PARKER C. FOLSE III (WA Bar No. 24895 – *Admitted Pro Hac Vice*)
pfolse@susmangodfrey.com
IAN B. CROSBY (WA Bar No. 28461 – *Admitted Pro Hac Vice*)
icrosby@susmangodfrey.com
FLOYD G. SHORT (WA Bar No. 21632 – *Admitted Pro Hac Vice*)
fshort@susmangodfrey.com
SUSMAN GODFREY, L.L.P.
1201 Third Avenue, Suite 3800
Seattle, Washington 98101-3000
(206) 516-3880 Tel
(206) 516-3883 Fax

SPENCER HOSIE (CA Bar No. 101777)
shosie@hosielaw.com
BRUCE WECKER (CA Bar No. 078530)
bwecker@hosielaw.com
HOSIE McARTHUR LLP
One Market, 22nd Floor
San Francisco, CA 94105
(415) 247-6000 Tel.
(415) 247-6001 Fax

*(additional attorneys listed on signature page)*

Attorneys for Defendant
BURST.COM, INC.

UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF CALIFORNIA (SAN FRANCISCO)

| | | |
|---|---|---|
| APPLE COMPUTER, INC.,<br><br>Plaintiff/Counterdefendant,<br><br>BURST.COM, INC.,<br><br>Defendant/Counterclaimant. | § | Case No. 3:06-CV-00019 MHP<br><br>**DECLARATION OF DR. SHEILA HEMAMI IN OPPOSITION TO APPLE'S SECOND MOTION FOR SUMMARY JUDGMENT OF INVALIDITY**<br><br>Hon. Marilyn Hall Patel<br><br>Complaint: January 4, 2006<br>Trial: February 26, 2008 |

# DECLARATION OF SHEILA S. HEMAMI IN SUPPORT OF BURST'S OPPOSITION TO APPLE'S SECOND MOTION FOR SUMMARY JUDGMENT OF INVALIDITY

I, SHEILA S. HEMAMI, declare that:

1. I am currently a Professor of Electrical and Computer Engineering at Cornell University in Ithaca, New York, where I direct the Visual Communications Laboratory.

2. Appendix A is my curriculum vitae, documenting the details of my professional experience in the areas of digital signal processing and compression. It also lists all of my publications.

3. In summary, I have performed research on the general topics of digital signal processing and compression as a graduate student at Stanford University, as a Member of Technical Staff at Hewlett-Packard Laboratories, and as an Assistant, Associate, and Full Professor of Electrical and Computer Engineering at Cornell University in Ithaca, New York. I have published over 100 refereed journal and conference papers, and I have supervised nine Ph.D. theses, two M.S. theses, and twenty Masters of Engineering projects on topics in digital signal processing and compression. I have taught graduate classes on digital signal processing, digital image processing, and Wiener and Kalman filtering. I also teach in my classes and have a high level of familiarity with image, video, and audio coding standards, including JPEG and JPEG-2000 (standards for still image compression) and MPEG-1/MPEG-2/MPEG-4 (standards for video and wideband audio compression).

4. I am a Senior Member of the Institute for Electrical and Electronics Engineers (IEEE) and a member of the Signal Processing Society (SPS) therein. *Signal processing* broadly deals with the manipulation or processing of an *information representation* (i.e., a signal) to achieve some end goal, such as compression or transmission. Within the IEEE, I have served as Associate Editor for signal representation, coding and compression for the *IEEE Transactions on Signal Processing* journal. In this position, I coordinated reviews and made editorial decisions on papers addressing both theoretical and practical aspects of data compression applied to a multitude of signals, including audio and video. I am currently the elected Chair of the Image & Multidimensional Signal Processing Technical Committee (IMDSP TC) of the IEEE for 2006-8. *Image and multidimensional signal processing* includes not only processing of conventional images and video signals, but also hyperspectral images, data from grids of sensors, and medical images, to name several examples. The purpose of the IMDSP TC is to promote and guide the

advancement of the field of image and multidimensional signal processing, through activities such as coordinating reviews for and sessions within the two major yearly IEEE signal processing conferences (the *International Conference on Acoustics, Speech, and Signal Processing* (ICASSP) and the *International Conference on Image Processing* (ICIP)), nominating community members for technical achievement and service awards, assisting in the selection of SPS Distinguished Lecturers, recruiting associate editors for SPS publications, participating in the development of IEEE standards, and organizing the IEEE's flagship image and multidimensional signal processing conference ICIP. I regularly serve as a reviewer for many IEEE journals and conferences. I have been selected as the next Editor-in-Chief for the *IEEE Transactions on Multimedia* and will begin my term in January 2008.

5. I have also served on various review panels for the National Science Foundation, to evaluate research proposals for funding; on the program committees of the *Data Compression Conference*, the *Asilomar Conference on Signals, Systems, and Computers*, and *Video Processing and Quality Metrics*; and on the program committees for several conferences organized by the International Society for Optical Engineering (SPIE): *Human Vision and Electronic Imaging* and *Visual Communications and Image Processing*.

6. I am currently providing expert consulting services for Burst.com, Inc. ("Burst") in the lawsuit Apple Computer vs. Burst.com, Inc. I am being compensated at my standard billing rate of $500/hour plus expenses. My compensation is not contingent on the testimony that I intend to offer in this case.

7. My participation in this case to date has included serving as Burst's claim construction expert, including submitting a report in support of Burst's proposed constructions in October 2006, giving a tutorial presentation to the Court in San Francisco on February 1, 2007 prior to the Markman Hearing, and attending the Markman Hearing in San Francisco on February 8, 2007. I have also submitted a previous declaration in connection with Apple's first invalidity summary judgment motion.

8. I have read and studied Burst's four patents — 4,963,995 ("'995"), 5,057,932 ("'932"), 5,164,839 ("'839"), and 5,995,705 ("'705"), which I will collectively refer to as the *Burst patents.* I have also read and studied the Court's claim construction ruling in this case.

9. I have read and reviewed Apple's Second Motion for Summary Judgment regarding invalidity, Apple's Reply in support of its First Motion for Summary Judgment of

invalidity, and the declaration of Dr. Stephen Wicker. I have read and studied Kramer et al. U.S. Patent No. 4,667,088 ("Kramer"), issued May 19, 1987; Kepley et al. U.S. Patent No. 4,790,003 ("Kepley"), issued December 6, 1988 with a filing date of April 27, 1987; Walter U.S. Patent No. 4,506,387 ("Walter") issued March 19, 1985 with a filing date of May 25, 1983; Tescher U.S. Patent No. 4,541,012 ("Tescher") issued September 10, 1985 with a filing date of January 4, 1982; and Gremillet U.S. Patent No. 4,499,568 ("Gremillet") issued February 12, 1985 with a filing date of December 13, 1982. I understand that Apple is arguing that Kramer, Kepley, Walter, Tescher, and Gremillet invalidate the Burst patents and that various combinations of these patents make the Burst patents obvious. I have also reviewed the CompuSonics material submitted with Apple's second motion.

## The Level of Ordinary Skill in the Art

10. Based upon my knowledge of the development of digital communications and networking and my personal involvement in the development of compression technology, a person of ordinary skill in the art at the time that the patent application leading to the '995 patent was filed would have had an understanding of: (1) digital communication technologies and their available bandwidths, and (2) audio and/or video compression techniques. In general, a person of ordinary skill in the art would work in the area of digital communication of audio/video source information. A person in this area could be specialized in digital communications having a familiarity with compression technology, or such a person could be specialized in compression technology having a familiarity with digital communications. Such a person of ordinary skill in the art would have had at least a bachelor's degree in electrical engineering with at least two to three years of experience working on digital communication of audio/video source information. Alternatively, such a person of ordinary skill in the art would have had a master's degree in electrical engineering with one year of experience working on digital communication of audio/video source information. As another alternative, such a person of ordinary skill in the art would have had a Ph.D. degree in electrical engineering or computer science in the area of digital communication of audio/video information.

## DPCM Audio Compression

11. My references to DPCM in both my deposition testimony and in my tutorial

clearly referred to DPCM as a compression technique which operated on digital input signals. While my tutorial slides do indeed state that DPCM is a "conventional algorithm" as Apple contends, they also clearly indicate that compression requires a digital input. For example, slides 5 and 55 which are attached as Exhibits 1 and 2 to this declaration show that the input is digital information and that compression results in fewer bits. I do not believe that the analog to digital conversion performed in Kramer falls within the Court's compression construction, and I certainly never implied this in my previous testimony or tutorial.

**The 19.2 Kilobits/second Link in Kepley Does not Carry the Voice Mail Messages**

12. In their reply brief, Apple refers to Kepley's 19.2 Kbps data link in arguing that Kepley provides faster than real time transmission of speech. However, Kepley's 19.2 Kbps data link is definitively described as not transmitting digital voice mail messages in the telecommunication system. This is discussed in detail in Paragraph 50 in my previous declaration.

**Voice Processing and Wideband Audio Processing are Vastly Different**

13. Also in their reply brief, Apple refers to an " 'allegation' that 'voice processing and wideband audio processing are vastly different' due to the 'divergent characteristics of speech and wideband audio.'" (Page 14) In fact, this is not an allegation but a well known fact to one of ordinary skill in the art. The differences are discussed in my previous declaration generally in Paragraphs 13-25.

**Kepley does not address retransmission**

14. Apple repeatedly suggests that "forwarded" voice mail as referred to in Kepley has been retransmitted. (Reply, Page 17 Section E, and Second SJ Motion, Page 13) Even a cursory read of the specification demonstrates that this is clearly incorrect. The cited sections in Apple's brief make clear that the message in question is the initial transmission and not a retransmission. My previous declaration cited exactly the same section that Apple cites (Footnote 24 of their reply brief) as supposedly supporting retransmission as in fact refining the high-level description of a voice mail transfer (see Paragraph 35). Furthermore, retransmission is not discussed in Kepley, as described in detail in Paragraph 54 of my previous declaration.

15. To rectify my omission as pointed out by Apple in Footnote 24 and to further

clarify my intent of the previous paragraph, Kepley wholly fails to address the concept of retransmission.

**Kepley does not transmit "works" or wideband audio**

16. Marcel Proust lived from 1871 to 1922. Apple suggests that Proust's listening to the opera over the telephone during his lifetime supports the argument that Kepley's voicemail system could transmit songs or other audio. While Proust may have judged the quality of this audio acceptable, there is no question that any modern day opera lover would judge it wholly unacceptable for reasons I have described in Paragraphs 21 and 22 of my previous declaration. Furthermore, I have never encountered "The Cambridge Companion to Proust" in any of my engineering courses, neither as a student nor as an instructor, and such material would not be well known to one of ordinary skill.

