CS5248: Systems support for continuous media

Content-based UEP: A new Scheme for Packet loss Recovery in Music Streaming

Guest Lecturer:

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Content

- Motivation for research on error resilient audio streaming
  - Source coding and channel characteristics
  - Methods for increased error robustness
  - Why new methods are needed
- Content-based UEP (C-UEP) scheme
  - Concept: Combination of FEC and error concealment
    - Audio segmentation, classification and prioritization
  - System implementation
    - Sender side
    - Receiver side
- Performance evaluation
- Discussion and conclusion

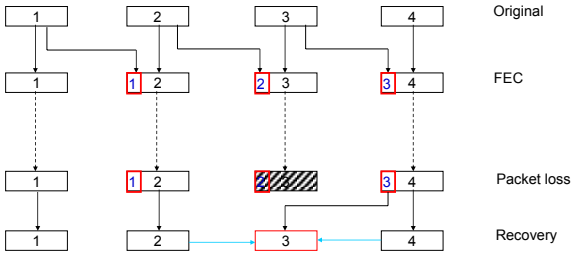
Motivations

- Mismatch between source coding and channel characteristics
  - Most existing audio codec are not designed for packet switched network transmission
  - Internet is not designed for delivery of continuous media
- Packet loss inevitable in IP+wireless networks
- Existing methods do not provide satisfactory solutions
- New methods are needed

Challenges to Existing Methods

- Sender-based methods (FEC, UEP)
  - Must balance between redundancy and QoS
- Network-based methods (retransmission, packetization)
  - Must consider system latency and availability of feedback channel
- Receiver-based methods (error concealment)
  - Effective only if
    - Packet loss is infrequent
    - Packet size is small
    - Signal is quasi-stationary

Error recovery using a Secondary Bitstream (FEC)



Limitation of the current FEC and a new Solution

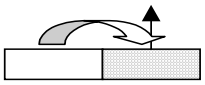
- Unnecessarily high redundancy
  - Don't use correlation between neighboring packets effectively
- Mismatch between primary and secondary coders
  - Characteristics of Modified Discrete Cosine Transform (MDCT)
  - Frame size constraints
- Solution: a good combination of FEC and concealment

Characteristics of Music Signals

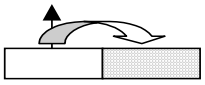
- Basic attributes of music signals
  - Beat (timing)
    - Double-beat and beat elimination
  - Pitch contour
    - Pitch contour disruption
  - Timbre
    - Piecewise homogenous texture
- Critical parts in music - transients

Drumbeat Elimination & Double-Drumbeat

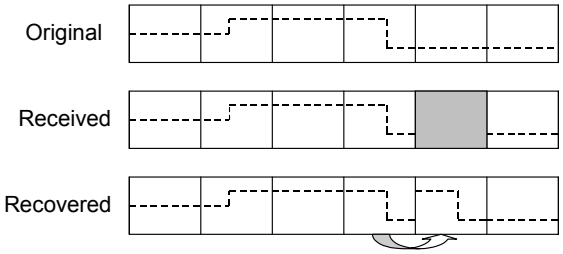
(a)



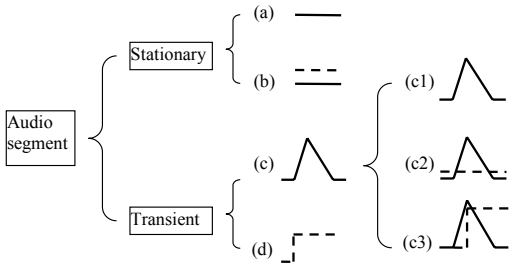
(b)



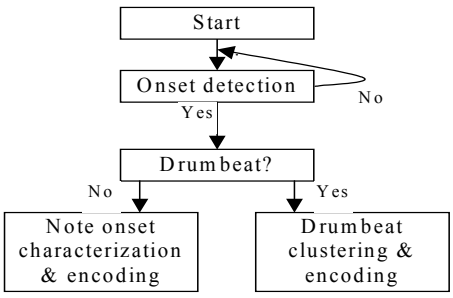
Pitch Contour Disruption



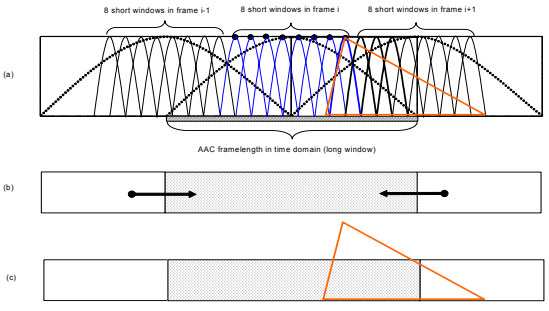
Music Segmentation and Classification (Concept)



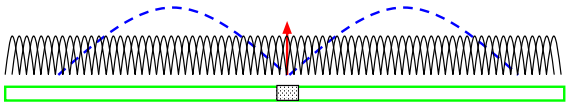
Onset Detection, Classification and Encoding (Block Diagram)



Onset Detection with sub-AAC Frame Accuracy

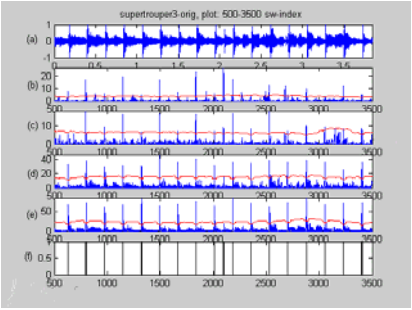


Onset Detection (Window and Threshold)

