TL;DR Future Contact Lenses

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Abstract:
The pace of innovation is rapid, and new technologies are abundant, but who has time to read every article, manuscript, and patent? This lecture will summarize upcoming innovations and research in contact lens technology. This includes contact lenses for biometrics, drug delivery, photobiomodulation, biomimicry, and mixed reality contact lens. TL;DR learn about future contact lenses.

Learning objectives:

1. Review research and development surrounding new applications of contact lenses
2. Discuss technology developments that enable contact lens innovations
3. Present challenges and obstacles to contact lens innovation

Outline:

1. Lecture relies on journal publication, patent search, and clinical research
    a. CLEAR Report: Jones et al
        i. Excellent overview
2. Dynamic vision
    a. Active pupil
        i. Filter acts as an artificial pupil
            1. Responsive to light
    b. Active accommodation
        i. Response to several
            1. Vergence
            2. Distance
    c. Adaptive optics
        i. Continuously optimized vision in real-time
            1. Liquid crystal
3. Extended Reality
    a. Augmented reality
        i. Virtual content in the real world
            1. Transparent display
                a. Overlays on the real world
            2. Closed circuit display
                a. A camera captured and full-screen playback of the real world with overlays
                    i. Make the invisible visible
                        1. Faster than vision
                            a. Slow motion playback
                        2. The limitation of vision is the visible
                            a. Sensory limitations could now be produced visually

i. Outside of the 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. The camera is located in another place
                    1. Drone
            b. Artificial
                i. Content projection
                    1. Video games

c. Why care about extended reality??
    i. IT'S ALL VISUAL!!!
    ii. PC era to Mobile era to Metaverse
    iii. What is the Metaverse?
        1. Metaverse is projected to be worth between $6 trillion and $13 trillion
        2. Unlimited number of users to experience real-time rendered, 3D virtual worlds synchronously and persistently
            a. Combination of technologies
                i. Most important is visual
            b. Not replace the internet
                i. Will build upon and extend it

4. Biometric monitoring
    a. Lab on a lens
        i. Osmolarity
        ii. Glucose
        iii. Tear film biomarkers
5. Drug delivery
    a. Over 144 publications
        i. Drug delivery layer
            1. Added to lens surface or contained within
        ii. Reactive drug delivery
            1. Combination of biometrics
            2. Iontophoresis assisted delivery
            3. Multiple medications loaded
6. Bioelectric
    a. Corneal wound healing
        i. Cell migration

ii. Bacteriolysis

7. Photobiomodulation
    a. Daylight mimic
    b. IR spectrum
    c. Crosslinking
8. Challenges of technology
    a. Multiple companies have an 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
            1. Unproven Technology
            2. Investment economy
        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. RFID
        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. The big benefit to contact lenses
            1. Less visible and inline with line of sight

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% were distracted while crossing