LRIO

Shaping light

one ray at a time

Reflecting on the role of AI in optical design

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Immervision Inc.

IMMERVISION see more, smarter

COPL Centre d'optique, photonique et laser

Introduction

All fields will be affected by the arrival of ChatGPT and other highly advanced generative artificial intelligence models.

We are studying how AI can be used in optical design or optical engineering in general. For our part, we're looking at two aspects:

- Designer’s assistant for starting up optical concepts
- Designer's assistant for exploring solution spaces.

How AI can be used in Lens Design?

- What was AI back in 80's

Applications of Artificial Intelligence to Computer-Aided Lens Design

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Abstract

A major research project at OSD involves investigating the potentials of artificial intelligence (AI) when applied to the problem of computer-aided lens design. Two primary approaches have been taken to date: natural-language interfacing and the use of expert systems.

The first allows the user to communicate with an intelligent processor routine to alter or inquire about nearly any lens or system parameter. Many different sentence syntaxes are parsed by the program, which determines what the sentence means and then acts accordingly.

The second, and potentially more powerful application, provides a means for the software to "learn" about optics by studying a set of lenses designed by experts, and formulating its own rules for going about the design process. In essence, the results of the program are not predetermined by the programmer, and the results get better as the program learns more. Finding starting points and escaping from local minima are two typical applications.

How AI can be used in Lens Design?

Goals:

- Accelerate the development process for optical systems
- Reveal trade-off between performance and constraints
- Find best solution (even under volatile boundary conditions
- Enhance productivity
- Reduce cost

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These goals were formulated by Dr Christoph Menke (Zeiss) in 2021.

HOW AI CAN BE USED IN LENS DESIGN?

Potential Benefits:

- Support for finding starting system (for quotation)
- Adapt the optimization algorithms
- Provide assistance for automatic exécution of routine tasks
- Allow access to the collective optical designers' expertise

How AI can be used in Lens Design?

Prerequisites:

- Need Database (how many design is required?)
- Define training scheme and strategy
  - Do we train AI to mimic the lens design job?
  - Do we train AI to classify the lens database?
  - …

Expending the solution space

Research Article
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Inferring the solution space of microscope objective lenses using deep learning

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Expending the solution space

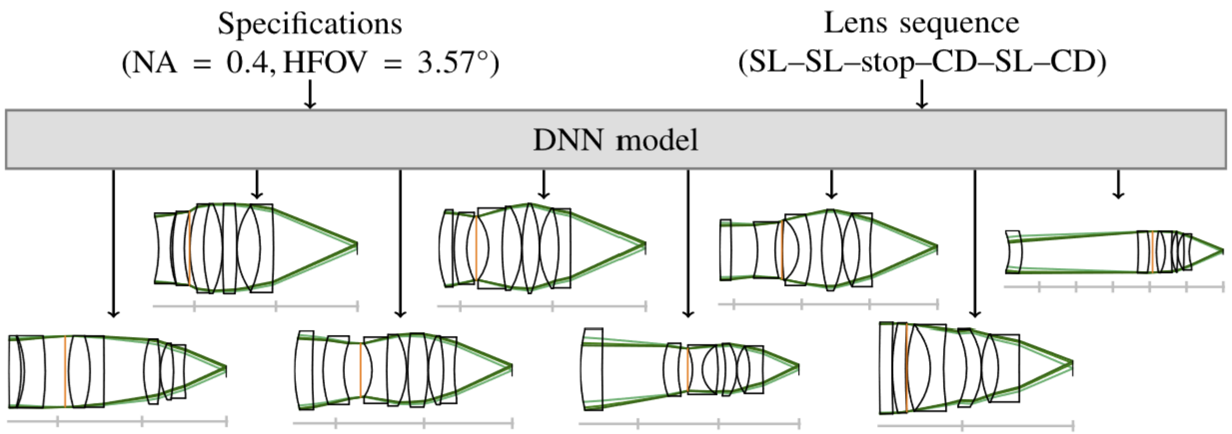
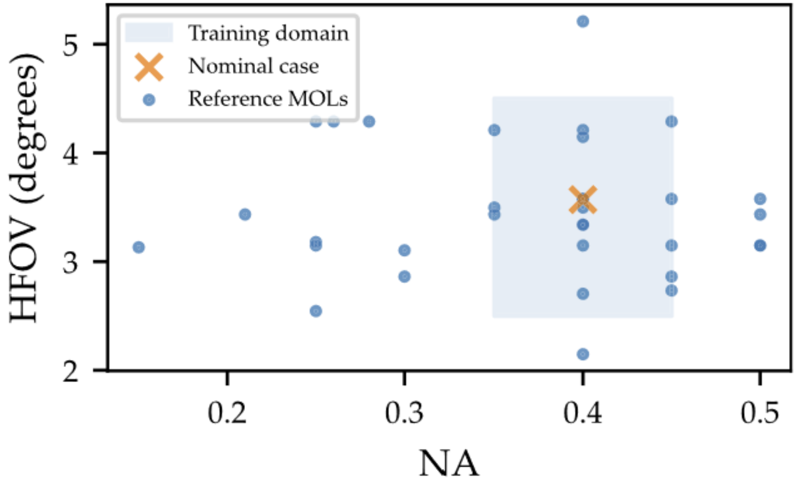


