Algorithms for Robust Information Embedding in Video

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Agenda

- Progress at Washington University
  - Jan. 5-30, 2004
- Proposed Modified Timeline
- Sidebar: Contract Issues
  - Jody, Jim, Dan N.

Progress at Washington University

- System Design Framework:
  - Constraints imposed by applications
  - Design goals outlined by VEIL
- Algorithm Design
  - Principles
  - Choices in applying principles (design paths)
- Current Instantiation of Block Diagram
  - MPEG-based information embedding
  - Information extraction
  - Design choices
- Information Embedding Issues
  - Spread spectrum versus quantization index modulation
  - Theoretical considerations (later)
- Identification of critical paths

System Design Framework

- Information Performance Constraints/Design Goals
- System Implementation Constraints/Design Goals

System Design Framework

- Information Performance Constraints/Design Goals
  - – Priority: Robustness to keying, translation, DCT compression, transformations to and from high definition and to and from selected other standards conversions
  - – Next: Robustness to scaling, rotation, playback rate changes
    - Comment: scaling may be hard, necessity may impact critical design paths
  - – Establish target values for robustness
- 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

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

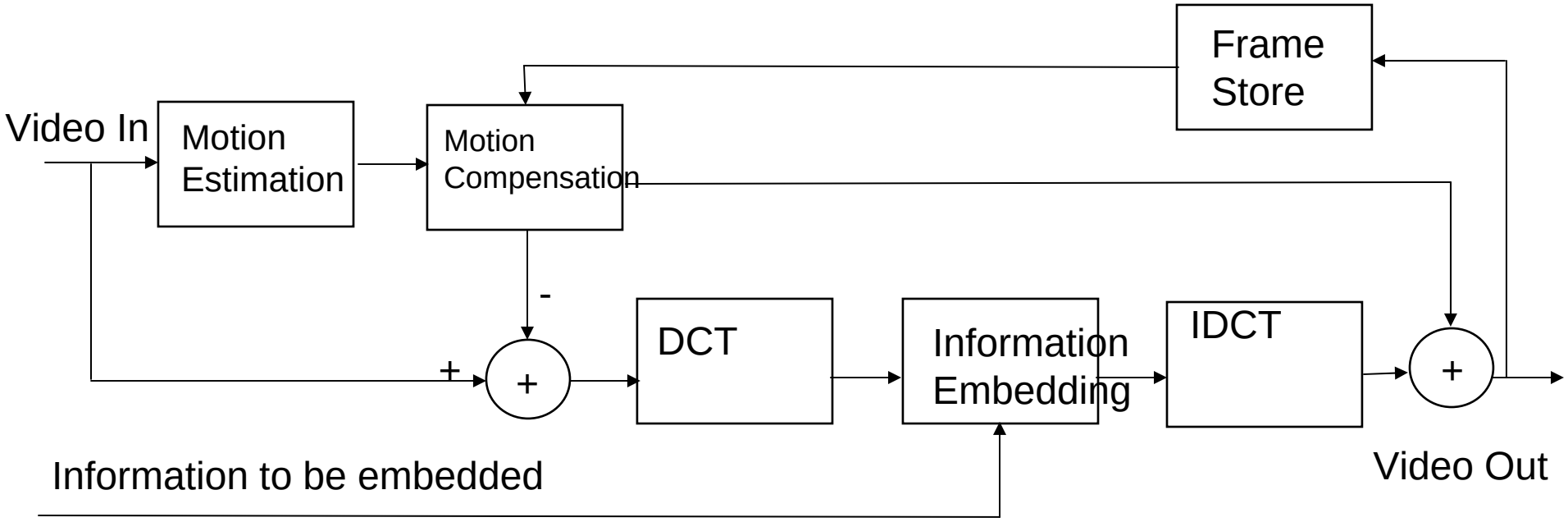
WU Approach to Algorithm Design

- Choices in Applying Principles: Critical Design Paths
  - Image vs. video (audio is not considered here)
    - frame-by-frame as images
      - shorter design cycle
      - design issues easier
      - potentially fast encoding/decoding
      - closer to VEIL 2
      - robustness to time warps is harder
      - little or no robustness to MPEG compression
    - video-based
      - greater robustness to video transformations
      - departure from VEIL 2 embedding technology
      - greater design efforts up front
      - more complexity in design issues
      - more computations required to implement

