People Metering Using Mobile Devices

Yehoraz Kasher Annual EE Projects Contest

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Outline

• People metering
• People metering using mobile devices
• Algorithm description
• Our innovations
• Conclusion
Rating Measurement

- Fast growing advertising market
- Based on rating data

"People Meter" - Drawbacks:
  - Designated hardware
  - Small control group
  - Hard to know who is watching what
People Metering Using Mobile Devices

Query Fingerprint Creation

Reference Fingerprint Creation

Matching

Matched Channel / No Match
People Metering Using Mobile Devices

- As suggested by MobileRL
  - Overcomes all "People Meter" drawbacks
  - Carried everywhere
  - Can also be used to monitor radio, video, music etc.

But -

Privacy must be kept
Based on "Waveprint" algorithm by
(Baluja & Covell, 2006)

System Layout

Fingerprint Creation

Fingerprints

Matching

Extracting significant data

Matched channel / No match
Wavelet Transform

Good for pointing out local data in images

Haar Wavelet Transform

Keeping strongest coefficients

Sparse Binary Vector

Min Hash Vector (p elements)

Sub-Fingerprint #1

Sub-Fingerprint #2

Sub-Fingerprint #3

Spectrogram

Fingerprint Creation

Fingerprint

Spectrogram creation

Spectrogram

Time

Frequency
Fingerprint Matching

Candidate Sub-Fingerprint Selection

Matching

Best Match
"Waveprint" Performance

System performance -

As described in the paper

However our problem is more difficult…

• Matching criterion is required
• Recordings in a noisy environment
Threshold Criterion - Metrics

Precision & Recall (per match grade threshold)

<table>
<thead>
<tr>
<th>Metric</th>
<th>True Identification</th>
<th>All Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision</td>
<td></td>
<td></td>
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<tr>
<td>Recall</td>
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</tbody>
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Datasets by

Two query types:

- Good Quality recordings
- Bad Quality recordings
Original Algorithm Results

Recall = 65%  
Precision = 78%

Recall = 13%  
Precision = 96%

Recall = 65%  
Precision = 78%

Bad recordings
Good recordings
Problem:

Bad recordings - very low success rate

Let's have a closer look...
Success Rates Problem

• Main problem appears in “bad recordings”
Proposed Solution

Biasing the wavelet picking

Strongest wavelets picking histogram

- Frequency dimension
- Time dimension

Percent

DC  Freq.  Time  Time/Freq.
After Weighted Wavelet Picking

Good Recordings

Recall=90%
Precision=97%

Recall=65%
Precision=78%
After Weighted Wavelet Picking
Bad Recordings

Recall=13%
Precision=96%

Recall=49%
Precision=99%
Matching Criterion

Recurrence check
Demanding consistent matches in a sequence of queries

Advantages
• Increases success rates
• Overcomes sporadic noise

\[ P_{true} = 93\% \quad P_{false} = 0.9\% \]

For bad recordings!

But…

Increases size of sent data
Reducing Signature Size – 1\textsuperscript{st} Solution

Google’s problem: Database Size  
Our problem: Sent Data Size

Adapting system parameters to our problem

Sent query size $\times 0.1$

Reducing Signature Size – 2\textsuperscript{nd} Solution

Golomb-Rice coding (Golomb & Solomon, 1966)

Cumulative Distribution Function

~20\% Compression
Conclusion

Implemented a people metering system using mobile devices

– Personal

– Carried everywhere

– Not only TV
Conclusion

Based on "Waveprint" algorithm by Google

Innovation #1
- Biasing the wavelet picking
  - Match rates $\times 3$

Innovation #2
- Recurrence check
  - Match rates $\uparrow \uparrow \uparrow$
Conclusion

Innovation #3
Reducing sent fingerprint size

Innovation #4
Compressing sent data

Single signature size:

13.24 KB → 1.32 KB → 1.06 KB

Sent data size × ~0.08
Conclusion

• System is suitable for commercial use
  
  For example:

  \[ P_{\text{true}} = 90\%, \quad P_{\text{false}} = 0.9\%, \quad E[\text{sent size}] = \sim 9\text{KB} \]

• Supplied to MobileRL

• A paper in the writing
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Thank You!