Modeling and Lighting Interior Spaces using Reflected Natural Light

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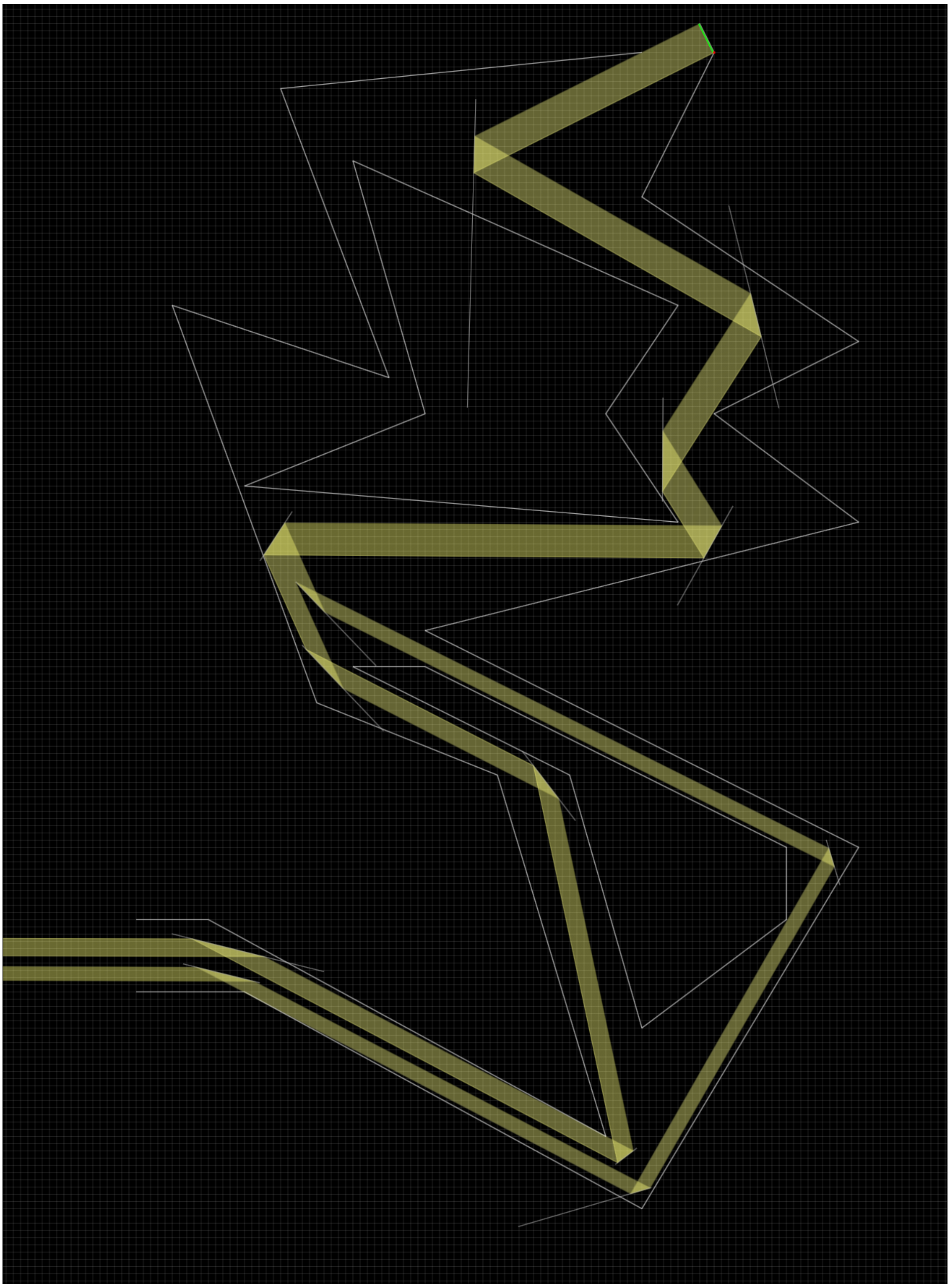

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1 Introduction

1.1 Premise

- Study aims to find optimal mirror placement for minimum decrease in intensity as light travels throughout the cave

1.2 Assumptions

In Order for a solution to be formed, a set of constants must be assumed.

- The mirrors and walls of the cave are perfectly parallel to the floor of the cave and extend upwards with an undefined height. This simplifies modeling and can easily be altered to fit revised specifications, such as only needing to light the floor of the cave.
- Either light does not decrease in intensity or increase in area according to the inverse square law, or the change is negligible. The suns rays have traveled so far that they can be considered effectively parallel and therefore will not diverge. **find a source for this**
- mirrors will reflect light across their entire surface, even at the very tips of their edges.
- Light will enter the cave parallel to the ground and of equal intensity from floor to ceiling.
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1.3 Observations

- Vectors can be modeled on the Cartesian plane as
- Light can be modeled as a relative position vector with origin at a mirror surface
- Light will reflect so that angle of incidence = angle of refraction. This relationship can be modeled as the vectors $\boldsymbol{i}$ co-ordinate being scaled by a factor of -1 when it reflects. i.e. a reflection on the x-axis.
- Light will not diverge however contaminatns in the air may decrease the intensity of light. Distance light travels in cave must me minimized
- Mirrors are not perfect and will only reflect a portion of light that hits them.
- Since it is assumed that light will not diverge. the maximum size a mirror must be to reflect all the light hitting it will be 2 units, or the size of the cave's entrance.

1.4 Translation

- As mentioned, mirrors are not perfect. The amount of light lost when a reflection occurs can be modeled as an exponential, $I = \text{Efficiency}^x$, where I is intensity of light, n is the number of mirrors, and efficiency is the percentage efficiency of the mirror in decimal form. Clearly adding more mirrors will lead to exponential losses in intensity.
- Vector addition can be used to join each given vector and form the walls of the cave and the obstacles
- Used Excel to do vector addition
- Took points from excel and inserted them as separate x and y list in desmos
- Graphed each point on list and joined points with lines.
- Imported Lists as points in physdemo.app

- Used the given lists and entry vector to draft a path through the cave
- clearly some sections of the cave are too narrow so split beam. More distance but drastic reduction in mirrors while maintianing full beam area
- translate mirrors from phyapp demo into lists of points for desmos
- graph linear equations from the lines formed between points (i.e. the locations of mirrors) and find intersections with initial beam of light
- trim mirrors to minimum size
- calculate angle of reflected beam
- repeat for all items and alter angles if a collision with the walls of the cave or an obstacle occurs

2 Solve

3 Evaluate

3.1 Extentions

- Use of Lenses

3.2 Reasonableness

3.3 Strengths and Limitations of Solution

4 Conclusion