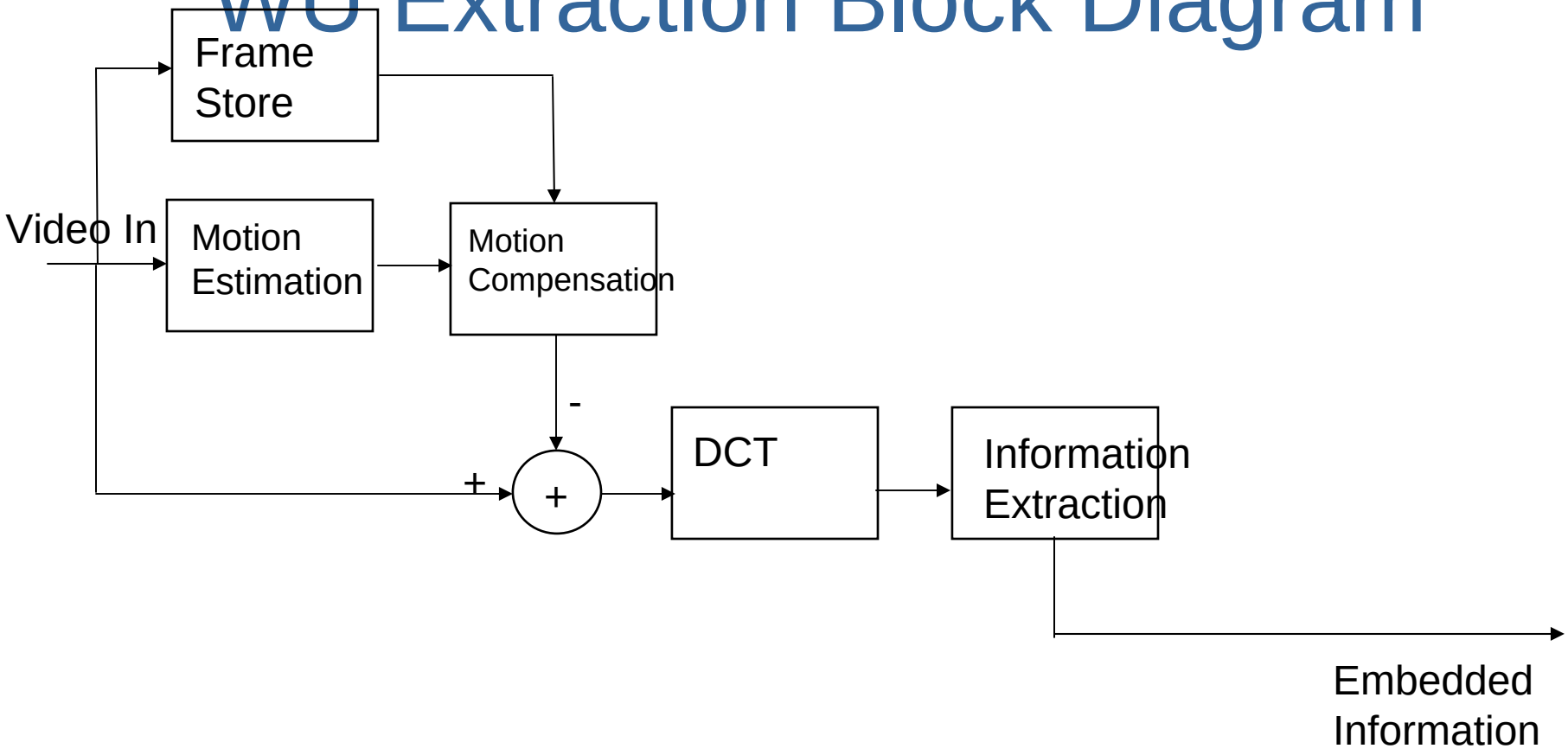
WU Approach to Algorithm Design

- Choices in Applying Principles: Critical Design Paths
  - Extraction of variables
    - pixel values, filtered differentials in space and time
    - choice of transform (block) DCT or wavelet coefficients
