The Mobile Future of eXtended Reality (XR)

Qualcomm Technologies, Inc.

June, 2017

XR is the next mobile computing platform

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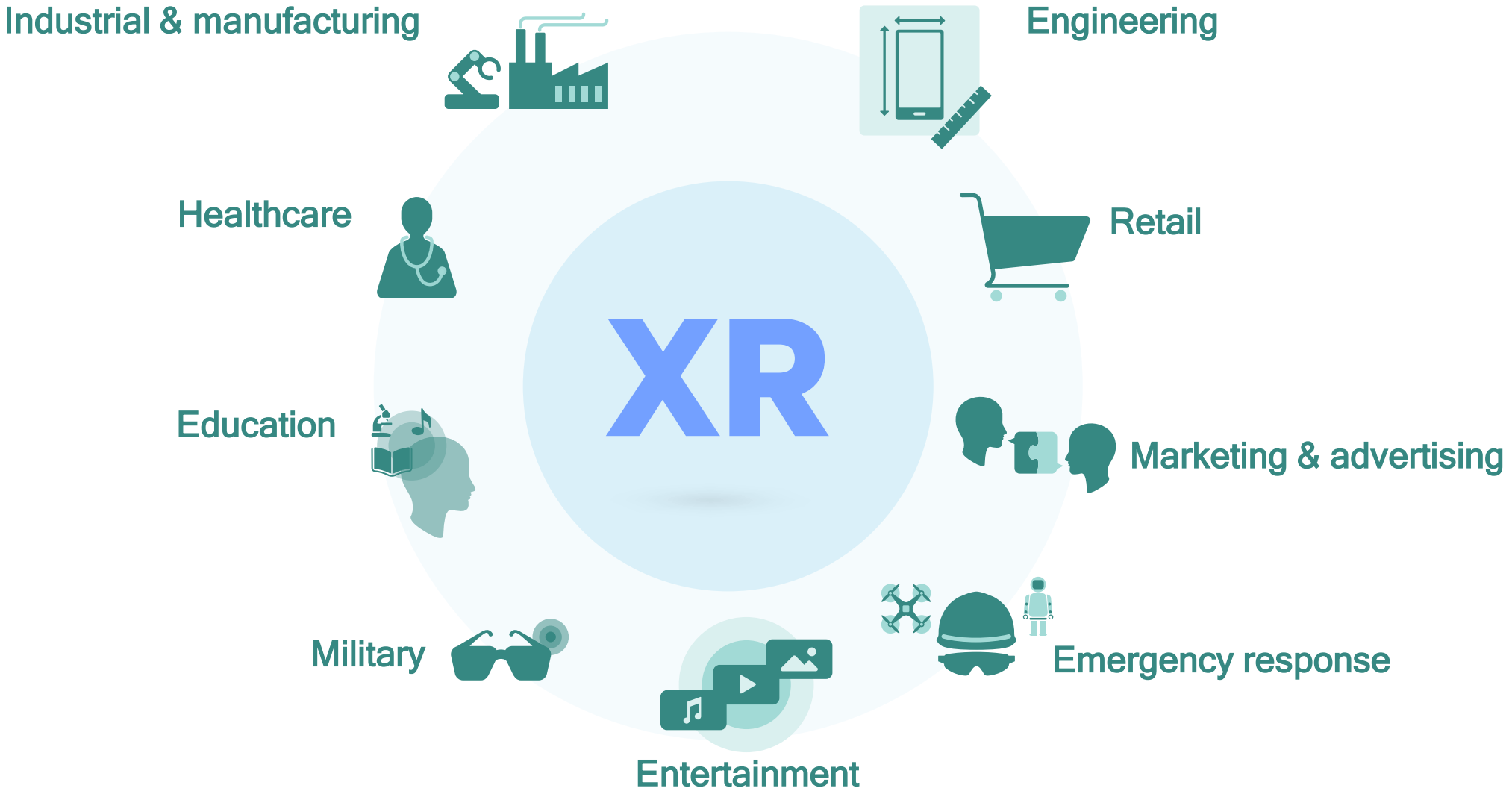
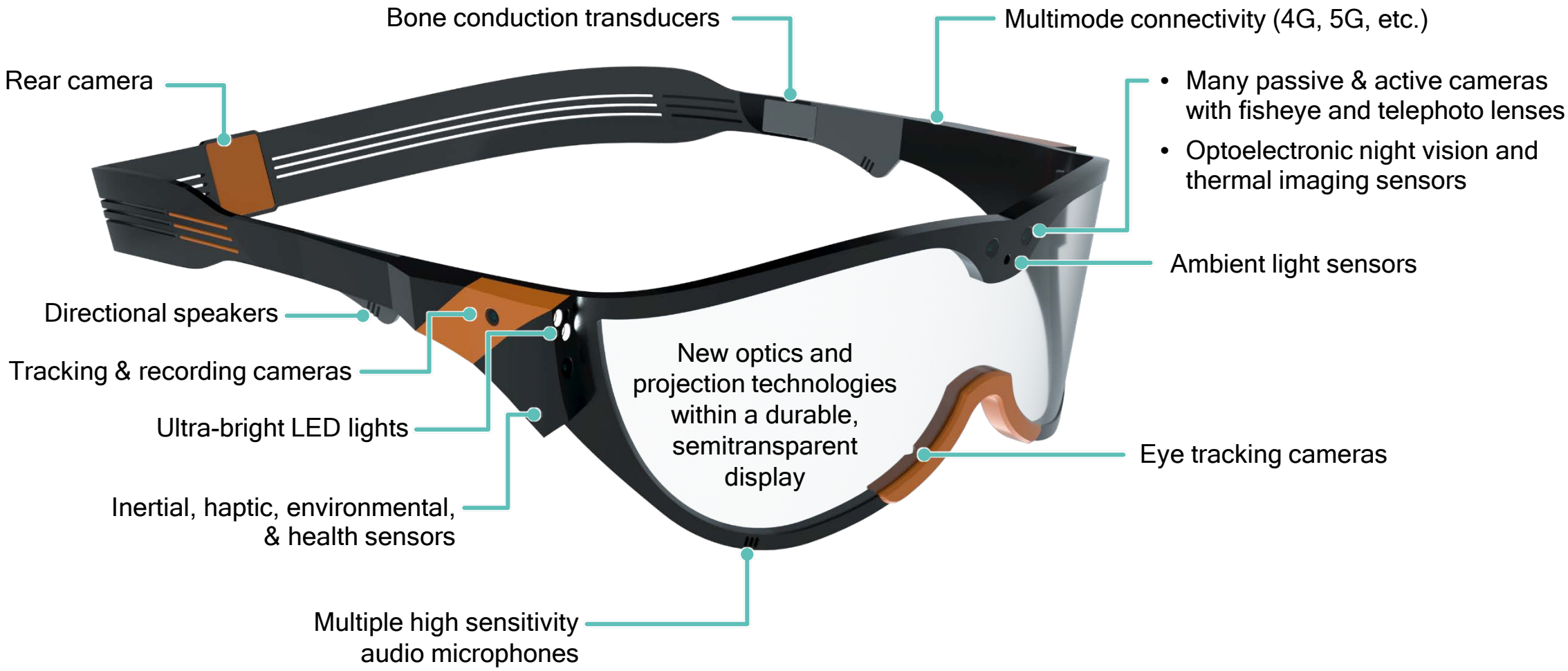


