Maestría en Ingeniería en Automatización de Procesos Industriales

Title

Implementation of an adaptive optics system to correct a wavefront

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Implementation of an adaptive optics system to correct a wavefront

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1. Introduction

Adaptive optics (AO) was used in the context of astronomical optics in 1953. It presents the solution to the problem of atmospheric turbulence on the astronomical images captured by ground telescopes. Nowdays, every telescope in the world is equipped with an adaptive optics system for the correction of atmospheric aberration.

In 1980 AO system began to be used to the correction of ocular aberrations [1].

Today, we detect early diseases in the eye with this method. The eye is not a perfect optical system. It is an aberrated system that produces images that are not perfectly sharp. The manifestation of ocular aberrations depends on multiple factors and conditions. They vary from one individual to another.

The AO system also is used in industrial quality control, aerospace, semiconductor construction, microscopy and bio-image [2].

2. Objectives

2.1. General objective

To implement an adaptive optics system to determine and correct aberration of a wavefront laser beam.

2.2. Specific objectives

- To implement PC communication of a Hartmann-Shack "HASO4 VIS Imagine Optic" sensor and an "MD 69 ALPAO" deformable mirror.
- To control a Hartmann-Shack " HASO4 VIS Imagine Optic" sensor and a "MD 69 ALPAO" deformable mirror of an adaptive optics system.
- To evaluate experimentally a wavefront real-time in WaveView software, and get correction wavefront in MATLAB and LabVIEW tools.

3. Method

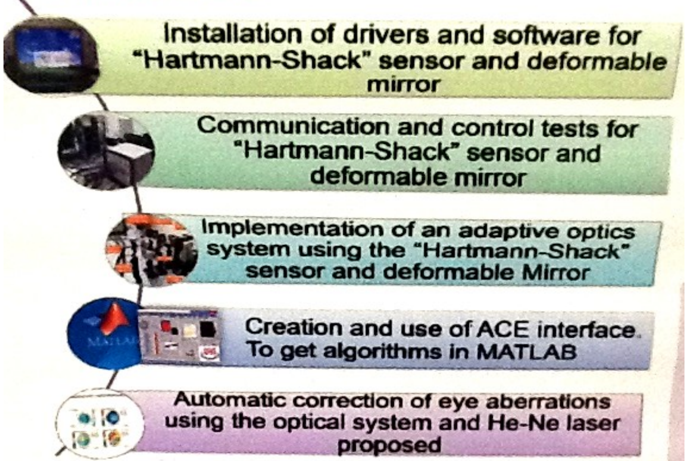

Figure 1. Methodology used in this research.

$$Z_n^m(r,\varphi)=\begin{cases} N_n^m R_n^m(r)\sin(m\varphi) \\ -N_n^m R_n^m(r)\cos(m\varphi)\end{cases}$$

Radial Function:

$$R_n^m(r)=\sum_{s=0}^{(n-|m|)/2}\frac{(-1)^s(n-s)!}{s!\,[(n+|m|)/2-s]!\,[(n-|m|)/2-s]!}\,r^{n-2s}$$

Standardization Function:

$$N_n^m=\sqrt{\frac{2(n+1)}{1+\delta_{m0}}}$$

Figure 2. General form of Zernike polynomials [3],[4].

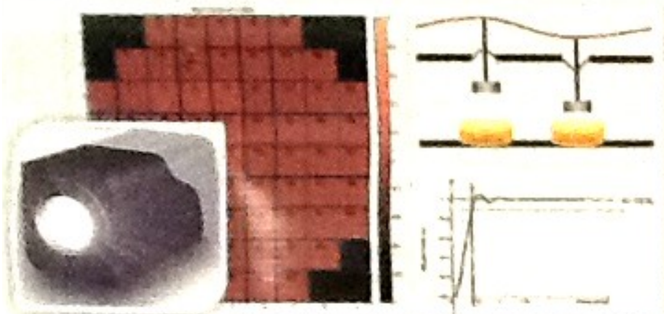

Figure 3. Functionality and number of actuators for "DM 69 ALPAO" Deformable Mirror control.

4. Results

The wavefront was obtained based on polynomials Zernike. The eye representation and it´s aberrations are shown in Figure 7 using WaveView. The values of PV or Pico Valley (difference between a flat wavefront and aberrated a wavefront) and RMS were: 2.423 micrometers and 8.256 micrometers respectively.

