Telehealth Eye and Associated Medical Services network - TEAMSnet – The MARVIN Project: Scale, Usability and Evolution

DR blindness is preventable by adhering to accepted standards of care and established best practices

- Identify all patients with DM
- Control confounding factors and co-morbidities
- Diagnose level of DR yearly
- Apply timely treatment

Background: Nepal Scenario

- Traditional fundus cameras are difficult to use at expected scale in these types of environments for delivering best practice care and management.
- Impact of technology failures: One of their two cameras has been down since December, with no real plan for getting it back online.
- Impact of environment using traditional retinal imaging devices:
    1. Hard to transport.
    2. Fragile.
    3. Difficult to use.
    4. Variable image quality.
    5. Hard to maintain.

The case for a MARVIN type of system solution really compelling given these types of logistical barriers and issues

Positive Tele-Ophthalmology Impact

- Indian Health Service Studies: Teleophthalmology increased access to eye care, saved sight and cost less than traditional ophthalmology services (0ver 100,000 patients)

- Assessed relationship of participation in a diabetes teleheath eye care program with diabetes-related care sequelae (historical data, prospective study design, 14,000 patients)

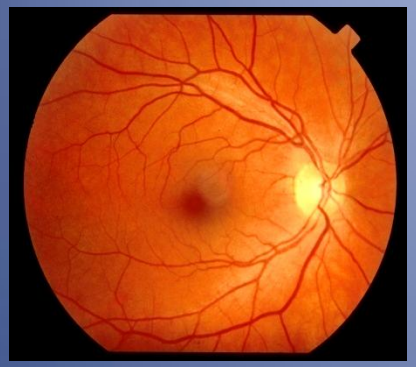
  Telehealth eye care significantly predicted whether subjects:

  - Had a subsequent clinic encounter
  - Obtained subsequent standard eye care
  - Improved HbA1c and LDL-C levels

- *Telehealth eye care programs that combine evaluation, education, and care planning are related to use of recommended care and improvements in diabetes-related health outcomes*

The Relationship of a Diabetes Telehealth Eye Care Program to Other Diabetes Care and Change in Health Outcomes. S. Fonda, S Bursell et al. Telemedicine and eHealth, 2007

