

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Kenji Sugiyama  
U.S. Patent No.: 6,845,128 Attorney Docket No.: 39843-0167IP1  
Issue Date: January 18, 2005  
Appl. Serial No.: 10/067,815  
Filing Date: February 8, 2002  
Title: VIDEO-EMPHASIS ENCODING APPARATUS AND  
DECODING APPARATUS AND METHOD OF VIDEO-  
EMPHASIS ENCODING AND DECODING

### **DECLARATION OF DR. SCOTT ACTON**

I, Dr. Scott Acton, of Charlottesville, Virginia, declare that:

#### **QUALIFICATIONS AND BACKGROUND INFORMATION**

1. I am currently the Lawrence R. Quarles Professor of Engineering and Applied Science at the University of Virginia. I am also Chair of the C.L. Brown Department of Electrical and Computer Engineering.

2. I earned a Bachelor of Science Degree (1988) in Electrical Engineering from Virginia Tech. I also earned both a Master of Science Degree (1990) and a Ph.D. (1993) in Electrical and Computer Engineering from The University of Texas at Austin. My Ph.D. research was in the field of signal and image processing.

3. From 1993 to present I have held a variety of professional and academic positions. I was a postdoctoral research associate at the Center for Space Research in 1994. From 1994-2000, I was assistant professor and then associate

professor at Oklahoma State University. From 2000-present, I have been associate professor and then professor at the University of Virginia. I am Director of the Virginia Image and Video Analysis laboratory.

4. Between 2019 and 2022, I was on loan to the federal government as a Program Director in the Computer and Information Science and Engineering directorate of the National Science Foundation (NSF). In 2021-2022, I was promoted to acting Deputy Division Director of the Computing and Communication Foundations division. At NSF, I contributed to programs in Communications and Information Foundations, Smart Health, Foundational Research in Robotics, the AI Institutes, and Predictive Intelligence for Pandemic Prevention.

5. I am a member of numerous professional societies and organizations. For example, I served a four-year term as the Editor in Chief of the *IEEE Transactions on Image Processing* (2014-2018).

6. For over 30 years, I have conducted research and taught classes in the field of image processing and image analysis. My research in the image processing area began with work in the Laboratory for Vision Systems (starting in 1988) and applied research with Motorola Semiconductor Products Sector (starting in 1990).

7. At the University of Virginia, I teach a variety of courses, including Digital Image Processing, Digital Signal Processing, Signals and Systems, and “How the iPhone works.” I have received several teaching awards such as the All University Teaching Award (2009) and the Educational Innovation Award (2017).

8. I have over 300 publications related to image processing and image analysis. In 1996, I was named the Outstanding Young Electrical Engineer by Eta Kappa Nu and IEEE (national award). In 2013, I was named an IEEE Fellow. I have several best paper awards and have led several international conferences, such as the IEEE International Symposium on Biomedical Imaging that I co-chaired in 2018 (Washington, D.C.). In 2021, I was given the Director’s Award for Superior Accomplishment from the National Science Foundation.

9. My research in image processing and analysis has been funded by a variety of government agencies, foundations and companies. The agencies include the National Institutes of Health, NSF, Defense Advanced Research Project Agency (DARPA), Army Research Office (ARO) and the U.S. Department of Transportation (USDOT). The Foundations include Robertson Foundation, Hobby Foundation, Whitaker Foundation and Swortzel Foundation. Companies that have funded my research include Lucent, PocketSonics, Zimmer, Motorola and SVS.

10. My current curriculum vitae (SAMSUNG-1003) further sets out my academic and professional background and qualifications.

11. In writing this Declaration, I have considered the following: my own knowledge and experience, including my work experience in the fields of digital video processing, digital image processing, and electrical engineering; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I have analyzed the following publications and materials, in addition to other materials I cite in my declaration:

- U.S. Patent No 6,845,128 (SAMSUNG-1001), and its accompanying prosecution history (SAMSUNG-1002)
- U.S. Patent No. 5,491,514 (“Fukuda”) (SAMSUNG-1005)
- U.S. Patent No. 5,241,387 (“Fujikawa”) (SAMSUNG-1006)
- U.S. Patent No. 6,801,665 (“Atsumi”) (SAMSUNG-1007)
- Japanese Patent Application Publication No. JPH 7-162862A (“JPH7-162862”) (SAMSUNG-1009)
- Excerpts of Japanese Patent Application No. 2001-033401 File History (SAMSUNG-1010)
- Excerpts of Gonzalez et al., Digital Image Processing, Second Edition, Prentice-Hall, Inc. (2002) (SAMSUNG-1011)
- Excerpts of Helt, Practical Television Engineering (1953) (SAMSUNG-1012)

- Excerpts of Kaufman, Introduction to Color TV (1956) (SAMSUNG-1013)
- Excerpts of Sillman, Television Captioning for the Deaf (1984) (SAMSUNG-1014)
- Excerpts of Jensema et al., Closed-Captioned Television Presentation Speed and Vocabulary (1996) (SAMSUNG-1015)
- Excerpts of Stott, Design Technique for Multiplexing Asynchronous Digital Video and Audio Signals (1978) (SAMSUNG-1016)
- Excerpts of MPEG 1SO/IEC 11172-3 (1993) (SAMSUNG-1017)
- Excerpts of Puri, Multimedia Systems, Standards, and Networks (2000) (SAMSUNG-1020)
- Excerpts of Woods, Subband Coding of Images (1986) (SAMSUNG-1021)

## **LEGAL PRINCIPLES**

### *Anticipation*

12. I have been informed that a patent claim is invalid as anticipated under 35 U.S.C. § 102 if each and every element of a claim, as properly construed, is found either explicitly or inherently in a single prior art reference. Under the principles of inherency, if the prior art necessarily functions in accordance with, or includes the claimed limitations, it anticipates.

13. I have been informed that a claim is invalid under 35 U.S.C. § 102(a) if the claimed invention was known or used by others in the U.S., or was patented or published anywhere, before the applicant's invention. I further have been informed that a claim is invalid under 35 U.S.C. § 102(b) if the invention was patented or published anywhere, or was in public use, on sale, or offered for sale in this country, more than one year prior to the filing date of the patent application (critical date). And a claim is invalid, as I have been informed, under 35 U.S.C. § 102(e), if an invention described by that claim was described in a U.S. patent granted on an application for a patent by another that was filed in the U.S. before the date of invention for such a claim.

*Obviousness*

14. I have been informed that a patent claim is invalid as “obvious” under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a POSITA, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of nonobviousness, which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others. For purposes of my analysis above and because I know of no indication from the

patent owner or others to the contrary, I have applied a date of February 8, 2002, as the date of invention in my obviousness analyses, although in many cases the same analysis would hold true even at an earlier time than February 8, 2002.

15. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason to modify the single prior art reference, or combine two or more references, in order to achieve the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference or references themselves, the knowledge or “common sense” of one skilled in the art, or from the nature of the problem to be solved, and may be explicit or implicit from the prior art as a whole. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

### **OVERVIEW OF CONCLUSIONS FORMED**

16. This expert Declaration explains the conclusions that I have formed based on my analysis. To summarize those conclusions:

- Based upon my knowledge and experience and my review of the prior art publications listed above, I believe that claims 1-6 and 8 of the '128 patent are rendered obvious by Fukuda.
- Based upon my knowledge and experience and my review of the prior art publications listed above, I believe that claims 1-4 of the '128 patent are rendered obvious by Fukuda in view of Fujikawa.
- Based upon my knowledge and experience and my review of the prior art publications listed above, I believe that claims 1-6 and 8 of the '128 patent are rendered obvious by Atsumi.

**BACKGROUND KNOWLEDGE ONE OF SKILL IN THE ART WOULD HAVE HAD PRIOR TO THE PRIORITY DATE OF THE '128 PATENT**

17. Based on the foregoing and upon my experience in this area, a person of ordinary skill in the art ("POSITA") relating to the subject matter of the '128 Patent as of February 8, 2002 would have had (1) at least a bachelor's degree in computer science, electrical engineering, computer engineering, or a related field, with 2-3 years of experience in digital video processing, or a related field. Additional graduate education could substitute for professional experience, and vice versa.

18. Based on my experiences, I have a good understanding of the capabilities of a POSITA as I was such an individual at the time of the Critical

Date. Moreover, I have taught, participated in organizations, and worked closely with many such persons over the course of my career.

### **INTERPRETATIONS OF THE '128 PATENT CLAIMS AT ISSUE**

19. I have been informed by Counsel and understand that the best indicator of claim meaning is its usage in the context of the patent specification as understood by one of ordinary skill. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. Counsel has also informed me, and I understand that, the words of the claims should be interpreted as they would have been interpreted by one of ordinary skill at the time of the invention was made (not today). I have been informed by Counsel that I should use February 8, 2002 as the point in time for claim interpretation purposes.

### **OVERVIEW OF THE '128 PATENT**

#### **I. The '128 Patent**

20. The '128 Patent is directed to a "video emphasis encoding apparatus" and "method of video emphasis encoding," as well as a "video-deemphasis decoding apparatus" and "method of video-deemphasis decoding." SAMSUNG-1001, 2:46-57. The '128 Patent describes "emphasis-level settings in accordance with quantization parameters for encoding of input video signals" where "the

emphasis-level settings are performed as the wider the quantization step width, the higher the emphasis” and “the narrower the quantization step width, the lower the emphasis level.” SAMSUNG-1001, 4:1-9. The ’128 Patent also describes “emphasis level settings in accordance with the level of enhancement processing already applied to input video signals” where “the higher the enhancement level, the lower the emphasis level.” SAMSUNG-1001, 4:10-18. An example “first embodiment” of the ’128 Patent is reproduced below in FIGS. 1 and 2.

SAMSUNG-1001, 3:43-49.

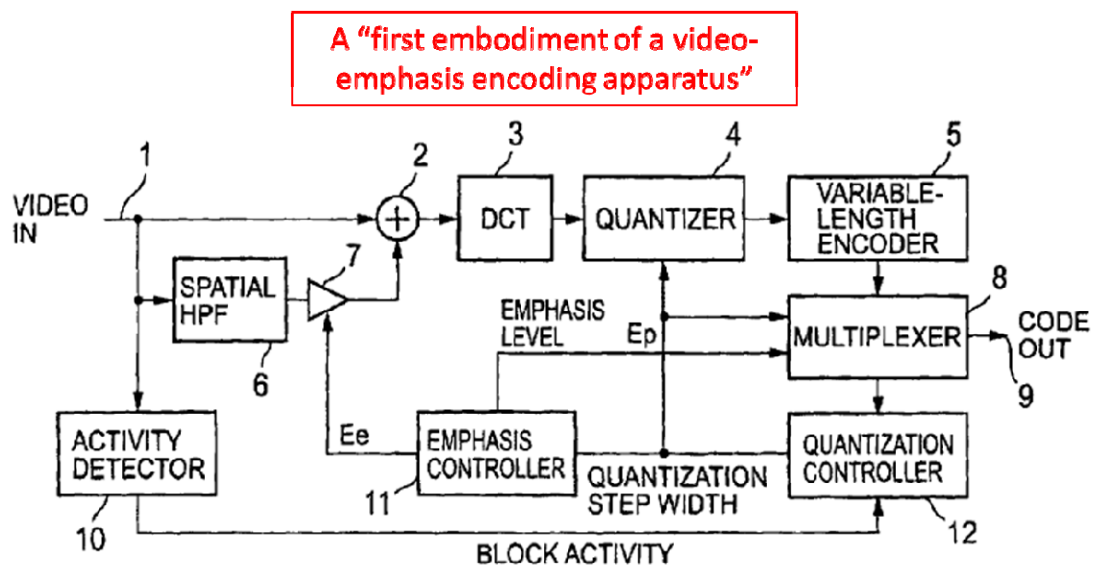
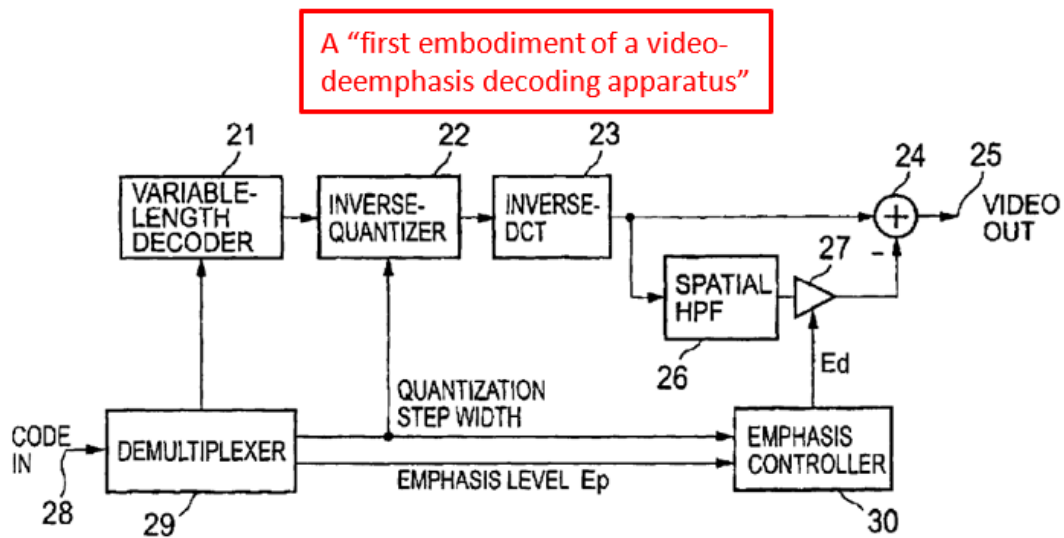


FIG.1

SAMSUNG-1001, FIG. 1<sup>1</sup>

<sup>1</sup> Annotations made to the figures throughout this declaration are shown in color.



SAMSUNG-1001, FIG. 2

## II. Prosecution History of the '128 Patent

21. Application Serial No. 10/067,815 (“the ’815 application”) that issued as the ’128 Patent was filed on February 8, 2002, claiming priority to Japanese Application Nos. 2001-033401 and 2001-033403 filed on February 9, 2001. SAMSUNG-1001, Cover (22), (30). The “BACKGROUND OF THE INVENTION” section of the ’815 application discussed “Japanese Un-examined Patent Publication No. 7-162862” (“JPH7-162862”; SAMSUNG-1009). SAMSUNG-1002, 3-4; SAMSUNG-1001, 2:4-6. The Applicant did not submit any information disclosure statement (IDS) citing JPH7-162862, and the Examiner did not cite JPH7-162862 to reject any of the claims. See SAMSUNG-1001, Cover (56); *see generally* SAMSUNG-1002. On September 2, 2004, the Examiner issued a notice of allowance with no prior art rejections for any claim.

SAMSUNG-1002, 78. The Applicant paid the issue fee on December 2, 2004.

SAMSUNG-1002, 96. The '815 application issued as the '128 Patent on January 18, 2005. SAMSUNG-1001, Cover (45).

22. On March 9, 2006, after issuance of the '128 patent, the Japanese Patent Office issued a Notice of Reasons for Refusal in Japanese Application No. 2001-033401 to which the '128 Patent claims priority. SAMSUNG-1010, p. 24-26. In the Notice, the Japanese Application was refused based on JPH7-162862 that was cited in the Background section of the '128 Patent. *Id.* Although the '128 Patent Background section states, as an alleged drawback of the video-emphasis encoding apparatus of JPH7-162862, that the “emphasis processing is applied to video signals with no emphasis-level control” and the “emphasis data transferred to the video-deemphasis decoding apparatus indicates only whether or not the emphasis processing has been applied to video signals” (SAMSUNG-1002, 4; SAMSUNG-1001, 2:25-32), the Japanese Patent Office disagreed. SAMSUNG-1010, p. 24-26. Specifically, the Notice of Reasons for Refusal stated that JPH7-162862 paragraphs [0097]-[0101] describe “setting [an] emphasis level according to [a] compression ratio” and thus render obvious setting “the emphasis level according to the degree of quantization” and paragraph [0195] describes “transmitting information related to the emphasis level along with a video code sequence.” SAMSUNG-1010, p. 24. With no response from the Applicant in the

Japanese Application, the Japanese Patent Office issued a final Decision of Refusal on July 7, 2006. SAMSUNG-1010, p. 26.

23. JPH7-162862 (filed January 14, 1994) and Fukuda (filed January 27, 1994) claim priority to the same three foreign Japanese applications JPH5-012286, JPH 5-174068, and JPH5-247893. SAMSUNG-1009, Cover (31)-(33); SAMSUNG-1009, Cover [30]. JPH7-162862 and Fukuda also contain the same disclosure. *See generally* SAMSUNG-1005 *and* SAMSUNG-1009. As described in detail below and confirmed by the Japanese Patent Office, Fukuda renders obvious the features that the '128 Patent alleges are the drawbacks of Fukuda's video-emphasis encoding apparatus.

## **ANALYSIS OF FUKUDA**

### **I. Overview of Fukuda<sup>2</sup>**

24. Fukuda describes one embodiment of a “coding and decoding apparatus” where input video signals are “enhanced by an emphasis circuit” which has a “nonlinear characteristic increasing an enhancement degree as [the] amplitude of the input video signal decreases.” SAMSUNG-1005, Abstract. The enhanced video signal is coded by an encoder into “a code stream,” and this “code

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<sup>2</sup> Descriptions of the references and combinations are incorporated into each mapping that includes citations to these references. Emphasis is added to text using bold and/or italicized font unless otherwise indicated.

stream” is then transmitted to a “decoder” which “decodes the code stream.” *Id.* The “decoded video signal” is then “fed to a de-emphasis circuit having a nonlinear characteristic increasing a suppression degree as amplitude of the input signal decreases.” *Id.*

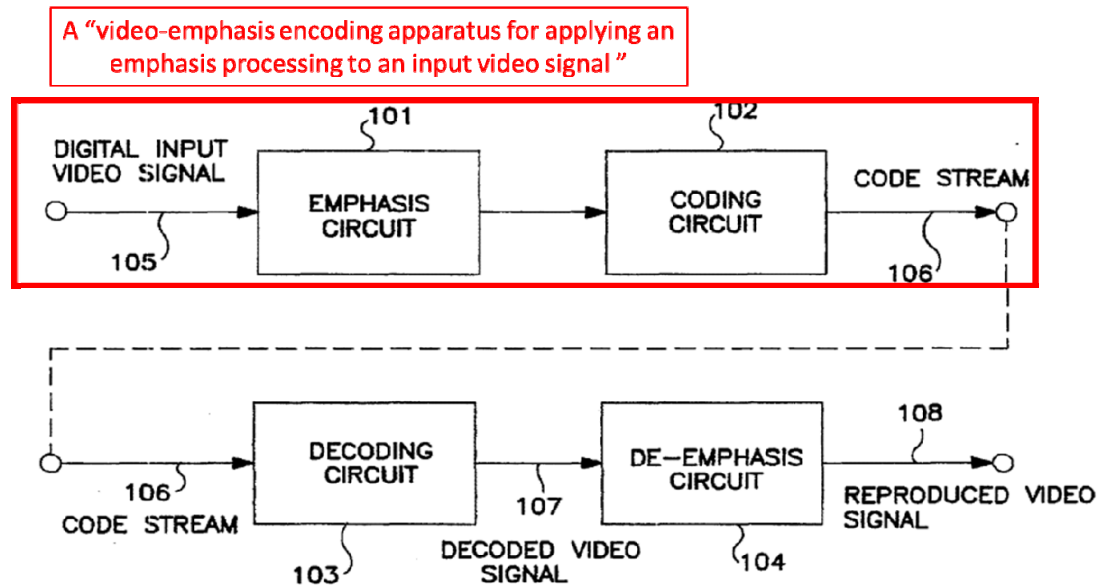


**FIG. 1**

SAMSUNG-1005, FIG. 1

25. Fukuda discloses other embodiments that provide a mode signal for controlling the signal enhancement degree of the emphasis circuit. SAMSUNG-1005, 11:1-40, 12:42-13:16, 14:46-15:4, 15:43-16:5, 16:45-67, 17:51-18:15, 18:28-46, 18:65-19:18, 20:29-64, 22:40-23:22, FIGS. 6-11, 13-14, 17. Fukuda discloses that these embodiments “may also comprise a transmitter for sending or recording mode signals together with coded image data, and the reproducing means may comprise means for receiving mode signals.” SAMSUNG-1005, 24:54-59. For

example, with respect to the FIG. 17 embodiment reproduced below, Fukuda discloses that “by transmitting the mode control signal m in emphasis or recording in a medium, the reproduction side DC level detection circuit 1701 and mode control signal generating circuit 1702 in FIG. 17 are not needed, and a reproduced image signal of higher precision may be obtained in a smaller circuit scale.”

SAMSUNG-1005, 23:17-22.

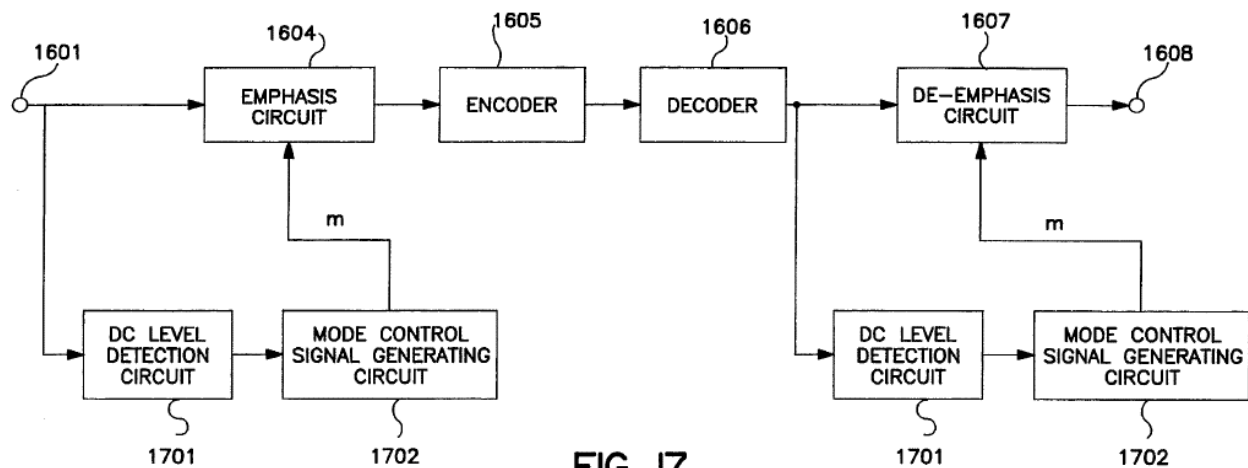


FIG. 17

SAMSUNG-1005, FIG. 17.

## II. Claims 1-6 and 8 are rendered obvious by Fukuda

*[1pre] A video-emphasis encoding apparatus for applying an emphasis processing to an input video signal to obtain a video bitstream comprising:*

26. To the extent the preamble is limiting, Fukuda renders it obvious in multiple ways. For example, Fukuda describes multiple embodiments of a “coding and decoding apparatus” that each individually render this claim element obvious and include an emphasis circuit that enhances input video signals. SAMSUNG-1005, 2:13-60; FIGS. 1-19. In one example, Fukuda

describes a “coding and decoding apparatus” where “[i]nput video signals are enhanced by an emphasis circuit” and “compression coded in an encoder” and “a code stream, representing a compression coded video signal, is outputted from the encoder” (“[a] video-emphasis encoding apparatus for applying an emphasis processing to an input video signal to obtain a video bitstream”).

SAMSUNG-1005, Abstract, 3:3-20, 5:29-39, 20:56-21:7, FIG. 1. The “code stream is transmitted to a decoder” and “the decoder decodes the code stream.”

SAMSUNG-1005, Abstract, 3:3-20, 5:29-39, 20:56-21:7, FIG. 1. The “decoded video signal is [then] fed to a de-emphasis circuit” where “low noise high quality video signals [are] reproduced from the de-emphasis circuit.”

SAMSUNG-1005, Abstract, 3:3-20, 5:29-39, 20:56-21:7, FIG. 1. An example apparatus according to Fukuda is presented below in FIG. 1.

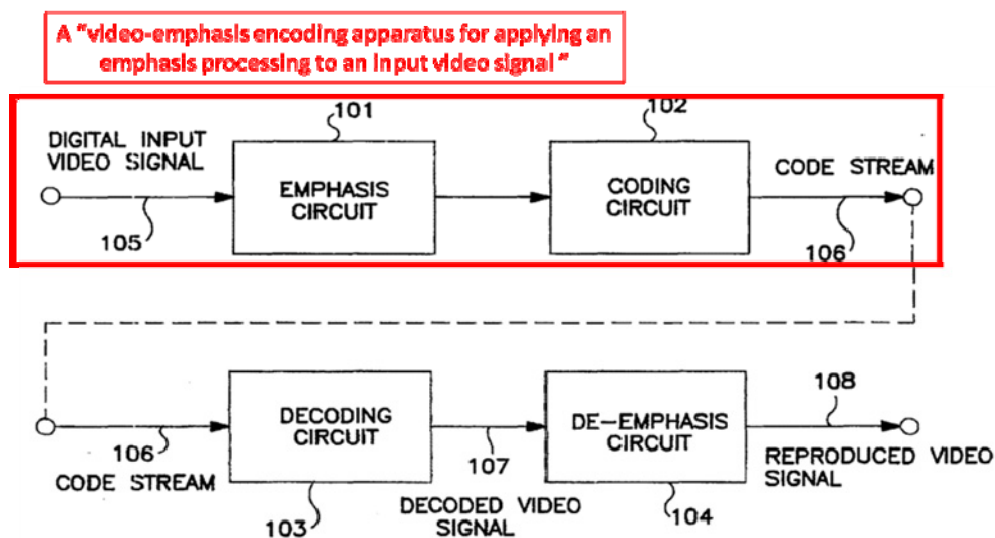
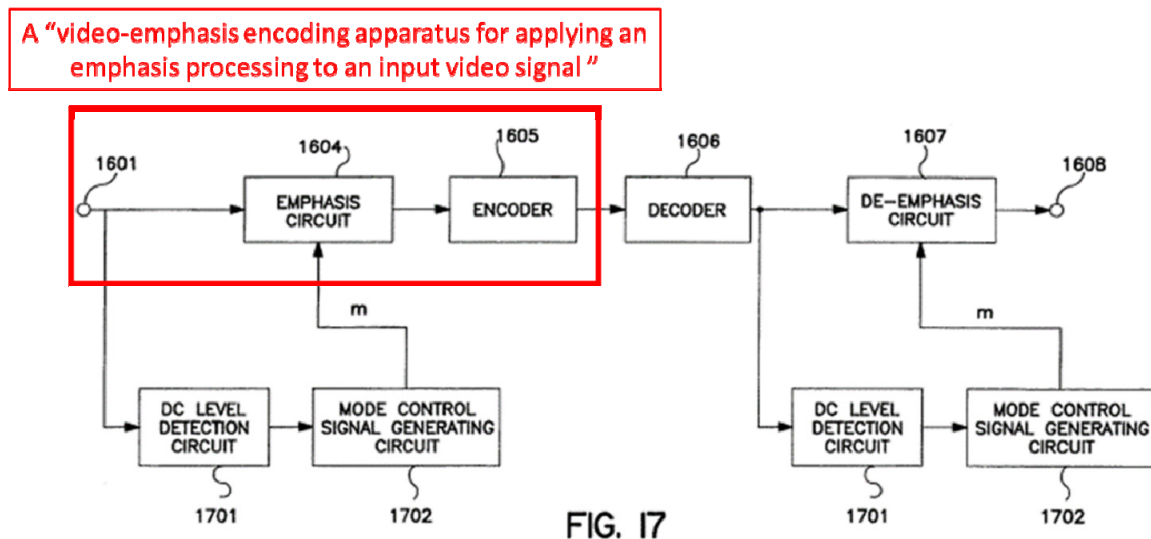


FIG. 1

SAMSUNG-1005, FIG. 1

27. Additionally, Fukuda describes an embodiment of a video coding and decoding apparatus shown in FIG. 17 that includes an “emphasis circuit 1604” that “enhances the signal in every component of the digital image signal.” SAMSUNG-1005, 20:56-21:7, FIG. 17. An example apparatus according to Fukuda is presented below in FIG. 17.



SAMSUNG-1005, FIG. 17.

***[1.1] an emphasis-level setter for setting an emphasis level to the input video signal in accordance with at least one factor among control data carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal;***

28. Fukuda renders this claim element obvious in multiple ways. For example, Fukuda describes multiple embodiments of a coding and decoding apparatus that each include an emphasis-level setter for setting an emphasis level. SAMSUNG-1005, 2:13-60; FIGS. 1-19. In many of these embodiments, the emphasis-level setter sets an emphasis level by at least one of “***control data***

*carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal.”*<sup>3</sup> *Id.*; SAMSUNG-1005, 2:13-60; FIGS. 1-19.

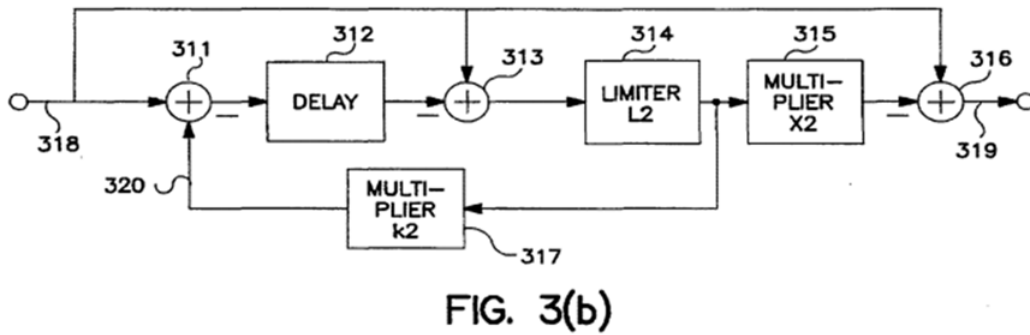
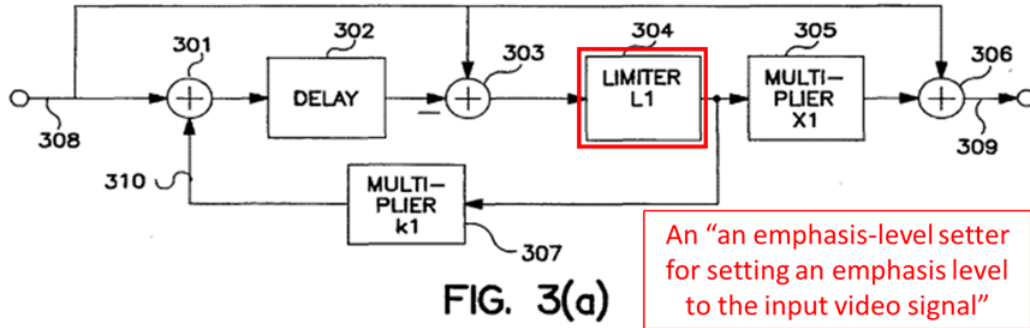
*setting an emphasis level to the input video signal in accordance with ... a picture state detected from the input video signal*

29. In a **first** example of Fukuda that renders obvious this option, Fukuda describes an “emphasis circuit having a nonlinear characteristic” (replacing the emphasis circuit 101 in FIG. 1) for “enhancing the signal with a smaller degree as the signal amplitude becomes larger.” SAMSUNG-1005, 5:29-50, 6:9-41. Fukuda explains that “by providing the signal amplitude with a nonlinear characteristic, the signal components having a similar amplitude to the generated noise components are enhanced and suppressed with a large degree.” SAMSUNG-1005, 5:40-50. Included in Fukuda’s non-linear emphasis circuit is a “limiter 304” (“*an emphasis-level setter*”) that “limits the amplitude of the output signal” based on whether amplitude of the input signal is greater than a set parameter “L” (“*a picture state detected from the input video signal*”). SAMSUNG-1005, 6:21-30. FIG. 4 below illustrates the amplitude of the “output characteristics” (“*emphasis level*”) of the limiter 304, which range from “-L” to “L,” relative to the amplitude of the input signal (thus

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<sup>3</sup> Only one of these three options is needed to satisfy this claim feature.

“enhancing the signal with a smaller degree as the signal amplitude becomes larger”). SAMSUNG-1005, 5:29-39, 6:21-30.



SAMSUNG-1005, FIGS. 3(a) and 3(b).

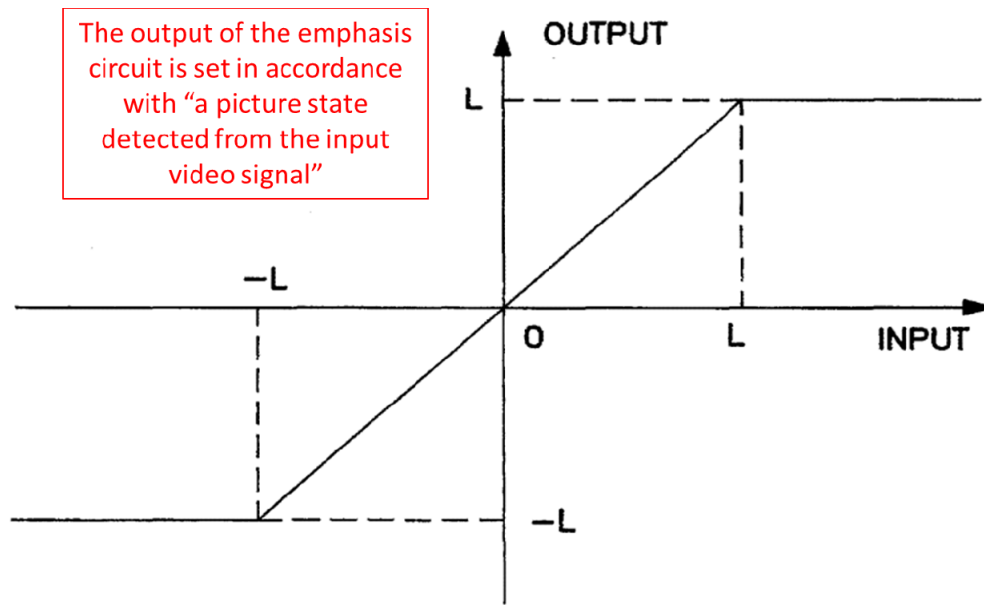


**FIG. 4**

SAMSUNG-1005, FIG. 4.

30. Moreover, similar disclosure from JPH7-162862 was used to reject this claim feature in the '128 patent's Japanese application (Application No. 2001-033401). SAMSUNG-1009, ¶¶[0044]-[0048], [0178]-[0183]; SAMSUNG-1010, p. 24.

31. In a **second** example, Fukuda describes an “activity detector 801 and a mode changeover circuit 802”<sup>4</sup> (“*an emphasis-level setter*”) where “[t]he signal enhancement of the emphasis circuit 803 decreases as activity of the video signal

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<sup>4</sup> Fukuda discloses that these components are “installed in a coding and decoding apparatus as shown in FIG. 1” (i.e., “emphasis circuit 803” is a similar component to “emphasis circuit 101,” and so on). SAMSUNG-1005, 14:46-51.

increases” (“*a picture state detected from the input video signal*”). SAMSUNG-1005, 14:46-15:4, 18:65-19:36, FIGS. 8 and 14. Fukuda discloses that the mode changeover circuit 802 issues a “mode signal 809 depending on activity” (“*emphasis level*”). SAMSUNG-1005, 14:52-63. The mode signals disclosed by Fukuda are used at “the reproduction side” where the “de-emphasis circuit suppresses the video signal decoded by the suppression degree depending on the mode signal.” SAMSUNG-1005, 11:57-59. Presented below are two embodiments of Fukuda’s activity detectors.