17. Ignoring Marcel Proust's operatic love, let us consider Apple's contention that "it would have been obvious that Kepley's voicemail system could transmit songs or other audio that Burst admits are 'works.'" Following the operation of Kepley's system to attempt to upload a song into the system for subsequent "voice mail forwarding," i.e., transmission to one or more recipients, the only manner by which a song could be entered into Kepley's voice mail system would be for a sender to play the song on an audio playback device (e.g., play a CD through his or her stereo) and then to hold the telephone receiver up to the loudspeaker such that the receiver functioned as a microphone. (This is nonsensical on its face.) The analog audio input would then travel over the telephone system to Kepley's system. As described in Paragraphs 21 and 22 of my previous declaration (which conveniently mentioned an aria from an opera), this transmission alone would eliminate nearly 85% of the frequency content.

18. Kepley's system digitizes the incoming (voice) signal in the voice storage processing 111 (Col. 5:37-39). The telephone system was well known to one of ordinary skill to digitize voice data by sampling at 8000 samples/second and representing each sample with 8 bits, yielding a digitized voice data rate of 64,000 bits/second. Were a song to be uploaded into the Kepley system as described in the previous paragraph, it would also be digitized to this rate. But this rate, which represents an uncompressed signal, is less than one tenth of the 705,600 bits/second which both sides have repeatedly cited as the rate for CD-quality audio. Kepley's system was not designed to handle the much higher data rates associated with wideband audio. Were it

possible for high fidelity wideband audio to be adequately represented in uncompressed form using only 64,000 bits/second, the audio industry would have embraced this lower rate because it would have been cheaper and simpler to implement and would have yielded more than 74 minutes on a compact disk.

19. Kepley does not disclose any alternate mechanism by which prerecorded works can be input into the voice mail system, besides simply using the telephone handset as a microphone. Spoken works such as audio books could, in theory, also be input in this manner. However, from everyday experience, audio books tend to be substantially longer than an average voice mail message. Common sense dictates that reading an audio book into a telephone for transmission using a voice mail system is not a reasonable thing to do and most likely the system will disconnect the speaker before the reading is completed due to the length of the resulting voice mail message.

20. Adjustment of the Kepley system to solve the problems enumerated in Paragraph 18 above would be at best impractical and more likely impossible. The telephone system, with which Kepley's system is designed to work, is fundamentally designed for high fidelity transmission of voice signals. Parameter selections which were made in the design of the telephone system include analog bandwidths of the transmission lines over which analog voice signals are carried, as well as the sampling rate of 8000 samples/second and the sample resolution of 8 bits/sample. Adjustment of the infrastructure to accommodate high fidelity transmission of wideband audio signals is virtually impossible — it would require replacing the entire telephone infrastructure, including all switching offices and signal conditioning equipment.

## It is not obvious to combine Kepley's voice message system with a T1 line or Ethernet

21. Apple argues that Kepley's invention could simply be used with a T1 line, with data rate 1.544 Megabits/second. To understand why this would clearly be recognized as not a viable option by one of ordinary skill, it is useful to consider the Kepley patent's use in the larger context of the telephone system, with which it was clearly designed to work. AT&T owned T1 lines at the time of the Kepley patent. These were considered to be high-capacity lines at the time, and they required special installation by the provider. They were also not envisioned to replace the copper twisted-pair telephone network which provided telephone services to customer premises.

22. Kepley's system transmitted the voice mail messages using a protocol for the D-

channel in an ISDN network. This is indicated by use of the LAPD protocol as I discussed in Paragraph 40 of my previous declaration. LAPD stood for "Link access procedure on the D-channel" and referred to the protocol defined in the ISDN standard for the D-channel. In 1988, planning of the *Integrated Services Digital Network* (ISDN) was well underway and the network was highly anticipated in the communications community. ISDN was to be a telephone network in which the internal network and the local loops (i.e., the lines going to residences) were entirely digital. ISDN was envisioned to replace the local loops. As such, it would be a network which would reach all telephone system customers, just as the copper wires reached all customers. No special installation would be required for an ISDN network connection.

23. With no special installation required for an ISDN connection, Kepley's system only required customers to purchase the voice mail system itself. Such a system was economically viable for both the customer and for the voice mail system manufacturer. In contrast, a voice mail system which required installation and use of a T1 line would not only be costly in comparison but would only be able to communicate with other voice mail systems also on T1 lines, thereby severely limiting its usefulness or making extreme the cost of implementing a complete system.

24. Apple also argues that Kepley's invention could simply be used with ethernet. One of ordinary skill would understand this approach is also not a viable option by similar arguments to those above. While ISDN was an anticipated technology for use in the telephone system, ethernet connections between telephone system components were not seen as a forthcoming technology. In fact, Kepley's system requires data transmission for control messages internal to the public switched telephone network, and rather than using ethernet, Kepley explicitly employed a 19.2 Kbps data link for control messages within the network.

**Kepley does not teach a transceiver in a common housing**

25. The Burst patents describe a consumer electronic device designed to interface with playback equipment. As with nearly all consumer electronics equipment today (e.g., VCRs, CD/DVD players), the device was self contained in a common housing to facilitate installation and use by average consumers. In contrast, a multi-component unit in separate housings would be less desirable due to additional set-up requirements such as added cabling and routing of cables and wires.

26. Kepley's voice mail system is not a consumer electronic device designed for home

use by the average consumer. Instead, Kepley's invention relates to "business communication systems" (Abstract) and the Background states that "Message services" (as appears in the patent's title) "is the term used to collectively identify the various office automation systems associated with a telephone switching system." (Col 1:12-14) As such, Kepley's system would generally reside in a dedicated telecommunication hardware room in a commercial building. (Note that we often see windowless doors leading to small rooms which are labelled "Telecom" in office buildings. This was also the case in 1988.) With the equipment generally being not only hidden from view but also isolated from casual contact with individuals not directly working with or on the equipment, the need for a single enclosure was eliminated.

27. Furthermore, such equipment by virtue of its purpose had many incoming and outgoing cables. Figure 2 in Kepley indicates that the voice mail service system in its entirety had multiple voice ports (210-21n) connected to the switching network, multiple processor data units (280-28n) connected to the telephone switching system via the data communication interface unit, and another connection from the data port circuit (115) to the switching network. Placing this equipment in a common housing would necessitate routing all of the cables through a single hole, making testing and maintenance time consuming and difficult as the equipment maintenance worker would have to tediously isolate and identify individual cables from a bundle. Creating individual holes for each of the cables, on the other hand, would be complicated and would make expansion of the system (as described in the next paragraph) unwieldy.

28. Telephone system hardware for commercial use such as Kepley's system was built modularly and was designed to be easily expandable. Business customers might start out with one incoming phone line and four internal lines and four voice mailboxes, and then expand as their call volume increased. Expansion was facilitated by a design which allowed the adding of "cards" to the system as more capacity was required for, for example, incoming phone lines, phone lines within a system, or voice mail capacity. Such additions and modifications could be easily done when the equipment was essentially "open for access" and was not enclosed. Were the equipment contained in a common housing, a new housing would be required any time the customer wished to expand its phone system capabilities and capacity. Such a solution would be economically unviable.

29. Apple argues that dashed lines as indicated in Izeki and Kepley have identical meanings. I am unaware of any patent office directives that indicate a universal meaning for

dashed lines in figures. In technical writing, authors employ dashed lines (and other types of lines) to facilitate the reader's understanding of figures. For example, in my claim construction report and infringement report, dashed lines appear in various figures (both drawn by me and imported from other documents). In none of these figures does a dashed line indicate a "common housing," which is clear from the context of the text and captions accompanying the figures. Dashed lines must be interpreted in the context of their presentation.

30. One of ordinary skill would understand that the dashed lines in Figure 1 of Kepley provide partitions of the components shown in the Figure into natural groupings for functionality and understanding: the telephone switching system (two are indicated, with three components each) and the voice mail service system (two are indicated, with three components each). Because Kepley describes transmission of a voice mail message from one service system (110) to another (150), Figure 1 shows two voice mail systems such that the sending system and receiving system can both be referred to in the specification. Without the dashed lines indicating that the systems 110 and 150 have multiple components (110 consisting of 112, 111, and 113; and 150 consisting of 152, 151, and 153), referring to the voice mail service systems in the text would require awkward referencing such as "the voice mail service system 112, 111, 113." A similar argument holds for the telephone switching systems 100 and 140. These switching systems contain hundreds or thousands of components and have no requirement (nor would be possible) to be in a common housing by similar arguments to those above in Paragraph 26. One of ordinary skill would not understand the dashed lines to indicate common housings in Kepley.

### Kepley does not teach editing of a compressed voice mail message

31. Apple gives two cites from the Kepley specification to support their claim that Kepley provides editing. In fact, neither of these cites indicates that Kepley provides editing. The first cite, in Col. 1:38-43, describes operation of a generic voice mail system under "Background of the Invention." It is not related specifically to the Kepley invention. The second cite, in Col. 6:68-8:9 (and more specifically Apple quotes from the paragraph at Col. 7:64-8:9), does not support the claim of editing. The description around the cite initially refers to voice files and non-voice files. One of ordinary skill in the art would understand that the described file manipulation functions pertaining only to the computer system files and not to the voice mail messages. This is clear from the statement "Data base processor system 113 provides *basic file system support* for

voice mail service with functions which include” (Col. 7:68-8:1; emphasis added), and the specification then goes on to list operations (file system management functions, file manipulation functions, file level concurrency control functions, data base processor system administration functions, data base processor system maintenance functions) which one of ordinary skill would understand as “file system operations” on the non-voice files.

32. Kepley does not teach editing of a compressed voice mail message. No process by which a stored message is decompressed, edited, and then recompressed is described in Kepley.

