Use of Passive Hearing Protectors and Adaptive Noise Reduction for Field Recording of Otoacoustic Emissions in Industrial Noise

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Hearing Health
Monitoring Earplug
Objectives of my presentation:

• **Inform** hearing conservationists about available technologies for hearing health monitoring

• **Motivate** hearing conservationists to request manufacturers for such technologies

• **Invite** manufacturers to offer such advanced hearing protection devices
Outline

• Motivation
• Proposed approach
• Methodology
• Research problem
• Developed system
• Experimental validation
• Results
• Conclusions
Motivation

Despite all our efforts...

...hearing loss is still a major occupational issue
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Proposed Approach

What is the best way to prevent hearing loss?

Traditional answer
Limiting noise exposure!

a) Noise control at the source
b) Administrative means (limit duration)
c) Hearing protection

Our proposed approach
Use of a hearing protector that continuously monitor’s the hearing health status of each individual
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Methodology

Continuous monitoring of hearing health

OAE monitoring system will measure the worker’s hearing health with distortion product OAEs (DPOAEs) daily.
Methodology

Use of a hearing protector that continuously monitors the hearing health status of each individual

Measurement of distortion product otoacoustic emissions (DPOAEs) to quickly and objectively detect hearing damage.
Many clinical systems exist, but only a few have an external microphone to reduce the ambient noise in the DPOAE signal.
Methodology

Hearing protection

Custom molded OAE probe providing high passive attenuation
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Research problem

Otoacoustic emissions are very sensitive to background noise.

Could adaptive noise reduction algorithm (ANR) reduce physiological and ambient noise enough to measure DPOAEs in a loud environment?
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Loud External Noise

OAE probe transfer function
$H(z)$

Tested ear DPOAE probe
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Validation

• Tests conducted
  • in double-wall audiometric booth;
  • on 8 otologically normal human subjects;

• Comparison with a clinical reference system;
  • in quiet conditions;
  • against Otodynamics ILO DPEchoport

• DPOAE Measurements
  • with white noise, condition [W70]
  • with industrial noise fragments (NOISEX database)
  • at 3 different sound pressure levels
    • 65dB(A), condition [I65]
    • 70dB(A), condition [I70]
    • 75dB(A), condition [I75]
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• Results
• Conclusions
Results in silence
Results at 70dB(A) 
no ANR
Results at 70dB(A)
Results

Effect on signal

Effect on noise

<table>
<thead>
<tr>
<th>ANR ON</th>
<th>ANR OFF</th>
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<tbody>
<tr>
<td>DP Signal (dB)</td>
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<td>I65</td>
<td>I70</td>
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Background noise condition
Conclusions

• A prototype of a hearing protector that continuously monitors the hearing health status was successfully developed.

• The developed noise reduction algorithm can reduce physiological as well as ambient noise.

• Conducted tests have shown that it is possible to measure DPOAEs in environments with ambient noise levels up to 75dB(A).
Future work

• Real world validation on a larger group;

• Automatically warn the wearer when a DPOAE shift is detected;

• Integration of an in-ear dosimeter to link the noise exposure to the auditory fatigue and assess personal exposure limit;

• Warn the wearer when he has reached his personal exposure limit.
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