Algorithms for Robust Information Embedding in Video: Progress Report 05/10/04

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Agenda

- Review project history
- Review Information Embedding Approach
- Block Diagrams as of 5/10/04
- Results of Testing
- Future Work

Review Project History

- Jan. 5, 2004, Nick joins project
- Jan. 30, 2004 report
  - Information Performance Constraints/Design Goals
  - System Implementation Constraints/Design Goals
- Mar. 1, 2004 report
  - System Design Framework: progress on block diagram implementations, understanding
  - Information embedding strategy outlined
  - Choices in applying principles: statistical analysis
    - DCT Coefficients
    - SVD Analysis
- Apr. 12, 2004 report
  - Details of distortion compensated quantization index modulation outlined
  - Method for obtaining primary information embedding direction defined

System Design Framework

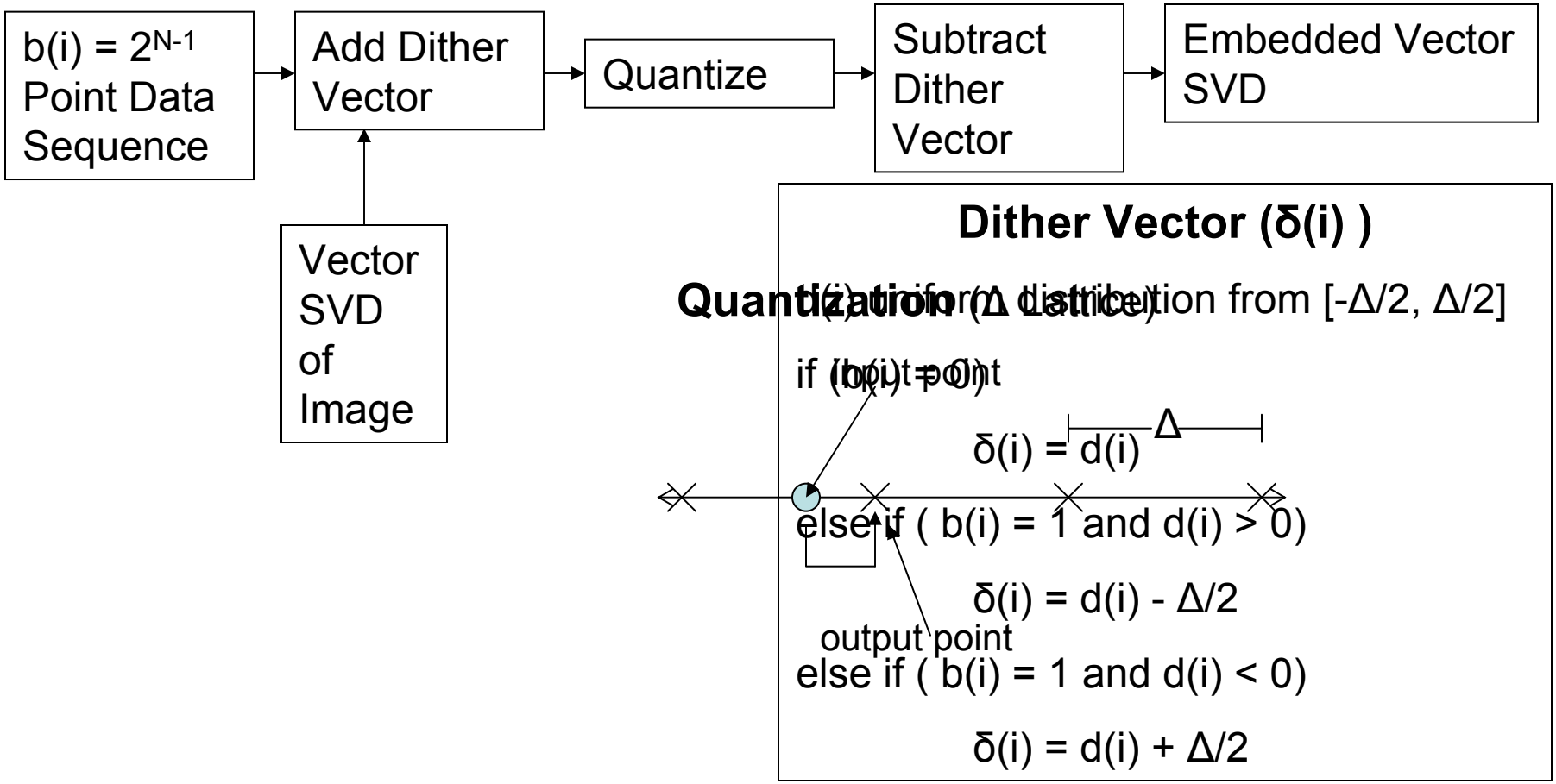
- Information Performance Constraints/Design Goals
  - – Priority: Robustness to keying, DCT compression, transformations to and from high definition and to and from selected other standards conversions
  - – Next: Robustness to translation, scaling, rotation, playback rate changes
    - Comment: scaling may be hard, necessity may impact critical design paths
- System Implementation Constraints/Design Goals
  - – Decoder implementable in real time using VEIL-developed hardware
  - – Encoding in near real time using VEIL-developed hardware
  - – Target hardware platforms include AD dual core Blackfin DSPs
- Robustness
  - – Robustness to additive noise, standards conversions, compression
  - – Establish target values for robustness
  - – Establish tradeoffs between robustness and distortion

