

Teaching optical design in the AI area

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ABSTRACT

All fields will be affected by the arrival of ChatGPT and other highly advanced generative artificial intelligence models, which show us just how brilliantly tasks can be reproduced by these engines. It is therefore natural to ask how the teaching of optical engineering, and in particular optical design, is and will be affected by this phenomenon. In this paper, we report on how, over the last 5 years, I have modified my introductory and advanced classes in optical design. Using a few examples, I'll try to show the positive points but also the impacts of using tools like LensNet. Finally, I'll conclude with some thoughts on what may or may not lie ahead, and how we can introduce these new technologies into the training of future optical system designers.

Keywords: Lens design, LensNet, first order optics, optical engineering, education.

1. INTRODUCTION

Novelty is certainly a scientist's greatest motivation. It is both a source of anxiety and excitement. So, we can see the arrival of AI as being precisely that, a novelty generating its share of anxiety and excitement, because how can we predict how it will develop, and particularly how generative AI will change the way we teach? Many students already use AI chatbots to help with their homework. Educators need to study how to include these tools in teaching and learning in order to minimize pitfalls [1].

This paper is an initial discussion of the impact of AI on lens design teaching. First, we'll look at a small experiment showing the limits of ChatGPT and its evolution. Next, we'll look at the power of AI in lens design. Then we'll trace the first traces of AI in lens design. Finally, via an in-class experience, we'll see the positive impact of a tool like LensNet.

2. EXPERIENCE: DOES CHATGPT KNOW HOW TO COUNT?

I've had the chance to chat with many people on the AI and someone presented a simple experiment, simply asking ChatGPT if it can count. Here's the experiment (from a private presentation by Dr. Simon Verret). I found this experience most revealing for students in terms of the notion of remaining critical of new developments. So I present it to my students, both graduate and undergraduate.

Figure 1 shows an exchange in October 2023 with ChatGPT about numbers. To conclusion was that ChatGPT is wrong, so it is very important to stay alert and remains critical of this new generative AI chatbot. The figure 2 shows a similar experiment in April 2024. Now the chatbot is more convincing and even arrogant, providing the right answer with a python code to prove it.

This little experiment shows many things. First, AI evolves over time, so what we see today may not be what we get tomorrow. Secondly, it clearly shows the reliability limits of these tools. Finally, I hope it will sow doubt in the minds of my students.

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what's the number between 3 and 6

The number between 3 and 6 is 4.

is there another one

No, there is no whole number between 3 and 6 other than 4.

what about 5

You're absolutely correct. I apologize for the oversight. There is, in fact, another whole number between 3 and 6, and it's 5. So, the numbers between 3 and 6 are 4 and 5. Thank you for pointing that out!

what about 7

You are correct; I apologize for the oversight. There is another whole number between 3 and 6, and it's 5. I also overlooked the number 7, which is indeed greater than 6. So, between 3 and 6, there are the numbers 4, 5, and 7. Thank you for pointing that out.

Figure 1. October 2023, What's the number between 3-6

What is the number between 5 and 8?

ChatGPT
The number between 5 and 8 is 6.5. [-]

```
Analysis ✕  
python 📄 Copy code  
# To find the number between 5 and 8, we simply need to calculate the average of 5 and 8.  
number_between = (5 + 8) / 2  
number_between  
Result  
6.5
```

Figure 2. April 2024, What's the number between 5-8.

3. HOW POPULAR AI IN OPTICS

Figures 3 and 4 show the number of publications in optics using different keywords such as 'deep learning', 'lens design', 'optical design', and 'artificial intelligence' over the last 3 years. The study is not exhaustive, it's a search on google scholar. It shows that it's getting more and more important.