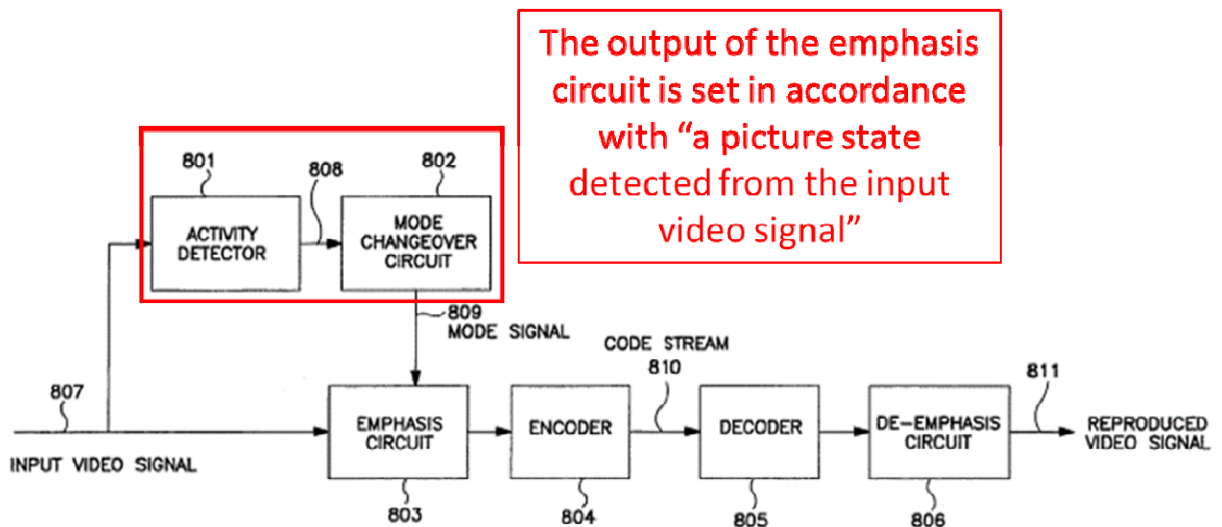


**FIG. 8**

SAMSUNG-1005, FIG. 8

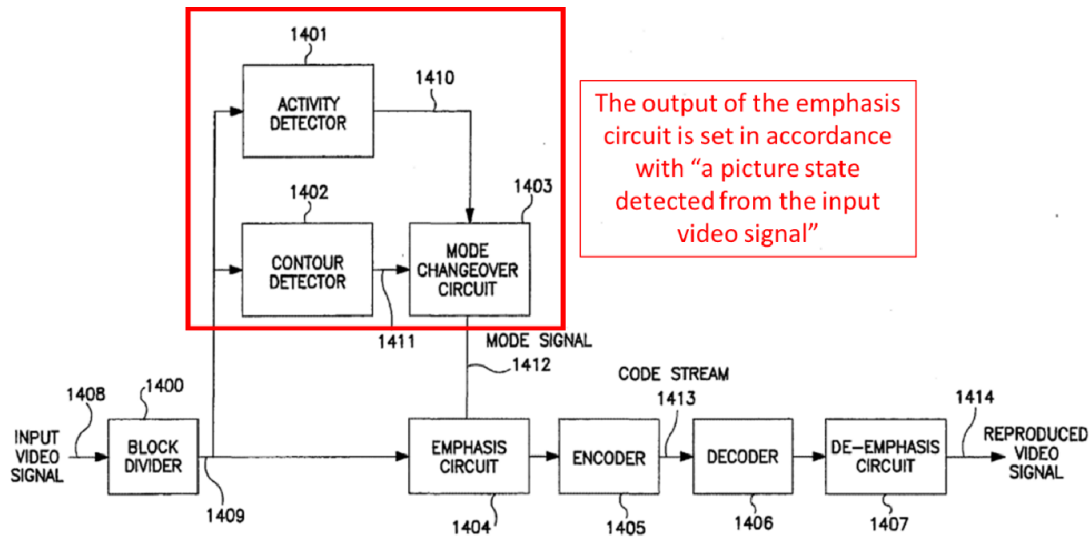


FIG. 14

SAMSUNG-1005, FIG. 14.

32. The '128 patent similarly describes an embodiment illustrated in FIG. 1 that includes an activity detector 10 that provides an output used by the quantization controller 12, whose output is used to set the emphasis level of the emphasis controller. SAMSUNG-1001, 4:39-41, 5:30-54.

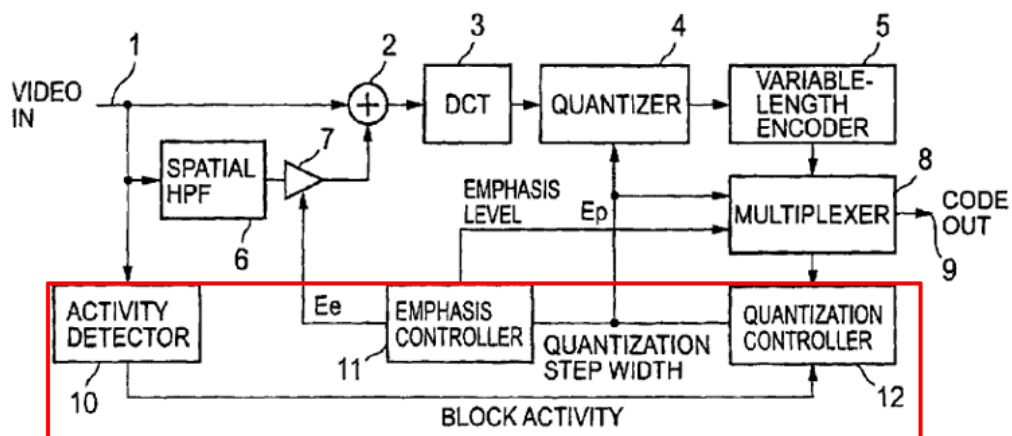


FIG. 1

SAMSUNG-1001, FIG. 1.

33. As a **third** example, Fukuda describes “an example of coding and decoding apparatus having a motion amount detector 901 and a mode changeover circuit 902 installed in the coding and decoding apparatus as shown in FIG. 1” (*“an emphasis-level setter”*) where “[t]he motion amount detector 901 detects the motion amount 908 of a video signal 907, and the mode changeover circuit 902 issues a mode signal 909 [*“emphasis level”*)] depending on the motion amount 908” (*“a picture state detected from the input video signal”*). SAMSUNG-1005, 15:43-48, FIG. 9. Then, “[a]n emphasis circuit 903 enhances the video signal 907 by the signal enhancement degree depending on the mode signal 909.” SAMSUNG-1005, 15:52-54. Fukuda further explains:

**The signal enhancement degree of the emphasis circuit 903 increases as the motion amount of the video signal increases.** This is because the video signal with a large motion amount is large in the information quantity, and coding noise is likely to occur in coding process. **Therefore, in the image with a large motion amount, the mode enhancing by a large signal enhancement degree is selected, and signal is suppressed according to the signal enhancement,** so that coding noise may be reduced more positively. Thus, by adaptively determining the signal enhancement degree depending on the motion amount, coding noise can be removed efficiently.

SAMSUNG-1005, 15:61-16:5. Presented below is an example of a motion amount detector within Fukuda.

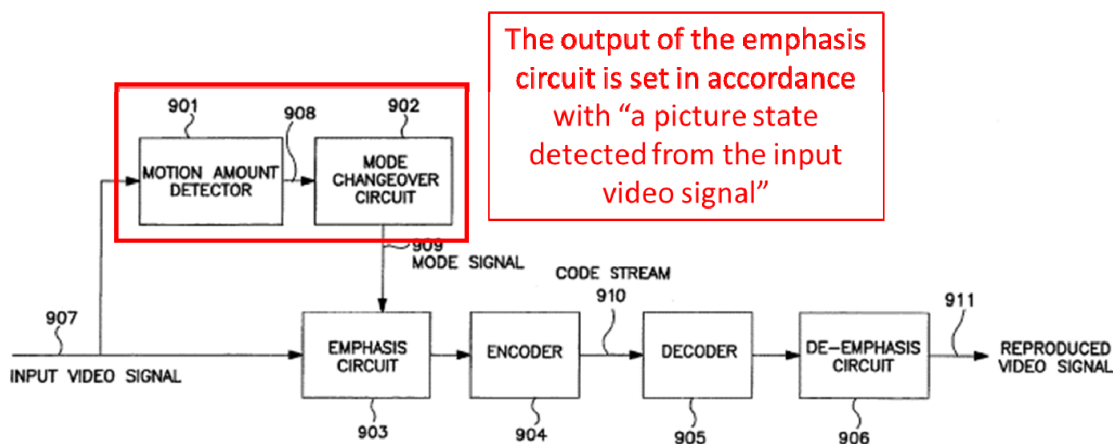


FIG. 9

SAMSUNG-1005, FIG. 9.

34. As a **fourth** example, Fukuda describes a “DC level detection circuit [1701]” and a “mode control signal generating circuit [1702]”<sup>5</sup> (“*an emphasis-level setter*”) which “adds the image data values for a specific period of input

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<sup>5</sup> Fukuda’s FIG. 17 shares components with FIG. 16. SAMSUNG-1005, 22:36-61.

FIG. 2(a) also provides an example of FIG. 16’s “emphasis circuit 1604.”

SAMSUNG-1005, 20:29-42. Fukuda discloses that “an example of the emphasis circuit 101 is shown in FIG. 2(a).” SAMSUNG-1005, 3:28-31. Taken together, this disclosure demonstrates that emphasis circuit 1604 illustrated in FIGS. 16-18 is a similar component to the emphasis circuit 101 of FIG. 1. SAMSUNG-1005, 3:28-31, 20:29-42, 22:36-61

digital image signal ... detects the DC level by calculating the mean ... [and] compares this DC level with, for example, three values (64, 128, 192), and issues a two-bit mode control signal m” (*“a picture state detected from the input video signal”*). SAMSUNG-1005, 22:40-23:5, FIG. 17. Fukuda explains:

... by detecting the DC level for a specified period of digital image signal, and controlling so that the enhancement degree and suppression degree may be small when the value is close to 0 level or 255 level, occurrence of overflow and underflow of signal amplitude may be decreased, thereby **decreasing mismatch between signal enhancement and signal suppression**, and also decreasing noise due to signal enhancement and signal suppression.

SAMSUNG-1005, 23:8-16. Presented below is Fukuda’s DC level detection circuit 1701 and mode control signal generating circuit 1702.

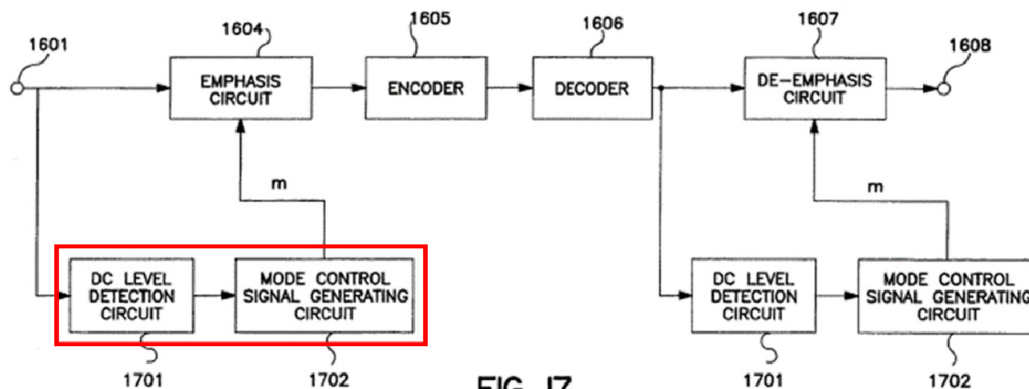


FIG. 17

The output of the emphasis circuit is set in accordance with “a picture state detected from the input video signal”

SAMSUNG-1005, FIG. 17.

setting an emphasis level to the input video signal in accordance with ... encoding conditions for the input video signal

35. As a **first** example of Fukuda that renders obvious this option, Fukuda describes a “mode changeover circuit 701” (incorporated into the “apparatus as shown in FIG. 1”) (“*an emphasis-level setter*”) that issues a “mode signal” that is dependent on the “coding compression rate control signal” (“*encoding conditions*”). SAMSUNG-1005, 12:42-55, FIG. 7. A POSITA would have recognized or found obvious that the compression rate of a video signal is representative of “*encoding conditions.*” See SAMSUNG-1001, 8:42-45. Similar disclosure from JPH7-162862 was used to reject this claim feature in the ’128 patent’s Japanese application (Application No. 2001-033401). SAMSUNG-1009, ¶¶[0097]-[0100]; SAMSUNG-1010, p. 24. Presented below is Fukuda’s mode changeover circuit 701.

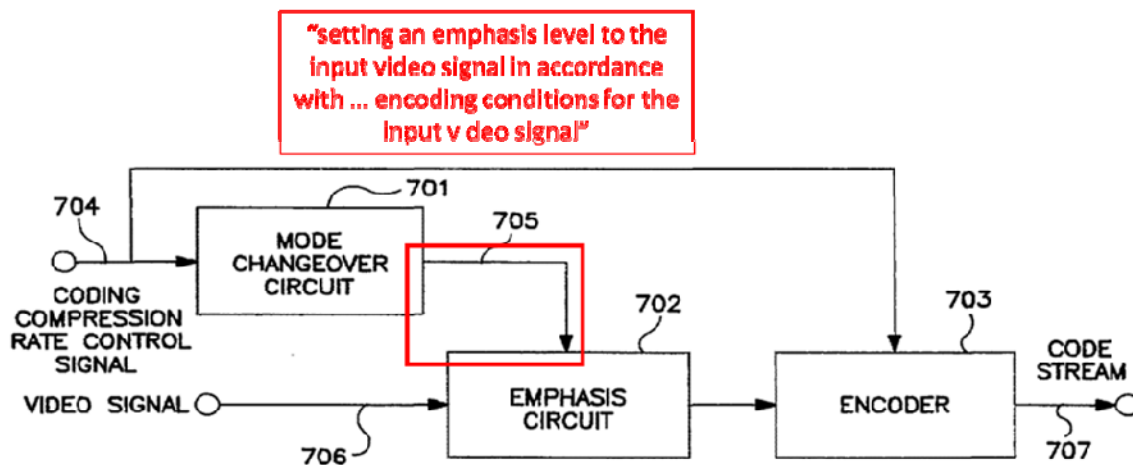


FIG. 7

SAMSUNG-1005, FIG. 7.

36. As a **second** example, Fukuda describes a “coding distortion measuring instrument 1001 and a mode changeover circuit 1002” (incorporated into the “apparatus as shown in FIG. 1”) (“*an emphasis-level setter*”) that “issues a mode signal 1009 depending on the coding distortion 1008” (“*encoding conditions*”). SAMSUNG-1005, 16:45-58, 17:29-50, FIG. 10. A POSITA would have recognized or found obvious that the coding distortion of a video signal is representative of “*encoding conditions*.” Indeed, Fukuda reinforces this understanding:

As the measurement of coding distortion, the difference between the original signal and the signal after coding process may be measured... **the amount of coding distortion may be expressed by the quantization step size used in quantizing the signal in coding process. To control to specified coding compression rate in coding process, the quantization step size in quantizing is controlled depending on the generated code amount.** That is, if the generated code amount is not much, the quantization step size is increased to suppress the code amount, and if the generated code amount is small, the quantization step size is decreased to control so that the code amount may be constant. As a result, the generated code amount increases, **and if the quantization step size increases accordingly, the coding distortion increases.**

SAMSUNG-1005, 17:29-45. Presented below is Fukuda’s coding distortion measuring instrument 1001 and mode changeover circuit 1002.

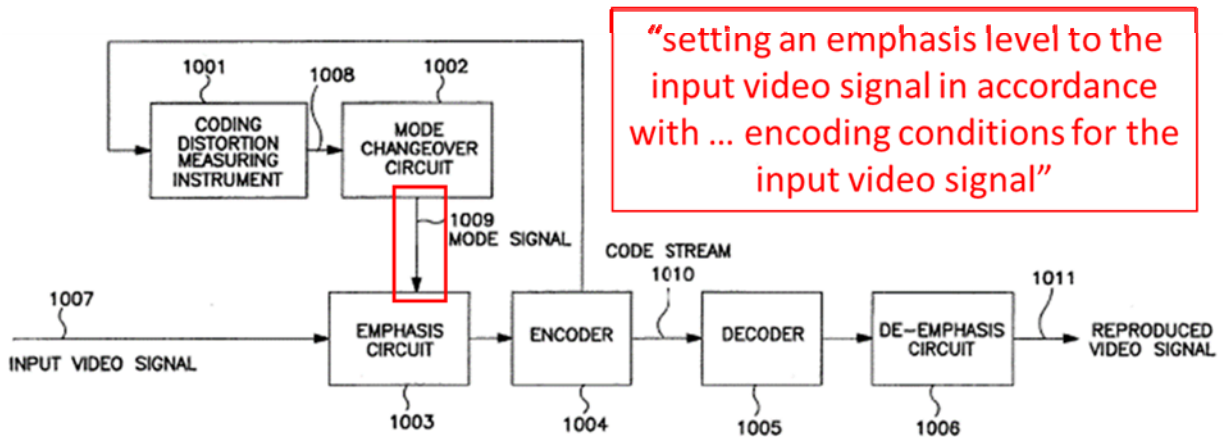


FIG. 10

SAMSUNG-1005, FIG. 10.

**[1.2] an emphasize for applying the emphasis processing to the input video signal at the emphasis level to obtain an emphasized video signal;**

37. Fukuda renders this claim element obvious in multiple ways. For example, multiple of Fukuda’s embodiments each includes an emphasis circuit for applying emphasis processing (e.g., “emphasis circuit” of Fukuda’s embodiments referenced above in [1.1]). SAMSUNG-1005, 2:13-60; FIGS. 1-19. A couple of examples are provided below.

38. As a **first** example, Fukuda describes an “emphasis circuit 101” (“**an emphasize**”) that enhances an “input video signal” by a “specified enhancement degree” (e.g., a “mode signal,” or “output characteristic” of a nonlinear emphasis circuit) (“**applying the emphasis processing to the input video signal at the emphasis level to obtain an emphasized video signal**”). SAMSUNG-1005, 3:8-46, FIG. 1; *see above* [1.1]. Presented below is Fukuda’s emphasis circuit 101.

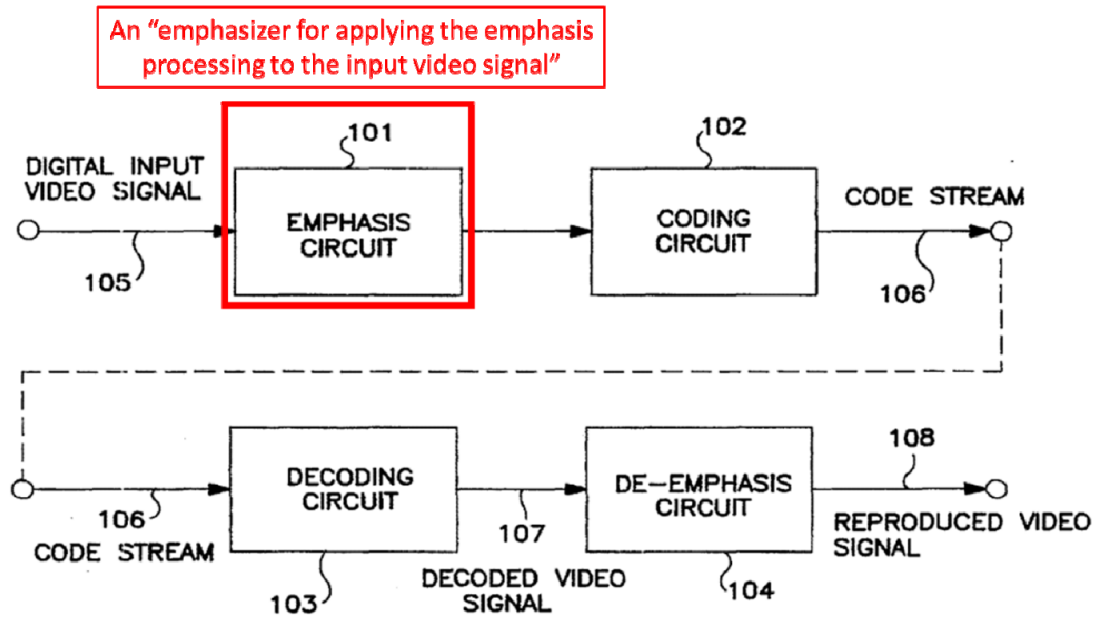
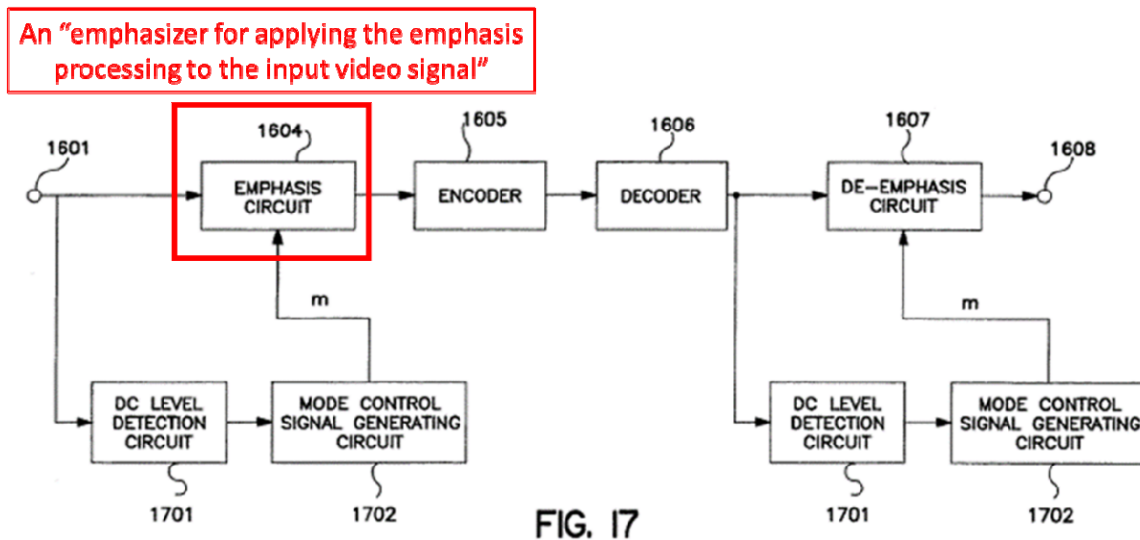


FIG. 1

SAMSUNG-1005, FIG. 1.

39. As a **second** example, Fukuda describes an “emphasis circuit 1604” (“*an emphasize*”) which “enhances the signal ... according to one of the plural types of emphasis characteristic selected by the mode control signal *m*” (“*applying the emphasis processing to the input video signal at the emphasis level to obtain an emphasized video signal*”). SAMSUNG-1005, 20:56-21:7, FIG. 17. Presented below is Fukuda’s emphasis circuit 1604.



SAMSUNG-1005, FIG. 17.

**[1.3] an encoder for encoding the emphasized video signal to obtain a video bitstream; and**

40. Fukuda renders this claim element obvious in multiple ways. For example, multiple of Fukuda’s embodiments each includes an encoder for encoding the emphasized video signal to obtain a code stream (e.g., “coding circuit” or “encoder” of Fukuda’s embodiments referenced above in [1.1] and [1.2]). SAMSUNG-1005, 2:13-60, FIGS. 1-19. A couple of examples are provided below.

41. As a **first** example, Fukuda describes a “coding circuit 102” that receives the emphasized “video signal” and produces a “code stream” (“**an encoder for encoding the emphasized video signal to obtain a video bitstream**”). SAMSUNG-1005, 3:8-15, FIG. 1. As a **second** example, Fukuda describes an “encoder 1605” which “encodes the output of the emphasis circuit

1604, and issues a code stream.” SAMSUNG-1005, 20:56-21:7, FIG. 17.

Examples of encoders within Fukuda are presented below.

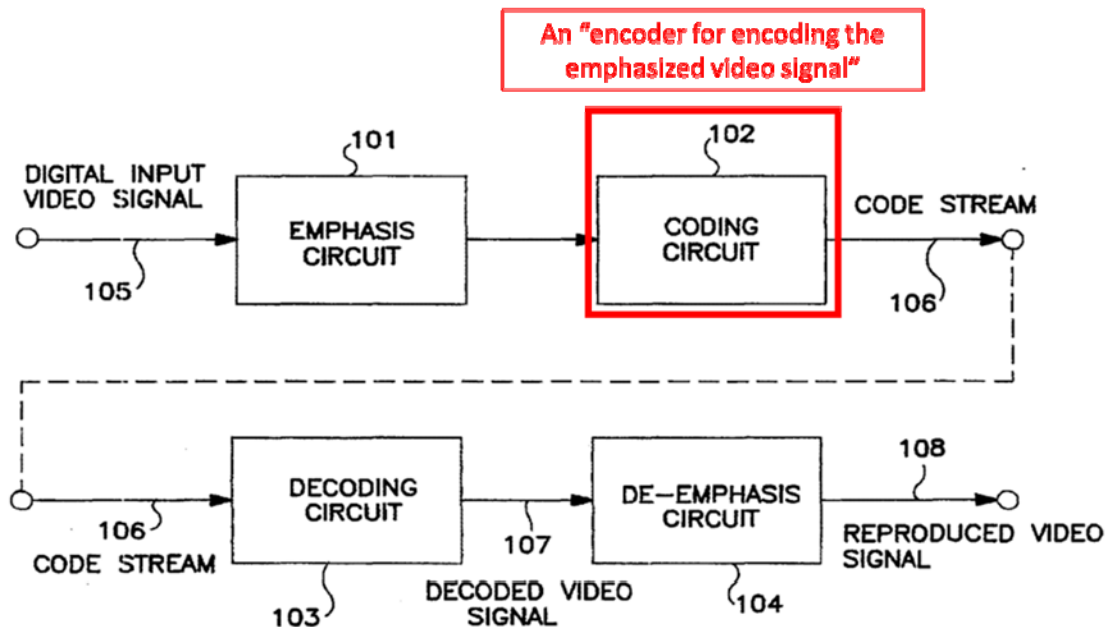


FIG. 1

SAMSUNG-1005, FIG. 1.

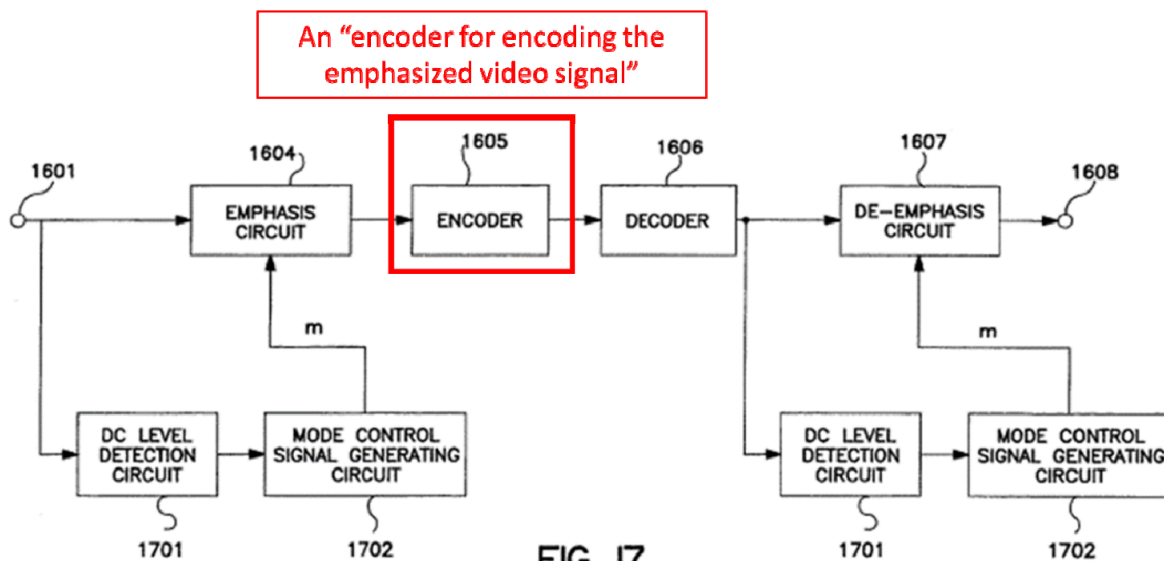


FIG. 17

SAMSUNG-1005, FIG. 17.

***[1.4] a multiplexer for multiplexing the Video bitstream and data on the emphasis level.***

42. Fukuda renders this claim element obvious in multiple ways. For example, Fukuda discloses many embodiments that provide a mode signal for controlling the signal enhancement degree of the emphasis circuit.

SAMSUNG-1005, 11:1-40, 12:42-13:16, 14:46-15:4, 15:43-16:5, 16:45-67, 17:51-18:15, 18:28-46, 18:65-19:18, 20:29-64, 22:40-23:22, FIGS. 6-11, 13-14, 17. Fukuda discloses that these embodiments “may also comprise a transmitter for sending or recording mode signals together with coded image data, and the reproducing means may comprise means for receiving mode signals.”

SAMSUNG-1005, 24:54-59. For example, with respect to the FIG. 17 embodiment, Fukuda discloses that “by transmitting the mode control signal *m* in emphasis or recording in a medium [(the “***emphasis level*”)]], the reproduction side DC level detection circuit 1701 and mode control signal generating circuit 1702 in FIG. 17 are not needed, and a reproduced image signal of higher precision may be obtained in a smaller circuit scale.” SAMSUNG-1005, 23:17-22, 23:63-24:5, 24:15-20, 24:54-59; *see above* [1.1]. For the FIG. 3 embodiment, although Fukuda does not describe sending/recording the signal enhancement degree determined by the limiter 304 with coded image data, it would have been obvious and straightforward to a POSITA to apply Fukuda’s teachings of “a transmitter” and “reproducing means” to Fukuda’s FIG. 3 embodiment to**

send/record the signal enhancement degree determined by the limiter 304 with coded image data and to receive the signal enhancement degree for reproducing the image signal. SAMSUNG-1003, ¶42. Fukuda discloses that the “nonlinear de-emphasis circuit [of FIG. 3(b) has] a complementary characteristic to the nonlinear emphasis circuit shown in FIG. 3(a).” SAMSUNG-1005, 6:54-60. A POSITA would have been motivated to modify Fukuda’s FIG. 3 embodiment for similar reasons as Fukuda explains with respect to FIG. 17 and other embodiments, e.g., to eliminate circuit elements so that “a reproduced image signal of higher precision may be obtained in a smaller circuit scale.” SAMSUNG-1005, 23:17-22, 23:63-24:5 (“so that the hardware such as ROM storing the characteristic table is not needed”), 24:15-20, 24:54-59. Additionally, similar disclosure from JPH7-162862 was used to reject this claim feature in the ’128 patent’s Japanese application (Application No. 2001-033401). SAMSUNG-1009, ¶[0195]; SAMSUNG-1010, p. 24.

43. Although Fukuda describes “sending or recording mode signals together with coded image data,” Fukuda does not describe the implementation details for how it sends the mode signals together with coded image data and leaves those details to the general knowledge and capabilities of a POSITA. SAMSUNG-1005, 24:54-59, 23:17-22. Accordingly, a POSITA reviewing Fukuda would have been motivated to assess the known options available for transmitting

image data together with control data. As part of this assessment, a POSITA would have readily considered multiplexing as an obvious solution that was well-known and within the general knowledge of a POSITA prior to the '128 Patent.

44. Indeed, a POSITA would have recognized or found obvious that one example of transmitting Fukuda's "mode signals together with coded image data" would have included a *multiplexer* to multiplex video bitstreams with data needed to reproduce the video images for transmission/recording, as this was well known in the art. SAMSUNG-1005, 24:54-59, 23:17-22; SAMSUNG-1012, p. 673; SAMSUNG-1013, p. 60; SAMSUNG-1014, p. 62; SAMSUNG-1015, p. 284; SAMSUNG-1016, pp. 601-610; SAMSUNG-1017, pp. 77-80. Additionally, a POSITA would have been aware of multiplexing data as a well-known option "for sending or recording mode signals together with coded image data" and would have found it to be simply a matter of design choice to multiplex the data with the image/video signal. *Id.* In fact, Fukuda itself describes multiplexing as an option for transmitting image data with control data used in displaying the image data. SAMSUNG-1005, 20:43-47 ("a digital image signal composed of three component signals [e.g., image data] is entered in synchronism with horizontal and vertical synchronizing signals [e.g., control data for displaying the image data] and in time division multiplex.").

45. Multiplexers for video have been known in the art since at least the 1950s. Originally, analog multiplexers were used to combine video signals in the same channel or to combine video with audio in the same channel. SAMSUNG-1012 at p. 673; SAMSUNG-1013 at p. 60. In terms of well-known applications of video multiplexing, a POSITA would be familiar with closed captioning, which combines video with encoded text data for the hearing impaired. One of the first shows to use this multiplexing technology was “Mod Squad” in an early 1970s test. SAMSUNG-1014 at p. 62; SAMSUNG-1015 at p. 284. By later in the 1970s, digital multiplexing was becoming standard. SAMSUNG-1016 at pp. 601-610. The well-known MPEG standards for encoding video emerged in the 1990s (including MPEG-1 in 1991), which codified the multiplexing of video data and metadata in the same program stream. SAMSUNG-1017 at pp. 77-80, for example.

46. In addition, the ’128 Patent acknowledges that it was well-known and disclosed in JPH7-162862 that a “bitstream is multiplexed with emphasis data” that “is then output for storage or transfer.” SAMSUNG-1001, 2:4-10. Further, Fujikawa corroborates a POSITA’s knowledge at the time of the ’128 Patent and describes that “[d]ata which will be subsequently necessary for decoding purposes ... are also encoded and are transmitted to the decoding apparatus in the output bit

stream from the encoding apparatus, multiplexed with the encoded data of the video signal.” SAMSUNG-1006, 1:50-55.

47. As demonstrated by the disclosure of time division multiplexing in Fukuda, the admitted prior art of multiplexing a bitstream with emphasis data, and third-party evidence (e.g., Fujikawa) corroborating that multiplexing was a well-known technique for transmitting image data with control data used in displaying the image data, multiplexing was a known option for transmitting Fukuda’s “mode signals together with coded image data” that was within a POSITA’s general knowledge and would have been obvious to use in Fukuda. SAMSUNG-1005, 20:43-47; SAMSUNG-1006, 1:50-55. In fact, the use of multiplexing to transmit Fukuda’s image data with its emphasis level control data amounts to application of a known technique to a known device (Fukuda’s apparatus) ready for improvement to yield predictable results. In this regard, Fukuda describes a base device (Fukuda’s apparatus), the prior art contained a known technique (multiplexing) that is applicable to the Fukuda’s device, and a POSITA would have recognized that applying the known technique (multiplexing) would have yielded predictable results and resulted in an improved system. SAMSUNG-1005, 3:3-15, 20:43-47.

48. In addition, a POSITA would have found multiplexing to be one of a finite number of identified, predictable solutions for transmitting image data with control data that would have been obvious to try. Indeed, there were only a finite

number of solutions for transmitting image data together with control data and a POSITA would have seen multiplexing as one of, if not the most, common and obvious option. And, given that multiplexing technology was well-developed at the time of the '128 Patent, a POSITA would have had a reasonable expectation of success in using the well-known technique of multiplexing in Fukuda. For example, multiple companies sold multiplexer devices that could have been used to achieve multiplexing in Fukuda and a POSITA certainly would have been able to use or modify these devices to achieve the combination of image data and emphasis level data in Fukuda. Thus, Fukuda renders obvious a multiplexer for multiplexing the video bitstream and data on the emphasis level.

