SPIE Student Chapter

Univ Politécnica de Madrid Chapter

Activity Report

Advisor:	Prof. Juan Carlos Miñano
President:	Milena Nikolic
Vice-President:	Bharathwaj Narasimhan
Secretary:	João Mendes Lopes

Chapter Roster

1. Angelica Ivone Aviles Rivero
2. Ehsan Dadrasnia
3. Adam Hirst
4. Jiayao Liu
5. João Mendes Lopes
6. Bharathwaj Narasimhan
7. Milena Nikolic
8. Guillermo del Campo (in process)
9. Jorge Gorospe Ballestros (in process)
10. Jie Song (in process)

1 Yearly Activities

1.1 Optics Lecture and overview of the activities for this year:

We had 4 lectures highlighting pre-publication research which serve as a precursor for the main talk to be held in various conferences across the globe. This also serves as a good platform for information exchange among different participants about their research and gives more room towards having wider perspective in their respective fields of interests. In addition to these lectures given by the chapter members, we had the opportunity to hear about work conducted in optics groups from the Technical University of Delft (TUD) and Vrije Universiteit Brussel (VUB). Zhe Hou from TUD presented his work related to the Saddle point method and landscape exploration, and Yunfeng Nie from VUB gave a talk "Direct design approach to calculate a two-surface lens with an entrance pupil for application in wide field-of-view imaging".

1.1.1 Joao Mendes Lopes (presented in SPIE Optics + Photonics, SD 2015)

Title:
Design of diffractive optical surfaces within the SMS design method

Abstract:
The Simultaneous Multiple Surface (SMS) method was initially developed as a design method in Nonimaging Optics and later, the method was extended for designing Imaging Optics. We present the extension of the SMS method to design diffractive optical surfaces. This method involves the simultaneous calculation of N/2 diffractive surfaces, using the phase-shift properties of diffractive surfaces as an extra degree of freedom, such that N one-parameter wavefronts can be perfectly coupled. Moreover, the SMS method for diffractive surfaces is a direct method, i.e., it is not based in multi-parametric optimization techniques. Representative diffractive systems designed by the SMS method are presented.

1.1.2 Milena Nikolic (presented in SPIE Optical System Design, Jena 2015)

Title:
Optical design through optimization using freeform orthogonal polynomials for rectangular apertures.

Abstract:
With the increasing interest in using freeform surfaces in optical systems due to the novel application opportunities and manufacturing techniques, new challenges are constantly emerging. Optical systems have traditionally been using circular apertures, but new types of freeform systems call for different aperture shapes.

First non-circular aperture shape that one can be interested in due to tessellation or various folds systems is the rectangular one. This paper covers the comparative analysis of a simple local optimization of one design example using different orthogonalized representations of our freeform surface for the rectangular aperture.

A very simple single surface off-axis mirror is chosen as a starting system. The surface is fitted to the desired polynomial representation, and the whole system is then

optimized with the only constraint being the effective focal length. The process is repeated for different surface representations, amongst which there are some defined inside a circle, like Forbes freeform polynomials, and others that can be defined inside a rectangle like a new calculated Legendre type polynomials orthogonal in the gradient.

It can be observed that with this new calculated polynomial type there is a faster convergence to a deeper minimum compared to "defined inside a circle" polynomials. The average MTF values across 17 field points also show clear benefits in using the polynomials that adapted more accurately to the aperture used in the system.

1.1.3 Bharathwaj Narasimhan (presented in SPIE Optics + Photonics, SD 2015)

Title:
Freeform aplanatic concentrators

Abstract:
Axisymmetric aplanatic concentrators have been used in the past for solar concentrators and condensers (Gordon et. al, 2010). It is well know that such a system must be stigmatic and satisfy the Abbe sine condition. This problem is well known (Schwarzschild, 1905) to be solvable with two aspherics when the system has rotational symmetry.

However, some of those axisymmetric solutions have intrinsically shading losses when using mirrors, which can be prevented if freeform optical surfaces are used (Benitez, 2007).

In this paper, we explore the design of freeform surfaces to obtain full aplanatic systems. Here we prove that a rigorous solution to the general non-symmetric problem needs at least three free form surfaces, which are solutions of a system of partial differential equations (PDE). We also present the PDEs for a three surface full aplanat. The examples considered have one plane of symmetry, where a consistent 2D solution is used as boundary condition for the 3D problem. We have used the x-y polynomial representations for all the surfaces, and the iterative algorithm formulated for solving the above said PDE has shown very fast convergence.

Bharathwaj Narasimhan was also chosen to represent the Chapter at the SPIE Leadership Workshop at SPE Optics + Photonics, SD 2015.

