Internal Memorandum

David Sarnoff Research Center
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To	**Distribution**	Memo #	**SBN-900507**	Date	**May 7, 1990.**
From	**S. B. Ng**	Location	**W-333**	Telephone	**x3035**
Subject	**Digital Simulcast — 5/2/90 Meeting Summary**				

The following is a list of topics discussed during the digital simulcast project meeting on 5/20/90. The main purpose of the meeting was to discuss various coding proposals for the digital simulcast project.

Krish gave a short description of an experiment he conducted on the RF test bed recently. The experiment was an attempt to get some insight on digital transmission over a terrestrial TV channel. The experiment comprised a narrow band QPSK digital signal, with some power adjustment to approximate the performance of a 16-QAM signal, and an impulse noise generator for the channel. No other noise was added. A rate (3,4) FEC was used. The FEC decoded bit error rate was observed to increase from about 10^{-5} to about 10^{-3}.

There was some discussion on the necessity of designing an end-to-end system, rather than looking at pieces of the problem. Specifically, Ray suggested that a channel model, albeit a simple one, ought to be included in our selection of a digital simulcast system. Others argued that the first order business is to convince ourselves that a 20-Mbps coding algorithm that delivers HDTV quality can be designed. The channel impairment issues ought to be addressed at a later stage. Similar issues were raised again toward the end of the meeting.

PROPOSAL #1

Len outlined a 3-D QMF system for an experimental study. Some of the key features of the system are:

- Time-varying spatial prefilter at the front end to “choke” on motion or buffer overload.
- 2 temporal sub-bands (sum and difference) and multiple spatial sub-bands.
- Priority assignment on block by block (within a sub-band) basis.

Krish agreed on the importance of the priority separation, and added that switched modulation as another means to prioritize the signals could be included in the study. Jerry and a few others expressed concern that the simple sum and difference temporal sub-band may not be efficient enough to achieve the high compression needed for HDTV. Motion compensation may offer a better framework for compression.

PROPOSAL #2

Charlie proposed a flow-field based sub-band compression system. Its key features include variable input video source with "continuous" resolution and a subsequent conversion to some working image dimension. Flow field information, motion compensation residue, and other parameters (scene change, image size) are quantized and coded for transmission. The residual information is decimated before being quantized in a sub-band representation. Look-ahead buffer management with the possibility of re-compute is also a feature of the system.

Krish was concerned about receiver complexity, while Ray asked the flow field computation requirement. Raj responded that in software, flow field computation was five times faster than a full-search block match motion vector computation.

On the question of decimated motion compensation residue, Joel commented that others (Haskell of Bell Labs?) have found that systems with frame interpolation present "extreme difficulty," even with motion vectors transmitted for the missing frames. This is probably a view shared by our clients in Hannover.

PROPOSAL #3

Ray presented a sub-band VQ system that incorporates a joint source/channel coding scheme. Among other things, the system has no DPCM-type recursion so that error propagation may be less of a problem. Instead of a temporal predictive coder such as motion-compensated DPCM, 3-D QMF is used to reduce temporal redundancy. A "video-specific" vector to channel symbol mapping approach is applied to the low-low band, with the VQ residue being scalar quantized and transmitted separately along with other sub-bands. Instead of Huffman coding, a robust mapping of the zero runs and the quantized non-zero values to channel (QAM) symbols is used for these high bands (including the residue band.)

Jerry has a concern regarding the vector training process (to generate code books). Ray and Joel suggested that a "lattice VQ" may provide a solution. The usual critique that VQ is sensitive to the type of source images surfaced and there was a general agreement that provided the residue is sent, such sensitivity can be significantly reduced. Joel commented that on NTSC images, a VQ coder with scalar quantized (SQ) residue could perform close to a DCT coder running on the interframe DPCM residue of the same picture. Jerry suggested applying entropy coder to the VQ indices. Joel pointed out that a "good" VQ should leave little room for improvement by an entropy coder.

PROPOSAL #4

Sheau outlined a spatial sub-band coder with a motion-compensated DPCM/DCT hybrid (the "me-too" system) applied to the low-low band. The highs are quantized according to some yet-undefined motion-adaptive bit allocation schemes. The motion information was derived before the sub-band decomposition so that the motion compensation at the low-low band will have the benefits of sub-pixel accuracy in the motion vectors. He also discussed two input source formats: 1050-interlace and 720-proscan formats. A super-frame concept was emphasized in terms of its desirable characteristic of channel error confinement. Spatial resolution diagrams were presented in terms of spatial frequency sub-bands. For the 720-proscan format, Zenith's horizontal and vertical resolution limits were noted in the resolution diagrams. The bands corresponding to a wide-screen NTSC picture was emphasized. The high bands may be sent at 15 Hz "flash".