**Walter teaches two separate locations, not one**

33. The Walter patent is titled “Programming-on-demand cable system and method” and describes a video-on-demand system by which a user can request a program from a video distribution center at a cable head-end, which is then downloaded to the user at the user’s location. Such a description clearly indicates two separate locations to one of ordinary skill. As such, when considering whether Walter's system invalidates the claims of the Burst patents, the central data station and the data receiving station must be separately considered. Components from both the central data station and the data receiving station cannot be “mixed and matched” to provide the required elements. Apple’s argument to simply place the central data station and the data receiving station in a single sheet metal housing would be rejected by one of ordinary skill as creating a device which has useless excess equipment for the required tasks: those of a central data station (in which case the data receiving station, designed to operate in the customer’s home, performs no useful function) and those of a data receiving station (in which case the central data station, which contains the video library from which the user requests programming, performs no useful function and in fact defeats the purpose of having a video library from which the user can request programming). Were the two devices in fact merged into a single device, the objective of the Walter patent as stated in Col. 3:18-23 would be defeated:

> “It is an object of the present invention to provide a programing-on-demand cable system which permits a user to selectively control which program he desires to view at a particular time, subject only to the contents of the library of video programs maintained at the central data station.”

34. In operation, Walter’s central data station transmits stored, compressed video (with accompanying audio) to a user’s data receiving station, which therefore receives the compressed

video and stores it. Apple's argument that Walter "discloses 'receiving compressed' (at the receiving station), storing (at both the receiving station and the central data station), and 'transmitting' (at the central data station)" would only be valid if (1) both units were treated as a single device, in which case no transmission would occur, and which is also incorrect as I described above, and (2) time ran backwards, which is contrary to not only common sense but also to the laws of physics. Transmission of a file from the central data station to the data receiving station cannot occur *after* that same file has been already received by the data receiving station.

35. The Walter specification is silent on whether and/or how content providers relay material to the central data station. Extensive use of the term "preprogrammed" to describe programs stored in the central data station's memory modules indicates to one of ordinary skill in the art that the memory modules are programmed elsewhere and then loaded or inserted into the central data station, rather than the program being transmitted to the central data station. With such extensive discussion of transmission to the consumer and no discussion of the transmission from the content providers, it would not have been obvious to simply assemble all system components in a single housing as Dr. Wicker suggests to achieve a transceiver apparatus which would receive compressed material faster than real time.

36. Dr. Wicker states that it would have been "routine and straightforward" to compress video at the site of the content provider such as a movie studio, transmit the compressed video to the central data station, and to receive compressed video at the central data station. Such an operation would require installation and operation of compression equipment and transmission equipment at the site of each and every content provider, which was clearly impractical. The Digital Video Interactive system, which Apple has relied on as prior art in the 1987 time frame, was envisioned as a system which would allow users broad access to high-quality compressed video. Even this system in 1987 required compression at a centralized location to which original content would be mailed by the content providers. The material was compressed at the centralized location, and then the compressed material was returned to the content providers by mail, for subsequent distribution to customers.

37. Operation as suggested by Dr. Wicker would also require the addition of components for receiving the compressed video at the central data station. This would add substantial complexity and cost to the central data station.

**Walter's Central Data Station Does Not Meet the Claim Limitations**

38. The Walter specification does not state or even suggest that all components of the central data station are contained in a common housing. Walter uses the terms "central location or library" (Col. 1:48) and "a host computer at the library" (Col. 1:50) in describing the programming-on-demand cable system. The specification then states that the host computer "is a part" of the central data station (Col. 1:57). The equipment comprising the central data station is listed in Col 3:57-60 and includes a host computer, an electronic switching system, and a library of memory modules, with connections to a multi-fiber data bus. The specification further clarifies that numerous such multi-fiber data buses can be used. (Col. 3:67) None of this language suggests a common housing. Furthermore, because this equipment resides at the cable system head-end and is not a piece of consumer electronics equipment, the need for a common housing is not present. Cable head-ends are commonly housed in dedicated buildings or dedicated equipment suites comprising multiple rooms.

39. Walter's central data station stores a single program in each memory module (Col. 4:7-14) and programs are included in the video library by physical addition of new memory modules (see Paragraph 40). For practical implementation, one of ordinary skill would understand that the central data station's memory module component is both easily accessible and expandable, such that a cable operator can add more programs as desired without having to purchase and install an entirely new central data station. Such accessibility and expandability is inconsistent with installation in a common housing.

40. While Apple suggests that Walter is unclear as to whether the compression is performed at the central data station or elsewhere, it would be clear to one of ordinary skill that the compression not performed at the central data station, and in fact that Walter teaches away from performing compression at the central data station. Evidence throughout the specification supports this conclusion. The invention is outlined in Col. 2:19-46, in which key elements of the central data station and data receiving station are described, including electrical-to-optical data converters, optical-to-electrical data converts, a fiber optic communication medium, and a mechanism by which the received data can be conveyed to a display device such as a television set. Notably, no structure for performing compression is described. In fact, the entire summary of the invention from Col. 1:38-3:30 does not describe that the central data station performs compression. The only mention of the compression in the summary states that "the electrical data

representing each video program is converted to compressed digital form and stored in suitable high density memory devices." (Col 2:15-18) This statement combined with the repeated and extensive references to "preprogrammed" programs in the aforementioned memory (e.g., Abstract, Col. 2:33-34, 2:62, 4:11, Claims 2, 9, 10) suggest to one of ordinary skill that the compression is not performed at the central data station. Use of the term "preprogrammed" suggests to one of ordinary skill in the art that the memory modules are programmed elsewhere, physically transported to the central data station, and then loaded or inserted into the central data station.

41. Walter does not describe the process of installing the preprogrammed memory modules into the central data station.

42. The memory modules in Walter do not perform compression. Col. 7:26-27 states "The digital data is compressed in memory modules 23-24 by a technique known as interframe differential pulse code modulation." One of ordinary skill would understand that the memory modules as described in Col. 6:32-47 and Figure 7 do not perform compression but rather provides serial storage, and the term "compression" in this sentence is used as an adjective and not as a verb.

43. There is no motivation to perform compression at Walter's central data station because the compressed video programs arrive preprogrammed into the memory modules, as described in Paragraph 40. Addition of a compressor/decompressor at the central data station would increase complexity substantially (requiring at minimum the equipment to perform the compression, with the potential addition of input mechanisms to receive the uncompressed data) to achieve a purpose which is explicitly taught away from in the specification. Furthermore, no decompression is performed at the central data station, as its only task is to process user requests and place the appropriate requested content on the fiber optic data bus, and addition of a decompressor would therefore be completely superfluous.

44. The central data station performs no editing, as its only task is to process user requests and place the appropriate requested content on the fiber optic data bus. With no editing, there is no need for random access to the stored video data.

45. Walter's central data station does not employ random-access storage and rather uses multiple memory modules to store a single program as described in Col. 5:30-6:5. This is further explained in Col. 6:32-47 which in conjunction with Figure 3 indicates that the data for a

single program is "striped" across multiple memory modules which are described as recirculating shift registers (Col. 6:36-37). Walter's system is specifically designed to operate with these recirculating shift registers as described in detail in Col. 5:30-46 and continuing at Col. 6:32-47 (the intermediate material describes the optical transmission), which substantially simplify the design of the system relative to using random-access storage and thereby reduce the cost.

46. As suggested by its name, data stored in a recirculating shift register travels through a sequence of shift registers and then "loops" around when it reaches the output end. This type of memory has only a single input port and single output port, and as such cannot be randomly accessed — data can only be read out when it is in the shift register connected to the output. Such memory is selected for speed of operation, such that data can be transmitted in parallel during transmission (Col. 5:30-45). Because no random-access of the video data is required, neither at the central data station nor at the data receiving station, use of recirculating shift registers substantially simplifies the system design, implementation, and operation — the addressing logic required for memory read operations is substantially simpler than if random access storage were used; in fact, it is eliminated. While random access requires that data locations are addressed, the recirculating shift register cycles through the data in a fixed order, and therefore no addressing logic is needed at all. Only the "next" location must be read, instead of providing the capabilities to be able to arbitrarily read any of the memory locations in any order. One of ordinary skill would understand that the use of random access storage would increase both the cost and complexity of the system for no reason, since it is not necessary for operation of the device to be able to randomly access the stored video.

47. Walter's central data station has no mechanism to record its stored programs onto a removable recording media.

48. Because Walter teaches that the source information arrives in the preprogrammed memory modules, there is no reason to include capabilities for receiving from a CD or erasable optical disc.

**Walter's Data Receiving Station Does Not Meet the Claim Limitations**

49. No compression is performed at the data receiving station, as its only task is to store and play back received content which is already compressed.

50. The memory in the data receiving station is of the same type as in the central data

station, and namely, of the recirculating shift register type. Because the only task of the data receiving station is to store and play back received content, random access to the memory contents is unnecessary.

51. One of ordinary skill would not use random access storage in the data receiving station for reasons discussed earlier regarding the memory in the central data station — it would add unnecessary complexity and cost.

52. The data receiving station performs no editing, as its only task is to store and play back received content.

**Tescher**

53. Tescher et al. describe a method for compression of video sequences and more particularly videoconferencing sequences. As such, Tescher is directed toward two-way, real-time video communication.

54. Tescher teaches a method for compression of videoconferencing signals. There is no indication that the blocks of the encoder as shown in Figure 1 would be in a common housing.

55. Tescher does not teach any editing of the compressed videoconference. Because of the real-time aspect of videoconferencing, editing is nonsensical.

56. Just as Kepley's voice mail message is not a work, Tescher's videoconference is not a work. Videoconferencing is a convenience for two-way real-time person-to-person communication, with the additional benefit over voice-only systems of allowing face-to-face communication. Real-time communication does not require the creative effort of a work.

**Tescher's system is for real-time video communication**

57. The operation of Tescher's system as described in the specification is very clearly for real-time video communication and not faster-than-real-time communication. Many indications throughout the specification make this clear. First, Tescher's system does not provide storage of the entire compressed sequence. While Figure 1 shows the output of coder 22 going to buffer 25, Col. 8:38-9:43 is dedicated to describing how the parameters during encoding are adjusted throughout the compression process to avoid buffer overflow, i.e., to avoid attempting to store more bits in the buffer than it can hold. Buffer 25 itself is described as having a "predetermined maximum capacity N." (Col 8:39). Were that maximum capacity able to hold the

entire compressed file, none of the parameter adjustment so carefully described would be needed.

58. Tescher's encoder does not contain random access storage or a magnetic disk. By virtue of the encoder's operation, such storage is not needed. The only memory taught is Tescher is input memory 13 and reference memory 14, each of which stores a single video field (comparable to a frame for the purposes of this discussion), diagonal memory 21 which stores 64 numbers, and buffer 25 which, as discussed in Paragraph 60, is of a fixed size and smaller than the entire compressed videoconference.

59. One of ordinary skill would recognize that the description of parameter adjustment is known as "rate control" and is a common requirement for video compression systems which employ real-time transmission, precisely to avoid buffer overflow as described.