Fig. 1. Upon receiving a given set of specifications and lens sequence, the model outputs $K = 8$ different lenses that share the same *sequence* but differ in *structure*. Here, the lens sequence is composed of single lenses (SLs) and cemented doublets (CDs) separated by air gaps (–). In all layout plots, the aperture stop is shown in orange, and the scale bar indicates the size of the designs in units of effective focal length (EFL).



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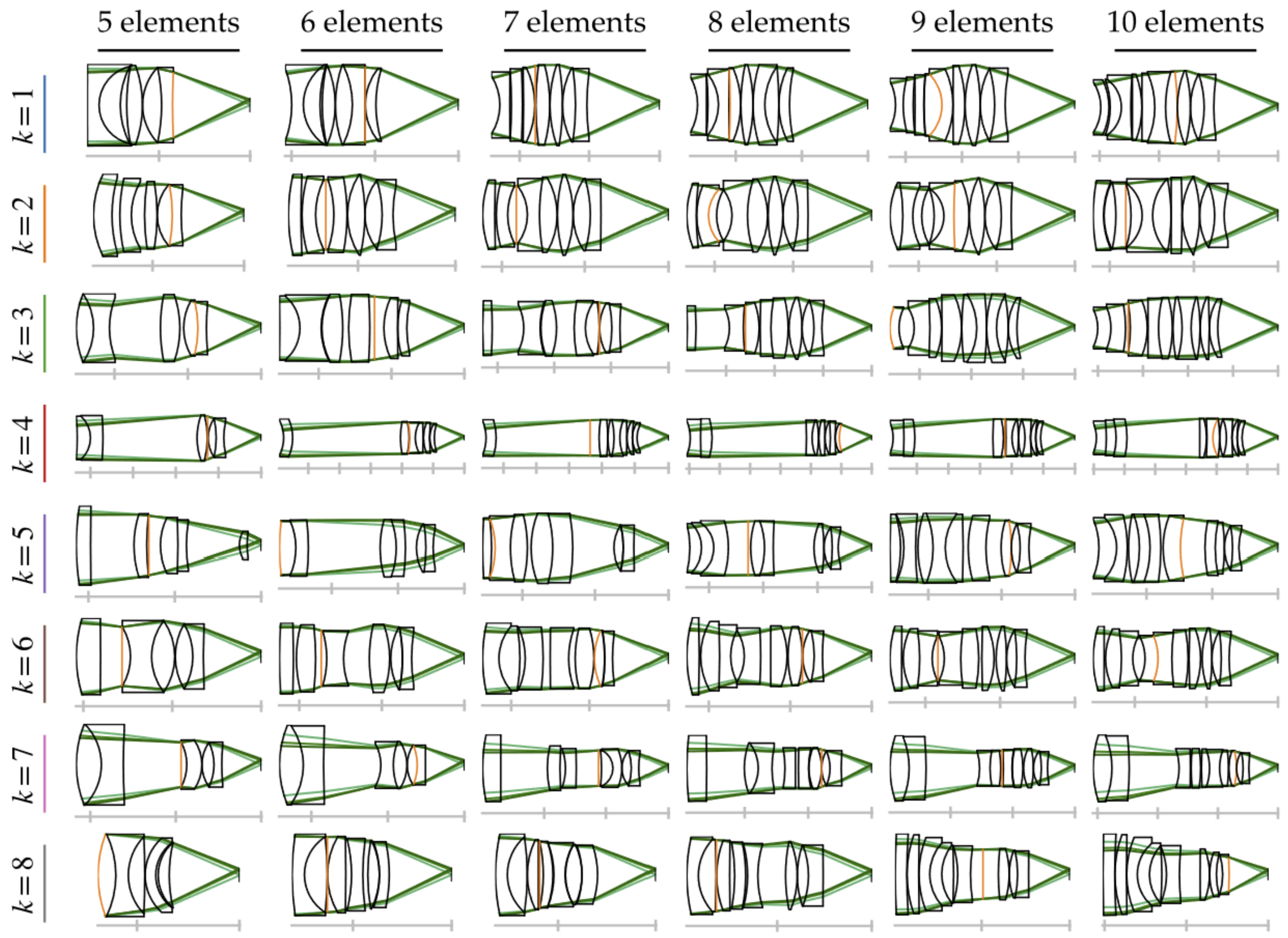

