

MELPe Speech Compression using Bit-plane based Arithmetic Coding

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Overview

- MELPe Speech Coding
 - LPC modeling
 - Vector Quantization of LSP
- Arithmetic Coding of LSP
 - DCT Transform
 - Bit Plane Quantization
 - Arithmetic Coding
 - Results
- Future work and Improvements

MELPe

- Low bit-rate LPC based coder

2.4 or 1.2 Kbps

D.o.D. Standard

Mixed pulse and noise excitation

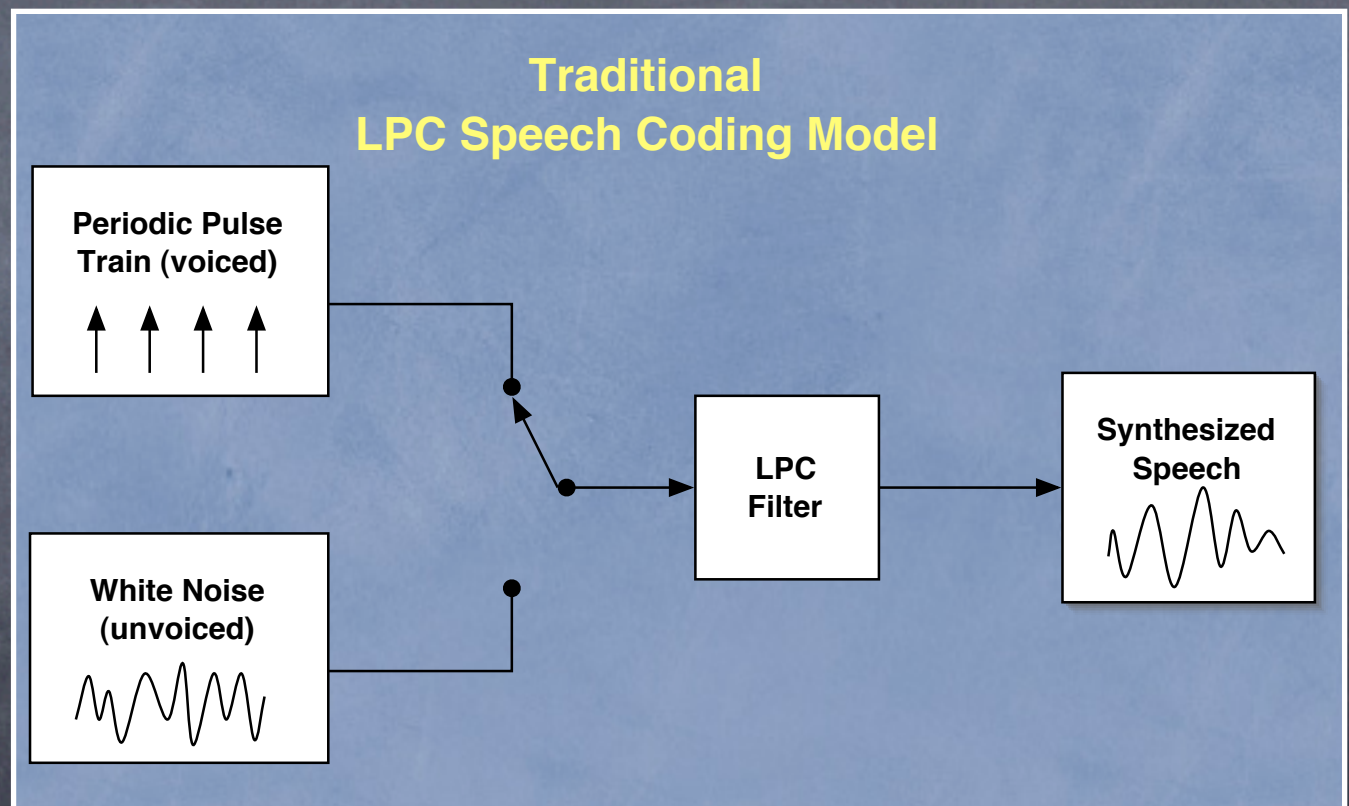
Noise Pre-processing

 Original

 MELPe 2.4 Kbps

Linear Predictive Coding

- Analysis / Synthesis Technique over a window of speech (22.5 ms)
- Models vocal tract with a filter
- Excite filter with pulse train (voiced) or white noise (unvoiced)