A glimpse into the future

First responder XR glasses




TEMPERATURE WARNING
457°F
Somebody help!
Building Map - First Floor
Captain Pat L.
Firefighter Miran C.
Evacuation complete, east wing all clear.
Lieutenant Tim L.
N

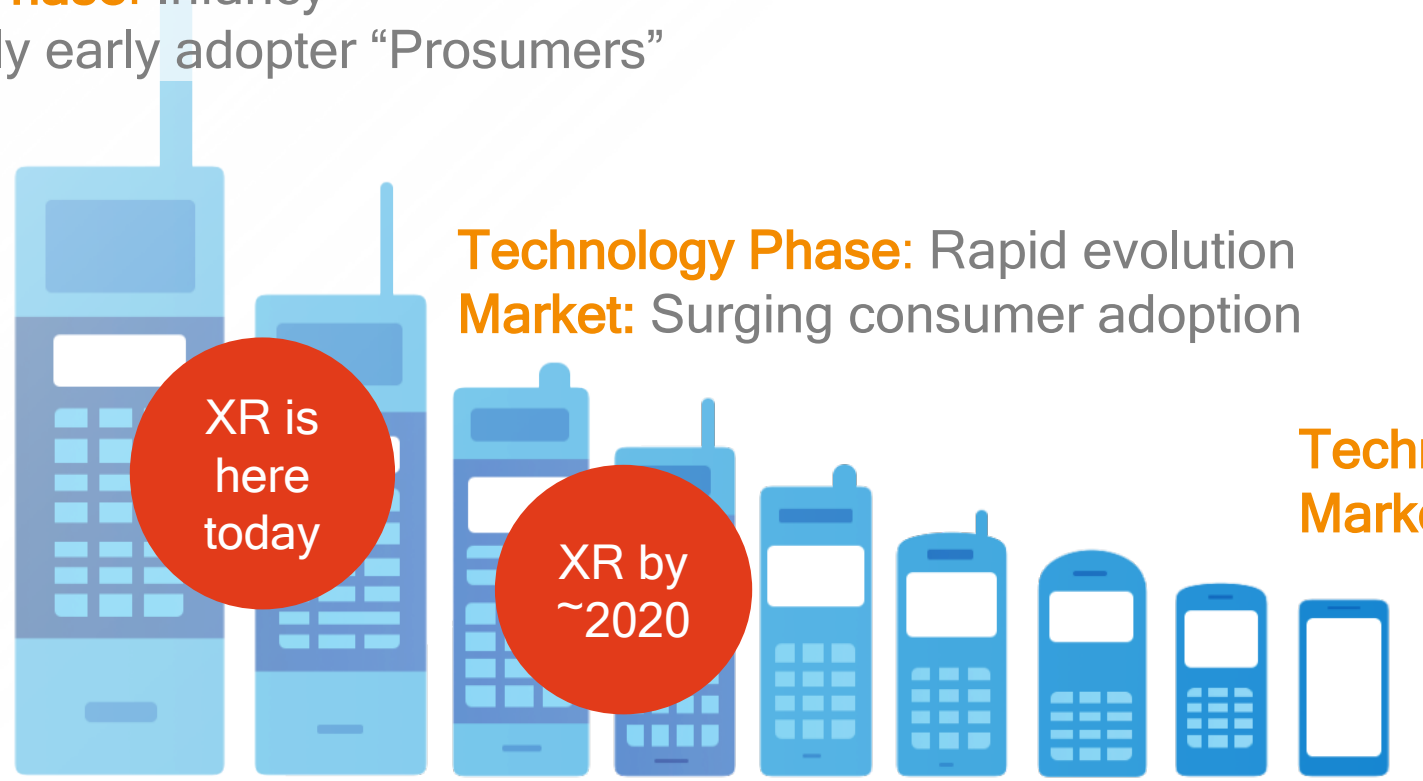

TEMPERATURE WARNING
457°F
Somebody help!
Rear Camera View
Building Map - First Floor
Captain Pat L.
Firefighter Miran C.
Evacuation complete, east wing all clear.
Lieutenant Tim L.
N

Will the smartphone become an XR wearable?

XR is here today, but it is still in its infancy

Analogy to smartphones: XR evolution will take years…opportunity will be immense

Technology Phase: Infancy
Market: Mostly early adopter "Prosumers"



Technology Phase: Rapid evolution
Market: Surging consumer adoption

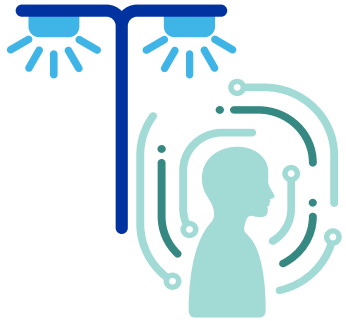
Technology Phase: Maturity
Market: Worldwide, ubiquitous use