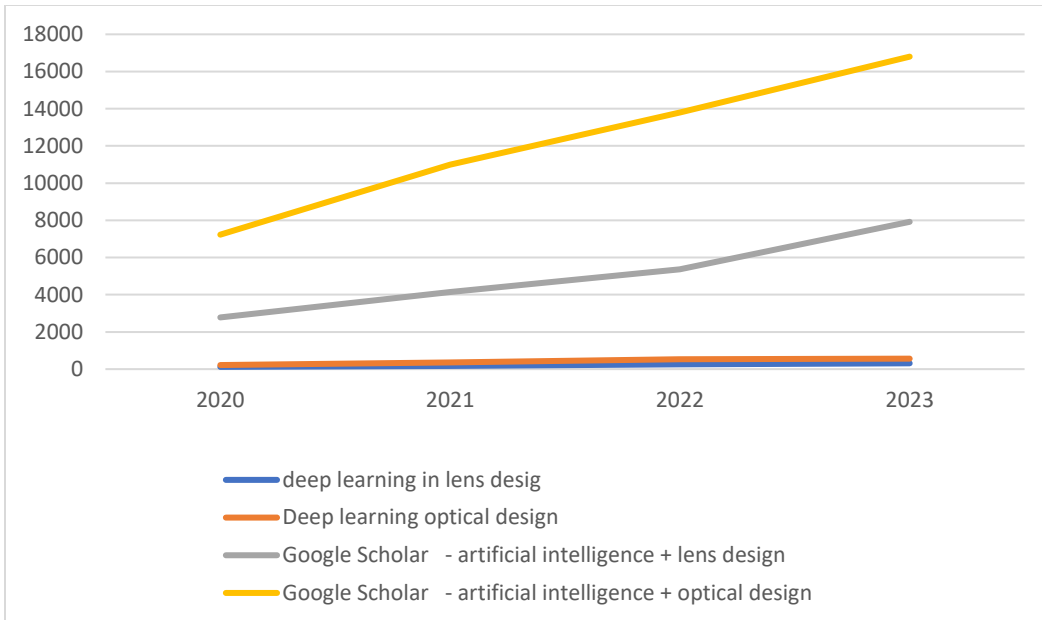


Figure 3. Number of publications.

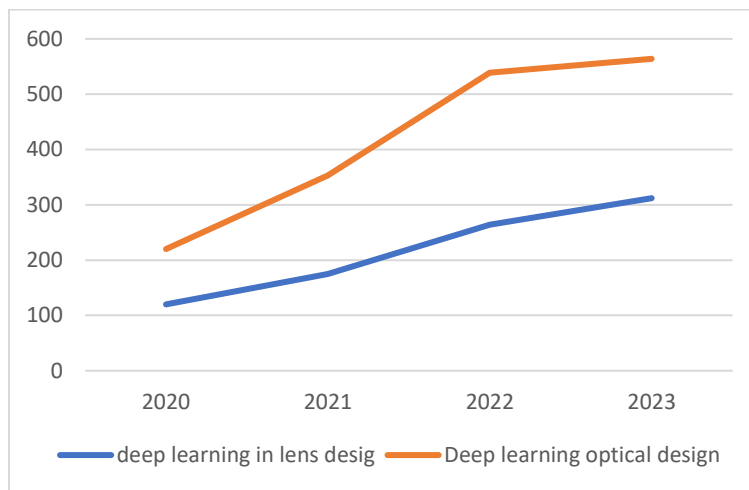


Figure 4. Number of publications using deep learning, lens design and optical design.

The first trace of the use or desire to use AI in lens design was traced at the OE LASE'87 and EO Imaging symposium in 1987 (Los Angeles, CA, United States) [2]. Figure 5 shows an extract from the proceedings. Two uses are mentioned. Firstly, to be able to communicate with the computer, and secondly, as an expert system. Let's just say that today's AI is a little different, but it's interesting to trace the early ideas in a field.