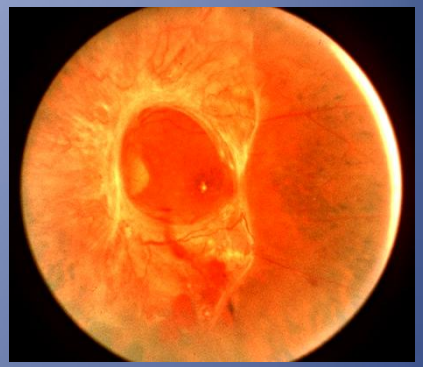
Services and Resources



None

Mild - Moderate

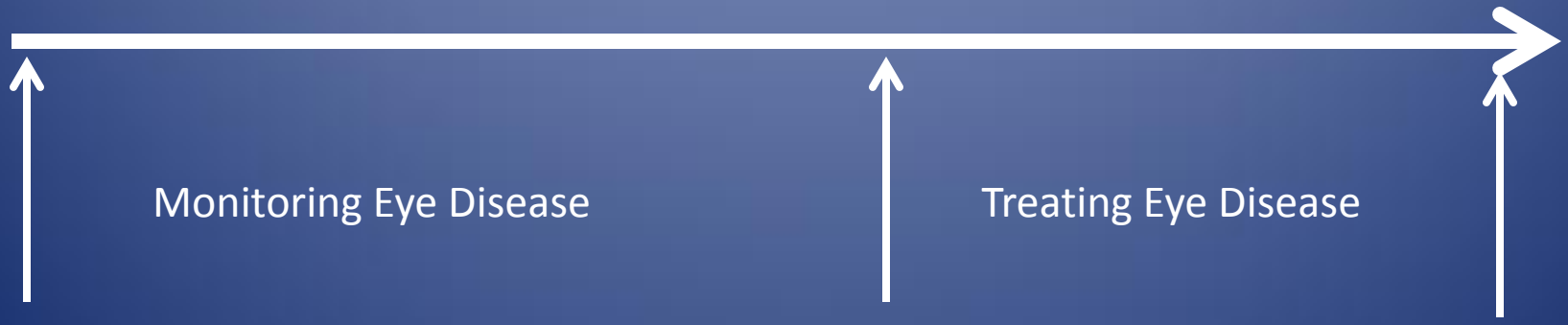
Moderate – Severe



Neovascularization

Wellness and Prevention Interventions
Telehealth and mHealth solutions

Specialty Interventions. Laser , Steroid and antiVEGF Therapies



What is Needed: A Massively Scalable Retinal Imaging Solution

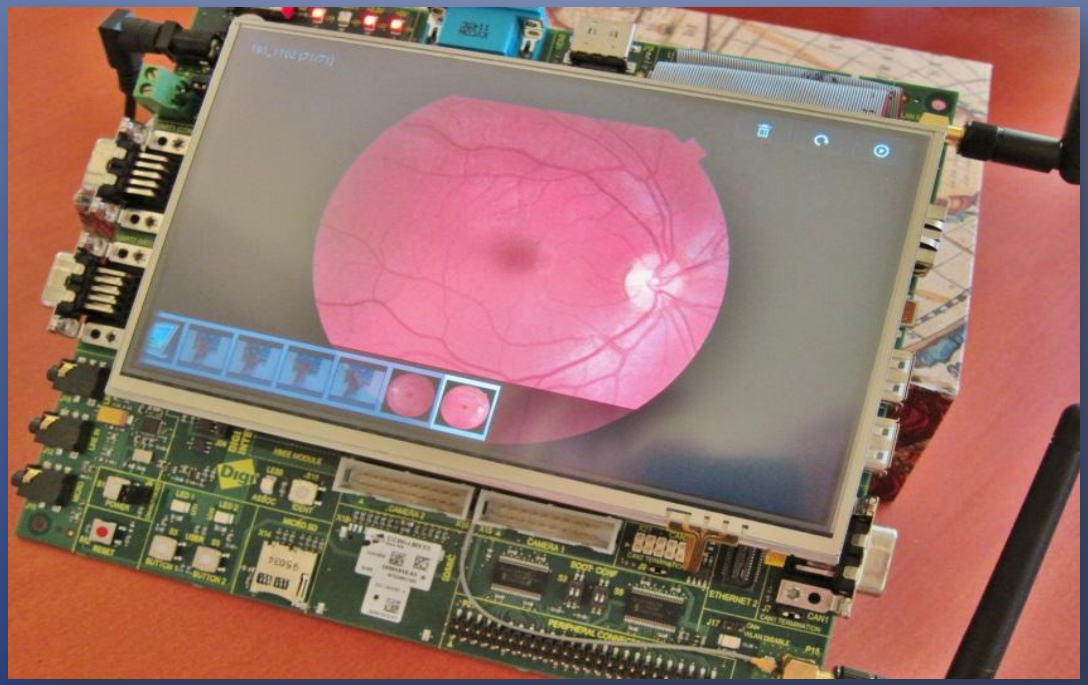
- Low cost camera- <$1K with scalable fabrication and distribution
- Small foot print, light weight, portable
- Multi-field capable or single wide field
- Automated
- Improved non-mydriatic performance (2.5 mm pupil diameter) with consistently good image quality
- Interoperability with EHR systems
- Automated lesion detection and diagnosis of level of DR
- Quality Assurance
- Linkage with Chronic Disease Management

Strategy

- Disperse medical intervention to where the patient is
- On-the-spot assessment and decision support
- Low cost, high usability, mobile
- Quality assurance, uniform images, integration
- Leverage billions invested in smartphone technology