XR will follow a similar ~30 year cycle of sleeker designs, with tremendously increasing functionality

Solving the key XR technology challenges ahead

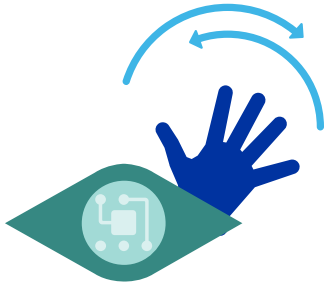
Display

Displaying richer visual content, and switching seamlessly between fully and partially virtual worlds



Common illumination

Making virtual objects in augmented worlds indistinguishable from real objects within the same view

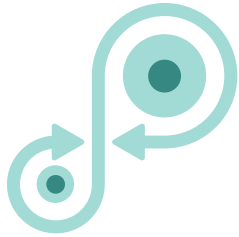


Motion tracking

Intelligent, completely on-device tracking for intuitive head, hands, and eye interactions

Power and thermal

All day battery life, years of recharging, and compatible with sleek, thin, light passively cooled devices with no fans



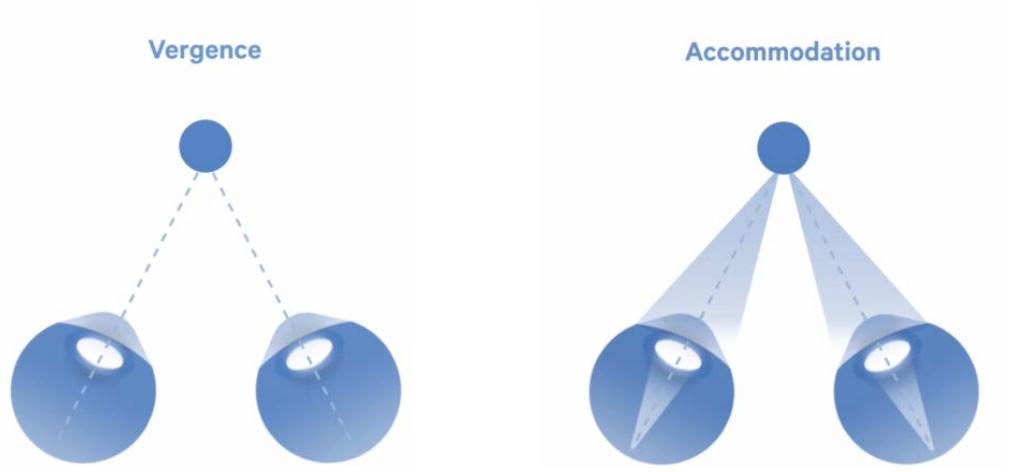
Connectivity

The next level of ubiquitous, wireless connectivity for anywhere usage at fiber-optic speeds

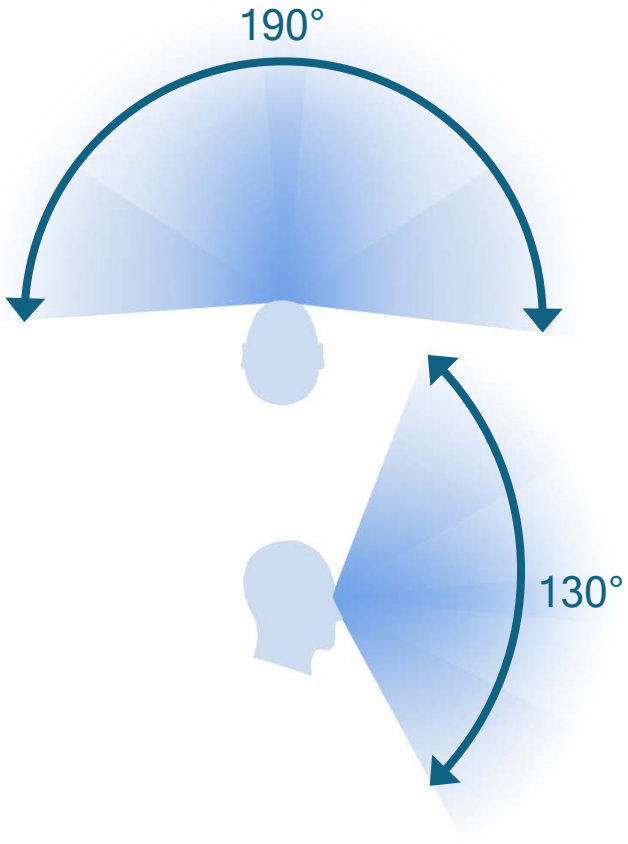
XR human factors challenges for displays