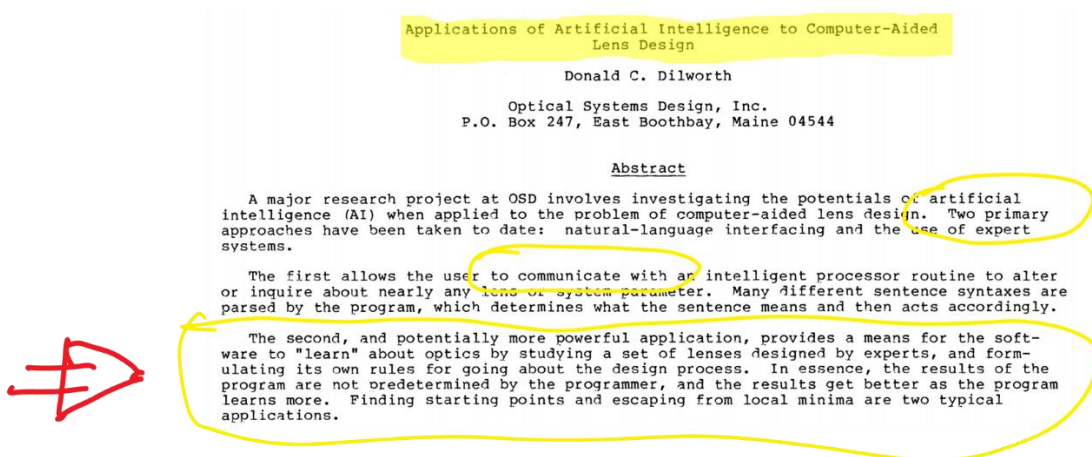
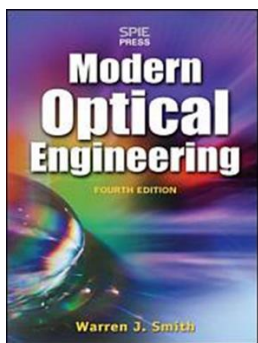


Figure 5. Applications Of Artificial Intelligence To Computer-Aided Lens Design, Donald C . Dilworth, 1987 [2].

4. USING AI IN A LENS DESIGN CLASS

Introducing the use of AI in the classroom is not necessarily obvious. The reason is that we teach difficult concepts in optical engineering that require a level of abstraction and mathematics. The AI can't replace the student, but it can certainly help him or her to understand the material, perhaps by providing examples. But it is a bit like using a search engine such as google.

For my part, I used two approaches to introduce AI in my classes. The first is to look at the content of my course to identify where AI could be useful. Figure 6 shows some of the content of the book I use. Of the 17 chapters, I can't see how AI could be used. So I took a second approach. I looked at the assignments and the course evaluation. In the course, I have 4 quizzes, 2 exams, 4 homework assignments and a design assignment. The quizzes and exams are in class, so the AI is not useful. For the homework assignments, students already work in teams to solve them (although they are individual assignments). As such homework assignments are important in preparing for exams, it is important that the student understand that using generative AI is maybe not a good idea. Moreover, we did some test and a chatbot like ChatGPT could be able to find an answer to some physic problems, but it needs a lot of guidance. In any case, students can find all this information on the web.



- Chapter 1. Optics Overview
- Chapter 2. Gaussian Optics: The Cardinal Points
- Chapter 3. Paraxial Optics and Calculations
- Chapter 4. Optical System Considerations
- Chapter 5. The Primary Aberrations
- Chapter 6. Third-Order Aberration Theory and Calculation
- Chapter 7. Prism and Mirror Systems
- Chapter 8. Characteristics of the Human Eye
- Chapter 9. Stops, Apertures, Pupils and Diffraction
- Chapter 10. Optical Materials
- Chapter 11. Optical Coatings
- Chapter 12. Principles of Radiometry and Photometry
- Chapter 13. Optical System Layout
- Chapter 14. Case Studies in System Layout
- Chapter 15. Wave-Front Aberrations and MTF
- Chapter 16. The Basics of Lens Design
- Chapter 17. Lens Design for Eyepieces, Microscopes, Cameras, etc.
- ...

Figure 6. Table of contents of the optical design introduction class.

The design assignment, on the other hand, is a task where students have to design a lens for a specific application. Figure 7 shows an example of an assignment about doorbell camera. In this case, students were asked to use codeV to design a lens for a door camera.