***[2] The video-emphasis encoding apparatus according to claim 1 further comprising a detector for detecting a degree of quantization applied to the input video signal, wherein the emphasis-level setter sets the emphasis level in accordance with the detected degree of quantization as the encoding conditions.***

49. Fukuda renders this claim obvious in multiple ways. As a **first** example, as described in [1.1] above, Fukuda discloses a “mode changeover circuit 701” (“***a detector for detecting a degree of quantization applied to the input video signal***”) that issues a “mode signal” that is dependent on the “coding compression rate control signal” (a “***degree of quantization***”). SAMSUNG-1005, 12:42-55, FIG. 7; *see above* [1.1]. Fukuda further explains that “[b]y thus selecting the mode enhancing the signal by the signal enhancement degree depending on the

quantization step size [(a “*degree of quantization*”)] in quantizing and suppressing the signal according to the signal enhancement, the coding noise can be removed efficiently.” SAMSUNG-1005, 17:46-50. A POSITA would have recognized or found obvious that the compression rate of a video signal is proportional to the “*degree of quantization.*” See SAMSUNG-1001, 8:42-45. In fact, the compression rate (equivalently expressed as a “compression ratio”) is inversely proportional to the bits per pixel (BPP). The degree of quantization controls the BPP (i.e., more quantization equals fewer bits per pixel).

50. Indeed, Fukuda reinforces this understanding:

As the measurement of coding distortion, the difference between the original signal and the signal after coding process may be measured ... **the amount of coding distortion may be expressed by the quantization step size used in quantizing the signal in coding process. To control to specified coding compression rate in coding process, the quantization step size in quantizing is controlled depending on the generated code amount.** That is, if the generated code amount is not much, the quantization step size is increased to suppress the code amount, and if the generated code amount is small, the quantization step size is decreased to control so that the code amount may be constant. As a result, the generated code amount increases, **and if the quantization step size increases accordingly, the coding distortion increases.**

SAMSUNG-1005, 17:29-45. Presented below is Fukuda's mode changeover circuit 701.

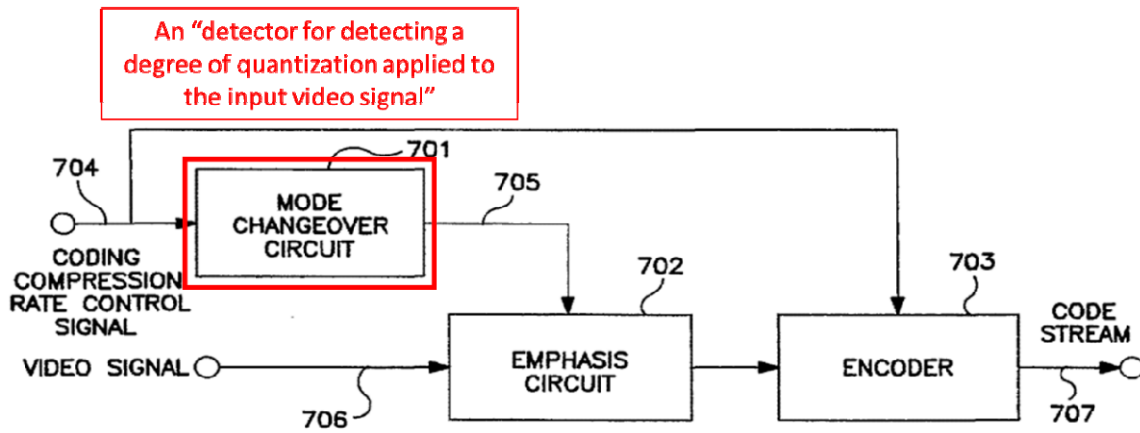


FIG. 7

SAMSUNG-1005, FIG. 7.

51. As a second example, as described in [1.1] above, Fukuda describes a “coding distortion measuring instrument 1001 and a mode changeover circuit 1002” (“*a detector for detecting a degree of quantization applied to the input video signal*”) that “issues a mode signal 1009 depending on the coding distortion 1008” (a “*degree of quantization*”). SAMSUNG-1005, 16:45-58, 17:29-50, FIG. 10; *see above* [1.1]. Fukuda further explains that “the amount of coding distortion may be expressed by the quantization step size used in quantizing the signal in coding process.” SAMSUNG-1005, 17:34-36. A POSITA would have recognized or found obvious that the coding distortion of a video signal is representative of the “*degree of quantization.*” SAMSUNG-1005, 17:29-45. Presented below is

Fukuda's mode changeover circuit 1002, which issues a mode signal based on coding distortion.

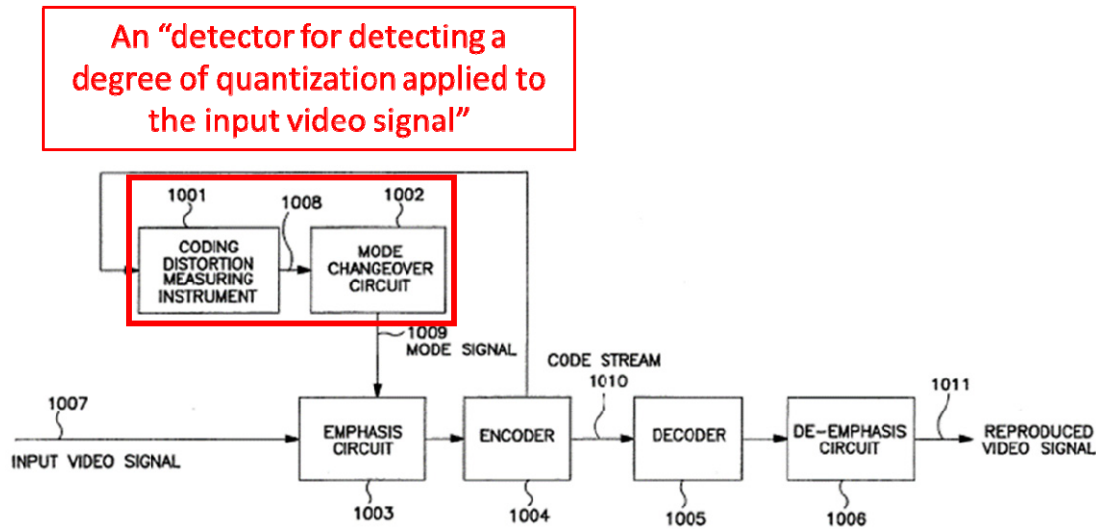


FIG. 10

SAMSUNG-1005, FIG. 10.

52. Further, similar disclosure from JPH7-162862 was successfully used to reject this claim feature in the '128 patent's Japanese application (Application No. 2001-033401). SAMSUNG-1009, ¶¶[0097]-[0100]; SAMSUNG-1010, p. 24.

**[3] The video-emphasis encoding apparatus according to claim 1 further comprising a detector for detecting a degree of enhancement effects already applied to the input video signal, wherein the emphasis-level setter sets the emphasis level in accordance with the detected degree of enhancement effects as the picture state detected from the input video signal.**

53. Fukuda renders this claim obvious. For example, as described in [1.1] and [2] above, Fukuda describes a "mode changeover circuit 701" that issues a "mode signal" that is dependent on the "coding compression rate control signal." SAMSUNG-1005, 12:42-55, FIG. 7. Fukuda also describes a

“coding distortion measuring instrument 1001 and a mode changeover circuit 1002” that “issues a mode signal 1009 depending on the coding distortion 1008.” SAMSUNG-1005, 16:45-58, 17:29-50, FIG. 10. Based on Fukuda’s disclosure, a POSITA would have recognized or found obvious that the coding compression rate and the coding distortion of a video signal is proportional to the quantization step size. SAMSUNG-1005, 17:29-45; *see also* SAMSUNG-1001, 8:42-45. In fact, Fukuda explicitly states that “...the amount of coding distortion may be expressed by the quantization step size used in quantizing the signal in the coding process.” SAMSUNG-1005, 17:34-36.

54. In its infringement contentions, the patent owner appears to advance a scope for “a degree of enhancement effects already applied to the input video signal” as encompassing quantization parameters derived from a rate control algorithm. In accordance with the scope of this claim advanced by the patent owner in its infringement contentions, Fukuda teaches that the “mode changeover circuit 701” and the “mode changeover circuit 1002” (“*emphasis-level setter*”) each includes a detector for detecting the quantization step size determined by a “coding compression rate control signal” or a “coding distortion measuring instrument” (“*degree of enhancement effects already applied to the input video signal*”) and issues a mode signal depending on the quantization step size (“*sets the emphasis level in accordance with the detected degree of enhancement*

*effects as the picture state detected from the input video signal*”) in a similar manner as the products that the patent owner alleges satisfies this claim.

**[4.pre]      *A method of video-emphasis encoding for applying an emphasis processing to an input video signal to obtain a video bitstream comprising the steps of:***

55.    To the extent the preamble is limiting, Fukuda describes that its “coding process and decoding process may be realized by any known method” (a “*method of video-emphasis encoding*”). SAMSUNG-1005, 25:44-47; *see above* [1.pre].

**[4.1]    *setting an emphasis level to the input video signal in accordance with at least one factor among control data carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal;***

56.    I believe this claim element is rendered obvious for the reasons established above in [1.1]. *See above*, [1.1].

**[4.2]    *applying the emphasis processing to the input video signal at the emphasis level to obtain a emphasized video signal;***

57.    I believe this claim element is rendered obvious for the reasons established above in [1.2]. *See above*, [1.2].

**[4.3]    *encoding the emphasized video signal to obtain a video bitstream; and***

58.    I believe this claim element is rendered obvious for the reasons established above in [1.3]. *See above*, [1.3].

**[4.4]    *multiplexing the video bitstream and data on the emphasis level.***

59. I believe this claim element is rendered obvious for the reasons established above in [1.4]. *See above*, [1.4].

***[5.pre] A video-deemphasis decoding apparatus for decoding and applying a deemphasis processing to an input video bitstream comprising:***

60. To the extent the preamble is limiting, Fukuda renders it obvious. Fukuda describes multiple embodiments of a “coding and decoding apparatus” for decoding and applying a deemphasis processing to an input video code stream. SAMSUNG-1005, 2:13-60, FIGS. 1-19. In one example, Fukuda describes that, after encoding the code stream, the “code stream is transmitted to a decoder” and “the decoder decodes the code stream.” SAMSUNG-1005, Abstract, 3:3-20, 5:29-39, 20:56-21:7, FIG. 1; *see above* [1.pre]. The “decoded video signal is [then] fed to a de-emphasis circuit” where “low noise high quality video signals [are] reproduced from the de-emphasis circuit” (“***[a] video-deemphasis decoding apparatus for decoding and applying a deemphasis processing to an input video bitstream***”). SAMSUNG-1005, Abstract, 3:3-20, 5:29-39, 20:56-21:7, FIG. 1; *see above* [1.pre]. An example apparatus according to Fukuda is presented below in FIG. 1.

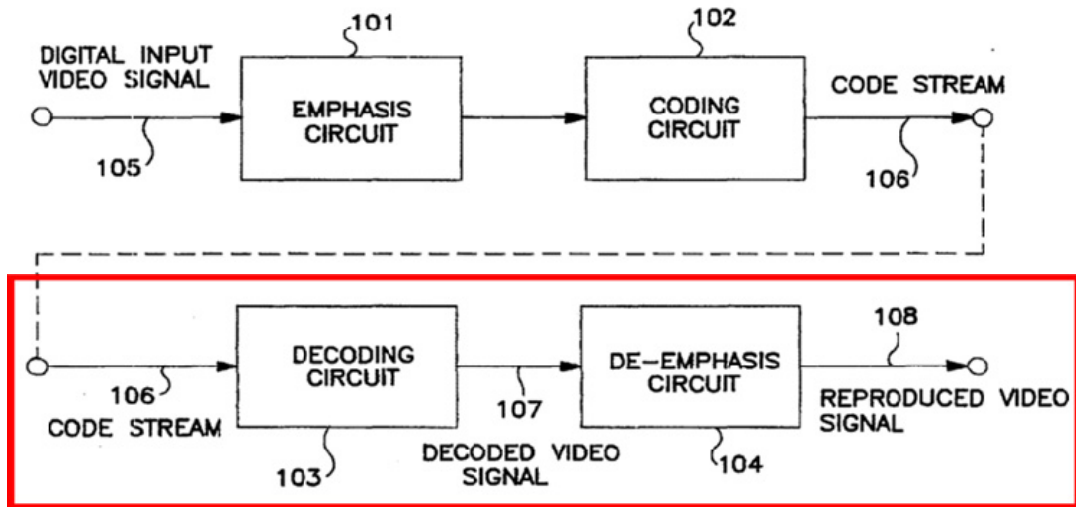
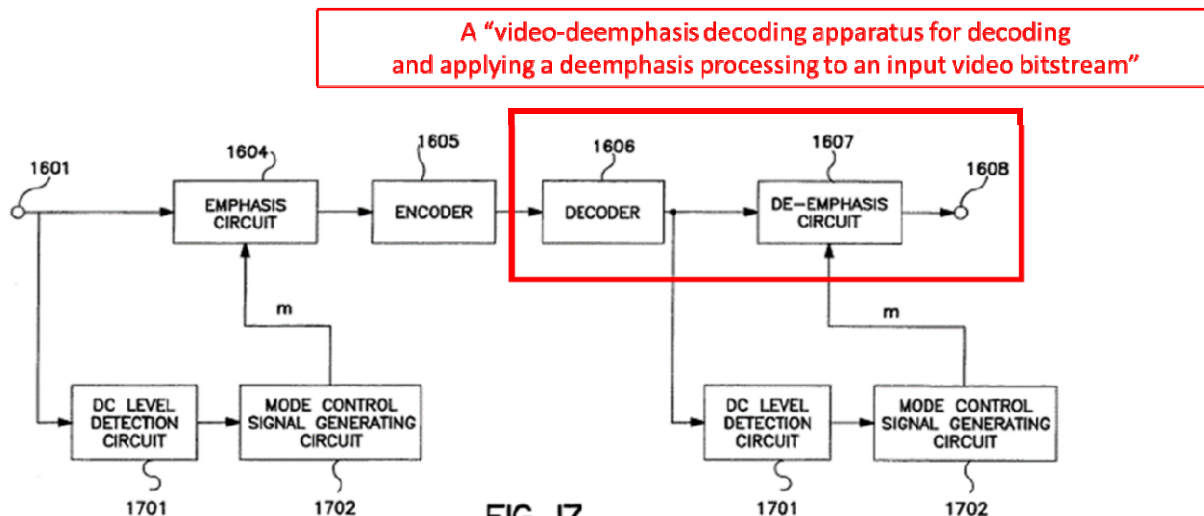


**FIG. 1**

**A "video-deemphasis decoding apparatus for decoding and applying a deemphasis processing to an input video bitstream"**

SAMSUNG-1005, FIG. 1.

61. Additionally, Fukuda describes another example illustrated in FIG. 17 that includes a "decoder 1606" that "decodes the code stream" and a "de-emphasis circuit 1607" that "suppresses the signal in every component of the decoded image signal." SAMSUNG-1005, 20:56-21:7, FIG. 17; *see above* [1.pre]. An example apparatus according to Fukuda is presented below in FIG. 17.



SAMSUNG-1005, FIG. 17.

***[5.1] a deemphasis-level setter for setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level;***

62. Fukuda renders this claim element obvious in multiple ways. For example, Fukuda describes multiple embodiments of emphasis coding/decoding, many of which render “***setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream***” obvious. For example, Fukuda describes, for many of the embodiments, that “signal enhancement and signal suppression are in complementary relation” and that “the de-emphasis circuit for signal suppression process may be in complementary relation with the emphasis circuit.” See, e.g., SAMSUNG-1005, 12:56-67, 13:1-16, 3:21-27, 4:8-10, 4:28-34, 6:54-56, 15:26-28, 16:16-18, 17:1-3, 21:2-7, 21:42-48, 22:27-28, 23:47-49.

A POSITA would have recognized or found obvious that Fukuda's video-deemphasis decoding apparatus would include a "*deemphasis-level setter*" which "[sets] the deemphasis level that matches the emphasis level" as this is consistent with Fukuda's disclosure. SAMSUNG-1005, 12:56-58, FIGS. 16 ("control signal generating circuit 1603"), 17 ("mode control signal generating circuit 1702").

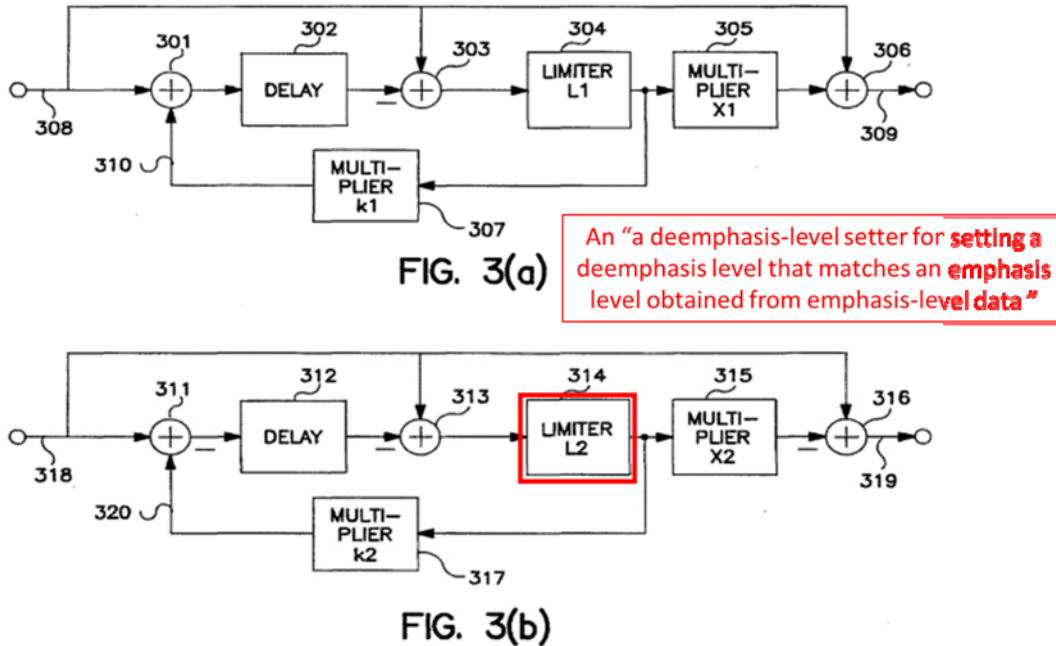
63. As a first example, Fukuda describes a "de-emphasis circuit having a nonlinear characteristic" (replacing the de-emphasis circuit 104 in FIG. 1) for "suppressing the signal with a smaller degree as the signal amplitude becomes larger." SAMSUNG-1005, 5:29-50, 6:9-41. Fukuda explains that "by providing the signal amplitude with a nonlinear characteristic, the signal components having a similar amplitude to the generated noise components are enhanced and suppressed with a large degree." SAMSUNG-1005, 5:40-50. Included in Fukuda's non-linear de-emphasis circuit is a "limiter 314" ("*a deemphasis-level setter*") that, similar to limiter 304 described in [1.1], "limits the amplitude of the output signal" based on whether amplitude of the input signal is greater than a set parameter "L." SAMSUNG-1005, 6:21-30, FIG. 3(b). Fukuda describes that the deemphasis circuit has "a complementary characteristic to the nonlinear emphasis circuit shown in FIG. 3(a)" ("*setting a deemphasis level that matches an emphasis level ... to which an input video*

*signal has been encoded and emphasized at the emphasis level”).*

SAMSUNG-1005, 6:61-67, 7:1-5; *see above* [1.1].

64. As discussed above in [1.4], it would have been obvious and straightforward to a POSITA to apply Fukuda’s teachings of a transmitter for sending or recording mode signals together with coded image data (SAMSUNG-1005, 24:54-59, 23:17-22) to Fukuda’s FIG. 3 embodiment to send/record the signal enhancement degree determined by the limiter 304 with coded image data. Fukuda discloses that the “nonlinear de-emphasis circuit [of FIG. 3(b) has] a complementary characteristic to the nonlinear emphasis circuit shown in FIG. 3(a).” SAMSUNG-1005, 6:54-60. A POSITA would have been motivated to modify Fukuda’s FIG. 3 embodiment for similar reasons as Fukuda explains with respect to FIG. 17 and other embodiments, e.g., to eliminate circuit elements so that “a reproduced image signal of higher precision may be obtained in a smaller circuit scale.” SAMSUNG-1005, 23:17-22, 23:63-24:5 (“so that the hardware such as ROM storing the characteristic table is not needed”), 24:15-20, 24:54-59; *see above* [1.4]. In this way, the emphasis level is obtained from emphasis-level data carried by the code stream and the de-emphasis level setter sets a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the code stream to which an input video signal has been encoded and emphasized at the emphasis

level. Fukuda also teaches similar efficiencies in conjunction with the embodiment shown in FIG. 18. SAMSUNG-1005, 23:63-24:5.



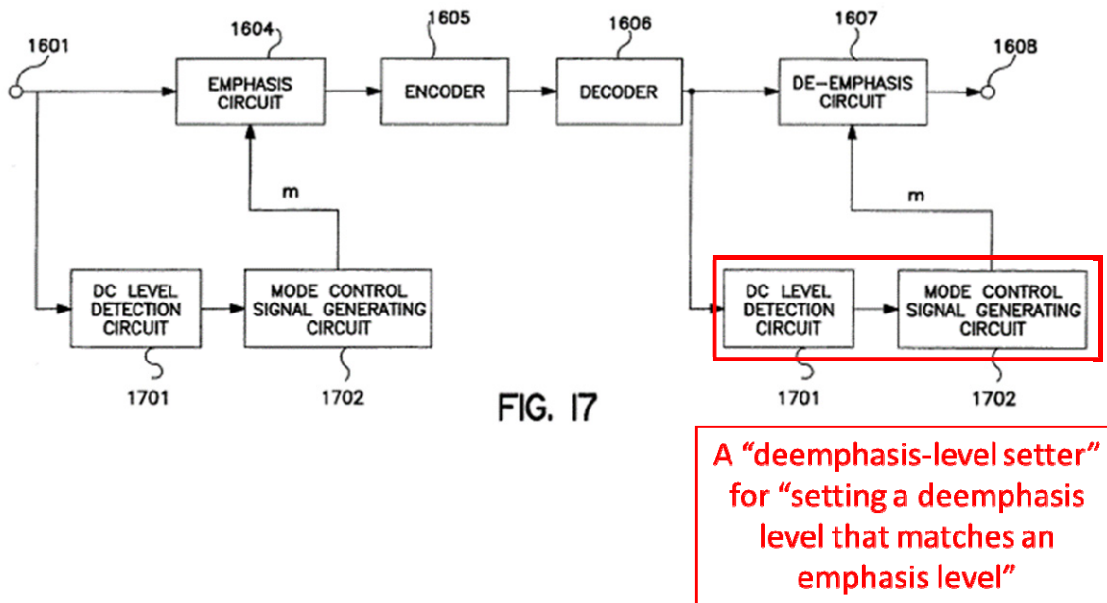
SAMSUNG-1005, FIG. 3(b).

65. As a second example, Fukuda describes a “DC level detection circuit [1701]” and a “mode control signal generating circuit [1702]”<sup>6</sup> (“a deemphasis-

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<sup>6</sup> Fukuda’s FIG. 17 shares components with FIG. 16. SAMSUNG-1005, 22:36-61. FIG. 2(b) also provides an example of FIG. 16’s “deemphasis circuit 1607.” SAMSUNG-1005, 20:38-42. Fukuda discloses that “an example of the emphasis circuit 101 is shown in FIG. 2(a)” and “An example of de-emphasis circuit having a complementary characteristic to the emphasis circuit in FIG. 2(a) is shown in FIG. 2(b).” SAMSUNG-1005, 3:28-31, 3:53-58. Taken together, this

*level setter*”) where “the emphasis characteristic of the emphasis circuit 1604 selected by the mode control signal m) and the de-emphasis characteristic of the de-emphasis circuit 1607 selected by the mode control signal m are in complementary relation” (“*setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level*”). SAMSUNG-1005, 22:40-23:5, FIG. 17; see above [1.1].



SAMSUNG-1005, FIG. 17.

disclosure demonstrates that de-emphasis circuit 1607 illustrated in FIGS. 16-18 is a similar component to the de-emphasis circuit 104 of FIG. 1. SAMSUNG-1005, 3:28-31, 20:29-42, 22:36-61

66. As a **third** example, with respect to the “mode changeover circuit 701” (incorporated into the “apparatus as shown in FIG. 1”) described in [1.1], Fukuda describes that “signal enhancement and signal suppression are in complementary relation” and that “the de-emphasis circuit” (“*a deemphasis-level setter*”) is in “complementary relation with the emphasis circuit 702” (“*setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level*”). SAMSUNG-1005, 12:42-48, 12:56-67, 13:1-16; *see above* [1.1].

67. As a **fourth** example, with respect to the “activity detector 801 and a mode changeover circuit 802” described in [1.1], Fukuda describes that “[t]he code stream 810 is decoded in a decoder 805, and suppressed in a de-emphasis circuit [806]”<sup>7</sup> (“*a deemphasis-level setter*”) by “the suppression degree depending on the enhancement degree of the emphasis circuit 803” (“*setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized*”).

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<sup>7</sup> Fukuda discloses that these components are “installed in a coding and decoding apparatus as shown in FIG. 1” (i.e., “deemphasis circuit 806” is a similar component to “deemphasis circuit 104,” and so on). SAMSUNG-1005, 14:46-51.

*at the emphasis level*"). SAMSUNG-1005, 14:59-63, 15:26-29 (“[t]he de-emphasis circuit 806 for signal suppression process may be a circuit in a complementary relation with the emphasis circuit 803”); *see above* [1.1].

68. As a **fifth** example, with respect to the “motion amount detector 901” and “mode changeover circuit 902 installed in the coding and decoding apparatus as shown in FIG. 1” described in [1.1], Fukuda describes that “[t]he obtained code stream 910 is decoded in a decoder 905, and suppressed in a de-emphasis circuit 906 by the suppression degree corresponding to the enhancement degree of the emphasis circuit 903” (“*setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level*”). SAMSUNG-1005, 15:56-60, 16:16-19 (“[t]he de-emphasis circuit 906 for signal suppression process may be a circuit in a complementary relation with the emphasis circuit 903”); *see above* [1.1].

69. As a **sixth** example, with respect to the “coding distortion measuring instrument 1001 and a mode changeover circuit 1002” (incorporated into the “apparatus as shown in FIG. 1”) described in [1.1], Fukuda describes that “[t]he code stream 1010 is decoded in a decoder 1005, and is suppressed in a de-emphasis circuit 1006 by the suppression degree depending on the enhancement degree of the emphasis circuit 1003” (“*setting a deemphasis level that matches an emphasis*

*level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level”).*

SAMSUNG-1005, 16:59-63, 17:1-4 (“[t]he de-emphasis circuit 1006 for signal suppression process may be a circuit in a complementary relation with the emphasis circuit 1003”); *see above* [1.1].

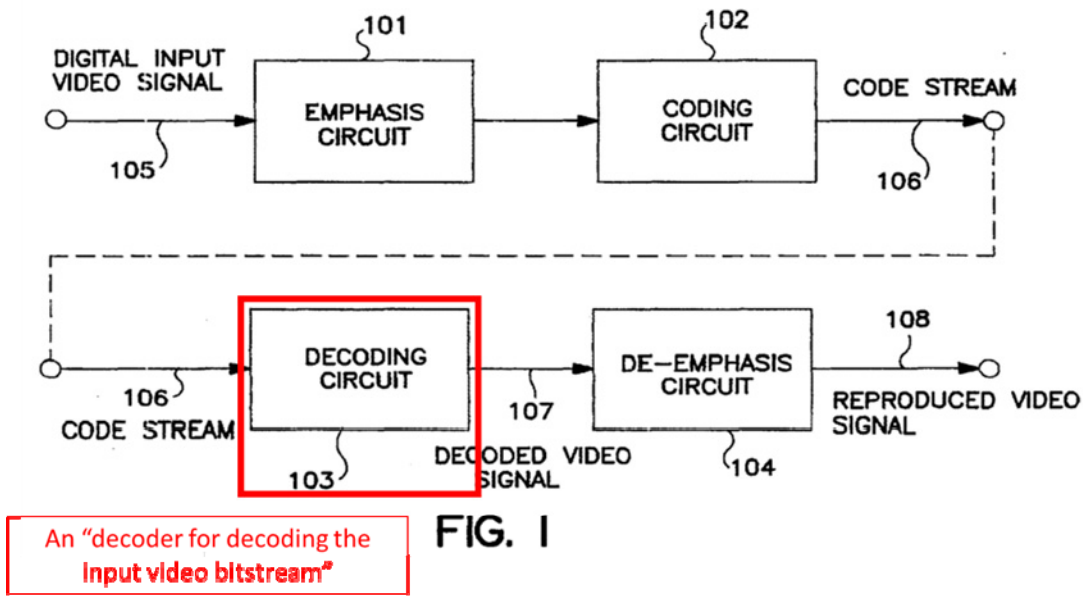
70. As discussed above in [1.4], Fukuda discloses many embodiments that provide a mode signal for controlling the signal enhancement degree of the emphasis circuit. SAMSUNG-1005, 11:1-40, 12:42-13:16, 14:46-15:4, 15:43-16:5, 16:45-67, 17:51-18:15, 18:28-46, 18:65-19:18, 20:29-64, 22:40-23:22, FIGS. 6-11, 13-14, 17. Fukuda discloses that these embodiments “may also comprise a transmitter for sending or recording mode signals together with coded image data, and the reproducing means may comprise means for receiving mode signals.” SAMSUNG-1005, 24:54-59. For example, with respect to the FIG. 17 embodiment, Fukuda discloses that “by transmitting the mode control signal *m* in emphasis or recording in a medium, the reproduction side DC level detection circuit 1701 and mode control signal generating circuit 1702 in FIG. 17 are not needed, and a reproduced image signal of higher precision may be obtained in a smaller circuit scale.” SAMSUNG-1005, 23:17-22, 23:63-24:5, 24:15-20, 24:54-59; *see above* [1.4]. In this way, the mode control signal indicating the emphasis level is obtained from emphasis-level data carried by the code stream and the de-

emphasis level setter sets a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the code stream to which an input video signal has been encoded and emphasized at the emphasis level. Fukuda also teaches similar efficiencies for FIG. 18. SAMSUNG-1005, 23:63-24:5.

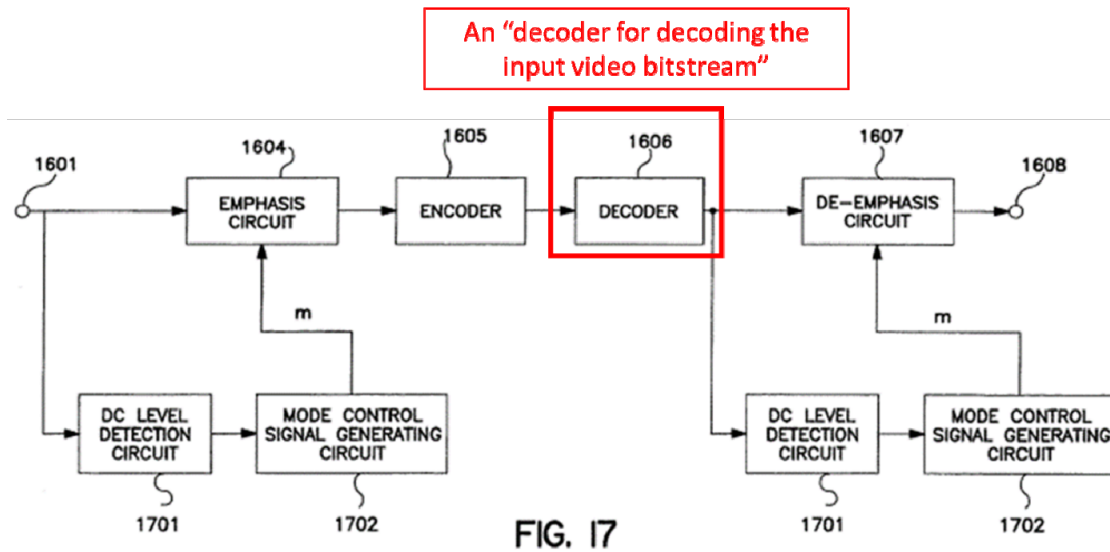
***[5.2] a decoder for decoding the input video bitstream for reproducing the video signal; and***

71. Fukuda renders this claim element obvious in multiple ways. For example, multiple of Fukuda's embodiments each includes a decoding circuit for decoding (e.g., "decoding circuit" or "decoder" of Fukuda's embodiments referenced above in [5.1]). SAMSUNG-1005, 2:13-60; FIGS. 1-19; *see above* [5.1]. A couple of examples are provided below.

72. As a **first** example, Fukuda describes a "decoding circuit 103" that receives the "code stream" and "issues a decoded video signal." SAMSUNG-1005, 3:8-15, FIG. 1. As a **second** example, Fukuda describes an "decoder 1606" which "decodes the code stream, and issues the decoded image signal." SAMSUNG-1005, 20:56-21:7, FIG. 17. Examples of decoders within Fukuda are presented below.



SAMSUNG-1005, FIG. 1.



SAMSUNG-1005, FIG. 17.

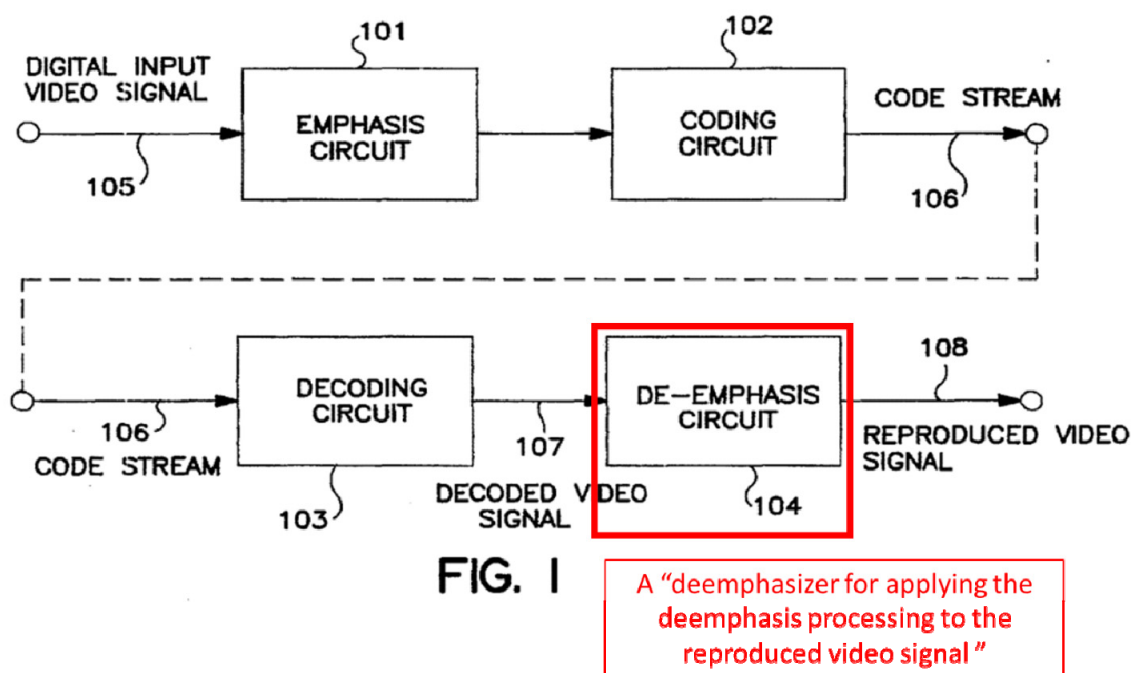
*[5.3] a deemphasizer for applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal.*

73. Fukuda renders this claim element obvious in multiple ways. For example, multiple of Fukuda's embodiments each includes a deemphasis circuit

for applying deemphasis processing (e.g., “de-emphasis circuit” of Fukuda’s embodiments referenced above in [5.1] and [5.2]). SAMSUNG-1005, 2:13-60; FIGS. 1-19; *see above* [5.1]-[5.2]. A couple of examples are provided below.