60. Buffer 25 is described as "generating bits at the output thereof at a constant rate of $2.39 \times 10^5$ bits/sec. in the preferred embodiment." (Col. 8:41-43) These bits are then transmitted to the decoder which receives them in buffer 25'. One of ordinary skill would recognize that the output rate of the buffer corresponds to the bit rate of the communication link, which is between buffer 25 and buffer 25'. This link provides an effective link bandwidth as seen by the encoder (transmitter) and decoder (receiver) of 0.239 Megabits/second.

61. If Tescher's system were to be used in a faster-than-real-time video transmission system, the buffer size would have to be substantially increased relative to the size that a designer would select based on the specification description, and the buffer-overflow avoidance algorithm as described in Col. 8:38- 9:43 and in the claims would require complete redesign.

62. The specification refers to "real time signal processing" in describing both the motivation (Col. 2:11) and the invention (Col. 2:30). The only application which is explicitly mentioned, videoconferencing, is without question a real-time application requiring both real-time signal processing and real-time transmission. No faster-than-real-time communication of a real-time conversation is possible.

## Tescher's Data Rate of 0.239 Megabits/second is for videoconference sequences and not general video content and not full motion video

63. Both Dr. Wicker and Apple describe Tescher as achieving video compression to a data rate of 0.239 Megabits/second. This is a gross misrepresentation of what in fact Tescher discloses. The specification states that this rate is for a video teleconferencing system (Col 11:52-

12:8) and more specifically that this is the output rate of the buffer 25 (Col. 8:42). The buffer outputs its data at a constant rate (e.g., at 0.239 Megabits/second) over a communication link. (Col. 8:48, 10:3-7) Furthermore, the specification then goes on to say "In addition, for applications in which the amount of interframe image motion is excessive (i.e., greater than that normally present in video conferencing applications), a small block size may be necessary in order to provide decoded video signals of good subjective quality. Selection of smaller block sizes, however, increase the required minimum bit rate for the buffer units 25, 25'." (Col. 12:24-32).

64. Even without explicitly stating this limitation in the specification, one of skill in the art would recognize solely based on the data rate of 0.239 Megabits/second that the video content would be limited to videoconferencing or some other type of extremely limited motion video, such as video surveillance, and not to general-content video including full-motion video.

65. Were Tescher's compression algorithm used to compress general-content full-motion video (i.e., not videoconferencing or other extremely low-motion video) to a rate of 0.239 Megabits/second, the resulting video may be nearly unrecognizable if there is a great deal of movement in the sequence.

66. The input data rate described in Tescher is 16.5 Megabits/second. Col. 4:55-568 indicates that the input video is in NTSC format (comprising colloquially 30 frames/second or more accurately 60 interlaced fields/second), and is spatially sampled at "less than the standard rate" to the preferred embodiment rate of 256 lines/frame and 256 samples/line, with each sample represented by eight bits (Col 5:18). The two quadrature chrominance components (i.e., the color information) are represented by arrays of size 64 lines/frame and 64 samples/frame, with each sample represented by 6 bits. This yields an input data rate of 16.5 Megabits/second for the uncompressed digital video.

67. One of ordinary skill in the art would recognize that Tescher's described system could only achieve compression from 16.5 Megabits/second to 0.239 Megabits/second if the majority of the content in the sequence was *stationary and not moving*. Tescher's compression involves three steps: (1) an averaging of the input video frames[1], to minimize small differences in adjacent frames, (2) a comparison of each 8×8 pixel block in the current averaged frame with the

---

[1] Tescher describes operations on fields. To simplify the description, I will use the term frames. Tescher's specific use of fields or frames does not change the fundamental operation as described here.

8×8 pixel block in the identical location in the previous averaged frame, and (3) re-coding independently the block in the current averaged if the comparison indicated such coding should be performed. Below, I further describe each of these steps individually.

68. The first step, an averaging of the input video frames, is achieved by forming "new frame data" as

$$\text{new\_frame\_data} = 0.75 \times \text{previous\_frame} + 0.25 \times \text{new\_frame}$$

It is this "new frame data" which is the input to the compression algorithm. Consider an 8×8 pixel block which does not change between the previous_frame and new_frame — the pixels are identical. In this case, new_frame_data will be exactly equal to the pixel data in both the previous frame and the new frame. This situation occurs when there is no motion between the two frames; for example, as in the background of a videoconferencing set. On the other hand, if an 8×8 pixel block belongs to an object which moves in the time period between the previous_frame and the new_frame, the resulting new_frame_data will be blurred, similar to what happens when one's hand moves when taking a photograph.

69. Consider a videoconference sequence (often called a "head-and-shoulders" sequence in the compression literature). The vast majority of motion from frame-to-frame occurs in the speaker's eyes and mouth, with less in the face and potentially hands. The background, desk, and any other inanimate objects are immobile, and the speaker's torso will only exhibit minimal movement. In this situation, the vast majority of 8×8 blocks in any frame will not be substantially blurred by the averaging operation. On the other hand, a video sequence without such stationary content can generally be expected to have far more blocks which end up being blurred by the averaging operation prior to commencing the compression operation. Since it is the averaged frames which are input to the compression algorithm and then decompressed at the receiver, this blurring can make the received video content nearly unrecognizable if there is a great deal of movement in the sequence.

70. The second step performs a comparison of each 8×8 pixel block in the new_frame_data with the 8×8 pixel block in the identical location in the previous averaged frame (i.e., in the previous new_frame_data). This comparison is computed by subtracting one block from another, squaring each of the 64 differences (to obtain 64 positive numbers), and then adding up the 64 squared differences to obtain a single value. The comparison of two blocks with zero or minimal differences would yield a zero or very small value; the comparison of two blocks with

large differences would yield a large value.

71. The third step compares the value with a threshold. If the value is below the threshold, the blocks are judged to be identical and no new information is coded. If the value exceeds the threshold, the block is independently coded.

72. If the above compression operation is executed on two subsequent frames from a videoconferencing sequence, as taught in Tescher, very few blocks from any one frame are expected to differ enough to produce a value which would exceed the threshold (only those blocks corresponding to the eyes or mouth, in most cases, would change substantially). As such, very few blocks require coding, and the resulting compressed data bit rate will be quite low. Tescher's quoted compressed data rate for videoconferencing sequences supports this.

73. If, on the other hand, the above compression operation is executed on two subsequent frames from a generic video sequence, with content which is not known *a priori* to contain minimal frame-to-frame differences, many blocks in each frame may produce values above the threshold and therefore require coding. This will necessarily substantially raise the data rate above the 0.239 Megabits/second which Tescher mentions for videoconferencing sequences. Tescher specifically mentions the increased data rate for general content sequences at Col. 12:24-32.

**Tescher's system yields variable-bit-rate (VBR) video**

74. Tescher's system produces variable-bit-rate (VBR) encoded video. This means that each frame is represented by a variable number of bits and not a constant number of bits. Coder unit 22 employs Huffman coding, which is a well known variable rate lossless compression technique. Other coding strategies employed in Tescher that would be understood by one of ordinary skill to produce VBR-encoded video include run-length encoding (e.g., Col. 3:32-22, 3:39-44) and end-of-block symbols. (Col. 3:43-46).

75. The output buffer 25 generates bits at a constant rate (0.239 Megabits/second in the preferred videoconferencing application), which indicates that the *average* number of bits per frame is 239,000 bits/second / 30 frames/second = approximately 8000 bits/frame. But the purpose of the output buffer is to "accept[] binary input bits at a variable rate and generat[e] bits at the output thereof at a constant rate of $2.39 \times 10^5$ bits/second in the preferred embodiment." (Col. 8:40-43) These "input bits at a variable rate" are the output of the coder 22 and represent the

encoded video frames. While some frames may be represented using more than 8000 bits, others may be represented using fewer than 8000 bits. In fact, the purpose of the rate control algorithm is to control the variation in the number of bits/frame required to ensure that the buffer 25 does not overflow (i.e., that several frames in a row require too much bits such that the buffer's capacity is exceeded).

**Gremillet**

76. Gremillet teaches a method by which uncompressed digital audio data is transmitted from a distribution center to a subscriber unit. Such a description clearly indicates two separate locations to one of ordinary skill. As such, when considering whether Gremillet's system anticipates the Burst claims, the distribution center and the subscriber unit must be separately considered. Components from both the distribution center and the subscriber unit cannot be "mixed and matched" to provide the required elements. Apple's argument to simply place the distribution center and the subscriber unit together would be rejected by one of ordinary skill as creating a device which has useless excess equipment for the required tasks: those of a distribution center (in which case the subscriber unit, designed to operate in the customer's home, performs no useful function) and those of a subscriber unit (in which case the distribution center, which contains the bank of musical recordings from which the user requests material, performs no useful function and in fact defeats the purpose of having a repository from which the user can request material — if the user already had the material, he or she would not have to request it).

77. Gremillet does not teach that the distribution center is contained in a single housing. Because the distribution center is not consumer electronics equipment, it is unnecessary for this equipment to have a single housing, and desired expansion of the contents would suggest that a single housing would be impractical, for similar reasons previously described with respect to Walter in Paragraph 38.

78. The Gremillet specification does not teach the existence of input ports in the distribution center. While the specification states that "recording support can be a video disk or a video recorder" (Col. 3:41-42), no evidence that the recording occurs at the distribution center is given.

79. Gremillet addresses audio content only and not full-motion video.

80. Gremillet's system does not perform any data compression of any type on the

digitized audio signal. No data compression whatsoever is discussed in Gremillet and the specification offers a definition of compression as "The compression of the sound information can be obtained by writing into a memory and then reading from the memory at the accelerated speed." (Col. 3:42-44)

81. Apple suggests that the sentence "the information flow rate linked with classical music is approximately 0.5 Mbits/s" (Col 2:3-4) indicates that the audio data has been compressed because this value is less than that for CD-quality audio. As Apple indicated in their first summary judgment brief, "Uncompressed CD-quality audio is 44,100 samples per second and 16 bits per sample, meaning 705,600 bits/second." One of ordinary skill would understand Gremillet's statement to indicate that his system could use lower-resolution samples. Sampling at 40,000 samples per second (corresponding to twice the highest frequency in the range of human hearing; see Paragraph 20 in my previous declaration) with 12- or 13-bit samples yields a data rate which is reasonably approximated at 0.5 Mbits/second. Gremillet further states that "Naturally the numerical values given hereinbefore are only intended as examples for illustrating the operation of the system" (Col. 6:25-27) and one of ordinary skill would not therefore conclude that Gremillet performed any compression.