Vergence and accommodation conflict and human field of view (FoV)

Vergence & accommodation



Field of view (binocular) in XR glasses



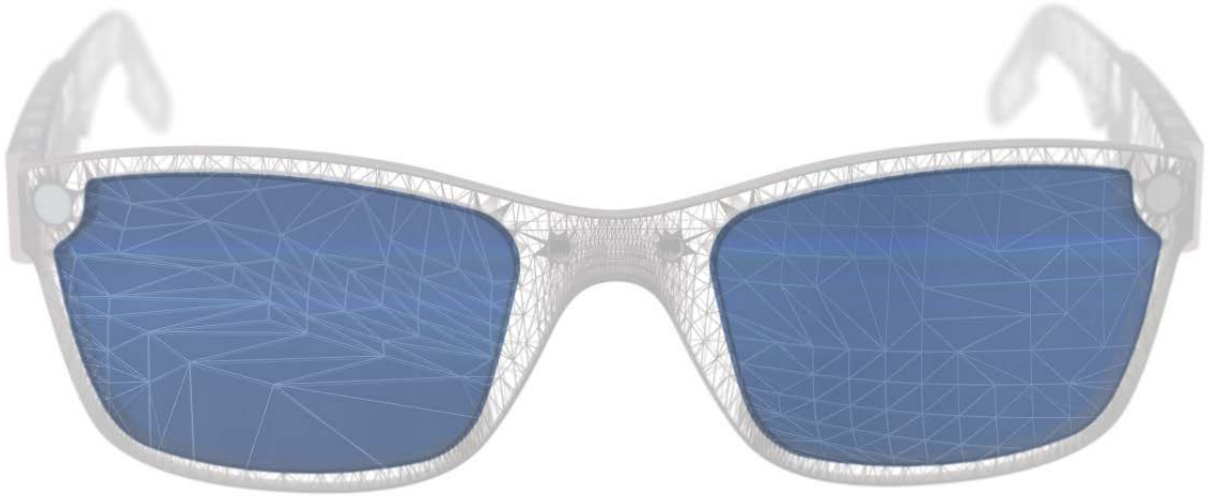
Future XR needs a disruption in display technology

First step towards high volume converged XR form factor are new displays

- Solve the vergence accommodation conflict
- Deliver necessary FoV both for immersive VR and useful AR
- Be completely opaque for VR, yet at least ~85% transparent for AR
- Support an angular resolution of at least 0.5 – 1.0 arc minutes per pixel
- Drive HDR, at least Rec. 2020 gamut, with ~5X improvement in nits
- Be capable of refreshing at a minimum of ~120Hz (per eye)
- Be light, mechanically flexible, very durable, and eventually cost under ~$100 at very high volumes

XR display questions that need answers

- What's the best technology to switch between opaque and nearly transparent display modes?



- Can LCOS or DLP with a mechanical shutter, better optics, and improved wave guides get us there?
- Can plastic AMOLED get us there? Can smaller transistor sizes improve transparency for AR?
- Or should the industry be working together on something more exotic to meet these needs?