74. As a **first** example, Fukuda describes a “de-emphasis circuit 104” (a “*deemphasizer*”) that suppresses a “decoded video signal” by a “specified enhancement degree, and issues a reproduced video signal 108” (“*applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal*”). SAMSUNG-1005, 3:8-15, FIG. 1.

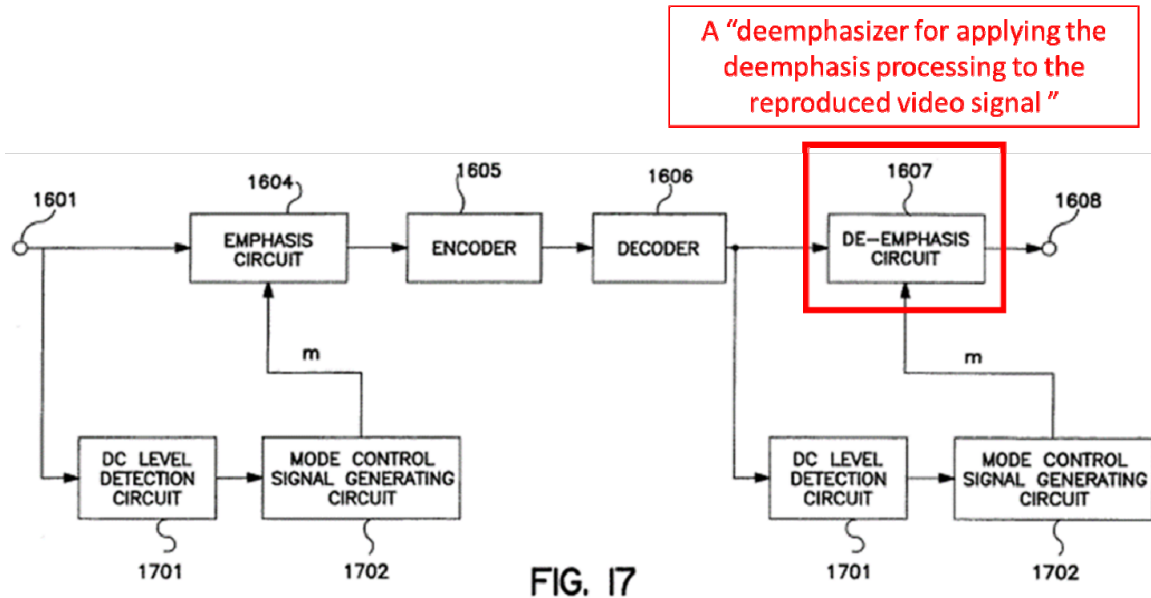
Presented below is Fukuda’s emphasis circuit 101.



SAMSUNG-1005, FIG. 1.

75. As a **second** example, Fukuda describes an “de-emphasis circuit 1607” (a “*deemphasizer*”) which “suppresses the signal ... according to one of the

plural types of de-emphasis characteristic selected by the mode control signal m”  
*(“applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal”)*. SAMSUNG-1005, 20:56-21:7, FIG. 17. Presented below is Fukuda’s de-emphasis circuit 1607.



SAMSUNG-1005, FIG. 17.

**[6]** *The video-deemphasis decoding apparatus according to claim 5, wherein the deemphasis-level setter obtains data including a degree of quantization applied to the input video signal as the emphasis-level data to obtain the emphasis level in accordance with the degree of quantization, thus setting the deemphasis level that matches the emphasis level.*

76. Fukuda renders this claim obvious in multiple ways. For example, Fukuda describes, for many of its embodiments, that “signal enhancement and signal suppression are in complementary relation” and that “the de-emphasis circuit for signal suppression process may be in complementary relation with the emphasis circuit.” See, e.g., SAMSUNG-1005, 12:56-67, 13:1-16, 3:21-27,

4:8-10, 4:28-34, 6:54-56, 15:26-28, 16:16-18, 17:1-3, 21:2-7, 21:42-48, 22:27-28, 23:47-49. As explained above in [5.1], the emphasis level is obtained from emphasis-level data carried by the code stream and the de-emphasis circuit sets a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the code stream to which an input video signal has been encoded and emphasized at the emphasis level. A POSITA would have recognized or found obvious that Fukuda's video-deemphasis decoding apparatus would include a "*deemphasis-level setter*" which "[sets] the *deemphasis level that matches the emphasis level*" as this is consistent with Fukuda's disclosure. SAMSUNG-1005, 12:56-58, FIGS. 16 ("control signal generating circuit 1603"), 17 ("mode control signal generating circuit 1702"). As discussed above in [2], Fukuda sets emphasis based on "*a degree of quantization applied to the input video signal*" and therefore would set the deemphasis level to match the emphasis level. *See above* [2].

**[8pre]      A video-deemphasis decoding method for decoding and applying a deemphasis processing to an input video bit stream comprising the steps of:**

77.    To the extent the preamble is limiting, Fukuda describes that its "decoding process may be realized by any known method" (a "*video-deemphasis decoding method*"). SAMSUNG-1005, 25:44-47; *see above* [5.pre].

***[8.1] setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level;***

78. I believe this claim element is rendered obvious for the reasons established above in [5.1]. *See above*, [5.1].

***[8.2] decoding the input video bitstream for reproducing the video signal; and***

79. I believe this claim element is rendered obvious for the reasons established above in [5.2]. *See above*, [5.2].

***[8.3] applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal.***

80. I believe this claim element is rendered obvious for the reasons established above in [5.3]. *See above*, [5.3].

## **ANALYSIS OF FUKUDA AND FUJIKAWA**

### **I. Fujikawa**

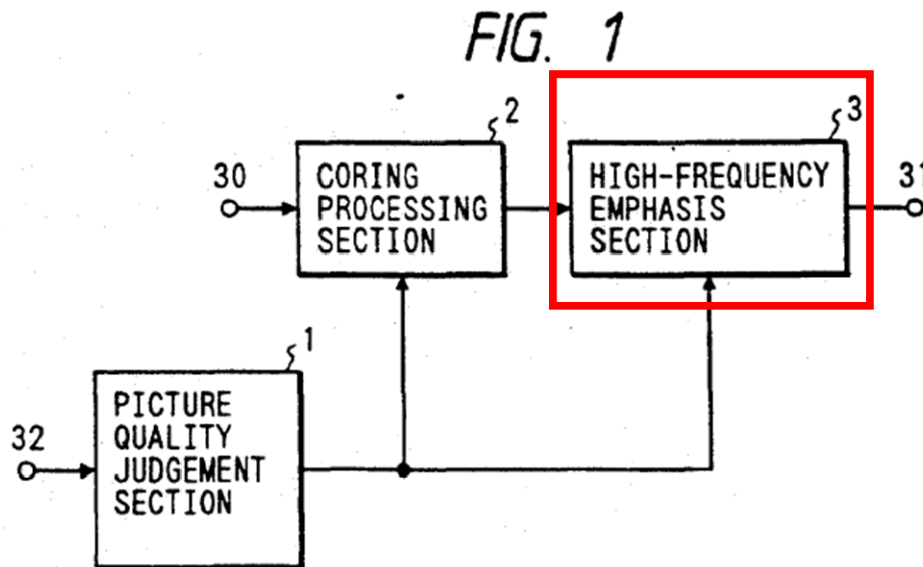
81. Fujikawa describes an “encoding noise reduction filter ... applicable to a decoded video signal produced from a digital video signal encoding and decoding apparatus” where “variable values of quantization step size are utilized within each video signal frame.” SAMSUNG-1006, Abstract. Fujikawa explains that known “methods have been proposed, for use with a moving-picture digital video signal encoding and decoding apparatus, whereby the quantization step size that is used in a quantization operation for the purpose of encoding the video signal is varied such as to maintain a constant bit rate for the encoded data.”

SAMSUNG-1006, 1:20-26. In these prior known methods, “[d]ata which will be subsequently necessary for decoding purposes, including the quantization step size values, are also encoded and are transmitted to the decoding apparatus in the output bit stream from the encoding apparatus, multiplexed with the encoded data of the video signal.” SAMSUNG-1006, 1:50-55. Fujikawa further explains that “with such a digital video signal encoding and decoding apparatus, when the quantization step size is large, a specific type of noise is produced in the display picture that is obtained from the decoded video signal. That noise is most conspicuous at the boundaries between different regions in picture conveyed by the video signal, and is conspicuous in the finally displayed picture. Such noise constitutes a significant problem.” SAMSUNG-1006, 2:5-12.

82. Fujikawa thus provides “an encoding noise reduction filter which is applicable to a decoded video signal produced from such a type of digital video signal encoding and decoding apparatus” that provides “an improvement in picture quality.” SAMSUNG-1006, 2:58-3:9, 4:8-10, FIG. 1. The encoding noise reduction filter includes a “coring processing section 2” that “is executed in order to exclude the noise components, which are mainly concentrated in the low-amplitude high spatial frequency components of the video signal.” SAMSUNG-1006, 5:6-23.

83. Fujikawa's encoding noise reduction filter also includes a "high frequency emphasis section 3" that "executes high frequency emphasis ... by calculating for each picture element a ... 'Laplacian' value." SAMSUNG-1006, 5:24-43. "The Laplacian values of picture elements ... provide an indication of the degree of contrast between the adjoining regions" of the picture. *Id.* Based on the Laplacian values of respective picture elements, the high frequency emphasis section 3 applies compensation for "a loss of resolution which results from the processing executed in the coring processing section 2." *Id.*

A "video-emphasis encoding apparatus for applying an emphasis processing to an input video signal"



SAMSUNG-1006, FIG. 1.

## II. Combination of Fukuda and Fujikawa

84. While Fukuda expressly discloses "a transmitter for sending or recording mode signals together with coded image data, and the reproducing

means may comprise means for receiving mode signals” (SAMSUNG-1005, 24:54-59), Fukuda lacks details regarding the format for transmitting the mode signals together with the coded image data. *See above* §II.[1.4]. As such, a POSITA naturally would have searched for implementation details for Fukuda’s “transmitter” (“sending or recording mode signals together with coded image data”). In this search, they would have found a reference that describes multiplexing, like Fujikawa.

85. A POSITA would have found it obvious and straightforward to complement Fukuda with Fujikawa’s disclosure that “[d]ata which will be subsequently necessary for decoding purposes ... are transmitted to the decoding apparatus in the output bit stream from the encoding apparatus, multiplexed with the encoded data of the video signal.” SAMSUNG-1006, 1:50-55. In reality, given one transmission channel (which is typically the case), the most obvious solution for transmitting the mode signal along with the video data is to multiplex these components, forming one stream. Accounting for Fujikawa, Fukuda’s transmitter would multiplex the mode signals needed to reproduce the image signal together with the coded image data into the code stream for sending or recording. SAMSUNG-1005, 24:54-59; SAMSUNG-1006, 1:50-55. Fujikawa confirms the notion that a POSITA would have been aware that multiplexing data necessary for reproducing an image/video signal together with coded image/video data was a

known option for sending/recording the data and image/video signal together as a code stream and would have found it to be simply a matter of design choice to multiplex the data with the image/video signal.

86. Additionally, a POSITA would have been motivated and would have found it obvious and straightforward to incorporate in Fukuda's coding and decoding apparatus, e.g., incorporated into Fukuda's emphasis circuit, Fujikawa's teachings of enhancement effects to exclude noise components in a picture and high frequency emphasis processing based on "an indication of the degree of contrast between the adjoining regions" of the picture as a result of the noise reduction enhancement effects applied to the picture. SAMSUNG-1006, 5:6-43. While Fujikawa describes a specific type of noise, it would have been obvious and straightforward to a POSITA to apply Fujikawa's teachings of noise reduction to a variety of noise present in a picture. For example, a POSITA knew that noise can arise during image acquisition, as "light levels and sensor temperature are major factors affecting the amount of noise in the resulting image." SAMSUNG-1011, 222. A POSITA would have been motivated to apply noise reduction to a noisy image to provide an improvement in picture quality. SAMSUNG-1006, 2:58-3:9, 5:6-43. Fujikawa further explains that the high frequency emphasis processing compensates for "a loss of resolution which results from" the noise reduction enhancement effects. *Id.* Thus, a POSITA would have been motivated to

incorporate Fujikawa's teachings to beneficially provide "an improvement in picture quality" by reducing noise in the picture and to provide compensation for "a loss of resolution which results from" noise reduction enhancement effects.

SAMSUNG-1006, 2:58-3:9, 5:6-43. Further, Fujikawa's method of setting emphasis level based on the degree of contrast between adjoining regions would have enhanced Fukuda's existing emphasis calculations, which are also conscious of quantization step size. SAMSUNG-1005, 12:42-55, 17:29-45; SAMSUNG-1006, 5:24-43, 7:42-67.

87. Moreover, combining Fukuda and Fujikawa would have been obvious at least because such a combination would have merely involved (1) combining prior art elements according to known methods to yield predictable results and (2) the use of known technique to improve similar devices (methods, or products) in the same way. Incorporating Fujikawa's teachings of multiplexing mode signals and coded image data and emphasis level setting based on the degree of contrast between adjoining regions into Fukuda's emphasis coding/decoding apparatus would also have been predictable and foreseeable with a reasonable expectation of success because Fukuda describes "sending or recording mode signals together with coded image data." SAMSUNG-1005, 24:54-59; *see Fukuda* [1.4] *above*. Additionally, Fukuda describes multiple embodiments of setting emphasis level

based on characteristics of a video signal. SAMSUNG-1005, 5:29-50, 6:9-41, 14:46-15:4, 15:43-48, 18:65-19:36, 22:40-23:5; *see* Ground 1A [1.1] *above*.

88. In an example of the combined Fukuda-Fujikawa system, illustrated below using Fukuda's FIG. 1, Fujikawa's teachings of multiplexing and high frequency emphasis/coring processing sections would have been incorporated into Fukuda's emphasis coding/decoding apparatus. (In Fujikawa, coring refers to the process of eliminating high frequency components below a threshold.) In the resulting Fukuda-Fujikawa system, emphasis information would be multiplexed with the video stream. SAMSUNG-1005, 24:54-59, FIG. 1; SAMSUNG-1006, 1:50-55. Additionally, in the combined system, Fujikawa's teachings of emphasis processing based on the degree of contrast between adjoining regions would have complemented those of Fukuda. SAMSUNG-1005, 5:29-50, 6:9-41, 14:46-15:4, 15:43-48, 18:65-19:36, 22:40-23:5; SAMSUNG-1006, 5:24-43, 7:42-67.

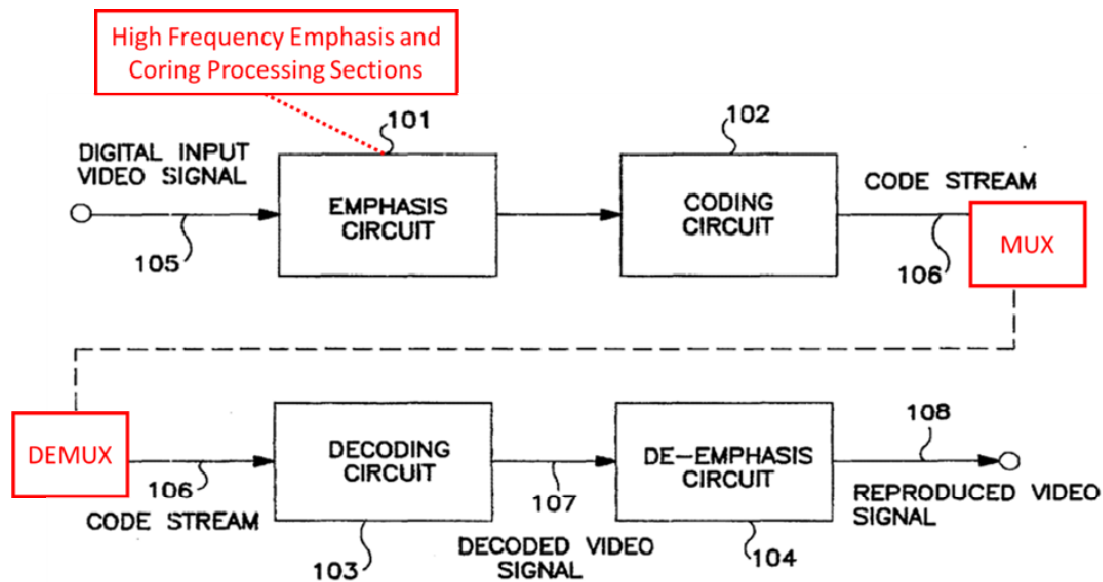


FIG. 1

SAMSUNG-1005, FIG. 1 (modified based on Fujikawa teachings).

### III. Claims 1-4 are rendered obvious by Fukuda and Fujikawa

89. My Fukuda-Fujikawa analysis is substantively identical to, and incorporates the analysis of, my Fukuda analysis. But where my Fukuda analysis relies on a POSITA's general knowledge and ordinary level of skill to satisfy elements [1.1], [1.4], [3], [4.1], and [4.4], my Fukuda-Fujikawa analysis of elements [1.1], [1.4], [3], [4.1], and [4.4] relies on Fukuda and Fujikawa as a combination in which Fujikawa is explicitly offered as part of the combination to demonstrate a broader concept that was obvious to a POSITA, namely *“a picture state detected from the input video signal”* of elements [1.1] and [4.1], *“multiplexing the video bitstream and data on the emphasis level”* of elements [1.4] and [4.4] and *“a detector for detecting a degree of enhancement effects*

*already applied to the input video signal, wherein the emphasis-level setter sets the emphasis level in accordance with the detected degree of enhancement effects as the picture state detected from the input video signal” of claim 3.*

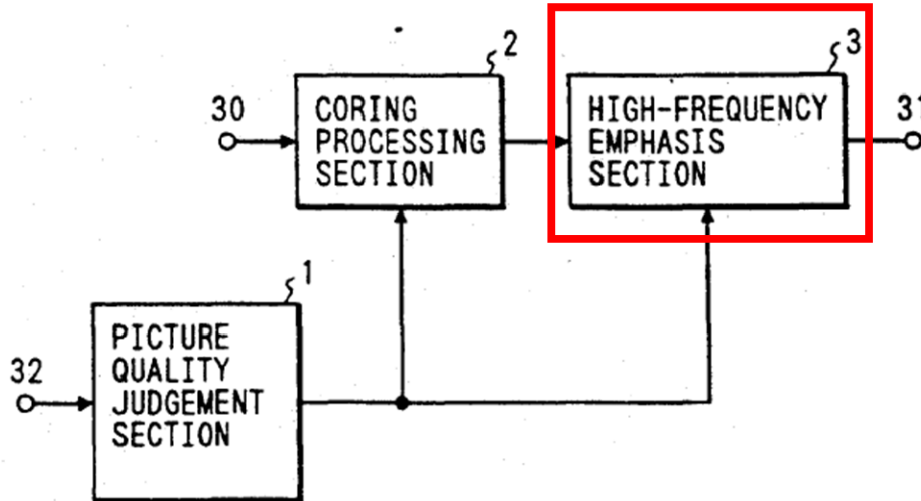
Integration of Fujikawa does not disturb the aspects of Fukuda mapped to the claim elements. To avoid repetition, and because my analysis of all other claim elements is identical, only [1.1], [1.4], [3], [4.1], and [4.4] are addressed below.

*[1.1] an emphasis-level setter for setting an emphasis level to the input video signal in accordance with at least one factor among control data carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal;*

90. Fukuda-Fujikawa renders this claim obvious. Fujikawa describes a “high frequency emphasis section 3” which applies “high frequency emphasis” (*“an emphasis-level setter for setting an emphasis level to the input video signal”*) to a signal produced by a “coring processing section 2” that “separates the high spatial frequency components ... from the low spatial frequency components, and converts to the value zero all of those picture element values contained in the high spatial frequency components which are below a predetermined threshold value” (*“in accordance with ... a picture state detected from the input video signal”*). SAMSUNG-1006, 5:6-43, 7:1-67, FIGS. 1, 3-4; *see below* [3].

“an emphasis-level setter for setting an emphasis level to the input video signal in accordance with ... a picture state detected from the input video signal”

FIG. 1



SAMSUNG-1006, FIG. 1.

**[1.4] a multiplexer for multiplexing the Video bitstream and data on the emphasis level.**

91. Fukuda-Fujikawa renders these claim elements obvious. As discussed above in my Fukuda analysis of [1.4] (incorporated here), Fukuda discloses “a transmitter for sending or recording mode signals together with coded image data, and the reproducing means may comprise means for receiving mode signals.” SAMSUNG-1005, 24:54-59. But Fukuda lacks details regarding the format for transmitting the mode signals together with the coded image data. As such, a POSITA naturally would have searched for implementation details for Fukuda’s

“transmitter” (“sending or recording mode signals together with coded image data”). In this search, they would have found a reference that describes multiplexing, like Fujikawa.

92. A POSITA would have found it obvious and straightforward to complement Fukuda with Fujikawa’s disclosure that “[d]ata which will be subsequently necessary for decoding purposes ... are transmitted to the decoding apparatus in the output bit stream from the encoding apparatus, multiplexed with the encoded data of the video signal.” SAMSUNG-1006, 1:50-55. Accounting for Fujikawa, Fukuda’s transmitter would multiplex the mode signals needed to reproduce the image signal together with the coded image data into the code stream for sending or recording. SAMSUNG-1005, 24:54-59; SAMSUNG-1006, 1:50-55. Fujikawa confirms the notion that a POSITA would have been aware that multiplexing data necessary for reproducing an image/video signal together with coded image/video data was a known option for sending/recording the data and image/video signal together as a code stream and would have found it to be simply a matter of design choice to multiplex the data with the image/video signal.

***[4.1] setting an emphasis level to the input video signal in accordance with at least one factor among control data carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal;***

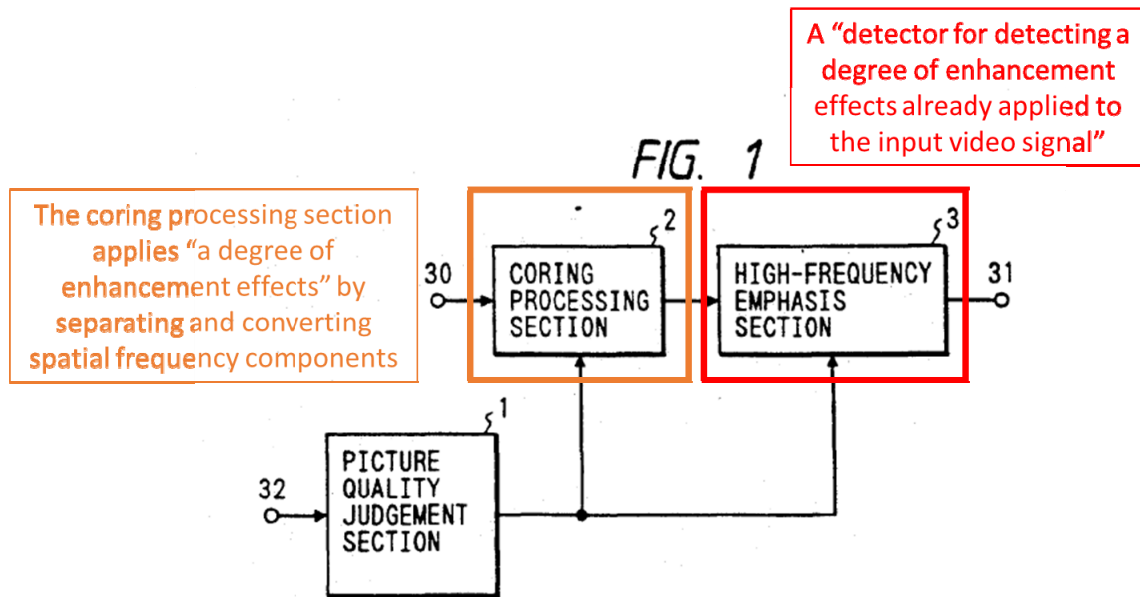
93. I believe this claim element is rendered obvious for the reasons established above in [1.1]. *See above*, [1.1].

***[4.4] multiplexing the video bitstream and data on the emphasis level.***

94. I believe this claim element is rendered obvious for the reasons established above in [1.4]. *See above, [1.4].*

***[3] The video-emphasis encoding apparatus according to claim 1 further comprising a detector for detecting a degree of enhancement effects already applied to the input video signal, wherein the emphasis-level setter sets the emphasis level in accordance with the detected degree of enhancement effects as the picture state detected from the input video signal.***

95. Fukuda-Fujikawa renders this claim obvious. Fujikawa describes a “high frequency emphasis section 3” (“*a detector for detecting a degree of enhancement effects already applied to the input video signal*”) which applies “high frequency emphasis” to a signal produced by a “coring processing section 2” that “separates the high spatial frequency components ... from the low spatial frequency components, and converts to the value zero all of those picture element values contained in the high spatial frequency components which are below a predetermined threshold value” (“*a degree of enhancement effects already applied to the input video signal*”). SAMSUNG-1006, 5:6-43, 7:1-67, FIGS. 1, 3-4. Reproduced below is an example encoding noise reduction filter according to Fujikawa that contains a coring processing section 2 and a high frequency emphasis section 3. SAMSUNG-1006, FIG. 1.



SAMSUNG-1006, FIG. 1.

96. Fujikawa describes that, in the high frequency emphasis section 3 (*“detector for detecting a degree of enhancement effects already applied to the input video signal”*), “[t]he Laplacian value calculation section 11 calculates, for each of the picture element values of the output signal from the coring processing section 2” (*“a degree of enhancement effects already applied to the input video signal”*). SAMSUNG-1006, 7:42-67. Once the Laplacian values have been generated, “[t]he compensation value calculation section 12 calculates, for each Laplacian value that is thus produced from the Laplacian value calculation section 11, a corresponding compensation value” (*“the emphasis-level setter sets the emphasis level in accordance with the detected degree of enhancement effects as the picture state detected from the input video signal”*). *Id.*

97. As discussed in [1.1] above, Fukuda describes multiple embodiments of a coding and decoding apparatus that each includes an emphasis-level setter for setting an emphasis level. SAMSUNG-1005, 2:13-60; FIGS. 1-19. As discussed above in my analysis of Fujikawa and the Fukuda-Fujikawa combination, Fujikawa teaches enhancement effects to exclude noise components in a picture and high frequency emphasis processing based on “an indication of the degree of contrast between the adjoining regions” of the picture as a result of the noise reduction enhancement effects applied to the picture. SAMSUNG-1006, 5:6-43.

98. While Fujikawa describes a specific type of noise, it would have been obvious and straightforward to a POSITA to apply Fujikawa’s teachings of noise reduction to a variety of noise types present in a picture. For example, a POSITA knew that noise could arise during image acquisition, as “light levels and sensor temperature are major factors affecting the amount of noise in the resulting image.” SAMSUNG-1011, 222. A POSITA would have been motivated to apply noise reduction to a noisy image to provide an improvement in picture quality. SAMSUNG-1006, 2:58-3:9, 5:6-43.

99. Fujikawa further explains that the high frequency emphasis processing compensates for “a loss of resolution which results from” the noise reduction enhancement effects. SAMSUNG-1006, 2:58-3:9, 5:6-43. Thus, a POSITA would have been motivated to incorporate Fujikawa’s teachings into Fukuda’s coding and

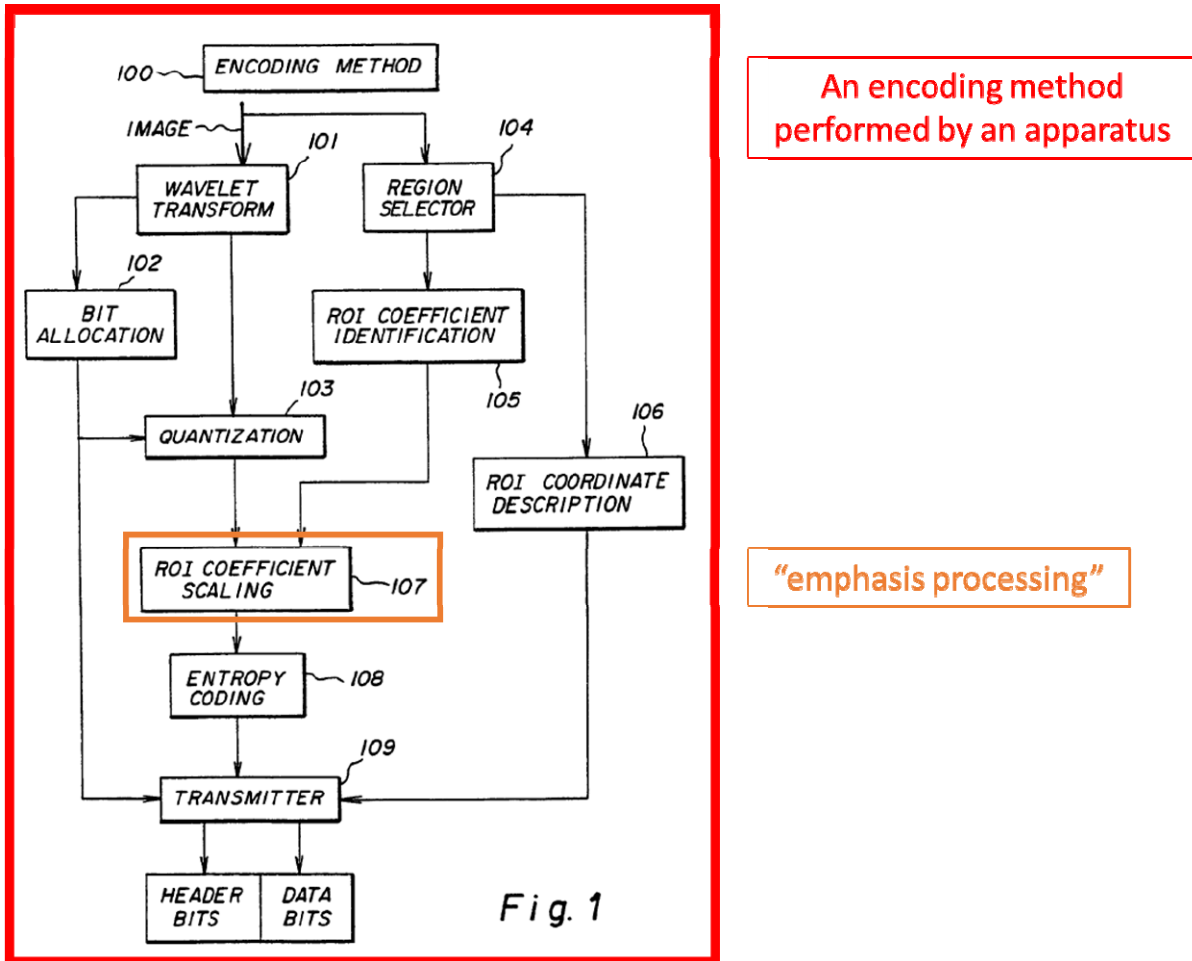
decoding apparatus, e.g., incorporated into Fukuda's emphasis circuit, to beneficially provide "an improvement in picture quality" by reducing noise in the picture and to provide compensation for "a loss of resolution which results from" noise reduction enhancement effects. SAMSUNG-1006, 2:58-3:9, 5:6-43. Further, Fujikawa's method of setting emphasis level based on the degree of contrast between adjoining regions would have enhanced Fukuda's existing emphasis calculations, which are also conscious of quantization step size. And certainly, quantization noise is an "encoding noise," which is the term used by Fujikawa. SAMSUNG-1005, 12:42-55, 17:29-45; SAMSUNG-1006, 5:24-43, 7:42-67.

## **ANALYSIS OF ATSUMI**

### **I. Atsumi**

100. Atsumi describes a "method and apparatus for encoding (622) digital image data" where "a region of interest (606) can be specified" such that "the encoder outputs are modified so as to place more emphasis on the region of interest." SAMSUNG-1007, Abstract, 5:22-52, 6:1-23, 10:14-38, FIG. 1. Atsumi describes that this process "[increases] the speed and/or [increases] the fidelity of the reconstructed region of interest." *Id.* Atsumi describes three different methods of applying emphasis to the region of interest ("ROI"). SAMSUNG-1007, 5:22-

52, 6:1-23, 10:14-38, FIGS. 1, 3A-3F, 5A-5C. Presented below is one example method of Atsumi's encoding method. SAMSUNG-1007, FIG. 1.



SAMSUNG-1007, FIG. 1.

## II. Claims 1-6 and 8 are rendered obvious by Atsumi

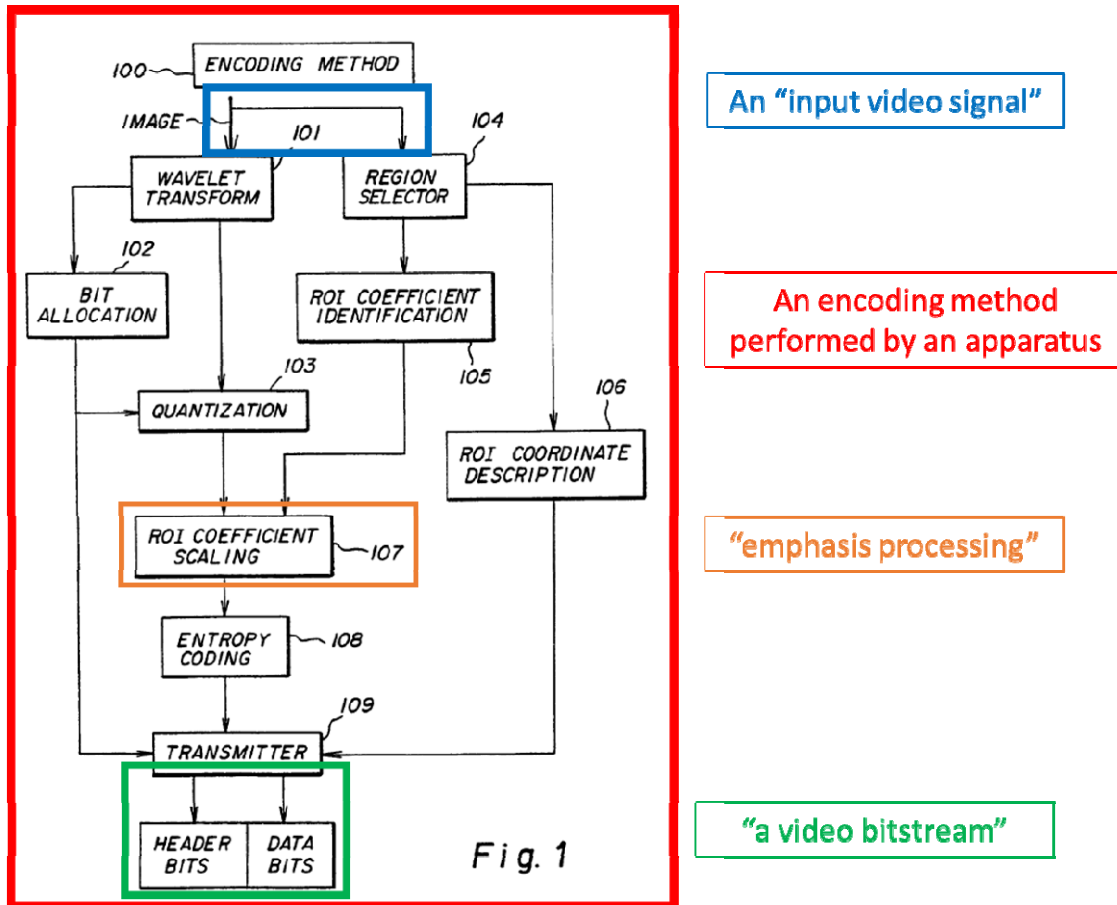
*[1pre] A video-emphasis encoding apparatus for applying an emphasis processing to an input video signal to obtain a video bitstream comprising:*

101. To the extent the preamble is limiting, Atsumi renders it obvious.

Atsumi describes an “apparatus for encoding (662) digital image data” which “place[s] more emphasis on [a] region of interest, therefore increasing the speed

and/or increasing the fidelity of the reconstructed region of interest” (“*[a] video-emphasis encoding apparatus for applying an emphasis processing to an input video signal to obtain a video bitstream*”). SAMSUNG-1007, Abstract, 2:56-60, 5:22-52, FIG. 1. FIG. 1 shows a method performed by an apparatus “for compressing an image with an emphasis on a selected region of interest in an image.” SAMSUNG-1007, 5:22-26. As shown in FIG. 1, the method includes “entropy coding [step 108] ... to form an encoded data stream.” SAMSUNG-1007, 6:25-32. “Encoded data formed at step 108 is sent to transmission step 109 where data bits and header bits are appended into a bit stream to be transmitted or stored.” SAMSUNG-1007, 7:18-21.