WU Approach to Algorithm Design

- Principles (Moulin-O'Sullivan, 1996-2003)
  - Use information-theoretic analysis to guide design
  - Extract independent random variables
  - Embed information in extracted variables
- Choices in Applying Principles
  - Extraction of random variables
    - necessarily approximate due to lack of underlying true distribution
    - based on parametric, semiparametric, or nonparametric principles
    - often have an invertible transform at the core
      - choice of transform: DCT, wavelet (further choices), Hough, Radon
    - motion compensation is typically semiparametric
    - 3D, 4D, nD mesh models are parametric
  - Embedding and extracting information
    - spread spectrum, QIM

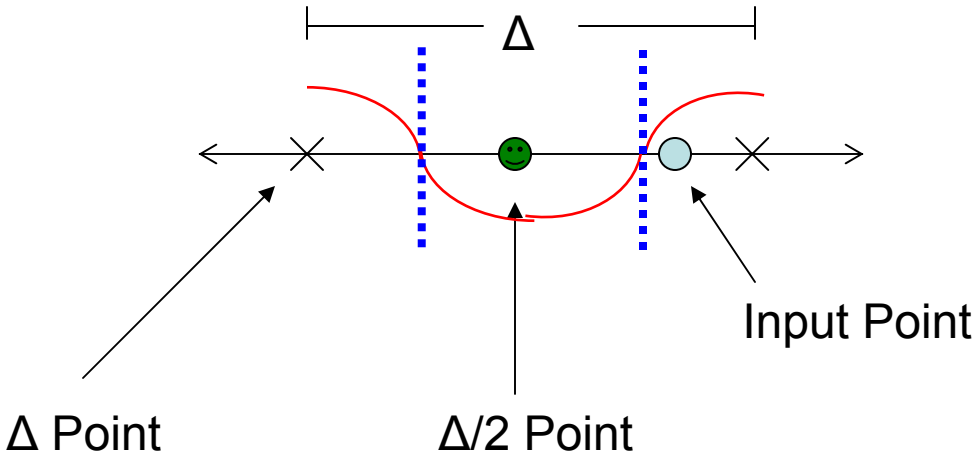
Review Information Embedding Approach

Embedding


b(i) = 2^N-1 Point Data Sequence
Add Dither Vector
Quantize
Subtract Dither Vector
Embedded Vector SVD
Vector SVD of Image
Dither Vector (δ(i))
δ(i) uniform distribution from [-Δ/2, Δ/2]
Quantization (Δ Lattice)
if (b(i) = 0)
δ(i) = d(i)
Δ
else if (b(i) = 1 and d(i) > 0)
δ(i) = d(i) - Δ/2
output point
else if (b(i) = 1 and d(i) < 0)
δ(i) = d(i) + Δ/2

Extraction

Quantization (Δ Lattice)



Cosine-Based Soft Decode:

Decision

If (Input is closest to a Δ Point)

Output = 0

If (Input is closest to a Δ/2 Point)

