

Augmented Reality Audio: The Next Generation of Hearables

With

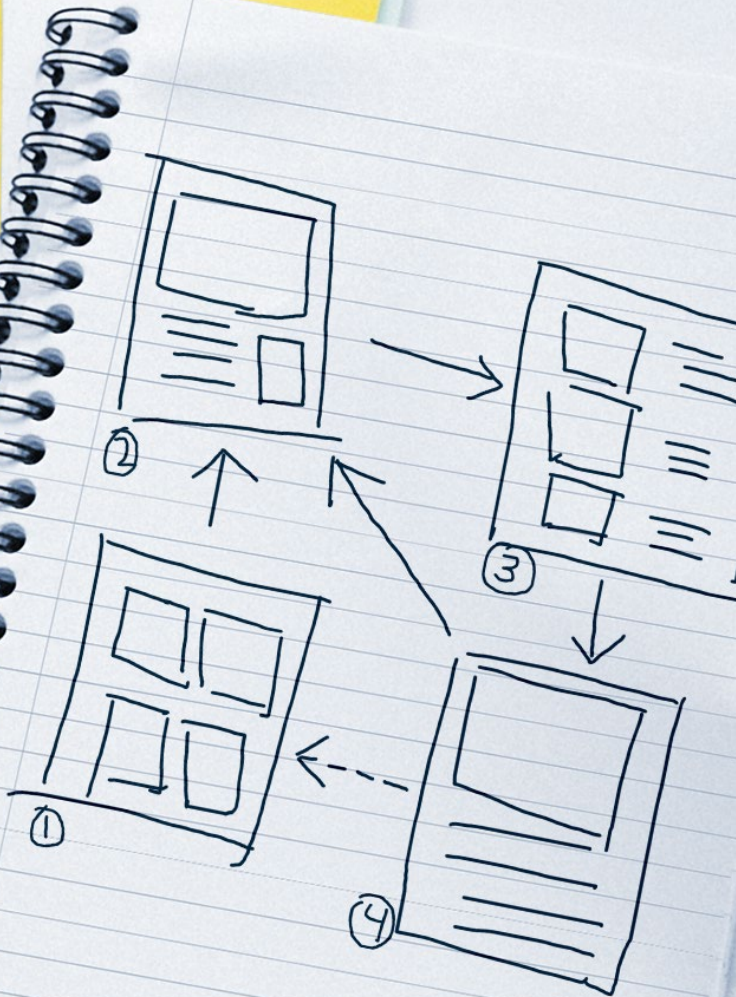
Adam Levenson, VP of Business Development, G-Audio

Introductions

Trilobyte Games
Interplay Entertainment
Immersive Sound
Electronic Arts
Shiny Entertainment/Atari
Activision
LAA
Somatone Interactive
CRI Middleware
Krotos
G-Audio

Scribblings on scrap paper

- The epiphany: what if there was an in-ear device that...
- The realization: wait, that exists?!



Session Roadmap

- What is Augmented Reality Audio?
- What are hearables?
- What products are available now?
- What are some of the current features?
- What the future might hold...

What is Augmented Reality Audio?

- The concept of having virtual control over what you hear
- Layering real-world, connected device, and virtual audio sources
- Having control over how, and whether you hear any given category of sound

What are hearables?

The product at the crossroads of headphone tech, hearing aid tech, and AR

- "A hearable is a wirefree hearing device that, at its core, enhances the audio quality of a user's environment and boasts an array of smart features."
-- *Greenlight Insights: Hearables Market Analysis*
- Poppy Crum, Chief Scientist at Dolby, said hearables are at the "convergence between entertainment, lifestyle and hearing health".
- David Cannington, co-founder of Nuheara said, a hearable is a device to "control the elements of your physical environment", to "orchestrate your soundscape", and provide an "on-the-fly personalized hearing experience".