Parameter Bit Allocation

- Line Spectral Pairs

A form of prediction coefficient. Strong correlation, usually 10 parameters per frame

- Excitation Signal

Voiced / Unvoiced decision, Pitch Period Estimation



Parameter	Voiced	Unvoiced
Line Spectral Pairs	25	25
Fourier Magnitude	8	-
Gain	8	8
Pitch	7	7
Bandpass Voicing	4	-
Aperiodic	1	-
Error Protection	-	13
Sync	1	1
TOTAL / Frame	54	54

Vector Quantization

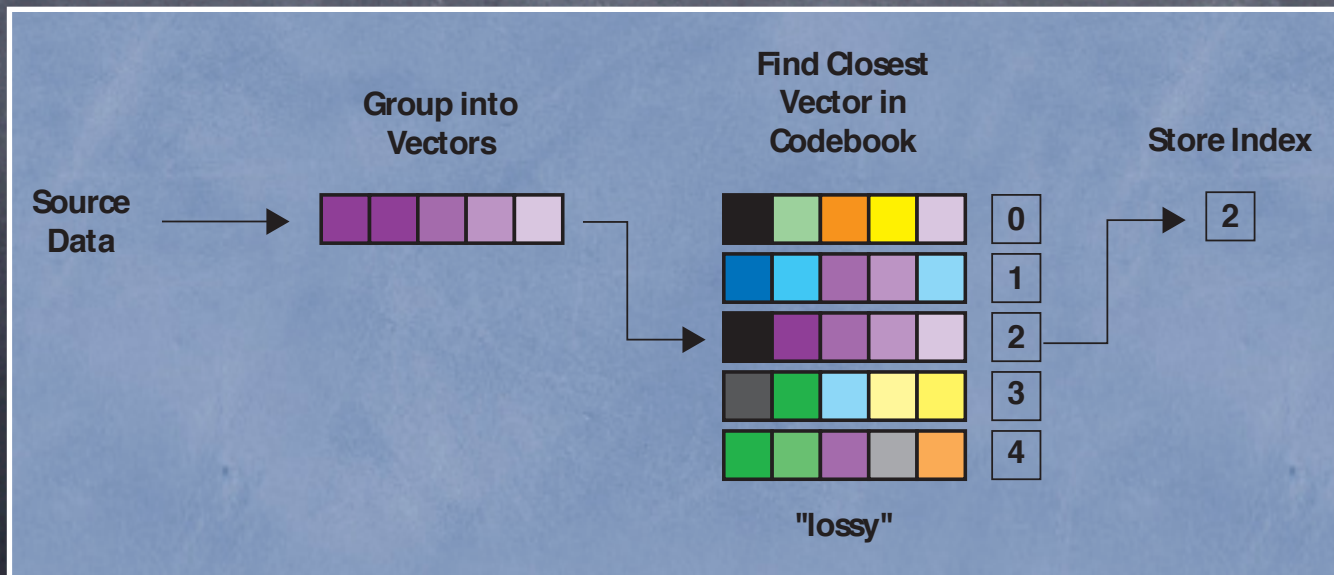
- MELPe uses vector quantization to code LSP and Fourier magnitudes

- VQ Groups parameters to be coded into "vectors"