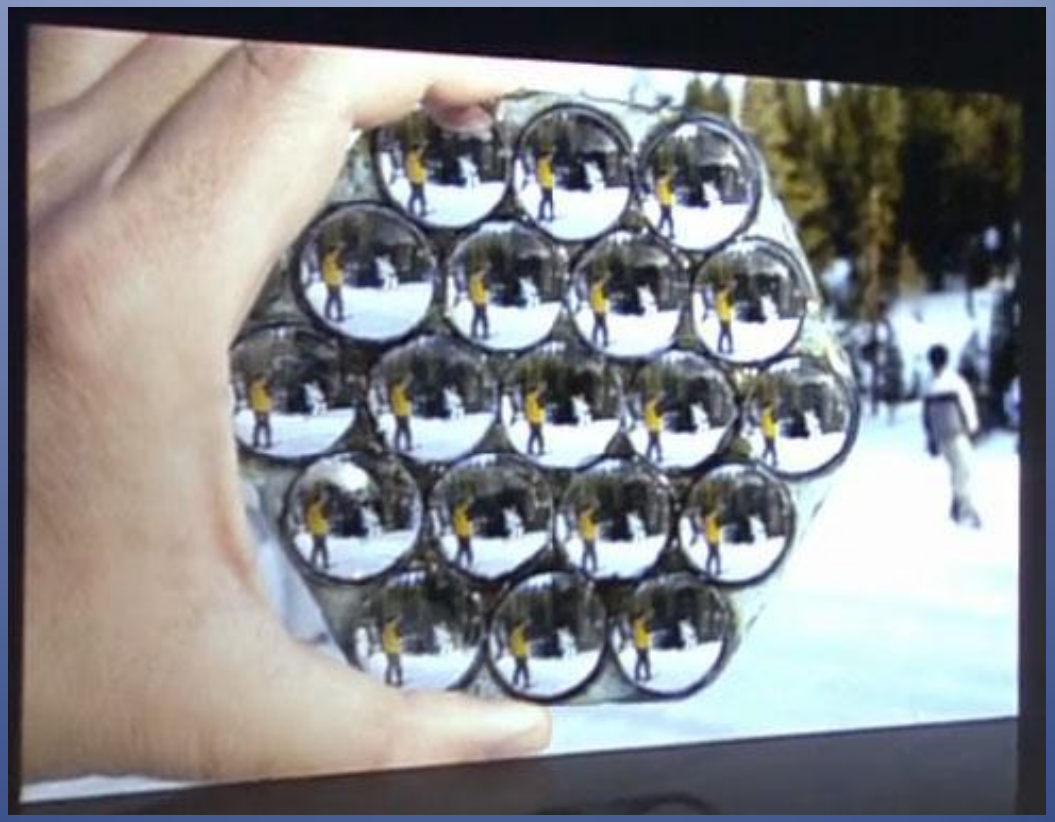
A Mobile Platform

Android or iOS-based tablet provides user interface coupled with a specialized retinal imaging front end comprised of novel optics, light sources and General-Purpose computing on Graphics Processor Units (GPGPU) onboard compute power for image display and diagnostic evaluation of DR through an open platform public API



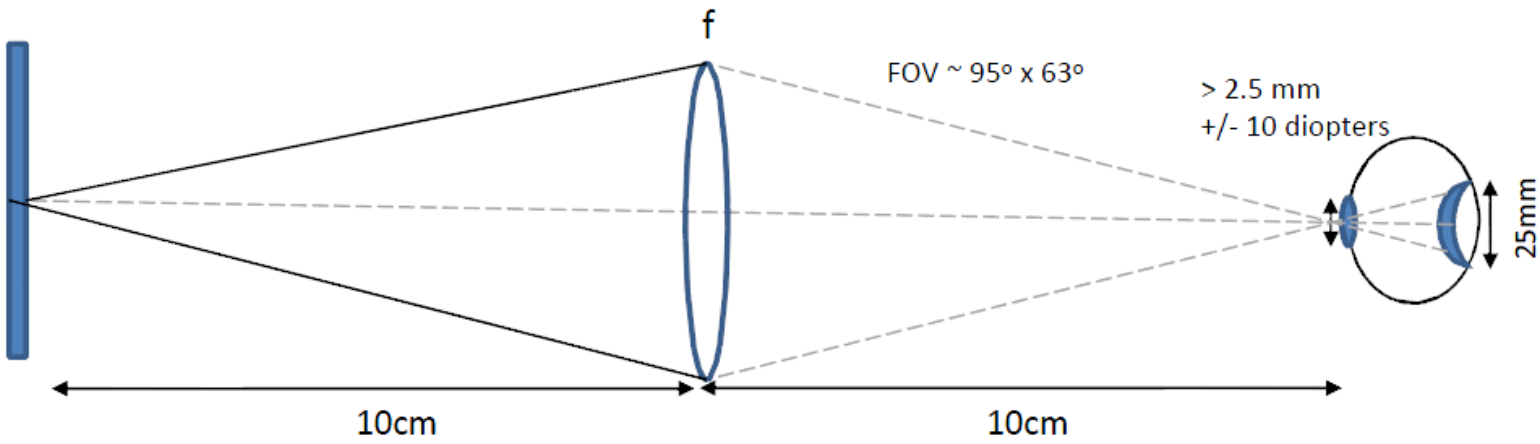
Novel Optics: Plenoptics Technology

Allows focus via software after taking picture; infinite depth of field.



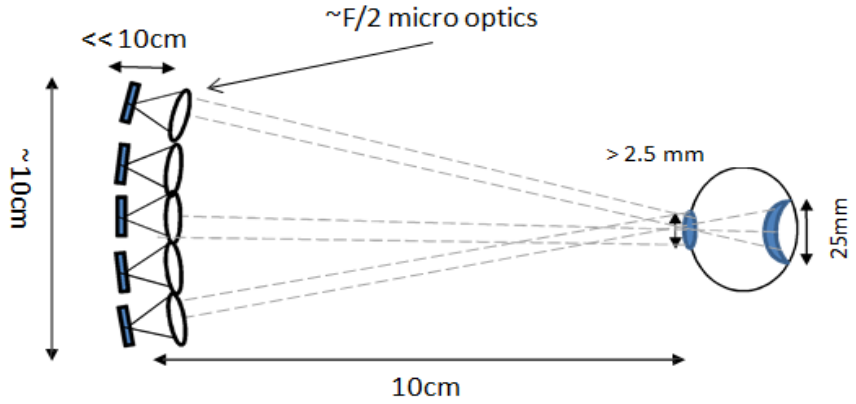
Technology for lenses already in use in mobile phones

