Superhuman Vision: Enhance, Restore and Extend Reality

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Course Abstract:

Wanna read like you were 20 again? Wanna eliminate those pesky higher order aberrations? Wanna never have to look at your phone? If yes, then this is the lecture for you. We will review what's new and next to provide superhuman vision! These technologies will enhance vision, mimic natural dynamic vision, and even extend reality! We'll cover the importance of optometry's role in these technologies as these technologies will enable the next technological evolution, the Metaverse! It's all about vision! Come learn about the tech that would make Tony Stark jealous.

Course Learning Objectives:

1. Learn about upcoming technologies to customize optics to enhance vision
2. Learn about biomimetic optics, extended reality with augmented and virtual reality, and optometry's role
3. Understand the challenges involved with creating and bringing these technologies to market

Course Outline:

1. The Human Visual Experience
    a. Environment
    b. Art
    c. Microscope and telescope
    d. Displays
    e. Head mounted displays
    f. Eye mounted displays
    g. Intraocular displays
    h. Direct visual cortex input
        i. A through G require functional retina
        ii. H bypasses the eye altogether
2. The Limits of Vision
    a. Campbell and Green et al
        i. Sin patterns project on to the macula
        ii. Eliminates all aberrations
        iii. Shows the retina brain limitations
            1. 20/8
                a. Almost 3x better than 20/20
3. Classic optical correction
    a. Lower order aberration correction
        i. Spherical
        ii. Toric
            1. Eccentricity optimizing quality of vision
                a. Not customized to the individual
    b. Magnification

i. Telescopes
1. Galilean or Keplerian
2. Hand-held, spectacle-mounted, or clip-on
3. Monocular or binocular
4. Fixed focus, focusable telescope, or autofocus

c. Contact lens advantages
i. Optics centered on eye

4. Static vision solutions
a. Improving the quality of vision
i. Wavefront guided optics
1. Principles laid out by Magnante patent from 2000
a. Follow by others such as:
i. Gemoules: 2011
ii. Johns et al.: 2012
2. Destructive interference
a. Similar concept to noise canceling headphones
i. Equal and opposite to cancel out distortion
3. Process
a. ScCL fit
i. WF Aberrometry measured with CL worn to collect HOA Data of the entire eye
ii. HOA data mirrored
iii. Manufactured onto surface of the ScCL
4. OPTICS TOTALLY CUSTOM TO INDIVIDUAL EYE
a. Why a scleral lens (ScCL)?
i. Lens stability & rigid material
5. HOA Sclerals in Research
a. Total HOA reduction of ~43-66%
b. 1-2 lines of vision improvement

ii. Improving near vision
1. Multifocal optics
a. Inducing aberrations
i. Spherical aberration
1. Must be centered to line of sight
a. Induce unwanted aberration
2. Decentered pupil size optimized
a. Legerton: 2004

iii. Combination of principals
1. Reduce unwanted aberration
2. Induce desired aberration in necessary amount

5. Dynamic vision
a. Active pupil
i. Filter acts as a artificial pupil
1. Responsive to light

- b. Active accomodation
    - i. Response to several
        1. Vergence
        2. Distance
- c. Adaptive optics
    - i. Constantly optimized vision

6. Extended Reality
    - a. Augmented reality
        - i. Virtual content on the real world
            1. Transparent display
                - a. Overlays on the real world
            2. Closed circuit display
                - a. Camera captured and full screen playback the real world with overlays
                    - i. Make the invisible visible
                        1. Faster than vision
                            - a. Slow motion playback
                        2. Limitation of vision is the visible
                            - a. Sensory limitations could now be produced visually
                                - i. Outside of visual spectrum
                                - ii. Temperature
                        3. Limited to 20/8
                            - a. Zoom
                                - i. Telescopic vision
                                - ii. Microscopic vision
    - b. Virtual reality
        - i. All virtual content
            1. Closed circuit display
                - a. Real
                    - i. Camera located in another place
                        1. Drone
                - b. Artificial
                    - i. Content projection
                        1. Video games

7. Why care about extended reality??
    - a. IT'S ALL VISUAL!!!
    - b. PC era to Mobile era to Metaverse
    - c. What is the Metaverse?
        - i. Metaverse projected to be worth between $6 trillion and $13 trillion
        - ii. Unlimited number of users to experience real-time rendered, 3D virtual worlds synchronously and persistently
            1. Combination of technologies
                - a. Most important is visual

2. Not replace the internet
    a. Will build upon and extend it

8. Challenges of technology
    a. Multiple companies have interest
        i. Contact lens companies
        ii. Technology companies
            1. Lots and lots of IP filed
            2. Multiple studies performed
                a. Why hasn't it been done yet?
    b. Multiple challenges
        i. Money
        ii. Regulatory pathway
            1. Medical indication to consumer products?
        iii. Components
            1. Size
                a. Bell's law
            2. Cost
                a. Moore's law
            3. Flexibility
            4. Permeability
            5. Disposability
            6. Biocompatibility
            7. Comfort
            8. Disinfection
        iv. Processing and data transmission
            1. On a lens?
        v. Connectivity
            1. Wifi
            2. Bluetooth
            3. RFDI
        vi. Power
            1. Auxiliary power sources
                a. Induction coils
                    i. Corded
                b. Battery
                    i. Size and efficiency
                        1. Life per charge
            2. Heat management
        vii. Social
            1. Acceptance
            2. Meeting consumer expectations
                a. Quality
                    i. Rich media
                    ii. 8K vs 16bit

1. Starting a new media
   b. Ease of use
3. Video recording
   a. Polarizing subject
      i. Big benefit to contact lenses
         1. Less visible

viii. Public Safety

1. Driving device distraction (CDC 2021)
   a. Visual: taking your eyes off the road
   b. Manual: taking your hands off the wheel
   c. Cognitive: taking your mind off driving
      i. Improvement in 2
2. Pedestrian device distraction (NYC DOT)
   a. 9% - 13% distracted while crossing