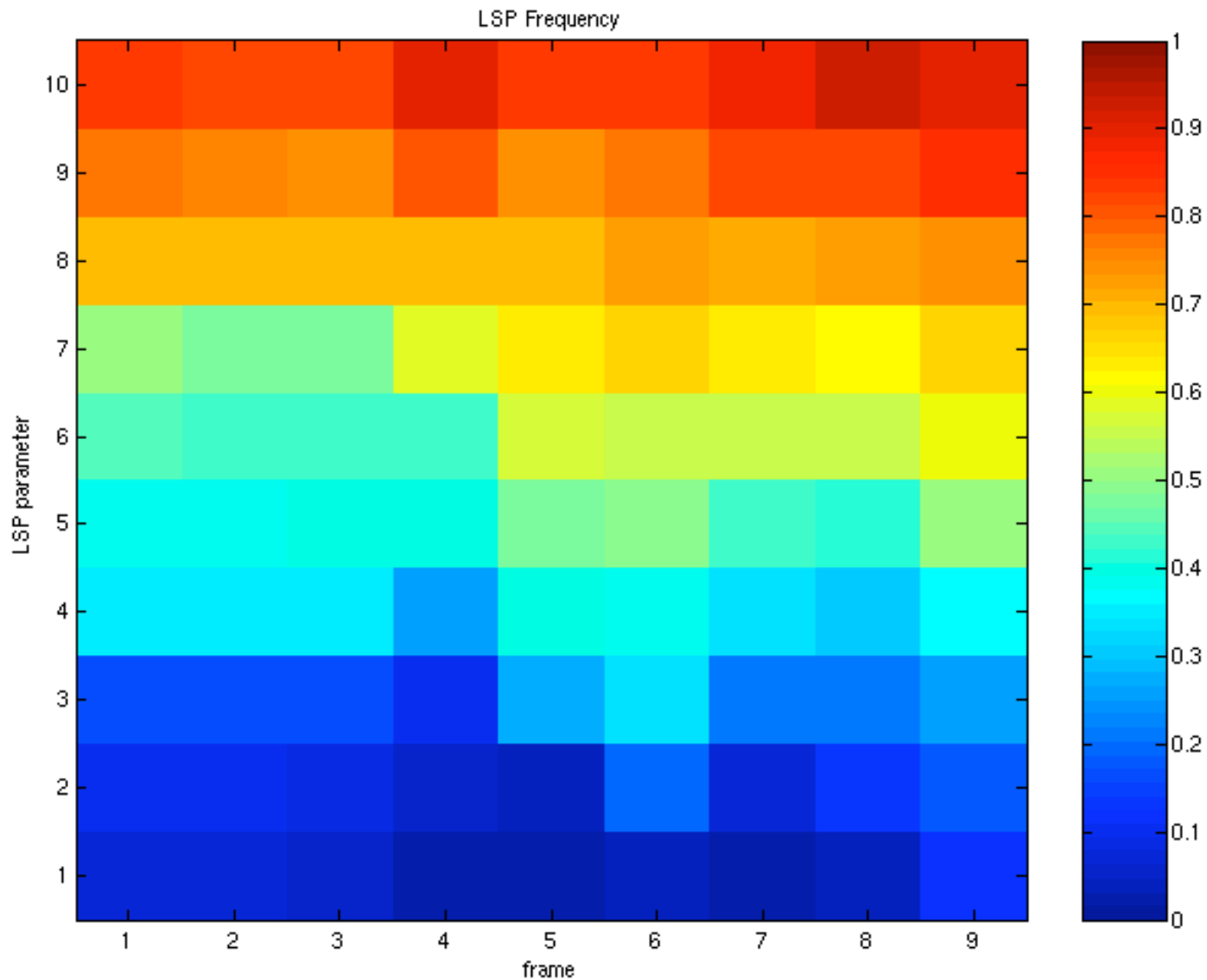
Create a codebook of representative vectors