Fig. 7. Subset of designs inferred from all branches k of the trained model, using the nominal specifications (the scale is in units of EFL). For each branch, only six lens sequences are shown out of 7432 candidates. The selected lens sequences are those that minimize the OLF for the given branch and number of elements.

EXPENDING THE SOLUTION SPACE

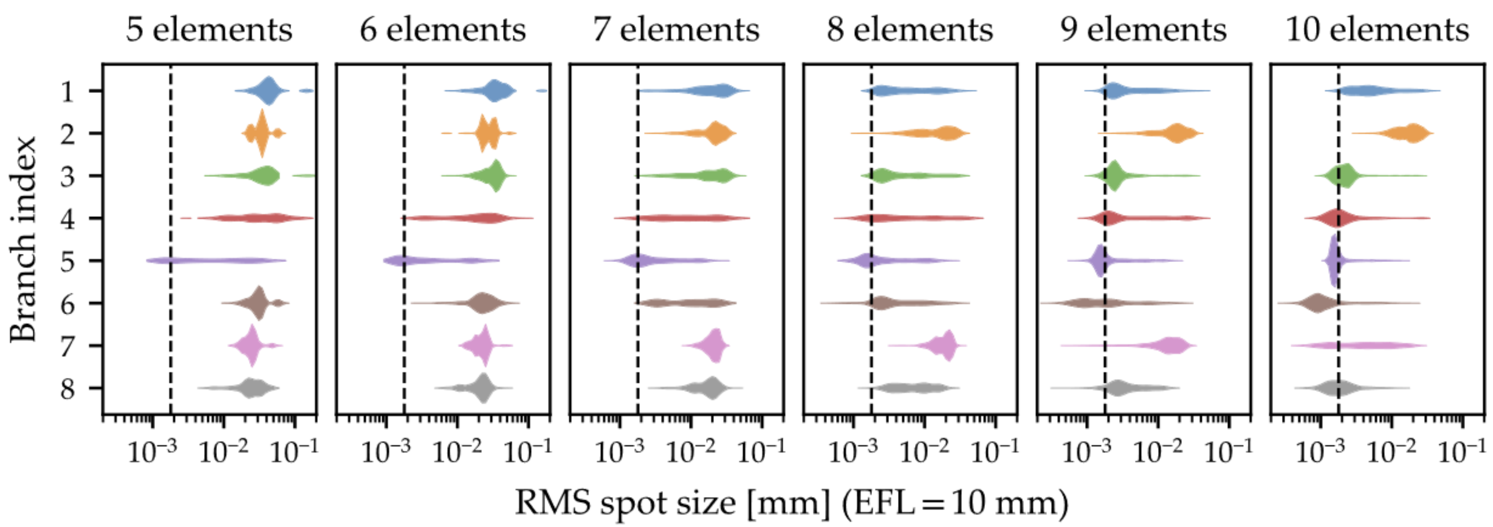

