Camera Imaging based on Monte-Carlo Algorithm

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Problem Statement

In the development of automobile lights, as the requirements for the appearance of lights and the uniformity of lights become higher, the visual simulation of the lights is becoming more and more important, and existing software is increasingly difficult to meet actual job needs. This project is to derive a 3D optics imaging simulation software, resembling CCD Camera.

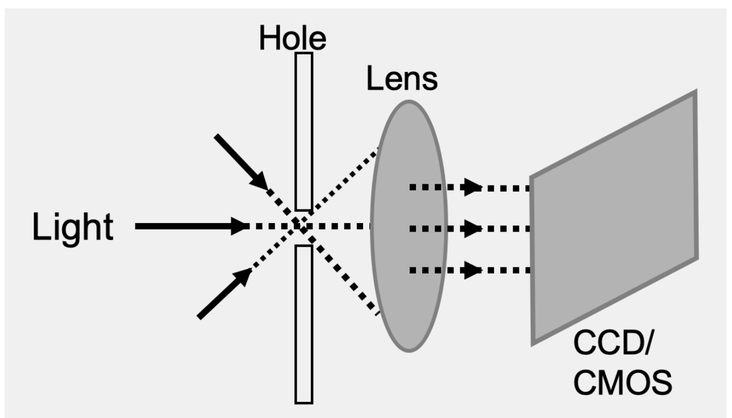

Fig.1 Principle of CCD camera imaging

Design & Modeling

Our simulation is based on a typical geometrical optics. Different from a common rasterization or ray-tracing algorithm, we organize optical devices in a layer structure, which reduces the complexity of simulation. In detail, a ray finally hitting on CCD must pass pinhole first and then hit the lens.

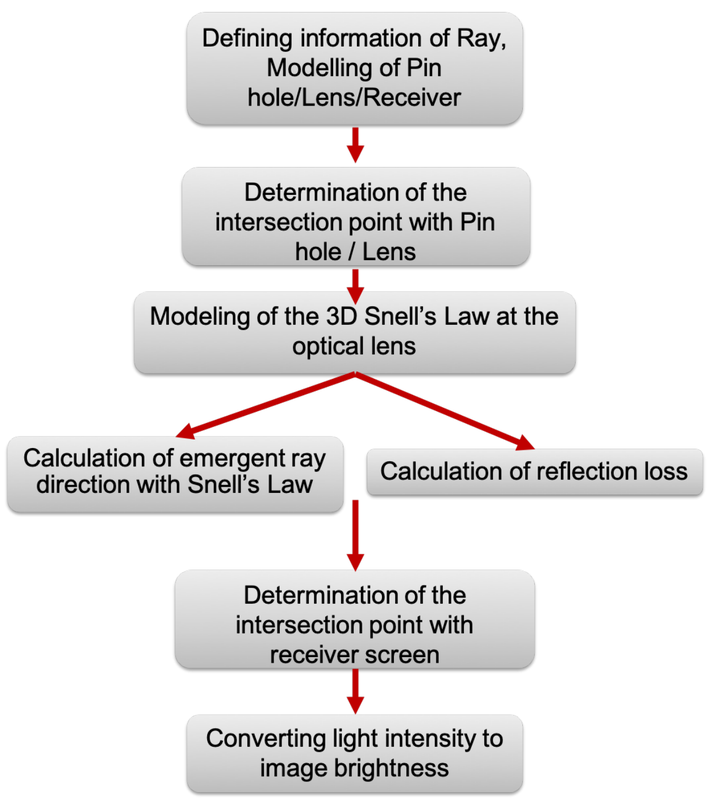

Fig.2 Design diagram for the algorithm

The figure above shows the flow diagram of our algorithm.

The input of the software includes starting point, direction and intensity of each incident ray. Based on Monte-Carlo Algorithm, we selected 200 million rays to represent the appearance of light source better. Then, we defined the mathematical modeling of the aperture, optical lens and CCD receiver. The core design focuses on the 3D modeling of Snell's law to determine refraction direction and refraction loss. Figure 3 shows the 3D model of Snell's law.