Encode a vector by finding closest codebook entry

Store / send codebook index

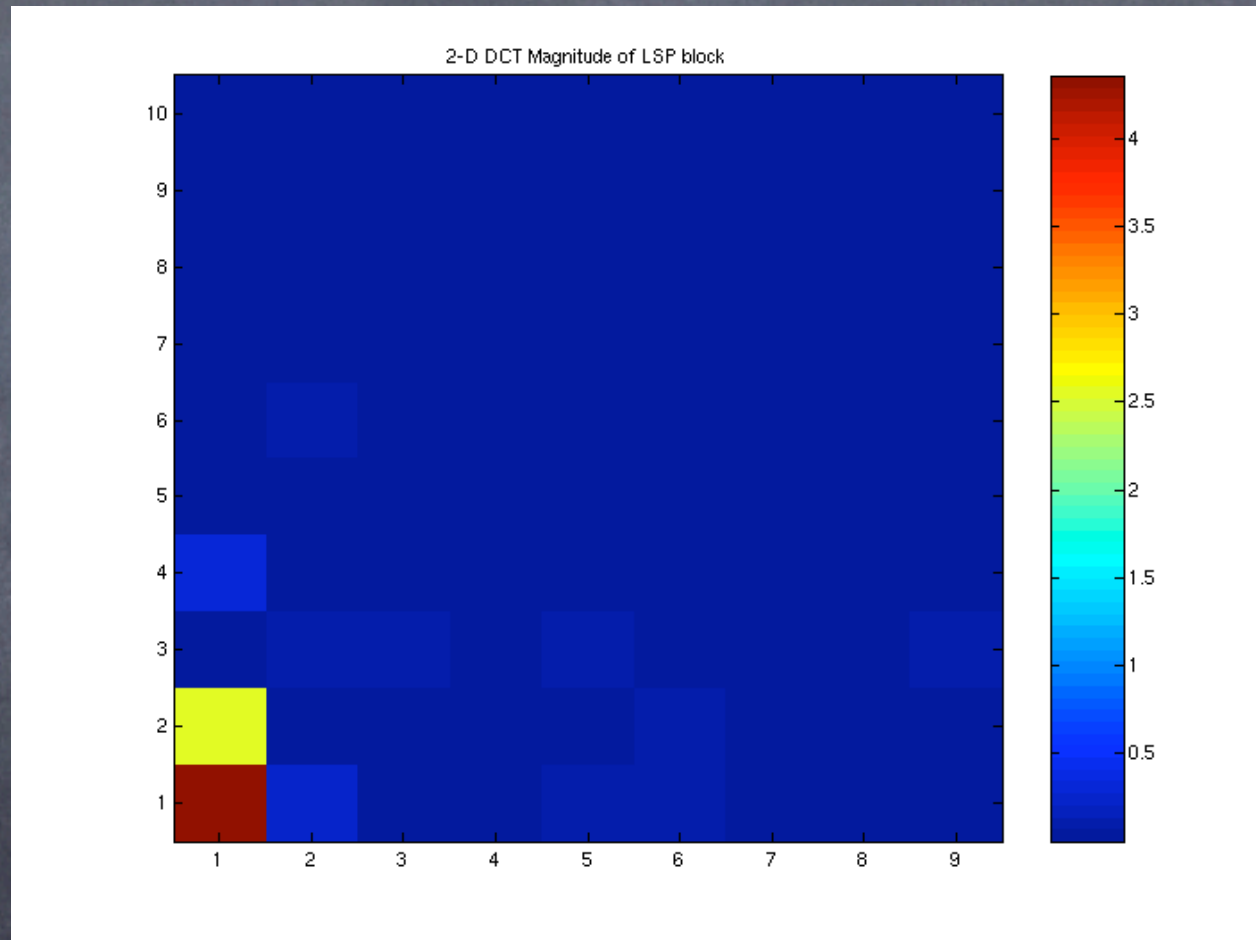


LSP Example

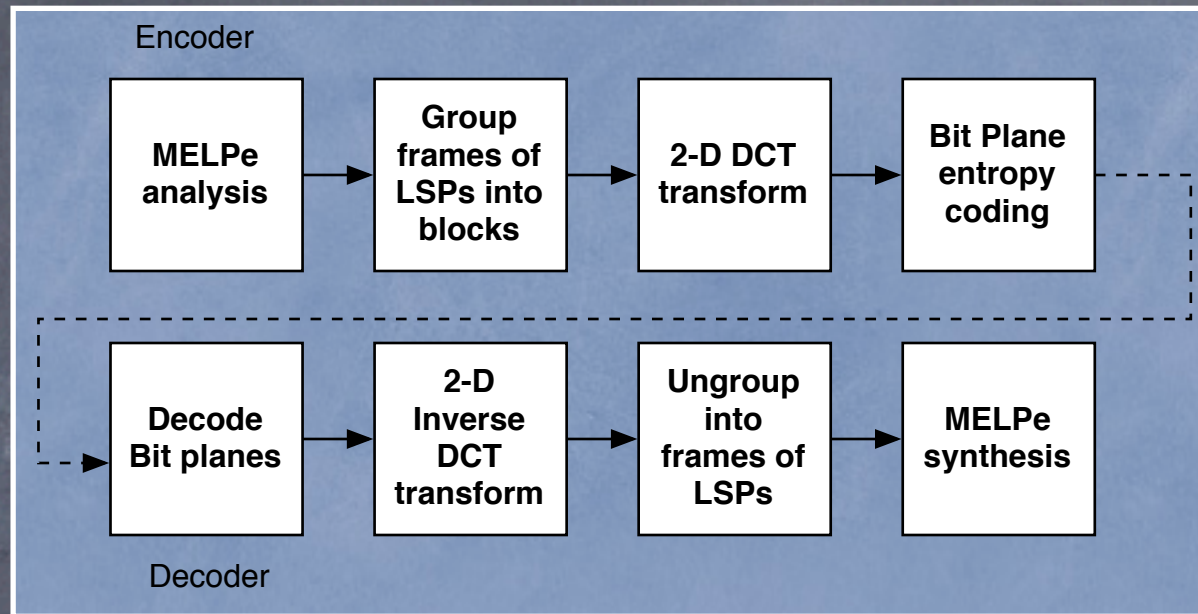


2-D DCT of LSP

- Invertible (one to one, onto)
- Discrete Cosine Transform provides energy compaction
- Most of the coefficients are approximately zero



New Coder Diagram



- Group frames of LSP parameters into a block
- Transform block with 2-D DCT
- Quantize with bit plane coding
- Perform lossless compression on bit planes with arithmetic coder