82. Further evidence of Gremillet's lack of data compression is found in Col. 2:37-39 where the inventor states that "the invention uses means, which, considered in isolation are in part known because they consist of telematic networks and recording means." The summarized operation of the system given in Col. 2:48-66 also includes no discussion of data compression. The subscriber equipment contains a "decelerator" which is also called a "rate converter" (Col. 3:14-17, 3:55-62) but no decompressor.

83. Col. 5:5-36 describes in detail the rate converter, which is illustrated in Figure 2. The operation of the device as described simply obtains the digital data from the storage (through an A/D converter), and then delivers it to the D/A converter for playback. No data decompression operations are described, because the signal is not data compressed.

84. The distribution center stores the audio for distribution on a video disk or a video recorder. (Col. 3:41-42) These were analog storage devices that did not provide random access. As such, Dr. Wicker's assertion that it would be obvious to substitute a known magnetic disk or disk array for the video recorder, both of which provide digital random access storage, for the distribution center is incorrect. The distribution center has no reason to employ random access

storage as no editing is performed and the data is accessed serially for transmission. The memory in the subscriber equipment is not random access but rather is described as a video recorder which provides serial access. Were the memory to be replaced with a digital memory, there is no motivation to employ a more expensive random-access storage for similar reasons described in Paragraph 45 above with respect to Walter. The data is serially accessed during playback, not randomly accessed. The system provides no editing capabilities, and hence there is no motivation to provide the capability of random access to the stored data.

85. Gremillet does not teach editing.

86. Gremillet does not teach receiving source information from CDs or erasable optical discs.

87. Gremillet delivers content to subscribers over a transmission channel, and does not include and further has no reason to include removable recording media at the distribution center.

**The combination of Tescher and Gremillet does not render the Burst claims obvious because such a combination would not work and is nonsensical**

88. One of ordinary skill would not be motivated to combine Tescher and Gremillet, and would immediately discard the combination as unworkable were it proposed. Gremillet teaches a method by which uncompressed digital audio data is transmitted from a distribution center to a subscriber unit. This involves a one-way transmission. Tescher describes a method for compression of video sequences and more particularly videoconferencing sequences for two-way, real-time video communication.

89. Because of real-time nature of videoconferencing, “burst” transmission of a videoconference is impossible.

90. Gremillet teaches that the video recorder reads the signal and delivers it to the A/D converter in fixed-size pieces (Col. 6:5-24). Gremillet’s discussion gives an example of reading a piece of data corresponding to a picture, and relates how a fixed-size piece of data corresponds to a length of sound (e.g., “...a complete picture corresponds to (200)/(25) = 8 seconds of sound and a segment of 1/10 of a picture of 0.8 s of sound. This is the switching period of the writing and reading phases in the rate converter.” Col. 6:19-24).

91. Because Gremillet’s system reads fixed-size pieces of data, and because the digital audio data is uncompressed and therefore corresponds to a fixed data rate (e.g., 0.5 Mbit/s for the

sake of argument), Gremillet's system *operates on a fixed number of bits in each readout/playback cycle.*

92. Simply inserting Tescher's compression algorithm into Gremillet's system would not work because Gremillet's system is fundamentally designed to work on fixed-rate data, and Tescher's compression algorithm fundamentally produces variable-rate data. Were Tescher's data stream to be used in Gremillet's system by insertion of a decompressor at the subscriber unit, the decompressor would be unable to decode a viewable videoconferencing sequence. The fixed number of bits might correspond to less than the number of bits for an entire frame at some point (in which case even that single frame could not be decoded, and no viewable frame could be decoded), and at another point the same number of fixed bits might correspond to greater than three frames (in which case three viewable frames might be decoded, but the remaining "extra" bits would cause no output). Furthermore, if the first bit in the fixed number of bits did not correspond exactly to the first encoded bit of a frame, the decoder would be unable to parse (i.e., understand) the bitstream in any manner.

93. Creating a working system would require substantial control apparatus being added to Gremillet, and potential modifications of the format of the encoded data in Tescher's system.

## One of ordinary skill would not be motivated to combine Kepley with other references

94. Kepley teaches a voice mail system for speech. This system does not deal with either general wideband audio content, nor video. I have described at length how speech and wideband audio are different and the processing systems are different. Video provides an even greater contrast with speech, in that it is a three-dimensional signal which is viewed and not listened to, and the accompanying audio with video in a system that processes general-content video and audio is expected to be general wideband content rather than only speech. Because of these fundamental differences between speech and both wideband audio and video, one of ordinary skill would not be motivated to combine Kepley with other references that address wideband audio and/or video. Additionally, the other prior art references are very different from Kepley. Kramer describes an "encoding system" at a commercial record store. Walter describes a video-on-demand system. Tescher describes a method for compression for videoconferencing sequences for two-way, real-time video communication. Gremillet describes a "music-on-

demand" system. One of ordinary skill would not be motivated to combine a voice mail system for speech with any of these references.

### One of ordinary skill would not be motivated to combine CompuSonics with other references

95. The CompuSonics DSP-2000 provided audio recording-studio capabilities digitally rather than in the traditional manner of using analog magnetic tapes. It was not designed for and nor could it be adapted to video. As such, one of ordinary skill would not be motivated to combine the CompuSonics DSP-2000 with either Walter or Tescher. Such a combination is technically nonsensical.

96. Gremillet and Kramer involve distribution of music. This is unrelated to audio recording-studio capabilities and one of ordinary skill would not be motivated to combine the CompuSonics DSP-2000 with either Gremillet or Kramer.

### Kramer does not teach a single housing for the encoding system

97. Nothing in the Kramer specification indicates that the encoding system has a single housing.

98. Attached to this declaration as Exhibit 3 is a true and correct copy of my expert report that was served August 24, 2007 entitled "Infringement Regarding Compression: Expert Report of Dr. Sheila S. Hemami."

**References Cited**

[Exhibit 1] Slide 5 from my Markman Tutorial

[Exhibit 2] Slide 55 from my Markman Tutorial

[Exhibit 3] "Infringement Regarding Compression: Expert Report of Dr. Sheila S. Hemami" served August 24, 2007

---

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that, based on my knowledge, qualifications, and experience, I am prepared to testify on the subjects addressed herein.

EXECUTED on August 28, 2007 at Ithaca, New York.

Sheila S. Hemami

Sheila S. Hemami, Ph.D.

## Appendix A

# Curriculum Vitae of Sheila S. Hemami

School of Electrical & Computer Engineering, Cornell University
332 Frank H. T. Rhodes Hall, Ithaca, NY 14853
(607) 254-5128 hemami@ece.cornell.edu http://foulard.ece.cornell.edu

## Education

Stanford University — Stanford, CA
Ph.D. in Electrical Engineering, December 1994.

Stanford University — Stanford, CA
M.S. in Electrical Engineering, April 1992.

University of Michigan — Ann Arbor, MI
B.S. in Electrical Engineering, Summa Cum Laude, May 1990.

## Professional Experience

Cornell University — Ithaca, NY
Professor, School of Electrical & Computer Engineering, November 2006-present
Associate Professor, School of Electrical & Computer Engineering, November 2000-October 2006.
Assistant Professor, School of Electrical Engineering, January 1995 - October 2000.

Hewlett Packard Laboratories — Palo Alto, CA
Member of Technical Staff, February-December 1994, Interactive Video Initiative: Multimedia Systems & Community Networking Group.

Visiting Positions: Visiting Fellow, Princeton University Dept. of Electrical Engineering, Fall 2001; Texas Instruments Associate Professor of Electrical Engineering, Rice University, Spring 2002.

## External Research Funding

### Sponsored Research

National Science Foundation, “ACCEL: Advancing Cornell’s Commitment to Excellence and Leadership (Cornell University ADVANCE Proposal),” $3,300,000, November 2006-October 2011 (1 of 5 Co-PIs).

National Science Foundation, “A Signal Processing. Approach to Modeling Visual Masking,” $255,873, July 2005-June 2008 (sole PI)

National Science Foundation, “A Framework for Encoding American Sign Language and Other Structured Video,” joint with University of Washington, $269,584 for Cornell, July 2005-June 2008 (1 of 3 Co-PIs)

National Science Foundation, “Workshop Series on Starting Successful Faculty Careers,” $20,000, September 2004-December 2005 (1 of 2 Co-PIs)

National Science Foundation, “Nomination of Professor Robert M. Gray for a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring,” $10,000 (to Stanford, matched by Stanford to fund a mentoring workshop) (1 of 4 Co-PIs)

Department of the Navy, “Channel and QOS Adaptive Wireless Multimedia Ad-hoc Networks,” $4,500,000, 1999-2004 (1 of 7 Co-PIs)

Department of Energy, “Visually Optimized Scalable Image Compression,” May 1999-April 2002, $309,000 (sole PI)

National Science Foundation, “Visually Optimized Supra-threshold Image Compression,” May 1999-April 2002, $205,000 (sole PI)

National Science Foundation Career Award, “Robust Visual Communications for Packet Networks,” May 1997 - April 2001, $209,000 (sole PI)

Department of Energy, “Visual Communications for Heterogeneous Networks,” September 1995 - August 1998, $375,000 (sole PI)

National Science Foundation, “A Next Generation Computing and Communication Substrate,” July 1997 - June 2002, $1,000,000 (1 of 16 Co-PIs)

**Corporate Sponsors**

Lockheed-Martin, Tektronix Corporation, Eastman Kodak Company, AT&T, GTE, Intel, Center for Electronic Imaging & Science (New York State)

## Memberships

IEEE (Senior Member), Tau Beta Pi, Eta Kappa Nu

Graduate fields of electrical engineering, computer science, and applied math at Cornell

## Professional Service Activities

Chair, Image & Multidimensional Signal Processing Technical Committee (IMDSP TC) of the IEEE, 2006-7; general member, October 2001-present (includes program committee duties for ICASSP & ICIP); Awards Subcommittee Chair, 2005

Technical Co-Chair, IMDSP Workshop on Image and Video Quality, June 2007

Program Committee Member: Human Vision and Electronic Imaging, 2007; Video Processing and Quality Metrics, 2006-present; Visual Communications and Image Processing, 2006; Asilomar Conference on Signals, Systems, and Computers, 2005; Data Compression Conference, 2003-present

Organizing/Program Committee, PAESMEM/Stanford School of Engineering Workshop on Mentoring in Engineering, June 2004

Associate Editor, *IEEE Transactions on Signal Processing*, August 2000-April 2006

IEEE International Conference on Image Processing — 2002 Publicity Chair

Reviewer: *National Science Foundation, IEEE Transactions on Signal Processing, IEEE Transactions on Image Processing, IEEE Transactions on Circuits & Systems for Video Technology, IEEE Transactions on Communications, IEEE Proceedings, Journal of Visual Communication and Image Representation, SPIE Journal of Electronic Imaging*.