Raj reminded everyone that Thomson (Hannover) may be unwilling to accept any interlace format as a proposal for video sources. John commented that there are only limited video formats available for F.C.C. testing. Glenn suggested that a format converter be considered as an interface to F.C.C. test images. Sheau noted the inevitable artifacts associated with any format conversion process.

Ray suggested that, in addition to the low-low band, some of the high bands can be motion compensated as well. Raj and Sheau remarked that motion compensation on the high bands is not easy and often leads to little or no improvement in performance. Sheau further pointed out that an alternative to the system may be to perform motion compensation on the front end before the sub-band decomposition.

PROPOSAL #5

Glenn described a hybrid motion-compensated pyramid and DCT approach in which at the lowest resolution level of a Laplacian pyramid structure, a 3-D DCT is applied. In the spatial domain, the transform is applied over the entire picture, albeit at a reduced resolution (128x128) relative to the original image (1024x1024.) The higher levels of the pyramid comprise either motion compensated (warped) residue or the Laplacian pyramid information itself. Spatial (8x8) DCT is applied to these levels.

Jerry remarked that there is no "real" decimation involved, (Glenn: "Only changes in representation.") therefore the compression that can be achieved may be limited. Ray pointed out that the pyramid structure allows problems to propagate up the resolution levels. He also suggested to use QMF as an alternative to the DCT.

Joel commented that the highest resolution level of the pyramid, which is mostly motion compensation residue, may be decimated without too much loss in visual quality. As an example, a four-field interlace sequence for the highs may be acceptable.

PROPOSAL #6 (Joel's shower idea—he doesn't sing, he thinks!)

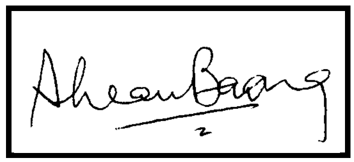
Joel gave a description of an adaptive 3-D VQ system. 16-dimensional vectors are quantized and transmitted using 8-bit indices to a codebook. Gain and shape/pattern information for each vector is extracted and transmitted as side information. More significantly, the vectors are formed by one of four possible ways: 1x1x16 (purely temporal vector), 2x1x8, 2x2x4, 4x4x1 (purely spatial vector). The main advantage of a VQ is its strong asymmetry in transmitter/receiver complexity. In Joel's system, because of the extension to the temporal direction, there may be an additional advantage in receiver frame store requirement since the indices instead of the decoded pixels can be stored. This is equivalent to storing the coded (and therefore highly compressed) data rather than the decoded pixel values at the receiver, thereby reducing its frame store requirement. The fixed-length nature of VQ indices coupled with the simple decoding algorithm (table look-up) of VQ makes it possible to store the coded data.

One comment is that the receiver memory reduction may be offset by a more complex address generator and/or a larger codebook size. Raj expressed concern that the decision on which of the four vector formations to use is a very difficult one to make. Sheau suggested that a transform coder such as a 1-D DCT can be applied to the vectors before they go into the quantizer.

CLOSING DISCUSSION

Much discussion followed. The focus of the discussion was on the "selection" of coding algorithms. One concern was that a realistic assessment of many of the system proposals will require a significant investment of manpower and effort. The ambivalence around the selection process was also noted. A remark was made that projects often have their own momentum which is not easily stopped or altered. Such a momentum, if directed toward an approach that seems sound at an early stage but turns out to be otherwise later on, will have adverse impact on the success of a project. This underlines the importance of a realistic assessment of as many system approaches as possible in the early phase of a project. Some members feel that simulations in which a noise-free channel is assumed has their value as an existence proof of coding algorithms capable of high compression at HDTV image quality. Others are more concerned because the algorithms revealed by these simulations may not withstand the hostile environment which characterizes the terrestrial broadcast channels. The wide spread of channel conditions in the terrestrial broadcast environment qualifies it as uniquely difficult for digital transmission compared to other transmission media such as fiber, copper wires, or satellite links. There was an agreement that results from simulations without any channel model must be guarded so that general conclusions will not be made thereof.

Another agreement was that the proposals outlined in this meeting should be simulated using a standard set of test images. The simulation results can at best be taken as partially indicative of the degree of compression efficiency of a particular system. Because of the high spread of channel condition in the terrestrial broadcast environment, the early experimental results on the performance of the various systems may be significantly different if a realistic channel model is included in the simulation. However, some comparison of early simulation results as a sanity check is desired. There was no firm agreement on when such a sanity check can be made. Suggestions ranged from 2 to 6 weeks.



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