UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NETFLIX, INC.,
Petitioner,

v.

AVAGO TECHNOLOGIES INTERNATIONAL SALES PTE. LIMITED,
Patent Owner.

Inter Partes Review No. IPR2021-00303

U.S. Patent No. 8,270,992 B2

DECLARATION OF GHASSAN ALREGIB

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I. BACKGROUND AND QUALIFICATIONS

1. I am qualified by education and experience to testify as an expert in the field of digital image and video processing, including data compression, encoding, decoding, and transmission. Attached as Exhibit 1 is a copy of my curriculum vitae detailing my experience and education. Additionally, I provide the following overview of my background related to my expert testimony.

2. I am a Professor at the School of Electrical and Computer Engineering at the Georgia Institute of Technology, where I am also the Director of the Center for Energy and Geo Processing and a faculty member of the Center for Signal and Information Processing. I have studied and practiced in the fields of electrical and computer engineering, and computer science generally, for close to 30 years, and have been a professor of electrical and computer engineering since earning my Ph.D. in 2003 from the Georgia Institute of Technology. I earned a bachelor's degree in electrical engineering in 1997 and a Master of Science degree in electrical engineering in 1998, both from King Fahd University of Petroleum and Minerals in Dhahran, Saudi Arabia.

3. Throughout my time as a professor, I developed and introduced three new courses titled "Multidimensional, Image, and Video Processing," "Fundamentals of Multimedia Systems," and "Fundamentals of Machine Learning," as well as a Digital Signal Processing Certificate Program. Among other things,

these courses and programs taught theoretical foundations and practical algorithms for multimedia compression, processing, communications, and analysis.

4. I am a Senior Member of the IEEE and was a voted member of the SPS Technical Committees on Multimedia Signal Processing (MMSP) from 2015-2017 and 2018-2020 and Image, Video, and Multidimensional Signal Processing (IVMSP), from 2015-2017 and 2018-2020. Additionally, I am a member of the Editorial Board of the *IEEE Transactions on Image Processing* (TIP) (from 2017-present), and I was an editor of the *IEEE Transaction on Circuits and Systems for Video Technology* from 2014-2016. I have also served as a co-chair of the Technical Program for the *IEEE International Image Processing* in 2021 and the *IEEE GlobalSIP* in 2016. I served in various capacities at the *IEEE International Conference on Multimedia and Expo* (ICME) and the *IEEE International Conference on Image Processing* (ICIP) over several years.

5. I also serve on the Editorial Board for the *Elsevier Journal Signal Processing: Image Communications* (2014-present) and served on the editorial board for the *Wireless Networks Journal* from 2009-2016.

6. Moreover, I have authored and co-authored over 230 technical publications in international journals and conference proceedings, focusing on the fields of multimedia data processing, communications, and analysis; and am the named inventor of 9 U.S. patents in related fields.

II. UNDERSTANDING OF THE LAW

A. Anticipation

7. I understand that to be valid, a patent claim must be non-obvious and novel. I also understand that a patent claim is not novel if it is anticipated by a single prior art reference – that is, a single prior art reference discloses each and every element of the claim either expressly or inherently. I also understand that a single reference cannot merely disclose each element of a claim to be found to anticipate. Rather, it must disclose all the elements as arranged in the claim.

8. I further understand that for a reference to "inherently" disclose something, the missing descriptive matter must necessarily be present in the reference, not merely probably or possibly present, and that it would be so recognized by a person of ordinary skill.

9. I understand that if an element of the claim is not disclosed by a prior art reference, then the claim is not anticipated by that reference.

10. I have been informed that a prior art reference that anticipates must enable one of ordinary skill in the art to make the claimed invention. The enablement cannot require undue experimentation.

B. Obviousness

11. I understand that to find a patent invalid for obviousness, the Petitioner must prove that the differences between the claimed invention and the prior art taken

as a whole would have been obvious to one of ordinary skill in the art at the time the invention was made.

12. I have been informed that to render a claim obvious, a combination of prior art references must disclose each and every claim element of that claim, and that obviousness is a question of law (*i.e.*, for the ALJ to determine) based on the underlying facts. I understand that the underlying factual inquiries are: (1) the scope and content of the prior art, (2) the differences between the prior art and the claims at issue, (3) the level of ordinary skill in the pertinent art, and (4) secondary considerations of nonobviousness.

13. I am also informed that the fact that all the elements of a claimed invention can be found separately in more than one prior art reference is not sufficient to warrant a finding that a claimed invention is obvious. There must be a reason why it would have been obvious to modify or combine the prior art to arrive at the claimed invention. I understand that a helpful insight into this determination is whether there is a teaching, suggestion or motivation in the prior art that would lead one of ordinary skill in the art to combine the elements. When there is no suggestion for the proposed combination, or when the prior art suggests something other than the combination, a finding of obviousness is generally not warranted.

14. I understand that the prior art must be considered in its entirety, including disclosures that teach away from the claimed invention. Furthermore, if a

proposed modification to a prior art reference would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification.

15. I am also informed that to render a claim obvious there must be a finding that a skilled artisan would have had a reasonable expectation of success in combining the teachings of the prior art references to achieve the claimed invention.

16. I understand that the pertinent obviousness inquiry takes place at the time of the invention. Therefore, the use of hindsight in an obviousness analysis is impermissible.

17. I further understand that, in deciding as to whether the claimed invention would have been obvious to a person of ordinary skill in the art ("POSITA"), the fact finder must consider certain objective factors, such as commercial success, long-felt, but unsolved need, unexpected results, copying, and praise by others in the field. The presence of such factors – known as "secondary considerations" – is evidence of nonobviousness. I also understand that a connection, or nexus, must exist between the secondary consideration and the claimed invention.

C. Claim Construction

18. I understand that in *inter partes* review, claims are given their "ordinary and customary meaning" which is the meaning that the term would have, in view of

the specification, to a person of ordinary skill in the art in question at the time of the invention. I have applied this standard in my analysis of the Challenged Claims, except where I have expressly stated otherwise.

19. I have been told that the "construction cannot be divorced from the specification and the record evidence" and that the construction must be reasonable in light of the claims and specification.

20. I have been told that the principle of antecedent basis means that, absent indications to the contrary, subsequent uses of a claim term should be understood to refer to the first use of that claim term. For example, if a patent claim recites "an item" and then later recites "the item" or "said item," those subsequent uses generally refer to the same item initially recited.

21. I understand that a patent claim requires an ordering of steps when the claim language, as a matter of logic or grammar, requires that the steps be performed in the order written. I understand that a claim also requires steps to be performed in the order written if the specification directly or implicitly requires an order of steps.

III. PERSON OF ORDINARY SKILL IN THE ART

22. In my opinion, a POSITA at the time of the invention of U.S. Patent No. 8,270,992 (the "'992 Patent" or "Karaoguz") would have had a bachelor's degree in Electrical Engineering, Computer Engineering, Computer Science, or a similar discipline, with one to two years of experience in this or a related field or would

have had a master's degree in Computer Engineering, Electrical Engineering, Computer Science, or a similar field. The POSITA would also have been familiar with digital media encoding and transport generally. I note that Dr. Myler employs a similar definition of a POSITA, although he describes a number of additional skills a POSITA would have to have possessed. *See* Ex. 1003 (Myler Decl.), ¶¶ 31-33. I view any differences in our definitions as insubstantial, and my analysis here is not affected by which definition is employed by the Board.

IV. OVERVIEW OF THE '992 PATENT

A. Disclosure

23. The '992 Patent was filed on July 18, 2011, and is entitled "Automatic Quality of Service Based Resource Allocation." Ex. 1001 ('992 Patent) at 1. It claims priority, through a series of continuation applications, to an original utility application filed June 24, 2004, and a provisional application filed September 23, 2003. *See id.* The claims of the '992 Patent generally are directed to a portable system and a method for providing digital media service to a user.

24. The quality of a digital media service in the early 2000s was limited by various constraints. The title of the '992 Patent aptly suggests that a solution to overcome some of these constraints is through "automatic quality of service based resource allocation." *Id*. As the Challenged Claims recite, and the description explains in detail, the '992 Patent teaches the delivery of a digital media content to a

user using a portable system and a second system (*e.g.*, a personal computer ("PC") or a server).

25. As the Challenged Claims recite, the portable system first delivers digital media content to a user at a particular (current) quality level. *See id.* at 26:31-32 (Claim 1). The portable system then determines if it can deliver the same media content at a higher quality level to the user using a second system (which, as noted above, can be a PC, server, etc. connected to the portable device via a network connection); this determination process involves determining that (1) the second system has the digital media content that can be provided to the user at a higher quality level than the current quality level and (2) a network connection between the portable system and the second system is available and has enough bandwidth to provide the digital media at the higher quality level. *See id.* at 26:33-37 (Claim 1). Once this determination has been made, the portable system uses the network connection with the second system to obtain the digital media at the higher quality level. *See id.* at 26:38-40 (Claim 1). Finally, according to the claimed invention, the portable system delivers the digital media at the higher quality level to the user. *See id.* at 26:41-43 (Claim 1).

26. Based on my review, I believe that Fig. 5 of the '992 Patent provides a nice overview of the system components of an exemplary embodiment covered by the Challenged Claims. I have reproduced that figure below.

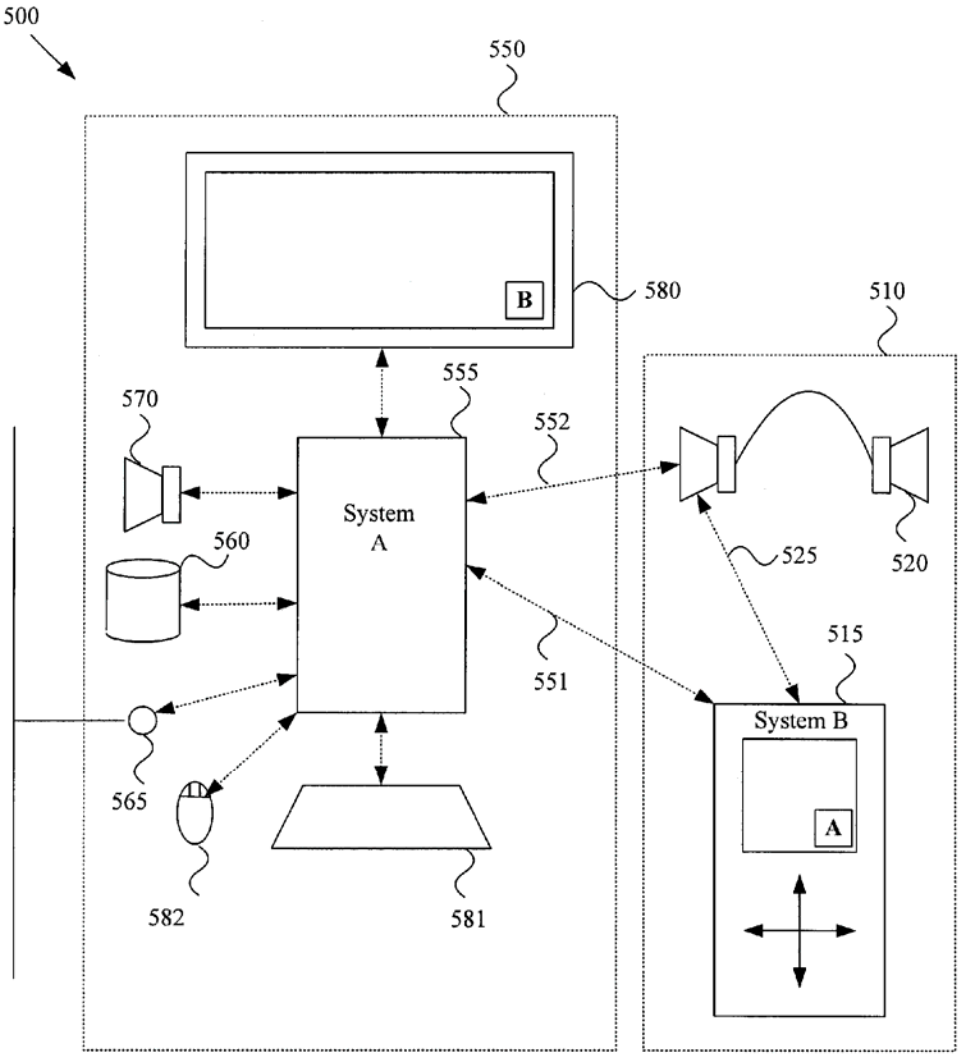

Figure 5

Ex. 1001, Fig. 5.

27. The '992 Patent teaches that the portable system in Fig. 5 (System B 515) provides a digital media service to the user, and the '992 Patent defines a service

in this way: "A 'service' is generally a function performed by the first system [the portable system] for the ultimate benefit of the user." *Id.* at 3:16-18. The '992 Patent also teaches that a portable system often has hardware constraints, which a POSITA would recognize are generally a function of the compromise between cost, size, and functionality inherent to a small system. Examples of such constraints can include, but are not limited to storage capacity, processing capability, communication capability, software applications, information presentation and display limitations, and access to information, and these constraints can limit the quality of digital media service that the portable system can deliver to the user. *See*, *e.g.*, *id.* at 7:16-29, 11:32-54, 12:15-49.

28. A good example of such a constraint is storage capacity. The '992 Patent discloses that the portable system "may have decided to store MP3 information in the PDA . . . memory in a highly compressed state, thereby trading audio quality for the ability to store more music." *Id*. at 4:55-58. A POSITA would understand, especially at the time of invention, that storage capacity in portable devices is often at a premium. In order to store more media (such as music), users would often highly compress that media (using a CODEC such as MP3, for example). A POSITA would understand that such compression represents a compromise between quality (*e.g.*, fidelity to the original recording) and file size. To illustrate, the table below shows exemplary file sizes I have calculated for a five-

minute stereo audio track sampled at 44.1 kHz (16-bit quantization) and encoded in different formats:

Encoding Format	File Size
WAV (CD-audio) (lossless)	50.4 MB
MP3, 320 kbps	11.4 MB
MP3, 192 kbps	6.86 MB
MP3, 128 kbps	4.57 MB

As the table above illustrates, the lossy, compressed MP3 files are significantly smaller than the lossless WAV file. At higher compression rates (*i.e.*, lower bitrates), the file sizes are correspondingly smaller, but the quality of the audio is compromised as well. For example, many people consider the audio of a 320 kbps MP3 file to be indistinguishable by the human ear from the lossless (WAV) audio file for most content, but most would agree that there are audible quality differences between a 128 kbps MP3 file and a WAV file. Similar compromises apply to the compression of photos and video files as well. Codecs such as MP3, JPEG, and MPEG are primarily lossy compression codecs. The encoder will produce a file size smaller than the original uncompressed file size but with loss of information that results in a degraded quality compared to the original file. Thus, in order to store more media (*e.g.*, songs or videos) on a device with a given limited capacity, files are often compressed significantly, resulting in a detectable loss of quality of the media. *See id.* at 4:51-60.

29. This compromise will allow a user to have more media content available, whether or not connected to a network or the Internet, at the cost of lower quality of the media. The '992 Patent provides an inventive solution to mitigate that compromise. Specifically, the '992 Patent teaches that, when the portable device has connectivity with a second system (for example, the desktop computing system 555 of Fig. 5), the portable system might be able to access higher quality versions of the media content stored on the portable device, such as CD-quality WAV audio, rather than the MP3 audio stored on the portable device. *See id.* at 6:43-44. This access can allow the portable system to improve the quality of the digital media content provided to the user, for example, by providing a CD-quality version of a song streamed from the second system, rather than the highly compressed MP3 version of the song locally stored on the portable device.

30. Thus, the '992 Patent teaches that the same media content (*e.g.*, the same video file or audio file) can have different quality levels. *See id.* at 6:40-49. To the extent that Dr. Myler believes that "the same song" with "different quality" and "different encoding" is "not the same digital media content" (Ex. 2003 (Myler Dep. Tr.) at 223:14-224:13), within the context of the '992 Patent, I disagree. I believe that the disclosure of the '992 Patent is clear in this regard:

> Referring to the exemplary scenario 500 illustrated in FIG. 5, the PDA 515 may have access to a local memory device having MP3 audio information encoded at 64 Kbps encoding, while the desktop

> computing system 555 may have access to CD-quality music information stored in a local memory device 560 or through a network 565. The first 510 or second 550 systems may consider such information access when determining whether utilizing resources of the second system 550 will provide the current service to the user at a higher level of quality.

Ex. 1001 at 6:40-49. As I will discuss in further detail below, the Challenged Claims specify that providing a digital media service to a user comprises delivering digital media content to a user, and I read the paragraph of the '992 Patent quoted above to mean that MP3 audio information stored locally and the CD-quality music information available from the desktop system are the same digital media content, but at different quality levels. I believe that this is the only reasonable way a POSITA could read the disclosure of the '992 Patent.

31. The '992 Patent further teaches that, if a higher quality version of digital media content is available on the second system (*e.g.*, the desktop 555 of Fig. 5), the portable device and the second system communicate to determine whether the higher quality digital media content can be obtained from the second system and delivered to the user from the portable device 115, as shown in Fig. 5 above. *See id.* at 5:18-6:30. In particular, the '992 Patent teaches these two systems exchange various information including information concerning relative processing and communication capabilities. *See id.* For example, "the PDA 515 and the desktop

computing station 555 may communicate information of audio decoding capability" (*id*. at 5:26-27), and "the PDA 515 and desktop computing system 555 may communicate information of communication capability." *Id*. at 5:18-20, 5:44-45; *see generally id*. at 5:18-52. As part of this determination, the sufficiency of the network connection between the two systems is evaluated, because "access to high quality information over a communication network may be of little value in certain scenarios if the communication network is slow or unreliable." *Id.* at 6:27-30.

32. As an example of how this determination can be made, the '992 Patent provides Fig. 4, which is "a diagram showing a system 400 that implements quality of service based resource allocation and utilization in a dynamic wireless network environment." *Id.* at 21:8-10.

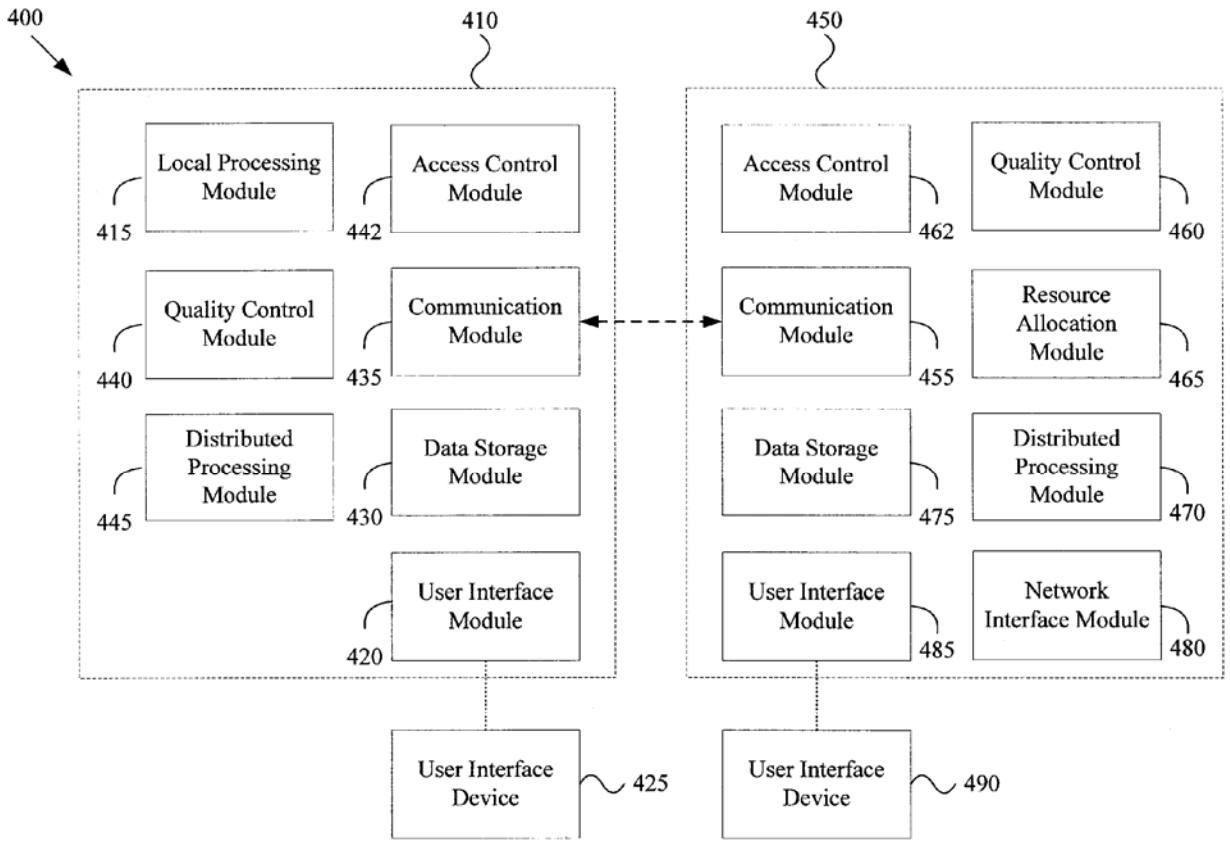

Figure 4

Ex. 1001, Fig. 4. This "resource allocation and utilization" can include, as discussed above, the determination of whether the portable device (*e.g.*, PDA 515) will obtain the higher quality digital media content from the second system (*e.g.*, desktop 555) to deliver to the user.