Achieving a wide Field of View (Plenoptics)



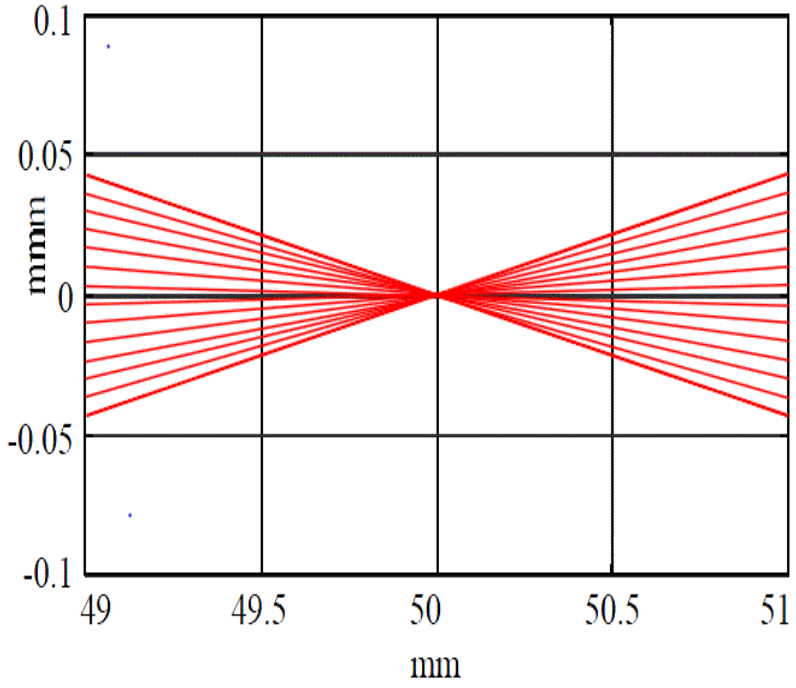
Mag = 1, di = 2f = 10cm
Dia ~ 10cm

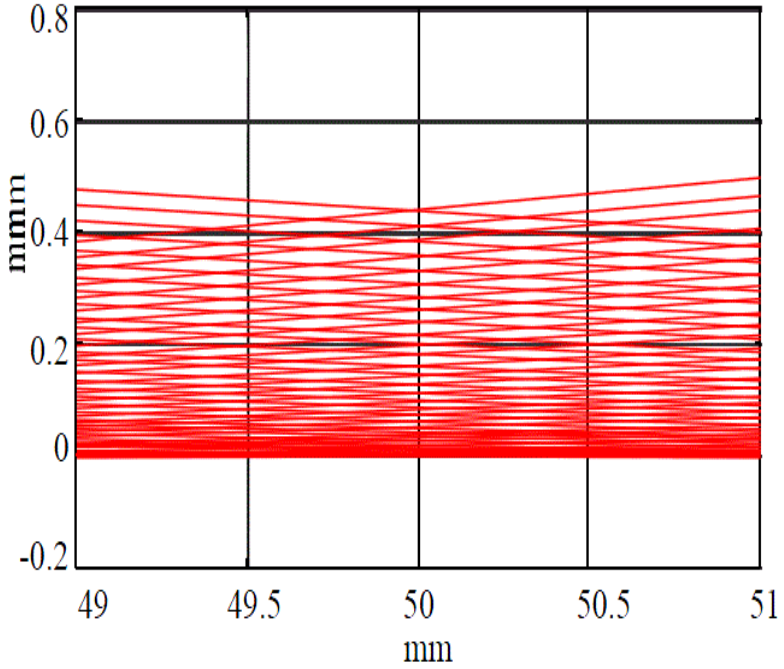
MARVIN CONCEPT



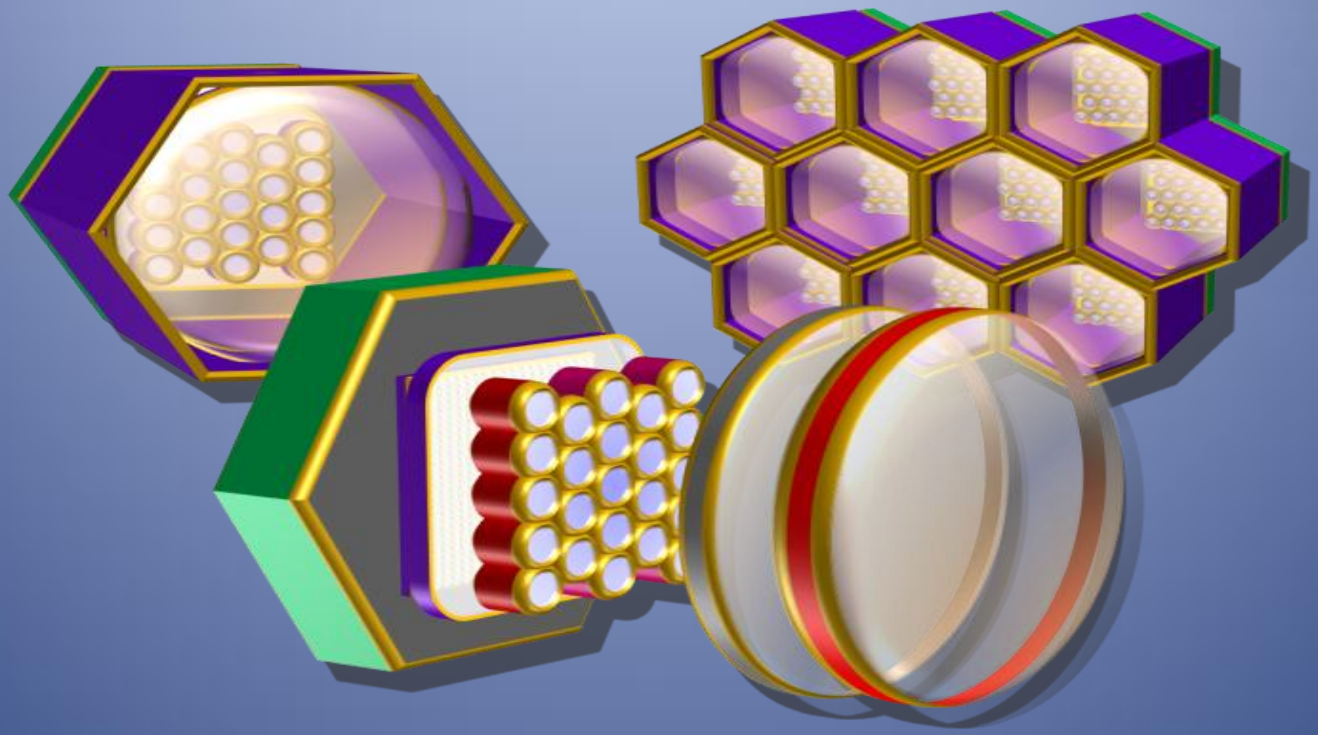
- Focal length of eye ~ 22mm
- Pupil diameter > 2.5mm
- Working F/# of eye ~ F/8

- Distant collection/eye geometry forces an effective magnification of ~10cm/25mm at data collection plane: Mag ~ 4.
- Image points of the retina at the image plane can be spaced at a mag = 1 with F/2 optics (Ratio of F/2 over F/8 is the optical mag)
- F/2 optics with 8 micron pixels has a depth of focus ~ 16 microns
- Depth of Field (at the retina) is then ~ 16 microns.