A Definition

- (1) Wireless -- for freedom of movement and Bluetooth device connectivity.
- (2) Earbud form -- unobtrusive, low-profile, with direct physical contact.
- (3) Supported by a mobile app -- processing power and access to settings and customization.
- (4) Noise reduction and cancellation -- controlling ambient noise is fundamental to augmented reality.
- (5) Speech enhancement -- primary to our audible experience.

Market Outlook

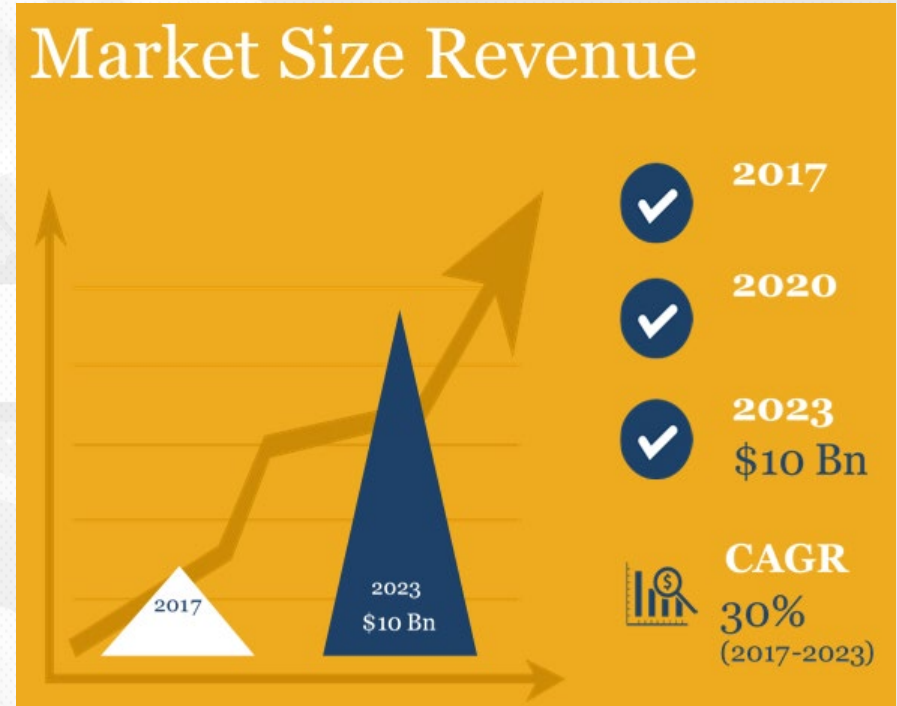
Arizton, Earbuds Market - Global Outlook and Forecast 2018-2023

Projections

- The global earbuds market is anticipated to reach values of approximately \$10 billion by 2023, growing at a CAGR of around 30% during through 2023.
- Global Earbuds Market Size by Revenue

Impetus for Growth

- “Personal voice assistants such as Amazon’s Alexa, Apple’s Siri, Google Assistant and Microsoft’s Cortana, have suddenly emerged as the biggest interface revolution since the iPhone popularized the touchscreen.” -- *Peter Burrows, The future is ear: Why “hearables” are finally tech’s next big thing.*



Current Products

The current product lineup

- Bose/Hearphone
- Sony/Xperia
- Jabra/Elite Sport
- Nuheara/IQBuds Boost
- Bragi/Dash



Nuheara's IQBuds Boost

Key Features



Basic

- ✓ Music streaming
- ✓ Input level adjustment from connected device



Audio enhancement

- ✓ Personalization based on a hearing test
- ✓ Noise cancellation
- ✓ Noise reduction



Smart Capabilities (enabled through a smartphone, or smartwatch)

- ✓ Speech amplification
- ✓ Listening directivity
 - ✓ Translation
- ✓ Voice assistant
- ✓ Biometric tracking