33. Regarding Fig. 4, the '992 Patent teaches that the quality control module (440) of the portable system (410) and the quality control module (460) of the second system (450) may determine whether utilizing resources from the second

system will increase the quality at which the current service is being provided to the user. *See id.* at 24:4-19. As I read the '992 Patent, higher quality digital media content is one aspect of higher quality service, but it is not the only aspect. For example, higher bitrate or file size certainly can indicate higher quality digital media content, but this higher quality digital media content does not automatically equate to a higher quality service level for the user. Instead, as I will explain in detail below, other quality metrics and constraints are also important, including audio/video output quality, response to user input, and the number of information consumption options available to a user. *See id.* at 22:16-23.

34. Some of these factors are characteristics of the portable device and can determine whether the device can actually process, deliver and/or present this higher quality digital media content to the user to result in a higher quality media service. For example, if a device has only two speakers and is delivering stereo audio to the user, it would be unhelpful for the system to expend resources to download audio in 7.1 surround sound format (with seven audio channels, plus the LFE (subwoofer) channel). Even though that content is higher quality, and even if sufficient bandwidth were available to obtain that higher quality content, the device would be able to use only two of the eight audio channels, so the delivered quality of the media service would not be improved over stereo audio. Similarly, on a portable device capable of displaying only standard definition (SD) video, there would be no point

to obtaining higher quality content high definition (HD) video, even if there were sufficient bandwidth and the content were available, because that higher quality content again could not be delivered to the user, due to device limitations, and the quality of the media service would not increase.

B. The Challenged Claims

35. I have been informed that the Challenged Claims include four independent claims: Claims 1, 6, 11, and 16 and that the remaining Challenged Claims depend on one of these four independent claims. Specifically, Claims 2-5 depend from Claim 1; Claims 7-10 depend from Claim 6; Claims 13-14 depend from Claim 11; and Claims 17-19 depend from Claim 16. I have analyzed each of these Challenged Claims with a view toward the teachings of the '992 Patent, as I discuss above, and the knowledge of a POSITA at the time of filing.

36. Claim 1 is directed to a method for providing a digital media service to a user, and Claim 6 is directed to a system that is configured to perform that method. I have reproduced Claim 1 below:

> 1. In a portable system, a method for providing a digital media service to a user, the method comprising:
>
> delivering digital media content having a current quality level to a user;
>
> determining that a network connection with a second system is available and is characterized by a communication bandwidth

that is high enough to provide the digital media content to the user at a quality level higher than the current quality level;

using the network connection to obtain the digital media content at the higher quality level from the second system; and

delivering the digital media content at the higher quality level to the user instead of the digital media content at the current quality level.

Ex. 1001 at 26:29-43.

37. To better understand the interrelationship between the various elements of Claim 1, I have annotated the following chart to highlight the individual phrases used in each limitation.

Preamble [1a]	In a portable system, a method for providing a digital media service to a user, the method comprising:
First Delivering Limitation [1b]	**delivering** digital media content having a current quality level to a user;
Determining Limitation [1c]	**determining** that a network connection with a second system is available and is characterized by a communication bandwidth that is high enough to provide the digital media content to the user at a quality level higher than the current quality level;

Using Limitation [1d]	**using** the network connection to obtain the digital media content at the higher quality level from the second system; and
Second Delivering Limitation [1d]	**delivering** the digital media content at the higher quality level to the user instead of the digital media content at the current quality level.

Id. (annotated) (emphasis added). For ease of reference, the above chart includes the Petitioner's claim annotations [1a] – [1d], a practice I will continue throughout this document. I do note the Petitioner includes both the Using Limitation and the Second Delivering Limitation within limitation [1d]. *See* Pet. at 24-25. To the extent Petitioner believes these two limitations to be a single limitation, I disagree.

38. Claim 11 is directed to a method and Claim 16 is directed to a corresponding system. I have reproduced Claim 11 below:

> 11. In a portable system, a method for providing a digital media service to a user, the method comprising:
>
> delivering digital media content having a current quality level to a user;
>
> communicating with a second system regarding communication bandwidth of a network connection with the second system;
>
> determining, based at least in part on said communicating, that the network connection

is available and characterized by at least a minimum determined communication bandwidth;

in response to at least said determining, utilizing the network connection to receive the digital media content at a quality level higher than the current quality level; and

delivering the digital media content at the higher quality level to the user instead of the digital media content at the current quality level.

Ex. 1001 at 27:21-37.

39. As shown below, Claim 11 has elements similar to those of Claim 1:

Preamble [11a]	In a portable system, a method for providing a digital media service to a user, the method comprising:
First Delivering Limitation [11b]	**delivering** digital media content having a current quality level to a user;
Communicating Limitation [11c]	**communicating** with a second system regarding communication bandwidth of a network connection with the second system;
Determining Limitation [11d]	**determining**, based at least in part on said communicating, that the network connection is available and characterized by at least a minimum determined communication bandwidth;

Utilizing Limitation [11e]	in response to at least said determining, **utilizing** the network connection to receive the digital media content at a quality level higher than the current quality level; and
Second Delivering Limitation [11e]	**delivering** the digital media content at the higher quality level to the user instead of the digital media content at the current quality level.

Id. at 27:21-38 (annotated) (emphasis added). As with Claim 1, above, I have adopted Petitioner's claim annotations [11a] – [11e]. Again, I note that the Petitioner includes both the Utilizing Limitation and the Second Delivering Limitation within limitation [11e]. *See* Pet. at 42-43. To the extent the Petitioner intends to indicate that these two limitations are a single limitation, I disagree.

40. As shown in the two tables above, each of the independent Challenged Claims includes the following elements:

i) a portable system and a second system;

ii) a digital media service;

iii) a user;

iv) digital media content with a current quality level and a quality level higher; and

v) a network connection with a communication bandwidth that is high enough / a minimum determined communication bandwidth.

41. My understanding is that, under the principle of antecedent basis, each element of each claim limitation is defined the first time it is cited in the claim (*e.g.*, "digital media content" and "a current quality level"). Thereafter, each time such elements are mentioned subsequently, those elements refer to the earlier defined elements using the term "the" (*e.g.*, "**the** digital media content" and "**the** current quality level"). *Id*. (emphasis added). This antecedent basis is reflected in the highlighting of Claims 1 and 11 in the tables above.

C. Prosecution History

42. It is also my understanding that positions and amendments made by the applicant for the '992 Patent during examination (i.e., the "prosecution history") can provide insight to the meaning of terms used in the claims. Accordingly, I have analyzed the prosecution history of the '992 Patent. In particular, I note the Applicant amended the Challenged Claims to make clear that the terms, "a current quality level" and "a quality level higher," refer specifically to the digital media **content** and not to the digital media **service** generally. *See* Ex. 1002 (File Hist.) at 43.

43. In particular, the Applicant amended Claim 38 as follows:

38. (Currently Amended) In a portable system, a method for providing a digital media service to a user, the method comprising:

~~providing a~~ delivering digital media content having a current quality level ~~service~~ to a user ~~at a current quality level~~;

determining that a network connection with a second system is available and is characterized by a communication bandwidth that is high enough to provide the digital media ~~service~~ content to the user at a quality level higher than the current quality level; ~~and~~

~~in response to at least said determining, utilizing the network connection to provide the digital media service to the user at a quality level higher than the current quality level.~~

using the network connection to obtain the digital media content at the higher quality level from the second system; and

delivering the digital media content at the higher quality level to the user instead of the digital media content at the current quality level.

Id. (I note that Claim 38 was renumbered as Claim 1 before the '992 Patent was granted.)

44. As shown by the markup above, the Applicant amended Claim 38 to replace "providing a digital media **service** to a user at a current quality level" with "delivering digital media **content** having a current quality level to a user" in the Delivering Limitation. The amendments also replaced "**service**" with "**content**" in the Determining Limitation. *Id.* (emphasis added). The Applicant similarly

amended Claim 48, which was renumbered as Claim 11. *See id.* at 46. Based on these amendments, I believe a POSITA would understand the terms "a current quality level" and "a quality level higher" refer specifically to the digital media **content**, not merely the digital media service.

45. As I note below, I believe that Petitioner focuses unduly on the networking aspects of the Challenged Claims. While it is true that the Challenged Claims require "a network connection" in providing the "digital media service," this network connection need only have "a communication bandwidth that is high enough" (Claims 1, 6) or "a minimum determined communication bandwidth" (Claims 11, 16) to obtain/receive the digital media content at the higher quality level. *See* Ex. 1001 at 26:29-43, 27:21-37. Based on my understanding of the Challenged Claims, and I believe a POSITA would agree, the provision of higher quality digital media content is the goal of the claims. Therefore, the Challenged Claims improve the overall quality of the digital media service to a user on a portable system by obtaining higher quality digital media content from a second system using a network connection that has a "high enough" or "minimum" bandwidth to obtain this higher quality content and delivering the digital media content at the higher quality level to the user. Other than providing sufficient bandwidth for the higher quality digital media content, the networking aspect of the claims is not of paramount importance.

46. One basis for my opinion is that the Applicant specifically relied on the distinction between digital media content and digital media service when traversing the Examiner's initial rejection of the Challenged Claims. In its March 16, 2012 Response, the Applicant argued that the prior art reference (Jagadeesan), cited by the Examiner, disclosed improving a digital media service by improving the communication "link quality" – not the quality of the digital media content. Specifically, the Applicant argued:

> However, though Jagadeesan may disclose a mobile station switching between communication links based on **link quality**, the source of the **content** transmitted across the communication links (i.e., the voice data) remains the same. Indeed, Jagadeesan specifically states '[a] handoff of the existing call may occur' if the **link quality of a second communication link is greater than the link quality of the communication link currently used by the mobile station**. (Jagadeesan, paragraph [0035], Emphasis added). That is, in Jagadeesan, prior to transmission by either the WLAN or the cellular network, the **voice data is the same**. And as a whole, Jagadeesan fails to disclose or suggest obtaining voice data from another source, **let alone obtaining digital media content at a higher quality level from the second system, as recited in claim 38**.

Ex. 1002 at 50 (emphasis added). The Applicant likewise distinguished a secondary reference (Kayama), arguing that "Kayama, like Jagadeesan, relates to selection of a communication medium, and fails to disclose, teach, or suggest **obtaining digital**

media content at a higher quality level from the second system, as recited in claim 38". *Id.* (emphasis added).

47. I note that these amendments, and the accompanying arguments, formed the basis for the Examiner's Reasons for Allowance: "Claims 38-57 are allowed for the reasons as set forth in applicant's response filed on 3/16/12." *Id.* at 21. On this basis, I conclude that the distinction between digital media content and digital media service is a point of novelty of the Challenged Claims.

V. Petitioner's Cited References

48. In arguing that the Challenged Claims are invalid, the Petitioner relies on the following two references:

i) U.S. Patent Publication No. 2003/0065805 to Barnes ("Barnes") (Ex. 1004); and

ii) U.S. Patent No. 7,299,291 to Shaw ("Shaw") (Ex. 1005).

While the Petitioner cites and describes other references in the Petition, the Ground of invalidity that Petitioner asserts is based exclusively on these two references.

A. Barnes

49. Barnes discloses a network-connected mobile phone or PDA (*i.e.*, device 101) that has a wide range of features relating largely to mobile commerce; most of these features are immaterial to the Challenged Claims. *See*, *e.g.*, Ex. 1004 (Barnes), ¶¶ 0035-39. In fact, Barnes is directed primarily to the use of such a device

for "providing location based services, mobile e-commerce, and other functions." *Id.*, ¶ 0003. This focus is reflected by Barnes' title: "System, method, and computer program product for providing location based services and mobile e-commerce." *Id.* at 1. It therefore does not surprise me to find little disclosure in Barnes that relates to the functionality of the Challenged Claims in any way. As noted above, the Challenged Claims are directed to improving the quality level of digital media content delivered to the user, especially within the environment of a portable system. While Barnes does deal with portable systems as well, Barnes provides virtually no disclosure of the quality of media content; indeed, to the extent Barnes discusses media content at all, that discussion is incidental to the purpose of Barnes' disclosure: network connectivity related to location-based services and electronic commerce.

50. I note, for example, that the disclosure of Barnes includes 537 numbered paragraphs, and that no more than fifteen of these paragraphs have anything to do with receiving digital media content, and only one paragraph discusses switching communication networks. *See id.*, ¶ 0074; *see also id.*, ¶¶ 0039-40, 0045-46, 0063, 0066-69, 0072-75, 0117, 0378. I note that Dr. Myler appears to be unable, as I am, to find in Barnes any disclosure related to improving the quality of digital media content delivered to a user. *See* Ex. 2003 at 115:25-117:11.

51. Notwithstanding Barnes' lack of disclosure on media content quality, Petitioner relies on Barnes' disclosure of a process to determine when to switch to a

different communication network. Pet. at 12-13. Barnes discloses several factors to consider when deciding to switch networks:

a) "[C]hanges in network conditions such as failure of a first network or the first network slowing down (due to high use such as multiple users and/or high levels of data being communicated), such as below a predetermined level (e.g., threshold speed), or increases in noise." Ex. 1004, ¶ 0074. In my view, this factor has nothing to do with media content quality, but instead concerns only network considerations. It appears that Dr. Myler agrees. *See* Ex. 2003 at 130:15-131:25.

b) "[T]he user making a request, or attempting to make the request, to communicate data that is more suitable for communication through a second network (e.g., the user requesting a video file or movie)." Ex. 1004, ¶ 0074. To me, this factor relates to a user request for new or different media content. Dr. Myler appears to agree. *See* Ex. 2003 at 132:1-19. In particular, neither this factor nor anything else in Barnes teaches anything about quality of media content, let alone the availability of media content of higher quality than the current media content or how bandwidth might be evaluated in that regard.

c) "[T]he anticipated request of the user (e.g., based on the user starting a particular application such as a video player)." Ex. 1004, ¶ 0074. In

my opinion, this factor is quite similar to factor (b) above, with the only difference being the anticipation by the device based on the opening of an application, rather than a direct request from the user. Dr. Myler appears to agree with me. *See* Ex. 2003 at 133:2-12. Once again, as with factor (b), Barnes teaches nothing with regard to media content quality in discussing this factor.

d) "[C]hanges in network availability (e.g., a new network becoming available)." Ex. 1004, ¶ 0074. Like factor (a) discussed above, this factor is concerned entirely with networking considerations and has nothing to do with the quality of media content or the availability of higher quality content. Dr. Myler appears to agree. *See* Ex. 2003 at 133:13-20.

e) "[C]hanges in conditions of the second network (e.g., more bandwidth or less noise)." Ex. 1004, ¶ 0074. Much like factors (a) and (d), this factor relates exclusively to networking considerations and has nothing to do with media content, the quality thereof, or evaluating bandwidth with regard to obtaining higher quality content. *See* Ex. 2003 at 133:21-134:14.

f) "[T]he available capacity or relative available capacity (e.g., how full to capacity a network is)." Ex. 1004, ¶ 0074. As do factors (a), (d), and

(e), this factor relates exclusively to networking considerations and has nothing to do with media content, the quality thereof, or evaluating bandwidth with regard to obtaining higher quality content. Dr. Myler agrees. *See* Ex. 2003 at 134:15-25.

g) "[T]he communication capabilities of the device." Ex. 1004, ¶ 0074. This factor also relates exclusively to networking considerations, rather than anything to do with media content, the quality thereof, or evaluating bandwidth with regard to obtaining higher quality content. Dr. Myler agrees. *See* Ex. 2003 at 135:1-25.

h) "[T]he historical (or anticipated) availability of bandwidth of network(s) (which may include, for example, use, volume, capacity, and/or speed data for days of the week or times of the day)." Ex. 1004, ¶ 0074. I find that this factor, like factors (a) and (d)-(g), relates solely to networking considerations, rather than media content, the quality thereof, or evaluating bandwidth with regard to obtaining higher quality content. Dr. Myler agrees. *See* Ex. 2003 at 136:1-137:2.

52. As this list of factors, as well as Dr. Myler's testimony, demonstrates, the majority of Barnes' "network switching conditions" relate to networking considerations (*i.e.*, conditions (a) and (d)-(h)). While conditions (b) and (c) relate to media content generally, none of these factors concern the **quality** of the digital

media **content** displayed on device 101. I note that Dr. Myler did not indicate that any of these conditions relate to switching a network connection to improve the quality of the digital media content being consumed by the user, let alone evaluating bandwidth of a network connection to determine whether higher quality content could be obtained and delivered to a user. I agree that none of them do. Indeed, I note that Dr. Myler never used the word "quality" in his entire description of Barnes' network switching conditions in connection with paragraph [0074] of Barnes. *See id.* at 130:15-137:2. Moreover, Dr. Myler also provided extensive testimony regarding paragraphs [0069]-[0073] of Barnes but never mentioned the quality of the digital media **content** provided to the user on the device. *See id*. at 119:20-129:16. Thus, I find nothing in Dr. Myler's deposition testimony to be inconsistent with my opinion that, although Barnes discloses both a portable device and the concept of switching networks, Barnes fails to provide adequate disclosure to invalidate any of the Challenged Claims, for the reasons I will discuss in further detail below.

53. More generally, as I explain below, the Petitioner identifies nothing in its cited references, including in particular, Barnes and Shaw (discussed below), that would indicate that evaluating network conditions to determine whether a particular network connection provides sufficient bandwidth (or a minimum bandwidth) to

obtain and deliver higher quality content to a user was somehow well-known or conventional at the time of invention.

B. Shaw

54. Shaw is directed to an enhancement of a client media player for finding the best server – and selectively switching servers as necessary – for a stream of digital media. *See* Ex. 1005 (Shaw) at 3:32-39. For instance, Shaw teaches, generally, "[t]he present invention relates generally to high-performance, fault-tolerant content delivery in a content delivery network (CDN)." *Id*. at 1:13-15. "A CDN is a network of geographically distributed content delivery nodes that are arranged for efficient delivery of digital content (e.g., Web content, streaming media and applications) on behalf of third party content providers." *Id*. at 2:40-43. Shaw uses the term, "stream," to mean media content transmitted over the network connection (*i.e*., the stream "received from the first server and rendered on the media player"). Ex. 2003 at 109:22-25. For the reasons discussed below, my opinion is that when Shaw refers to "a stream," and later, "the stream" (albeit from a difference source), Shaw's disclosure means the same media content and the same quality, i.e., an exact same copy of the same media content.

55. I believe it is important to understand the general technology area of Shaw's invention to provide context for my discussion of the materiality of Shaw to the Challenged Claims. Specifically, Shaw is an invention of Akamai Technologies,

Inc. ("Akamai"). Ex. 1005 at 1. As Dr. Myler described, when Akamai filed the Shaw patent, and when the invention of the '992 Patent was invented, Akamai was in the business of "provide[ing] networking content delivery services." Ex. 2003 at 22:5-19. My understanding of Akamai's business at the time is consistent with this description. Dr. Myler further explained "[i]n fact, this patent, as far as I recall – actually, throughout the patent it describes the various specific Akamai Technologies devices so they were basically patenting their CDN." *Id*. Dr. Myler agreed that Akamai's technology, including the Shaw patent, acted as a "conduit, if you will, between content – content creators and content consumers." *Id*. at 22:20-23:1. I find these characterizations to be consistent with my understanding of the technology at the time and the Shaw patent specifically.