Bit Planes

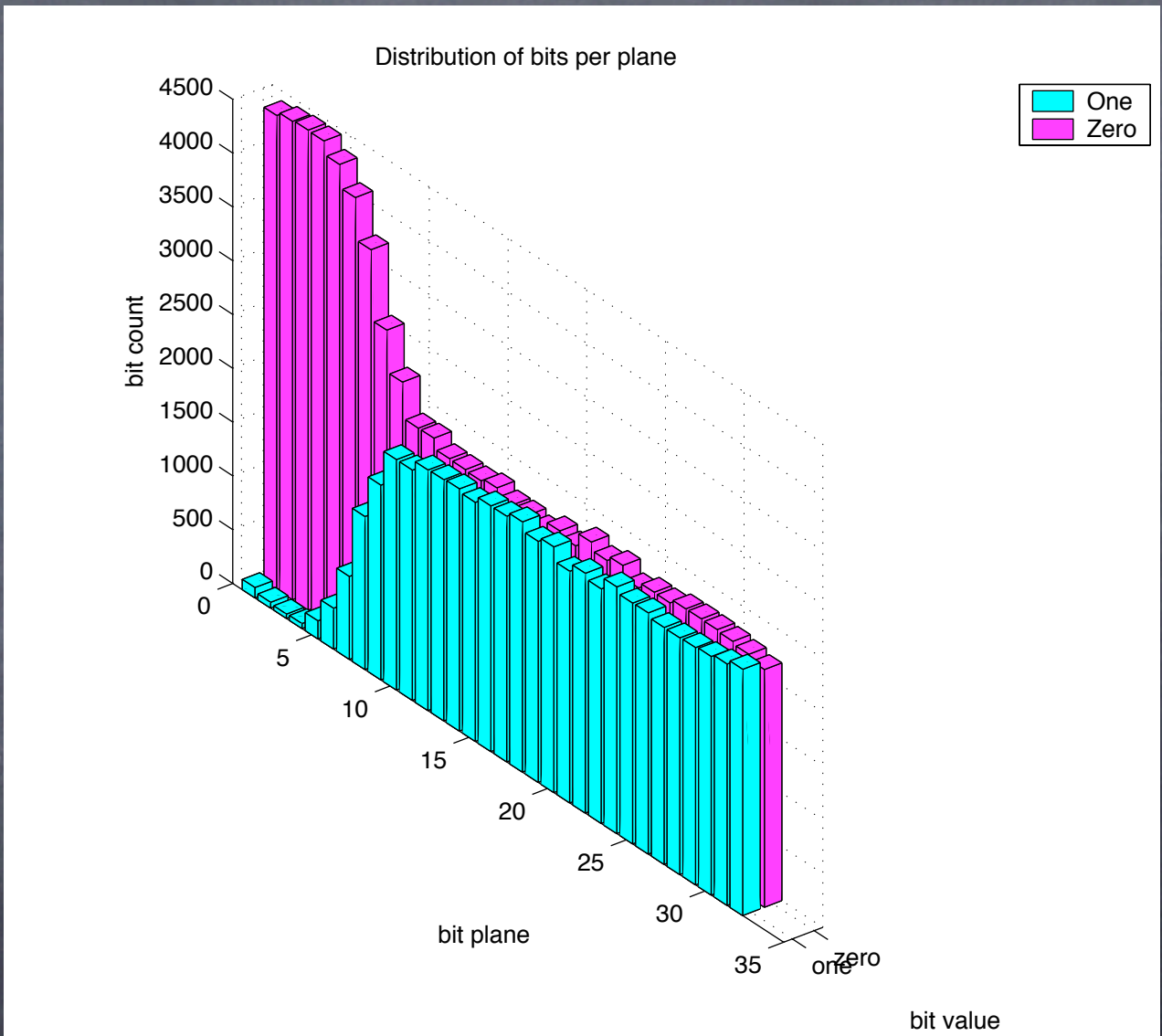
- A method to quantize the coefficients to be compressed
- Allows for a progressive encoder / decoder
- Allows a variable bit rate, more bits for hard to code frames.
- Truncation at a particular bit plane favors larger coefficients

Bit Plane 3

Coefficient 1	1	0	0	1	1	1	1	0
Coefficient 2	0	0	1	0	1	1	0	1
Coefficient 3	0	0	0	0	1	0	1	0
Coefficient 4	0	1	0	0	0	1	0	1
Coefficient 5	0	0	1	0	1	1	1	0

Bit Plane coding

Early bit planes have a biased distribution suggesting that resulting bit-stream can be coded further