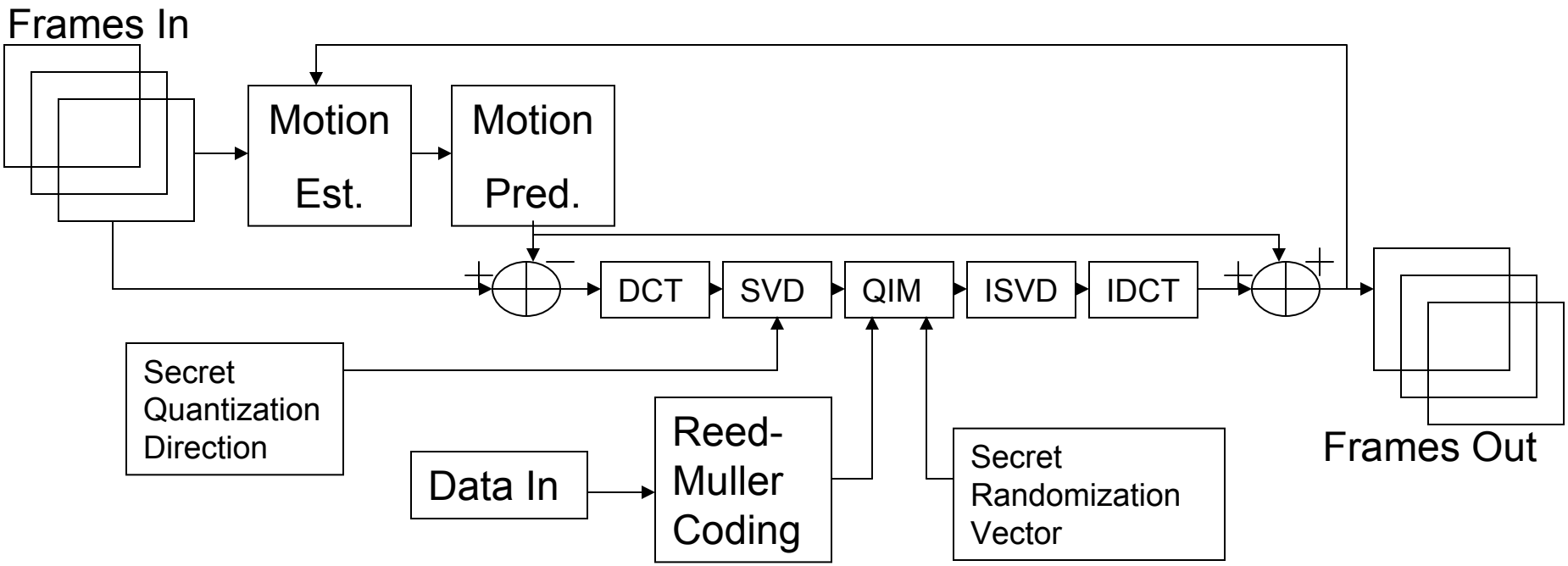
Output = 1

-Hadamard-Transform Decode needs non-zero entries

-Used to add robustness to the Hadamard-Transform Decode

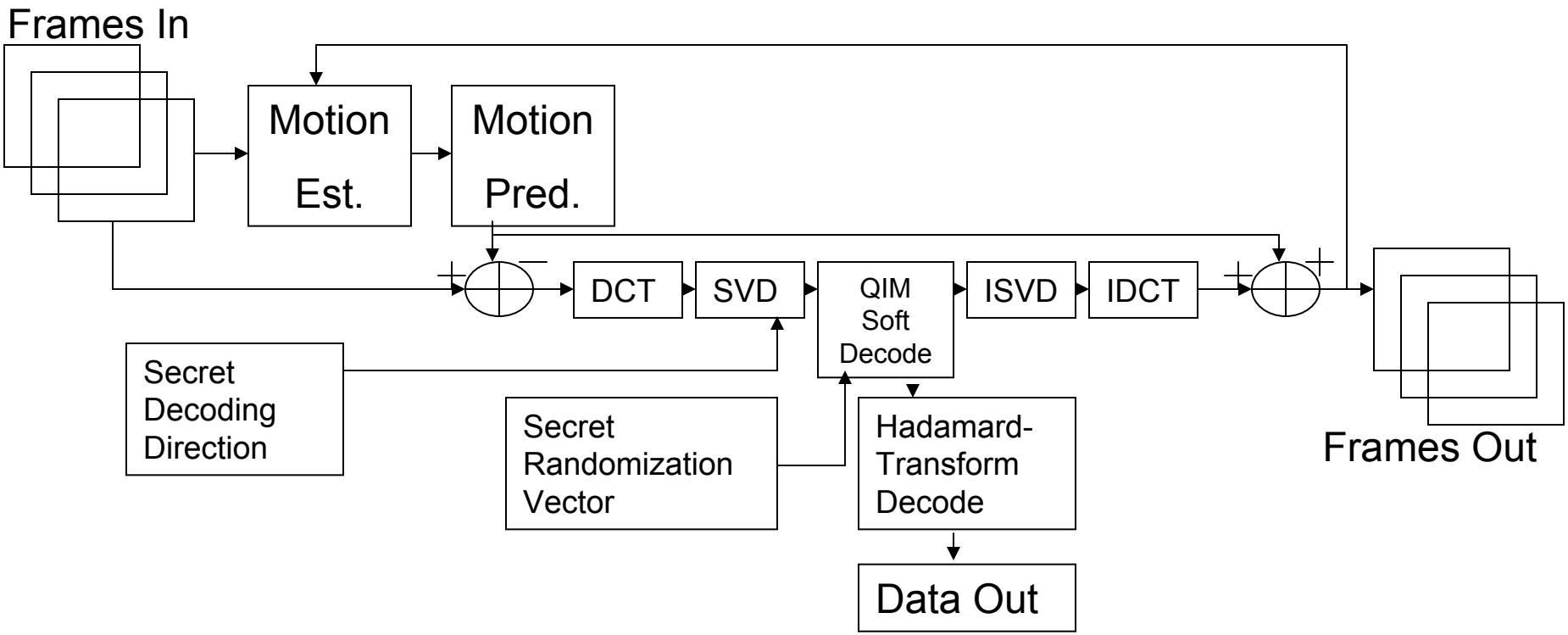
Block Diagrams as of May 10, 2004

Encoder



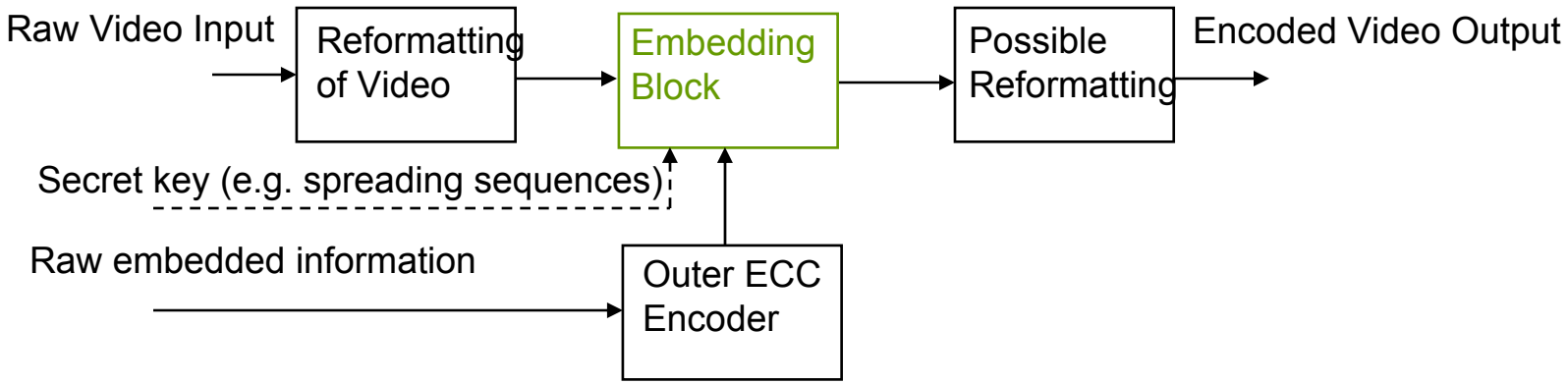
Note: After testing different GOP sequences, the choice of all I frames seems to give the best performance; this would further simplify this block diagram

Decoder



An outer error control codes such as a Reed-Solomon code can be added on top of this design.