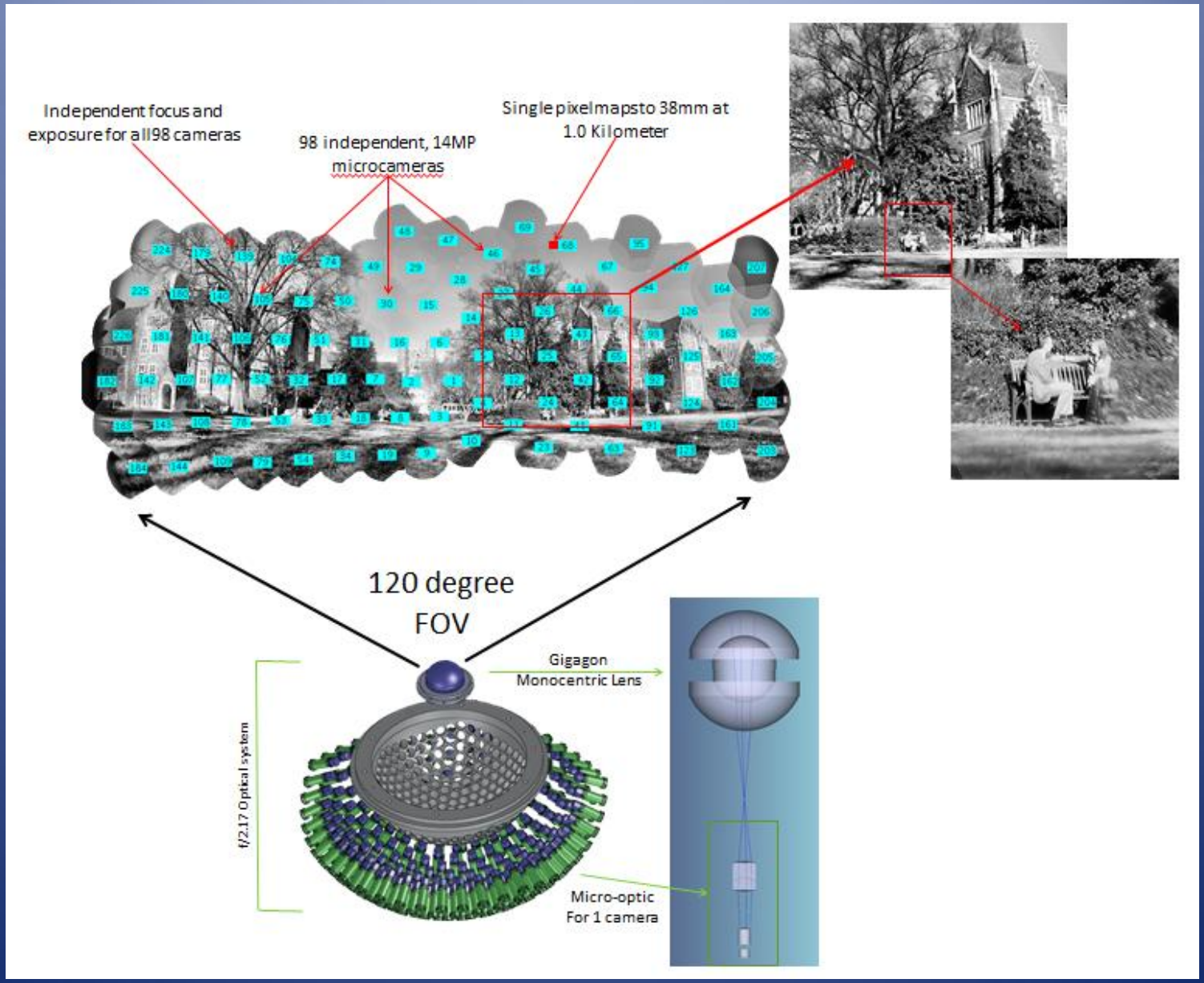


Ray tracing of regular lens shows a zone of sharp focus at 50 mm (left figure). Wavefront coded optics (right figure) show ray density that is uniformly defocussed over a wide range. Sharp images are reconstructed in software.

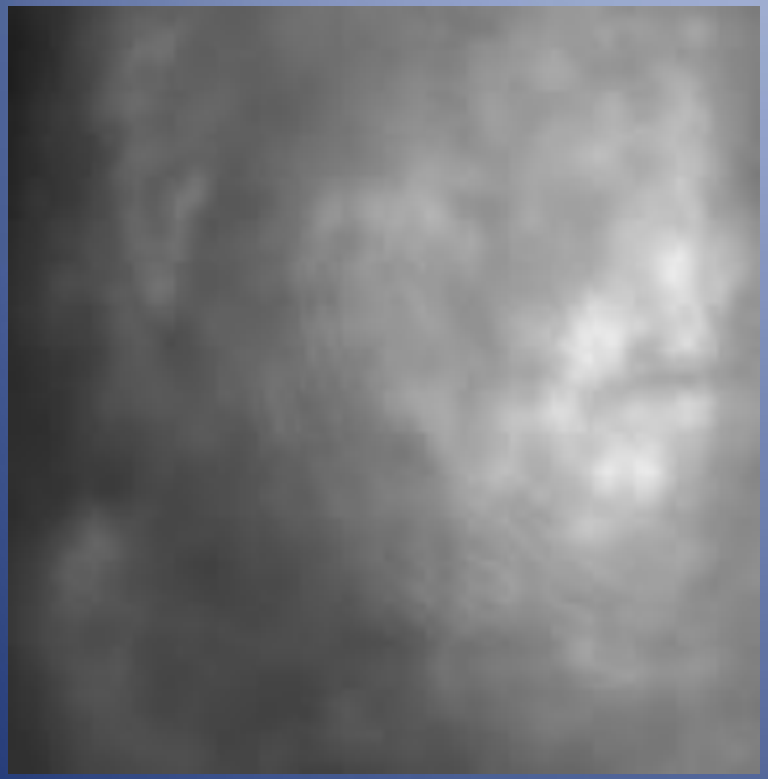


Stacked microcamera array with schematic view of lenses, microlens arrays, wavefront encoding filter and light-sensing array