102. Atsumi also discloses that “the above discussed encoding methods and apparatus can also be adapted to digitally reproduced motion pictures. For example, a selected portion of a bit stream being transmitting to allow for real time reproduction of an image could be dedicated to transmitting a region of interest in the resulting motion picture. Furthermore, the dimensions and location of the region of interest could be constantly changing as the motion picture progresses.” SAMSUNG-1007, 29:28-36. Based on Atsumi’s disclosure that its apparatus can be adapted to reproduce digital motion pictures, a POSITA would have understood that such apparatus applies an emphasis processing to an input video signal to obtain a video bitstream.



SAMSUNG-1007, FIG. 1

**[1.1] an emphasis-level setter for setting an emphasis level to the input video signal in accordance with at least one factor among control data carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal;**

103. Atsumi renders this claim element obvious. For example, Atsumi describes a “bit allocation step 102” where “a bit per coefficient (i.e., representation accuracy of the coefficient) is assigned to the transform coefficients in each subband in order to represent the transform coefficients with digitized values” and “is determined in such a way that the subband which has higher variance or higher energy of the transform coefficients will be allocated a larger

number of bits per coefficient, which is equivalent to being allocated a smaller quantization step size.” SAMSUNG-1007, 5:30-39, 15:7-14. Atsumi further describes “a quantization step 103” where “quantization is performed on the transform coefficients in each subband in order to represent the transform coefficients of each subband with quantization indices whose representation accuracy is specified by the allocated bits per coefficient or by the quantization step size for each subband.” SAMSUNG-1007, 5:30-47, 7:22-42, 15:14-18. Based on Atsumi’s disclosure, a POSITA would have understood that the bit per coefficient, quantization step size, and quantization indices are “*encoding conditions for the input video signal.*” For example, in Puri’s 2000 text, he describes, “... encoding conditions (such as motion range and search technique, quantization matrices, code mode decisions, I/P/B structure, intra frequency, and rate control)...” SAMSUNG-1020 at p. 218. Also, based on Atsumi’s disclosure, a POSITA would have understood that the variance or energy of the transform coefficients of the subband from which the bit per coefficient, quantization step size, and quantization indices are determined corresponds to “*a picture state detected from the input video signal.*” For example, in the classic subband coding paper of Woods and O’Neil (1986), they explain, “... in each of the subband images, we can use the local variance to separate the blocks into busy, nonbusy, and quiet categories.” So, the subband variance, as used in Atsumi, corresponds to

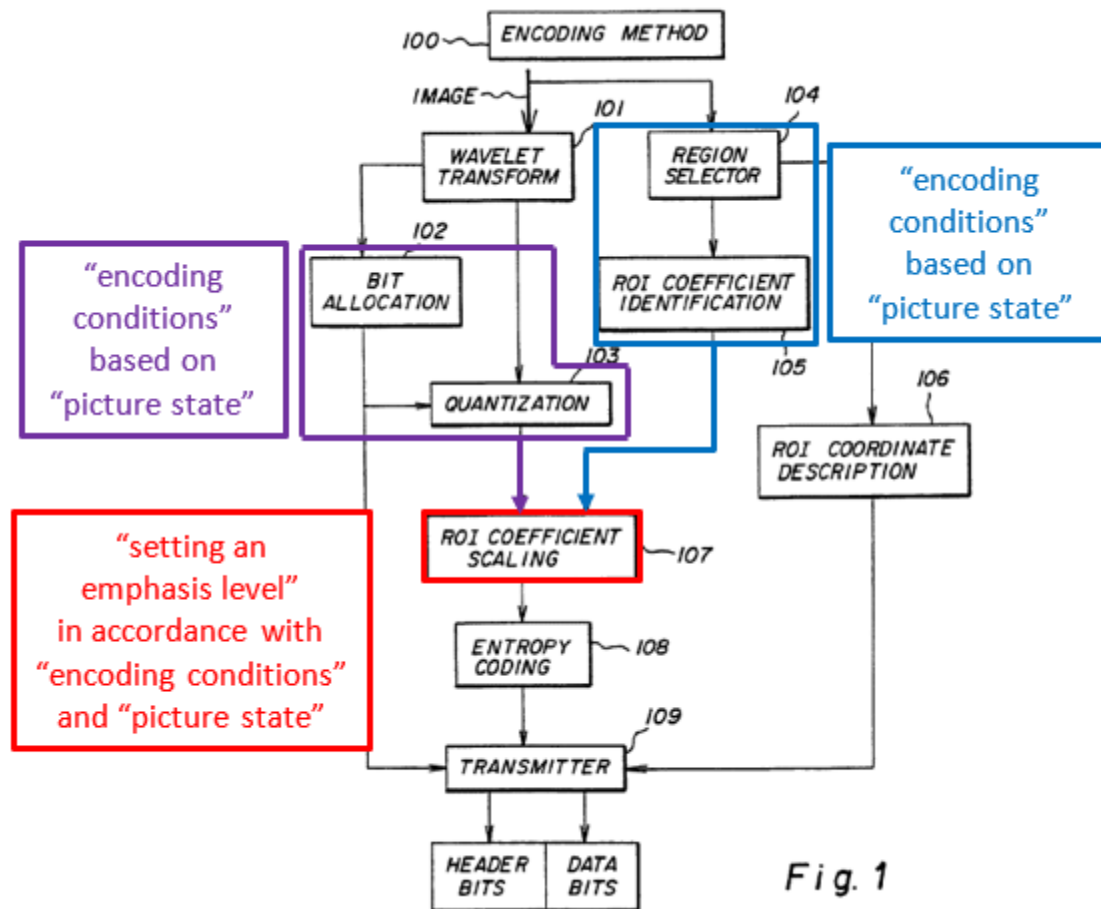
a “*a picture state detected from the input video signal.*” And the picture states in this example are “busy,” “nonbusy,” and “quiet.” SAMSUNG-1021 at p. 1285.

104. Atsumi further describes “region of interest selection step 104” where a “region of interest is selected on the input image.” SAMSUNG-1007, 5:53-58. Atsumi discloses the region of interest selection step 104 being “performed by a method wherein an automatic target recognition system defines a region or regions of interest based on a set of criteria. The automatic target recognition system may utilize a variety of approaches to identify the region of interest. For example, pattern recognition software may be used to identify objects of interest in the image.” SAMSUNG-1007, 15:31-37. In Atsumi, “the coordinates of the selected region of interest are input” to a “ROI coefficient identification step 105” where “wavelet transform coefficients corresponding to the selected region of interest, i.e., ROI coefficients, in each subband are identified in order to emphasize the selected region of interest in the image by emphasizing the ROI coefficients in each subband containing the wavelet transform coefficients.” SAMSUNG-1007, 5:53-63, 15:66-18:17. In Atsumi, the “identification result of the ROI coefficients (i.e., categories of the coefficients) ... depicts whether the transform coefficients correspond to each region of interest or regions outside of the region of interest.” SAMSUNG-1007, 5:64-67. Based on Atsumi’s disclosure, a POSITA would have understood Atsumi’s “identification result of the ROI coefficients” based on the

identified region of interest is “*encoding conditions for the input video signal*” determined in accordance with “*a picture state detected from the input video signal.*”

105. Atsumi further describes that “ROI coefficient scaling step 107” receives the “quantization indices” (“*encoding conditions*” determined based on “*a picture state*”) and the “identification result of the ROI coefficients” (“*encoding conditions*” determined based on “*a picture state*”). SAMSUNG-1007, 5:42-67. Atsumi discloses that at “ROI coefficient scaling step 107, ... the quantization indices for the transform coefficients corresponding to the region of interest are emphasized in such a way that the quantization indices for the ROI coefficients are scaled up by a left bit shift value (S) specified by a priority assigned to the region of interest so that the indices for the ROI coefficients are to be encoded as if the indices had larger values than their actual values.” SAMSUNG-1007, 6:8-23. Atsumi explains that, therefore, the quantization indices for the ROI coefficients “are encoded with a larger number of bits at a given bit rate or encoded at the earlier stages of the encoding process.” SAMSUNG-1007, 6:8-23. Accordingly, Atsumi describes the “ROI coefficient scaling step 107” (“*an emphasis-level setter*”) setting an emphasis level to the input video signal in accordance with “quantization indices” (“*encoding conditions for the input video signal*” based on “*a picture state detected from the input video signal*”) and an “identification result

of the ROI coefficients” (“*encoding conditions for the input video signal*” based on “*a picture state detected from the input video signal*”). SAMSUNG-1007, 5:30-6:23, FIG. 1.



SAMSUNG-1007, FIG. 1.

[1.2] an *emphasizer* for applying the emphasis processing to the input video signal at the emphasis level to obtain an emphasized video signal;

106. Atsumi renders this claim element obvious. For example, Atsumi describes that the “ROI coefficient scaling” component also applies emphasis (“*an* *emphasizer* for applying the emphasis processing to the input video signal at the

*emphasis level to obtain an emphasized video signal*”). SAMSUNG-1007, 5:53-67, 6:8-23, 7:43-12:20, FIGS. 1, 3A-6C; *see above* Ground 2, [1.1].

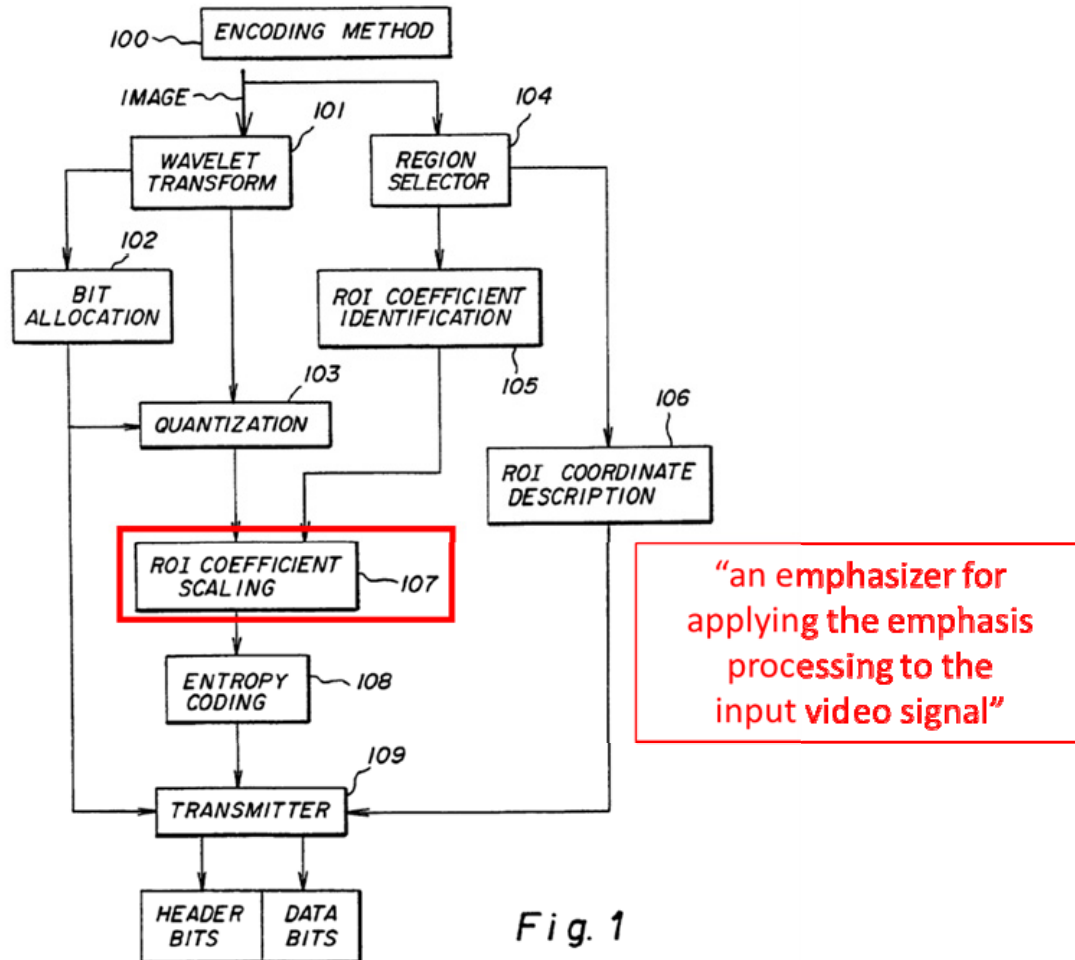


*Fig. 1*

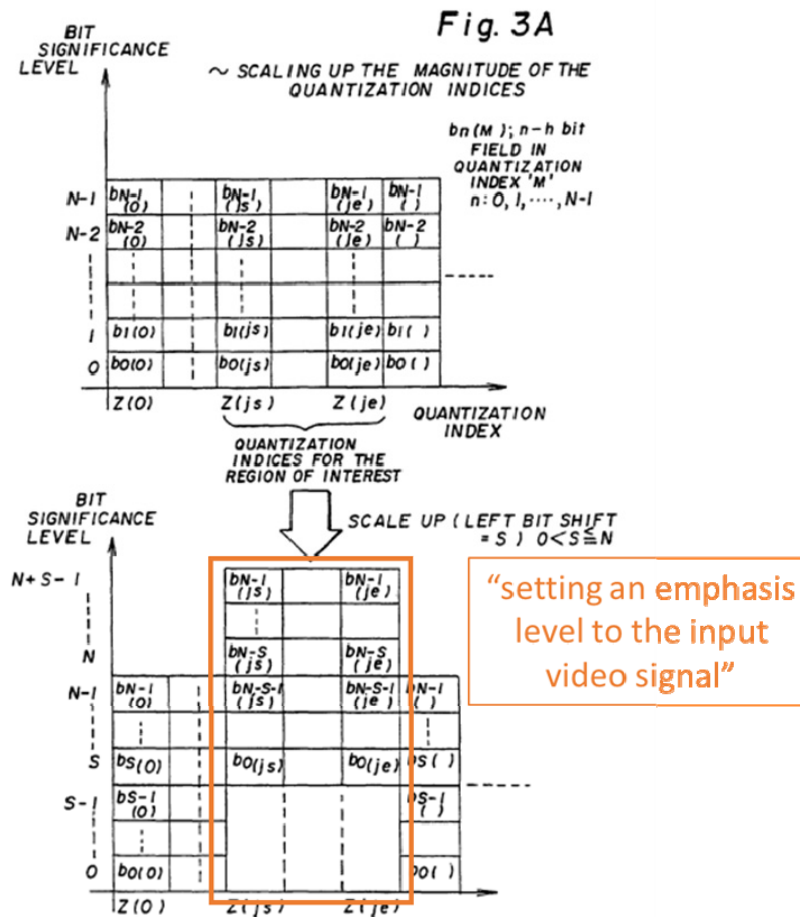
SAMSUNG-1007, FIG. 1.

107. Atsumi describes multiple methods of applying emphasis at the emphasis level set in accordance with the quantization indices and the identification result of the ROI coefficients, including: (1) “scaling up the value of the quantization indices corresponding to the region of interest,” (2) “scaling up the bit significance levels of the bit fields associated with the region of interest,” and

(3) “reassigning encoding ordering.” SAMSUNG-1007, 9:46-58. These three methods are discussed in more detail below.

### Scaling Up Values of Quantization Indices

108. Atsumi describes a method of applying emphasis that “scales up part of the value of the quantization index for a region of interest (the value consisting of some of the bit fields in the quantization index).” SAMSUNG-1007, 10:14-38, 8:13-44, FIGS. 3A, 3D. This process is illustrated below in Figures 3A and 3D of Atsumi.



SAMSUNG-1007, FIG. 3A.

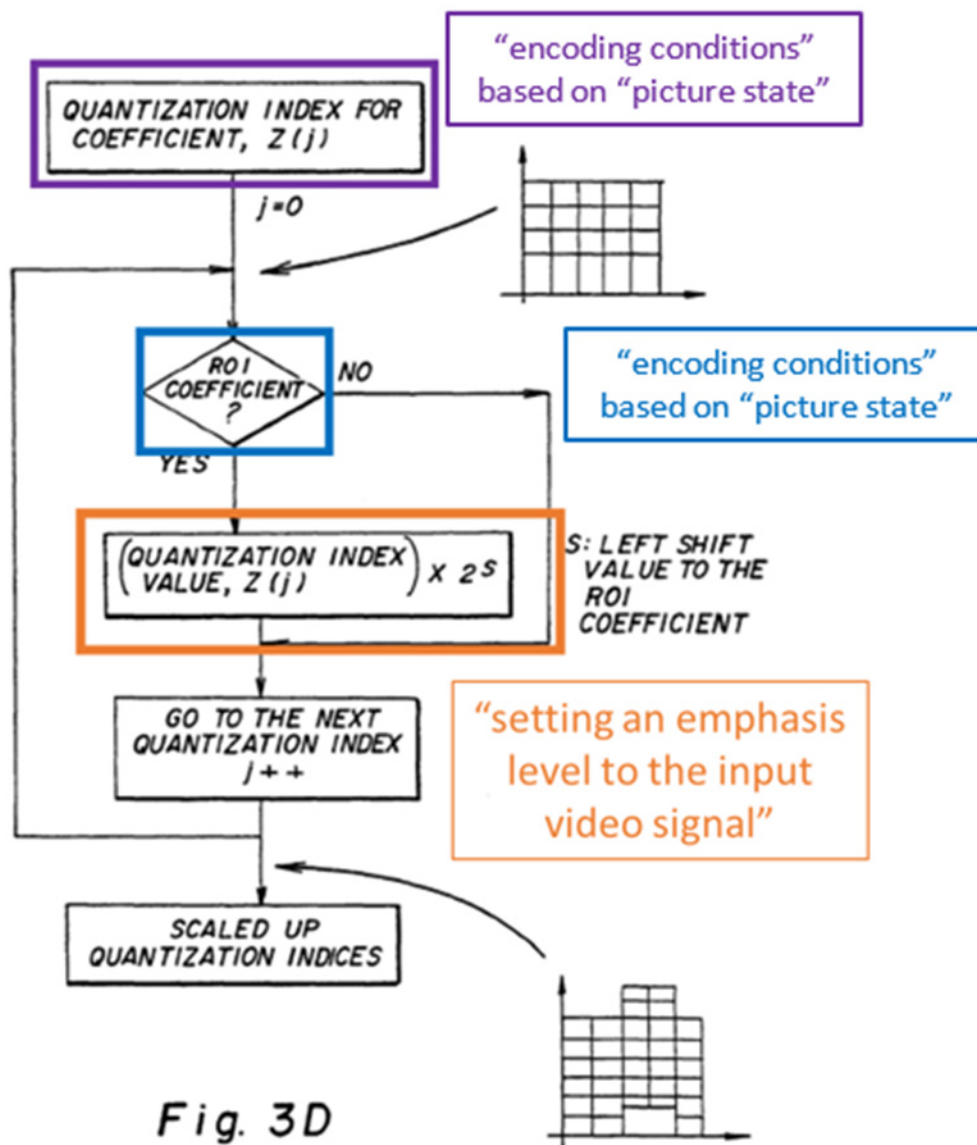


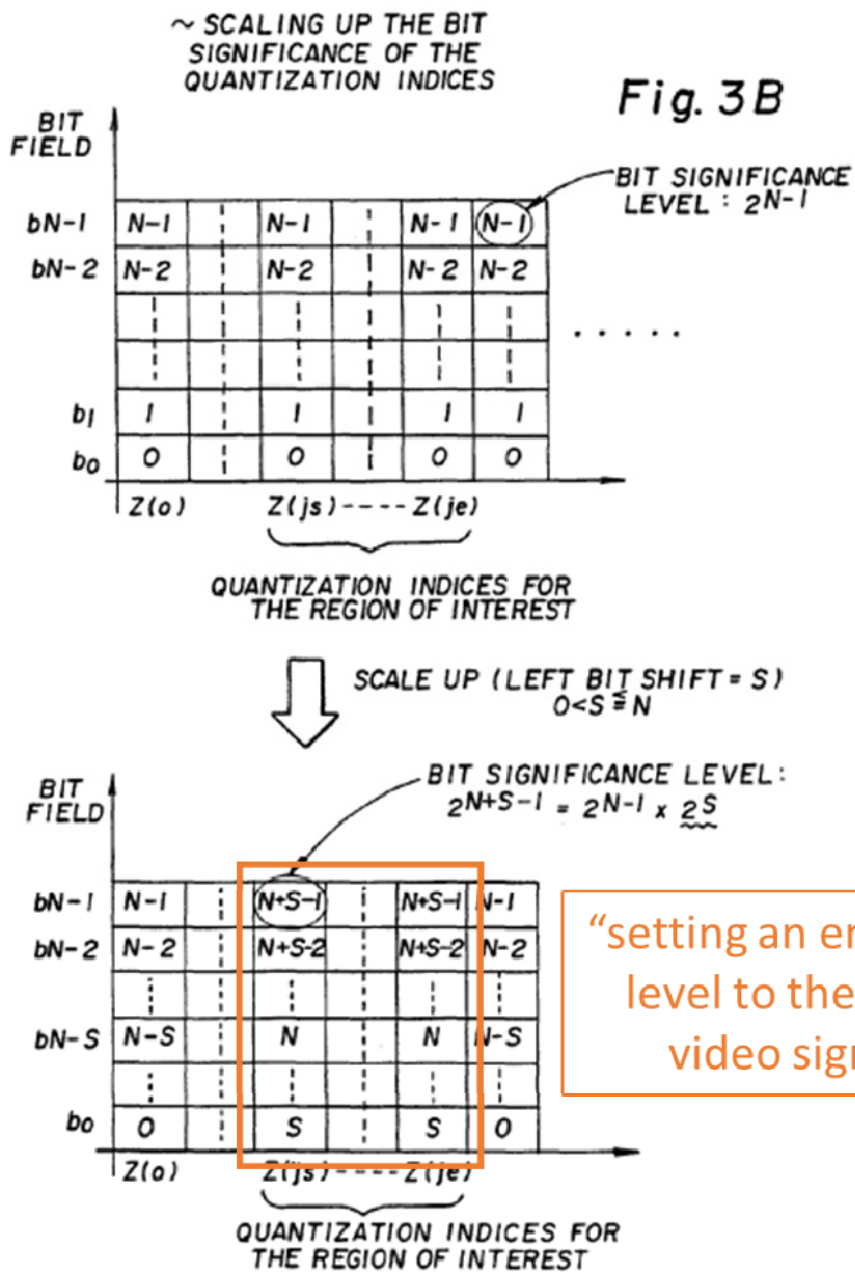
Fig. 3D

SAMSUNG-1007, FIG. 3D.

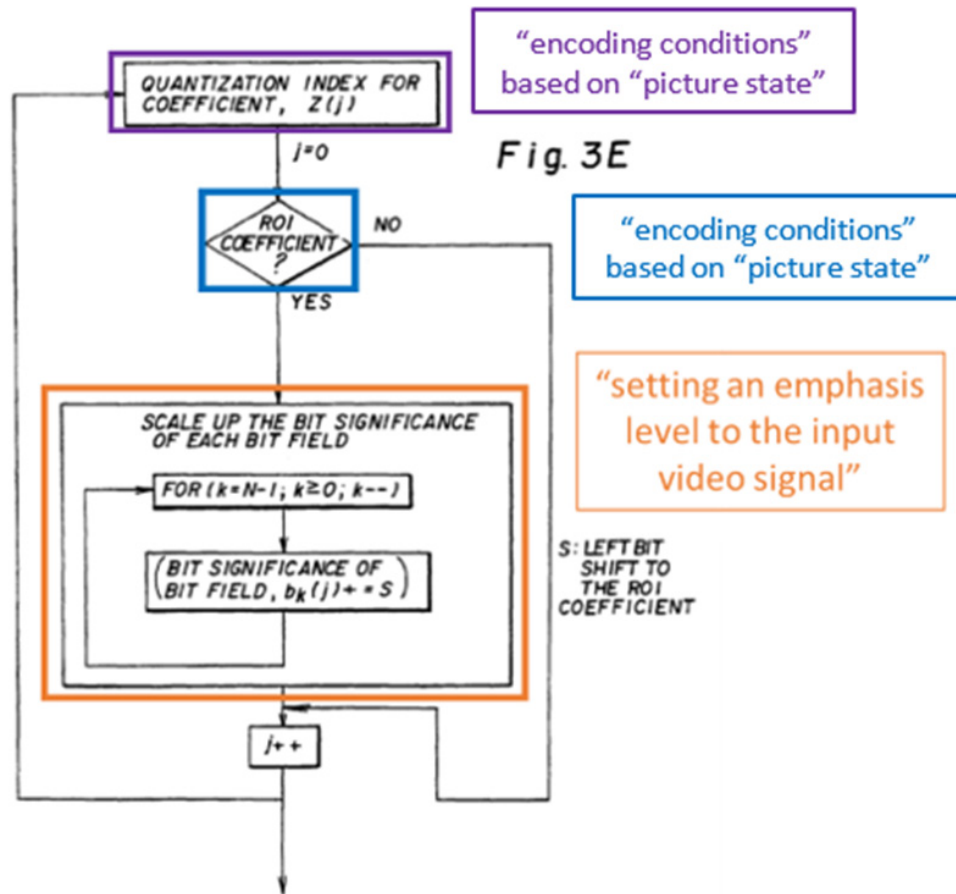
Scaling Up Bit Significance Level of Quantization Indices

109. Atsumi describes a method of applying emphasis that “scales up the bit significance level of some of the bit fields in the quantization indices.”

SAMSUNG-1007, 10:14-38, 8:13-44, FIGS. 3B, 3E. This process is illustrated below in Figures 3A and 3D of Atsumi.



SAMSUNG-1007, FIG. 3B.

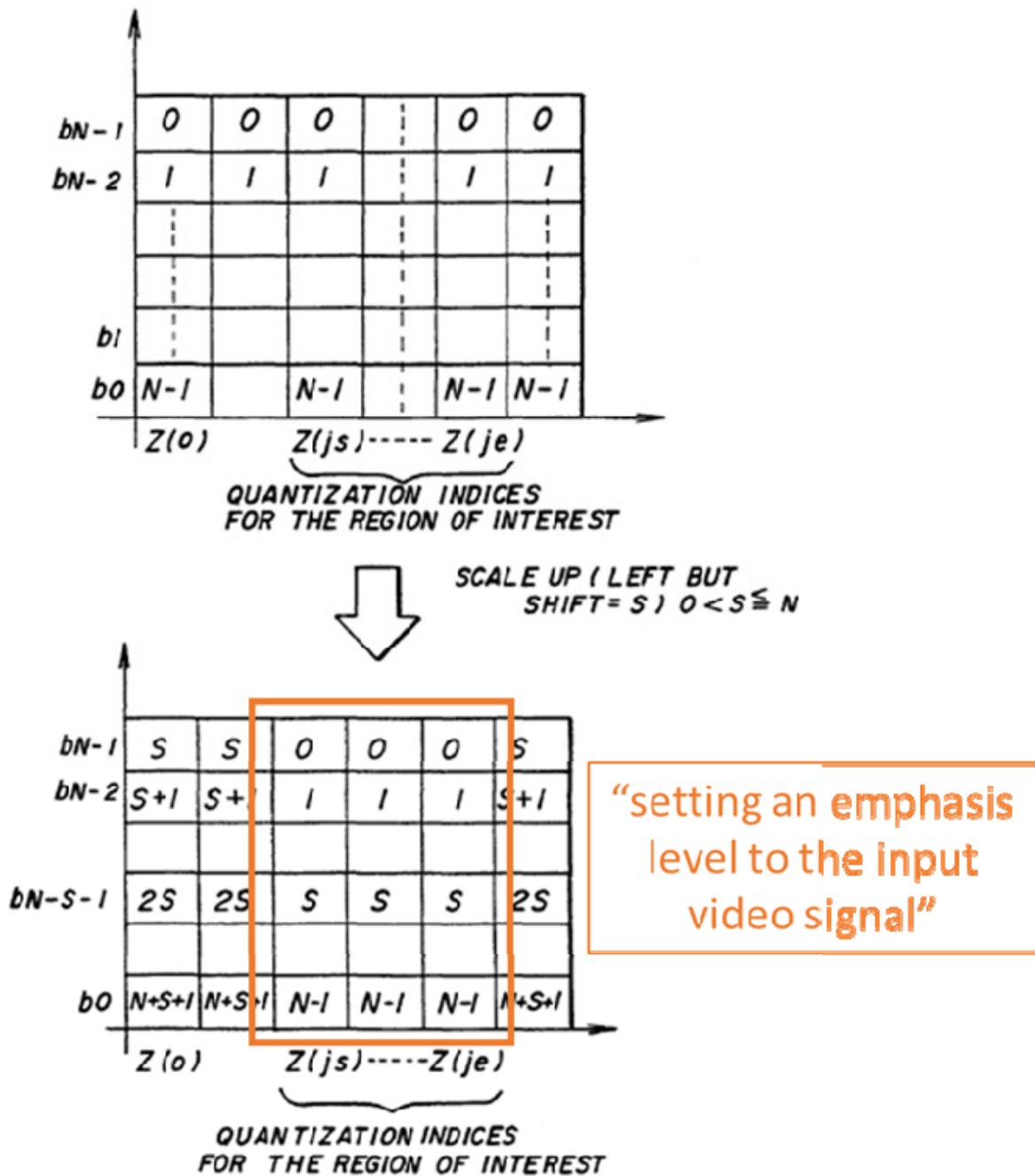


SAMSUNG-1007, FIG. 3E.

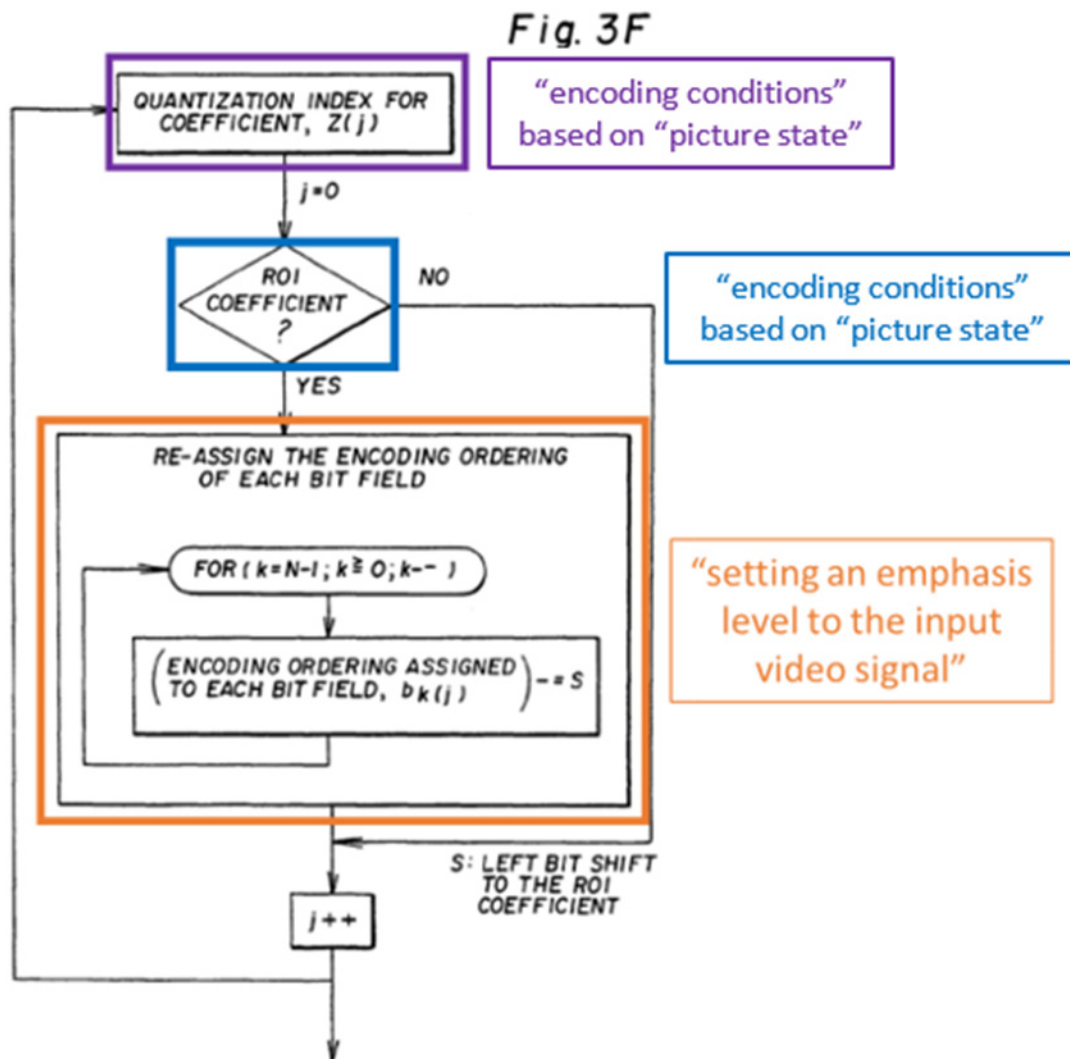
Reassigning Encoding Ordering of the Bit Fields of the Quantization Indices

110. Atsumi describes a method of applying emphasis that “reassigns encoding ordering of every bit field of the quantization indices.” SAMSUNG-1007, 10:14-38, 8:44-9:45, FIGS. 3B, 3E. This process is illustrated below in Figures 3C and 3F of Atsumi.

Fig. 3C



SAMSUNG-1007, FIG. 3C.



SAMSUNG-1007, FIG. 3F.

**[1.3] an encoder for encoding the emphasized video signal to obtain a video bitstream; and**

111. Atsumi renders this claim element obvious. For example, Atsumi describes that “entropy coding” is performed following ROI coefficient scaling to “form an encoded data stream” (“*an encoder for encoding the emphasized video signal to obtain a video bitstream*”). SAMSUNG-1007, 6:24-7:17, 12:21-14:55, FIGS. 7A-8C.