Further Embedding System Design



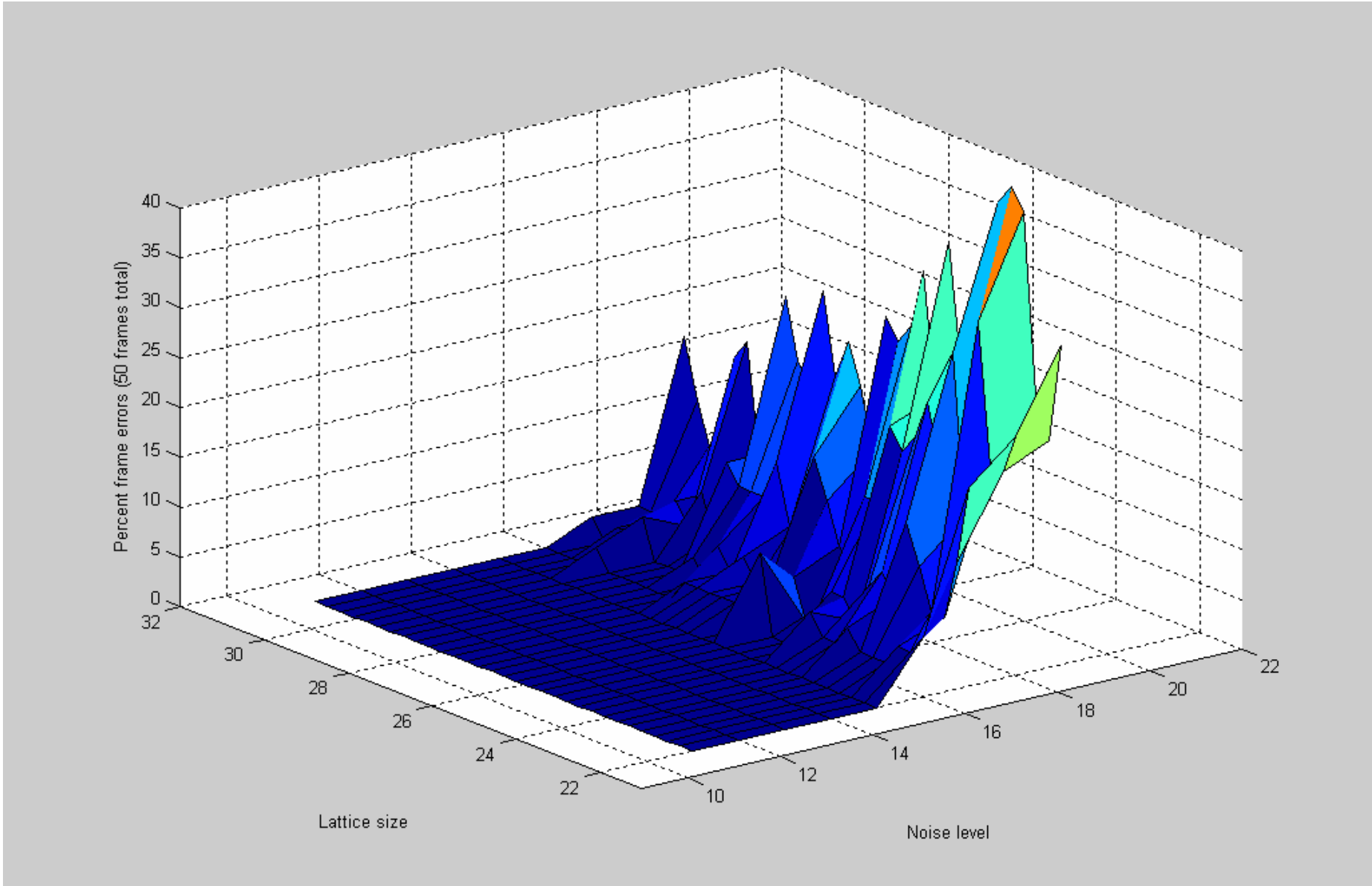
Comment: proposed embedding block from previous slide

