Robustness of Video and Image Compression In Noisy Source and Communication Channel Environments

Progress Report 1
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prepared by Björn Jawerth, Summus, Ltd.

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PI: Björn Jawerth, Summus, Ltd.
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1 Basic Information

The following is a progress report for worked performed under the ONR's ***Robustness of Video and Image Compression In Noisy Source and Communication Channel Environments*** contract over the period 20 October 1997 through 6 February 1998. Summus, Ltd. is a small business located at **950 Lake Murray Blvd., Irmo, SC 29063**. Funds expended during this period were $36,855.74. For further information please contact the principal investigator and primary business contact for this effort **Dr. Björn Jawerth, 803-781-5674 (tel), 803-781-5679 (fax), bj@summus.com**.

2 Overview

This initial phase of the effort is focused on developing and understanding appropriate definitions, tools, and methods applicable to the problem of providing reliable information in highly dynamic physical and communication environments. A fundamental criterion of the "defining" phase is to apply computationally efficient methods and to investigate relationships within the available information space that are heirarchical in their segmentation, assignment and processing of information. This process establishes a foundation for the objectivication of the underlying properties in the information space that is consistent with the capabilities provided by the methods and tools used to extract, enhance, or verify the information.

Ultimately, this should lead to an information alphabet that allows rapid identification objects within the information environment. As applied to this project, the alphabet and the associated syntax for building objects, will be used to define, and hence reduce, the impacts and effects created by noise in the information gathering,

fusion, and transmission processes. This formulation of the information environment will also be applicable to other object related activities, such as, compression, identification, tracking, and enhancement, and thus, will provide a computationally efficient foundation for various information processing activities in highly dynamic environments, such as those anticipated for UCAV or hypersonic missile systems.

Specifically, we have investigated the following methods and tools for application to the central focus of this project.

- Low Complexity Forward Error Correction
- segmentation and prioritity structures
  - Dynamic Probabilistic Networks (DPNs)
  - Wavelet Libraries
- 3D - 2D Error Sensitivity

3 Technical Information

3.1 Low Complexity Forward Error Correction

Forward error correction (FEC) is one of the tools for establishing robust transmission characteristics of compressed image and video data. Typically, such FEC techniques are numerically quite complex and require hardware support for real-time operation. The initial investigations as part of this effort have focused on establishing new very low complexity, flexible FEC techniques. Following L. Rizzo we have started investigating algorithms with the ability to correct erasures, i.e. missing data in known locations. By assuming that the location is known significantly simplifies the general error correction problem and it is possible to establish very low complexity correction algorithms. We are currently studying so called Linear Codes with respect to performance, complexity, and their ability to adapt to different priorities and rates.

3.2 Segmentation and Priority Structures

A fundamental part of our approach to robust channel/source coding is to segment the data into sets of different priorities. Certain specific techniques for segmentation

and for defining priority structures are currently being investigated for this purpose, including Dynamic Probabilistic Networks (DPNs) and Wavelet Libraries.

3.2.1 DPNs

Dynamic Probabilistic Networks have proved to be effective tools for monotoring partially observable systems and for complex decision making and projections. We have started the investigation into how the DPN's state evolution model can be tied into a video compression system and used to track the behavior of object assigned a certain priority, and to decide algorithmically how to detect errors in the transmitted, compressed video stream.

3.2.2 Wavelet Libraries

We have implemented an environment for using Wavelet Libraries for classifying image/signal content. Initial investigations have focused on recognizing small sized objects in highly cluttered environments and for distinguishing the noise component from the real (one-dimensional) signal. We intend to extend this in several directions and, in particular, use the environment both for segmentation purposes as well as recognition of noise in transmitted image data.

3.3 3D - 2D Error Sensitivity

As part of other efforts we have developed photometric stereo methods for representing three dimensional structures and surfaces in terms of intensity in images. We have also shown how to use nonlinear approximation of the image information to obtain compact representations of the three dimensional data. As part of this effort, we are investigating how errors in the images affect the surface reconstruction. We are also studying the dependence of the location of the light sources.

4 Directions for Continued Research

Our next efforts will continue the definition phase of this project by defining objects in the information space based on the methods discussed in this report. Additionally, we will develop information environment simulations, consistent with the physical

environment simulations under developed by other participants in this project. These simulations will provide us with a significant tool for probing the potential alphabets and relationships in the information.