The observed aberration is in the coefficients 4 and 5, which are astigmatism and defocus (irregular curvature of the cornea). These are the principal aberrations in a normal human eye.

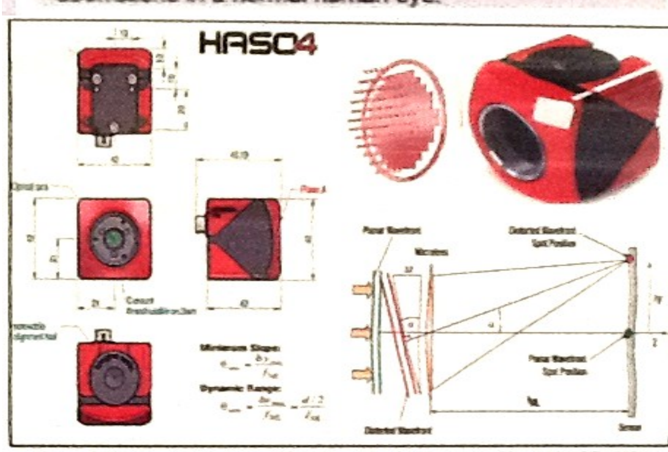

Figure 4. Mechanical design and functionality of a Hartmann-Shack "HASO4 VIS" sensor [5],[6].

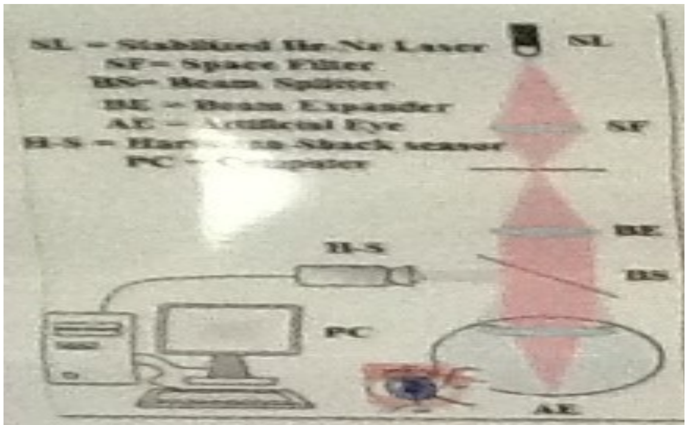

Figure 5. General diagram to get a wavefront of an artificial eye.

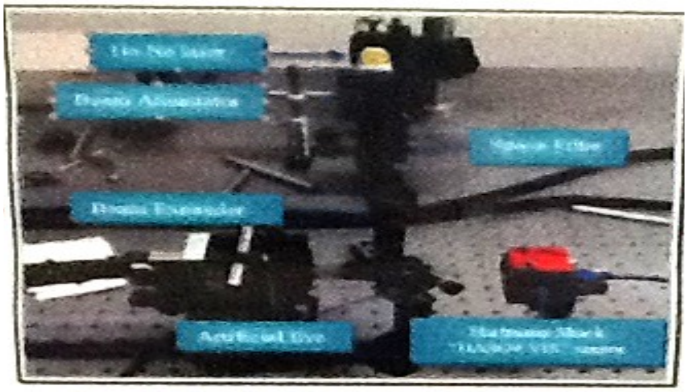
Figure 6. Photo of the implementation of an AO system to measure a wavefront.

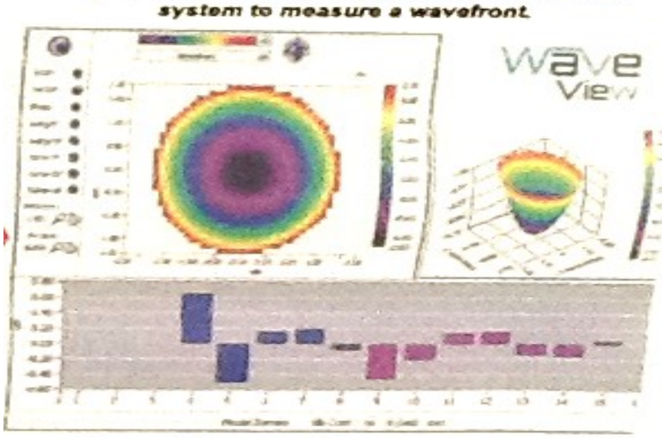

Figure 7. Results of the measurement wavefront of an artificial eye.