Aware Multi Aperture Camera



Marvin Wavefront Coding Technology

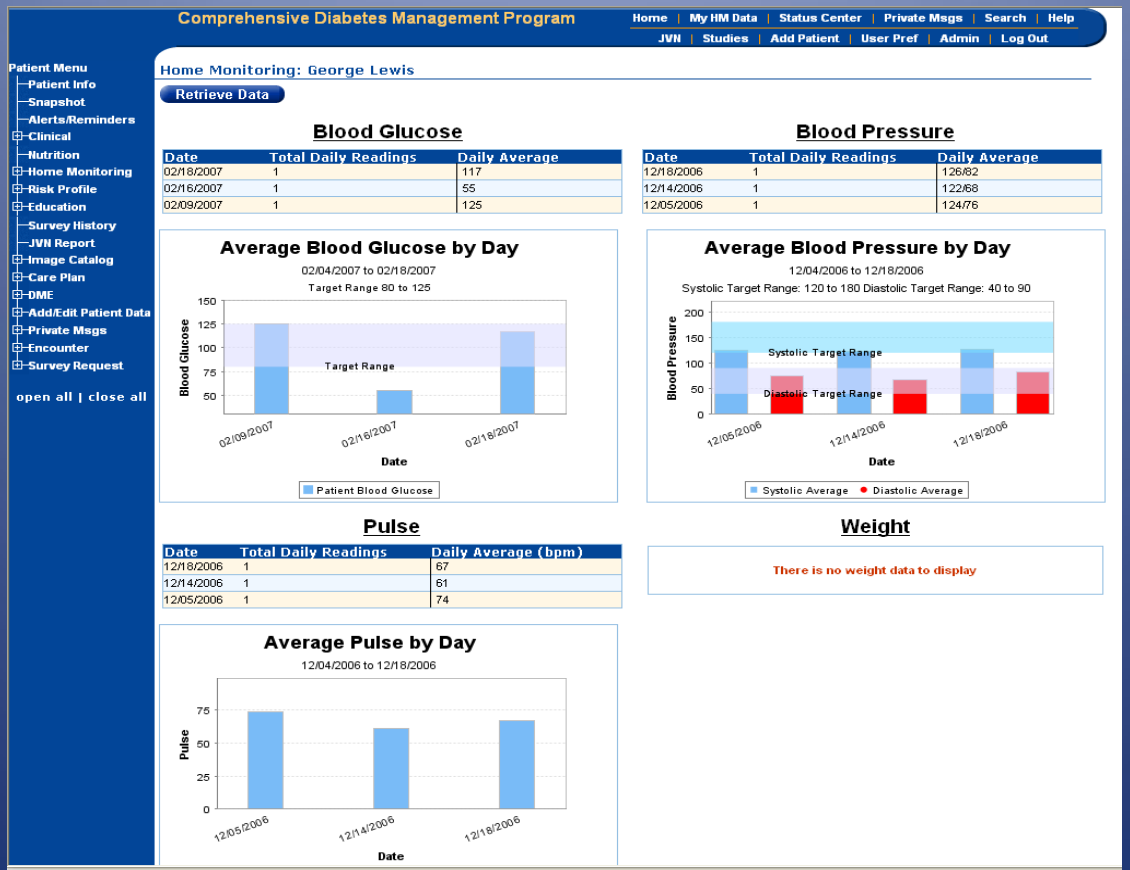


Comparison between traditional imaging of a fingerprint on left and that obtained using wavefront coding of same fingerprint on right