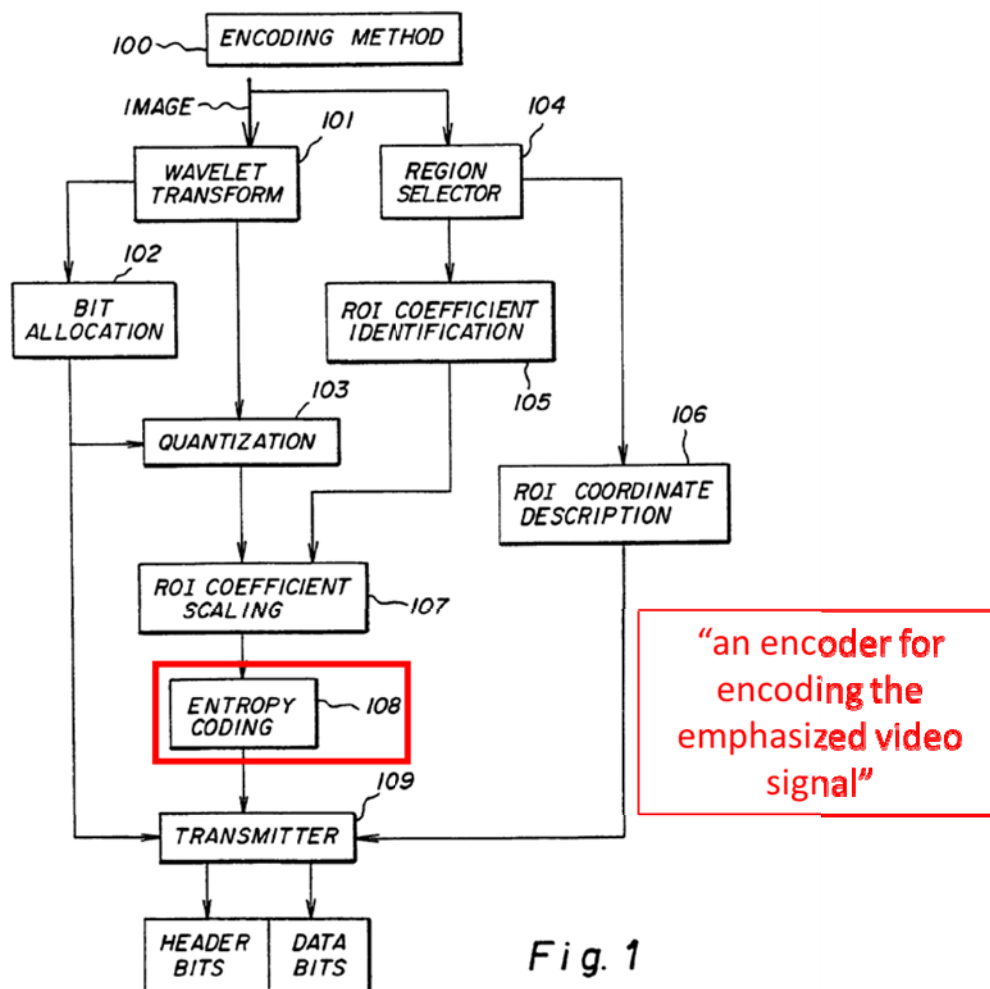


Fig. 1

SAMSUNG-1007, FIG. 1

**[1.4] a multiplexer for multiplexing the Video bitstream and data on the emphasis level.**

112. Atsumi renders this claim element obvious. For example, Atsumi describes that “coordinates of the selected region of interest are encoded in order to effectively transmit or store the ROI coordinate information, from which decoder can tell what region of interest is selected to be emphasized in the reconstructed image,” the “ROI description information” (“*data on the emphasis level*”) “is added to the header bits in the bit stream in transmission step 109,” and “[e]ncoded

data formed at step 108” (“*video bitstream*”) “is sent to transmission step 109 where data bits and header bits are appended into a bit stream to be transmitted or stored.” SAMSUNG-1007, 6:1-7, 7:18-21, 15:53-65, FIG. 1. This transmitter step is illustrated below in Atsumi’s Figure 1. In fact, FIG. 1 of Atsumi shows multiplexing as part of Transmitter step 109. In FIG. 1, two streams are observed, one containing “header bits” and one containing “data bits.” The figure has two arrows representing these two streams. The two streams (header bits and data bits) are combined into one stream in the figure, i.e., they are multiplexed. SAMSUNG-1007, FIG. 1.

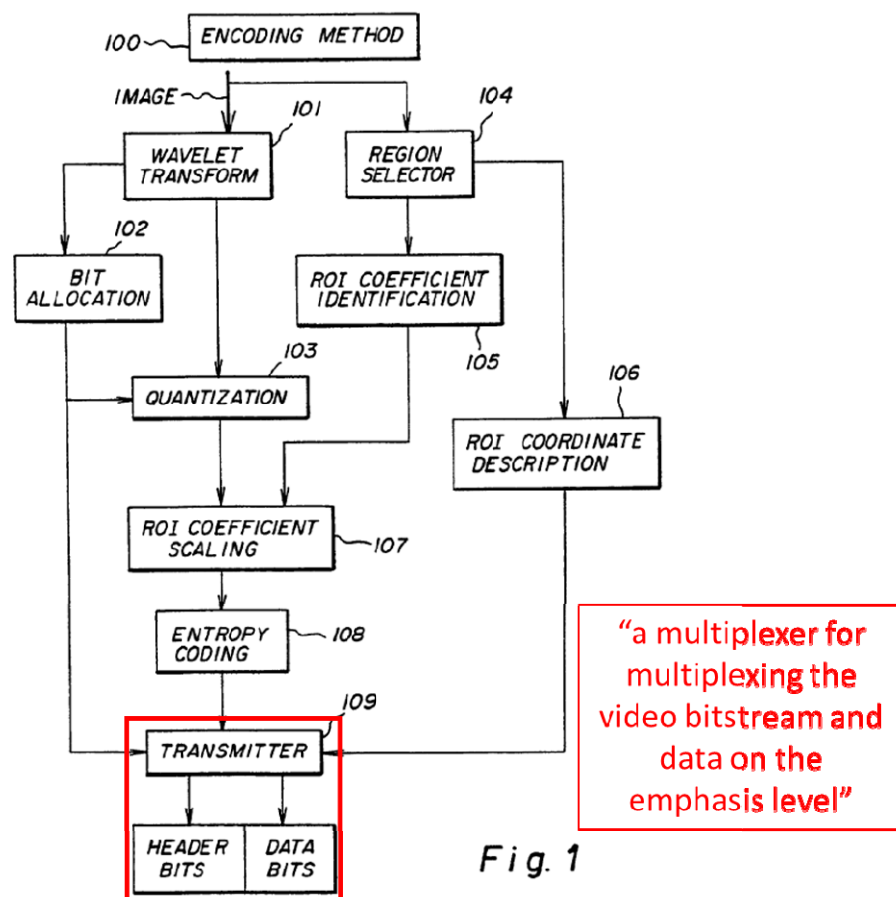


Fig. 1

SAMSUNG-1007, FIG. 1.

113. As discussed in [1.pre], Atsumi discloses that “the above discussed encoding methods and apparatus can also be adapted to digitally reproduced motion pictures, e.g., digital video. For example, a selected portion of a bit stream being transmitting to allow for real time reproduction of an image could be dedicated to transmitting a region of interest in the resulting motion picture. Furthermore, the dimensions and location of the region of interest could be constantly changing as the motion picture progresses.” SAMSUNG-1007, 29:28-36. Based on Atsumi’s disclosure, a POSITA would have recognized or found obvious that the transmitter of Atsumi would include a “*multiplexer*” that multiplexes the video bitstream and data on the emphasis level. Such digital multiplexers were well known decades before the priority date of the ’128 Patent. Samsung-BBC at 601-610. A POSITA would have been motivated to implement Atsumi’s transmitter to include such a multiplexer in light of Atsumi’s disclosure that “the dimensions and location of the region of interest could be constantly changing as the motion picture progresses” and to allow Atsumi’s decoder to process the encoded video data “for real time reproduction” while it is being received to reduce delay in reproducing the video signal, consistent with the goal of Atsumi’s invention. *Id.*; SAMSUNG-1007, 29:28-36.

114. Further, a POSITA would have been aware that multiplexing data necessary for reproducing an image/video signal together with coded image/video data was a known option for sending/recording the data and image/video signal together as a bitstream and would have found it to be simply a matter of design choice to multiplex the data with the image/video signal. Indeed, the '128 Patent acknowledges that it was well-known and disclosed in JPH7-162862 that a “bitstream is multiplexed with emphasis data” that “is then output for storage or transfer.” SAMSUNG-1001, 2:4-10. Further, Fujikawa corroborates a POSITA’s knowledge at the time of the '128 Patent and describes that “[d]ata which will be subsequently necessary for decoding purposes ... are also encoded and are transmitted to the decoding apparatus in the output bit stream from the encoding apparatus, multiplexed with the encoded data of the video signal.” SAMSUNG-1006, 1:50-55.

***[2] The video-emphasis encoding apparatus according to claim 1 further comprising a detector for detecting a degree of quantization applied to the input video signal, wherein the emphasis-level setter sets the emphasis level in accordance with the detected degree of quantization as the encoding conditions.***

115. Atsumi renders claim 2 obvious. As discussed in [1.1], Atsumi describes that “ROI coefficient scaling step 107” receives the “quantization indices” (“***encoding conditions***” determined based on “***a picture state***”) and the “identification result of the ROI coefficients” (“***encoding conditions***” determined

based on “*a picture state*”). SAMSUNG-1007, 5:42-67. Atsumi discloses that at “ROI coefficient scaling step 107, ... the quantization indices for the transform coefficients corresponding to the region of interest are emphasized in such a way that the quantization indices for the ROI coefficients are scaled up by a left bit shift value (S) specified by a priority assigned to the region of interest so that the indices for the ROI coefficients are to be encoded as if the indices had larger values than their actual values.” SAMSUNG-1007, 6:8-23. Atsumi explains that, therefore, the quantization indices for the ROI coefficients “are encoded with a larger number of bits at a given bit rate or encoded at the earlier stages of the encoding process.” SAMSUNG-1007, 6:8-23. Accordingly, Atsumi teaches that the “ROI coefficient scaling step 107” (“*an emphasis-level setter*”) includes a detector for detecting “quantization indices” (“*degree of quantization as the encoding conditions*”) and an “identification result of the ROI coefficients” (“*degree of quantization as the encoding conditions*”) applied to the input video signal and scales up the quantization indices for the ROI coefficients (“*sets the emphasis level*”) in accordance with the detected “quantization indices” (“*degree of quantization as the encoding conditions*”) and the “identification result of the ROI coefficients” (“*degree of quantization as the encoding conditions*”). SAMSUNG-1007, 5:30-6:23, FIG. 1.

**[3] The video-emphasis encoding apparatus according to claim 1 further comprising a detector for detecting a degree of enhancement effects already**

*applied to the input video signal, wherein the emphasis-level setter sets the emphasis level in accordance with the detected degree of enhancement effects as the picture state detected from the input video signal.*

116. Atsumi renders claim 3 obvious. As discussed in [1.1], Atsumi describes that “ROI coefficient scaling step 107” receives the “quantization indices” (“*encoding conditions*” determined based on “*a picture state*”) and the “identification result of the ROI coefficients” (“*encoding conditions*” determined based on “*a picture state*”). SAMSUNG-1007, 5:42-67. Atsumi discloses that at “ROI coefficient scaling step 107, ... the quantization indices for the transform coefficients corresponding to the region of interest are emphasized in such a way that the quantization indices for the ROI coefficients are scaled up by a left bit shift value (S) specified by a priority assigned to the region of interest so that the indices for the ROI coefficients are to be encoded as if the indices had larger values than their actual values.” SAMSUNG-1007, 6:8-23. Atsumi explains that, therefore, the quantization indices for the ROI coefficients “are encoded with a larger number of bits at a given bit rate or encoded at the earlier stages of the encoding process.” SAMSUNG-1007, 6:8-23.

117. In its infringement contentions, the patent owner appears to advance a scope for “a degree of enhancement effects already applied to the input video signal” as encompassing quantization parameters derived from a rate control algorithm or quantization parameters identifying high detail/complex areas. In

accordance with the scope of this claim advanced by the patent owner in its infringement contentions, Atsumi teaches that the “ROI coefficient scaling step 107” (“*an emphasis-level setter*”) includes a detector for detecting “quantization indices” (“*degree of enhancement effects applied to the input video signal*” “*as the picture state*”) and an “identification result of the ROI coefficients” (“*degree of enhancement effects applied to the input video signal*” “*as the picture state*”) applied to the input video signal and scales up the quantization indices for the ROI coefficients (“*sets the emphasis level*”) in accordance with the detected “quantization indices” (“*degree of enhancement effects applied to the input video signal*” “*as the picture state*”) and the “identification result of the ROI coefficients” (“*degree of enhancement effects applied to the input video signal*” “*as the picture state*”) in a similar manner as the products that Patent Owner alleges satisfies this claim. SAMSUNG-1007, 5:30-6:23, FIG. 1

**[4.pre]      A method of video-emphasis encoding for applying an emphasis processing to an input video signal to obtain a video bitstream comprising the steps of:**

118. To the extent the preamble is limiting, Atsumi describes “a method and apparatus for encoding images for transmission or storage where a region of interest (ROI) or certain regions of the image are to be emphasized and for decoding the encoded image after transmission or retrieval from storage” (a

*“method of video-emphasis encoding”*). SAMSUNG-1007, 2:56-60; *see above*

Ground 2, [1.pre].

***[4.1] setting an emphasis level to the input video signal in accordance with at least one factor among control data carried by the input video signal, a picture state detected from the input video signal and encoding conditions for the input video signal;***

119. I believe this claim element is rendered obvious for the reasons established above in [1.1]. *See above*, [1.1].

***[4.2] applying the emphasis processing to the input video signal at the emphasis level to obtain a emphasized video signal;***

120. I believe this claim element is rendered obvious for the reasons established above in [1.2]. *See above*, [1.2].

***[4.3] encoding the emphasized video signal to obtain a video bitstream; and***

121. I believe this claim element is rendered obvious for the reasons established above in [1.3]. *See above*, [1.3].

***[4.4] multiplexing the video bitstream and data on the emphasis level.***

122. I believe this claim element is rendered obvious for the reasons established above in [1.4]. *See above*, [1.4].

***[5pre] A video-deemphasis decoding apparatus for decoding and applying a deemphasis processing to an input video bitstream comprising:***

123. To the extent the preamble is limiting, Atsumi renders it obvious. For example, Atsumi describes “a method of decompressing an image which is encoded with an emphasis on the selected region of interest in FIG. 1” (“*[a] video-*

*deemphasis decoding apparatus for decoding and applying a deemphasis*

*processing to an input video bitstream*”). SAMSUNG-1007, 18:60-67, 19:1-7,

19:34-44, FIG. 2. Atsumi describes, with respect to FIG. 2, “the decoding method

200 comprises a receiver step 201 for receiving an encoded bit stream consisting of

header bits and data bits. Step 201 is followed by region coordinate decoding step

202 and entropy decoding step 204. At step 202, encoded data of the region

coordinates are decoded in order to obtain the coordinates of the region of interest

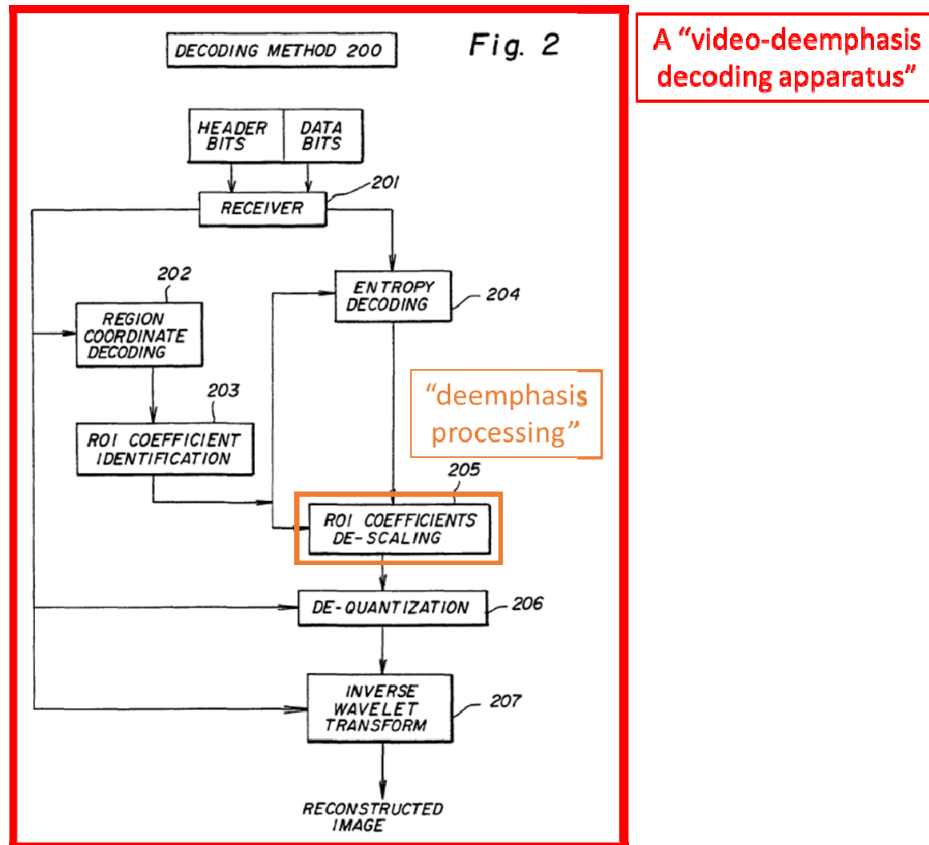
(ROI) which is to be reconstructed with an emphasis in the reconstructed image.”

SAMSUNG-1007, 18:62-19:2. At the ROI coefficients de-scaling step 205, the

quantization indices corresponding to the region of interest are scaled down in

order to perform de-quantization on the quantization indices at step 206.”

SAMSUNG-1007, 19:34-36.



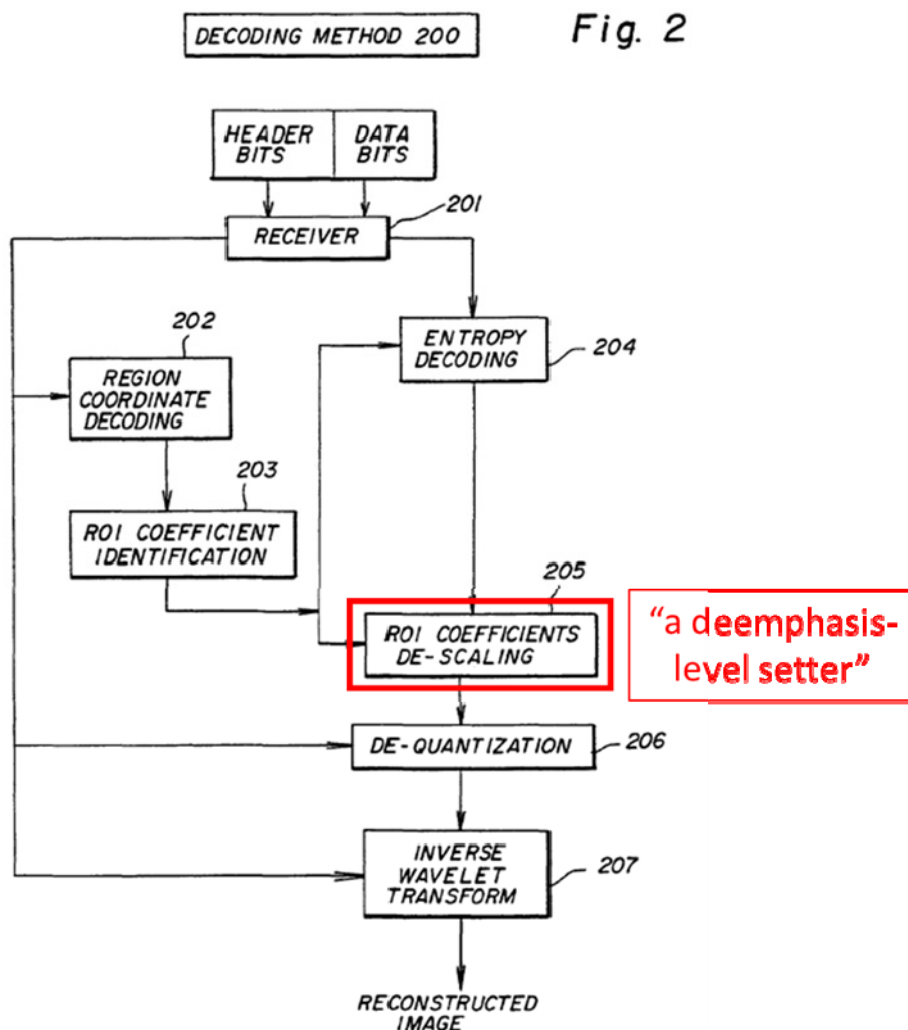
SAMSUNG-1007, FIG. 2.

**[5.1] a deemphasis-level setter for setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level;**

124. Atsumi renders this claim element obvious. For example, Atsumi describes “a receiver step 201 for receiving an encoded bit stream consisting of header bits and data bits.” SAMSUNG-1007, 18:62-64. At region coordinate decoding step 202, “encoded data of the region coordinates are decoded in order to obtain the coordinates of the region of interest (ROI) which is to be reconstructed with an emphasis in the reconstructed image” (“*emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized*”).

*at the emphasis level*”). SAMSUNG-1007, 18:66-19:2; 19:59-20:2. “The decoded ROI coordinates are given to ROI coefficient identification step 203 where wavelet transform coefficients corresponding to the region of interest are identified.” SAMSUNG-1007, 19:3-5, 20:3-14.

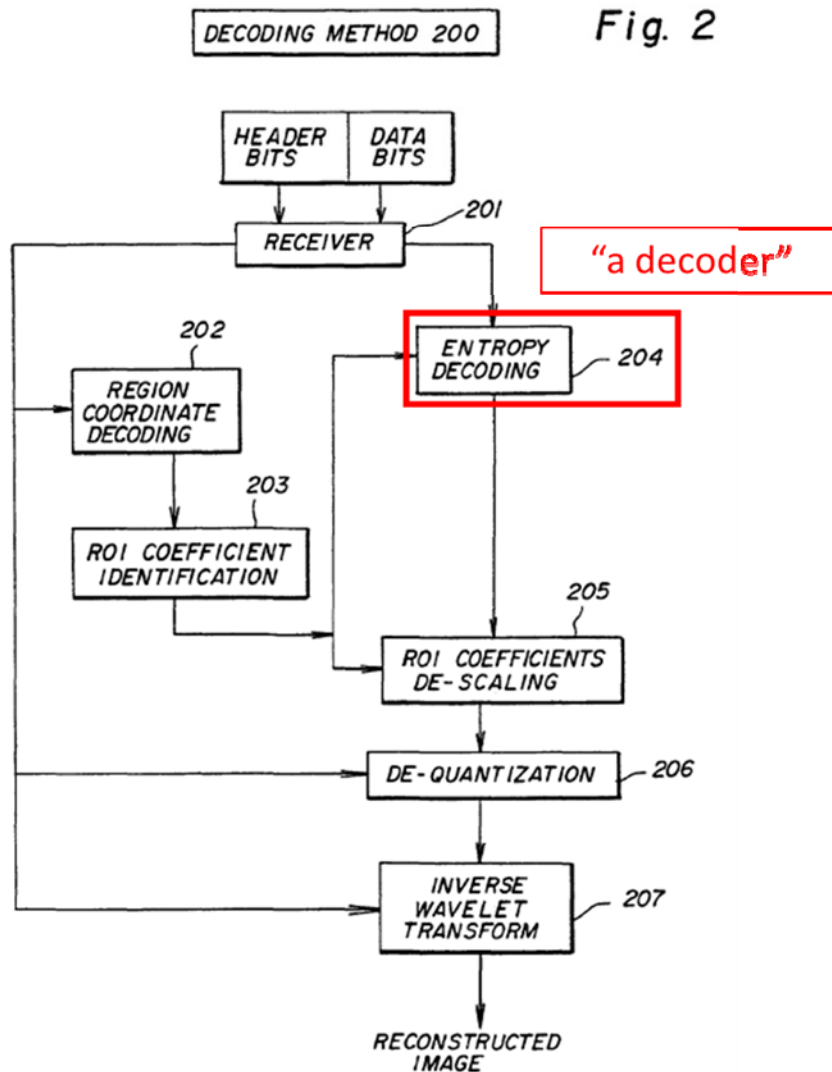
125. Atsumi further describes the “ROI coefficient descaling step 205” (“*a deemphasis-level setter*”) scaling down “the values of the quantization indices corresponding to the region of interest or the bit significance levels of the quantization indices corresponding to the region of interest.” SAMSUNG-1007, 20:63-67, 19:34-44. “Which quantization indices are to be scaled down is given by the ROI coefficient identification result at step 203, and how many bit shifts the indices are scaled down is taken out from the header bits received at step 201” (“*setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level*”). SAMSUNG-1007, 18:60-19:7, 19:34-44, 20:63-21:7, FIG. 2. Atsumi describes that “[t]he details of this step are exactly the same as the details of ROI coefficient scaling step 107 in the encoding method 100.” SAMSUNG-1007, 21:1-7.



SAMSUNG-1007, FIG. 2.

**[5.2] a decoder for decoding the input video bitstream for reproducing the video signal; and**

126. Atsumi renders this claim element obvious. For example, Atsumi describes that “entropy decoding” is performed “on the incoming bit stream with the data bits which are received at receiver step 201” (“*a decoder for decoding the input video bitstream for reproducing the video signal*”). SAMSUNG-1007, 19:8-33, 20:14-62, FIG. 2.

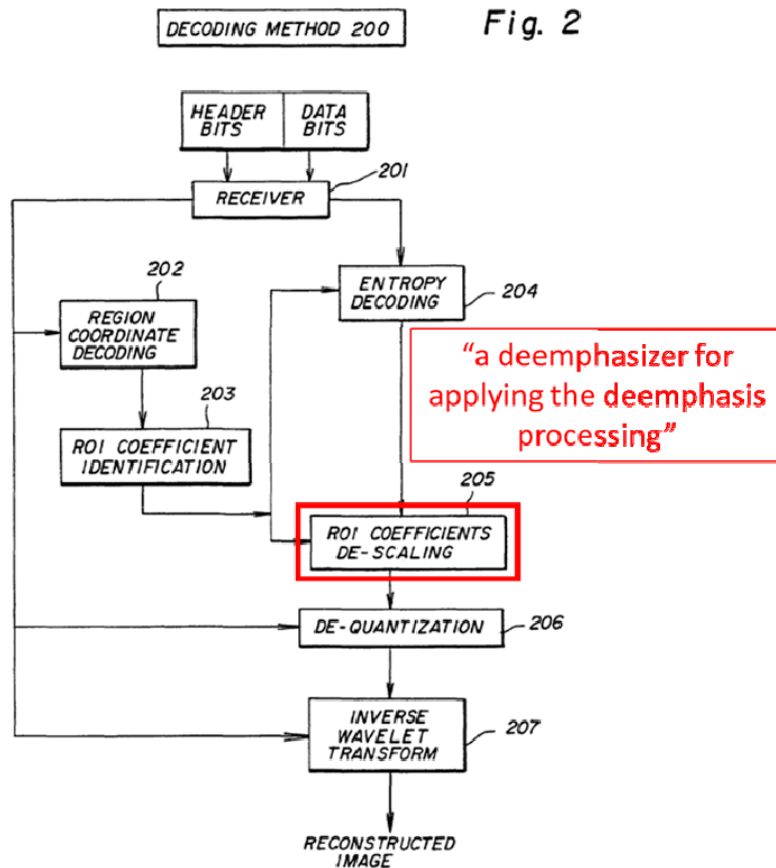


SAMSUNG-1007, FIG. 2.

***[5.3] a deemphasizer for applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal.***

127. Atsumi renders this claim element obvious. As discussed in [5.1], Atsumi describes an “ROI coefficient descaling step 205” (“*a deemphasizer*”) that scales down “the values of the quantization indices corresponding to the region of interest or the bit significance levels of the quantization indices corresponding to

the region of interest” “given by the ROI coefficient identification result at step 203, and how many bit shifts the indices are scaled down is taken out from the header bits received at step 201” (“*applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal*”). SAMSUNG-1007, 18:60-19:7, 19:34-44, 20:63-21:7, FIG. 2; *see above* Ground 2, [5.1]. Atsumi describes that “[t]he details of this step are exactly the same as the details of ROI coefficient scaling step 107 in the encoding method 100.” SAMSUNG-1007, 21:1-7; *see above* Ground 2, [1]-[3].



SAMSUNG-1007, FIG. 2.

**[6] The video-deemphasis decoding apparatus according to claim 5, wherein the deemphasis-level setter obtains data including a degree of quantization applied to the input video signal as the emphasis-level data to obtain the emphasis level in accordance with the degree of quantization, thus setting the deemphasis level that matches the emphasis level.**

128. Atsumi renders claim 6 obvious. As discussed in [5.1], Atsumi describes the “ROI coefficient descaling step 205” (“*the deemphasis-level setter*”) scaling down “the values of the quantization indices corresponding to the region of interest or the bit significance levels of the quantization indices corresponding to the region of interest.” SAMSUNG-1007, 20:63-67, 19:34-44. “Which quantization indices are to be scaled down is given by the ROI coefficient identification result at step 203 [obtained from encoded data of the region coordinates received at step 201], and how many bit shifts the indices are scaled down is taken out from the header bits received at step 201” (“*obtains data including a degree of quantization applied to the input video signal as the emphasis-level data to obtain the emphasis level in accordance with the degree of quantization, thus setting the deemphasis level that matches the emphasis level*”).

SAMSUNG-1007, 18:60-19:7, 19:34-44, 19:59-20:2, 20:63-21:7, FIG. 2.

**[8pre] A video-deemphasis decoding method for decoding and applying a deemphasis processing to an input video bit stream comprising the steps of:**

129. To the extent the preamble is limiting, Atsumi describes “a method and apparatus for encoding images for transmission or storage where a region of interest (ROI) or certain regions of the image are to be emphasized and for

decoding the encoded image after transmission or retrieval from storage” (“***video-deemphasis decoding method***”). SAMSUNG-1007, 2:56-60; *see above* Ground 2, [5.pre].

***[8.1] setting a deemphasis level that matches an emphasis level obtained from emphasis-level data carried by the video bitstream to which an input video signal has been encoded and emphasized at the emphasis level;***

130. I believe this claim element is rendered obvious for the reasons established above in [5.1]. *See above*, [5.1]

***[8.2] decoding the input video bitstream for reproducing the video signal; and***

131. I believe this claim element is rendered obvious for the reasons established above in [5.2]. *See above*, [5.2].

***[8.3] applying the deemphasis processing to the reproduced video signal at the deemphasis level to obtain a deemphasized video signal.***

132. I believe this claim element is rendered obvious for the reasons established above in [5.3]. *See above*, [5.3].

### **ADDITIONAL REMARKS**

133. I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

134. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code..

Dated: October 30, 2023

By:  \_\_\_\_\_

# **APPENDIX A**

# **APPENDIX A**

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## EDUCATION

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| <b>MS</b>  | University of Texas at Austin, Electrical & Computer Engineering | May 1990  |
| <b>BS</b>  | Virginia Tech, Electrical Engineering                            | May 1988  |

## EXPERIENCE

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Chair, Electrical & Computer Engineering, 2022-  
Lawrence R. Quarles Professor of Engineering and Applied Science, 2023-  
Acting Deputy Division Director, Directorate for Computer and Information Science  
and Engineering, National Science Foundation, 2021-2022  
Program Director, Directorate for Computer and Information Science and  
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Professor, University of Virginia, 2005-  
Editor-in-Chief, *IEEE Transactions on Image Processing*, 2014-2018  
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2003-2005  
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Asst. Professor, Oklahoma State University, Stillwater, OK, 1994 - 1997  
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The University of Texas at Austin, Austin, TX, 1990 - 1993  
Research and Development Engineer, Motorola, Inc., Phoenix, AZ, 1991  
Microelectronics and Computer Development Fellow, The University of  
Texas at Austin, Austin, TX, 1988 - 1990  
Member of the Technical Staff, The MITRE Corp., McLean, VA, 1988  
C<sup>3</sup>I Intern, The MITRE Corp., McLean, VA, 1985 - 1987  
Programmer, AT&T Corp., Oakton, VA, 1982 - 1984

## HONORS AND AWARDS

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- Fellow, IEEE. For “contributions to biomedical image analysis,” 2013
- Director’s Award for Superior Accomplishment, National Science Foundation, 2021
- Best paper recognition (top 10% of accepted papers), IEEE International Conference on Image Processing, 2019 (with J. Wang, T. Batabyal, A. Gahlmann)
- Educational Innovation Award, 2017
- Best paper recognition (top 10% of accepted papers), IEEE International Conference on Image Processing, 2015 (with T. Batabyal & A. Vaccari)
- Best Oral Presentation (with Ed Hoppe), Transport Research Arena, 2014
- Finalist, Thomas E. Hutchinson Award, 2013 for “contributions to the students of the Engineering School”
- External Advisory Board, Carnegie Mellon University, 2013-2016, 2018-2021
- Best Paper Award, 2011 IEEE International Symposium on Biomedical Imaging (with U.Va. student Saurav Basu and Dr. Barry Condron)
- Finalist, State Council of Higher Education Outstanding Faculty Award, 2010
- All University Teaching Award, University of Virginia, 2009
- Visiting Professor, University of New Mexico, 2007-2008
- Selected for UVA’s Unforgettable Lectures, 2007, 2009
- Darden Business Concept Contest Award, 2006
- Walter N. Munster Associate Professorship for Research in Intelligence Enhancement, 2003
- Faculty Fellow of the School of Engineering and Applied Science, 2003
- New Faculty Teaching Award, 2002
- Best Paper Award, IEEE International Conference on Image Processing, 2002 (with U.Va. student Nilanjan Ray)
- Whitaker Biomedical Engineering Research Grant, 2001
- Outstanding Young Electrical Engineer, 1996  
(National award given by Eta Kappa Nu annually since 1936)
- Halliburton Outstanding Young Faculty Award, 1997
- Senior Member, IEEE, 1999
- Big 12 Faculty Fellowship, 1998
- Most Influential Professor, OSU Athletics, 1998
- Army Research Office Young Investigator Award, 1995
- Motorola Partnerships in Research Award, 1993
- Microelectronics and Computer Development Fellowship, 1988
- Member, Eta Kappa Nu Honorary Society, 1987
- Marshall Hahn Engineering Fellowship, 1985
- Virginia Scholar's Award, 1984

## PUBLICATIONS

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- M.S. Pattichis, S.T. Acton, C.S. Pattichis and A.S. Panayides, "Large-scale medical image and video analytics for clinical decision support," *IEEE Journal of Biomedical and Health Informatics*, vol. 27, pp. 2-6, 2023.
- J. Zhang, Y. Wang, E.D. Donarski, T.T. Toma, M.T. Miles, S.T. Acton and A. Gahlmann, "BCM3D 2.0: Accurate segmentation of single bacterial cells in dense biofilms using computationally generated intermediate image representations," *Biofilms and Microbiomes*, vol. 8, pp. 1-13, 2022.
- J. Wang, N. Tabassum, T.T. Toma, Y. Wang, A. Gahlmann and S.T. Acton, "3D GAN image synthesis and dataset quality assessment for bacterial biofilm," *Bioinformatics*, vol. 38, pp. 4598-4604, 2022.
- T. Batabyal, D. Weller, J. Kapur and S.T. Acton, "Efficient learning of transform-domain LMS filter using graph Laplacian," *IEEE Transactions on Neural Networks and Learning Systems*, February 2022.
- H. Ma, S.T. Acton and Z. Lin, "CAT: centerness-aware anchor-free tracker," *Sensors*, vol. 22, pp. 354-367, 2022.
- N. Sadeghzadehyazdi, T. Batabyal, A. Glandon, N. Dhar, B. Familoni, K. Iftekharuddin and S.T. Acton, "Using skeleton correction to improve flash Lidar-based gait recognition," *Applied Artificial Intelligence*, vol. 16, pp. 1-33, 2022.
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- T. Ly, J. Wang, K. Bisht, U. Eyo and S.T. Acton, "C3VFC: A method for tracing and quantification of microglia in 3D temporal images," *Applied Sciences* (Special issue on Medical Image Analysis: From Small Size Data to Big Data), vol. 11, p. 6078, 2021.
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- Z. Hu and S.T. Acton, "Morphological pyramid image registration," *Proc. IEEE Southwest Symposium on Image Analysis and Interpretation*, Austin, Texas, April 2-4, 2000.
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- B. Raghunathan and S.T. Acton, "A content based retrieval engine for circuit board inspection," *Proc. IEEE Int. Conf. on Image Processing*, Kobe, Japan, Oct. 25-29, 1999.
- C.A. Segall, S.T. Acton and A.K. Katsaggelos, "Sampling conditions for anisotropic diffusion," *Proc. of the SPIE Symposium on Visual Communications and Image Processing*, San Jose, January 23-29, 1999.
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- J.H. Bosworth and S.T. Acton, "Morphological image segmentation by local monotonicity," *Proc. Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, California, October 24-27, 1999.
- C.A. Segall and S.T. Acton, "Adaptive templates in scale-space," *Proc. of the SPIE Conference on Real-time Imaging (part of Photonics West)*, San Jose, January 23-29, 1999.