Arithmetic Coding

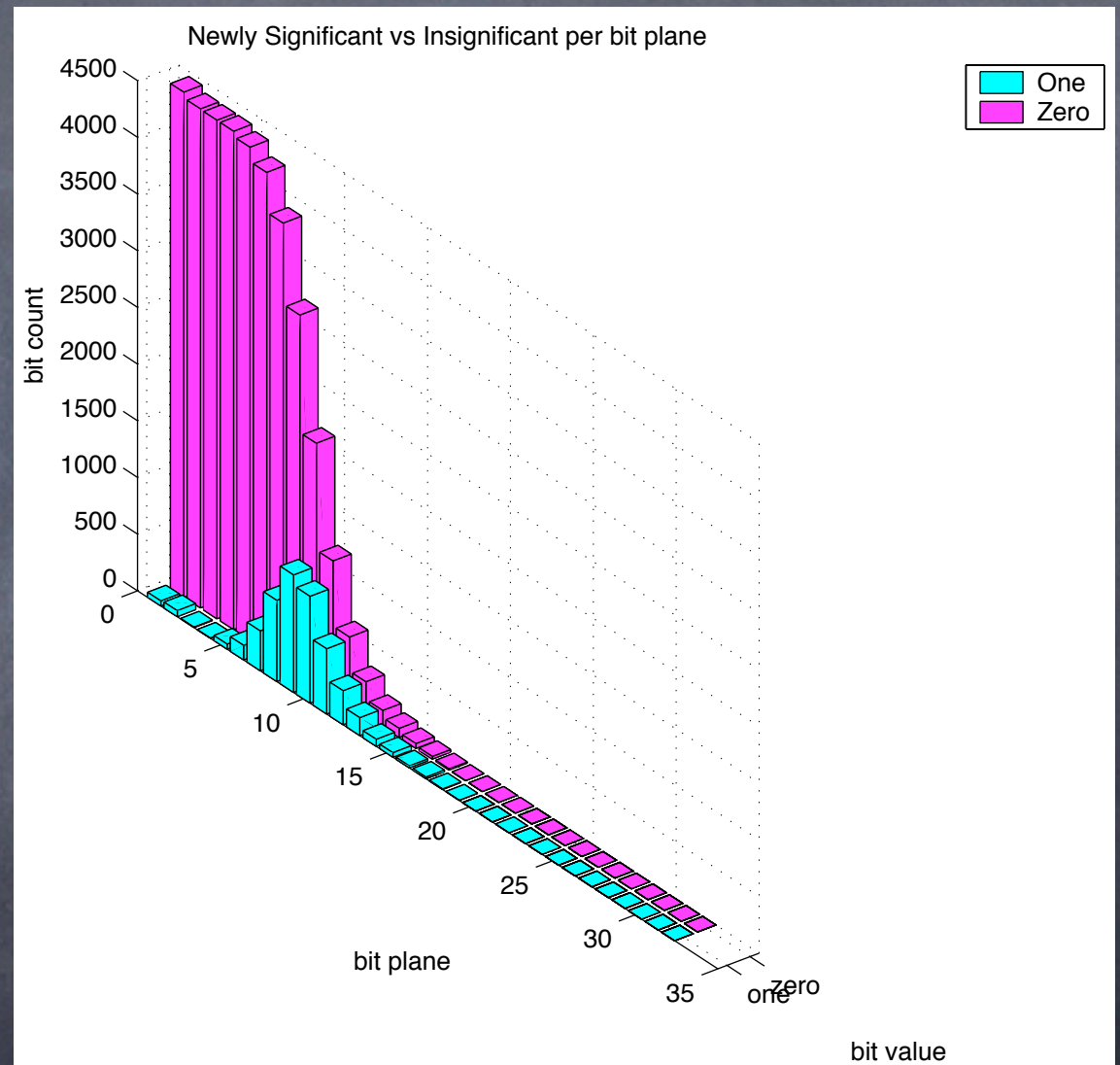
- Codes one bit at a time
- Relies on statistics to compress well
- Fewer bits for more probable symbols or sequences
- Statistics can adapt over time