56. To provide digital media content more effectively to consumers, Shaw discloses that a "broadcast stream 200" is received/obtained at a "CDN entry point 202" and then distributed through a series of "reflectors" 204*a-n* to regional servers 206*a-n*, which contain a series of edge nodes 208*a-n*. *See* Ex. 1005 at 5:66-6:20. FIG. 2 shows each of these elements below:

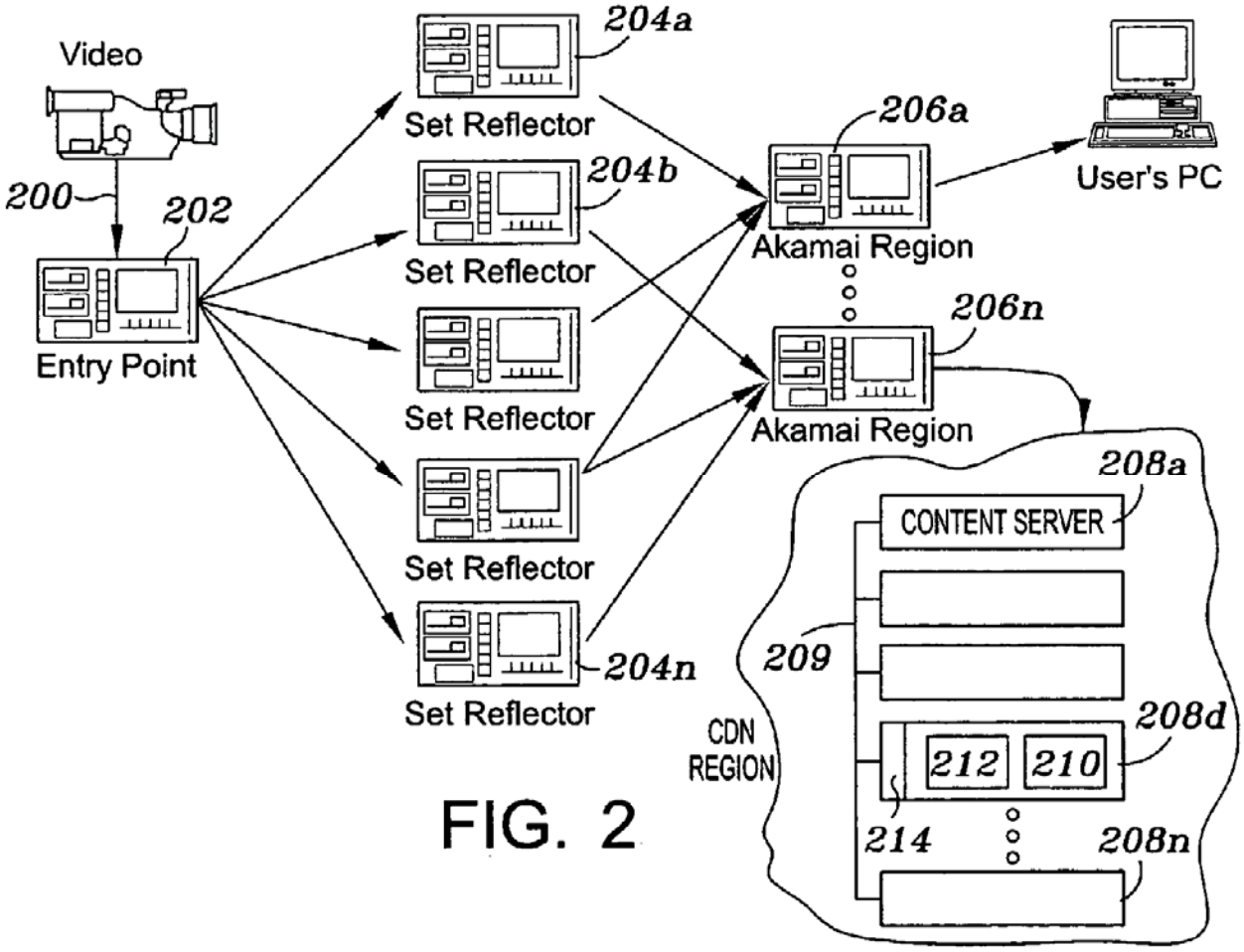

FIG. 2

Id., FIG. 2.

57. As Shaw explains, "FIG. 2 is a simplified diagram illustrating how live streaming can be further enhanced by having the CDN send multiple copies of the same stream over different routes from a CDN entry point to the optimal streaming server at the edge of the Internet." *Id*. at 4:23-26. Shaw further explains that in a traditional CDN "a single source stream can be replicated into thousands or more identical copies"). *Id*. at 2:27-37. Notably, Shaw provides no disclosure that might indicate that the "source stream" might be transcoded, re-encoded, or modified in

any way that might change the quality of the source stream, either before or after it has been "replicated." My opinion, based on the term "replicated," which I take to mean "copied exactly," in the absence of any disclosure to the contrary, is that the clear import of Shaw's teaching indicates that all the replicated streams are the same stream (*i.e.*, the same media content of the same quality level). Dr. Myler's testimony indicates that he agrees with my assessment of Shaw's teachings in this regard. *See* Ex. 2003 at 33:17-34:7.

58. Because the same content, at the same quality level, has been replicated to the various servers throughout the network, Shaw does not disclose, and in fact reasonably cannot be read by a POSITA to teach or suggest, switching networks to obtain higher quality content. Instead, Shaw teaches switching to get the same content at the same quality level on a better network connection. Shaw explains that "[t]he present invention provides a method for enabling a client player to identify a best server dynamically and, in addition, to selectively switch to that server to receive the stream or portions thereof." Ex. 1005 at 6:57-61 (emphasis added). As I noted above, when Shaw refers to receiving a stream from one server and then switching to another server to receive "the stream," Shaw teaches that the receiving device continues to receive the very same stream (*i.e.*, the same media content at the same quality level). I believe this to be true based on both the antecedent use of "a

stream" and "the stream," as well as the entirety of Shaw's disclosure, which teaches only the replication (*i.e.*, exact copying) of the same stream to different servers.

59. Shaw's teachings confirm this understanding: Shaw teaches, "[a]s appropriate, the stream switch process includes the capability to match data packets from first and second servers to enable a substantially seamless switch to the new stream source." *Id*. at 9:63-66 (emphasis added). If the two streams from different servers were somehow different, this packet matching technique would not provide a workable solution, as the streams would be highly unlikely to have matching sequences of data packets. I note here that Shaw describes the matching at a network (packet) level, not at a content level (*e.g.*, matching video frames or audio timing). To me, this indicates once again that Shaw is unconcerned with the payload (content), but rather the network transport of the stream. Dr. Myler appears to agree with my assessment that Shaw teaches that the streams from different servers are identical (packet by packet). *See* Ex. 2003 at 46:13-47:4 (emphasis added); *see also id*. at 44:15-47:4.

60. Because Shaw is unconcerned with differential quality between streams (and in fact teaches expressly, as I note above, that all the streams have the same quality), a POSITA would not understand Shaw to even suggest any sort of determination that a network connection might be able to obtain higher quality

content, let alone a determination that such higher quality content might be deliverable to a user.

61. Shaw uses FIGS. 3 and 4 to further describe its server connection and switching process. Shaw teaches, "FIG. 3 illustrates a representative client browser having a streaming media client player that is enhanced to include the functionality of the present invention." Ex. 1005 at 4:27-29. This enhancement "comprises several processes, namely, a DNS lookup process **304**, a server testing process **306**, a decision process **308**, and a stream switch process **310**." *Id*. at 7:11-14 (emphasis added).

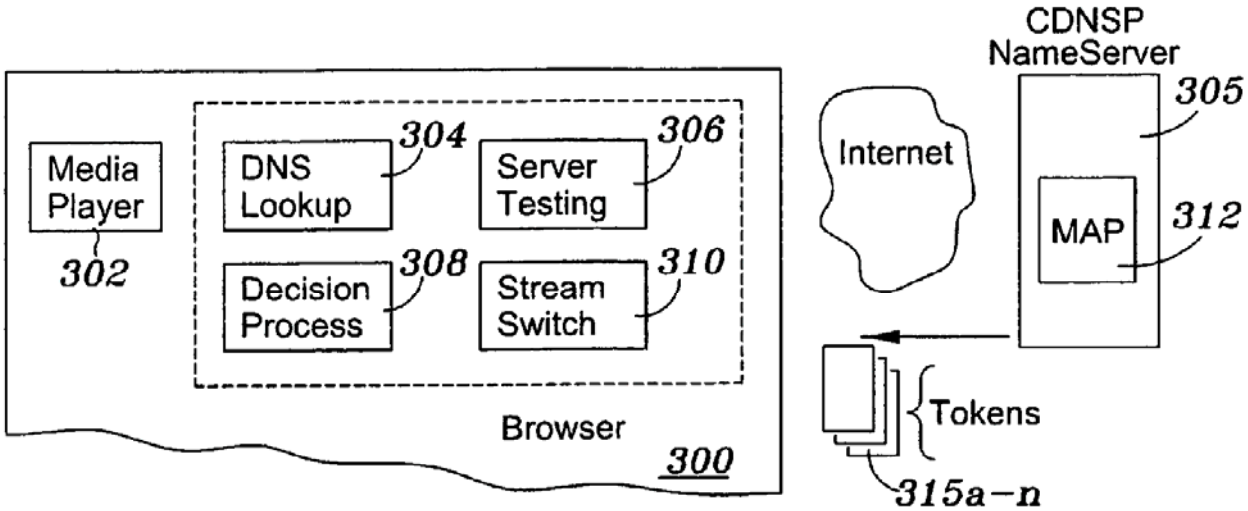

FIG. 3

Id., Fig. 3.

62. Shaw teaches that the DNS (*i.e.*, Domain Name Service) lookup process **304** performs a DNS lookup at a NameServer 305 and receives back tokens

315*a-n*, where each "token 315 provides a distinct answer to the query and defines a machine or, in the preferred embodiment, a group of machines, from which the client should seek to obtain the stream." *Id*. at 7:26-46; *see also* Ex. 2003 at 54:15-25. In other words, each server token represents a server (or group of servers) from which the client browser can obtain the same stream (*i.e.*, the same media content at the same quality level).

63. Shaw further teaches that, after the client browser obtains a list of server locations from which it can obtain the desired content, the browser then uses server testing process **306** to determine which server to initially contact to obtain the content. With respect to server testing process 306, Shaw states:

> The request-response is timed by the server testing process, which then determines the "best" server (e.g., usually the one providing the fastest response). In this way, the server testing may be used to "fine tune" the server chosen by the CDN DNS request routing system with an additional piece of information, namely, the actual pipe the client is using for the connection.
>
> Once the fastest responding server is selected, the client connects to it and sends a usual command, e.g., the RTSP DESCRIBE command.

Ex. 1005 at 8:22-31. I note that Shaw teaches here that the "best" server to be selected is generally the "fastest responding server." A POSITA would understand that a "fastest responding" server does not necessarily mean that the server provides the highest bandwidth. Instead, the "fastest responding" server is the server with the

least latency (*e.g.*, a server that is topologically closest to the client or a server with the most available processing cycles), irrespective of relative bandwidths among the different server connections. This is because a request-response test generally is a low-data transmission (such as a PING request) that cannot possibly be used to evaluate for sustained bandwidth, simply because there is insufficient data transmitted to provide such information. I note that Dr. Myler agrees that "fastest response" is not the same as "best bandwidth" (*see* Ex. 2003 at 65:12-66:11), and that the speed test disclosed in Shaw "is sort of like a ping" and the "server that comes back the fastest with the ping is the one that was, oh, they're paying attention. Let's use them." *Id.* at 59:3-10; 65:12-66:2.

64. A POSITA would understand that the term "bandwidth" refers to the rate of data (*e.g.*, bits/second) that can be delivered, while "latency" refers to the amount of time (delay) between a request for data and the return of that data. *See* Ex. 2001 (Newton's Telecom Dictionary) at 99 (defining "bandwidth"), 473 (defining "latency"). Dr. Myler correctly described "bandwidth" as "a bitrate of the channel, what the channel is capable in terms of bitrate." Ex. 2003 at 64:5-11.

65. A POSITA would also understand that, given the goals of Shaw's invention (maximizing the performance and efficiency of a CDN), the "fastest responding" (i.e., generally closest server and/or the server having the most available processing capability) would generally be more important to Shaw than any sort of

bandwidth consideration. Specifically, a POSITA would recognize that a well-known goal of most CDNs is to deliver data to a client from the "closest" server to the client, in order to maximize network efficiency. Indeed, Shaw teaches that "acceptable" delivery often can mean "acceptable from a stream management point of view" (Ex. 1005 at 9:29), which I believe a POSITA would mean to understand "acceptable from a network efficiency standpoint."

66. Along those lines, I have identified nothing in Shaw that indicates any criteria for identifying a "best" server other than "fastest responding," and my understanding is that Dr. Myler has not either. *See* Ex. 2003 at 63:14-64:1. Moreover, Shaw teaches, as Dr. Myler acknowledged, that the server testing process 306 does not necessarily need to do any testing when initially selecting a server for the stream, but instead can merely select one of the servers from the list of tokens from the DNS lookup process. *See* Ex. 1005 at 8:6-13; *see also* Ex. 2003 at 58:4-20.

67. After the client browser selects the initial server and starts receiving the stream, Shaw teaches that the decision process 308 can decide to switch servers if it is no longer receiving an "acceptable stream from the first server." *See* Ex. 1005 at 9:19-24. Shaw further teaches,"[t]he decision process 308 is used to determine whether the player should switch servers mid-stream. Because it is likely there will be some cost to switching (e.g., perhaps a short interruption in service), a client

should only switch servers if it is not getting an acceptable stream from the first server." *Id.* at 9:19-24 (emphasis added). I believe a POSITA would understand this teaching to mean that Shaw does not even suggest attempting to find higher quality content, but instead that Shaw's system seeks only to find a better source for the same content (at the same quality level), when the current stream from the current server has become unacceptable for whatever reason. This is because, as I have noted before, Shaw expressly teaches that all the streams are the same replica of the original media content at the original quality level. *See supra* ¶ 57.

68. Shaw discloses that "[t]he decision process 308 makes a decision regarding whether the stream being received is 'acceptable,' e.g., a stream that is not currently being thinned by the server, or some other metric." Ex. 1005 at 9:24-27. Shaw also teaches that what is acceptable can "mean acceptable from a stream management point of view. For example, the client could be actually told by the server that the stream is unacceptable, e.g., if the server knows it is to be taken down soon (for a software update or other servicing). It could also declare a stream unacceptable if new advertising or newer content (e.g., a fast breaking news story) becomes available." *Id.* at 9:27-35.

69. I believe that a POSITA would understand this teaching to mean that the thinning of a stream is a networking consideration, much like other stream management concerns. I understand that Dr. Myler acknowledged that Shaw uses

the term "thinned" to mean that "there's an insufficient communication bandwidth between the server and the client," and in response, "the server may . . . 'thin' the stream by dropping information (example: Frames from the stream) so that the client can keep up." Ex. 2003 at 115:3-14 (referring to paragraph 72 of Dr. Myler's declaration (Ex. 1003)). Therefore, as taught by Shaw, the client browser may switch servers to receive a better connection (*i.e.*, a better conduit) to avoid having the server "thin" the stream when the server is transmitting the stream to the client browser. *See, e.g.,* Ex. 2003 at 22:20-23:1, 82:12-23.

70. Once again, however, I note that Shaw teaches that each stream, from every source, comprises the same content at the same quality level. *See supra* ¶¶ 57, 67. I note that Dr. Myler agrees with my interpretation of Shaw:

> Q Okay. So going back to our original example, with respect to Figure 3. Block 304 of the DSN look-up, let's say, for example, sends out the query, comes back with three tokens from **three different servers that have the stream that it wants**. It selects the best, which, in this case, is the fastest response one. Then, during that process of watching the -- **the video, whatever the stream is**, there becomes some degradation in the network connection, and it's no longer an acceptable stream. Block 308 would then decide to potentially switch **to get the same stream from a different server that has a better network connection**. Is that a fair example of how the client browser functionality of Shaw works?
>
> MR. PONDER: Objection. Form.

THE WITNESS: **I -- I think that's how we interpret it on reading it.**

Ex. 2003 at 74:25-75:17 (emphasis added); *see also id*. at 85:16-23.

71. In describing its network switching process, Shaw explains that its process provides the client browser with a way "to identify a 'better' source for a stream being received and to switch to that source 'on the fly,' i.e., while **the stream** is being received and rendered on the client." Ex. 1005 at 9:14-19 (emphasis added). A POSITA would understand, from this teaching, that while the client browser might switch servers when the stream is being received and rendered, the client browser is still receiving and rendering **the same stream** after the switch (*i.e*., the client browser is receiving and rendering the same stream from the second server that it was originally receiving from the first server). This teaching is consistent with the entire disclosure of Shaw. *See supra* ¶ 70.

72. Finally, once the decision process 308 makes the decision to switch servers, stream switch 310 implements the switch. Ex. 1005 at 9:37-40; *see also* Ex. 2003 at 83:3-13. Shaw teaches that the actual switching process "from a first server to a second server typically is media type-dependent and any convenient technique may be used." Ex. 1005 at 9:40-42. Shaw provides examples of such switching processes, including (a) buffering the stream from the first server and then switching to receiving the stream from the second server, (b) matching data packets

from the stream being received by both the first and second servers, and (c) synchronizing a voice stream. *Id*. at 9:52-10:3; *see also* Ex. 2003 at 89:13-91:4; 93:11-94:10.

73. I believe that each of these techniques would indicate to a POSITA that the new stream is the same media content as the old stream, with no difference in the level of quality of the media content itself. For instance, as I note above, Shaw teaches that "[a]s appropriate, the stream switch process includes the capability to match data packets from first and second servers to enable a substantially seamless switch to the new stream source." Ex. 1005 at 9:63-66 (emphasis added). As I explain above, this matching of data packets provides a strong indication that the media content of both streams is the same, bit for bit. *See supra* ¶ 59.

74. In my opinion, therefore, regardless of how the switching process takes place, the objective of the switch is to receive the same digital media content, at the same quality level, from the second server, that was initially being received from the first server, but through a better network connection. In fact, Dr. Myler has indicated, if the switch is done well, the user of the client browser would not notice the switch:

> Q Okay. So after that synchronization is done, and it's before the switch and then the switch happens, the -- the listener in this case, because this is voice, the listener wouldn't know a difference in the voice stream from one to the other because that synchronization would

> have happened ahead of time and allowed that switch to happen without the listener noticing; is that true?
>
> A That -- that's what is implied by this example. You know, he says: "The above are merely exemplaries and a convenient switching technique may be implemented." But that's one way you could do it, is what they're saying.

Ex. 2003 at 94:11-24. I agree with this understanding, and to me, this indicates that Shaw teaches maintaining the same quality level of media content, not attempting to access or provide media content at a higher quality level. This is consistent with the remainder of Shaw's teachings, because Shaw does not disclose storing, let alone transmitting media at different quality levels. *See supra* ¶¶ 57, 67.

75. In addition to FIG. 3, Shaw provides a flow chart in FIG. 4 that provides a further description of this process:

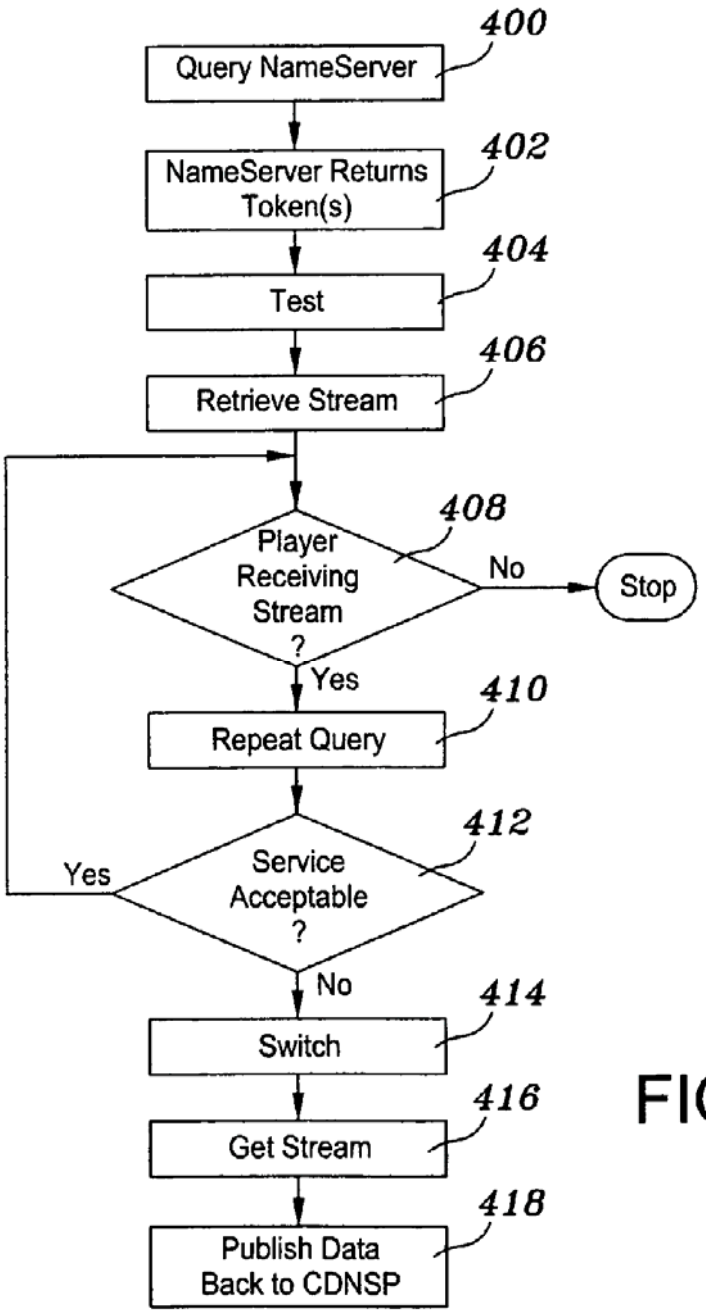

FIG. 4

Ex. 1005, FIG. 4. As Dr. Myler indicated, the process described by Shaw in conjunction with FIG. 4 is largely the same as the operations described in

conjunction with FIG. 3. *See* Ex. 2003 at 96:4-99:25. I do note, however, that Dr. Myler described Block 416 thus: "[A]t Step 416, the client player continues to obtain the remainder of the stream from the new source." Ex. 2003 at 99:14-16. I understand this testimony to mean that the user receives the same stream (*i.e.*, the same media content at the same quality level) after the stream has been switched to the new source. To the extent that I understand Dr. Myler's testimony correctly, I agree.