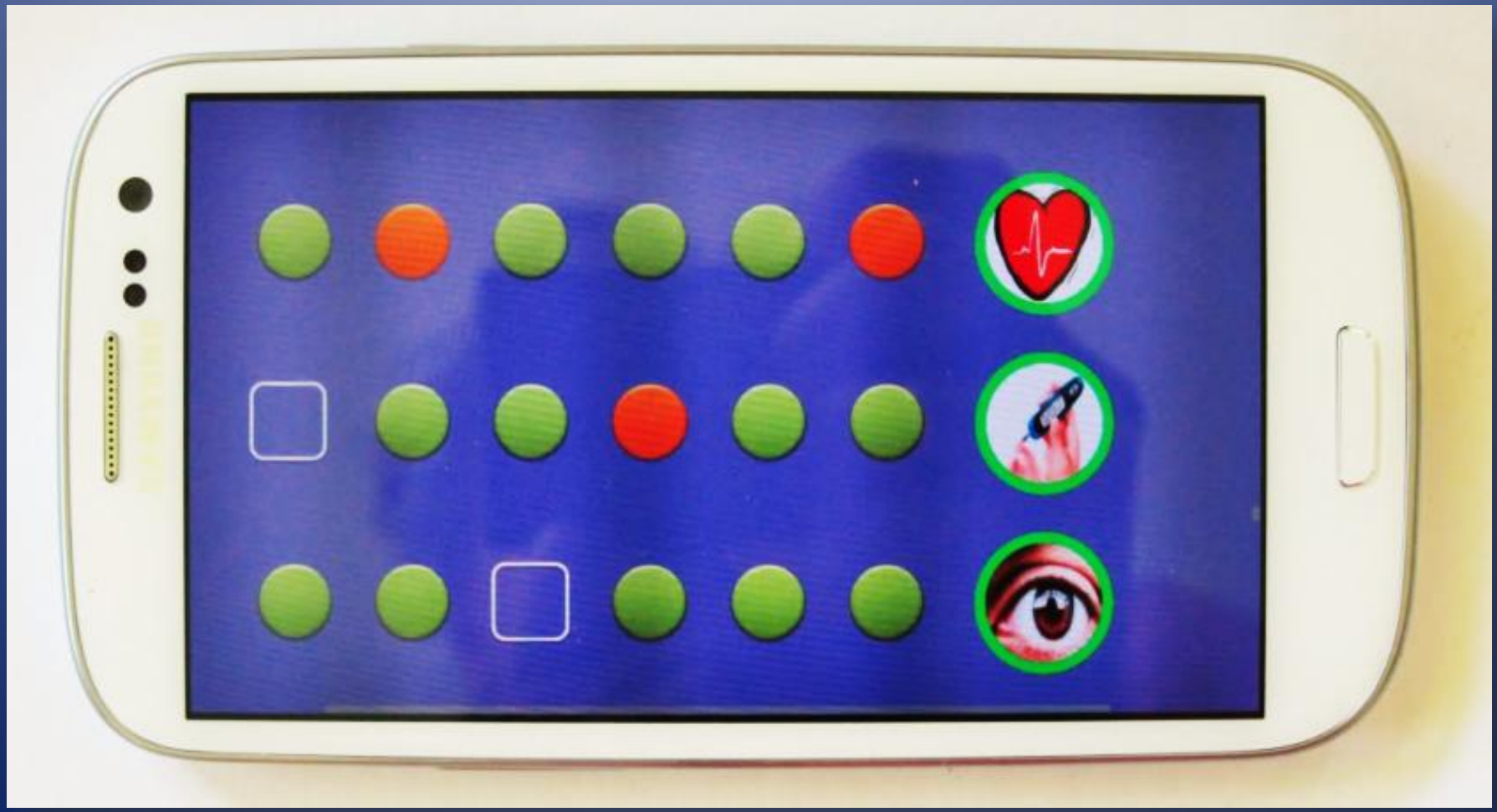
3-D printing of complex parts can take place within a matter of hours.

Remote Monitoring and Mobile Health

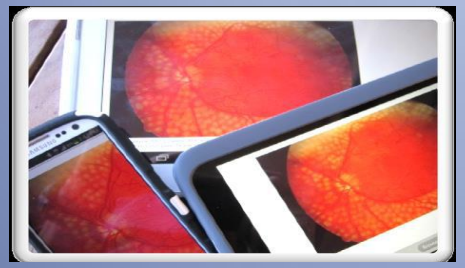
CDMP Application accepts data from mobile remote monitoring devices and provides a platform for aggregation and display of data from multiple devices and applications

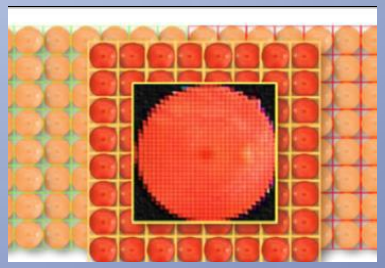


MARVIN daily adherence and tracking app



MARVIN SERVICE TRACKING CONCEPT





Program Partners

Ascentia Imaging, computational imaging and optics
AQT Imaging, computational imaging and optics
Distant Focus, optics, miniature electromechanical systems
EM Photonics, image processing, real-time system control
Estenda Solutions, CDMP and user experience
Eyenuk, image processing and automated retinal lesion identification
Photon Engineering, illumination
SRI Sarnoff, project management
BDO, business assurance
McCarter & English, intellectual property
Wilson Sonsini Goodrich Rosati, corporate counsel

Summary

- MARVIN prevents blindness by accessing people into appropriate eye care at massive scale, before they progress to ore expensive tertiary care
- MARVIN delivers a complete solution, from GIS-based needs assessment models, to in-the-field diagnosis and patient adherence support, as well as public-health-management informatics.
- MARVIN takes advantage of demographics (services and where the people are). Natural integration with existing social networks of schools, village healthcare workers, *etc.*
- MARVIN as a retinal imaging devices is designed to adopt to appropriate field conditions (fits in a backpack, solar powered, locally-replaceable components).
- Massive numbers of retinal studies are accumulated worldwide; they become the basis for improved efficiency, new diagnostic abilities and optimal resource allocation.
- Development capital is required, but this cost is very small given the economic impact of the larger problem.