Results of Testing

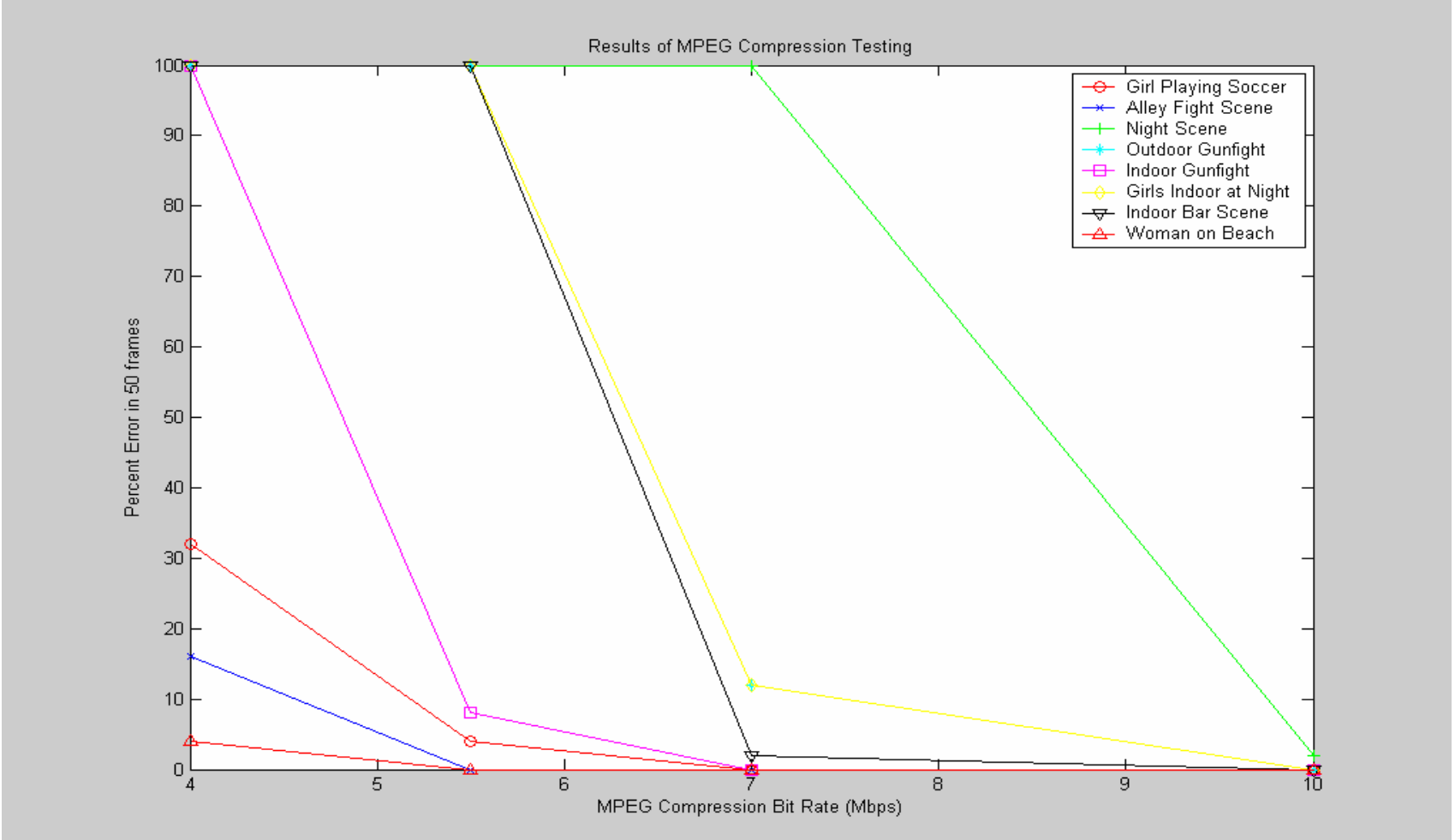
Tests Performed

- Gaussian Noise added in the RGB pixel domain
- MPEG Processing at different bit rates

Additive Gaussian Noise Attacks Performance



MPEG Compression Results



Future Work

- Develop plan for interactions
  - Implementation of existing block diagrams
  - Upgrade paths in software, algorithms
- Identify priorities on upgrades
  - Translations
  - Rotations
  - Time and/or space scaling
- Discuss other possible upgrades