A Next Generation High Resolution Adaptive Optics Fundus Imager

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Introduction

- First instrument built under a NATO SfP program.
- This is the continuation under the auspices of NIH
- Redesigned instrument
- Same team from Russia and the US
High Resolution Retinal Imaging

- Increase the resolution of retinal imagers to detect pathologies and provide a diagnosis at an earlier stage
  - Vascular abnormalities
  - Drusen

- Provide a “familiar” image interpretation.
  - Not stray too much from the operation of a regular imager

- Package for ease of use and clinical installation
  - Self contained instrument
Adaptive Optics

- The resolution is limited to 20-30um due to aberrations in the eye.

- Diffraction limit is about 3um for an optical instrument with a pupil of about 6mm

- An order of magnitude improvement is available

- Eye Aberrations
  - Low order
  - Large amplitude
  - Slow temporal change
New Vs Old

• Better optical design and layout
• Mechanical integration
• Improvement of the AO close loop response
• Larger stroke mirror for increased dynamic range
• Onboard calibration source
• New user interface
System Integration
Old Optical Layout

- KFG Fundus Imager
- Deformable Mirror
- Shack-Hartmann Sensor
- Dithering Mirror
- Data Camera
- Laser
- Light Box
- Scene Camera
- Eye
New Optical Layout

- 4K x 4K CCD
- Fundus camera
- Laser Projector
- Shack-Hartmann Sensor
- Calibration Laser and Collimator
- DM
Image Uniformity and Filling
Bimorph Deformable Mirror

- Mirror Parameters
  - 40mm aperture
  - 18 actuators
  - 9µm defocus
• Mirror Parameters
  – 38mm aperture
  – Double stack
  – 20 actuators
  – 35µm defocus stroke
  – 25um astigmatism stroke
Clinical Environment

• Fundus photographer
  – Trained professional to interact with patient but with little experience of advanced optical system. They must concentrate on imaging the patient, not on operating the instrument

• Limited time
  – Patients are people and must be tended with care and timeliness. The instrument must be easy to set-up.

• Examination rooms
  – Small rooms with little space to move around
  – No space for extra equipment

• To meet the requirements, the alignment / set-up and the operation of the instrument must be simplified.
Previous Calibration Procedure
Onboard Calibration Laser
Ease of use
New User interface

- **Control panel**
  - Go-No-Go condition
  - Filter selection
  - Exposure control

- **Viewing panel**
  - Direct View of Data
  - Simple image manipulation
Testing Results

- Deformable mirror performance
- Spatial resolution
- Clinical Human Testing
DM Testing results

- Stroke measurement
  - Focus distance measurement
  - 35um focus
  - 25um astigmatism
  - 15% hysteresis
Spatial Resolution

- Resolution
  - Group 6-4, 6-5
  - 90 to 100 cycles/mm
  - 5um line-width
Human testing

• In collaboration with the Moscow Eye Institute
• 14 patients
• Clinical environment
• Performed by a resident doctor

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<th>Diagnosis</th>
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<td>ARMD (wet, CNV)</td>
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</tbody>
</table>
Proliferative small vessel

10-15um
Disc Vascular Features

10-15um
Microaneurisms

- 90 um
- 50 um
- 20 um
- 90 um
Nerve Fiber Layer

1.5mm
Conclusion

- Instrument performs as designed
- Clinical deployment was a success
- Continue the evaluation at Kestrel
- Moving to Iowa University for larger studies
Acknowledgment

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