    - video: MPEG-2, MPEG-4, or other compression algorithm as basis
  - Design environment
    - Matlab, C (Microsoft Visual), C++, etc.
    - Custom vs. downloaded software package

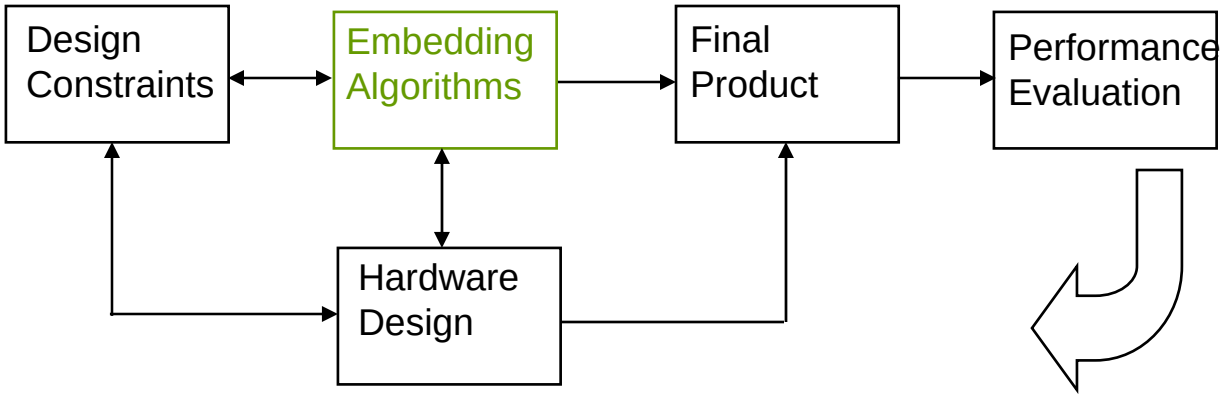
Current Instantiation of WU Embedding Block Diagram