76. While I understand that the claims of a reference are not dispositive, I do note that the claims of Shaw confirm my understanding of Shaw's disclosed mode of operation. For example, Claim 1 of Shaw reads as follows:

> 1. An apparatus, comprising:
> a processor;
> a media player,
> a program code module comprising code executable by the processor to carry out the following method steps:
> receiving a list of a set of servers, wherein the set of servers is identified by a content delivery network (CDN) map generating process;
> issuing a request to each of the set of servers and receiving a response to the request, and using data associated with the response from each of the set of servers to identify a given server in the set of servers;

as a media stream is being received from a first server and rendered by the media player, determining whether the media stream is acceptable according to a given metric;

if the media stream is not acceptable, and as the media stream continues to be received, taking a given action to initiate delivery of the media stream from the given server, wherein the given action includes the steps of: (a) creating a buffer; (b) receiving from the first server and caching in the buffer advanced portions of the media stream; (c) issuing a request to the given server to initiate delivery of the media stream at a given offset; and (d) rendering the advanced portions of the media stream;

receiving the media stream from the given server; and

when the given offset is reached, rendering in the media player the media stream received from the given server.

Ex. 1005 at 13:47-14:13. As this claim recites, when a media stream is switched, the system obtains the same stream, at a given offset, from a different server; when that offset is reached, seamlessly switching the stream from the first server to the stream from the second server. Notably, the claim indicates that this is the very same stream. I find this to be merely more evidence that Shaw teaches only the delivery of the same stream (*i.e.*, the same media content at the same quality level) from two different servers, and seamless switching of that same stream between the two different servers. I believe Dr. Myler agrees with my understanding of Claim 1. *See* Ex. 2003 at 112:14-21. Claim 3 recites,

> 3. The apparatus as described in claim 1, wherein the code is executable by the processor to match data packets received from the first server and the given server such that the media stream rendered in the media player appears continuous.

Ex. 1005 at 14:18-22. This claim is consistent with the teachings I have identified above with regard to the data packet switching technique described by Shaw (*see supra* ¶¶ 59, 73), and the point of this technique is to ensure that the transition of the stream from one server to another is unnoticeable by the user (which would indicate to me that the stream remains at the same level of quality). I believe Dr. Myler agrees with my understanding of this claim as well. *See* Ex. 2003 at 113:15-114:12.

77. As I will explain further below, Shaw therefore does disclose the concept of switching networks to receive a better network connection, but Shaw does not teach or suggest switching servers to obtain media content at a higher quality level from the second server. In fact, as I have explained above, Shaw teaches providing media content of the same quality at all times, but Shaw teaches a process to improve the quality of the media **service** as a whole through switching to a better network connection. This teaching, however, does nothing to improve the quality of the media **content** itself (which, again, remains the same at all times). Shaw therefore cannot meet the limitations of the Challenged Claims, as I explain further below.

VI. CLAIM CONSTRUCTION

78. Petitioner argues that the term, "a portable system" should be considered limiting as it is used in the preamble of the Challenged Claims. I do not necessarily agree with this position. Nonetheless, this position is not material to my opinions herein, and therefore will not address this claim construction issue in detail.

VII. VALIDITY ANALYSIS

79. In my opinion, the Petitioner has not demonstrated that any Challenged Claim is invalid over the alleged combination of Barnes and Shaw, for the reasons I will discuss below.

A. Independent Claims 1, 6, 11, and 16

1. Digital Media Service

80. In reviewing the Challenged Claims, I find that each of them is directed to a method or system "for providing a digital media **service**." Ex. 1001 at 26:29-30, 26:55-56, 27:22-23, 28:9-10 (emphasis added). The '992 Patent defines a "service" as:

> generally a function performed by the first system for the ultimate benefit of the user. For example and without limitation, a service may comprise an audio output service, a video output service, a textual interface service, an audio interface service, a video interface service, a data processing service, an email service, etc.

Id. at 3:16-22. As I read the '992 Patent, therefore, I understand the provided "digital media service" to include two different components: (1) digital media content and (2) the delivery of such content. I understand that Dr. Myler generally agrees with this understanding. *See* Ex. 2003 at 150:24-151:25 (explaining the two different portions of a digital media service to be (1) digital media content and (2) a server to deliver such content through a network connection). As I will explain below, the Challenged Claims clearly recite these two portions of a digital media service.

a) Digital Media Content

81. The '992 Patent uses the term "information" to refer to "media content." For example, in the context of comparing the quality of information (*e.g.*, digital media content) on two different systems, the '992 Patent explains:

> For example, the second system may have access to **higher quality <u>information</u>** than the first system. As an example, such higher quality information may include information encoded utilizing a lower loss encoding technique than used to encode the information to which the first system has access. As another example, such higher quality information may include information to which the second system has access and to which the first system has no access.

Ex. 1001 at 6:11-18 (emphasis added); *accord* Ex. 2003 at 150:25-151:2 ("'[M]edia' implies some sort of specifically formatted information.") From this example, I believe a POSITA would understand that "quality" of the information (*e.g.*, digital media content) refers specifically to the quality of the information itself. Indeed, the

'992 Patent teaches, "such **higher quality information** may include information encoded utilizing a **lower loss encoding technique** than used to encode the information to which the first system has access." Ex. 1001 at 6:12-16 (emphasis added).

82. I observe that the First Delivering Limitation recites, "delivering digital media content having a current quality level to a user." *Id.* at 26:31-32, 26:58-59, 27:23-24, 28:12-13. I note that the "current quality level" of the "digital media content" is defined in the Challenged Claims before a network connection is mentioned. In fact, the example provided in the specification from Fig. 5 states that user may initially be listening on headset 520 to music that is stored locally on PDA 515 – *i.e.*, the digital media content at the current quality level of the Challenged Claims can be delivered to the user without a network connection. *Id.* at 3:25-33. To me, this indicates that the quality level of the media content, as those terms are used in the Challenged Claims, is independent of delivery considerations, such as network quality.

b) Network Connection

83. While, as I have noted, the quality level of digital media **content** is independent of a network connection, the quality level of the digital media **service** is not. Indeed, the network connection is what can provide for the delivery of the media content (specifically, in the Context of the Challenged Claims, the higher

quality media content, which is obtained from the network). As the '992 Patent teaches, access to higher digital media content from a second system depends greatly on whether the first system can establish a sufficient network connection with the second system. This network connection provides access to higher quality information:

> The information regarding access to various information sources may also include information of the media over which such access exists. For example, access to various information sources may comprise local access or networked access. The type of access to various information sources, as well as the quality of the information, may be considered in determining whether utilizing various resources of the second system will provide the current service to the user at a higher quality level. For example, access to high quality information over a communication network may be of little value in certain scenarios if the communication network is slow or unreliable.

Id. at 6:19-30. Thus, two important considerations in the quality of the media service are (1) the quality of the information and (2) the access to such information.

84. The Challenged Claims acknowledge these two considerations in the recited limitations. Specifically, and as explained above, each of the Challenged Claims require:

a) digital media content with a current quality level and a quality level higher; and

b) a network connection that is available and has a communication bandwidth high enough / a minimum determined communication bandwidth

See supra ¶¶ 35-41.

85. As Dr. Myler acknowledges, the overall quality of the digital media service includes these two requirements. *See* Ex. 2003 at 150:24-151:25. The '992 Patent likewise discusses how these considerations interact:

> Referring to the exemplary scenario 500 illustrated in FIG. 5, the PDA 515 may have access to a local memory device having MP3 audio information encoded at 64 Kbps encoding, while the desktop computing system 555 may have access to CD-quality music information stored in a local memory device 560 or through a network 565. The first 510 or second 550 systems may consider such information access when determining whether utilizing resources of the second system 550 will provide the current service to the user at a higher level of quality.

Ex. 1001 at 6:40-49. As this disclosure indicates, whether the second system (in this example, the desktop computing system) has access to the CD-quality music determines whether using the second system will provide a higher quality of service. This determination involves both factors: (1) the quality of the information (CD-quality music) and (2) whether the portable system has access to that information though the second system.

c) Service Quality Metrics

86. The '992 Patent explains the relationship between the quality of the media content and the access thereto "determine whether utilizing the second system (or various resources thereof) will increase the **quality** at which the current **service** is being provided to the user." *Id.* at 4:26-28 (emphasis added). With respect to the flow chart in Fig. 1, the '992 Patent states that the two systems exchange information over the communication link established in step 140 to make such a determination. *Id.* at 4:28-31. As Dr. Myler acknowledged, the '992 Patent teaches that there are several "criteria" that are considered when deciding to "switch" to higher quality media. *See* Ex. 2003 at 169:20-170:6. I agree.

87. With respect to these "criteria," the '992 Patent explains that there are a wide range of "quality metrics" used to make the quality determination of the overall service. Ex. 1001 at 4:31-33. Specifically, as the '992 Patent discloses, these metrics relate to both the quality of information and the ability to access such information using a network connection:

i) audio/video output quality;

ii) rate of response to user input;

iii) duration over which the service may be provided;

iv) number of information consumption options available to a user;

v) variety of information that may be accessed;

vi) quality of information that may be accessed; and

vii) rate at which such information may be accessed.

See id. at 4:31-38.

88. A POSITA would understand, based on these exemplary metrics, that such considerations include metrics regarding the access (*i.e.*, network connection) to the information between the first and second systems (quality metrics 2, 3, 7) as well as regarding the quality of the information (*i.e.*, digital media content) itself (quality metrics 1, 4, 5, and 6). For example, in describing the first quality metric, Dr. Myler acknowledged the relationship between the metric and the quality of information itself. *See* Ex. 2003 at 170:11-171:8 (discussing the first quality metric and confirming that the quality difference between SD video and HD video is an example of the first quality metric).

89. In my opinion, the sixth and seventh quality metrics provide a useful distinction between the quality of information and the access to that information. The sixth metric (quality of information that can be accessed) clearly relates to the quality of the information, as Dr. Myler acknowledged:

> Q Okay. And then -- and maybe I skipped ahead a bit here, but the next one says a quality -- quality of information to be accessed. Do you see that?
>
> A Yes.
>
> Q Okay. And what would that mean to a person of ordinary skill?

A Well, since this is -- we're talking about quality metrics, there may be -- the information, you might have multiple video files of the exact same material at the same resolution, same frame rates, one of the media files was digitally mastered and the other media file somebody snuck a camcorder into a movie theater and recorded a movie, you know, to bootleg, kind of thing.

Q Uh-huh.

A I think we can say the digitalization scheme would affect the quality of the information that can be accessed. So that would be one example of this, you know, coming off of what would a POSITA think of this metric.

Id. at 177:22-178:17.

90. In my opinion, however, the seventh metric (the rate at which the information can be accessed) pertains to access to the information. Once again, Dr. Myler appears to agree:

Q Right. Okay. And the last one is just rate at which such information can be accessed. Do you see that?

A Yes.

Q So what would a person of ordinary skill in the art view or understand that metric to be?

A Well, that metric could be -- could be is the network speed fast enough, high enough rate to access that information, and if it's not -- we're talking about a quality metric here. So, you know, what -- what -- how does that impact the quality -- the quality that we can -- that we

> can access. So that -- that's the rate of which such information may be accessed. We were talking about dropping – thinning and dropping frames and things like that, that that impacts the rate and ultimately will impact the quality.

Id. at 178:18-179:10 (emphasis added).

91. I find it notable that Dr. Myler raised the concept of "thinning" from Shaw when discussing the seventh metric (which we both agree relates to access to information, not the quality of information). Of all the reasons Shaw discloses that a stream might be unacceptable (and therefore justify switching sources for that stream), the only one that conceivably relates to the media content of the stream itself is the concept of thinning. *See supra* ¶¶ 67-69. Yet, Dr. Myler has indicated that, within the framework of the '992 Patent, the concept of thinning is entirely a phenomenon of access to the information, not the quality of information. *See supra* ¶ 90. At least as used by Shaw, and within the context of the '992 Patent, which clearly considers the inherent quality of the media content to be independent of any connectivity issues that affect access to that content, I find no reason to disagree with Dr. Myler's assessment that thinning relates to the quality of the network connection.

2. Claims 1 and 6

92. In my opinion, for the reasons I discuss below, the combination of Barnes and Shaw does not invalidate Claims 1 and 6 for several independent and distinct reasons.

a) Determining Limitation

93. After careful review and analysis, I do not believe that the combination of Barnes and Shaw discloses or suggests the Determining Limitation (*i.e.*, limitations [1c] and [6c]) of Claims 1 and 6, respectively.

94. As I have explained in detail above, the Challenged Claims, as well as the entirety of the '992 Patent, consider the quality of the media content to be separate from quality level of the media service provided to the user (which, as I have discussed, includes both the quality of the digital media content as well as the access to the digital media content). *See, e.g., supra* ¶¶ 33, 42-44, 80-85. In my opinion, Petitioner overlooks this distinction and therefore confuses the overall quality level of the digital media service with the relative quality levels of the digital media content itself. As I explain above, Shaw is directed to considerations of access and in fact discloses that the quality level of the media content in a stream is consistent by definition (because all streams are replicated from the same source media). *See supra* ¶¶ 57, 67, 70. In my opinion, therefore, Shaw's teaching relates to the network – not the quality of the media content transported by the network. By design, this allows the client browser to switch between servers if it experiences a degradation of network connection with the current server (*i.e.*, access) and still receive the same content at the same quality level (*i.e.*, the same "stream"). My understanding of this disclosure is reinforced by Shaw's consistent teaching that, if

the network switch is done correctly, the user will not notice the switch because the "stream" will seamlessly switch from the first server to the second server, for example, using Shaw's packet switching techniques. *See supra* ¶¶ 59, 73.

95. If the user cannot tell the difference in the media content after Shaw's client browser switches from the first server to the second server, Shaw has achieved its objective of providing the same quality media content, not providing higher quality media content. As I have noted, the whole purpose behind the network switching conditions of Shaw is to maintain (or enhance) the network connection to obtain the same media content for the user. I acknowledge that this will certainly improve the overall quality of the service, but the improvement in quality of the service is a result of the network connection (*i.e.*, the access to digital media content) – not the improvement of quality in the digital media content.

96. Thus, in my opinion, the '992 Patent provides a more robust consideration of the quality of the digital media service provided to a user, which accounts for both the quality of the digital media content and the access to that media content. Shaw, on the other hand, discloses techniques only for improving access to that media content. Thus, in my opinion, Shaw's techniques pertain to one aspect of the '992 Patent's quality of service consideration—the access portion—but Shaw utterly fails even to suggest any consideration of the second aspect—the quality of the media content itself. In other words, the '992 Patent seeks to improve the quality

of the digital media content through obtaining higher quality digital media content, while Shaw seeks to improve the quality of the digital media service through maintaining (or enhancing) the network connection.

97. These differences in approach are material to the Challenged Claims. To the extent that Shaw discloses determining a network connection with a second system as required by the Challenged Claims, Shaw fails even to suggest, as the Challenged Claims require, determining whether that network connection "is high enough to provide the digital media content to the user at a **quality level higher** than the current quality level." Ex. 1001 at 26:35-37 (emphasis added). As I have explained above, Dr. Myler and I agree that Shaw's concept of thinning, on which Petitioner relies heavily (*see* Pet. at 36-37), applies to the access component of quality of digital media service, not to the quality of the digital media content itself. *See supra* ¶¶ 90-91. Moreover, Shaw suggests no other reason for switching streams that even conceivably could relate to the quality of the digital media content.

98. In my opinion, Barnes fails to teach or suggest the Determining Limitation for similar reasons. As explained above, none of the "network switching conditions" referenced by Barnes considers the **quality** of the digital media **content** displayed on device. *See supra* ¶¶ 51-52. Indeed, as I note above, Dr. Myler appears to share my difficulty finding in Barnes any disclosure of media "quality" at all, let alone any consideration of relative media quality or obtaining a higher quality of the

digital media content on the second system, as required by the Challenged Claims. *See id.*

99. It is worth noting that the Examiner originally shared Petitioner's confusion between the overall quality level of the digital media service and the quality levels of the digital media content. This confusion, in fact, motivated the Applicant to amend the Challenged Claims during prosecution. *See supra* ¶¶ 42-47. As I explain above, Applicant specifically amended the Determining Limitation to change "digital media **service**" to "digital media **content**" to make this point clear, and after this amendment (and corresponding explanation by the Applicant), the Examiner understood the distinction and allowed the Challenged Claims over the Jagadeesan and Kayama references. *See id.*; *accord* Ex. 1002 at 21, 43, 50. These events from the prosecution history provide more evidence, in my view, that the Challenged Claims are valid over Barnes and Shaw for the same reasons they are valid over the Jagadeesan and Kayama references cited during examination.

b) Using Limitation

100. For many of the same reasons I have discussed above, the combination of Barnes and Shaw does not disclose the Using Limitation (*i.e.*, limitations [1d] and [6d]) of Claims 1 and 6, respectively. Because, as I have explained, neither Barnes nor Shaw considers whether the digital media content is at "a higher quality level than the current quality level" as required by the Determining Limitation, it is

therefore impossible for either reference to use "the network connection to obtain the digital media content at the higher quality level from the second system" as required by the Using Limitation. Ex. 1001 at 26:31-40; *see supra* ¶¶ 93-99.

c) Second Delivering Limitation

101. Moreover, in my opinion, Petitioner cannot establish that either Barnes or Shaw (or their combination) can teach or suggest the Second Delivering Limitation (*i.e.*, limitation [1d] and [6d]) of Claims 1 and 6, respectively, for several reasons. First, as I have explained at length above, neither Barnes nor Shaw teach "delivering the digital media content at the higher quality level to the user instead of the digital media content at the current quality level" as required by the Second Delivering Limitation. *See supra* ¶¶ 93-99. Second, I disagree with Petitioner that the Using Limitation and Second Delivery Limitation are part of the same limitation, effectively reading out the Second Delivery Limitation from the Challenged Claims. *See* Pet. at 39.

102. Instead, I agree with the position Dr. Myler took in his deposition, acknowledging that the Using Limitation and the Second Delivery Limitation are separate and distinct requirements of the Challenged Claims. *See* Ex. 2003 at 225:19-24. In more detail, Dr. Myler explained the difference between obtaining the content and delivering the content to a user:

Q Okay. So, for example, if I have a device, let's say a PDA, that only has -- I think you gave this example earlier -- only has the capability of showing a movie in **SD format**. **Even though I could obtain an HD version of the movie through the network and from the second system, there would be no way to deliver that to the user because the user is looking at a screen that doesn't support that format, the HD format; is that correct**?

A **That's correct**. Whether it -- the second system has **processing capability**, which, if utilized, would result in the current service being provided to the user at a higher level of quality than the current quality level, yeah.

Q Yeah. **So even though I could obtain the higher quality content, I couldn't deliver it to the user because a user is using a device that doesn't have the correct processing capability**; is that correct?

A **I think I called that the utilizing elements**, you know, can you -- can you utilize it or not. Yeah, you may find it. You may have it in your hand. It's sort of like a little lockbox full of rare gems. Well, you're not going to have those rare gems unless you have the key, you know, that kind of thing.

Q Right.

A Even though getting at the gems would increase your quality of life, let's say.

Id. at 181:24-183:2 (emphasis added).

103. I have no dispute with this colorful analogy, which adequately explains the difference between the Using Limitation and the Delivering Limitation. More precisely, I believe the Using Limitation is concerned with the use of the network to "obtain" the digital media content at the higher quality level. Ex. 1001 at 26:38-40. On the other hand, I believe the Second Delivering Limitation is concerned with providing the digital media content at the higher quality level in a form that the user can use. *Accord* Ex. 2003 at 225:19-24.