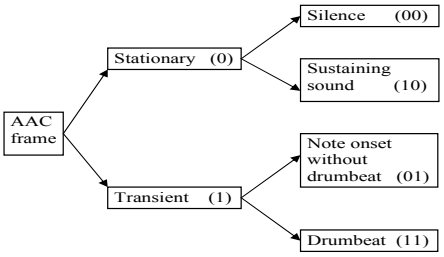


$$F_{thr} = m + k \cdot std + C$$

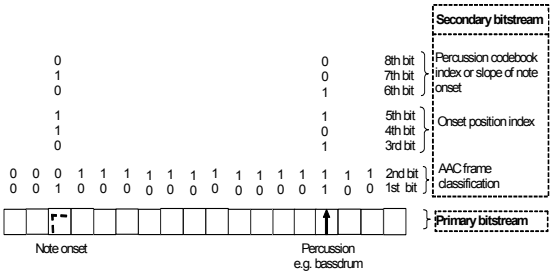
Onset detection (Wave, Feature and Threshold)



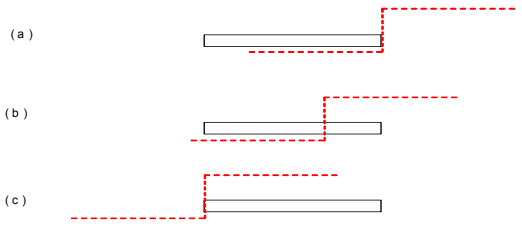
Pre-classification of an AAC frame



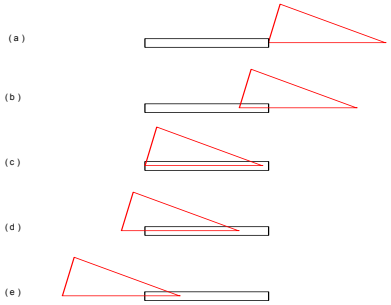
Data Structure of the Secondary Bitstream



The lost Packet Relative to the Note Onset



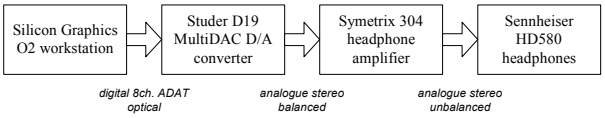
The lost Packet Relative to the Drumbeat



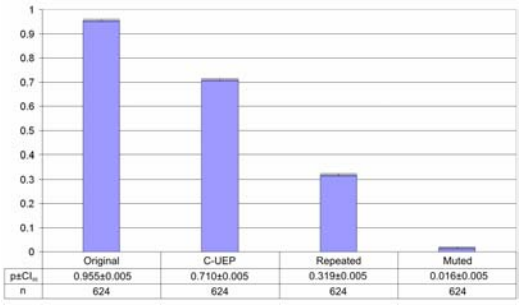
Test Samples

Programme	Time signature	Tempo (qpm)	Description
Slow Rock	4/4	81	Distorted guitar, bass, piano and drums wt melodic instruments sustaining held chord. Dynamics dominated by drums. No vocals.
Dance	4/4	123	Electronic dance music with prominent female vocal through entire programme. Consistent “disco” type bass drum on every beat.
Prog. Rock	9/8	112*	Progressive rock with drums playing polyrhythms with unconventional use of accented individual drums. No vocals.
Country	4/4	120	Prominent strummed acoustic guitar, female vocals and laptop slide guitar. Guiro is also played throughout with drums less prominent
* Specified tempo is equivalent quarter note tempo			

Audio Signal Chain for Presentation of Test Stimuli



Averaged Proportions for Streaming Scenarios



	Original	C-UEP	Repeated	Muted
$p \pm CI_{95}$	0.955±0.005	0.710±0.005	0.319±0.005	0.016±0.005
n	624	624	624	624

Discussions

- Strength, weakness and possible improvements
  - Improved utilization of the bandwidth
    - Possibility for further improvement
    - Suitable for multicast
    - Scalability
  - Not suitable for two-way real-time communications
    - Prioritization scheme needs to be studied further
- Generalized C-UEP
  - Audio-visual streaming example

Conclusion

- The proposed content-based unequal error protection (C-UEP) is effective in music streaming scenario
- Useful to exploit characteristics of music signals
- The combination of FEC and receiver-based error concealment seems to be a suitable strategy for streaming music over Internet and wireless channels

References

- Wang, Y., Ahmaniemi, A., Isherwood, D., Huang, W., "Content-based UEP: A new Scheme for Packet Loss Recovery in Music Streaming," ACM International Conference on Multimedia, November 2-8, 2003, Berkeley, California, USA
- Wah, B.W., Su, X. and Lin, D., "A Survey of Error Concealment Schemes for Real-time Audio and Video Transmissions over the Internet," IEEE International Symposium on Multimedia Software Engineering, Taipei, Taiwan, pp.17-24, Dec. 2000
- Perkins, C., Hodson, O., Hardman, V., "A Survey of Packet Loss Recovery Techniques for Streaming Audio," IEEE Network, pp.40-48, Sept/Oct, 1998