Current Instantiation of WU Extraction Block Diagram

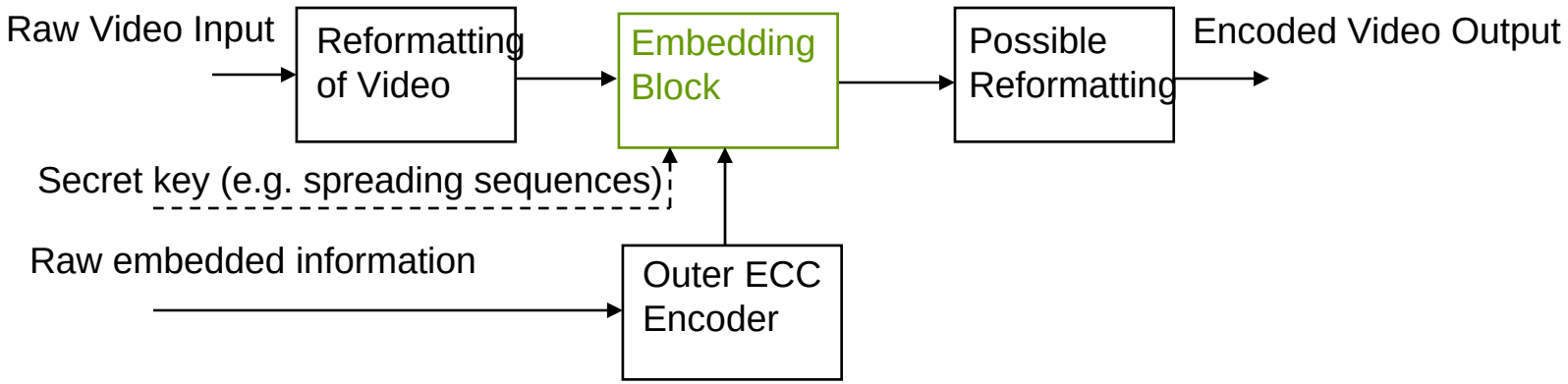


Proposed Design Process



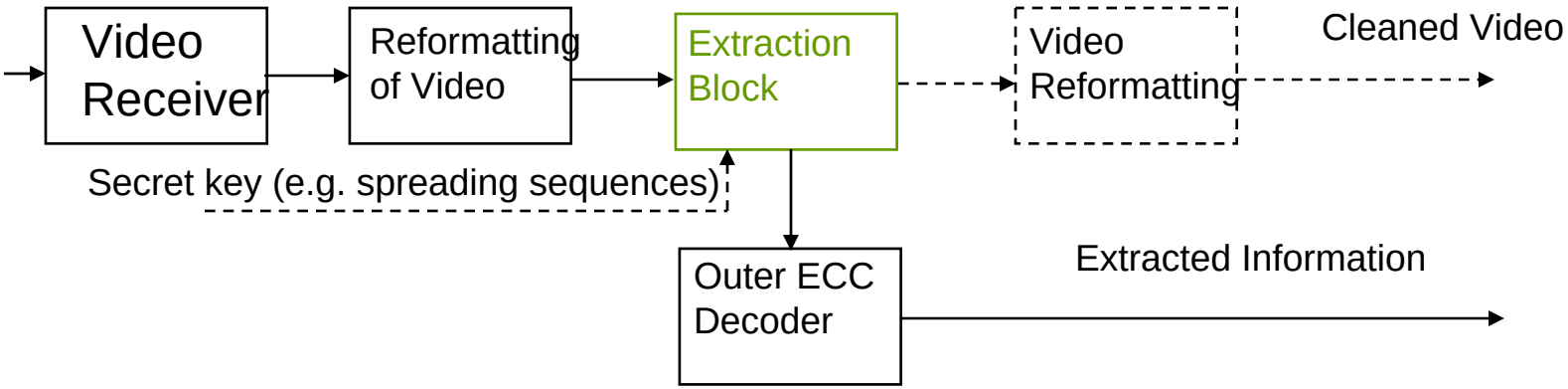
WU: design issues related to algorithms

Further Embedding System Design



Comment: proposed embedding block from previous slide

Further Extraction System Design



Comments:

- proposed extraction block earlier
- dashed blocks are optional

Embedding Issues

- Spread Spectrum versus QIM
  - Debate in literature is ongoing
  - Each can be made practical
  - Spread spectrum is more intuitive
  - DC-QIM is provably optimal
  - Spread spectrum with adaptive gain control can approach DC-QIM

Proposed Performance Goals

- Finalize development environment at WU: Feb. 6
  - C code; role of Matlab
  - Windows environment
  - extraction of relevant MPEG code blocks
- Further development of WU block diagram for information embedding/extraction: Feb. 20
  - spread spectrum, QIM, DC-QIM, combination
  - choice of transforms
  - analysis of distributions of coefficients
- Demonstration of MPEG blocks: March 12
- Demonstration of information embedding/extraction blocks: April 2
- Demonstration of MPEG blocks together with information embedding/extraction blocks: April 30

Further Comments

- Nick Fichtenbaum is committed through April 30
- Further development will be needed after April 30—envisioned primarily as tweaking the design outlined here and hardware implementation issues
- Substantial progress has been made at WU since Jan. 5, using WU funds
- Novel approach to information embedding has been identified—search for prior art is ongoing
- Modified goals of project outlined