Design Thought

Developing a specialized headset for shooting and target practice, which can effectively isolate the loud noise of gunshots while amplifying other relevant sounds (such as human voices), is feasible. The following is a potential solution that combines Active Noise Cancellation (ANC) technology, passive noise reduction, ambient sound enhancement, and shooting noise detection and suppression technologies.

1. Passive noise reduction design

Material selection and design  
  
Earmuff design: Earmuffs made of high-density foam and sound-isolating materials completely cover the ears, forming a physical barrier to effectively isolate external noise.  
  
Sealing: Ensure that the earmuffs fit tightly against the head to reduce noise leakage.

1. Active Noise Cancellation (ANC)

Technical principles & implementation steps

1. Environmental noise monitoring  
  
Microphone: High-sensitivity microphones are installed inside and outside the earmuffs to capture environmental noise in real time  
  
Digital signal processor (DSP): Use high-performance DSP to process noise signals collected by the microphone  
  
2. Noise analysis  
  
Signal analysis: DSP analyzes the frequency, phase and amplitude of noise signals  
  
Noise model: Generate a noise model based on the analysis results to identify and track noise changes  
  
3. Generate anti-phase sound waves  
  
Phase reversal: DSP generates sound waves with opposite phases to the noise signal  
  
Sound wave output: Play anti-phase sound waves through the speaker of the headset to interfere with environmental noise to achieve noise reduction effect

3. Ambient sound enhancement technology

Ambient Microphone  
  
High-Sensitivity Microphone: Multiple high-sensitivity microphones are installed on the outside of the headset to capture ambient sound and human voice.  
  
Digital Signal Processing (DSP)  
  
Speech Enhancement: Use digital signal processing technology to distinguish and enhance human voices while suppressing environmental noise. Machine learning algorithms can be used to train models to more accurately identify and enhance human voices.  
  
Volume Control: By adjusting the volume, the enhanced human voice is transmitted to the inside of the headset so that the user can hear it clearly.

4. Shooting sound detection and suppression

Shooting sound detection and suppression  
  
Shooting sound is a high-decibel, transient noise that requires a fast-response noise reduction mechanism  
  
1. Shooting sound detection  
  
Fast response microphone: The microphone installed on the outside of the earmuff monitors the ambient noise in real time, especially the high-decibel, transient shooting sound  
  
Signal processing: The DSP processes the signal collected by the microphone in real time and uses algorithms to quickly identify the characteristics of shooting sound (such as high decibel, short-time pulse)  
  
2. Shooting sound recognition  
  
Pattern recognition algorithm: Use machine learning algorithms (such as convolutional neural networks) to train the model and identify the characteristics of shooting sound  
  
Real-time analysis: After receiving the noise signal, the DSP immediately analyzes and identifies whether it is a shooting sound  
  
3. Generate anti-phase sound waves  
  
Transient noise suppression: At the moment when the shooting sound is recognized, the DSP generates a sound wave with the opposite phase to the shooting sound  
  
Fast response: The high processing speed of the DSP ensures that the anti-phase sound wave is generated and played in a very short time (within a few milliseconds)  
  
4. Output sound waves  
  
Speaker playback: Play the anti-phase sound wave through the internal speaker of the headset to interfere with and offset the shooting sound

Specific steps for DSP implementation  
  
  
Hardware architecture  
Microphone array: multiple high-sensitivity microphones capture ambient sound  
Analog-to-digital converter (ADC): converts the analog signal of the microphone into a digital signal  
DSP chip: high-performance DSP chip for signal processing  
Digital-to-analog converter (DAC): converts the processed digital signal into an analog signal  
Speaker: plays inverted sound waves to achieve noise reduction  
  
Software architecture  
Signal acquisition module: responsible for collecting digital signals from microphones  
Feature extraction module: extracts features from audio signals (such as MFCC, spectrum graph)  
Shooting sound recognition module: uses CNN model to recognize shooting sounds  
Inverted sound wave generation module: generates sound waves with opposite phase to the shooting sound  
Audio output module: outputs inverted sound waves through DAC and speakers

TEST/MAKING

Data preparation  
  
Data collection: Record a large number of audio samples of shooting and non-shooting sounds

Data preprocessing: Divide the audio samples into frames and extract MFCC or spectrogram features

1. Shooting sound recognition  
     
   2.1 Pattern recognition algorithm  
     
   Data preparation  
   Data collection: Collect a large number of audio samples of shooting and non-shooting sounds  
   Data preprocessing: Divide the audio samples into frames and extract features (such as MFCC, spectrogram)  
   Model training  
   Model selection: Use convolutional neural network (CNN) for shooting sound feature recognition  
   Training data: Input the preprocessed audio features into CNN for training  
     
   2.2 Real-time analysis  
     
   Real-time processing: Extract the features of the real-time audio signal and input it into the trained CNN model for classification to identify whether it is a shooting sound
2. Generate inverted sound waves  
     
   3.1 Transient noise suppression  
     
   Generate inverted sound waves: At the moment the sound of a gunshot is recognized, the DSP generates a sound wave with a phase opposite to that of the gunshot  
     
   Output sound waves: Converted to analog signals through a digital-to-analog converter (DAC) and played through the headphone speakers  
     
   3.2 Fast response  
     
   High processing speed: The high processing speed of the DSP ensures that the inverted sound waves are generated and played within a few milliseconds to achieve transient noise suppression

Python code demonstrating how to use a convolutional neural network (CNN) to train a model for gunfire detection