## Awards and Honors

Constance E. Cook and Alice H. Cook Recognition Award, 2005 (from the Cornell University Advisory Council on the Status of Women)

Cornell University College of Engineering Faculty Diversity Award, 2005

Joel & Ruth Spira Excellence in Teaching Award (Cornell), 2004

Elected Senior Member of the IEEE, 2003

Eta Kappa Nu Outstanding Young Electrical Engineer Finalist, 2002

Fulbright Distinguished Lecturer, Morocco, 2001

HKN C. Holmes MacDonald Outstanding Teaching Award, 2000

National Science Foundation CAREER Award, 1997

Kodak Term Professor of Electrical Engineering, 1997, 1998, 1999

Lilly Teaching Fellowship, 1996-7

Cornell College of Engineering Michael Tien ‘72 Teaching Award, 1996-7, 1999-2000.

## Graduate Students

### Ph.D. Students Graduated

Matt Gaubatz, Ph.D., May 2006, “Practical Rate-Control Tools for Wavelet-Based Image Compression” (Hewlett-Packard)

Chao Tian, Ph.D., August 2005, “Multiple Description Quantization: Improvement and New Approach” (Ecole Polytechnic Federale de Lausanne, Switzerland)

Yegnaswamy Sermadevi, Ph.D., August 2005, “Optimal bit allocation for efficient encoding and transmission of video” (Microsoft)

Damon M. Chandler, Ph.D., May 2005, “Visual Detection and Perception of Distortion in Wavelet-Compressed Images” (Oklahoma State University)

Mark A. Masry, Ph.D., January 2004, “Perceptual Metrics for Video Quality Evaluation and Image Watermarking” (CARIS, Fredrickton, New Brunswick)

Aaron Deever, Ph.D. (Applied Math), November 2000, “Projection-based Techniques for Lossy and Lossless Wavelet Image Compression,” (Eastman Kodak Research Labs, Rochester, NY)

Marcia Ramos, Ph.D., May 2000, “Perceptually-Based Image Coding” (Dorsey & Whitney, LLP)

Yan Yang, Ph.D., January 2000, “Rate Control for Video Coding and Transmission” (Infineon, Shanghai, China)

Knox Carey, Ph.D., August 1999, “Applications of Wavelet Coefficient Decay” (previously of InterTrust, San Jose, CA)

21 Masters of Engineering graduates, 2 Masters of Science graduates

**Current Ph.D. students**
Frank Ciaramello, David Rouse

## Teaching

Image & Video Coding Standards Seminar — senior/1st-year-graduate JPEG/MPEG course.
Visual Motion Seminar — 1st-year-graduate "short course."
Digital Signal Processing — senior-level Oppenheim & Schafer-style course.
Introduction to Digital Signal Processing — junior-level Oppenheim & Schafer-style course.
Signals & Information: Multimedia Signal Processing — sophomore-level DSP course.
Statistical Signal Processing — senior/1st-year-graduate course.
Digital Image Processing — graduate course.
Wiener & Kalman Filtering — advanced graduate course.

## Publications

### Refereed Journal Publications

1. D. M. Chandler, S. S. Hemami, "VSNR: A visual signal-to-noise ratio for natural images based on near-threshold and supra-threshold vision," to appear in *IEEE Transactions on Image Processing*.
2. M. D. Gaubatz, S. S. Hemami, "Efficient entropy estimation with doubly stochastic models for quantized wavelet image data," *IEEE Transactions on Image Processing*, Volume 16, Issue 4, April 2007, pp. 967 - 981 .
3. M. D. Gaubatz, S. S. Hemami, "Ordering for Embedded Coding of Wavelet Image Data Based on Arbitrary Scalar Quantization Schemes," *IEEE Transactions on Image Processing*, Volume 16, Issue 4, April 2007, pp. 982 - 996.
4. M. D. Gaubatz, S. S. Hemami, "Robust rate-control for wavelet-based image coding via Bootstrapping with Probability Models," *IEEE Transactions on Image Processing*, Volume 16, Issue 3, March 2007, pp. 649 - 663.
5. J. Chen, C. Tian, T. Berger, S. S. Hemami, "Multiple description quantization via Gram-Schmidt Orthogonalization," *IEEE Transactions on Information Theory*, Volume 52, Issue 12, Dec. 2006, pp. 5197 - 5217.
6. Y. Sermadevi, "Convex programming formulations for rate allocation in video coding," *IEEE Transactions on Circuits and Systems for Video Technology*, August 2006
7. M. A. Masry, S. S. Hemami, "A wavelet-based scalable video quality metric and applications," *IEEE Transactions on Circuits and Systems for Video Technology*, February 2006.
8. C. Tian, S. S. Hemami, "A new class of multiple description scalar quantizer and its application to image coding," *IEEE Signal Processing Letters*, Vol. 12, No. 4, pp. 329-332, April 2005.

9. D. M. Chandler, S. S. Hemami, "Dynamic contrast-based quantization for lossy wavelet image compression," *IEEE Transactions on Image Processing*, Vol. 14, No. 4, pp. 397-410, April 2005.
10. C. Tian, S. S. Hemami, "On the analysis of multiple description lattice vector quantization," *IEEE Transactions on Information Theory*, Vol. 50, No. 10, pp. 2458-70, October 2004.
11. C. Tian, S. S. Hemami, "Universal multiple description scalar quantization: analysis and design," *IEEE Transactions on Information Theory*, Vol. 50, No. 9, pp. 2089-2102, September 2004.
12. M. A. Masry, S. S. Hemami, "A metric for continuous quality evaluation of compressed video with severe distortions," *Signal Processing: Image Communication*, Vol. 19, No. 2, pp. 133-46, February 2004.
13. W. Xu, S. S. Hemami, "Robust adaptive transmission of images and video over multiple channels," *Signal Processing: Image Communication*, Vol. 18, No. 10, pp. 981-1000, November 2003.
14. D. M. Chandler, S. S. Hemami, "Effects of natural images on the detectability of simple and compound wavelet subband quantization distortions," *Journal of the Optical Society of America:A.*, July 2003.
15. A. T. Deever, S. S. Hemami, "Efficient sign coding and estimation of zero-quantized coefficients in embedded wavelet image codecs," *IEEE Transactions on Image Processing*, Vol. 12, No. 4, pp. 420-30, April 2003.
16. A. T. Deever, S. S. Hemami, "Projection-based modelling and context modelling for lossless image compression," *IEEE Transactions on Image Processing*, Vol. 12, No. 5, pp. 489-99, May 2003.
17. M. G. Ramos, S. S. Hemami, "Supra-threshold wavelet coefficient quantization in complex stimuli: psychophysical evaluation and analysis," *Journal of the Optical Society of America:A*, October 2001.
18. Y. Yang, S. S. Hemami, "Rate control for VBR video over ATM networks: simplification and implementation," *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. 11, No. 9, pp. 1045-58, September 2001.
19. Y. Yang, S. S. Hemami, "Generalized rate-distortion optimization for motion-compensated video coding," *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. 10, No. 6, pp. 942-55, September 2000.
20. S. S. Hemami, "Robust image transmission using resynchronizing variable-length codes," *IEEE Journal on Selected Areas in Communications, Special Issue on Error Resilient Image and Video Transmission*, Vol. 18, No. 6, pp. 927-39, August 2000.
21. W. K. Carey, S. S. Hemami, P. N. Heller, "Smoothness-Constrained Wavelet Image Compression," *IEEE Transactions on Image Processing*, Vol. 8, No. 12, pp. 1807-1811, December 1999.
22. G. C. Conklin, S. S. Hemami, "A Comparison of Temporal Scalability Techniques," *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. 9, No. 6, pp. 909-19, September 1999.

23. W. K. Carey, D. B. Chuang, S. S. Hemami, “Regularity-Preserving Image Interpolation,” *IEEE Transactions on Image Processing,* Vol. 8, No. 9, pp. 1293-7, September 1999.
24. M. G. Ramos, S. S. Hemami, “Perceptually-Based Scalable Image Compression for Packet Networks,” *Journal of Electronic Imaging, special issue on Image/Video Compression and Processing for Visual Communications,* Vol. 7, No. 3, pp. 453-64, July 1998.
25. S. S. Hemami, R. M. Gray, “Subband Coded Image Reconstruction for Lossy Packet Networks,” *IEEE Transactions on Image Processing,* Vol. 6, No. 4, pp. 523-39, April 1997.
26. S. S. Hemami, R. M. Gray, “Subband Filters Optimized for Lost Coefficient Reconstruction,” *IEEE Transactions on Signal Processing,* Vol. 45, No. 3, pp. 763-7, March 1997.
27. S. S. Hemami, “Reconstruction-Optimized Lapped Orthogonal Transforms for Robust Image Transmission,” *IEEE Trans. Circuits & Systems for Video Technology, special issue on Wireless Visual Communications*, Vol. 6, No. 2, pp. 168-81, April 1996.
28. S. S. Hemami, T. H.-Y. Meng, “Transform Coded Image Reconstruction Exploiting Interblock Correlation,” *IEEE Transactions on Image Processing*, Vol. 4, No. 7, pp. 1023-6, July 1995.

**Conference Publications/Presentations**

29. Rahul Vanam, Eve A. Riskin, Sheila S. Hemami, Richard E. Ladner, “Distortion-Complexity Optimization of the H.264/MPEG-4 AVC Encoder using the GBFOS Algorithm,” *Data Compression Conference, 2007,* March 2007.
30. D. M. Rouse, S. S. Hemami, “Quantifying the use of structure in cognitive tasks,” *Human Vision and Electronic Imaging*, San Jose, CA, January 2007.
31. F. Ciaramello, S. S. Hemami, “Can you see me now? An objective metric for predicting intelligibility of compressed American Sign Language video,” *Human Vision and Electronic Imaging*, San Jose, CA, January 2007.
32. M. D. Gaubatz, S. Kwan, S. S. Hemami, “The role of spatially adapted versus non-spatially adapted structural distortion in supra-threshold compression,” *Human Vision and Electronic Imaging*, San Jose, CA, January 2007.
33. M. D. Gaubatz, S. Kwan, B. Chern, D. M. Chandler, S. S. Hemami, “Spatially adaptive wavelet image compression via structural masking,” *ICIP 2006*.
34. C. Tian, S. S. Hemami, “Visually optimized multiple description image coding,” *ICASSP 2006*.
35. M. Gaubatz, A. Vosoughi, A. Scaglione, S. S. Hemami, “Efficient, low complexity encoding of multiple burred noisy downsampled images via distributed source coding principles,” *ICASSP 2006*.
36. D. C. Chandler, K. L. Lim, S. S. Hemami, “Effects of spatial correlations and global precedence on the visual fidelity of distorted images,” *Human Vision and Electronic Imaging*, San Jose, CA, January 2006.

