Sonar-Based Measurement of User Attention

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We show how a laptop computer can use its audio hardware to determine whether or not a computer user is present without relying on mouse and keyboard activity.

**Ultrasonic Sonar**

Speaker continuously emits an inaudible 20kHz sine wave.

**Motivation**

For power-management, security, etc., the OS wants to know whether a user is present.
- Input inactivity can reliably indicate user absence only after a very long timeout period.
- Webcam surveillance can be faster, but is potentially costly and unreliable.

**Hypothesis:** sonar measurements will be much higher when user is passively engaged versus when user is absent.

**Echo Signal Processing**

Sonar recordings are processed as follows:

- **Windowing:** Break the recording into a series of 100 millisecond windows.

- **Echo intensity:** In each window, calculate energy at 20 kHz. Assume all of this energy represents sonar echoes. This gives a series of echo intensities: \( e_i \)

- **Echo delta:** Calculate the average absolute difference in the sequence of echo intensities:

\[
\Delta_e(e_1...e_N) = \frac{1}{N} \sum_{i=1}^{N-1} |e_{i+1} - e_i|
\]

**User Study**

Purpose was to test the correlation between user state and sonar echo delta. Sonar measurements were taken while twenty paid volunteers were guided through the following attention states:

<table>
<thead>
<tr>
<th>state</th>
<th>definition</th>
<th>user study task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>using the keyboard or mouse</td>
<td>typing a document</td>
</tr>
<tr>
<td>Passively engaged</td>
<td>reading the computer screen</td>
<td>watching a video</td>
</tr>
<tr>
<td>Disengaged</td>
<td>sitting in front of the computer, facing away</td>
<td>using telephone beside computer</td>
</tr>
<tr>
<td>Distant</td>
<td>in room, but moved away from the computer</td>
<td>completing a puzzle on desk nearby</td>
</tr>
<tr>
<td>Absent</td>
<td>left the room</td>
<td>after the participant left</td>
</tr>
</tbody>
</table>

**Results**

- **Absent and passively engaged user states are easily distinguished by echo delta measurements using recordings as short as 10 seconds long, so presence detection is enabled by sonar.**

**Conclusion**

For details: [http://empathicsystems.org](http://empathicsystems.org) and Technical Report NWU-EECS-09-06, Department of Electrical Engineering and Computer Science, Northwestern University, April 2009.

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