1.1.4 Jiayao Liu

Title:
Design and development of compact optical systems

Abstract:
Novel design approaches of compact optical systems for both imaging and nonimaging applications are presented. Collimator is a typical application of nonimaging optics in illumination, and can be used in concentration

photovoltaic as well due to the reciprocity of light. There are several approaches for collimator designs. In general, all of these approaches have an aperture diameter to collimator height not greater than 2. In order to reduce the height of the collimator while maintaining the illumination area, a multichannel design is presented in this thesis. In imaging optics, aspheric and freeform surfaces are useful in controlling image aberrations and reducing the number and size of optical elements. Due to the rapid development of digital computing systems, ray tracing can be easily performed to evaluate the performance of optical system. This has led to the modern optical designs created by using different multi-parametric optimization techniques. These techniques require a good initial design to be a starting point so that the final design after optimization procedure can reach the optimum solution. This requires a direct design method for aspheric and freeform surface close to the optimum. A differential equation based design method is presented to obtain single freeform and double aspheric surfaces.

Lectures by visiting students:

During the previous year we had two visiting student from ADOPSYS project (http://www.adopsys.eu/index.php): Zhe Hou from TU Delft and Yunfeng Nie from VUB. They both gave presentations related to their projects.

Zhe Hou, "Saddle-point construction method":

Abstract:
Unlike other global optimization methods, saddle-point construction (SPC) uses a specific behavior of the merit function landscape when the number of variables is increased in a certain way: local minima become saddle points.
In lens design, SPC is a new method to insert lenses into an existing design. Designers frequently insert lenses into their designs and, in the traditional way, one new system shape results after optimization. However, when a lens is inserted with SPC, two distinct system shapes result and for further design one can choose the better one. With SPC, by inserting and then, if necessary, by extracting lenses, new system shapes can be obtained very rapidly, even for complex systems with many variables. The practical implementation is very easy and the method can be fully integrated with all other traditional design tools.
In principle, SPC should also be applicable in other optimization problems, which satisfy certain mathematical conditions, e.g. in thin-film optimization.

About the speaker:

Zhe Hou (TU Delft) did his undergraduate study in optical engineering at Zhejiang University, Hangzhou, China (http://opt.zju.edu.cn/english/). In 2011, he graduated as a bachelor of engineering (with honors). His bachelor thesis is the study and simulation of thermal-optical actuator. Right after his bachelor, he got a scholarship from Erasmus Mundus program. He spent his first year at Warsaw University in 2012 and the lat 11 months of his Master at Delft University of Technology. After a short return to Chine, Zhe started to work as a PhD candidate on the ADOPSYS project within the group of Optica, TU Delft. The topic of his project is saddle point (SP) method for imaging and non-imaging systems. In cooperation with his colleagues, Zhe is trying to see the regularity in the optical design landscape.

Yunfeng Nie, "Direct design approach to calculate a two-surface lens with an entrance pupil for application in wide field-of-view imaging":

Abstract:

In this work, a multifields optical design method aiming to calculate two high-order aspheric lens profiles with an embedded entrance pupil is proposed. This direct design algorithm is capable of partially coupling more than three ray bundles that enter the same pupil with only two surfaces. Both infinite and finite conjugate objectives can be designed with this approach. Additional constraints such as surface continuity and smoothness are taken into account to calculate smooth and accurate surface contours described by point clouds. The calculated points are then fitted with rotationally symmetric functions commonly used in optical design tools. A presented subaperture sampling strategy that introduces a weighting function for different fields allows for a very well-balanced imaging performance over a wide field of view (FOV). As an example, a ±45 degf/7.5 wide-angle objective is designed and analyzed to demonstrate the potential of this design method. It provides an excellent starting point for further optimization of the surfaces' coefficients and initial design parameters, resulting in a very good and well-balanced imaging performance over the entire FOV.

About the speaker:

Yunfeng Nie (VUB) obtained her Master's degree in Optical Engineering in July 2012 at the University of Chinese Academy of Sciences in China. Her research

interests focuses on optical design, computational imaging, optical modelling and optical manufacturing. Within the ADOPSYS project she is working on exploring novel numerical and analytic approaches based on Fermat's principle to allow the design of N free-form surfaces that couple more than 2 ray-bundles. In addition, diffractive micro-structures will be studied for broadband performance. The target application areas are machine vision and imaging systems for inspection and safety.

We also had a small dinner outing with our chapter members.

2 Financial Statement

SPIE student chapter fund	+ 441,00€
Monthly presentations	210.80€
End of year dinner	-180.20€
Current Balance	**50€**

3 Election

We had an election to decide our new chapter officers and the following individuals were chosen as the officer bearers for this year.

President – Milena Nikolic
Vice President – Bharathwaj Narasimhan
Secretary - João Mendes-Lopes