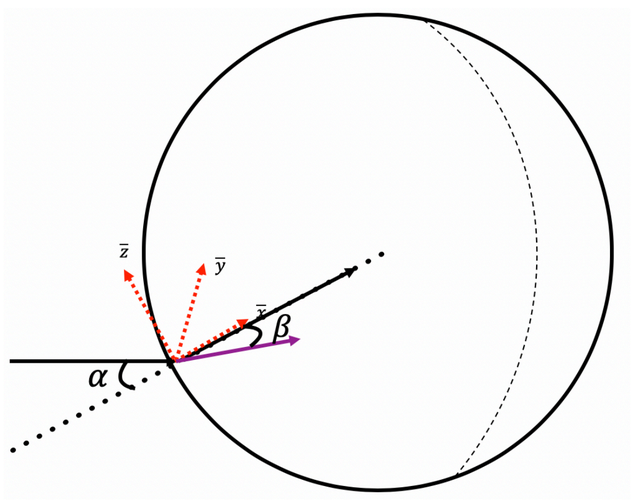

Fig.3 3D model of Snell's law.

Referential Experiment

A referential experiment is conducted using the tail light and high standard optical elements. This aims to simplify the tuning process and provides reliable optical parameters for the program. Real images are captured with digital camera and compared with computer simulated ones for quantitative accuracy analysis.

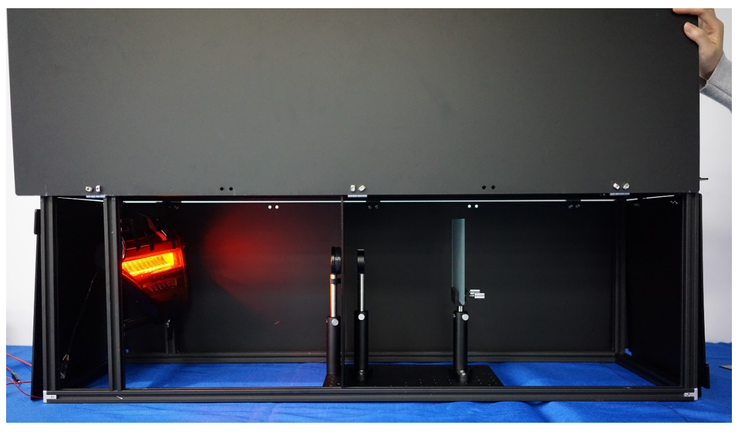

Fig.4 The experiment setup

Validation

Validation Process:

MATLAB is applied to calculate the pixel by pixel fitting difference between two pictures. LED number is obtained by recognition of special pixel points with MATLAB coding. The LED distance ratio is found by scaling up the pictures and measuring on screen with a digital ruler.

Validation Results:

According to validation part, all the specifications can be met.

- ✓ Size of output file <=2MB
- ✓ Running time <=500s
- ✓ Resolution>=800*600
- ✓ Error of LED distance ratio<=20%
- ✓ Error of LED number<=20%
- ✓ Error of total pixel<=40%
- ✓ Cost<=5000RMB

√ means having been verified and · means to be determined.

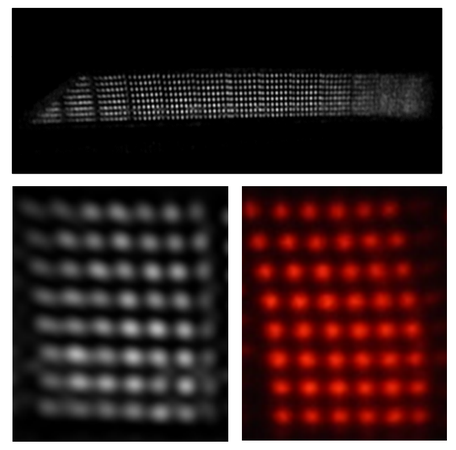

Fig.5 Simulated result (top) and Comparison between simulated result(left) and referential image(right)

Conclusion

The CCD camera simulation software based on the geometrical optics can simulate the appearance of light successfully. What's more, the image quality satisfies the accuracy requirement and the software can reach the operating rate requirement.

Acknowledgement

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Reference

[1]http://labs.seas.wustl.edu/bme/Wang/index.html