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Revolutioning Lens-Based Systems Design: showcasing the power of OptiMat

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Abstract. OptiMat, by Sagittal Optics, is a tool developed to generate spherical designs for color-corrected lens-based systems. OptiMat analytically achieves optimum optical materials selection, key to correcting chromatic aberration. However, this tool extends beyond material selection; it is also used to establish initial systems in the design process, which optical designers can further refine. By selecting from a catalog of materials and specifying the number of lenses in the system, optical designers receive ideal assemblies correcting chromaticity, spherical and field aberrations, together with a set of parameters to further improve the provided systems. Additionally, engineers can filter combinations based on different metrics, such as chromatic and monochromatic aberrations. By handling material selection and lens shaping at the project's outset, OptiMat significantly streamlines optical system design times.

1 Introduction

In the current landscape of optical system design, optimization-based software are deemed essential, as they help optical designers to find balanced solutions for targeted optical requirements. However, these software tools present a notable drawback: since they numerically optimize a merit function, convergence is slow when analysing a great number of parameters. Processes like material selection for chromatic aberration correction may extend over a period of several weeks. In light of these challenges, the Sagittal Optics team has developed OptiMat, an optical design tool based on analytical calculations instead of brute-force optimization. Optimat is under development by Sagittal Optics, a newly established company based in Tenerife dedicated to the development of optical systems.

1.1 Current software limitations

Material selection for chromatic correction is a process that, with modern software tools, is seldomly performed at early stages of the optical design procedure. This approach is suboptimal because it first seeks to improve the achromaticity of the system using predefined materials, which often necessitates recalculating the lens-shape parameters. Subsequently exploring new material combinations that provide better color correction typically requires these recalculations to be performed again, adding to the complexity and inefficiency of the process. Thus, material selection becomes an additional parameter in an already computationally intensive task that continually collides with the definition of lens shape parameters. This means that the simultaneous optimization of color and field aberrations are processes that struggle against each other during the optimization process, especially when using conventional brute-force methods.

1.2 OptiMat: Optimizing material selection

Employing analytical methods to identify the optimal material combinations along with the appropriate lens shape parameters to minimize field aberrations significantly reduces the time required for optical system development. OptiMat analytically automates this selection process providing initial assemblies such that the time taken to design reliable final systems is exponentially reduced. It enables optical engineers to achieve preliminary configurations that are very close to the final one.

2 OptiMat: Input and Output parameters

The software initiates by requesting the initial requirements to start building the optical system. Following an analytical examination accomplished by OptiMat, the best thin-lens and spherical-lens based systems in terms of colour correction and field aberrations are presented.

2.1. Input

Hereinafter detailed are the inputs required by OptiMat to initiate its operation:

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- Material catalogue, both pre-generated by OptiMat or provided by the user.
- Number of lenses required or allowed in the system.
- Wavelengths to correct.
- Base wavelength to work with.
- Focal length of the system.
- Choice of metrics for the ordering of the output.

2.2 Output

Hereinafter detailed are the outputs provided by OptiMat as a result of its operation:

- Combinations of materials that minimize chromatic aberration.
- Lenses ordering within the system.
- Several solutions for the structural parameters of each ordering within the combination, in the thin-lenses approximation.
- Analytical thickening for the preferred solutions, generating multiple spherical-lens based systems and ordering them based on different metrics.
- Layout for the thickened systems, together with focal shift curves.

3 Results

The case example requested from OptiMat to provide chromatically corrected systems has the following parameters:

Table 1. Specifications for the system

Focal length (mm)	10
F/#	F/1.67
Number of lenses	2
Wavelength range (µm)	0.4861-0.6322

With these specifications, after analysing all possible material combinations from a provided catalog, OptiMat obtains several thin-lens based systems. One of the possible combinations of material satisfies the following focal shift curve:

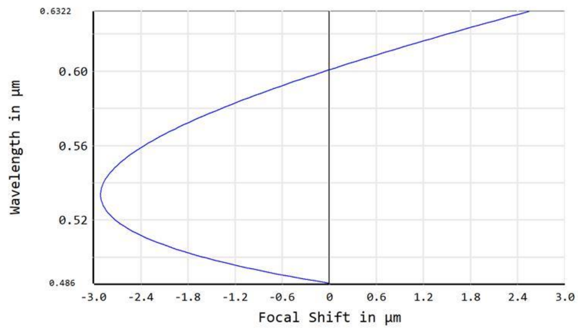

Figure 1. Example of the chromatic focal shift result provided by OptiMat in the thin-lens based solution.

After thickening, OptiMat obtains several possible solutions. In the next plot, it is shown one of them:

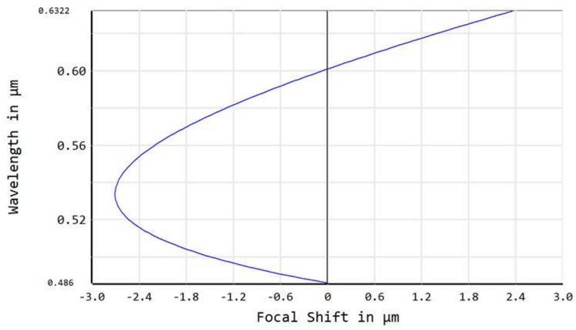

Figure 2. Example of the chromatic focal shift result provided by OptiMat in the spherical lens-based solution.

As observed, the thickening process has preserved the achromaticity initially provided by the thin-lens stage. Upon careful examination of both curves, it is shown that the thick-lens result corrects chromatic aberration better compared to the original thin-lens based system.

4 Conclusions

OptiMat is a software that allows optical designers to obtain initial system designs in a fast, analytic way. In the example that we have just reviewed, the best combinations of materials for the thin-lens approximation are provided within seconds, and after the analytical thickening we obtain a system with the same color performance compared to the original target. This procedure proves to be more time-efficient and accurate than any conventional brute-force based approach.