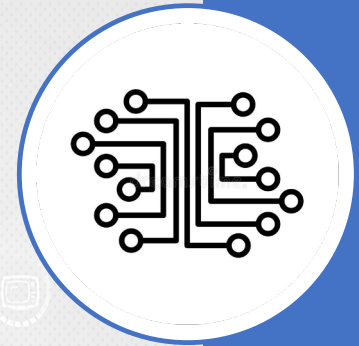
The Proto Hearables

- Apple AirPods
 - Truly wireless
 - Noise reduction for voice
 - Voice assistant
- Google Pixel Buds
 - Real-time translation
 - Voice assistant
- Proto hearables are opening the door for full-featured, long-wear hearables



The Future Feature Set

- Powered by machine learning (ML) algorithms, digital signal processing (DSP), and binaural rendering
- On the horizon
 - Situational Responsiveness
 - Focused Listening
 - Selective Hearing
 - Virtual Objects



Machine Learning

Hearing devices usually lack automatic “environment classification” and typically require wearers to manually adjust settings

-- DeLiang Wang, Perception and Neurodynamics Lab at Ohio State University

“A mobile phone is capable of running sophisticated ML algorithms in real time”

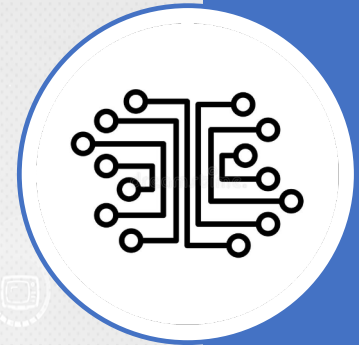
– Dr. Shehroz S. Khan, University of Toronto

“A machine learning algorithm is a mathematical function that enables the machine to identify relationships among inputs and outputs”. “Machine learning is a fit when “you’re dealing with massive amounts of data and a system that must adapt to changing inputs.”

-- Doug Rose, Artificial Intelligence for Business

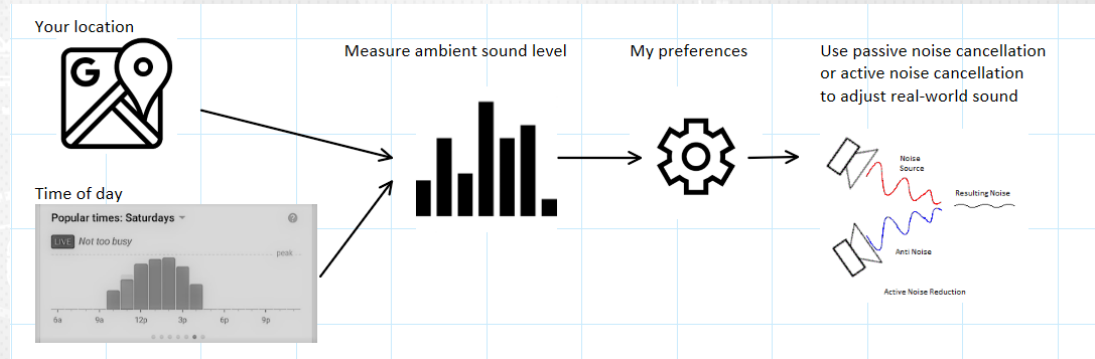
"Incorporating AI will be the next step in personalized audio"

-- Greenlight Insights: Hearables Market Analysis



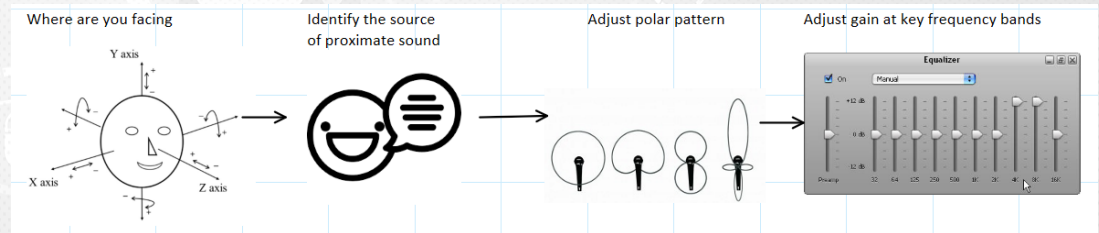
- Goal
 - Personalizing your audio experience in a given environment
- Data
 - Google Maps + Google popular times + ambient noise level
- Tech
 - Running machine-learning algorithms that identify, classify location, and monitor the audible environment
 - Adjust ambient noise using passive or active noise cancellation