37. S. S. Hemami, D. C. Chandler, B. G. Chern, J. A. Moses, “Suprathreshold visual psychophysics and structure-based visual masking,” *Visual Communication and Image Processing*, San Jose, CA, January 2006.
38. M. D. Gaubatz, S. S. Hemami, “Fast Accurate Rate Control for Low-Rate Wavelet-Based Image Coding via Bootstrapping,” *IEEE International Conference on Image Processing*, Genoa, Italy, September 2005.
39. J. Chen, C. Tian, S. Hemami, T. Berger, “A new class of universal multiple description lattice quantizers,” *IEEE International Symposium on Information Theory*, Adelaide, Australia, September 2005.
40. M. D. Gaubatz, D. M. Chandler, S. S. Hemami, “Spatially selective quantization and coding for wavelet-based image compression,” *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Philadelphia, PA, March 2005.
41. S. S. Hemami, “Robust Video Coding — An Overview,” *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Philadelphia, PA, March 2005.
42. Y. Sermadevi, S. S. Hemami, “Bit allocation in video is easy,” *Data Compression Conference*, Snowbird, Utah, March 2005.
43. C. Tian, S. S. Hemami, “Staggered Lattices in Multiple Description Quantization,” *Data Compression Conference*, Snowbird, Utah, March 2005.
44. C. Tian, J. Chen, S. S. Hemami, “Multiple descriptions with central refinement,” *39th Annual Conference on Information, Sciences, and Systems* (CISS), Baltimore, MD, March 2005.
45. D. M. Chandler, N. L. Dykes, S. S. Hemami, “Visually lossless compression of digital radiographs based on contrast sensitivity and visual masking,” *SPIE Medical Imaging: Image Perception, Observer, and Technology Assessment*, San Diego, CA, February 2005.
46. M. D. Gaubatz, D. M. Chandler, S. S. Hemami, “Spatial quantization via local texture masking,” *SPIE Human Vision and Electronic Imaging 2005*, Santa Clara, CA, January 2005.
47. Y. Sermadevi, S. S. Hemami, “Convexity results for a predictive video coder,” *Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, November 2004.
48. C. Tian, S. S. Hemami, “An embedded image coding system based on tarp filter with classification,” *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Montreal, CA, May 2004.
49. M. Gaubatz, S. S. Hemami, “Scalable image embeddings from arbitrary wavelet-based perceptual models,” *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Montreal, CA, May 2004.
50. W. Xu, S. S. Hemami, “Distortion optimized multiple channel transmission under delay constraints,” *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Montreal, CA, May 2004.
51. C. Tian, S. S. Hemami, “Sequential design of multiple description scalar quantizers,” *Data Compression Conference*, Snowbird, Utah, March 2004.

52. Y. Sermadevi, S. S. Hemami, “Efficient bit allocation for dependent video coding,” *Data Compression Conference*, Snowbird, Utah, March 2004.
53. M. D. Gaubatz, S. S. Hemami, “Local entropy estimation for low rate wavelet image coding,” *38th Annual Conference on Information, Sciences, and Systems* (CISS), Princeton, NJ, March 2004.
54. Y. Sermadevi, M. A. Masry, S. S. Hemami, “Rate control with a perceived quality metric,” *Visual Communications and Image Processing*, Santa Clara, CA, January 2004.
55. D. M. Chandler, M. A. Masry, S. S. Hemami, “Quantifying the visual quality of wavelet-compressed images based on local contrast, visual masking, and global precedence,” *Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, November 2003.
56. M. A. Masry, D. M. Chandler, S. S. Hemami, “Digital watermarking using local contrast-based texture masking,” *Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, November 2003.
57. G. Yadavalli, M. A. Masry, S. S. Hemami, “Frame rate preferences in low bit rate video,” *IEEE International Conference on Image Processing*, Barcelona, Spain, September 2003.
58. Y. Sermadevi, S. S. Hemami, “Linear approximations and linear programming for video rate control,” *IEEE International Conference on Image Processing*, Barcelona, Spain, September 2003.
59. W. Xu, S. S. Hemami, “Delay-optimized robust transmission of images over multiple channels,” *International Conference on Multimedia and Exposition*, Baltimore, MD, March 2003.
60. C. Tian, S. S. Hemami, “Universal multiple description scalar quantization: analysis and design,” *Data Compression Conference 2003*, Snowbird, Utah, March 2003.
61. Y. Sermadevi, S. S. Hemami, “Linear programming optimizations for video coding under multiple constraints,” *Data Compression Conference 2003*, Snowbird, Utah, March 2003.
62. C. Tian, S. S. Hemami, “On the asymptotic analysis of multiple description scalar quantization,” *37th Annual Conference on Information, Sciences, and Systems*, Baltimore, MD, March 2003.
63. D. M. Chandler, S. S. Hemami, “Suprathreshold image compression based on contrast allocation and global precedence,” *Human Vision and Electronic Imaging 2003.*
64. M. A. Masry, S. S. Hemami, “CVQE: a continuous video quality evaluation model for low bit rates,” *SPIE Human Vision and Electronic Imaging 2003.*
65. D. M. Chandler, S. S. Hemami, “Contrast-based quantization and rate control for wavelet-coded images,” *Proceedings IEEE Intl. Conf. Image Processing*, Rochester, NY, September 2002. Winner (2nd prize), Best Student Paper Award.
66. M. A. Masry, S. S. Hemami, “Perceived quality metrics for low bit rate compressed video,” *Proceedings IEEE Intl. Conf. Image Processing*, Rochester, NY, September 2002.

67. W. Xu, S. S. Hemami, “Efficient partitioning of unequal error protected MPEG video streams for multiple channel transmission,” *Proceedings IEEE Intl. Conf. Image Processing*, Rochester, NY, September 2002.
68. D. M. Chandler, S. S. Hemami, “Additivity models for suprathreshold distortion in quantized, wavelet-coded images,” *Proceedings SPIE Human Vision and Electronic Imaging*, San Jose, CA, January 2002.
69. M. Masry, S. S. Hemami, “Subjective quality evaluation of low-rate video,” *Proceedings IEEE Intl. Conf. Image Processing*, Thessaloniki, Greece, October 2001.
70. S. S. Hemami, M. G. Ramos, “Quantifying Visual Distortion in Low-Rate Wavelet-Coded Images,” *Proceedings IEEE Intl. Conf. Image Processing*, Thessaloniki, Greece, October 2001.
71. S. S. Hemami, “Supra-threshold wavelet coefficient quantization in natural images: analysis and application to compression,” *Int. Conf. on Image and Signal Processing*, Agadir, Morocco, May 2001.
72. M. Masry, S. S. Hemami, W. Osberger, A. M. Rohaly, “Subjective quality evaluation of low-rate video,” *Proceedings SPIE Human Vision and Electronic Imaging*, San Jose, CA, January 2001.
73. Y. Yang, S. S. Hemami, “Rate-distortion optimization for region- and object-based wavelet video coding,” *Proceedings Thirty-fourth Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, October 2000.
74. A. T. Deever, S. S. Hemami, “Scalable Image Coding with Projection-Based Context Modelling,” *Proceedings IEEE Intl. Conf. Image Processing*, Vancouver, BC, September 2000.
75. M. Masry, S. S. Hemami, “Data Hiding in Images with Psychovisual Thresholding,” *Proceedings IEEE Intl. Conf. Image Processing*, Vancouver, BC, September 2000.
76. M. Eoin Buckley, M. G. Ramos, S. S. Hemami, S. B. Wicker, “Perceptually-based Robust Image Transmission over Wireless Channels,” *Proceedings IEEE Intl. Conf. Image Processing*, Vancouver, BC, September 2000.
77. M. G. Ramos, S. S. Hemami, “Perceptual Quantization for Wavelet-Based Image Coding,” *Proceedings IEEE Intl. Conf. Image Processing*, Vancouver, BC, September 2000.
78. A. T. Deever, S. S. Hemami, “What’s Your Sign? Efficient Sign Coding in an Embedded Wavelet Image Coder,” *Proceedings Data Compression Conference , Snowbird, UT, March 2000*.
79. Y. Yang, S. S. Hemami, “Separate Source and Channel Rate Selection for Video over ATM,” *Proceedings Data Compression Conference, Snowbird, UT, March 2000*.
80. S. S. Hemami, M. G. Ramos, “Wavelet coefficient quantization to produce equivalent visual distortion in complex stimuli,” *Proceedings of SPIE Human Vision & Electronic Imaging*, San Jose, CA, Jan. 2000.