104. As I have detailed above, the specification explains, as part of the Determining Limitation, that the portable system and the second system share information, including the various processing capabilities (*e.g.*, decoding capabilities) of the two systems. *See supra* ¶¶ 31-34, 86-88. This communication between the two systems helps ensure that, if the higher quality digital media content can be obtained from the second system, the portable system will be able to deliver it to the user; otherwise, there would be no point in expending resources to obtain higher quality content that could not be delivered to the user. *See id.* As the '992 Patent explains,

> Step 150 may comprise communicating information between the first and second systems of whether the first or second system has processing capability, which if utilized, would result in the current service being provided to the user at a higher level of quality than the current quality level. For example and without limitation, the first and

> second systems may communicate information of data decoding and processing capability. Such processing capability may be, for example, related to available hardware or software resources.

Ex. 1001 at 5:18-52; *see also id.* at 5:3-17.

105. Thus, one part of the determining step is evaluating not only the bandwidth of the network connection to see whether it would support reception of higher quality content, but also evaluating whether this higher quality content could actually be delivered to the user, based, *inter alia*, on the specific capabilities of the portable device. *See supra* ¶¶ 31-34, 86-88. This explanation from the specification of how the system performs the Determining Limitation provides important information that a POSITA would understand provides additional technical novelty.

3. Claims 11 and 16

106. In my opinion, the combination of Barnes and Shaw does not invalidate Claims 11 and 16 for many of the same reasons that these references do not invalidate Claims 1 and 6.

107. First, the Determining Limitation and Utilizing Limitation of Claims 11 and 16 (*i.e.*, limitations [11d], [11e], and [16d], [16e]), respectively, require "determining, based at least in part on said communicating, that the network connection is available and characterized by at least a minimum determined communication bandwidth" and "in response to at least said determining, utilizing

the network connection to receive the digital media content at a quality level higher than the current quality level." Ex. 1001 at 27:28-34, 28:17-23.

108. As I have explained above with respect to Claims 1 and 6, Shaw and Barnes both teach switching servers to obtain better bandwidth, but neither reference teaches anything about "utilizing the network connection to receive the digital media content at a quality level higher than the current quality level" as required by the Utilizing Limitation. *See supra* ¶ 100.

109. Second, neither Barnes nor Shaw disclose the Second Delivery Limitation of Claims 11 and 16 (*i.e.*, limitations [11e] and [16e]), respectively, for the same reasons I have described above with regard to the Second Delivery Limitation in Claims 1 and 6. *See supra* ¶¶ 101-105.

B. Dependent Claims 2-5, 7-10, 12-13, and 17-18

110. Challenged Claims 2-5, 7-10, 12-13, and 17-18 depend from Claims 1, 6, 11, or 16. Thus, my opinion is that these dependent claims are valid over the Barnes and Shaw references for at least the reasons discussed above with regard to independent Claims 1, 6, 11, and 16.

C. Dependent Claims 14 and 19

111. In my review of the Petition, I find no evidence to support its assertions that Claims 14 and 19 are obvious. *See* Pet. at 9 (listing Claims 14 and 19 in Ground 1). Specifically, other than listing Claims 14 and 19 within the group of

Challenged Claims, Petitioner never even mentions Claims 14 and 19 in the Petition. Petitioner thus fails to discuss the limitations of those claims or argue why the cited references might disclose those limitations. Accordingly, my opinion is that Claims 14 and 19 are valid both for the reasons discussed in conjunction with Claims 11 and 16, as well as because Petitioner has not established otherwise.

D. The Combination of Barnes and Shaw

112. In my opinion, Barnes and Shaw cannot be combined in any way observable to a POSITA to reach the limitations of the Challenged Claims. I understand that Dr. Myler testified that a POSITA would seek to combine the teachings of Barnes and Shaw. *See* Ex. 2003 at 117:16-118:2. Dr. Myler provided a lengthy explanation for this conclusion. *See id.* at 137:3-142:6. I respectfully disagree with this analysis.

113. For one thing, Dr. Myler's analysis omits any mention of the quality of the media content being delivered by the supposed combination. Conversely, the quality of the digital media content is a key consideration of all the Challenged Claims. As I have explained, Applicant specifically amended the Challenged Claims during examination to emphasize the importance of obtaining digital media content at a higher quality level from the second system. *See supra* ¶¶ 42-47. Given the clear importance of the quality level of the digital media content to the patentability of the Challenged Claims, I believe an adequate justification for combining two

references would at least consider that limitation. Assuming *arguendo* that a POSITA would find any other reason to attempt to combine the Barnes and Shaw references (a proposition for which I find little evidence), any such combination would not fail to disclose, or even suggest, this critical limitation of the Challenged Claims.

VIII. CONCLUSION

114. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct and 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 Title 18 of the United States Code.

Executed on this 26th day of September 2021 in Johns Creek, Georgia.

By: 

Ghassan AlRegib

Exhibit 1

GHASSAN ALREGIB, PH.D.

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I. EARNED DEGREES

Ph.D. – Electrical and Computer Engineering, Georgia Institute of Technology, 2003
M.S. – Electrical Engineering, King Fahd University of Petroleum and Minerals, 1998
B.S. – Electrical Engineering, King Fahd University of Petroleum and Minerals, 1997

II. EMPLOYMENT HISTORY

John and Marilu McCarty Chair Professor in ECE, Georgia Tech, 04/2021 – present
Director, Center for Energy and Geo Processing (CeGP), Georgia Tech, 8/2012 – present
Professor, School of ECE, Georgia Institute of Technology, 07/2015 – present
Director, Georgia Tech's Programs and Initiatives in MENA, 2015 – 2017
Associate Professor, School of ECE, Georgia Institute of Technology, 7/2009 – 2015
Assistant Professor, School of ECE, Georgia Institute of Technology, 8/2003 – 6/2009

III. TEACHING

A. INDIVIDUAL STUDENT GUIDANCE

A1. Postdoctoral Fellows

1. Dr. Tamir Hegazy (fall 2013 – fall 2015)
   Research Area: Information Processing and Automation
2. Dr. Entao Liu (fall 2013 – fall 2017)
   Research Area: Compressive Sensing
3. Dr. Zhiling Long (fall 2013 – summer 2019)
   Research Area: Machine Learning for Visual Signals
4. Dr. Haibin Di (summer 2016 – fall 2018)
   Research Area: Seismic Interpretation
5. Dr. Dogancan Temel (spring 2017 – summer 2020)
   Research Area: Machine Learning

A2. Ph.D. Students

Current Students

1. Student Name: Mohit Prabhushankar
   Research Topic: Robust Machine Learning
2. Student Name: Gukyeong Kwon
   Research Topic: Robust Machine Learning
3. Student Name: Jinsol Lee
   Research Topic: Detection of Adversarial Images in ML
4. Student Name: Charles Lehman
   Research Topic: Robust Machine Learning
5. Student Name: Ahmad Mustafa
   Research Topic: Machine Learning for Seismic Interpretation
6. Student Name: Joseph Aribido
   Research Topic: Machine Learning for Seismic Interpretation
7. Student Name: Chen Zhou
   Research Topic: Intent Prediction
8. Student Name: Yash-Yee Logan
   Research Topic: OCT Analysis
9. Student Name: Ryan Benkert
   Research Topic: Active Learning and Explainability
10. Student Name: Kiran Kokilepersaud
    Research Topic: Explainability in Medical Imaging and Analysis

Former Students

1. Student Name: Dihong Tian
   Major: ECE at Georgia Tech
   Graduation Date: Fall 2006
   Dissertation Title: Streaming Three-Dimensional Graphics with Optimized Transmission and Rendering Scalability
   Current Employer: Samsung
   Awards: The Outstanding Research Award from the Center for Signal and Image Processing (CSIP) at Georgia Tech in spring 2006
2. Student Name: Junlin Li
   Major: ECE at Georgia Tech
   Graduation Date: Fall 2008
   Dissertation Title: Distributed Estimation in Resource-constrained Wireless Sensor Networks

Current Employer: Broadcom Corp.
Awards: The Outstanding Research Award from the Center for Signal and Image Processing (CSIP) at Georgia Tech in fall 2008

3. Student Name: Mashhour Solh
Major: ECE at Georgia Tech
Graduation Date: Fall 2011
Dissertation Title: Depth-based 3D Videos: Quality Measurement and Synthesized View Enhancement
Current Employer: Amazon.com
Awards: School of ECE GRA Excellence Award

4. Student Name: Michael Santoro
Major: ECE at Georgia Tech
Co-Advisor: Prof. Yucel Altunbasak
Graduation Date: Summer 2012
Dissertation Title: Valid Motion Estimation for Super-Resolution (SR) Image Reconstruction
Current Employer: University of Chile
Awards: Top 10% Paper Award, IEEE MMSP 2012

5. Student Name: Aytac Azgin
Major: ECE at Georgia Tech
Co-Advisor: Prof. Yucel Altunbasak
Graduation Date: Spring 2013
Dissertation Title: Service Quality Assurance for the IPTV Networks
Current Employer: Huawei, Santa Clara

6. Student Name: Mingyu Chen
Major: ECE at Georgia Tech
Co-Advisor: Prof. Biing-Hwang (Fred) Juang
Graduation Date: Fall 2013
Dissertation Title: Universal Motion-based Control and Motion Recognition
Current Employer: Qualcomm Inc.

7. Student Name: Fred Stakem
Major: ECE at Georgia Tech
Semester Advisement Began: Fall 2004
Co-Advisor Name: Prof. Biing-Hwang (Fred) Juang
Passed Preliminary Exam: Fall 2003
Dissertation Proposal: Spring 2010
Expected Graduation: TBD
Research Topic: Networking Collaborative Virtual Environments

8. Student Name: Nejat Kamaci
Major: ECE at Georgia Tech
Semester Advisement Began: Fall 2010

Passed Preliminary Exam: Fall 2003
Dissertation Proposal: Spring 2015
Expected Graduation: TBD
Research Topic: Rate Control for H.26x Video Sequences
Current Employer: Broadcom

9. Student Name: Hasan Al-Marzouqi
Major: ECE at Georgia Tech
Graduation Date: Fall 2014
Dissertation Title: Curvelet Transform with Adaptive Tiling
Current Employer: Assistant Professor at Petroleum Institute, UAE

10. Student Name: Mohammed Aabed
Major: ECE at Georgia Tech
Graduation Date: Fall 2016
Dissertation Title: Perceptual Video Quality Assessment and Analysis using Adaptive Content Dynamics
Current Employer: Amazon Research Lab

11. Student Name: Dogancan Temel
Major: ECE at Georgia Tech
Graduation Date: Fall 2016
Research Topic: Understanding Perceived Quality Through Visual Representations
Current Employer: Georgia Institute of Technology

11. Student Name: Tariq AlShawi
Major: ECE at Georgia Tech
Advisement Began: Fall 2013
Graduation Date: Spring 2018
Thesis Title: Uncertainty Estimation of Visual Attention Models Using Spatiotemporal Analysis
Current Employer: Assist. Professor at King Saud University in Saudi Arabia

12. Student Name: Zhen Wang
Major: ECE at Georgia Tech
Advisement Began: Fall 2012
Graduation Date: Spring 2018
Thesis Title: Computational seismic interpretation using geometric representation and tensor-based texture analysis
Current Employer: Senior Machine Learning Engineer at Qualcomm Technologies, Inc, San Diego, CA

13. Student Name: Mohamed Amir Shafiq
Major: ECE at Georgia Tech
Advisement Began: Fall 2014
Graduation Date: Spring 2018
Thesis Title: Computational seismic interpretation using attention models, texture

dissimilarity, and learning
Current Employer: Team Lead, Pointivo

14. Student Name: Yazeed AlOudah
Major: ECE at Georgia Tech
Advisement Began: Fall 2012
Graduation Date: Spring 2019
Thesis Title: Weakly Supervised Semantic Labeling of Migrated Seismic Data
Current Employer: Airbus Aerial

15. Student Name: Yuting Hu
Major: ECE at Georgia Tech
Advisement Began: Fall 2014
Graduation Date: Spring 2019
Thesis Title: Texture Representation and Analysis in Material Classification and Characterization
Current Employer: Qualcomm Technologies, Inc.

16. Student Name: Motaz Alfarraj
Major: ECE at Georgia Tech
Advisement Began: Fall 2015
Graduation Date: Fall 2019
Thesis Title: *Learning from Seismic Data to Characterize Subsurface Volumes*
Current Employer: Assist. Prof at KFUPM

17. Student Name: Chih-Yao (Kevin) Ma
Major: ECE at Georgia Tech
Advisement Began: Fall 2014
Graduation Date: Spring 2020
Thesis Title: *Toward Grounded Spatio-temporal Reasoning*
Current Employer: Facebook

18. Student Name: Min-Hung (Steve) Chen
Major: ECE at Georgia Tech
Advisement Began: Fall 2014
Graduation Date: Spring 2020
Thesis Title: *Bridging Distributed Discrepancy with Temporal Dynamics for Video Understanding*
Current Employer: MediaTek Inc.

A3. M.S. Students

Former Students

1. Student Name: Gerardo Orozco
Major: ECE at Georgia Tech
Graduation Date: Fall 2005

Dissertation Option: No thesis
Research Topic: Video Compression
Current Employer: National Instruments

2. Student Name: Wenhui Xu
Major: ECE at Georgia Tech
Co-Advisor: Prof. Monty Hayes
Graduation Date: Fall 2011
Dissertation Option: No thesis
Research Topic: Hand Gesture Recognition
Current Employer: Apple Inc.

3. Student Name: Sanjay Kariyappa
Major: ECE at Georgia Tech
Graduation Date: Spring 2014
Dissertation Option: No thesis
Research Topic: Video Compression - HEVC
Current Employer: N/A

4. Student Name: Keerthi S. Arumugam
Major: ECE at Georgia Tech
Graduation Date: Spring 2014
Dissertation Option: No thesis
Research Topic: Quality Measure of Video
Current Employer: May start Ph.D. at Georgia Tech

5. Student Name: Julie Petta
Major: ECE at Georgia Tech
Graduation Date: Spring 2016
Dissertation Option: No Thesis
Research Topic: Machine Learning for Image Quality Assessment
Current Employer: Local Company in France

6. Student Name: Haider Khan
Major: ECE at Georgia Tech
Graduation Date: Spring 2017
Dissertation Option: No Thesis
Research Topic: Saliency Detection in Videos
Current Employer: N/A

7. Student Name: Gukyeong Kwon
Major: ECE at Georgia Tech
Graduation Date: May 2016
Dissertation Option: No Thesis
Research Topic: Perceptions in Video Processing
Current Employer: Ph.D. student at Georgia Tech

8. Student Name: Mohit Prabhushankar
   Major: ECE at Georgia Tech
   Graduation Date: May 2016
   Dissertation Option: No Thesis
   Research Topic: Perceptions in Video Processing
   Current Employer: Ph.D. student at Georgia Tech

9. Student Name: Niranjan Kumar Kannabiran
   Major: ECE at Georgia Tech
   Graduation Date: May 2016
   Dissertation Option: No Thesis
   Research Topic: Perceptions in Video Processing
   Current Employer: Ph.D. student at Georgia Tech

10. Student Name: Jinsol Lee
    Major: ECE at Georgia Tech
    Graduation Date: May 2016
    Dissertation Option: No Thesis
    Research Topic: Perceptions in Video Processing
    Current Employer: Ph.D. student at Georgia Tech

11. Student Name: Adnan Chaudhry
    Major: ECE at Georgia Tech
    Graduation Date: May 2016
    Dissertation Option: No Thesis
    Research Topic: Perceptions in Video Processing
    Current Employer: Ph.D. student at Georgia Tech

12. Student Name: Alex Mussa
    Major: ECE at Georgia Tech
    Graduation Date: Summer 2019
    Dissertation Option: No Thesis
    Research Topic: Seismic Interpretation
    Current Employer: GTRI

13. Student Name: Charles Lehman
    Major: ECE at Georgia Tech
    Graduation Date: May 2019
    Dissertation Option: No Thesis
    Research Topic: Machine Learning
    Current Employer: ML Ph.D. students at Georgia Tech

14. Student Name: Anush Ananthakumar
    Major: ECE at Georgia Tech
    Graduation Date: N/A
    Research Topic: Machine Learning

Dissertation Option: No Thesis
Current Employer: N/A

15. Student Name: Aravind Battaje
Major: ECE at Georgia Tech
Graduation Date: December 2019
Research Topic: Machine Learning
Dissertation Option: No Thesis
Current Employer: N/A

16. Student Name: Shan Gao
Major: ECE at Georgia Tech
Graduation Date: December 2018
Research Topic: Machine Learning
Dissertation Option: No Thesis
Current Employer: N/A

17. Student Name: Pranav Shenov Kasargod Pattanashetty
Major: ECE at Georgia Tech
Graduation Date: N/A
Research Topic: Machine Learning
Dissertation Option: No Thesis
Current Employer: N/A

18. Student Name: Rahul Solanki
Major: ECE at Georgia Tech
Graduation Date: December 2018
Research Topic: Machine Learning
Dissertation Option: No Thesis
Current Employer: N/A

19. Student Name: Anirudha Sundaresan
Major: ECE at Georgia Tech
Graduation Date: N/A
Research Topic: Machine Learning
Dissertation Option: No Thesis
Current Employer: N/A

19. Student Name: Moamen Soliman
Major: ECE at Georgia Tech
Graduation Date: Spring 2020
Research Topic: Machine Learning with Limited Labels
Dissertation Option: No Thesis
Current Employer: N/A

20. Student Name: Yutong Sun
Major: ECE at Georgia Tech

Graduation Date: Spring 2020
Research Topic: Machine Learning and Saliency in Deep Networks
Dissertation Option: No Thesis
Current Employer: N/A

21. Student Name: Shirley Liu
Major: ECE at Georgia Tech
Graduation Date: Spring 2020
Research Topic: Robustness in Machine Learning
Dissertation Option: No Thesis
Current Employer: N/A

A4. Undergraduate Students

Former Students

1. Student Name: Hai Nguyen
Major: ECE at Georgia Tech
Research Topic: DSP Applications

2. Student Name: Olusegun Adeyemo
Major: ECE at Georgia Tech
Project Title: Image and Video Watermarking

3. Student Name: Steven Vaughn
Major: ECE at Georgia Tech
Project Title: Educational Tools for Distance Learning

4. Student Name: David Whitney
Major: ECE at Georgia Tech
Program: UG Research
Research Topic: Video-based Health Monitoring

5. Student Name: Derek Jin
Major: ECE at Georgia Tech
Program: UG Research
Research Topic: Video-based Health Monitoring

6. Student Name: Chuyao (Daniel) Feng
Major: ECE at Georgia Tech
Program: UROP/PURA
Research Topic: Video Streaming for Automative Applications

7. Student Name: Adhithya Rajasekaran
Major: ECE at Georgia Tech
Program: UROP
Research Topic: Feature Extraction for Automatic Grading

8. Student Name: Ke (Olivia) Tang
   Major: ECE at Georgia Tech
   Program: UG Research and UROP
   Research Topic: Streaming UHD and 4K Videos

9. Student Name: Chenyu Li
   Major: ECE at Georgia Tech
   Program: UROP
   Research Topic: Video Coding and Streaming

10. Student Name: Varol Burak Aydemir
    Major: ECE at Georgia Tech
    Program: UG Research and UROP
    Research Topic: Non-invasive Diagnosis of Vital Metrics

11. Student Name: Huijie Pan
    Major: ECE at Georgia Tech
    Program: UROP
    Research Topic: Denoising of Heart Rate Measurements

12. Student Name: Ziran Ling
    Major: ECE at Georgia Tech
    Program: UROP
    Research Topic: Video Processing for Semi-Autonomous Cars

13. Student Name: Paloma Casteleiro
    Major: ECE at Georgia Tech (Visiting Student from Spain)
    Program: Research Experience
    Research Topic: Saliency Detection in Videos

14. Student Name: Brighton Ancelin
    Major: ECE at Georgia Tech
    Program: Research Experience
    Research Topic: Python Library for Digital Image Processing

A5. Service on thesis or dissertation committees

MS Thesis Committees

- Served on the M.S. Thesis committee of Page Siplon, July 2005
- Served on the M.S. Thesis committee of Yinghao Li (CSE), April 2020
- Served on the M.S. Thesis committee of Pierre Faure-Geiovanoli (GTL), July 2020

Ph.D. Thesis Committees

- Served on the Ph.D. Thesis Defense committees of the following students:
  1. Ali Cengiz Begen November 2006
  2. Dihong Tian November 2006 (Chair and Thesis Advisor)
  3. Talal Jaafar May 2007
  4. Toygar Akgun December 2007