Situational Responsiveness



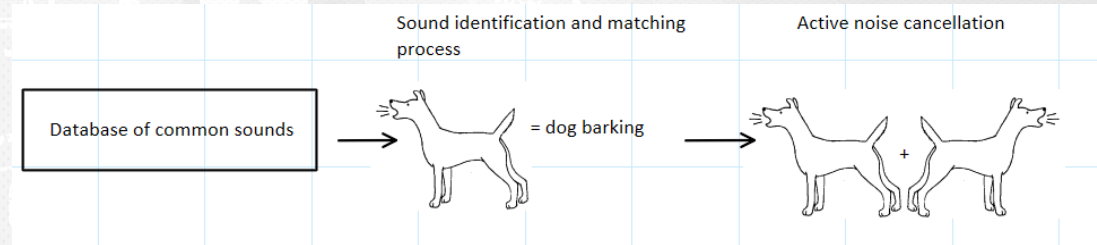
Focused Listening

- Goal
 - Enhance the "cocktail party effect": the brain's ability to focus one's auditory attention on a particular stimulus while filtering out a range of other stimuli
- Data
 - Head-tracking, voice
- Tech
 - Running machine-learning algorithms that seeks-out the human voice sound object relative to head position
 - Digital signal processing including cardioid pattern adjustment + multiband limiting
- "With the right sensors and processing on board, a hearable can tell if your head is pointed toward a store shelf in front of your face or at a billboard down the road." -- Peter Burrows, The future is ear: Why "hearables" are finally tech's next big thing



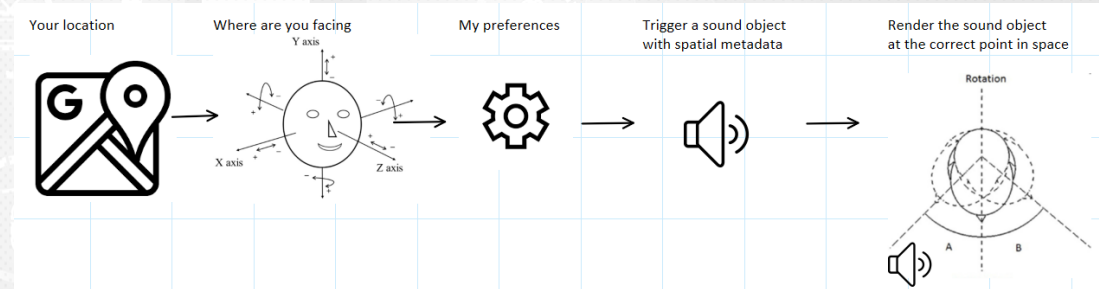
Selective Hearing

- Goal
 - Precise noise cancellation by sound category
 - Choose to filter loud, short, transients like dogs barking and jack hammers
- Data
 - Common sound database
- Tech
 - Machine learning algorithms that can accurately recognize sounds
- "If there's a jackhammer nearby, you could program your headphones to always remove that sound while keeping all other noises around you". -- Kevin Hague, VP of Technology Strategy at Harman



Virtual Objects

- Goal
 - Augmenting Google Maps and similar guides
- Data
 - Google Maps location data
- Tech
 - "Augmented Audio" -- identifying places and things and providing relevant information in real-time
 - Binaural rendering of sound objects associated with virtual places and things to provide position