Advantages of Arithmetic Coding with Bit-planes

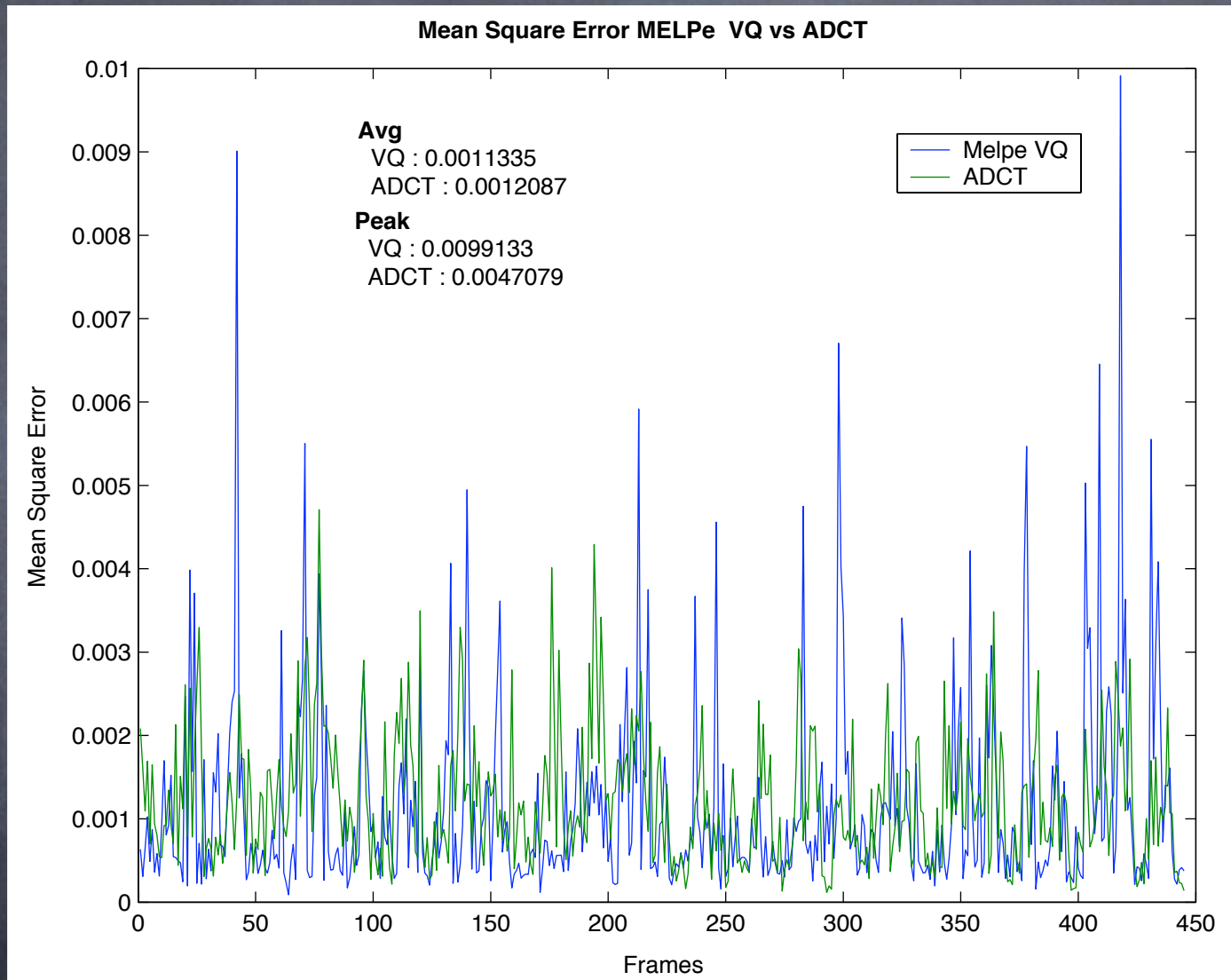
- Our technique allows for progressive transmission, while MELPe currently is fixed
- Does not require training, can adjust to characteristics of different languages.
- Arithmetic coding with bit-plane quantization has been shown better than VQ techniques in other coding applications

Better Context

- For good results, an arithmetic coder needs accurate statistics and contexts that bias the distribution of bits
- For example, distribution of bits in a bit plane for coefficients that are not yet significant is different than for those that are significant



Current Results



MELPe 2.4 Kbps



Current

Future work

- Find better contexts

Current research coder has several groups of contexts for each bit plane :

insignificant, first refinement, refinement, sign

- Each block is relatively small

Need history from previous blocks to have good statistics

Modulate the history based on distance in time from current frame

- How to apply perceptual weighting to quantization in DCT domain?

Thanks!

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