5. Junlin Li — November 2008 (Chair and Thesis Advisor)
6. Mehmet Demircin — May 2008
7. Zafer Aydin — September 2008
8. Tarik Arici — March 2009
9. Seydou Ba — October 2009
10. Jeannie Lee — June 2010
11. Mashhour Solh — Fall 2011 (Chair and Thesis Advisor)
12. Mu-Hsin Wei — Fall 2012
13. Michael Santoro — Summer 2012 (Chair and Thesis Advisor)
14. Cheng-Lin Tsao — Spring 2012
15. Aytac Azgin — Summer 2013 (Chair and Thesis Advisor)
16. Mingyu Chen — Fall 2013 (Chair and Thesis co-Advisor)
17. Hasan Al Marzouqi — Fall 2014 (Chair and Thesis Advisor)
18. Jason Dixon — Fall 2015
19. Alexander Dawson — Fall 2015
20. Sadia Khan — Spring 2016
21. Lingchen Zhu — Summer 2016
22. Josh Wells — Fall 2016
23. Mohammed Aabed — Fall 2016 (Chair and Thesis Advisor)
24. Dogancan Temel — Fall 2016 (Chair and Thesis Advisor)
25. Sun, Yixuan — Spring 2017
26. Pauline Le Bouteiller — Fall 2018 (Sorbonne University, Reporter and Examiner)
27. Soumi Chaki — Spring 2019 (IIT Kharagpur)
28. Ruizhi Chai — Spring 2019
29. Santosh Kumar Behera — Spring 2019 (IIT Bhubaneswar)
30. Yazeed Alaudah — Spring 2019
31. Yuting Hu — Spring 2019
32. Cibi Pranav P S — Summer 2019 (CEE, Georgia Tech)
33. Fu-Jen Chu — Summer 2020
34. Afshin Abdi — Summer 2020

- Served on the Ph.D. Dissertation Proposal committees of the following students:
  1. Ali Cengiz Begen — November 2004 (Chair)
  2. Hyungjoon Kim — April 2005
  3. Dihong Tian — Spring 2006
  4. Talal Jaafar — April 2006 (Chair)
  5. Zafer Aydin — December 2006 (Chair)
  6. Mehmet Demircin — December 2006
  7. Michael Fonseca — December 2006
  8. Jeannie Lee — December 2007
  9. Soo Hyun Bae — December 2007
  10. Seydou Ba — April 2008 (Chair)
  11. Tarik Arici — April 2008

12. Junlin Li — Spring 2008
13. Winston Percybrooks — May 2010 (Chair)
14. Ramanathan Palaniappan — Fall 2010
15. Fred Stakem — Spring 2010
16. Aleem Mushtaq — Fall 2010 (Chair)
17. Mashour Solh — Spring 2011
18. Hengzhao Yang — Fall 2011
19. Michael Santoro — Fall 2011
20. Qing Li — Fall 2011
21. Ilseo Kim — Fall 2012
22. Mingyu Chen — Fall 2012
23. Sourbh Khire — Spring 2012
24. Hasan AlMarzouqi — Spring 2014
25. Alexander Dawson — Spring 2014 (Chair)
26. Xiangmin Wei (CoC) — Spring 2014
27. Sadia Khan — Fall 2015 (Chair)
28. Lingchen Zhu — Fall 2015 (Chair and Reading Committee)
29. Mohammed Aabed — Fall 2015 (Advisor)
30. Dogancan Temel — Fall 2015 (Advisor)
31. Ola Salman — Fall 2017 [AUB Lebanon]
32. Yipu Zhao — Spring 2019
33. Chih-Yao Ma — Spring 2019
34. Min-Hung (Steve) Chen — Spring 2019
35. Motaz Alfarraj — Summer 2019
36. Xiaolong Wu — Summer 2019 (Chair)
37. Fu-Jen Chu — Fall 2019
38. Afshin Abdi — Fall 2019

B. OTHER TEACHING ACTIVITIES

- Developed and offered (Sp'21) the first undergraduate course on Machine Learning in ECE, titled "*Fundamentals of Machine Learning* (**FunML**)."
- Hosted three visiting faculty members (3 months, one year, and one year) and one visiting researcher (three months)
- Organized a public poster session, every fall, as the term project presentations in the course ECE6258 (Digital Image Processing) and it was very well received by both students and the invited visitors from industry.
- Co-developed with colleagues across campus a model for a new professional master's degree in Sustainable Electrical Energy Systems to be offered by Georgia Tech worldwide.
- Introduced a new course, ECE-4283, titled "Multidimensional, Image, and Video Processing," that was offered in spring 2012.

- Introduced a new course, ECE-3813, titled "Fundamentals of Multimedia Systems" offered in fall 2008 and spring 2009. In this course, theoretical foundations and practical algorithms for multimedia compression, processing, and communications are taught.
- Developed, with other ECE faculty members, a Digital Signal Processing (DSP) Certificate Program for practicing engineers that is funded and run by Georgia Tech's Distance Learning and Professional Education (DLPE) Department. The program consists of four core courses and two laboratory courses that utilize Texas Instruments (TI) boards.

IV. SCHOLARLY ACCOMPLISHMENTS

A. Refereed Publications

A1. PUBLISHED AND ACCEPTED JOURNAL ARTICLES

1. M. Kousa and G. AlRegib, "Coding-Quantization Exchange for Constant-Bit-Rate Image Transmission Over Wireless Channels," in *Journal for Science and Engineering*, vol. 24, no. 2C, pp. 115-124, Dec. 1999.
2. G. AlRegib, Y. Altunbasak, and R. Mersereau, "Hierarchical Motion Estimation With Content-Based Meshes," in *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 13, no. 10, pp. 1000-1005, Oct. 2003.
3. G. AlRegib, Y. Altunbasak, and R. Mersereau, "Bit Allocation for Joint Source and Channel Coding of Progressively Compressed 3D Meshes," in *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 15, no. 2, pp. 256-268, Feb. 2005.
4. G. AlRegib, Y. Altunbasak, and J. Rossignac, "Error-Resilient Transmission of 3-D Models," in *ACM Transactions on Graphics*, vol. 24, no. 2, pp. 182-208, Apr. 2005.
5. G. AlRegib, Y. Altunbasak, and J. Rossignac, "An Unequal Error Protection Method for Progressively Transmitted 3D Models," in *IEEE Transactions on Multimedia*, vol. 7, no. 4, pp. 766-776, Aug. 2005.
6. G. AlRegib and Y. Altunbasak, "3TP: An Application-Layer Protocol for Streaming 3-D Models," in *IEEE Transactions on Multimedia*, vol. 7, no. 6, pp. 1149-1156, Dec, 2005.
7. D. Tian and G. AlRegib, "On-Demand Transmission of 3D Models Over Lossy Networks," in *EURASIP Journal on Signal Processing: Image Communication*, vol. 21, pp. 396-415, Jun. 2006.
8. D. Tian and G. AlRegib, "Parity Streams - A Novel FEC Scheme With the Stream Control Transmission Protocol," in *IEEE Communications Letters*, vol. 10, no. 6, pp. 498-500, Jun. 2006.
9. J. Li, D. Tian, and G. AlRegib, "Vector Quantization in Multi-Resolution Mesh Compression," in *IEEE Signal Processing Letters*, vol. 13, no. 10, pp. 616-619, Oct. 2006.
10. J. Li and G. AlRegib, "Rate-Constrained Distributed Estimation in Wireless Sensor Networks," in *IEEE Transactions on Signal Processing*, vol. 55, no. 5, pp. 1634-1643, May, 2007.
11. D. Tian and G. AlRegib, "Multi-Streaming of 3D Scenes With Optimized Transmission and Rendering Scalability," in *IEEE Transactions on Multimedia*, vol. 9, no. 4, pp. 736-745, Jun. 2007.
12. D. Tian, J. Li, and G. AlRegib, "Joint Source and Channel Coding for 3D Scene Databases Using Vector Quantization and Embedded Parity Objects," in *IEEE Transactions on Image Processing*, vol. 16, no. 6, pp. 1675-1685, Jun. 2007.
13. D. Tian and G. AlRegib, "BaTex3: Bit-Allocation for Progressive Transmission of Textured 3D Models," in *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 18, no. 1, Aug. 2007.
14. G. AlRegib, M. Hayes, E. Moore, and D. Williams, "Technology and Tools to Enhance Distributed Engineering Education," in *Proc. of the IEEE*, vol. 96, no. 6, pp. 951-969, Jun. 2008.

15. J. Li and G. AlRegib, "Function-Based Network Lifetime for Estimation in Wireless Sensor Networks," in *IEEE Signal Processing Letters*, vol. 15, pp. 533-536, Jul. 2008.
16. J. Li and G. AlRegib, "Network Lifetime Maximization for Estimation in Multi-Hop Wireless Sensor Networks," in *IEEE Transactions on Signal Processing*, vol. 57, no. 7, Jul. 2009.
17. J. Li and G. AlRegib, "Distributed Estimation in Energy-Constrained Wireless Sensor Networks," in *IEEE Transactions on Signal Processing*, vol. 57, no. 10, Oct. 2009.
18. F. Porikli, A. Bovik, C. Plack, G. AlRegib, J. Farrell, P. Le Callet, Quan Huynh-Thu, S. Moller, and S. Winkler, "Multimedia Quality Assessment [DSP Forum]," in *IEEE Signal Processing Magazine*, vol. 28, no. 6, pp. 164-177, Nov. 2011.
19. M. Solh and G. AlRegib, "MIQM: A Multi-Camera Image Quality Measure," in *IEEE Transactions on Image Processing*, vol. 21, no. 9, pp. 3902-3914, Sep. 2012.
20. M. Solh and G. AlRegib, "Hierarchical Hole-Filling for Depth-Based View Synthesis in Free Viewpoint Television (FTV) and 3D Video," in *IEEE Journal of Selected Topics in Signal Processing*, vol. 6, no. 5, pp. 495-504, Sep. 2012.
21. M. Chen, G. AlRegib, and B.-H. Juang , "Feature Processing and Modeling for 6D Motion Gesture," in *IEEE Transactions on Multimedia*, vol. 15, no. 3, pp. 561-571, Apr. 2013.
22. M. Santoro, G. AlRegib, and Y. Altunbasak, "A Joint Framework for Motion Validity and Estimation Using Block Overlap," in *IEEE Transactions on Image Processing*, vol. 22, no. 4, pp. 1610-1619, Apr. 2013.
23. A. Azgin, G. AlRegib, and Y. Altunbasak, "Cooperative Delivery Techniques to Support Video-On-Demand Service in IPTV Networks," in *IEEE Transactions on Multimedia*, vol. 15, no. 8, pp. 2149-2161, Dec. 2013.
24. Z. Wang, T. Hegazy, Z. Long, and G. AlRegib, "Noise-Robust Detection and Tracking of Salt Domes in Post-Migrated Volumes Using Texture, Tensors, and Subspace Learning," in *Geophysics*, vol. 80, no. 6, Nov. 2015.
25. M. Chen, G. AlRegib, and B.H. Juang, "Air-Writing Recognition, Part2: Detection and Recognition of Writing Activity in Continuous Stream of Motion Data," in *IEEE Transactions on Human-Machine Systems*, vol. 46, no. 3, pp. 436-444, Jun. 2016.
26. M. Chen, G. AlRegib, and B.H. Juang, "Air-Writing Recognition, Part1: Modeling and Recognition of Characters, Words and Connecting Motions," in *IEEE Transactions on Human-Machine Systems*, vol. 46, no. 3, pp. 403-413, Jun. 2016.
27. D. Temel and G. AlRegib, "CSV: Image Quality Assessment Based on Color, Structure and Visual System," in *Signal Processing: Image Communication*, vol. 48, pp. 92-103, Oct. 2016.
28. D. Temel, M. Prabhushankar, and G. AlRegib, "UNIQUE: Unsupervised Image Quality Estimation," in *IEEE Signal Processing Letters* , vol. 23, no. 10, pp. 1414-1418, Oct. 2016. [Link]
29. Z. Wang and G. AlRegib, "Interactive Fault Extraction in 3D Seismic Data Using the Hough Transform and Tracking Vectors," in *IEEE Transactions on Computational Imaging*, vol. 3, no. 1, pp. 99-109, Mar. 2017.
30. M. Shafiq, Z. Wang, G. AlRegib, A. Amin, and M. Deriche, "A Texture-Based Interpretation Workflow With Application to Delineating Salt Domes," in *Interpretation*, vol. 5, no. 3, Mar. 2017.
31. H. Al-Marzouqi and G. AlRegib, "Curvelet Transform With Learning-Based Tiling," in *Signal Processing: Image Communication*, vol. 53, pp. 24-39, Apr. 2017.
32. Amin, M. Deriche, M. A. Shafiq, Z. Wang, and G. AlRegib, "Automated Salt Dome Detection Using an Attribute Ranking Framework With a Dictionary-Based Classifier," in *Interpretation*, vol. 5, no. 3, Jun. 2017.
33. T. Alshawi, Z. Long, and G. AlRegib, "Unsupervised Uncertainty Estimation Using Spatiotemporal Cues in Video Saliency Detection," in *IEEE Transactions on Image Processing*, vol. 27, pp. 2818-2827, Jun. 2018.

34. G. AlRegib, M. Deriche, Z. Long, H. Di, Z. Wang, Y. Alaudah, M. A. Shafiq, M. Alfarraj, "Subsurface Structure Analysis Using Computational Interpretation and Learning," in *IEEE Signal Processing Magazine*, vol. 35, no. 2, pp. 82-98, Mar. 2018.
35. D. Temel and G. AlRegib, "Traffic Signs in the Wild: Highlights From the IEEE Video and Image Processing Cup 2017 Student Competition [SP Competitions]," in *IEEE Signal Processing Magazine*, vol. 35, no. 2, pp. 154-161, Mar. 2018.
36. S. AlGhadban, A. Muqaibel, G. AlRegib, and A. AlShaikhi, "Seeding Undergraduate Research Experience: From Georgia Tech to KFUPM Case Study," in *International Journal of Electrical Engineering Education*, vol. 5, no. 4, Oct. 2018.
37. Y. Hu, Z. Long, and G. AlRegib, "A High-Speed, Real-Time Vision System for Texture Tracking and Thread Counting," in *IEEE Signal Processing Letters*, vol. 25, no. 6, pp. 758-762, 2018.
38. M. Alfarraj, Y. Alaudah, Z. Long, and G. AlRegib, "Multiresolution Analysis and Learning for Computational Seismic Interpretation," in *The Leading Edge*, 2018.
39. M. A. Shafiq, H. Di, and G. AlRegib, "A Novel Approach for Automated Detection of Listric Faults Within Migrated Seismic Volumes," in *Journal of Applied Geophysics*, Jun. 2018.
40. Z. Long, Y. Alaudah, M.A. Qureshi, Y. Hu, Z. Wang, M. Alfarraj, G. AlRegib, A. Amin, M. Deriche, S. Al-Dharrab, and H. Di, "A Comparative Study of Texture Attributes for Characterizing Subsurface Structures in Seismic Volumes," in *Interpretation*, vol. 6, no. 4, pp. 1055-1066, Oct. 2018.
41. Z. Wang, H. Di, M. A. Shafiq, Y. Alaudah, and G. AlRegib, "Successful Leveraging of Image Processing and Machine Learning in Seismic Structural Interpretation: A Review," in *The Leading Edge*, vol. 37, no. 6, pp. 451-461, Jun. 2018.
42. H. Di and G. AlRegib, "Reflector Dip Estimates Based on Seismic Waveform Curvature/Flexure Analysis," in *Interpretation*, vol. 7, no. 2, pp. SC1-SC9, Feb, 2019.
43. H. Di, D. Gao, and G. AlRegib, "3D Dip Vector-Guided Auto-Tracking for Weak Seismic Reflections: A New Tool for Shale Reservoir Visualization and Interpretation," in *Interpretation*, vol. 6, no. 4, pp. SN47-SN56, Sep. 2018.
44. M. Shafiq, T. Alshawi, Z. Long, and G. AlRegib, "The Role of Visual Saliency in the Automation of Seismic Interpretation," in *Geophysical Prospecting*, vol. 66, no. 1, pp. 132-143, Mar. 2018.
45. H. Di, M A. Shafiq, and G. AlRegib, "Multi-Attribute K-Means Clustering for Salt Boundary Delineation From 3D Seismic Data," in *Geophysical Journal International*, vol. 215, no. 3, pp. 1999-2007, Dec. 2018.
46. Y. Alaudah, M. Alfarraj, and G. AlRegib, "Structure Label Prediction Using Similarity-Based Retrieval and Weakly-Supervised Label Mapping," in *Geophysics*, vol. 84, no. 1, pp. V67-V79, Dec. 2018.
47. C. Ma*, M. Chen*, Z. Kira and G. AlRegib, "TS-LSTM and Temporal-Inception: Exploiting Spatiotemporal Dynamics for Activity Recognition," in *Signal Processing: Image Communication*, 2018. (*: equal contribution)
48. M. Aabed and G. AlRegib, "PeQASO: Perceptual Quality Assessment of Streamed Videos Using Optical Flow Features," in *IEEE Transactions on Broadcasting*, 2018.
49. H. Di, M. Alfarraj, and G. AlRegib, "Three-Dimensional Curvature Analysis of Seismic Waveforms and Its Interpretational Implications," in *Geophysical Prospecting*, vol. 67, no. 2, pp. 265-281, Dec. 2018.
50. Y. Hu, Z. Wang, and G. AlRegib, "Texture Classification Using Block Intensity and Gradient Difference (BIGD) Descriptor," in *Signal Processing: Image Communication*, Dec. 2019.
51. D. Temel, M. J. Mathew, G. AlRegib, and Y. M. Khalifa, "Relative Afferent Pupillary Defect Screening Through Transfer Learning," in *IEEE Journal of Biomedical and Health Informatics*, Aug. 7 2019.
52. D. Temel, M-H. Chen, and G. AlRegib, "Traffic Sign Detection Under Challenging Conditions: A Deeper Look Into Performance Variations and Spectral Characteristics," in *IEEE Transactions on Intelligent Transportation Systems*, Jul. 2019.

53. D. Temel and G. AlRegib, "Perceptual Image Quality Assessment Through Spectral Analysis of Error Representations," in *Signal Processing: Image Communication*, vol. 70, pp. 37-46, 2019.
54. H. Di and G. AlRegib, "Semiautomatic Fault/Fracture Interpretation Based on Seismic Geometry Analysis," in *Geophysical Prospecting*, vol. 67, no. 5, pp. 1379-1391, May, 2019.
55. H. Al-Marzouqi, Y. Hu, and G. AlRegib, "Texture Retrieval Using Periodically Extended and Adaptive Curvelets," in *Signal Processing: Image Communication*, vol. 76, pp. 252-260, 2019.
56. Y. Alaudah, P. Michalowicz, M. Alfarraj, G. AlRegib, "A Machine Learning Benchmark for Facies Classification," in *Interpretation*, Aug. 2019.
57. H. Di, M. A. Shafiq, Z. Wang, and G. AlRegib, "Improving Seismic Fault Detection by a Super-Attribute-Based Classification," in *Interpretation*, vol. 7, no. 3, pp. SE251-267, Aug. 2019.
58. M. Alfarraj, and G. AlRegib, "Semi-Supervised Sequence Modeling for Elastic Impedance Inversion," in *Interpretation*, Aug. 2019.
59. H. Di, D. Gao, and G. AlRegib, "Developing a Seismic Texture Analysis Network for Automated Seismic Pattern Recognition and Classification," in *Geophysical Journal International*, vol. 218, no. 2, pp. 1262-1275, Aug, 2019.
60. Y. Hu, Z. Long, A. Sundaresan, M. Alfarraj, G. AlRegib, S. Park, and S. Jayaraman, "Fabric Surface Characterization: Assessment of Deep Learning-Based Texture Representations Using a Challenging Dataset," in *The Textile Institute*, Mar. 12 2020.
61. A. Mustafa, M. Alfarraj, and G. AlRegib, "Joint Learning for Spatial Context-Based Seismic Inversion of Multiple Datasets for Improved Generalizability and Robustness," in *Geophysics*, vol. 86, no. 4, Mar. 26 2021.