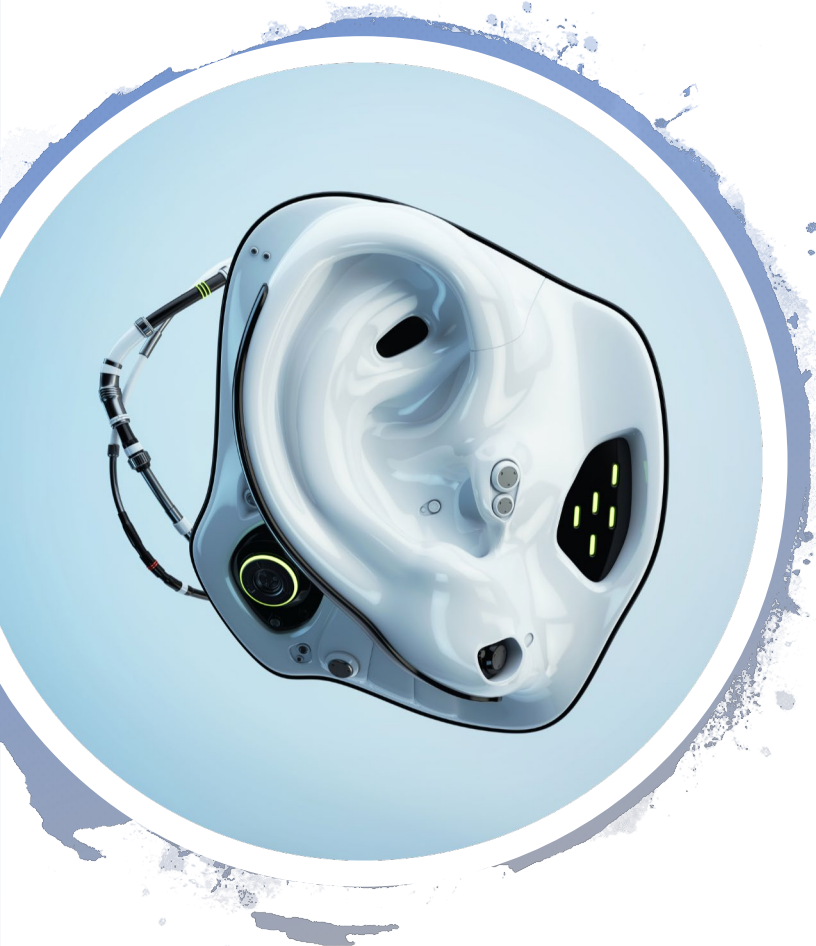
The Starkey Stunner

- Starkey is one of the leading manufacturers of hearing aid products
- Announced the Livio AI on August 27th, 2018
- Livio AI
 - Adjusts to the best listening mode for the wearer's acoustic conditions using a combination of directional microphones and machine learning algorithms
 - ML is employed to classify the wearer's listening environment
 - Relies on traditional machine learning algorithms rather than deep learning algorithms due to limited onboard computing power
- Obstacles
 - Livio AI is a hearing aid only and requires a prescription
 - Very expensive



More news

- Qualcomm introduced its first family of chips specifically for hearables in March, the XR1, and other chip companies are expected to follow by the end of the year.
- "Amazon, Apple, and Google...are working on products that combine the utility of the hearing aid with the entertainment value of a pair of high-end headphones, and potentially much more" -- *Peter Burrows, The future is ear: Why "hearables" are finally tech's next big thing.*



Challenges

- The software hurdles
 - "Consumer audio device manufacturers and hearing aid manufacturers have patents and technology that accomplish different goals, different pieces to the puzzle of the all-in-one hearable. One thing they all are lacking is software, both onboard and mobile-based, needed to make a truly smart hearable." -- Greenlight Insights: Hearables Market Analysis
- The physical hurdles
 - Particular sensitivity of the ear canal to heat presents a power scalability issue for future designs.
 - Additional sensors and features impacts battery life
 - A hearable may not be able to physically fit all required hardware
 - Processing power
- The marketing hurdle
 - Consumers do not understand what a hearable is or what it can do.



Thank you!

Questions? Comments?