Advanced Features in Earbuds and AirPods: A Literature Review (2022-2024)

Introduction

This literature review focuses on the advancements in features of earbuds and AirPods over the past two years (2022-2024). The review covers improvements in audio quality, noise cancellation, human motion sensing, and security features.

Audio Quality and Speech Enhancement

One of the primary areas of advancement has been in improving audio quality and speech enhancement. Chatterjee et al. (2022) introduced ClearBuds, a system using a neural network to enhance speech streamed from wireless earbuds, with a synchronized binaural microphone array and a lightweight dual-channel speech enhancement neural network running on a mobile device [1]. This system notably reduces artifacts in the audio output. Apple's AirPods Pro 2 also features the H2 chip, designed to communicate at high speed to unlock a revolutionary new format rendering pure, uncompressed sound in real time [5].

Active Noise Cancellation and Hearing Health

Active Noise Cancellation (ANC) remains a key area of focus. Apple has introduced a hearing health experience with AirPods Pro 2, indicating ongoing development in integrating health-related features into earbuds [2].

Human Motion Sensing

Earbuds are evolving into wearable platforms for personal-scale human motion sensing. Ma et al. (2021) proposed OESense, an acoustic-based in-ear system that utilizes the occlusion effect and an inward-facing microphone for general human motion sensing. This system has been shown to reliably detect both intense and light motions, with applications in step counting, activity recognition, and hand-to-face gesture interaction [4].

Security Features

With the increasing use of voice assistants, security has become a crucial aspect. Huang et al. (2023) introduced AirBone authentication for head-wearable smart voice assistants, focusing on the coupling of air and bone conduction from the same vocalization for multi-factor authentication. This approach aims to defend against voice spoofing attacks by leveraging the unique bone conduction features of a user's voice [3].

Other Considerations

While advancements are being made, degradation of earbuds is a concern. Beveridge et al. (2020) investigated the degradation effects of water immersion on earbud audio quality, finding significant degradation in terms of RMS noise loudness, Total Harmonic Distortion (THD), and changes in frequency responses after laundering [6].

Conclusion

The past two years have seen significant advancements in earbud and AirPod technology, with improvements spanning audio quality, noise cancellation, human motion sensing, and security. These advancements aim to enhance user experience, improve health monitoring capabilities, and provide more secure interactions with voice assistants.

References

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