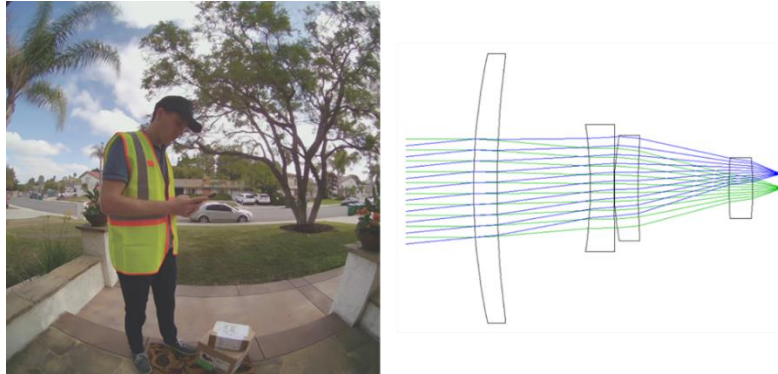


Figure 7. Design assignment, the doorbell camera.

In this assignment, students are asked to design a 3-6 element lens using an optical design software (codeV), based on specifications such as sensor resolution, field of view and spectral bands. Using first-order calculations, students determine the focal length of the lens. Students then begin the design on the computer. Getting started with a design can be difficult, and this is where the designer's experience comes into play. A student new to the field can't draw on past experience. The result is often long hours of trial and error to find a suitable starting point for the design. Of course, we trained students how to do this by giving them typical examples, but it's still a major investment on their part. This is where LensNet[3-6] comes in. LensNet is an AI tool that generates starting points for optical design.

LensNet: lens design starting point generator

Get started

Enter the effective focal length, f-number and half field of view desired for your lens design project. Our deep learning framework will infer a selection of lens designs tailored to those specifications.

Focal length (in mm)

F-number

Half field of view (in degrees)

[Submit](#)

Results

focal length: 30.0 mm, f-number: 4.0, half field of view: 12.0°

<p>Code V file Zemax file</p>	<p>Code V file Zemax file</p>	<p>Code V file Zemax file</p>
<p>Code V file Zemax file</p>	<p>Code V file Zemax file</p>	<p>Code V file Zemax file</p>
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Figure 8. LensNet interface [3-6]

LensNet is an AI tools developed in order to output lens design starting point. Original it was for demonstration only but it terns that it was so powerful that we made it available. For every query made, we filter the lens structures that fit the

desired specifications and pass on the specifications to our trained deep neural network, which infers a number of lens designs for every selected lens structure. Then, out of all designs from a given structure, we showcase the one with the lowest RMS spot size and provide a quick overview of the lens aberrations. The Code V (.seq) and Zemax (.zmx) files of the designs are available for download.

Our deep neural network was trained to optimize the RMS spot size of the designs based on the C, d and F wavelengths in the visible spectrum, by extrapolating from 150 reference designs across 80 different lens structures. Though we cannot completely prevent ray failures or overlapping surfaces, the vast majority of inferred designs should be devoid of those. The glass materials are fictitious materials, but our training objective favors glass materials that are close to the ones in the popular Schott catalog, as well as reasonable diameter-to-thickness ratios.

For the user, LensNet requires only the focal length, field of view and f-number. The purpose here is not to discuss lensnet, but rather to see the impact it has had on my class. I've been using the tool for 5 years and asked my students to comment on the assignment. Before LensNet, students complained that they wasted a lot of time finding a starting configuration and didn't have enough time for optimization, which is really the aim of the project, i.e. to optimize for suitable optical performance. Comments from the student after using LensNet (2023 class):

'the design was quite easy, as we could quickly test different concepts'

'it's a great way of showing how AI can be useful. It's refreshing to just ask chatGPT to write python code'

'I made my own code to find a starting point, but lensnet is more efficient'

'I felt I could really concentrate on design and optimization.'

5. CONCLUSION

AI is here to stay and can be useful, we're just at the beginning. On the other hand, it is clearly possible to develop tools that meet a specific need. In my case, it was the development of LensNet that paved the way for its use in the classroom, even though this was not the original aim of LensNet. A side effect of this exercise was that the students saw a real application in AI optical engineering. I think that exposing the students by demonstrating how AI can be used will certainly be a source of inspiration for them.

Finally, for me the use of LensNet was also interesting because the quality of the assignments increased and the correction time was reduced by a lot because all the optical designs were mostly good!

ACKNOWLEDGEMENTS

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