- D.P. Mukherjee and S.T. Acton, "On disocclusion of fingerprint images," *Advances in Pattern Recognition and Digital Techniques*, Calcutta, India, Dec. 27-29, 1999.
- S.T. Acton, "Anisotropic diffusion and local monotonicity," *Proc. of the IEEE Int. Conf. on Acoustics, Speech and Signal Processing (ICASSP-98)*, Seattle, May 12-15, 1998.
- C.A. Segall and S.T. Acton, "Gradient independent translation via differential morphology," *Proc. of the IEEE Int. Conference on Image Processing*, Chicago, October 4-7, 1998.
- S.T. Acton, "A PDE technique for generating locally monotonic images," *Proc. of the IEEE Int. Conference on Image Processing*, Chicago, October 4-7, 1998.
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- C.A. Segall and S.T. Acton, "Morphological anisotropic diffusion," *Proc. of the IEEE Int. Conference on Image Processing*, Santa Barbara, Ca., October 26-29, 1997.
- A. Wright and S.T. Acton, "Watershed pyramids for edge detection," *Proc. of the IEEE Int. Conference on Image Processing*, Santa Barbara, Ca., October 26-29, 1997.
- M.C. Burton and S.T. Acton, "Target tracking using the anisotropic diffusion pyramid," *Proc. of the IEEE Southwest Symposium on Image Analysis and Interpretation*, San Antonio, April 8-9, 1996.
- W. Chen and S.T. Acton, "Processing issues in the automated inspection of power insulators," *Proc. of the IEEE Southwest Symposium on Image Analysis and Interpretation*, San Antonio, April 8-9, 1996.
- K.A. Davis, S.T. Acton, and B.J. Ackerson, "Segmentation of colloidal crystal images by local histogram analysis," *Proc. of the IEEE Southwest Symposium on Image Analysis and Interpretation*, San Antonio, April 8-9, 1996.
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- S.T. Acton, "A pyramidal edge detector based on anisotropic diffusion," *Proc. of the IEEE Int.*

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- S.T. Acton, A.C. Bovik and M.M. Crawford, "Anisotropic diffusion pyramids for image segmentation," *Proc. of the IEEE Int. Conference on Image Processing*, Austin, Texas, November 13 - 16, 1994.
- S.T. Acton and A.C. Bovik, "Image segmentation via piecewise constant regression," *Proc. of the SPIE Symposium on Visual Communications and Image Processing (VCIP-94)*, Chicago, September 25 - 28, 1994.
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- S.T. Acton, J. Ghosh, and A.C. Bovik, "Fast combinatorial optimization using generalized deterministic annealing," *Proc. of the SPIE Conf. on the Science of Artificial Neural Networks (part of OE/Aerospace Science and Sensing)*, Orlando, Florida, April 12-16, 1993.
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- S.T. Acton and A.C. Bovik, "GRUPO: A 3-D structure recognition system," *Proc. of the SPIE Symposium on Visual Communications and Image Processing (VCIP-90)*, Lausanne, Switzerland, October 2-4, 1990.

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**INVITED CONFERENCE PAPERS**


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- M. Korban, P. Youngs and S.T. Acton, "Instructional activity detection using deep neural networks," *Proc. Conf. on Digital Signal Processing*, Rhodes, Greece, June 11, 2023.
- M. Korban, S. Singh, G. Watson, P. Youngs, and S.T. Acton, "AI assisted object and activity detection in K-6 classroom environments: A preliminary framework to assist in pedagogical performance evaluation," *Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 1-3, 2021.
- N. Sadeghzadehyazdi, T. Batabyal, L. Barnes and S.T. Acton, "Graph-based classification of healthcare provider activity," *Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 6-9, 2016.
- T. Ly, R. Sarkar, K. Skadron and S.T. Acton, "Feature extraction and image retrieval on an automata structure," *Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 6-9, 2016.
- N. Tabassum, A. Vaccari and S.T. Acton, "Speckle removal by distance-driven anisotropic diffusion of SAR temporal stacks," *Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, November 8-11, 2015.
- R. Sarkar, S. Ozer, K. Skadron and S.T. Acton, "Image classification by multi-kernel dictionary learning," *Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 2-4, 2014.
- S. Mukherjee, B. Condrón and S.T. Acton, "Chasing the neurome: segmentation and comparison of neurons," *European Signal Processing Conference*, Marrakesh, Morocco, September 9-13, 2013.
- S. Mukherjee and S.T. Acton, "Neuron segmentation with level sets," *Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2013.
- A. Vaccari and S.T. Acton, "Spatiotemporal Gaussian feature detection in sparsely sampled data with application to InSAR," *Proc. SPIE 8746, Algorithms for Synthetic Aperture Radar Imagery XX*, Baltimore, May 2, 2013.
- Q. Sang, Z. Lin and S.T. Acton, "An enhanced grid-based Bayesian array for target tracking," *Proc. SPIE Electronic Imaging*, San Jose, California, February 14, 2013.
- A. Vaccari, K.K. Gamage, S. Nachum, B. Condrón, C.D. Deppmann and S.T. Acton, "Assessment of Wallerian degeneration by automated image analysis," *Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2012.
- S.T. Acton and A. Aksel, "An information theoretic trackability measure," *Proc. SPIE Electronic Imaging*, San Francisco, California, January 23-25, 2012.

- S. Basu, B. Condrón, S.T. Acton, "Path-space algebra for constructing an average neuronal atlas from multi-class neuronal datasets," *Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2010.
- S. Basu, J. Poulin and S.T. Acton, "Human pose tracking from monocular video by traversing an image motion mapped body pose manifold," *Proc. SPIE Electronic Imaging*, San Jose, California, January 17-19, 2010.
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- S.T. Acton, "Biomedical image analysis at the cellular level," *Proc. Int. Machine Vision and Image Processing Conference*, Northern Ireland, September 3-5, 2008.
- N. Ray, B. Saha and S.T. Acton, "Oil sand image segmentation using the inclusion filter," *Proc. IEEE Conf. on Image Processing*, San Diego, California, September, 2008.
- S.T. Acton, P. Soliz, M.S. Pattichis, "Content based image retrieval: The foundation for future case-based and evidence-based ophthalmology," *Proc. IEEE Int. Conf. on Multimedia and Expo*, Hannover, Germany, June 23-26, 2008.
- A.D. Gilliam and S.T. Acton, "Murine spatiotemporal cardiac segmentation," *Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2007.
- S. Basu and S.T. Acton, "Estimation of cell statistics on a cell manifold for high content screening with automated cell segmentation," *Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2007.
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- S.T. Acton and N. Ray, "Detection and tracking of rolling leukocytes from intravital microscopy," *Proc. IEEE Int. Symp. On Biomedical Imaging*, Arlington, Virginia, April 15-18, 2004.
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- N. Ray and S.T. Acton, "Adaptive image processing via snake filters," *Proc. 35<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2001.
- Y. Yu and S.T. Acton, "Segmentation of ultrasound imagery using anisotropic diffusion," *Proc. 35<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers*, Pacific Grove, California, November 4-7, 2001.
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- N. Ray and S.T. Acton, "Image segmentation by curve evolution with clustering," *Proc. 34<sup>th</sup> Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, California, October 29 – November 1, 2000.
- B. Raghunathan and S.T. Acton, "Image segmentation by level set analysis," *Proc. 34<sup>th</sup> Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, California, October 29 – November 1, 2000.
- S.T. Acton, "Diffusion based image and video processing," *Advances in Pattern Recognition and Digital Techniques*, Calcutta, India, Dec. 27-29, 1999.
- D.P. Mukherjee and S.T. Acton, "Document page segmentation using multiscale clustering," *Proc. IEEE Int. Conf. on Image Processing*, Kobe, Japan, Oct. 25-29, pp. 234-238, 1999.
- C.A. Segall and S.T. Acton, "Multi-scale video tracking," *Workshop on the Detection and Classification of Difficult Targets*, Redstone Arsenal, Huntsville, AL, June 9-10, 1998.
- C.A. Segall, W. Chen, and S.T. Acton, "Nonlinear pyramids for object identification," *Proc. 30<sup>th</sup> Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, California, Nov. 3-6, 1996.

ABSTRACTS

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- J. Zhang, Y. Wang, M. Zhang, J. Wang, A. Achimovich, S.T. Acton and A. Gahlmann, "Non-invasive single-cell morphometry in living bacterial biofilms," *Biophysical Journal*, vol. 120, p. 358, 2021.
- S.T. Acton, "Image analysis for neuroscience and relevant signal, image and data processing at the NSF," *SPIE Optics and Photonics for Information Processing XIV*, 11509, 1150902, San Diego, California, August 2020.
- S. Singh, G.S. Watson, P.A. Youngs and S.T. Acton "A Neural Network Approach to Automated Classification of Elementary Mathematics Instructional Activities," *IEEE SSIAI*, Santa Fe, New Mexico, March 29 - April 1, 2020.
- M. Zhang, J. Zhang, J. Wang, A.M. Achimovich, A.A. Aziz, J. Corbitt, S.T. Acton, A. Gahlmann, "3D imaging of single cells in bacterial biofilms using lattice light-sheet microscopy," *Biophysical Society Meeting*, Baltimore, Maryland, March 3, 2019.
- T. Batabyal, A. Dutta and S.T. Acton, "Predicting Coronary Artery Disease - A Neural Network Approach." *American Association for the Advancement of Science (AAAS)*, Washington D.C., February 13-17, 2019.
- R. Bailey, C. Fleming, W.T. Scherer, M. Smith, W. Guilford, D. Elsey, S. Russell and B. Smith, "Integrating Systems Approaches into Education Using Active Case Studies," *Frontiers in Education (FIE) conference*, San Jose, CA, October 3-6, 2018.
- B. Bruckno, A. Vaccari, E. Hoppe, S.T. Acton and E. Campbell, "Integration and Delivery of interferometric synthetic aperture radar data into stormwater planning within karst terranes," *Proceedings of the 14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst*, Rochester, MN, pp 371-379, October 5-9, 2015.
- B. Bruckno, A. Vaccari, E. Hoppe, S.T. Acton, "Use of Interferometric Synthetic Aperture Radar [InSAR] Data for Identification and Evaluation of Rock Slopes," *Association of Environmental and Engineering Geologists*, Pittsburgh, PA, September 24, 2015.
- A. Vaccari, B. Bruckno, E. Hoppe, S.T. Acton, and E. Campbell, "Delivering geohazard and geotechnical data: from the satellite to the field," *Geological Society of America*, Northeastern Section, 49th Annual Meeting, Lancaster, Pennsylvania, March 23-25, 2014.

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- S.T. Acton, M. Stuecheli, A. Vaccari, E. Hoppe and B. Bruckno, "Model for sinkhole detection by InSAR", *Transportation Research Board*, Washington DC, January 2013.
- S.T. Acton, "Image analysis in neuromics," *Bioinformatics 2012*, Dresden Germany, September 19, 2013.
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- P. Soliz, V. Murray, M.S. Pattichis, S.T. Acton and S. Murillo, "Video tracking of retinal photoreceptor fields using adaptive optics," *Proc. Association for Research in Vision and Ophthalmology*, Ft. Lauderdale, Florida, April 27-May 1, 2008.
- S.T. Acton, "Tracking and detection of rolling leukocytes in vivo," *NSF Workshop on Bio-image Informatics*, Santa Barbara, California, 2008.
- J.J. Rychak, B. Li, S.T. Acton, A. Leppanen, R.D. Cummings, K. Ley and A.L. Klibanov, "Targeted ultrasound contrast agent retention under flow conditions," *Proc. Annual Meeting of the Society for Molecular Imaging*, Waikoloa, HI, August 30 - September 2, 2006.
- S. Millington, B. Li, S. Trattnig and S.T. Acton, "Topography of talar articular cartilage determined by high resolution MRI and semi-automated image segmentation," *Proc. International Cartilage Repair Society Meeting*, San Diego, CA, January 6-11, 2006.
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- "Targeted ultrasound contrast agents for molecular imaging in high-shear flow," *Contrast Media Research 2005*, Evian, France, October 11-16, 2005.
- G. Dong, S.T. Acton, E. Damiano, "Detecting microspheres in venules for automated particle image velocimetry via a marked point process," *2005 Summer Bioengineering Conference*, Vail, CO, June 22-26, 2005.
- J.J. Rychak, A.L. Klibanov, W. Yang, B. Li, S. Acton, A. Leppanen, R.D. Cummings, K. Ley, "Enhanced Microbubble Adhesion to P-selectin with a Physiologically-tuned Targeting Ligand," *10<sup>th</sup> Ultrasound Contrast Symposium*, San Diego, California, March 4-5, 2005 (Winner: Best Presentation Award).
- R.L. Janiczek, N. Ray, B. French, F. Epstein and S.T. Acton, "Automated calculation of myocardial mass and infarct size in mice using a Monte Carlo Markov chain active contour," *Society for Cardiovascular Magnetic Resonance*, San Francisco, California, January 21-23, 2005
- S.A. Millington, J. Tang, S.R. Hurwitz, S.T. Acton and J.R. Crandall, "Quantitative measurement of ankle cartilage using an isotropic MRI sequence and a directional gradient vector flow snake," *9<sup>th</sup> World Congress of the OsteoArthritis Society*, Chicago, Illinois, December 2-5, 2004.
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- Y. Yu, J. Molloy and S.T. Acton, "Automated segmentation of the prostate from ultrasound imagery using the instantaneous coefficient of variation," *Proc. American Association of Physicists in Medicine*, San Diego, California, August 10-14, 2003.
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- S.T. Acton and A.C. Bovik, "Local and piecewise classes of nonlinear regression for image enhancement," *IEEE Signal Proc. Soc. Workshop on Multidimensional Signal Processing*, Cannes, France, September 8-10, 1993.

## INVITED PRESENTATIONS

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- “State of the Artificial,” Keynote Address, UVA Research Retreat, Afton, Virginia. August 10, 2023.
- “Bioimage Analysis, the Brain, and ChatGPT,” University of Alabama Special Seminar, March 30, 2023.
- “Microscopic image analysis for answering questions in smart health,” Keynote Address, IEEE/ACM Conference on Connected Health Applications, Systems and Engineering Technologies, Washington, DC, November 17, 2022.
- “Bioimage Analysis at Microscopic Scales,” Invited Talk, Boston University, October 27, 2022.
- “Bioimage Analysis at Microscopic Scales,” NSF CISE-CCF Tech Talk, January 13, 2021.
- “Statistics and Imaging Data,” Keynote talk, *Recent Advances in Statistical Analysis of Imaging Data*, Tallahassee, Florida, December 5, 2020.
- “Image analysis for neuroscience and relevant signal, image, and data processing at the NSF,” Plenary Address, SPIE Optics and Photonics, San Diego, California, August 25, 2020.
- “You, Image Analysis and the NSF,” Invited Talk, IEEE SSIAl, Santa Fe, New Mexico, April 1, 2020.
- “Signal Processing for Neuroscience,” Invited Seminar, National Science Foundation, March 11, 2019.
- “Research at VIVA,” Invited Speaker, Siemens, February 13, 2019.
- “Brain Pixels: image analysis for neuroscience,” Keynote Address, IEEE SSIAl, Las Vegas, April 9, 2018.
- “Research at VIVA,” General Electric, May 1, 2018.
- “An Engineer among Scientists: Research in image analysis for neuroscience,” Department of Biochemistry and Molecular Genetics Colloquium, UVA, Charlottesville, Virginia, February 22, 2018.
- “Reverse Engineering of Neurons,” ECE Departmental Seminar, UVA, Charlottesville, Virginia, November 10, 2017.
- “Neuroscience image analysis in progress,” Brain, Immunology and Glia Research-in-progress, UVA, Charlottesville, Virginia, October 23, 2017.
- “Virginia Image and Video Analysis,” UVA Brain, Charlottesville, Virginia, September 28, 2017.
- “Solving the mysteries of the brain, one pixel at a time,” Keynote Address, International Symposium on Image Computing and Digital Medicine, Chengdu, China, September 23, 2017.
- “Engineering and Biology Team Together to Reverse Engineer the Brain: An Image Analysis Perspective,” Invited Talk, Tsinghua University, Beijing, China, September 21, 2017.
- “State of the Transactions,” IEEE ICIP, Beijing, China, September 20, 2017.
- “Machine Learning and Image Processing: the Future,” ICIG, Shanghai, China, September 15, 2017.
- “Using Image Processing to Reverse Engineer the Brain,” Plenary Talk, ICIG, Shanghai, China, September 14, 2017.
- “Overview of the International Symposium on Biomedical Imaging,” IEEE ISBI, Melbourne, Australia, April 21, 2017.
- “State of the Transactions,” IEEE ICASSP, New Orleans, Louisiana, March 6, 2017.
- “Do Engineers have a Heart?” Keynote speech, Thomas E. Hutchinson Dinner, Rotunda, UVA, January 28, 2017.
- “Best Practices for Associate Editors,” IEEE SPS editorial meeting, Phoenix, October 27, 2016.

- “Engineers help unravel mysteries of the brain,” Distinguished Lecture, OSU, Stillwater, OK, October 11, 2016.
- “Image analysis in the century of the brain,” Invited Lecture, UESTC, Chengdu, China, March 24, 2016.
- “Workshop on Radar for Transportation,” TRB, Washington, D.C., January 8, 2016.
- “An encyclopedia via media: Image analysis for the Neurome,” IEEE ISM Distinguished Lecture, Miami, December 14, 2015.
- “InSAR Remote Sensing for Performance Monitoring of Transportation Infrastructure at the Network Level,” Commercial Remote Sensing & Spatial Information Technologies Workshop, Oklahoma City, December 3, 2015.
- “Network level infrastructure inspection,” Geotechnical Research Advisory Committee Meeting, Virginia Department of Transportation, October 16, 2015.
- “How to be an effective Editor,” IEEE ICIP, Quebec City, Quebec, September 30, 2015.
- “How to be an effective Editor,” IEEE SPS, Brisbane, Australia, April 22, 2015 (w/ Alessandro Foi).
- “You’ve got a nerve to be doing your engineering on my biology,” IEEE W. North Carolina section invited talk, April 10, 2015.
- “Integration of Interferometric Synthetic Aperture Radar Data into Geotechnical Planning and Design,” Transportation Research Board, Washington, D.C., January 11, 2015 (w/ B. Bruckno).
- “Visual media reasoning: Self-nomination in retrieval,” DARPA, Arlington, Virginia, February 26, 2014 (w/ K. Skadron, S. Ozer).
- “Updates to applications of Interferometric Synthetic Aperture Radar to sinkhole detection and rock slope monitoring,” Transportation Research Board, Washington, D.C., January 12, 2014 (w/ B. Bruckno).
- “Image Analysis Challenges in the Drosophila Neurome,” Plenary Talk, Video Bioinformatics Conference, UCLA Conference Center, December 6, 2013.
- “Blood and Neurons – Digital Image Analysis Conquers ALL,” Penn State University, March 22, 2013.
- “Image Analysis in Neuromics,” Bioinformatics 2012, Dresden Germany, September 19, 2012.
- “Image Analysis in Biology: From Blood to Fruit Flies,” Iowa State University, September 14, 2012.
- “Image Analysis in Heterogeneous Computer Systems,” Cloud Day, Washington DC, May 17, 2012.
- “Object Identification and Dynamics in Biological Images,” ISBI, Barcelona, Spain, May 1, 2012.
- “Investigating Interferometric Synthetic Aperture Radar for Transportation Infrastructure Monitoring,” Transportation Research Board, Washington DC, January 22, 2012.
- “Electrical Engineering Attacks Biology with Image Analysis,” Old Dominion U., Norfolk, VA, February 9, 2012.
- “Image Analysis for UAVs,” Bosh, Charlottesville, VA, November 17, 2011.
- “ATR: Not just for the Battlefield Anymore,” MITRE, July 11, 2011.
- “Image Analysis at Virginia,” DARPA, Falls Church, VA, June 1, 2011.
- “Challenges in Biological Image Analysis: Blood and Brains,” Purdue University, April 22, 2011.
- “Detection of Sinkholes using InSAR Imagery,” Dept. of Transportation, Washington DC, February 2, 2011.
- “The Next Grand Challenge for Image Analysis: the Neurome,” Groningen University,

- Netherlands, November 23, 2010.
- "Can Image Processing Help Neuroscience?" Shanghai Jiao Tong University, Shanghai, China, September 24, 2010.
- "Biomedical Image Analysis," Waterloo University, Waterloo, Ontario, Canada, July 8, 2010.
- "A Graph theoretic Approach to Neuron Segmentation," HHMI Janelia Farm, Ashburn, Virginia, May 11, 2010.
- "Cellular Level Image Analysis," U. of Aachen, Aachen, Germany, April 20, 2010.
- "Image and Video Analysis at the University of Virginia," Advanced Research Institute Seminar, Charlottesville, Virginia, March 4, 2010.
- "Image and Video Analysis," IARPA program director briefing, Charlottesville, Virginia January 13, 2010.
- "Image Analysis at the Cellular Level," ECE Eminent Speaker, Carnegie Mellon U., April 2, 2009.
- "Billy the Kid and The Fourier Transform," LASE 360: UVA's Unforgettable Lectures, March 11, 2009.
- "Cellular Image Analysis in 2009," U. of Alberta, March 20, 2009.
- "Advanced Image Segmentation using Active Models," AFRL Meeting, Pittsburgh, November 2, 2009.
- "Image Analysis at the Cellular Level," IMVIP Plenary Talk, September 2, 2009.
- "The Future: Cellular Image Analysis," U. of New Mexico, April 25, 2008.
- "The Future: Cellular Image Analysis," U. of Texas, February 19, 2008.
- "Linear Filters," U. of Texas, February 21, 2008.
- "Analysis of Intravital Microscopic Images of Rolling Leukocytes," U.C.S.B., January 18, 2008.
- "The Future: Cellular Image Analysis," New Mexico State University, March 13, 2008.
- "Anisotropic Diffusion," U. of Texas, February 20, 2008.
- "The Future: Cellular Image Analysis," Texas Tech University, April 11, 2008.
- "Anisotropic Diffusion," U. of New Mexico, March 10, 2008.
- "Speckle Reducing Anisotropic Diffusion," U. of New Mexico, March 31, 2008.
- "Image and Video Analysis Research at VIVA," Department of Homeland Security, July 9, 2007.
- "Automated Detection and Tracking of Cells," Boston College, Chestnut Hill, Massachusetts, April 24, 2007.
- "Content Based Image Retrieval," Lockheed Martin, Rockville, Maryland, January 29, 2007.
- "CellTrek: a Tool for Drug Discovery and Validation," Darden School of Business, U.Va., Charlottesville, Virginia, October 24, 2006.
- "The Aorta Stomp: Image Analysis for Leukocytes and the Myocardium," BME Seminar Series, University of Virginia, Charlottesville, September 24, 2004.
- "Detection and tracking of rolling leukocytes from intravital microscopy," IEEE Int. Symp. On Biomedical Imaging, Invited Session on Image Formation and Analysis in Microscopy, Arlington, Virginia, April 16, 2004.
- "Tracking Targets: from Military to Biomedical," Air Force Research Laboratory Invited Lecture, Boston, Massachusetts, March 2, 2004.
- "Snakes, blood and pixels," U. of Maryland Center for Automation Research Invited Lecture, College Park, Maryland, November 21, 2003.
- "Tracking Targets through Scale Changes and Clutter using a Monte Carlo Method," Army Research Laboratory, Adelphi, Maryland, May 19, 2003.
- "Enhancements to Image2000," Invited Talk, NASA Goddard, Maryland, July 3, 2002 (with Kate Weber).

- "Signal and Image Compression," Naval Surface Warfare Center, Dahlgren Division, Virginia, November 13, 2002.
- "Tracking Leukocytes using Active Contours," Imaging Science, Boston, Mass., March 4, 2002.
- "Simplifying the Use of Automated Liquid Handling Robotics Using Computer Vision," LabAutomation 2002, Palm Springs Convention Center, CA, January 26-30, 2002 (with Joseph Bosworth, Chris Estey and Robin Felder).
- "Attacking Inflammatory Disease with Snakes: Intravital Video Tracking for Rolling Leukocytes," Biomedical Engineering Seminar, Charlottesville, Virginia, October 19, 2001.
- "Image Segmentation with Application to Medical Imaging," Invited Seminar, NIH, Bethesda, Maryland, October 24, 2000.
- "Image and Video Processing Using Anisotropic Diffusion," Invited Seminar, Center for Imaging Science, Johns Hopkins University, October 23, 2000.
- "NASA-related Image Processing Research at the University of Virginia," Invited Talk, NASA Goddard, Maryland, October 23, 2000.
- "Image Segmentation and Medical Applications," Invited Seminar, Varian Medical Systems, Charlottesville, Virginia, October 5, 2000.
- "Diffusion-based Image and Video Processing," Plenary Talk, International Conference on Advances in Pattern Recognition and Digital Techniques, ICAPRDT '99, Calcutta, India, December 28, 1999.
- "Document page segmentation using multiscale clustering," IEEE Int. Conf. on Image Processing Special Session on Document Compression, Kobe, Japan, October 25, 1999.
- "PDE-based Video Processing," Northwestern University invited seminar, Evanston, Illinois, February 17, 1999.
- "Image Diffusion," Wichita State University Seminar Series, Wichita, Kansas, September 18, 1998.
- "Multiscale Video Tracking and Related Topics," Science Applications International Corporation (SAIC), Denver, August 7, 1998.
- "Image Diffusion," University of Texas Signal Processing Seminar, Austin, March 12, 1998.
- "The Miracle of Vision," Fellowship of Christian Faculty and Staff, Stillwater, March 25, 1998.
- "Anisotropic Diffusion," OSU Center for Laser and Photonics Research Colloquium, Stillwater OK, March 27, 1998.
- "Order statistic filters," Electrical and Computer Engineering Seminar, University of Oklahoma, Norman, March 30, 1998.
- "Image enhancement and binary image processing," Electrical and Computer Engineering Seminar, University of Oklahoma, Norman, Feb. 11, 1998.
- "Annealing methods for high-speed optimization," U. of Houston Computer Science Invited Talk, Houston, May 11, 1993.

## RESEARCH FUNDING

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**Title:** Creating InstructionNet

**Source:** Schmidt Futures

**Duration:** 1/1/23-12/31/26

**Title:** Non-Invasive Single-Cell Morphometry and Tracking in Living Bacterial Biofilms

**Source:** NIH R01

**Duration:** 10/1/20-9/31/24

**Title:** Secondly generalized tonic clonic seizure: a functional anatomy

**Source:** NIH R37

**Duration:** 9/1/21-8/31/25

**Title:** Using Neural Networks for Automated Classification of Elementary Mathematics Instructional Activities

**Source:** NSF

**Duration:** 9/1/20-8/31/23

**Title:** CISE/CCF IPA Agreement

**Source:** NSF

**Duration:** 9/1/19-8/31/22

**Title:** A Deep Reinforcement Learning based Long-term Tracker for Salient Event Detection

**Source:** ARO

**Duration:** 7/1/20-6/30/23

**Title:** Using Neural Networks for Automated Classification of Elementary Reading and Mathematics Instructional Activities

**Source:** Robertson Foundation

**Duration:** 7/1/20-6/31/23

**Title:** ABI: Innovation: Analyzing Neuroglial Cell Dynamics in their Natural Environment with Video Microscopy

**Source:** NSF

**Duration:** 3/1/18-2/27/21

**Title:** A systems approach to understanding a neuronal circuit for detecting motion

**Source:** Three Cavaliers

**Duration:** 3/1/19-2/28/20

**Title:** Myeloid Cell Control Of CNS Infection

**Source:** NIH

**Duration:** 3/1/19-2/28/20

**Title:** Data Science Fellowship: Visualizing Cellular Behaviors in Bacterial Biofilms using Lattice Light Sheet Microscopy

**Source:** DSI

**Duration:** 6/1/19-5/30/20

**Title:** Image Analysis, Machine Learning and Advanced Imaging for Brain Immunology

**Source:** SEAS Research Innovation Award

**Duration:** August 2017 – August 2018

**Title:** Case-based Curricular Integration of Systems Thinking

**Source:** SEAS Teaching Innovation Award

**Duration:** August 2017 – August 2018

**Title:** Graph-based representations and multifidelity machine learning for anthropometrics-based human identity recognition

**Source:** Army Night Vision and Electronics Sensors Directorate

**Duration:** January 2017 – March 2020

**Title:** Automating Glia Neuroimaging

**Source:** UVA Brain

**Duration:** January 2017 – January 2018

**Title:** Breaking Barriers to Building Better Brains

**Source:** SEAS Research Innovation Award

**Duration:** August 2016 – August 2017

**Title:** Harnessing the Power of Bacterial Populations

**Source:** Jeffress Trust

**Duration:** June 2016 – August 2017

**Title:** A Sparse Coding Approach to Spatiotemporal Saliency Detection in Image and Video Databases

**Source:** ARO

**Duration:** June 2015 – May 2018

**Status:** Granted

**Title:** Bioimage Informatics for the Neurome

**Source:** Hobby Foundation

**Duration:** May 2015 – April 2017

**Co-PIs:** S.T. Acton, B.G. Condron

**Title:** Autoimage Development, Neuronal Degeneration and Stem Cell Adhesion

**Source:** Jeffress Trust

**Duration:** June 2015 – March 2017

**Title:** Activity Detection & Retrieval for Image & Video Data with Limited Training

**Source:** ARO

**Duration:** August 2014 – May 2015

**Title:** InSAR Remote Sensing for Performance Monitoring of Transportation Infrastructure at the Network Level

**Source:** U.S. DOT

**Duration:** January 2014-January 2016

**Title:** ABI Innovation: Towards the Neurome -- Automated Image Analysis for Neuroinformatics

**Source:** NSF

**Duration:** May 2011-April 2016 (on no-cost extension)

**Title:** Historical Study of Displacements at the Approaches to the Monitor Merrimac Memorial Bridge Tunnel

**Source:** VDOT

**Duration:** November 2013-June 2014

**Title:** Prototype for Meta-Algorithmic, Content-Aware Image Analysis

**Source:** DARPA

**Duration:** June 2012-July 2014

**Title:** Surface Characterization and Identification

**Source:** CCAM

**Duration:** January 2012 – January 2014

**Title:** Sinkhole Detection & Bridge/Landslide Monitoring for Transportation Infrastructure by Automated Analysis of Interferometric Synthetic Aperture Radar Images

**Source:** DOT

**Duration:** July 2011-July 2013

**Title:** Portable Ultrasound Image Analysis

**Source:** Army SBIR through PocketSonics, Inc.

**Duration:** January 2013 – July 2013

**Title:** Tracking and Image Characterization Research

**Source:** Night Vision, ARL via CACI, Inc. (CACI is the main contractor; UVA is a sub)

**Duration:** June 2010-May 2014

**Title:** Video Data Mining and Target Tracking: A Model Adaptation and Feedback Control Approach

**Source:** ARO

**Duration:** September 2010-August 2014

**Title:** High Resolution 3D Ultrasound Imaging and Quantification of the Murine Heart

**Source:** NIH

**Duration:** August 2009-September 2013

**Title:** Tracking and Classification Services III (add-on to previous NRO work)

**Source:** NSF WiCAT Center (NRO project)

**Duration:** April 2008- Dec. 2008

**Title:** Tracking and Image Characterization Research

**Source:** Night Vision, ARL via CACI, Inc. (CACI is the main contractor; UVA is a sub)

**Duration:** June 2007-May 2010

**Title:** Pilot Study of the Dermagram

**Source:** Swortzel Foundation

**Duration:** May 2008-April 2009

**Title:** Tracking and Classification Services II (add-on to previous NRO work)

**Source:** NSF WiCAT Center (NRO project)

**Duration:** Jan. 2008- Dec. 2008

**Title:** STIR: Model Adaptation and Feedback Control in Multi-Sensor Image Fusion and Multiple Target Tracking

**Source:** Army Research Office

**Duration:** September 2007 – May 2008

**Title:** SEI: Hierarchical Dependency Graphs for Col-Space Design with Application to Leukocyte Detection and Tracking

**Source:** NSF

**Duration:** June 2006 – May 2009

**Title:** Sequential Monte Carlo Method for Real-time Tracking of Multiple Targets

**Source:** Army Research Office

**Duration:** July 2006 – June 2008

**Title:** Image Processing Architecture in Support of Mobile Users with Limited Support Technology

**Source:** NRO through NSF WiCAT Center

**Duration:** Jan. 2007- Dec. 2007

**Title:** Automated hemodynamic analysis in microvessels using  $\mu$ -particle image velocimetry

**Source:** NIH

**Duration:** Dec. 2005- Nov. 2007

**Title:** Changes in Cartilage Thickness in the Ankle Following Compressive Loads that Exceed the Deformation Threshold of the Joint Surface But Do Not Fracture the Subchondral Bone