A2. CONFERENCE PRESENTATION WITH PROCEEDINGS

1. A. Alattar and G. Al-Regib, "Evaluation of Selective Encryption Techniques for Secure Transmission of MPEG Video Bit-Streams," in *IEEE International Symp. on Circuits and Systems*, 1999, pp. 340-343.
2. A. Alattar, G. Al-Regib, and S. Al-Semari, "Improved Selective Encryption Techniques for Secure Transmission of MPEG Video Bit-Streams," in *IEEE International Conference on Image Processing (ICIP)*, 1999, pp. 256-260.
3. G. Al-Regib and Y. Altunbasak, "Two-Dimensional Motion Estimation With Hierarchical Content-Based Meshes," in *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, May, 2001, pp. 1621-1624.
4. G. Al-Regib and Y. Altunbasak, "A System Level Framework for Streaming 3D Meshes Over Packet Networks," in *International Conference on Networking*, Jul. 2001, pp. 745-753.
5. G. Al-Regib, Y. Altunbasak, and J. Rossignac, "An Unequal Error Protection Method for Progressively Compressed 3D Models," in *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, Orlando, FL, May, 2002, pp. 2041-2044.
6. G. Al-Regib and Y. Altunbasak, "An Unequal Error Protection Method for Packet Loss Resilient 3D Mesh Transmission," in *Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM)*, New York, NY, Jun. 2002, pp. 743-752. (Acceptance Rate: 17%)
7. G. Al-Regib, Y. Altunbasak, J. Rossignac, and R. Mersereau, "Protocol for Streaming Compressed 3-D Animations Over Lossy Channels," in *IEEE International Conference on Multimedia and Expo (ICME)*, Lausanne, Switzerland, Aug. 2002, pp. 353-356.
8. G. Al-Regib, Y. Altunbasak, and J. Rossignac, "A Joint Source and Channel Coding Approach for Progressively Compressed 3D Mesh Transmission," in *IEEE International Conference on Image Processing (ICIP)*, Rochester, NY, Sep. 2002, pp. 161-164.

9. G. Al-Regib and Y. Altunbasak, "3TP: An Application-Layer Protocol for Streaming 3-D Graphics - Experimental Approach," in *IEEE International Conference on Multimedia and Expo (ICME)*, Baltimore, MD, Jul. 2003, pp. 421-424.
10. D. Tian, X. Li, G. AlRegib, Y. Altunbasak, and Joel Jackson, "Optimal Packet Scheduling for Wireless Video Streaming With Error-Prone Feedback," in *IEEE International Conference on Wireless Communications and Networking*, Atlanta, GA, Mar. 2004, pp. 1287-1292.
11. G. AlRegib and Y. Altunbasak, "3TP: 3-D Models Transport Protocol," in *International Conference on 3D Web Technology*, Monterey, CA, Apr. 2004, pp. 155-163.
12. S. Yaman and G. AlRegib, "A Low-Complexity Video Encoder With Decoder Motion Estimator," in *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, MontrÃ©al, Canada, May, 2004, pp. 157-160.
13. D. Tian, Y.C. Lee, G. Al-Regib, and Y. Altunbasak, "Packetized Media Streaming Over Multiple Wireless Channels," in *IEEE International Conference on Communications (ICC)*, Jun. 2004, pp. 1335-1339.
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141. M. A. Shafiq, M. Prabushankar, and G. AlRegib, "Leveraging Sparse Features Learned From Natural Images for Seismic Understanding," in *EAGE Annual Conference & Exhibition*, Copenhagen, Denmark, Jun. 11-14 2018.
142. M. A. Shafiq, M. Prabhushankar, H. Di, and G. AlRegib, "Towards Understanding Common Features Between Natural and Seismic Images," in *Expanded Abstracts of the SEG Annual Meeting*, Anaheim, CA, Oct. 14-19 2018.
143. M. Alfarraj and G. AlRegib ., "Petrophysical Property Estimation From Seismic Data Using Recurrent Neural Networks," in *Expanded Abstracts of the SEG Annual Meeting*, Anaheim, CA, Oct. 14-19 2018.
144. Y. Alaudah, S. Gao, and G. AlRegib, "Learning to Label Seismic Structures With Deconvolution Networks and Weak Labels," in *Expanded Abstracts of the SEG Annual Meeting*, Anaheim, CA, Oct. 14-19 2018.
145. H. Di, Z. Wang, and G. AlRegib, "Real-Time Seismic-Image Interpretation via Deconvolutional Neural Network," in *Expanded Abstracts of the SEG Annual Meeting*, Anaheim, CA, Oct. 14-19 2018.
146. H. Di, Z. Wang, and G. AlRegib, "Why Using CNN for Seismic Interpretation? An Investigation," in *Expanded Abstracts of the SEG Annual Meeting*, Anaheim, CA, Oct. 14-19 2018.
147. H. Di, M. A. Shafiq, and G. AlRegib, "Patch-Level MLP Classification for Improved Fault Detection," in *Expanded Abstracts of the SEG Annual Meeting*, Anaheim, CA, Oct. 14-19 2018.
148. C. Ma, A. Kadav, I. Melvin, Z. Kira, G. AlRegib, and H. P. Graf, "Attend and Interact: Higher-Order Object Interactions for Video Understanding," in *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2018.
149. M. Prabhushankar*, G. Kwon*, D. Temel, and G. AlRegib, "Semantically Interpretable and Controllable Filter Sets," in *IEEE International Conference on Image Processing (ICIP)*, Athens, Greece, Oct. 7-10 2018
150. D. Temel*, J. Lee*, and G. AlRegib, "CURE-OR: Challenging Unreal and Real Environments for Object Recognition," in *IEEE International Conference on Machine Learning and Applications (ICMLA)*, Orlando, FL, Dec. 2018
151. D. Temel, M. J. Mathew, G. AlRegib, and Y. M. Khalifa, "Automated Pupillary Light Reflex Assessment on a Portable Platform," in *International Symposium on Medical Robotics*, Atlanta, GA, Apr. 2019.
152. C. Ma, J. Lu, Z. Wu, G. AlRegib, Z. Kira, R. Socher, and C. Xiong., "Self-Monitoring Navigation Agent via Auxiliary Progress Estimation," in *International Conference on Learning Representations (ICLR)*, May, 2019.
153. C. Ma, Z. Wu, G. AlRegib, C. Xiong, and Z. Kira., "The Regretful Agent: Heuristic-Aided Navigation Through Progress Estimation," in *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Jun. 2019.

154. Y. Alaudah, M. Soliman, and G. AlRegib, "Facies Classification With Weak and Strong Supervision -- A Comparative Study," in *Expanded Abstracts of the SEG Annual Meeting*, San Antonio, TX, Sep. 15-20 2019.
155. A. Mustafa, M. Alfarraj, and G. AlRegib, "Estimation of Acoustic Impedance From Seismic Data Using Temporal Convolutional Network," in *Expanded Abstracts of the SEG Annual Meeting*, Sep. 15-20 2019.
156. M. Alfarraj and G. AlRegib, "Semi-Supervised Learning for Acoustic Impedance Inversion," in *Expanded Abstracts of the SEG Annual Meeting*, Sep. 15-20 2019.
157. D. Temel*, J. Lee*, and G. AlRegib, "Object Recognition Under Multifarious Conditions: A Reliability Analysis and a Feature Similarity-Based Performance Estimation," in *IEEE International Conference on Image Processing (ICIP)*, Taipei, Taiwan, Sep. 2019
158. Y. Hu, Z. Long, and G. AlRegib, "Multi-Level Texture Encoding and Representation (MuLTER) Based on Deep Neural Networks," in *IEEE International Conference on Image Processing (ICIP)*, Taipei, Taiwan, Sep. 2019.
159. G. Kwon*, M. Prabhushankar*, D. Temel, and G. AlRegib, "Distorted Representation Space Characterization Through Backpropagated Gradients," in *IEEE International Conference on Image Processing (ICIP)*, Taipei, Taiwan, Sep. 2019.
160. C. Lehman, D. Temel, and G. AlRegib, "Implicit Background Estimation for Semantic Segmentation," in *IEEE International Conference on Image Processing (ICIP)*, Taipei, Taiwan, Sep. 2019.
161. M. Chen, Z. Kira, and G. AlRegib, "Temporal Attentive Alignment for Video Domain Adaptation," in *IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Workshop on Learning from Unlabeled Videos*, Jun. 2019.
162. M. Chen, Z. Kira, G. AlRegib, J. Yoo, R. Chen, and J. Zheng, "Temporal Attentive Alignment for Large-Scale Video Domain Adaptation," in *International Conference on Computer Vision (ICCV)*, Seoul, Korea, Oct. 2019.
163. M. Chen, B. Li, Y. Bao, and G. AlRegib, "Action Segmentation With Mixed Temporal Domain Adaptation," in *IEEE Winter Conference on Applications of Computer Vision (WACV)*, Snowmass Village, CO, Mar. 2-5 2020.
164. M. Chen, B. Li, Y. Bao, G. AlRegib, and Z. Kira, "Action Segmentation With Joint Self-Supervised Temporal Domain Adaptation," in *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Seattle, WA, Jun. 14-19 2020.
165. O. J. Aribido, G. AlRegib, and M. Deriche, "Self-Supervised Annotation of Seismic Images Using Latent Space Factorization," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
166. C. Lehman, D. Temel, and G. AIRegib, "On the Structures of Representation for the Robustness of Semantic Segmentation to Input Corruption," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
167. M. Soliman, C. Lehman, and G. AlRegib, "S6: Semi-Supervised Self-Supervised Semantic Segmentation," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
168. M. Prabhushankar, G. Kwon, D. Temel, and G. AlRegib, "Contrastive Explanations in Neural Networks," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
169. Y. Sun, M. Prabhushankar, and G. AlRegib, "Implicit Saliency in Deep Neural Networks," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
170. J. Lee and G. AlRegib, "Gradients as a Measure of Uncertainty in Neural Networks," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.

171. S. Liu, C. Lehman, and G. AlRegib, "Robustness and Overfitting Behavior of Implicit Background Models," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
172. G. Kwon, M. Prabhushankar, D. Temel, and G. AlRegib, "Novelty Detection Through Model-Based Characterization of Neural Networks," in *IEEE International Conference on Image Processing (ICIP)*, Abu Dhabi, United Arab Emirates, Oct. 2020.
173. A. Mustafa, M. Alfarraj, and G. AlRegib, "Spatiotemporal Modeling of Seismic Images for Acoustic Impedance Estimation," in *Expanded Abstracts of the SEG Annual Meeting*, Houston, TX, Oct. 11-16 2020.
174. A. Mustafa, and G. AlRegib, "Joint Learning for Seismic Inversion: An Acoustic Impedance Estimation Case Study," in *Expanded Abstracts of the SEG Annual Meeting*, Houston, TX, Oct. 11-16 2020.
175. G. Kwon, M. Prabhushankar, D. Temel, and G. AlRegib, "Backpropagated Gradient Representations for Anomaly Detection," in *Proceedings of the European Conference on Computer Vision (ECCV)*, SEC, Glasgow, Aug. 23-28 2020.
176. C. Ma, Y. Kalantidis, G. AlRegib, P. Vajda, M. Rohrbach, and Z. Kira, "Learning to Generate Grounded Visual Captions Without Localization Supervision," in *Proceedings of the European Conference on Computer Vision (ECCV)*, SEC, Glasgow, Aug. 23-28 2020.

A3. SUBMITTED JOURNAL ARTICLES

1. T. Alshawi, G. AlRegib, "Predicting Self-Correlation of Eye-Fixation Maps Using Optical Flow in Visual Attention Applications," *IEEE Transactions on Multimedia*, submitted on Mar. 2017.
2. M. A Shafiq, Z. Long, H. Di, and G. AlRegib, "Attention Models in Perception and Interpretation of Seismic Volumes," *Geophysics*, submitted on Feb. 2018.
3. N. Iqbal, M. Deriche and G. AlRegib, "Blind Curvelet Based Denoising of Seismic Surveys in Coherent and Incoherent Noise Environments," *IEEE Access*, submitted on Jun. 2018.
4. O.J. Aribido, G. AlRegib, and Y. Alaudah, "Unsupervised Delineation of Geological Structure Components Using Latent Space Factorization," *Geophysics*, submitted on Jul. 25 2020.
5. M. Prabhushankar and G. AlRegib, "Contrastive Reasoning in Neural Networks," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, submitted on Jan. 9 2021.
6. G. Kwon and G. AlRegib, "A Gating Model for Bias Calibration in Generalized Zero-Shot Learning," *IEEE Transactions on Image Processing (TIP)*, submitted on Feb. 4 2021.
7. J. Lee, C. Lehman, and G. AlRegib, "Towards Understanding the Purview of Neural Networks via Gradient Analysis," *IEEE Transactions on Image Processing (TIP)*, submitted on Feb. 25 2021.
8. R. Benkert, O.J. Aribido, and G. AlRegib, "Example Forgetting for Deep Model Explainability in Seismic Imaging," *IEEE Transactions on Neural Networks and Learning Systems (TNNLS), Special Issue on Deep Learning for Earth and Planetary Geosciences*, submitted on Mar. 9 2021.

A5. SUBMITTED CONFERENCE PROCEEDINGS PAPERS

1. A. Mustafa, and G. AlRegib, "MAN-RECON: Manifold Learning for Reconstruction With Deep Autoencoder for Smart Seismic Interpretation," submitted to *IEEE International Conference on Image Processing (ICIP)*, Anchorage, AK, Jan. 14 2021.
2. R. Benkert, O.J. Aribido, and G. AlRegib, "Explaining Deep Models Through Forgettable Learning Dynamics," submitted to *IEEE International Conference on Image Processing (ICIP)*, Anchorage, AK, Jan. 13 2021.
3. J.Lee and G. AlRegib, "Open-Set Recognition With Gradient-Based Representations," submitted to *IEEE International Conference on Image Processing (ICIP)*, Anchorage, AK, Jan. 18 2021.

4. M. Prabhushankar and G. AlRegib, "Extracting Causal Visual Features for Limited Label Classification," submitted to *IEEE International Conference on Image Processing (ICIP)*, Anchorage, AK, Jan. 24 2021.
5. Y. Logan, K. Kokilepersaud, G. Kwon and G. AlRegib, "Multi-Modal Learning via Physician's Diagnostics for OCT Classification," submitted to *IEEE International Conference on Image Processing (ICIP)*, Anchorage, AK, Jan. 25 2021.
6. M. Prabhushankar and G. AlRegib, "Robust Second-Order Representations for Neural Networks," submitted to *IEEE International Conference on Machine Learning (ICML)*, Feb. 5 2021.
7. C. Lehman, D. Temel, and G. AlRegib, "Sigmoid Cross Entropy Implicit Background Estimation for Weakly Supervised Segmentation," submitted to *IEEE International Conference on Machine Learning (ICML)*, Feb. 5 2021.
8. A. Mustafa and G. AlRegib, "A Comparative Study of Transfer Learning Methodologies and Causality for Seismic Inversion With Temporal Convolutional Networks," submitted to *SEG Technical Program Expanded Abstracts*, 2021.
9. R. Benkert, O. J. Aribido and G. AlRegib, "Exploiting Learning Patterns of Neural Networks for Detecting Irregularities in Seismic Interpretation," submitted to *SEG Technical Program Expanded Abstracts*, 2021.
10. R. Benkert, O. J. Aribido and G. AlRegib, "Explainable Seismic Neural Networks Using Learning Statistics," submitted to *SEG Technical Program Expanded Abstracts*, 2021.

B. Other Publications

B1. Invited Articles

1. G. AlRegib, "Quality matters, especially in sharing knowledge [From the Editor]", in the *Signal Processing Magazine*, IEEE vol. 26, issue: 2, pp. 2, March 2009.
2. G. AlRegib, "Immersive Telecommunications; Why Now?" IEEE COMSOC *MMTC E-Letter*, vol. 4, no. 3, April 2009.
3. G. AlRegib, "From Admiration, Celebration, and Guessing to Innovation [From the Editor]", *Signal Processing Magazine*, IEEE vol. 27, issue: 3, pp. 2, May 2010.
4. A. Kwasinski and G. AlRegib, "Gadgets and Signal Processing: the 2010 International CES", *Signal Processing Magazine*, IEEE, May 2010.
5. G. AlRegib, "SPS Global Presence and Extinct Technologies [From the Editor]", *Signal Processing Magazine*, IEEE vol. 28 , issue: 3, pp. 2, May 2011.

C. Presentations

C1. Invited Talks

1. "Graphics Streaming: Techniques and Research Directions," at Digimarc Corp., Portland, OR, February 2003
2. "Interactive 3D Animation and Networked 3D Applications," Lucas Animations, Savannah, GA, February 2004
3. "Streaming Textured Models," Georgia Tech Broadband Institute IAB and Symposium, Atlanta, GA, October 2004
4. "Multimedia Research at Georgia Tech," Harris Corporation, Melbourne, FL, November 02, 2007
5. "Immersive Communication: Trends and Challenges," King Fahd University of Petroleum and Minerals (KFUPM), December 2009
6. "Advances in 3DTV," HP Labs, Palo Alto, CA, April 2010
7. "Advances in 3DTV," Sony Research, San Jose, CA, April 2010

8. "User Experience in Immersive Multimedia (uxim)," Qualcomm, April 2010
9. "Georgia Tech's Work in the Middle East," at the COE Advisory Board Meeting, Atlanta, GA, April 27, 2012
10. "Perceptual Video Processing and Seismic Interpretation," Penn State University, March 2014
11. "Mentorship Experience," the 4th U-Beyond Annual Conference, Atlanta, GA, January 30, 2016
12. "Upstream Technologies in the Information Age," the Energy southhub Workshop on Big Data and Energy, Atlanta, GA, September 06, 2016
13. "Opportunities for using Artificial Intelligence and Data Analytics in the Upstream Petroleum Industry," i-Quest Forum, Silicon Valley, CA, August 8-9, 2018
14. "Leveraging Human Visual System Modeling and Machine Learning in Computational Seismic Interpretation," Aramco EXPEC ARC, Dhahran, Saudi Arabia, March 22, 2018
15. "Leveraging Human Visual System Modeling and Machine Learning in Computational Seismic Interpretation," KAUST, Dhahran, Saudi Arabia, March 14, 2018
16. "Machine Learning in and Healthcare: Potential Advances and Challenges," Thought Leaders Summit, Emory University, February 09, 2019
17. "Machine Learning in Seismic Interpretation: Challenges and Opportunities," SEG Workshop on Machine Learning, Muscat, Oman, April 2019
18. "Machine Learning for UG Students," Sultan Qaboos University, Muscat, Oman, April 2019
19. "Learning With Limited Supervision: Lithology Interpretation Case Study," at *SEG Workshop on Machine Learning and Data Analytics Algorithms and Workflows for Geoscience Applications*, San Antonio, TX, Invited, Sept. 19 2019.
20. "Learning With Limited Supervision: Structure Interpretation Case Study," at *SEG Workshop on Artificial Intelligence Frontiers in Geosciences*, San Antonio, TX, Invited, Sept. 20 2019.
21. "Seismic Interpretation Using Machine Learning, School of Earth and Atmospheric Sciences Spring Seminars Series, Georgia Tech, January 2020
22. "Explainable and Generalizable AI Models for Seismic Interpretation," at *the SEG Annual Meeting*, Houston, TX, Invited, Oct. 15 2020.
23. "Mitigating the Data Bottleneck Using Joint Learning for Seismic Inversion," at *the SEG Annual Meeting*, Houston, TX, Invited, Oct. 16 2020.
24. M. Alfarraj and G. AlRegib, "Estimation of Elastic Properties from Seismic Data Using Semi-Supervised Sequence Modeling," at *SIAM conference on Imaging Science*, Toronto, Canada, Invited, Jul. 6-17 2020.

C2. KEYNOTE PRESENTATIONS

1. "ADVANCES AND TRENDS IN GEO-SIGNAL PROCESSING," *KFUPM*, SAUDI ARABIA, JUNE 2010.
2. "CEGP: AN OVERVIEW," *KFUPM*, SAUDI ARABIA, DECEMBER 2012.
3. "CEGP: AUTOMATION OF SEISMIC ACQUISITION SYSTEMS," KFUPM, SAUDI ARABIA, OCTOBER 2014.
4. WEBINAR SPEAKER, SOCIETY OF PETROLEUM ENGINEERS (SPE)'S PETROLEUM DATA-DRIVEN ANALYTICS (PD2A) TECHNICAL SECTION, NOVEMBER 08, 2017.
5. "Machine Learning in Seismic Interpretation: Challenges and Opportunities," SEG Workshop on Machine Learning, Muscat, Oman, April 2019

C3. CONFERENCE PRESENTATIONS WITHOUT PROCEEDINGS

1. G. AlRegib, "Multi-Modal Communications: Chess Game Demo," at *DARPA Tech Day*, Anaheim, CA, Mar. 2004.
2. D. Temel and G. AlRegib, "Depthless Streaming of Depth-Based 3D Videos," at *IEEE International Workshop on Multimedia Signal Processing (MMSP)*, Banff, Canada, Sep. 17-19 2012.