Fig. 8. Distribution of the on-axis RMS spot size of all inferred designs, grouped by number of elements and output branch, for the nominal case (lower is better). For reference, the Airy disk diameter at the "d" Fraunhofer line is shown with a dashed line.

EXPENDING THE SOLUTION SPACE

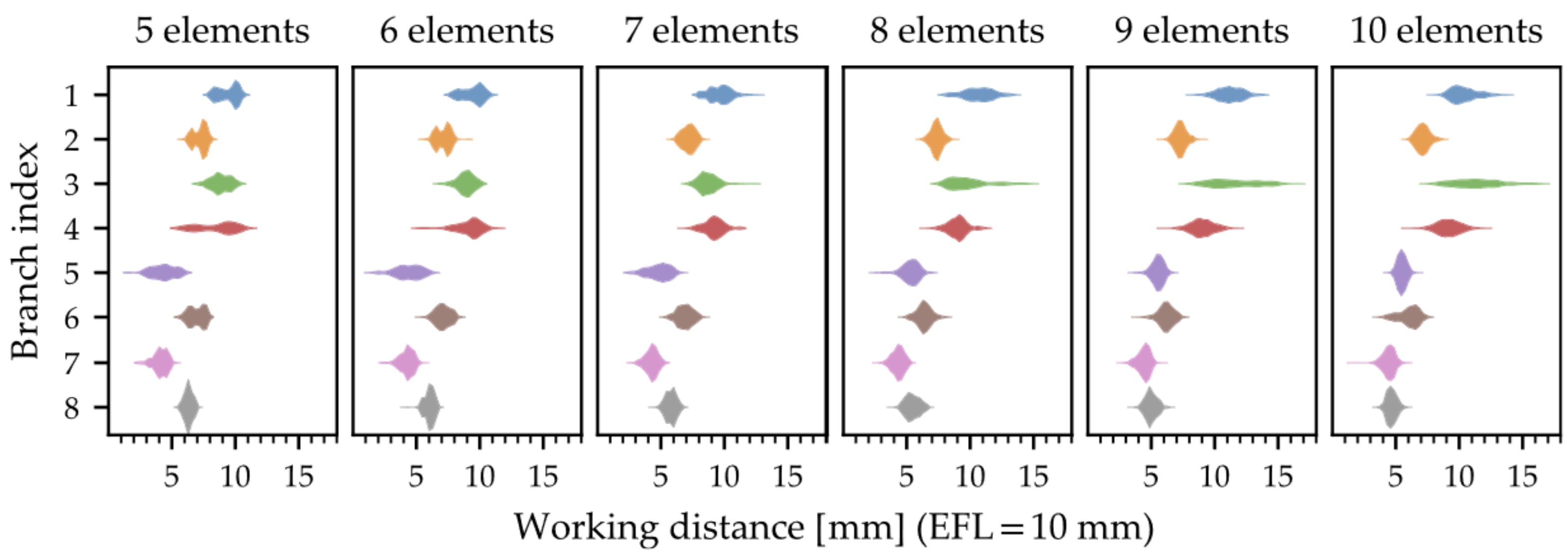

Fig. 9. Distribution of the WD of all inferred designs, grouped by number of elements and output branch, for the nominal case. Longer WD enables more applications.

