**Neural networks for image-based wavefront sensing for astronomy**

**神经网络对天文学中基于图像的波前传感的作用**

1.在Direct determination中哪里提到该文章

In adaptive optics, deep learning was initially applied to astronomical telescopes [18–20] and has recently been revisited with the advent of modern architectures [21,22].

2.该文章逻辑是什么

第一段简要介绍大型地面望远镜，可用后处理/自适应光学来补偿大气模糊

第二段目前的神经网络和传感器发展使大气模糊在软件上即可实现

第三段目前的困难是计算负担大，不适合小型望远镜矫正大气模糊

第四段神经网络的历史和目前现状

第五段介绍大致工作内容，最多用了66个Zernike系数

第六段是生成图像过程

第七段添加噪声后效果，fig1介绍

第八段介绍Zernike系数，对系数的处理

第九段研究需要最少多少个Zernike才能近似大气的波前

第九段利用tensorflow软件，建立不同数据集

第七段训练CNNs过程

第八段神经网络的选择

第九段A1: Full training with 129 × 129 PSFs and 35 Zernikes

第十段A2: Full training with 257 × 257 PSFs and 38 Zernikes

第十一段A3: Full training with modified PSFs.

第十二段A4: Full training with only one input PSF.

第十三段A5: Full training with bright stars.

第十四段A6: Full training with 65 Zernikes.

第十五段A7: Full training with 65 Zernikes and a larger field.

第十六段发现A2效果较好，进一步实验

第十七段实验假设及发现问题

第十八段简介fig4，发现A6无法估算39以上的系数

第十九段神经网络估计值较为准确

第二十段可见在小型望远镜上有前景，同时在红外波段效果更好

第二十一段未来展望

3.该文章核心是什么？

该文章对比了多种神经网络形式，在其中分析聚焦图像和离焦图像，发现尽管无法矫正衍射极限，但是对2-4m的小型望远镜残余相位误差的改善是很有希望的。

4.英语表达该文章核心

This article compares various neural network forms, analyzes the focused image and the defocused image, and finds that although the diffraction limit cannot be corrected, the improvement of the residual phase error of the 2-4m small telescope is promising.

5.积累的问题

Strehl ratios

Strehl ratio：艾里斑内聚光强度比

RMS magnitude 在π情况下 均方差大小

<https://www.telescope-optics.net/aberrations.htm>

<http://www.astronomycorner.net/notes/strehl.html>

<https://www.telescope-optics.net/Strehl.htm>

<https://wenku.baidu.com/view/6eaca0fde43a580216fc700abb68a98270feac7f.html>

PSF

https://blog.csdn.net/weixin\_39750861/article/details/84556204

<https://blog.csdn.net/miscclp/article/details/7456470>

<https://blog.csdn.net/weixin_40300818/article/details/86794116>

<https://bitesizebio.com/22166/a-beginners-guide-to-the-point-spread-function-2/>

<http://web.ipac.caltech.edu/staff/fmasci/home/astro_refs/PSFtheory.pdf>

<https://wp.optics.arizona.edu/jcwyant/wp-content/uploads/sites/13/2016/08/psfandmtfcurves.pdf>

<https://www.mathworks.com/matlabcentral/answers/343558-point-spread-function-of-an-optical-system>

Zernike

<https://baike.baidu.com/item/Zernike%E5%A4%9A%E9%A1%B9%E5%BC%8F/2735195?fr=aladdin>

<https://en.wikipedia.org/wiki/Zernike_polynomials>

<http://www.dm.unibo.it/home/citti/html/AnalisiMM/Schwiegerlink-Slides-Zernike.pdf>

<https://www.opt.indiana.edu/vsg/library/vsia/vsia-2000_taskforce/tops4_2.html>

<https://wenku.baidu.com/view/f92e4346a8956bec0975e3d9.html>

<http://xuebao.jlu.edu.cn/gxb/article/2014/1671-5497-44-6-1860.html>

<https://blog.csdn.net/qq_26898461/article/details/47123009>

<https://blog.csdn.net/piaoxuezhong/article/details/65444605>

<https://www.cnblogs.com/chensheng-zhou/p/5054354.html>

<http://wyant.optics.arizona.edu/zernikes/Zernikes.pdf>

<https://wp.optics.arizona.edu/jsasian/wp-content/uploads/sites/33/2018/04/Schwiegerling-Zernike-2018.pdf>

<https://telescope-optics.net/zernike_aberrations.htm>

<http://jan.ucc.nau.edu/jmn3/students/zernike.pdf>

<http://paristech.institutoptique.fr/site.php?id=562&fileid=6769>

<https://www.gatinel.com/recherche-formation/wavefront-sensing/zernike-polynomials/>

<https://www.telescope-optics.net/zernike_aberrations.htm>

像差补偿aberration compensation

<https://www.edmundoptics.com/knowledge-center/application-notes/optics/an-in-depth-look-at-spherical-aberration-compensation-plates/>

<https://optics.org/news/10/8/6>

波前传感器- Shack-Hartmann型

<https://zhidao.baidu.com/question/102215035.html>

<https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=5287>

<http://www.astrosurf.com/cavadore/optique/shackHartmann/Shack-Hartmann.htm>

<http://www.optics.arizona.edu/sites/optics.arizona.edu/files/pdf/Historical-Development-Shack-Hartman-Wavefront-Sensor.pdf>

<https://www.rp-photonics.com/shack_hartmann_wavefront_sensors.html>

剪切干涉仪shearing interferometer

<https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=2970>