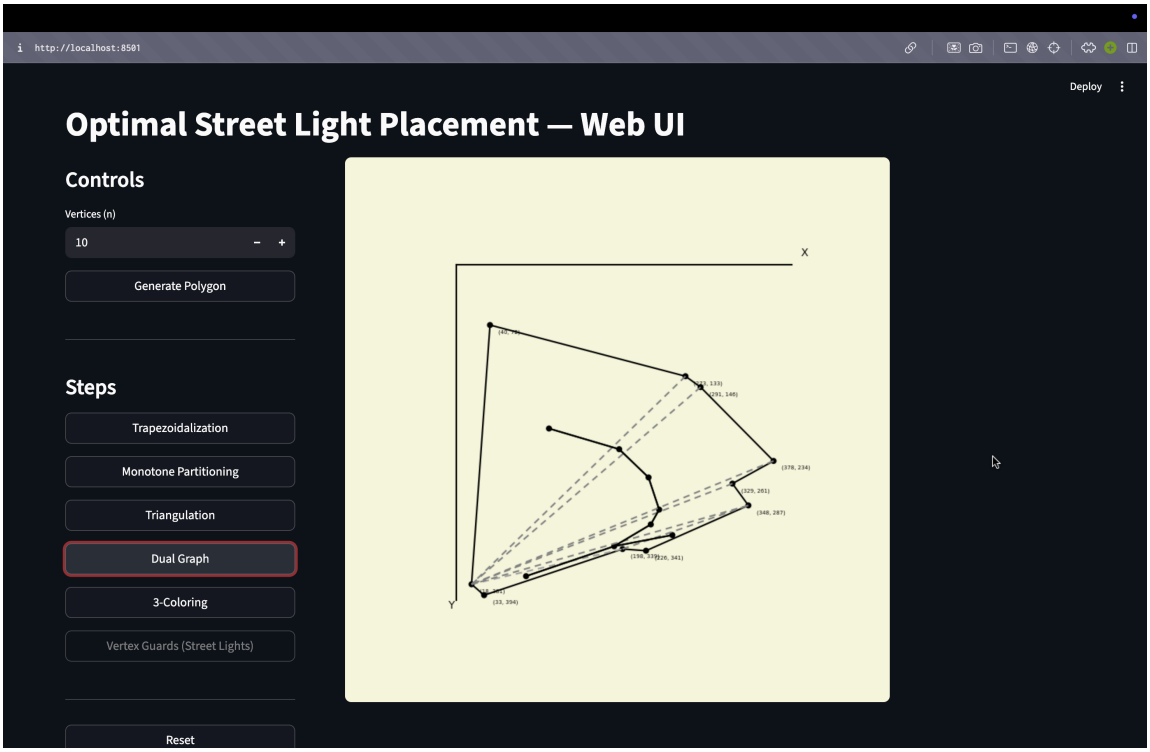

Figure 5: Dual Graph

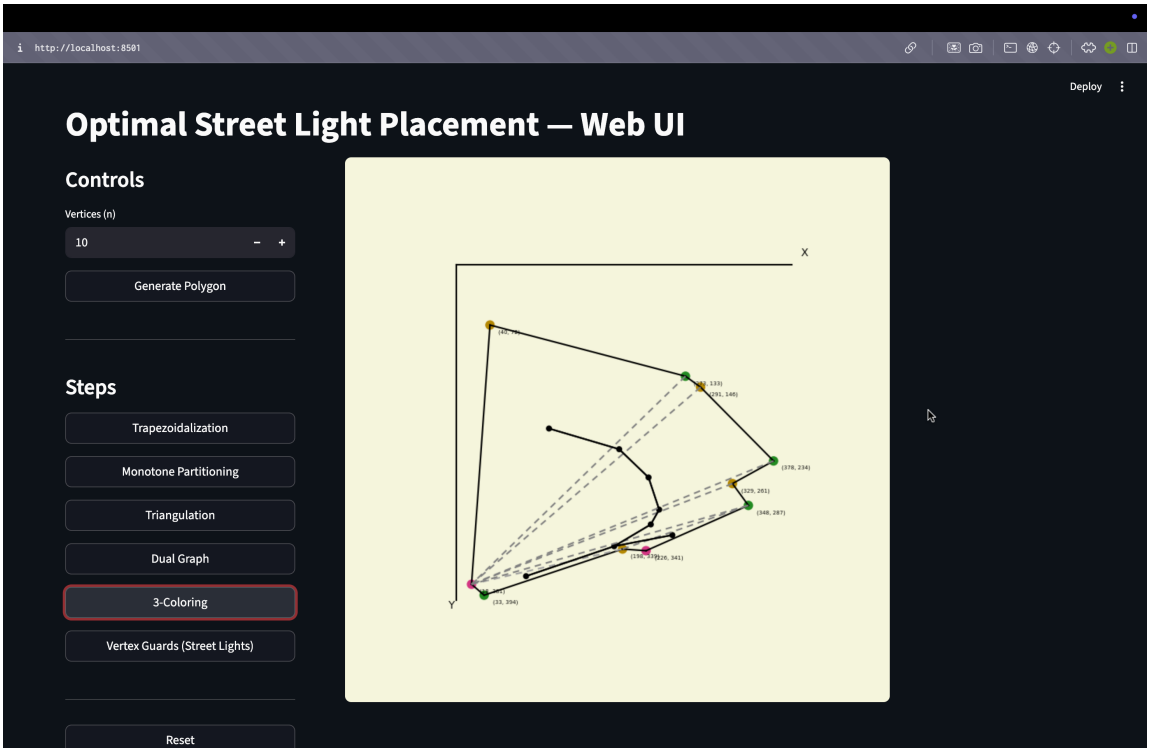

Figure 6: Three Coloring

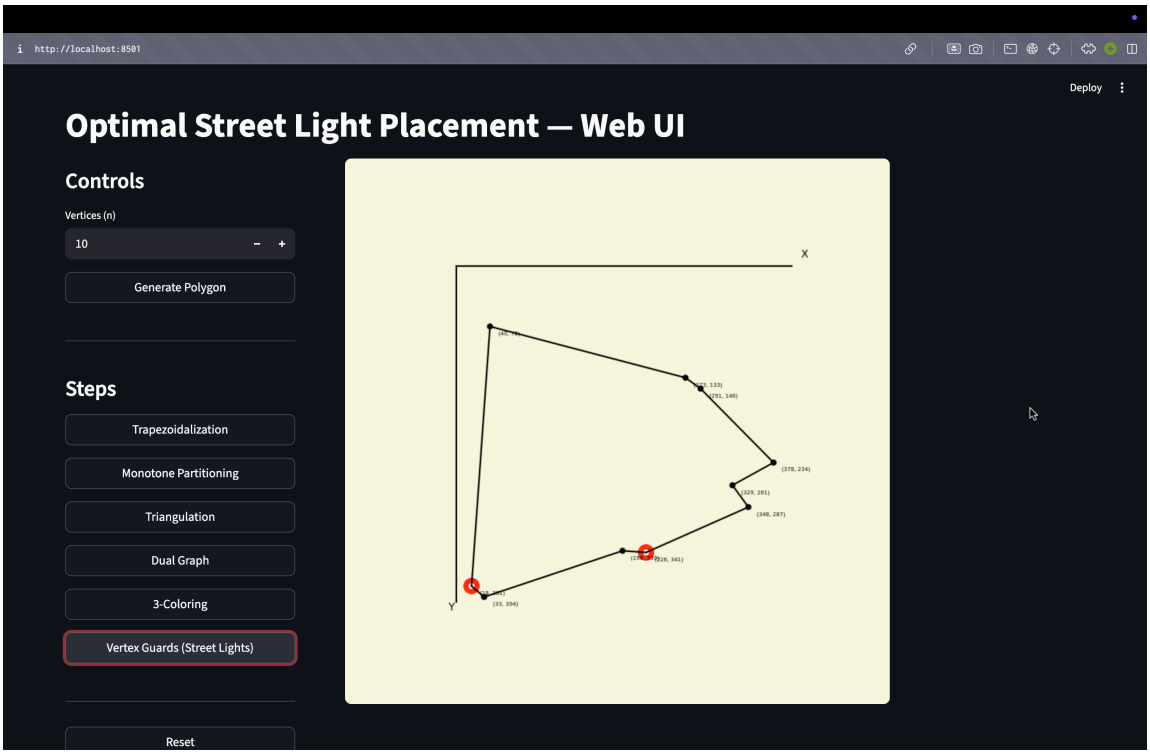

Figure 7: Final Guard Placement

Demonstration Video

A short video demonstrates:

- Setting up the project

- Polygon input and generation.
- Step-by-step decomposition.
- Streetlight placement

Video URL: Video Link

References

[1] V. Chvátal, "A combinatorial theorem in plane geometry," *Journal of Combinatorial Theory, Series B*, vol. 18, no. 1, pp. 39–41, 1975.

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[3] B. Chazelle, "Triangulating a simple polygon in linear time," *Discrete & Computational Geometry*, 6, 485–524, 1991.

[4] F. P. Preparata and M. I. Shamos, *Computational Geometry: An Introduction*. Springer, 1985.

[5] L. Guibas, A. L. Rosenberg, and F. F. Preparata, "Separable geometric graphs," *Information and Control*, 59(1-3): 13–33, 1983.

[6] S. Fisk, "A short proof of Chvátal's watchman theorem," *Journal of Combinatorial Theory, Series B*, 24(3):374, 1978.

[7] M. de Berg, O. Cheong, M. van Kreveld, M. Overmars, *Computational Geometry: Algorithms and Applications*, 3rd ed., Springer, 2008.

[8] S. K. Ghosh, *Visibility Algorithms in the Plane*. Cambridge University Press, 2007.

[9] CGAL: Computational Geometry Algorithms Library. https://www.cgal.org/. Accessed: Sept. 2025.

[10] ¡Additional reference on streetlight/illumination application if used¿.