EXPENDING THE SOLUTION SPACE

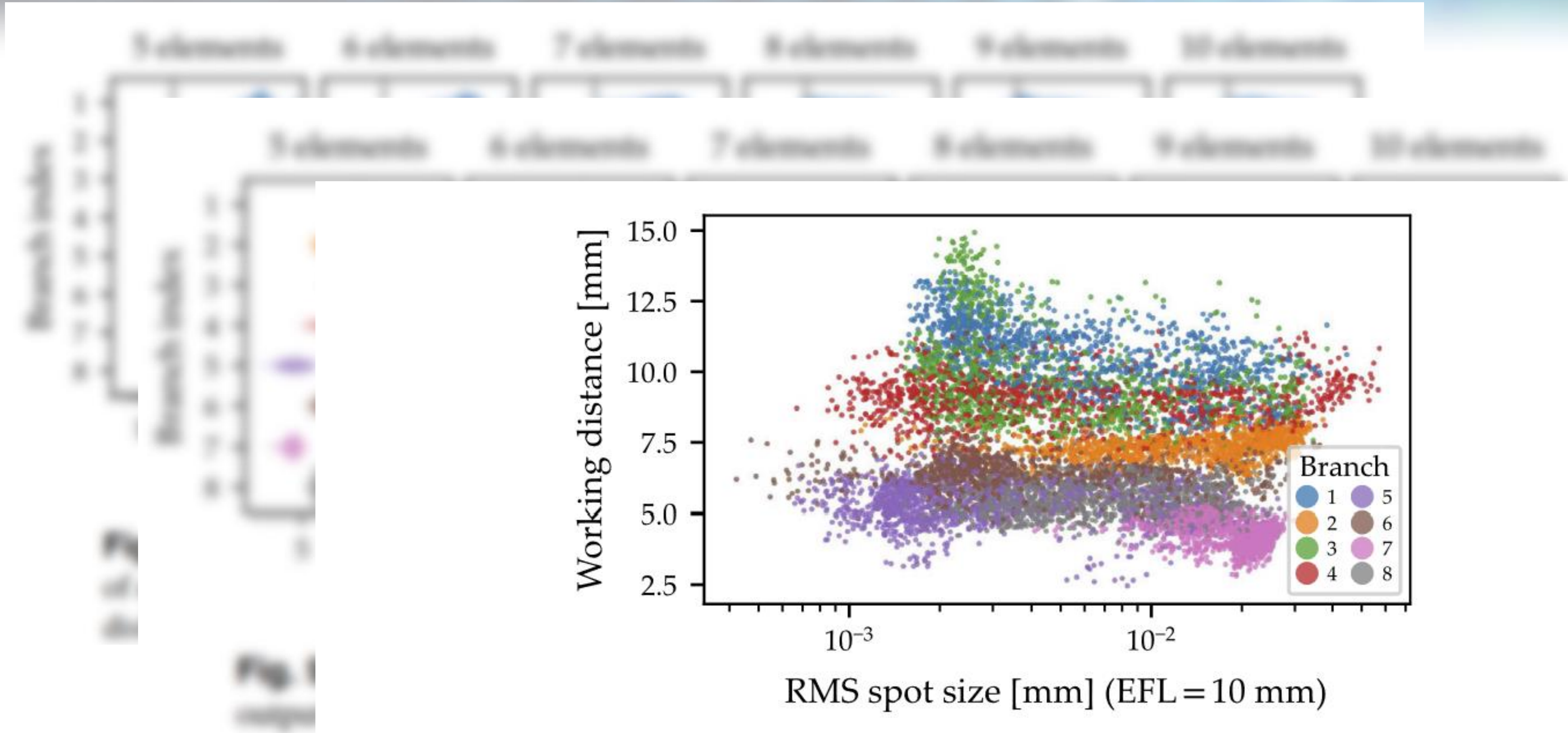

Fig. 10. Tradeoff between on-axis RMS spot size and WD for all 8-element designs, for the nominal case. The Pareto front is populated by designs from different branches.

Take aways from the presentation

- Automatic learning is a science of optimization
- AI is there to stay and can be useful:
  - Accelerate the development process for optical system design
  - Enhance productivity of the people
  - …
- We are still at the beginning
- Training set is less important than network size (Energy consomption)


Thank you,
Question?