81. Y. Yang, S. S. Hemami, "Minmax Frame Rate Control using a Rate-Distortion-Optimized Wavelet Coder," *Proceedings of IEEE Int. Conf. on Image Processing*, Kobe, Japan, Oct. 1999.
82. S. S. Hemami, "Distortion Analyses for Temporal Scalability Coding Techniques," *Proceedings of IEEE Int. Conf. on Image Processing*, Kobe, Japan, Oct. 1999.
83. Y. Yang, S. S. Hemami, "VBR Rate-distortion optimization for a motion compensated video coder," *Proceedings of IEEE Int. Conf. on Image Processing*, Kobe, Japan, Oct. 1999.
84. Y. Yang, S. S. Hemami, "A rate-distortion optimized wavelet video coder," *Proceedings of Picture Coding Symposium*, Portland, OR, April 1999, pp. 61-4.
85. S. S. Hemami, T. Chang, R. Lau, "Resynchronizing Variable-Length Codes for Robust Image Transmission," *Data Compression Conference*, Snowbird Utah, April 1999, pp. 529.
86. M. G. Ramos, S. S. Hemami, "Activity-Selective SPIHT Coding," *Proceedings SPIE Visual Communications & Image Processing*, Vol. 3653, Pt. 1, San Jose, CA, Jan. 1999, pp. 315-26.
87. A. T. Deever, S. S. Hemami, "Dense Motion Field Reduction for Motion Estimation," *Thirty-second Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 1998, Vol. 2, pp. 944-8.
88. Y. Yang, S. S. Hemami, "Rate-distortion-based Combined Motion Estimation and Segmentation," *IEEE Int. Conference on Image Processing*, Chicago, IL, Oct. 1998, Vol. 3, pp. 920-4.
89. W. K. Carey, L. A. Von Pischke, S. S. Hemami, "Rate-distortion Based Scalable Progressive Image Coding," *SPIE Conf. on Mathematics of Data and Image Coding, Compression, and Encryption*, San Diego, CA, July 1998, Vol. 3456, pp. 197-208.
90. S. S. Hemami, "Visual Sensitivity Considerations for Subband Coding," *Proceedings of Thirty-first Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 1997, Vol. 1, pp. 652-6.
91. Y. Yang, S. S. Hemami, "Rate-Constrained Motion Estimation and Perceptual Coding," *Proceedings of IEEE Int. Conference on Image Processing*, Santa Barbara, CA, Oct. 1997, Vol. 1, pp. 81-4.
92. M. G. Ramos, S. S. Hemami, "Psychovisually-Based Multiresolution Image Segmentation," *Proceedings of IEEE Int. Conference on Image Processing*, Santa Barbara, CA, Oct. 1997, Vol. 3, pp. 66-9.
93. G. J. Conklin, S. S. Hemami, "Evaluation of Temporally Scalable Video Coding Techniques," *Proceedings of IEEE Int. Conference on Image Processing*, Santa Barbara, CA, Oct. 1997, Vol. 2, pp. 61-4.
94. W. K. Carey, D. B. Chuang, S. S. Hemami, "Regularity-Preserving Image Interpolation," *Proceedings of IEEE Int. Conference on Image Processing*, Santa Barbara, CA, Oct. 1997, Vol. 1, pp. 901-4.
95. G. Conklin, S. S. Hemami, "Multiresolution Motion Estimation," *Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Munich, Germany, April 1997, pp. 2873-6.

96. M. G. Ramos, S. S. Hemami, “Robust Image Coding with Perceptual-Based Scalability,” *Proceedings Data Compression Conference ‘97*, Snowbird, Utah, March 1997, p. 466.
97. W. K. Carey, S. S. Hemami, P. Heller, “Smoothness-Constrained Wavelet Image Compression,” *Proceedings IEEE International Conference on Image Processing*, Lausanne, Switzerland, September 1996, pp. 569-72.
98. S. S. Hemami, “Reconstruction-Optimized Lapped Orthogonal Transforms,” *Proceedings of IEEE ICASSP ‘96*, Atlanta, Georgia, May 1996, pp. 1542-5.
99. M. Ramos, S. S. Hemami, “Edge-Adaptive JPEG Image Compression,” *Proceedings of SPIE Conference on Visual Communications and Image Processing*, Orlando, Florida, March 1996, pp. 1082-93.
100. M. Ramos, S. S. Hemami, “Eigenfeatures Coding of Videoconferencing Sequences,” *Proceedings of SPIE Conference on Visual Communications and Image Processing*, Orlando, Florida, March 1996, pp. 100-10.
101. S. S. Hemami, “Digital Image Coding for Robust Multimedia Transmission,” *Proceedings of Symposium on Multimedia Communications and Video Coding*, New York, October 1995, pp. 491-98.
102. S. S. Hemami, R. M. Gray, “Subband Filters Designed for Lost Coefficient Reconstruction,” *Proceedings of IEEE ICASSP ‘95*, Detroit, Michigan, April 1995, pp. 1520-3.
103. S. S. Hemami, R. M. Gray, “Subband Coded Image Reconstruction for Lossy Packet Networks,” *Proceedings of The Twenty Eighth Asilomar Conference on Signals, Systems, and Computer*s, October 1994. pp. 497-91.
104. S. S. Hemami, R. M. Gray, “Image Reconstruction Using Vector Quantized Linear Interpolation,” *Proceedings of IEEE ICASSP ‘94*, Adelaide, Australia, April 1994, pp. 629-32.
105. T.-H. Meng, E. K. Tsern, A. C. Hung, S. S. Hemami, B. M. Gordon, “Video Compression for Wireless Communications,” *Proceedings of Virginia Tech’s Third Symposium on Wireless Personal Communications*, Blacksburg, VA, June 1993, pp. 1-17.
106. S. S. Hemami, T. H.-Y. Meng, “Reconstruction of Lost Transform Coefficients Using a Smoothing Criterion,” *Proceedings of 1993 Picture Coding Symposium*, Lausanne, Switzerland, March 1993.

**Book Chapters & Other**

107. E. Riskin, M. Ostendorf, P. Cosman, M. Effros, J. Li, S. Hemami, R. M. Gray, ed., “Mentoring for Academic Careers in Engineering: Proceedings of the PAESMEM/Stanford School of Engineering Workshop,” Graphics Publishing, 2005.
108. S. S. Hemami, “Robust image communication over wireless channels,” *IEEE Communications Magazine*, November 2001.
109. S. S. Hemami, “Image Compression,” *Image Databases: Search and Retrieval of Digital Imagery*, L. Bergman and V. Castelli, ed., John Wiley & Sons, 2001.

110. S. S. Hemami, R. M. Gray, "Subband Coding for Lossy Packet Networks," in *Recovery Techniques for Image and Video Compression and Transmission*, A. Katsaggelos and N. Galatsanos, ed., Kluwer Academic Publishers, October 1998.

**Workshop Presentations**

111. F. Ciaramello, S. S. Hemami, "Can you see me now? An objective metric for predicting intelligibility of compressed American Sign Language video," *Video Processing and Quality Monitoring Workshop*, Scottsdale, AZ, January 2007.
112. D. M. Rouse, S. S. Hemami, "Quantifying the Use of Structure in Cognition," *Western New York Image Processing Workshop*, Rochester, NY, September 2006, Winner, best student presentation.
113. F. Ciaramello, S. S. Hemami, "'Can you see me now?' An Objective Metric for Predicting the Intelligibility of Compressed American Sign Language Video," *Western New York Image Processing Workshop*, Rochester, NY, September 2006.
114. F. Ciaramello, S. S. Hemami, A. Cavender, R. Ladner, E. Riskin, "Predicting Intelligibility of Compressed American Sign Language Video with Objective Quality Metrics," *Video Processing and Quality Monitoring Workshop*, Scottsdale, AZ, January 2006.
115. S. S. Hemami, "A Signal Processor's Approach to Modeling the Human Visual System, and Applications," *Mathematics and Multimedia Workshop*, Banff, Alberta, Canada, July 2005.
116. S. S. Hemami, M. A. Masry, "A scalable video quality metric and applications," *Video Processing and Quality Monitoring Workshop*, Scottsdale, AZ, January 2005.
117. C. Tian, S. S. Hemami, "A special class of multiple description scalar quantizers," *IEEE Information Theory Workshop*, Austin, TX, October 2004.
118. M. D. Gaubatz, S. S. Hemami, "Embedding from arbitrary perceptual models," *Western New York Image Processing Workshop*, Rochester, NY, September 2004.
119. Y. Sermadevi, S. S. Hemami, "Convexity results for predictive video coding," *Western New York Image Processing Workshop*, Rochester, NY, September 2004, Winner, best student presentation.
120. D. M. Chandler, S. S. Hemami, "Quantifying the visual quality of wavelet-compressed images based on contrast signal-to-noise ratios and global precedence," *Western New York Image Processing Workshop*, Rochester, NY, October 2003.
121. M. D. Gaubatz, S. S. Hemami, "Perceptual embedded coding," *Western New York Image Processing Workshop*, Rochester, NY, October 2003, Best Student Poster Presentation.
122. W. Xu, S. S. Hemami, "Rate control for video transmission over multiple channels in ATM networks," *Western New York Image Processing Workshop*, Rochester, NY, October 2003.
123. C. Tian, S. S. Hemami, "An embedded image coding system based on Tarp filtering with classification," *Western New York Image Processing Workshop*, Rochester, NY, October 2003.

124. Y. Sermadevi, S. S. Hemami, "Optimal bit allocation for video coding under multiple rate constraints," *Western New York Image Processing Workshop*, Rochester, NY, October 2003, Best Student Oral Presentation.
125. S. S. Hemami, "Robust Visual Communications: Possibilities for Sensor Networks," *Upstate New York Workshop on Sensor Networks*, Syracuse, NY, October 2002.
126. W. Xu, S. S. Hemami, "Spectrally efficient partitioning of MPEG video streams for efficient transmission over multiple channels," *Proceedings of the International Packet Video Workshop*, Pittsburgh, PA, April 2002.
127. M. Masry, S. S. Hemami, "Modeling the subjective quality of low bitrate coded video," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 2001.
128. D. Chandler, S. S. Hemami, "Additivity models for suprathreshold distortion in quantized, wavelet-coded images," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 2001.
129. A. Deever, S. S. Hemami, "What's Your Sign? Efficient Sign Coding in an Embedded Wavelet Image Coder," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1999.
130. Y. Yang, S. S. Hemami, "Rate control for region-based coding using a wavelet video coder," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1999.
131. M. Ramos, S. S. Hemami, "Towards a perceptual model for supra-threshold subband image coding," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1999.
132. S. S. Hemami, *IBM Interactive TV Workshop*, Yorktown Heights, NY, August 1999, "Rate-Distortion Optimizations for Content-based Coding"
133. Y. Yang, S. S. Hemami, "Rate-distortion-based Combined Motion Estimation and Segmentation," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1998.
134. M. G. Ramos, S. S. Hemami, "Activity-Selective SPIHT Coding," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1998.
135. S. S. Hemami, "Human Sensitivity to Quantization Noise in Image Subbands," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1997.
136. M. G. Ramos, S. S. Hemami, "Activity-Selective JPEG Coding," *Western New York Image Processing Workshop*, Rochester, NY, Sept. 1997.
137. M. G. Ramos, S. S. Hemami, "Robust Image Coding with Perceptual-Based Scalability," *Data Compression Conference Industry Workshop*, Snowbird, Utah, March 1997.
138. S. S. Hemami, T. H.-Y. Meng, "Spatial and Temporal Video Reconstruction for Non-layered Transmission," *Proceedings of the Fifth International Workshop on Packet Video*, Berlin, Germany, March 1993.