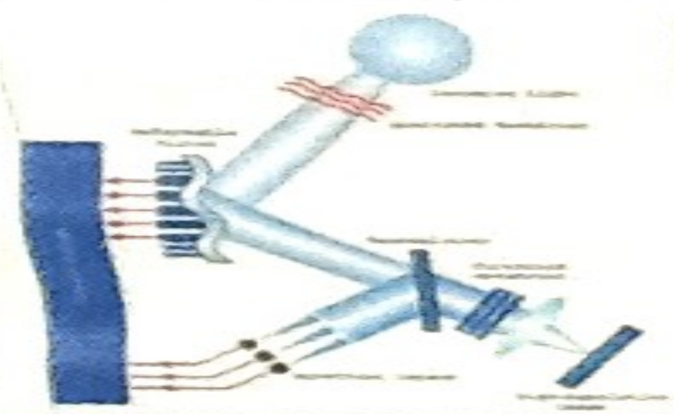
Figure 8. Control system Adaptive Optics.

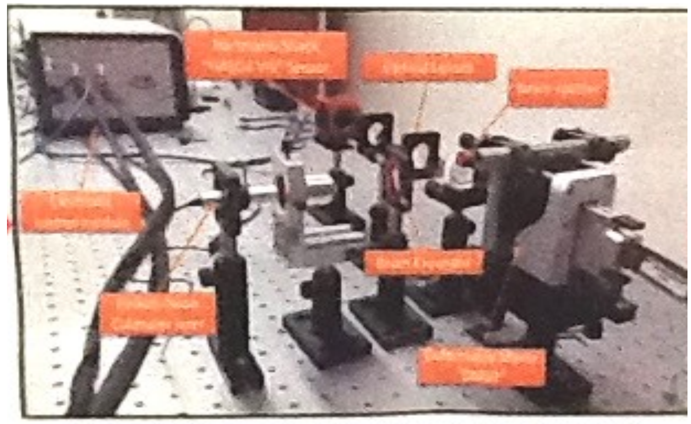
Figure 9. Photo of the implementation of an AO system to get the correction a wavefront laser beam.

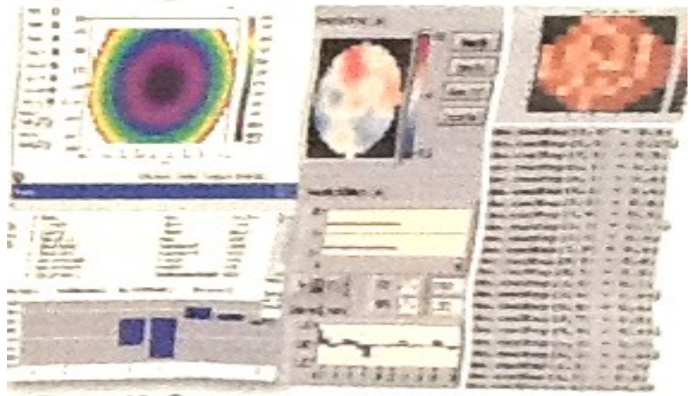
Figure 10. Correction results of a wavefront in MATLAB and Ace interface.

5. Conclusion

According to results, we can conclude that:

A Hartmann-Shack "HASO4 VIS Imagine Optic" sensor and a "DM 69 ALPAO" deformable mirror are in communication with the PC, which gives the manipulation complete.

We have implemented an optical system with alignment to measure a wavefront and modify its aberrations.

The adaptive optics system that contains a Hartmann-Shack "HASO4 VIS Imagine Optic" sensor and a "DM 69 ALPAO" deformable mirror can be controlled by algorithms and commands in MATLAB.

Now we can evaluate wavefront real-time in the WaveView software, and get wavefront correction in ACE interface.

The proposed systems have an open architecture that allow the integration of other optical instruments as well as optomechanical and optoelectronic parts for the use, learning, teaching and research of the AO.

6. Acknowledgements

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7. References

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