Common illumination
makes virtual objects look real

Where we are today

Virtual objects look fake

- In part due to mostly static lighting that's often incorrect for the environment
- Even when dynamic, the graphics shader's lights don't consistently match real world light sources or intensity
- Consequently objects and materials look physically incorrect for the scene
- It is always immediately obvious which objects are real and which are virtual

Where we must eventually be

Virtual objects must look real

- With sampled light from cameras or ALS used to determine final color of every pixel in the virtual object
- Virtual lights should be very frequently updated with real world lights to be perceptually correct for real environment

Making it possible

- New, more intelligent, faster interaction between many different sensors and rendering systems
- New computer vision and global illumination algorithms that use real world lights to dynamically render and overlay more realistic virtual objects

Improvements needed in motion tracking

Taking immersive mobile XR experiences to the next level will require:

- Improved head/body tracking
  - User friendly, inside-out 6 DoF head tracking
  - Power efficient, sub-10ms motion to photon latency with sub-millimeter drift
  - Functional at world scale with capability to appropriately alert for collision avoidance
- Improved eye tracking
  - Automatic IPD calibration
  - Tracking accuracy for foveation/depth of field rendering and viewport aware video
  - Also for more natural intent-based interaction and interfaces

Other improvements needed in motion tracking

Intuitively interacting in virtual worlds

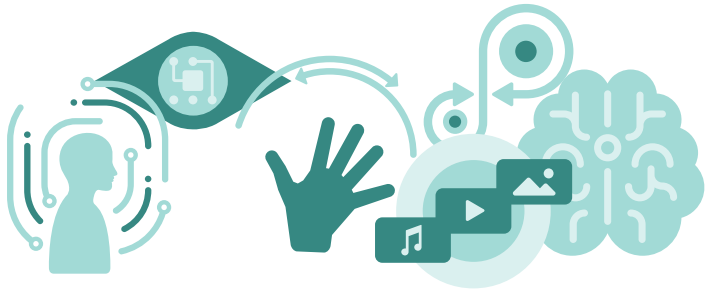
- Controllers, when required, must be 6 DoF, responsive and low cost
- However, for most use cases, the best controller is no controller

Making it possible

- New, better 3DR so that virtual hands in VR mode look just like your own
- CV, machine learning, and graphics convergence so they *work* just like them too

Power and thermal efficiency is essential for XR

The XR headset needs to be appropriate to wear and use all day



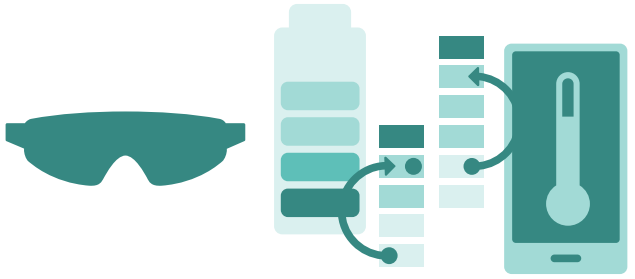
The challenge of XR workloads

Very compute intensive

Complex concurrencies

Always-on

Real-time



Constrained mobile, wearable environment

Must be thermally efficient for sleek, ultra-light designs

Requires long battery life for all-day use

Able to be quickly recharged at least 1,000 times

Power & thermal efficiency is essential for XR

So how do we get there?

- IHVs: Double perf/watt every ~3 years
- Battery companies: Improve battery capacity per gram by at least ~5X over the next 10 years
- Researchers: Innovate in mobile HMD materials science and passive cooling
- App developers: Tune your code to be more power efficient
- Consortiums: Standardize XR multimedia compression, foveation, and other areas that save power and boost performance
- Network operators: Provide much more efficient wireless connectivity access to internet and cloud services

5G enhanced mobile broadband

is required for XR mass adoption

Extreme throughput – multi Gbps
Ultra-low latency – down to 1 ms
Uniform experience – even at cell edge

XR video will be the killer use case for 5G

~10 to 50 Mbps

Current-generation
360° 4K/30fps video

~200 to 5000 Mbps, very low latency

Next-decade
Interactive, real-time 3D "Free-Viewpoint"
6-DoF 8K/90-120fps HDR-next video

Sustained network performance

~50 to 200 Mbps, lower latency

Next-generation (2019)
3D 360° 8K/30fps viewport-aware HDR10 video

XR is the next mobile computing platform

Many technology breakthroughs are required

Call to arms for XR market acceleration: cooperation is key


“You can’t depend on your eyes
when your imagination is out of focus”
- Mark Twain

Thank you

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