**Source:** Zimmer, Inc.

**Duration:** June 2004 – Jan 2006

**Title:** Real-time Hardware for Enhancement and Segmentation of Ultrasonic Imagery of the Prostate

**Source:** Mellon Prostrate Cancer Research Institute

**Duration:** October 2003 – September 2005

**Title:** MRI of myocardial function in post-infarct knockout mice

**Source:** NIH

**Duration:** January 2004 – December 2007

**Title:** High Resolution Anatomic and Elastographic Transrectal Ultrasound for Improved Diagnosis of Prostate Cancer

**Source:** U.S. Army Medical Research and Materiel Command

**Duration:** January 2004 – December 2006

**Title:** Quantitative 3D Ultrasound Imaging of The Murine Heart

**Source:** NIH

**Duration:** January 2004 – December 2006

**Title:** System for Automated Tracking of Leukocytes *In Vivo* (R33 Mechanism)

**Source:** NIH

**Duration:** October, 2002 – September, 2005

**Title:** System for Automated Tracking of Leukocytes *In Vivo* (R21 Mechanism)

**Source:** NIH

**Duration:** October, 2001 – September, 2002

**Title:** Decentralized Image Retrieval for Education

**Source:** NSF

**Duration:** January, 2002 – December, 2004

**Title:** Advanced Biomedical Image Processing for Tracking Leukocytes *In Vivo* from Video Microscopy

**Source:** Whitaker Foundation (Biomedical Engineering Research Award)

**Duration:** September, 2001 – August, 2004

**Title:** Clutter-reducing, Scalable Image Processing Methods for Target Acquisition and Tracking

**Source:** U.S. Army Research Office

**Duration:** May, 2001 – April, 2004

**Title:** Advanced Image Processing for Image2000 Enhancements

**Source:** NASA

**Duration:** July, 2001 – April, 2004

**Title:** Rapid deployment of drug discovery automation using machine vision

**Source:** Carilion Biomedical Institute

**Duration:** September 2000 – May 2002

**Title:** Multi-Resolution Segmentation via Fusion of Mesonet Data and Remotely Sensed Imagery (Years 4 and 5)

**Source:** NASA (subcontract to U.Va. from OU)

**Duration:** November, 1999 - February, 2002

**Title:** Multiresolution Sensor Fusion Using Morphological Pyramids

**Source:** NSF

**Duration:** July, 1997 – June, 1998

**Title:** Multiresolution, Multi-Scale Target Identification and Tracking Using the Anisotropic Diffusion Pyramid

**Source:** U.S. Army Research Office (**Young Investigator Award**)

**Duration:** September, 1995 – August, 1998

**Title:** Processing Digital Images Obtained From Indium Antimonide Sensors

**Source:** NSF

**Duration:** August, 1996 - July, 1997

**Title:** Multi-Resolution Segmentation via Fusion of Mesonet Data and Remotely Sensed Imagery

**Source:** NASA

**Duration:** November, 1996 - November, 1999

**Title:** Fusion of Infrared and X-ray Imagery for Automated Circuit Inspection

**Source:** Lucent Technologies

**Duration:** December, 1997 – November, 1998 (extension)

**Title:** Vision-based Circuit Board Inspection System

**Source:** Lucent Technologies

**Duration:** September, 1996 – November, 1997

**Title:** Fusion of Infrared and X-ray Imagery for Automated Circuit Inspection (Feasibility Study)

**Source:** Lucent Technologies

**Duration:** June, 1996 - August, 1996

**Title:** Automated Video Tracking and Inspection (additional time and funds)

**Source:** SVS, Inc., Albuquerque NM

**Duration:** October, 1995 - July, 1996

**Title:** Image Processing for Agricultural Remote Sensing

**Source:** Site-Specific Technology Development Group, Stillwater OK

**Duration:** August, 1995 – June, 1996

**Title:** Automated Video Tracking and Inspection

**Source:** SVS, Inc., Albuquerque NM

**Duration:** June, 1995 – September, 1995

## GRADUATE STUDENTS DIRECTED

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| <i><b>Ph.D. Students and Dissertation Title</b></i>                                                                                                                                   | <i><b>Graduation Date</b></i> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Wei Chen<br>"Morphological Image Pyramids for Automatic Target Recognition"<br>(Currently: Senior Research Scientist with KLA Tencor)                                                 | Summer, 1997                  |
| Joseph Bosworth<br>"Morphological Local Monotonicity for Multiscale Image Segmentation"<br>(Currently: Founder and Owner at Black Mesa Imaging, LLC)                                  | Spring, 2002                  |
| Yongjian Yu<br>"Ultrasound Image Enhancement for Detection of Contours Using Speckle Reducing Anisotropic Diffusion"<br>(Currently: Senior Research Engineer with Axon Connected)     | Spring, 2003                  |
| Nilanjan Ray<br>"Tracking Rolling Leukocytes In Vivo Using Active Contours with Motion Gradient Vector Flow"<br>(Currently: Associate Professor at University of Alberta)             | Spring, 2003                  |
| Dong Gang<br>"Detection of Rolling Leukocytes from Intravital Microscopy Images"<br>(Currently: Senior Research Scientist with KLA Tencor)                                            | Fall, 2005                    |
| Jing Cui (co-advised w/ Z. Lin)<br>"In Vivo Multi-leukocyte Tracking by Enhanced Particle Filter"<br>(Currently: with University of Michigan)                                         | Spring, 2006                  |
| Michael Grant<br>"Surface Reflected Global Positioning System Signals for Terrain Classification"<br>(Currently: Chief Engineer w/ NASA Langley Research Center)                      | Summer, 2006                  |
| Bing Li<br>"Image Segmentation Using Vector Field Convolution Active Models and Poisson Inverse Gradient Initialization"<br>(Currently: General Manager and Cofounder, SVision, Inc.) | Summer, 2007                  |
| Drew Gilliam<br>"MRI-assisted Segmentation of Cardiac Ultrasound using Active Trajectory Models"<br>(Currently: Vision Scientist at Vision Systems, Inc.)                             | Summer, 2008                  |
| Robert Janiczek<br>"Measurement of wall stress using magnetic resonance imaging"<br>(Currently: Scientific Director, Glaxo Smith Kline)                                               | Summer, 2012                  |
| Saurav Basu<br>"Using manifold geometry in image analysis: shape based recognition and pose tracking"<br>(Currently: with IBM)                                                        | Summer, 2012                  |
| Alla Aksel                                                                                                                                                                            | Fall, 2014                    |

|                                                                                                                                                                                  |                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| “Automated tracking and analysis of aerial surveillance data”<br>(Currently: with Northrup Grumman)                                                                              |                                               |
| Andrea Vaccari                                                                                                                                                                   | Spring, 2014                                  |
| “An automated image analysis framework for model-based feature detection in sparse data”<br>(Currently: Assistant Professor of Computer Science, Middlebury College)             |                                               |
| Suvadip Mukherjee                                                                                                                                                                | Fall, 2015                                    |
| “Segmentation and enhancement of filamentous objects for biological image analysis”<br>(Currently: Senior Engineer with KLA)                                                     |                                               |
| Rituparna Sarkar                                                                                                                                                                 | Spring, 2017                                  |
| “Dictionary learning and sparse representation for image analysis with application to segmentation, classification and event detection”<br>(Currently: Senior Engineer with KLA) |                                               |
| Tamal Batabyal                                                                                                                                                                   | Spring, 2019                                  |
| “Graph-theoretic data modeling with application to neuromorphology, activity recognition and event detection”<br>(Currently: with MIT)                                           |                                               |
| Nasrin Sadeghzadehyazdi                                                                                                                                                          | Spring, 2021                                  |
| Topic: Image analysis of lidar for person identification<br>(Currently with Chemours, formerly Dupont)                                                                           |                                               |
| Tiffany Ly                                                                                                                                                                       | Summer, 2021                                  |
| Topic: Image analysis of Glia<br>(Currently with IBM)                                                                                                                            |                                               |
| Jie Wang                                                                                                                                                                         | Fall, 2021                                    |
| Topic: Super-resolution Microscopy Image Analysis<br>(Currently with Nanjing University of Posts and Telecommunications)                                                         |                                               |
| Nazia Tabassum                                                                                                                                                                   | Spring, 2021                                  |
| Topic: Image Analysis for Meningeal Lymphatics<br>(Currently with SAS Institute)                                                                                                 |                                               |
| Haoyi Ma                                                                                                                                                                         | Spring, 2022                                  |
| Topic: Long-term Video Tracking, Reinforcement Learning for Tracking<br>(Currently with Meta)                                                                                    |                                               |
| Samarth Singh                                                                                                                                                                    | Spring, 2024 (expected)                       |
| Topic: Machine learning for video activity recognition                                                                                                                           |                                               |
| Tanjin Toma                                                                                                                                                                      | Spring, 2024 (expected)                       |
| Topic: Tracking of bacteria in biofilms                                                                                                                                          |                                               |
| Soumee Guha                                                                                                                                                                      | Spring, 2025 (expected)                       |
| Topic: Machine learning in video analysis                                                                                                                                        |                                               |
| Shuhan Ding                                                                                                                                                                      | Spring, 2026 (expected)                       |
| Topic: Machine learning in video analysis                                                                                                                                        |                                               |
| <b><i>M.S. Students and Thesis Title</i></b>                                                                                                                                     |                                               |
| Auapong Yaicharoen                                                                                                                                                               | <b><i>Graduation Date</i></b><br>Summer, 1995 |
| "The Anisotropic Diffusion Coefficient"<br>(Currently: Professor, KMUTT, Thailand)                                                                                               |                                               |

|                                                                                                                     |              |
|---------------------------------------------------------------------------------------------------------------------|--------------|
| Melynda Reed                                                                                                        | Summer, 1995 |
| "B-Spline Representations for Moire Fringes"                                                                        |              |
| (Currently: with Williams Communications)                                                                           |              |
| Timothy Jackson                                                                                                     | Spring, 1996 |
| "Automated Video Tracking and Inspection of Power Transmission Components"                                          |              |
| (Currently: U.S. Air Force)                                                                                         |              |
| Darren Tepe                                                                                                         | Spring, 1996 |
| "Infrared Inspection Techniques"                                                                                    |              |
| (Currently: Senior Engineer with the Federal Aviation Administration)                                               |              |
| Jerome Landis                                                                                                       | Spring, 1996 |
| "A Multispectral Algorithm for Anisotropic Diffusion"                                                               |              |
| (Currently: with Seagate, Inc.)                                                                                     |              |
| Mark Taiclet                                                                                                        | Fall, 1996   |
| "Spatially Adaptive Anisotropic Diffusion"                                                                          |              |
| (Currently: with U.S. Sprint telecommunications)                                                                    |              |
| C. Andrew Segall                                                                                                    | Fall, 1997   |
| "Construction of the Scale Aware Anisotropic Diffusion Pyramid with Application to Multi-scale Tracking"            |              |
| (Currently: Sharp USA Research)                                                                                     |              |
| Kelsey Pope                                                                                                         | Summer, 1997 |
| "Modified Gradient Mean Curvature Motion and Vector Distance Dissimilarity for Multispectral Anisotropic Diffusion" |              |
| (Currently: with Seagate, Inc.)                                                                                     |              |
| Takashi Koshimizu                                                                                                   | Summer, 1998 |
| "Watershed merging with application to remote sensing"                                                              |              |
| (Currently: engineering manager for Bayer, Inc., Japan)                                                             |              |
| Anthony Wright                                                                                                      | Fall, 1998   |
| "Multiresolution Watershed Segmentation"                                                                            |              |
| (Currently: Director of Network Planning at Solinet, Inc.)                                                          |              |
| Matthew Burton                                                                                                      | Spring, 1999 |
| "Sliding Mode Control Study for Application to Disk Drive Servo Systems"                                            |              |
| (Currently: with Rational Corp.)                                                                                    |              |
| David Cary                                                                                                          | Summer, 1999 |
| "Differential Average Equal-Size Image Compression"                                                                 |              |
| (Currently: working on GPS systems with Brunswick)                                                                  |              |
| Zhongxiu Hu                                                                                                         | Fall, 1999   |
| "Morphological Pyramid Image Registration"                                                                          |              |
| (Currently: with Motorola, Inc.)                                                                                    |              |
| Badrinarayan Ragunathan                                                                                             | Summer, 2000 |
| "Image Segmentation and Content-based Retrieval"                                                                    |              |
| <b>Winner, Graduate Research Award (Best Thesis), 2000</b>                                                          |              |
| (Currently: with Bosch Corporation.)                                                                                |              |
| Junaid Ahmed                                                                                                        | Summer, 2000 |
| "Image Segmentation for Object Based Image Compression"                                                             |              |
| (Currently: with Applied Science Fiction, Inc.)                                                                     |              |
| Kate Weber                                                                                                          | Spring, 2003 |

|                                                                                        |  |              |
|----------------------------------------------------------------------------------------|--|--------------|
| "On Connected Filters in Color Image Processing"                                       |  |              |
| (Currently: with Night Vision Laboratories)                                            |  |              |
| Michael Welser                                                                         |  | Spring, 2003 |
| "Projection Model Snakes for Tracking Using a Monte Carlo Approach"                    |  |              |
| (Currently: with Air Force Research Laboratories)                                      |  |              |
| Adam Goobic                                                                            |  | Spring, 2003 |
| "Image Registration and Stabilization for Tracking Leukocytes in the Microvasculature" |  |              |
| (Currently: with Air Force Research Laboratories)                                      |  |              |
| Sridhar Reddy                                                                          |  | Fall, 2003   |
| "Segmentation using classification and spatial constraints applied to image retrieval" |  |              |
| (Currently: with image processing start-up in CA)                                      |  |              |
| Sean Jellish                                                                           |  | Summer, 2004 |
| "Real-Time Video Detection and Tracking of Rolling Leukocytes"                         |  |              |
| (Currently: with Night Vision Laboratories)                                            |  |              |
| Robert Janiczek                                                                        |  | Fall, 2005   |
| "Automated Segmentation of Cardiac MRI"                                                |  |              |
| (Currently at GSK)                                                                     |  |              |
| John Pickard                                                                           |  | Spring, 2005 |
| "Automated MCE Perfusion Analysis"                                                     |  |              |
| (Currently with UVA Patent Foundation)                                                 |  |              |
| Bing Li                                                                                |  | Spring, 2005 |
| "Multiassignment Interactive Multiple Model for Multiple Target Tracking"              |  |              |
| (Currently with SVision, Inc.)                                                         |  |              |
| Marija Cvijetic                                                                        |  | Summer, 2007 |
| "Intravital Cell Detection"                                                            |  |              |
| (Currently with Anderson Consulting)                                                   |  |              |
| Adam Bergeron                                                                          |  | Spring, 2008 |
| "Video Tracking Using Base View Active Contours"                                       |  |              |
| (Currently with Lockheed Martin)                                                       |  |              |
| Katherine Outland (Co-advised with Barry Johnson)                                      |  | Spring, 2008 |
| "Face Detection and Tracking via Active Contours"                                      |  |              |
| (Currently with MITRE Corp.)                                                           |  |              |
| Josh Poulin                                                                            |  | Spring, 2010 |
| "Human pose tracking from monocular video"                                             |  |              |
| (Currently with Air Force Research Labs)                                               |  |              |
| Michael Landau                                                                         |  | Spring, 2011 |
| "Adaptive acceptance gate for target tracking"                                         |  |              |
| (Currently with APL, Johns Hopkins U.)                                                 |  |              |
| Kirill Orlov                                                                           |  | Spring, 2012 |
| "The missing cone problem in hyperspectral imaging"                                    |  |              |
| Clare Yang                                                                             |  | Summer, 2012 |
| "Multiscale Vector Field Convolution for Image Segmentation"                           |  |              |
| Michael Stuecheli                                                                      |  | Fall, 2013   |
| "Image analysis methods for locating geohazards"                                       |  |              |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Anoosha Papireddy                                                                                                                                                             | Summer, 2013 |
| “Image segmentation for multimodal radiography”<br>(Currently with Google)                                                                                                    |              |
| Aanchal Gupta (M.E.)                                                                                                                                                          | Fall, 2013   |
| Nazia Tabbasum                                                                                                                                                                | Summer, 2016 |
| “Speckle Removal and Change Preservation by Distance-Driven Anisotropic<br>Diffusion of Synthetic Aperture Radar Temporal Stacks”                                             |              |
| Jie Wang                                                                                                                                                                      | Spring, 2017 |
| “3D Segmentation for Super-Resolution Imaging of Bacterial Biofilms”                                                                                                          |              |
| Tiffany Ly                                                                                                                                                                    | Spring, 2017 |
| “IP on AP: Exploring Image Processing on the Automata Processor”                                                                                                              |              |
| Ruoyi Zeng (M.E.)                                                                                                                                                             | Spring, 2019 |
| Filip Sluzeski                                                                                                                                                                | Summer, 2019 |
| “Methods for Analyzing Microglial Signaling and Cortical Spreading Depression<br>Wavefronts in 2-Photon Calcium Images”<br>(Currently with Allen Institute for Brain Science) |              |

### ***Undergraduate Theses***

|                                                                                              |              |
|----------------------------------------------------------------------------------------------|--------------|
| Michael Welser                                                                               | Spring, 2002 |
| "Clutter Reducing Filters for Target Tracking"                                               |              |
| Adam Goobic                                                                                  | Spring, 2002 |
| "A Comparison of Trackers for Rolling Leukocytes <i>In Vivo</i> "                            |              |
| <b>Finalist, Undergraduate Research Design Symposium (Best Thesis)</b>                       |              |
| Conor Sibley                                                                                 | Spring, 2002 |
| "Content-based Image Retrieval"                                                              |              |
| Alexander Kepler                                                                             | Spring, 2002 |
| "Gabor Filters in Texture Recognition and Matching, for Content-based Image<br>Retrieval"    |              |
| Robert Janiczek                                                                              | Spring, 2003 |
| "Classification of Lung Ventilation in Hyperpolarized Helium-3 Magnetic<br>Resonance Images" |              |
| Aaron Domnitch                                                                               | Spring, 2003 |
| "An Image Compressor that Removes Psycho-Visual Redundancies"                                |              |
| Avneet Kang                                                                                  | Spring, 2003 |
| "Naturalness in Text-to-Speech Synthesis"                                                    |              |
| Kevin Schaal                                                                                 | Spring, 2003 |
| "A comparison of trackers on military targets"                                               |              |
| Stacey Opaska                                                                                | Spring, 2003 |
| "Developing a Directional Filtering Algorithm for Improving Image<br>Compression"            |              |
| Mark Peverill                                                                                | Spring, 2003 |
| "Tracking actin filaments in vitro"                                                          |              |
| John Hunter                                                                                  | Fall, 2003   |
| "Motion tracking for T-cells"                                                                |              |
| Xung Nham                                                                                    | Fall, 2003   |

|                                                                                               |              |
|-----------------------------------------------------------------------------------------------|--------------|
| “Compression of elevation data”                                                               |              |
| Dorothy Wang                                                                                  | Spring, 2004 |
| “Biometric identification using retinal scans”                                                |              |
| Marquita Henderson                                                                            | Spring, 2005 |
| “Cartilage volume computation for MR images”                                                  |              |
| Kirill Orlov                                                                                  | Spring, 2005 |
| “Robust Multiple Event Detection in Hyperspectral Infrared Video”                             |              |
| Marija Cvijetic                                                                               | Spring, 2006 |
| “A Graphical User Interface for Leukocyte Detection and Tracking”                             |              |
| Henry Abbot                                                                                   | Spring, 2007 |
| “dvoc: An Open Source Real-time Vocoder”                                                      |              |
| Ashley Elkin                                                                                  | Spring 2007  |
| “RFID for Mobile Nurse Station”                                                               |              |
| Edward Farley Will                                                                            | Spring, 2009 |
| “Dermagram image processing”                                                                  |              |
| Jisoon Kim                                                                                    | Spring 2009  |
| “Skin cancer imaging system”                                                                  |              |
| Lindsay Browder (Co w/ Harry Powell)                                                          | Spring 2009  |
| “Signal processing for gait analysis”                                                         |              |
| Sattyik Kundu                                                                                 | Spring 2012  |
| “Iris recognition using gray level co-occurrence matrix based features and classifier fusion” |              |
| Ashutosh Priyadarshy                                                                          | Spring 2012  |
| “Segmentation of vascular endothelial cells”                                                  |              |
| R. Ben Campbell                                                                               | Spring 2013  |
| “Matching Neurons in <i>Drosophila</i> ”                                                      |              |
| Silvio Mancone                                                                                | Fall 2013    |
| “UAVs for Viticulture Inspection”                                                             |              |
| Adam Campbell                                                                                 | Spring 2014  |
| “Image Recognition using Automata Architecture”                                               |              |
| Elizabeth Orrico                                                                              | Spring 2015  |
| “Momentum Algorithm for Quantifying Dendritic Cell Movement”                                  |              |
| <b>Winner, Undergraduate Research Design Symposium (Best Thesis)</b>                          |              |
| Caroline Crockett                                                                             | Spring 2015  |
| “Momentum Algorithm for Quantifying Dendritic Cell Movement”                                  |              |
| <b>Winner, Undergraduate Research Design Symposium (Best Thesis)</b>                          |              |
| Leo Cao                                                                                       | Spring 2016  |
| “InSAR Analysis on Culverts: Applying Remote Sensing on Infrastructure Maintenance”           |              |

### ***Visitors and Postdoctoral Fellows***

Dr. Alfredo Restrepo, Summer 1998

Current position: Associate Professor, Universidad de los Andes, Bogota,  
Colombia

Dr. Dipti Prasad Mukherjee, 1999-2000, 2001-2002, 2013

Current position: Full Professor, Indian Statistical Institute, Calcutta, India

Dr. Nilanjan Ray, Research Associate, 2003-2005, 2013

Current position: Professor, University of Alberta, Alberta, Canada

Dr. Jinshan Tang, Research Scientist, 2002-2005

Current position: Professor, George Mason University

Dr. Peter Tay, Research Associate, 2005-2006

Current position: Associate Professor, W. Carolina University

Dr. Sedat Ozer, Research Associate, 2013-2015

Current position: Research Scientist, M.I.T.

Dr. Andrea Vaccari, Research Scientist, 2014-2019

Current position: Assistant Professor, Middlebury College

Dr. Matthew Korban, Research Associate, 2022-

Dr. Felix Mo, Research Associate, 2023-

## SERVICE TO THE UNIVERSITY

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- Graduate, Leadership in Academic Matters, University of Virginia, 2021
- Senator, Faculty Senate, University of Virginia, 2018-2019
- Chair, Neural Engineering Search committee, 2016-2019
- Member, SEAS Tenure and Promotions Committee (out of cycle cases), 2018
- Member, ECE P&T Process Support Committee, 2018-2019
- Member, University Committee on Information Technology, 2018-2019
- Member, SEAS Faculty Council, 2018-2019
- Member, Diversity and Inclusion Committee, UVA, 2018-2019
- Member, UVA Fontaine Research Building Committee, 2018-2019
- Member, Neuroscience internal review committee, 2017-2019
- Member, Neuroscience Cluster hiring committee, 2017-2019
- Member, CS Peer Assessment Committee, 2016, 2017
- Member, Search Committee, ECE Department Chair, 2017
- Member, SEAS Tenure and Promotions Committee, 2013-2015
- Chair, Search Committee (two positions), ECE, 2013-2014
- Member, ECE Peer Assessment Committee, 2013
- Chair, SEAS Graduate Module implementation committee, 2011-2014
- Member, ECE Chair Search Committee, 2012
- Member, ECE Search committee (opto-electronics), 2013
- Member, ECE ASSET speaker committee, 2012-2014
- Member, SEAS strategic planning (graduate module), 2010-2011
- Member, Committee on Post-Tenure Review and Teaching Load Policy, 2010-2011
- Chair, ECE Graduate Fellowships Committee, 2009-2013
- Chair, ECE Eminent Speaker Series, 2004-2007
- Chair, ECE Graduate Recruiting Committee, 2003-2007
- Member, ECE Faculty Recruiting Committee, 2004-2007
- Member, ECE Faculty Recognition Committee, 2003-2007
- Member, Dean's Research Advisory Council, SEAS, 2003-2007
- Member, Nominations and Elections Committee, SEAS, 2003-2007
- Chair, Teaching Effectiveness Committee, SEAS, 2004-2005
- Member, SEAS Faculty Fellows, 2003-2005
- Member, Teaching Effectiveness Committee, SEAS, 2002-2004
- Speaker, SEAS New Faculty Orientation, 2003
- Mentor, Faculty-Student Mentoring Program, Office of African-American Affairs, 2001-2002
- Member, ECE Chair Search Committee, 2003
- First Year Advising, SEAS, 2004-2007
- Chair, ECE Undergraduate Planning Committee, 2001-2002
- Exhibitor, SEAS Open House, 2001, 2002, 2003
- Exhibitor, ECE Open House, 2000, 2001, 2002
- Member, hiring committee for support staff, 2003, 2004
- Member, ECE Graduate Committee, 2002-2003

- Member, STS 401/402 Committee, 2001-2004
- Member, ECE Undergraduate Committee, 2000-2002
- Member, ABET Planning Committee, 2000-2001
- Member, ECE Computer Resources Committee, 2000-2002
- Member, SEAS Student Affairs Committee, 2000-2001
- Member, Ad Hoc Committee on Teaching Loads, Spring 2001
- Chair, Graduate Programs Committee, OSU, 1998-2000
- Member, Hall of Fame Award Committee, OSU, 1998
- Member, ECEN Head Search Committee, OSU, 1997-1998
- Member, Faculty Search Committee, OSU, 1996-1997, 1998-1999, 1999-2000
- Member, Halliburton Awards Committee, OSU, 1998
- Member, Lohmann Medal Committee, OSU, 1997
- Member, ECEN Computer Committee, OSU, 1995-1997
- Member, ECEN Laboratory Development Committee, OSU, 1995-1997
- Member, Technical Advisory Committee, Center for Sensors and Sensor Technologies, OSU, 1997-2000
- Mentor, OKAMP-SEM (Oklahoma Alliance for Minority Participation in Science, Engineering and Mathematics), 1995-1997

## SERVICE TO THE PROFESSION

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### *Membership in Professional Societies*

- Institute of Electrical and Electronics Engineers (IEEE), Fellow
- Signal Processing Society of the IEEE
- Engineering in Medicine and Biology Society of the IEEE
- Virginia Neuroscience Initiative

### Editorial Work

- **Editor-in-Chief, *IEEE Transactions on Image Processing*, 2014-2018**
- Guest Editor, *IEEE Journal on Biomedical and Health Informatics*, Special Issue on Large scale video analytics for clinical decision support, 2021-2022
- Guest Editor, *IEEE Journal on Special Topics in Signal Processing*, Special Issue on Machine Learning for Medicine, 2019-2020
- Guest Editor, *IEEE Journal on Special Topics in Signal Processing*, Special Issue on Bioimaging, 2014-2015
- Associate Editor, *IEEE Transactions on Image Processing*, 1997-2003, 2007-2011, 2013- 2014

- Associate Editor, *IEEE Signal Processing Letters*, 2001-2004
- Guest Editor, Special Issue on Multimedia System Technologies for Educational Tools, *Multimedia Systems Journal*, 2005

### **IEEE (or other international) Committees**

- Member, IEEE Fellow Evaluating Committee, 2023-2024, Signal Processing Society
- Member, IEEE Fellow Evaluating Committee, 2022-2023, Engineering in Medicine and Biology Society
- Member (elected), IEEE Bioimaging and Signal Processing Technical Committee, 2019-2022
- Asilomar SS&C Conference Corporation Board of Directors, Member, 2008-
- Member, IEEE SPS Technical Directions Board (ISBI Representative), 2018-2019
- Member, IEEE Fellow Evaluating Committee, 2017-2019, Engineering in Medicine and Biology Society
- Member, IEEE Signal Processing Society Publications Board, 2015-2018
- Chair, IEEE Bioimaging and Signal Processing Technical Committee Awards Board, 2013-2014
- Member, IEEE Image, Video, and Multidimensional Signal Processing Technical Committee, 2011-2016 (re-elected in 2013)
- Member, IEEE Bioimaging and Signal Processing Technical Committee, 2011-2016 (re-elected in 2013)

### **Conference Organization and Leadership**

- North American Liaison Chair, IEEE International Conf. on Image Processing, 2019
- **General Co-Chair**, IEEE Int. Symposium on Biomedical Imaging, 2018
- Associate Editor, IEEE International Symposium on Biomedical Imaging, 2017
- Student Paper Contest Chair, Asilomar Conf. on Signals, Systems and Computers, 2017
- Student Paper Contest Chair, Asilomar Conf. on Signals, Systems and Computers, 2016
- Special Sessions Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2016
- North American Liaison, IEEE International Conf. on Image Processing, 2019
- Awards Chair, IEEE GlobalSIP, 2015
- SPS Liaison to ISBI, 2013-
- Technical Area Chair, IEEE International Conf. on Image Processing, 2013
- Program Committee, 2013 Computational Imaging Conference
- Publicity Chair, 2013 IEEE International Symposium on Biomedical Imaging
- Technical Area Chair, IEEE International Conf. on Image Processing, 2011
- Technical Area Chair, IEEE International Symposium on Biomedical Imaging, 2011
- **General Co-Chair**, 2010 IEEE SW Symposium on Image Analysis and Interpretation

- Vice Technical Chair, 43<sup>rd</sup> Asilomar Conf. on Signals, Systems and Computers, 2009
- Finance Chair, 2009 IEEE International Symposium on Biomedical Imaging
- Technical Area Chair, 42<sup>nd</sup> Asilomar Conf. on Signals, Systems and Computers, 2008 (in charge of organizing six sessions in the Biomedical Signal & Image processing area)
- **Program Co-Chair**, 2008 IEEE Southwest Symposium on Image Understanding and Interpretation
- Technical Area Chair, IEEE International Conf. on Image Processing, 2009
- Technical Area Chair, IEEE International Conf. on Image Processing, 2008
- Special Sessions Chair, IEEE International Conf. on Image Processing, 2007
- **General Chair**, 40<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers, 2006
- **Technical Program Chair**, 38<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers, 2004
- Student Paper Contest Chair, 37<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers, 2003
- Track Chair, 45<sup>th</sup> Midwest Symposium on Circuits and Systems, 2002 (in charge of organizing five sessions in the image processing area)
- Technical Area Chair, 35<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers, 2001 (in charge of organizing nine sessions in the signal & image processing area)
- Technical Area Chair, 34<sup>th</sup> Asilomar Conf. on Signals, Systems and Computers, 2000 (in charge of organizing eight sessions in the signal & image processing area)
- **Program Co-Chair**, 1996 IEEE SW Symposium on Image Understanding and Interpretation

### **Conference Committees**

- Member of Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 2020
- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2018
- Member of Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 2018
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2017
- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2017
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2016
- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2016
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2015
- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2015

- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2014
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2014
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2014
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2011
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2011
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2013
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2013
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2010
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2010
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2010
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2009
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2009
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2008
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2007
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2008
- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2007
- Member of Review Board, Medical Image Computing and Computer-Assisted Intervention, 2007
- Member of Review Board, IEEE International Symposium on Biomedical Imaging, 2007
- Member of Program Committee, International Conference on Advances in Pattern Recognition, 2007
- Member of Technical Program Committee, Workshop on Microscopic Image Analysis with Applications in Biology, 2006
- Member of Technical Program Committee, Workshop on Orthopedic Image Analysis with Applications in Biology, 2006
- Member of Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 2006
- Member of Review Board, IEEE International Symposium on Biomedical Imaging,

2006

- Member of Review Board, IEEE International Conference on Acoustics, Speech and Signal Processing, 2006
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2005
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2004
- Member of Program Committee, SIAM Imaging Science, 2004
- Member of Program Committee, Conf. on Computer Vision, Graphics and Image Processing, 2004
- Member, Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 2004
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2003
- Member of Advisory Committee, ICAPR, 2003
- Member, Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 2002
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2002
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 2001
- Member, ACIVS 2001 Program Committee
- Member, Referee Board, International Conference on Pattern Recognition, 2000
- Member, Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 2000
- Member of Review Board, IEEE International Conf. on Image Processing, 1999
- Member of the Advisory Committee, International Conference on Advances in Pattern Recognition and Digital Techniques, ICAPRDT '99
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 1998
- Member, Technical Program Committee, IEEE SW Symposium on Image Understanding and Interpretation, 1998
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 1997
- Member, Organizing Committee, IEEE SW Symposium on Image Understanding and Interpretation, 1995-1998
- Member of Technical Program Committee, IEEE International Conf. on Image Processing, 1994

### **Conference Session Chair**

- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2020
- Session Chair, IEEE International Conf. on Image Processing, 2019
- Session Chair, IEEE International Conf. on Image Processing, 2018

- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2018
- Session Chair, IEEE International Conf. on Image Processing, 2017
- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2017
- Session Chair, IEEE International Conf. on Image Processing, 2016
- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2016
- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2015
- Session Chair, IEEE International Conf. on Image Processing, 2015
- Session Chair, IEEE International Conf. on Image Processing, 2014
- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2014
- Session Chair, IEEE International Conf. on Acoustics, Speech and Signal Processing, 2014
- Session Chair, IEEE CAMSAP, 2014
- Session Chair, IEEE International Conf. on Image Processing, 2013
- Session Chair, Asilomar Conference on Signals, Systems and Computers, 2013
- Session Chair, Asilomar Conference on Signals, Systems and Computers, 2012
- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2012
- Session Chair, IEEE International Conf. on Image Processing, 2012
- Session Chair, Asilomar Conference on Signals, Systems and Computers, 2011
- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2011
- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2010.
- Session Chair, Asilomar Conference on Signals, Systems and Computers, 2010
- Session Chair, IEEE International Conf. on Image Processing, 2009
- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2009
- Session Chair, Asilomar Conference on Signals, Systems and Computers, 2007
- Session Chair, IEEE International Conf. on Image Processing, 2007
- Session Chair, IEEE Int. Symposium on Biomedical Imaging, 2007
- Session Chair, IEEE International Conf. on Image Processing, 2006
- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2006.
- Session Chair, IEEE International Conf. on Image Processing, 2005
- Session Chair, Asilomar Conference on Signals, Systems and Computers, 2005
- Session Chair, Computer Based Medical Systems, NIH, 2004
- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2004.
- Session Chair, IEEE International Conf. on Image Processing, 2003
- Session Chair, IEEE International Conf. on Image Processing, 2002
- Session Chair, IEEE Southwest Symposium on Image Understanding and Interpretation, 2002.
- Session Chair, IEEE International Conf. on Image Processing, 2001
- Session Chair, IEEE International Conf. on Image Processing, 2000

- Session Chair, IEEE International Conf. on Acoustics, Speech and Signal Processing, 2000
- Session Chair, IEEE International Conf. on Image Processing, 1999
- Session Chair, International Conference on Advances in Pattern Recognition and Digital Techniques, ICAPRDT '99, Calcutta, India
- Session Chair, IEEE International Conf. on Acoustics, Speech and Signal Processing, 1999
- Session Chair, IEEE International Conf. on Image Processing, 1998
- Session Chair, IEEE International Conf. on Image Processing, 1994

### **Service at the National Science Foundation**

- Acting Deputy Division Director, Computing and Communication Foundations, 2021-2022
- Program Director, Communication and Information Foundations (within CISE-CCF), 2019-2022
- Program Director, Smart and Connected Health, 2019-2022
- Program Director, National Robotics Initiative, 2019-2020
- Program Director, Foundational Research in Robotics, 2020-2022
- Program Director, Artificial Intelligence Institutes, 2020-2022
- Member, Committee on Pandemic Predictive Intelligence, 2020-2022
- Member, CISE Committee on Diversity in Panels, 2020-2022
- Member, Working Group on Large Proposals, 2021-2022
- Member, Tiger Team on Hybrid Panels, 2021

### **Proposal Review**

- Proposal Reviewer, Engineering in Medicine, 2018, 2019
- Proposal Reviewer, Center for Innovative Technology (state of Virginia), 2018
- Panelist, Portuguese National Science Foundation, 2015, 2017
- Technical Proposal Evaluator for the Army Research Office, 1996- (served every year since 1996)
- Proposal Reviewer, Hobby Foundation, 2017
- Member (ad hoc), NIH Study Section
  - Enabling Bioanalytical and Imaging Technology, 2015
  - Microscopic Imaging, 2004-2008, 2010-2012
  - Immunology, 2005-2006
  - Bioengineering Research Partnerships, 2006-2007
- Panelist, NSF SBIR Review, 2006, 2007
- Proposal Reviewer, Michigan Technology Corridor, 2004, 2005, 2006
- Proposal Reviewer, Nebraska EPSCoR competition, 2005
- Proposal Reviewer, Tennessee DEPSCoR competition, 2005, 2006, 2007
- Panelist, NSF, 1997-2000, 2002, 2023
- Proposal Reviewer, Netherlands Organization for Scientific Research, 2002
- Proposal Reviewer, U.S. Civilian Research and Development Foundation (CRDF), 2001