Modeling and Lighting Interior Spaces using Reflected Natural Light
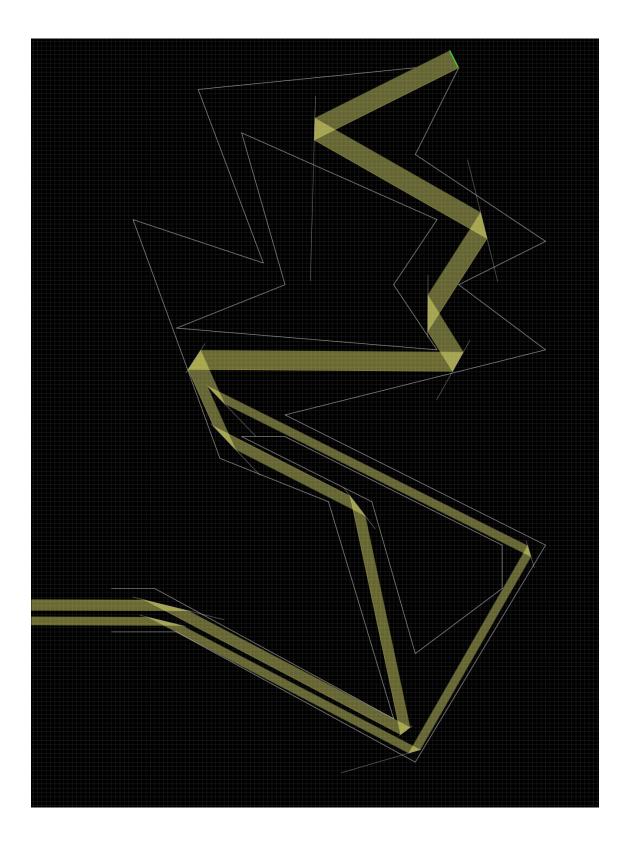
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Contents

1 Draft Note

Hey Sir! Hope this finds you well (i.e. without any more snakes around you),
If you could provide a short answer to a few of these questions (which I forgot to ask you in class) it would be really helpful

Major Questions:

- Should I be describing how I got to my solution the way I am (in tems of number of steps as I am yet to flesh each step out fully)

- What excatly goes in the solve section? I am describing a lot of my math in the translation section and I believe I should be moving a lot of it to my solve section. Would you agree or disagree?

- I have multiple solutions that are iterations on the previous one. I have one that I know is the best, but I also have another that I believe was a major inprovement on the previous one and directly leads to my final solution. Any advice on if, and how, I should integrate this into my final submission.

- I believe that I am on the right track when it comes to my strengths and limitations, I just dont have much there yet. As to say i think what I have is good I just need more of it. Agree or disagree?

Sorry for hitting you with a wall of text before you even got to the assignment. Especially considering im probably submitting this at 11:59pm on saturday night...
oh and also I didnt use spell check because its broken on linux. I will fix this in my final
Thanks,
- Noah

2 Introduction

2.1 Premise

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

2.2 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.

- mirrors are perfectly flat and do not distort or affect light beams in any other way than reflecting them

- Light will enter the cave parallel to the ground and of equal intensity from floor to ceiling.

2.3 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 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.

2.4 Translation

- As mentioned, mirrors are not perfect. The amount of light lost when a reflection occurs can be modelded 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 phydemo.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

- if a colission occurs, then tweak mirror angle to correct and repeat

- verify light exiting cave is aligned with exit vector by measusing angle against entry vector

3 Solve

what do i put here exactly?

4 Evaluate

4.1 Extentions

- Use of Lenses or curved mirrors to focus or manipulate light

- Quantification of intensity and how factors such as distance and number of mirrors affect it in order to further optimize for maximum intensity.

- use of algortihms to find the most mathematically correct solution.

- Conversion into an optimisation problem

4.2 Reasonableness

- verified that solution was valid through visual inspection in desmos and through checking angle of exit vector

4.3 Strengths and Limitations of Solution

4.3.1 Strengths

- No light was lost through absoption into the cave walls

- the solution used the minimum amount of mirrors found to be required

4.3.2 Limitations

- Low tollerance for error in mirror placement in case of physical instalation, which is imminent considering the context of the task

5 Conclusion