3. G. AlRegib, "3D Video Quality Measures," at *STEM workshop*, Dhahran , Saudi Arabia, Dec. 2012.
4. Alaudah, Y., M. Shafiq, and G. AlRegib, "A Hybrid Spatio-Frequency Approach for Delineating Subsurface Structures in Seismic Volumes," at *SIAM conference on Imaging Science*, Albuquerque, NM, May 23-26 2016.
5. M. Shafiq, T. Alshawi, Z. Long, and G. AlRegib, "The Role of Visual Saliency in Seismic Interpretation With an Application to Salt Dome Delineation," at *SIAM conference on Imaging Science*, Albuquerque, NM, May 23-26 2016.
6. Y. Alaudah and G. AlRegib, "Weakly-Supervised Subsurface Structure Labeling," at *SBGf/SEG Machine Learning Workshop*, Rio De Janeiro, Brazil, 2018.
7. M.A. Shafiq, M. Prabhushankar, H. Di, G. AlRegib, "Bridging Gaps Between Natural and Seismic Image Analysis," at *SBGf/SEG Machine Learning Workshop*, Rio De Janeiro, Brazil, 2018.
8. M. Alfarraj, N. Keni, and G. AlRegib, "Property Prediction From Seismic Attributes Using a Boosted Ensemble Machine Learning Scheme," at *SBGf/SEG Machine Learning Workshop*, Rio De Janeiro, Brazil, 2018.
9. O. J. Aribido and G. Alregib, "Weakly Supervised Structural Interpretation Using Projection Matrices for Latent Space Factorization," at *AAPG 2020 Annual Convention & Exhibition*, Houston, TX, Jun. 7-10 2020.
10. A. Mustafa, M. Alfarraj, and G. Alregib, "A Transfer Learning Approach to Rock Property Estimation Workflows," at *AAPG 2020 Annual Convention & Exhibition*, Houston, TX, Jun. 7-10 2020.

C4. SEMINARS

1. G. AlRegib, "3D Compression: Concepts and Applications," at *The Center for Signal and Image Processing at Georgia Tech*, Atlanta, GA, Seminar, Feb. 2001.
2. G. AlRegib, "3D Graphics Streaming Over Lossy Channels," at *the School of Computer Science, California State University*, Sacramento, CA, Seminar, Apr. 2003.
3. G. AlRegib, "Error-Resilient Streaming of 3D Models," at *the School of Electrical and Computer Engineering, Michigan Institute of Technology*, Haughton, MI, Seminar, Apr. 2003.
4. G. AlRegib, "Multimedia & Immersive Worlds Technologies," at *School of ECE Advisory Board Meeting*, Savannah, GA, Seminar, Apr. 2004.
5. G. AlRegib, "Multimedia Processing and Collaborative Systems," at *GT-ECE Graduate Students Seminars*, Atlanta, GA, Seminar, Sep. 2005.
6. M. A. Aabed and G. AlRegib, "Spatiotemporal Pooling for Different Distortions and Visual Maps for Perceptual Video Quality Assessment â€“ Technical Report," at *Tech. Rep., Multimedia & Sensors Lab, Georgia Institute of Technology*, Atlanta, GA, Seminar, Sep. 2016.
7. G. AlRegib, "Upstream Technologies in the 21st Century," at *GT SEI's Workshop on Energy in the Information Age*, Seminar, Jan. 30 2016.
8. G. AlRegib, "Machine Learning for UG Students," at *Sultan Qaboos University*, Muscat, Oman, Seminar, Apr. 2019.

D. Other Scholarly Accomplishments

D1. PATENTS AND PATENTS APPLICATIONS

1. J. Li, G. AlRegib, W. H. Chen, D. Tian and P. S. Chang, "Reduced Code Table Size in Joint Amplitude and Position Coding of Coefficients for Video Compression," U.S. Patent No. 2009/0087109 A1, granted on Feb. 13 2008.

2. J. Li, G. AlRegib, W. H. Chen, D. Tian and P. S. Chang, "Joint Amplitude and Position Coding of Coefficients for Video Compression," U.S. Patent No. 8,036,471, granted on Oct. 11 2011.
3. J. Li, G. AlRegib, W. H. Chen, D. Tian and P. S. Chang, "Variable Length Coding of Coefficient Clusters for Image and Video Compression," U.S. Patent No. 8,041,131, granted on Oct. 18 2011.
4. J. Li, G. AlRegib, D. Tian, and W. H. Chen, "Context Adaptive Hybrid Variable Length Coding," U.S. Patent No. 8,204,327, granted on Jun. 19 2012.
5. J. Li, G. AlRegib, W. H. Chen, D. Tian and P. S. Chang, "Context Adaptive Hybrid Variable Length Coding," U.S. Patent No. 8,520,965, granted on Aug. 27 2013.
6. M. Solh and G. AlRegib, "Hierarchical Hole-Filing (HHF): Depth Image Based Rendering Without Depth Map Filtering for 3d-Tv," U.S. Patent No. 9,094,660, granted on Jul. 28 2015.
7. G. AlRegib, Y. M. Khalifa, M. J. Mathew, and D. Temel, "Ocular Monitoring Headset," U.S. Patent No. 16/382,363, filed on Mar. 2019.
8. G. AlRegib, M. Chen, D. McCreadie, D. L. Boston, "Color Learning," U.S. Patent No. 83/781,490 , filed on Mar. 2019.
9. G. AlRegib, G. Kwon, M. Prabhushankar, and D. Temel, "Detecting and Classifying Anomalies in Artificial Intelligence Systems, filed on Sept. 4 2020.

D2. PROVISIONAL PATENT APPLICATIONS

1. B.-H Juang, G. AlRegib, and G. Bouzit, "Macro-Micro Kinematics: A New Approach to 3D Object Manipulation and Assembly," GTRC ID 3306, granted on Oct. 2004.
2. G. AlRegib and D. Tian, "Perceptual Evaluation of Progressively Compressed Textured 3D Models," GTRC ID 3300, granted on Apr. 2005.
3. M. Solh and G. AlRegib, "Hierarchical Hole-Filing (HHF): Depth Image Based Rendering Without Depth Map Filtering for 3d-Tv," GTRC ID 5260, granted on Apr. 2010.
4. M. Solh and G. AlRegib, "MIQM: A Novel Multi-View Image Quality Measure.," GTRC ID 5259, No. 61/348,989, granted on May 27 2010.
5. M. Chen, G. AlRegib, and B.-H. Juang, "An Integrated Universal Interface and Control," GTRC ID 5916, granted on Feb. 15 2012.
6. G. AlRegib, B. Bras, D. McReadie, T. AlShawi, M. Aabed, and R. Rahul, "Management of Remote Vehicle Control," Ford Motor Company, Serial No. 62097633, granted on Dec. 30 2014.
7. G. AlRegib and Y. Khalifa, "Automated Eye Drop Device to Improve Patient Compliance and Outcomes," GTRC ID: 7312, granted on Jun. 2 2016.
8. C. Ma, G. AlRegib, "Automated and Robust Fabrics Tracking With Buckling Detection and Occlusion-Prone Capabilities," GTRC ID: 7340, granted on Jun. 22 2016. (officially filed with Yuting as first author)
9. Y. Hu, Z. Long, G. AlRegib, "High-Speed Near-Regular Texture Tracking," GTRC ID: 7341, granted on Jun. 28 2016.
10. G. AlRegib and M. Chen, "Color Learning for Traffic Sign Detection," GTRC ID: 7508, granted on Jan. 2017.
11. G. AlRegib, C. Lehman, and C. Temel, "Hyperpolar Labels and Classification," GTRC ID: 7831, No. 62,633/686, granted on Feb. 22 2018.
12. G. AlRegib, C. Lehman, and C. Temel, "Vision System for Context-Aware Parking Detection," GTRC ID: 7844/7845, No. 62/649,757, granted on Mar. 29 2018.
13. G. AlRegib, C. Lehman, and C. Temel, "Adaptive Thresholding for Hyperpolar Classification," GTRC ID:7846, granted on Mar. 2018.

14. G. AlRegib, Y. M. Khalifa, M. J. Mathew, and D. Temel ., "Lab-On-A-Headset: Multi-Purpose Ocular Monitoring," No: 62/642,279, granted on Mar. 2018.
15. G. AlRegib, M. J. Mathew, and D. Temel, "Transfer Learning for Medical Applications Using Limited Data," No: 62/853,753, granted on May, 2019.
16. A. Mussa and G. AlRegib, "Three Stage Similarity Retrieval," GTRC ID:8136, filed on Apr. 2019.
17. G. AlRegib, M. Prabhushankar, G. Kwon, and D. Temel, "System and Method for Detecting and Protecting Against Deceptive Inputs for AI Systems and Measuring Vulnerabilities of Existing AI Systems," GTRC ID 8263, filed on Aug. 07 2019.
18. G. AlRegib, G. Kwon, M. Prabhushankar, and D. Temel, "Task-Generalizable System and Method for Detecting and Classifying Anomalies in Artificial Intelligence Systems," GTRC ID 8261, filed on Aug. 06 2019.
19. G. AlRegib, and D. Temel, "Method and System for Active Learning With Medical Images Using Limited or No Labels," No. 62/985,085, filed on Mar. 4 2020.
20. G. AlRegib, and D. Temel, "Method and System for Quality Control of Medical Images With Limited or No User Interaction ," No. 62/985,144, filed on Mar. 4 2020.
21. G. AlRegib, and Y. Logan, "Fluid Identification, Segmentation and Quantification in OCT," GTRC ID: 8584, filed on Sept. 28 2020.

D3. Software and Datasets

1. LANDMASS: A Large Post-Migrated Seismic Dataset, Dec. 2014. [Link]
2. S3I: Seismic Simulation, Survey, and Imaging, Version 1, Oct. 2014. [Link]
3. ISI: Interactive Salt Interpretation Tool, Version 1, Dec. 2015. [Link]
4. CURE-TSD: Challenging Un-Real and Real Environments for Traffic Sign Detection, Aug. 2017. [Link]
5. CURE-OR: Challenging Unreal and Real Environments for Object Recognition, Aug. 2017. [Link]
6. Dippykit: A Python Library for Digital Image Processing, Version 2.0.2, Aug. 2018. [Link]
7. CURE-TSR: Challenging Unreal and Real Environments for Traffic Sign Recognition, Nov. 2018. [Link]
8. A Machine Learning Benchmark for Facies Classification, Apr. 2019. [Link]
9. CoMMonS: Challenging Microscopic Material Surface Dataset, 2019.

D4. Demos and Publicity

1. "Mobility Experiment: Remote Repositioning, Atlanta," Ford Media Center, Jan. 06 2015. [Link]
2. "CEO Mark Fields Drives Ford Into the 'Mobility' Business (Post + Podcast)," HuffPost, Dec. 06 2017. [Link]
3. "I Drove Ford's Golf Cart in Atlanta (Note: I Was in Silicon Valley at the Time)," FASTCOMPANY, Jan. 22 2015. [Link]
4. "Ford's Working on a Remote Control for Your Car," WIRED, Jan. 26 2015. [Link]
5. "Remote Valet Mode and Revolutionized Parking: Ford's Smart Mobility," Ars Technica, Feb. 27 2015. [Link]
6. "Ford Opens Lab in Silicon Valley," Bits – The New York Times, Jan. 22 2015. [Link]
7. "Ford Might Just Move the Driver, Not Go Driverless," SLASH GEAR, Jan. 23 2015. [Link]
8. "Live From Ford's 2015 CES Keynote," THE VERGE, Jan. 06 2015. (https://live.cnet.com/Event/Fords_2015_CES_keynote?Page=0) [Link]

9. "Ford at Ces Announces Smart Mobility Plan and 25 Global Experiments Designed to Change the Way the World Moves," Ford Media Center, Jan. 06 2015. [Link]
10. "Ford Opens New Silicon Valley Research Center to Drive Innovation in Connectivity, Mobility, Autonomous Vehicles," Ford Media Center, Jan. 22 2015. [Link]
11. Hosted, by Gill Eapen, on Scientific Sense, a daily podcast focused on science and economics. [Link]

V. SERVICE

A. PROFESSIONAL CONTRIBUTIONS

Editorial Activities

- Technical Reviewer for the following Books and Books Chapters:
  - *The Handbook of Computer Networks* (Wiley), 2 Chapters, 2007
  - *Computer Communications Networks* (Springer), 2 Chapters, 2007
  - *3DTV System with Depth-Image-Based Rendering: Architectures, Techniques and Challenges*, 1 chapter, 2011
  - *3D Visual Communications* (John Wiley), 2011
  - *Geo-Signal Processing: A Digital Signal Processing Prospective for Processing Seismic Data (Cambridge University Press)*, 2011
- Technical Reviewer for the following Magazines, Journals, and Transactions:
  - *IEEE Communications Magazine*, 2007-present
  - *IEEE Trans. on Signal Processing*, 2007-present
  - *IEEE Trans. on Image Processing*, 2001-present
  - *IEEE Trans. on Multimedia*, 2001-present
  - *IEEE Trans. on Circuits and Systems for Video Technology*, 2001-present
  - *IEEE Trans. on Wireless Communications*, 2006-present
  - *IEEE Signal Processing Letters*, 2006-present
  - *IEEE Trans. on Education*, 2007-present
  - *IEEE Journal on Selected Areas in Communications*, 2006-present
  - *ACM Multimedia Systems Journal*, 2004-present
  - *ACM Trans. on Multimedia Computing, Communications, and Applications*, 2004-present
  - *EURASIP Signal Processing: Image Communications*, 2003-present
  - *EURASIP Journal on Applied Signal Processing*, 2007-present
  - *Wireless Communications and Mobile Computing Journal*, 2007-present
  - *Computer Networks Journal*, 2007-present
  - *Journal of Computer Science and Technology (China)*, 2007-present
  - *Tsinghua Science and Technology*, 2007-present
- Technical Reviewer for the following Conferences, Workshops, and Symposiums:
  - *SIGGRAPH*, 2002-present
  - *IEEE Globecom: Ad-hoc and Sensor Networks Symposium*, 2007-present

- *IEEE Inter. Conf. on Acoustics, Speech, and Signal Processing* (ICASSP), 2000-present
- *IEEE Inter. Conf. on Image Processing* (ICIP), 2000-present
- *IEEE Inter. Conf. on Communications* (ICC), 2001-present
- *IEEE Inter. Conf. on Multimedia and Expo* (ICME), 2000-present
- *IEEE Inter. Symp. on Circuits and Systems* (ISCAS), 2001-present
- *IEEE Wireless Communications and Networks Conf.* (WCNC), 2003-present
- *ACM Inter. Wireless Communications and Mobile Computing Conf.*, 2006-2010
- *Int. Conf. on Immersive Telecommunications* (IMMERSCOM), 2007-2009
- *IEE Proc. on Vision, Image, and Signal Processing*, 2006-2008
- *Int. Symp. on Multimedia over Wireless*, 2004-2009
- *EuroIMSA Conference*, 2006

Leadership Activities

- Member, IEEE SPS Image, Video, and Multidimensional Signal Processing (IVMSP) Technical Committee, 2015 – 2017, 2018-2020
- Member, IEEE SPS Multimedia Signal Processing (MMSP) Technical Committee, 2015 – 2017, 2018-2020
- Member, Editorial Board, *IEEE Trans. on Image Processing* (TIP), 2019-present
- Member, SPS Technical Directions Board (TDB), 2019 - 2020.
- Organizing Committee, the joint (AAPG, SEG, SPE) data-oriented conference (EnergyIN data), Austin, TX, June 17-19, 2019
- Guest Editor, *Interpretation* Special Issue on Machine Learning Advances in Seismic, August 2019
- Member, Editorial Board, *Elsevier Signal Processing: Image Communications*, 2014-present
- Technical Program Co-Chair, *IEEE International Conference in Image Processing* (ICIP), Abu Dhabi, UAE, 2020
- Lead Guest Editor, *IEEE Signal Processing Magazine* Special Issue on Subsurface Exploration: Recent Advances in Geo Signal Processing, Interpretation, and Learning
- Tutorial Co-Chair, *IEEE International Conference on Image Processing*, ICIP 2021
- Area Chair, IEEE ICIP'17 TPC
- Area Chair, IEEE ICME'17 TPC, "Image/Video Signal Processing" area
- Area Chair, IEEE ICME'16 TPC, "Image/Video Signal Processing" area
- Area Chair, IEEE ICME'15 TPC, "Multimedia Networking and Communication" area
- Area Editor and Member of Editorial Board, Signal Processing: Image Communication, 2015-2018
- Member, Technical Program Committee, *Khalifa University Internal Research Fund Program*, 2014 – 2017
- Tutorial Co-Chair, *IEEE International Conference on Image Processing*, ICIP 2016

- Member, *IEEE Signal Processing Society (SPS) Technical Directions Board*, 2014-15
- Member, the *5th European Workshop on Visual Information Processing*, Paris, 2014
- Member, TPC, *IEEE International Conference on Image Processing*, ICIP 2014
- Associate Editor, *IEEE Transactions on Circuits and Systems for Video Technology* (CSVT), January 2014- 2017
- Member, TPC of the *International Workshop on Hot Topics in 3D*, ICME 2014
- Co-Chair, Technical Program, *IEEE GlobalSIP* 2014, Atlanta, GA
- Member, TPC of the *International Workshop on Hot Topics* in 3D, ICME 2013
- Member, Committee, SP*IE-EI Conference on Video Surveillance and Imaging Transportation*, 2013
- Member, Program Committee, the *IEEE International Conference on Social Computing* (SocialCom), 2012
- Member, TPC of the *International Workshop on Hot Topics in 3D*, ICME 2012
- Guest Editor, *IEEE Journal on Selected Topics in Signal Processing* (J-STSP), Special Issue on "Emerging Techniques in 3D: 3D Data Fusion, Motion Tracking in Multi-View Video, 3DTV Archives and 3D Content Protection," 2012
- Member, TPC of the *Packet Video workshop*, 2012
- Member, TPC of the *IEEE International Conference on Multimedia and Expo*, ICME 2012
- Member, TPC of the *ICME 2012 Workshop on Human-Focused Communications in the 3D Continuum* (HFC3D)
- Technical Area Chair, *Asilomar Conference on Signals, Systems, and Computers*, 2012
- Member, Program committee of the "*International Conference on 3D Imaging* (IC3D), 2011
- Track Chair, *IEEE International Conference on Multimedia and Expo*, ICME 2011
- Member, TPC of the *International Conference on Image Processing*, ICIP 2010
- Member, TPC of the *International Workshop on Hot Topics in 3D*, ICME 2010
- Member, TPC of the *International Workshop on Hot Topics in 3D*, ICME 2011
- Co-Chair, *IEEE MMTC IG on 3D Rendering, Processing, and Communications*, 2010-2012
- Session Chair, The *First International Workshop on Quality of Multimedia Experience* (QOMEX), 2009
- Member, Technical Committee, The *First International Workshop on Quality of Multimedia Experience* (QOMEX), 2009
- Member, Technical Committee, *Multimedia Signal Processing Workshop*, 2009
- Member, Editorial Board, *Wireless Networks Journal* (WiNET), Jan. 2009-present
- Area Editor (Elect), *IEEE Signal Processing Magazine*, Jan. 2009- Dec. 2011
- Associate Editor, *IEEE Signal Processing Magazine*, Jun. 2006- Dec. 2008
- Co-Chair, Steering Committee, *the Second International Conference on Immersive* Communications (IMMERSCOM), 2009

- General Co-Chair and Co-Founder, *the First International Conference on Immersive Telecommunications Conference* (IMMERSCOM*)*, 2007
- Chair and Founder, Immersive Communications Technical and Business Unit (TAB), *Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering* (*ICST*), 2007-present
- Chair, Special Sessions Program, *IEEE International Conference on Image Processing*, 2006
- Guest Editor, *Advances in Multimedia*, Special Issue on "Multimedia Immersive Technologies and Networking"
- Tutorials Co-Chair, *IEEE International Conference on Image Processing*, 2009
- Session Chair, *First Workshop on IP Multimedia Communications*, 2008
- Member, Editorial Board, *The Open Electrical and Electronic Engineering Journal*, 2007-present
- Member, Technical Program Committee, *International Symposium on Multimedia over Wireless*, 2005-2008
- Member, International Program Committee, *The IASTED International Conference on Internet and Multimedia Systems and Applications* (EuroIMSA 2007 & 2008)
- Member, Technical Program Committee, *IEEE Globecom 2007 Ad-hoc and Sensor Networking Symposium*
- Member, Technical Program Committee, *IEEE Wireless Communications & Networking conference* (*WCNC*), 2008

Memberships

- Society for the Advancement of Science and Tech. in the Arab World, SASTA, 2013 – present
- IEEE, 1999-present
- Association for Computing Machinery (ACM), 2001-2006
- Society for Exploratory Geophysics (SEG), 2013 – present
- SPIE Electronic Imaging, 2013 – present
- Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering (ICST), 2007-2014

B. CAMPUS CONTRIBUTIONS

- Member, International Council, 2017-2019
- Member, Denning Faculty Award Committee, 2018-2019
- Member, Denning Seed Fund Committee, 2018-2019
- Chair, DSP TIG, School of ECE, 2017-2019
- Member, School of ECE Search Committee for Chair of School of ECE, 2017-18
- Member, School of ECE Committee for Strategic Planning
- Member, School of CEE Search Committee for Dickerson Chair, 2016-2017
- Member, Georgia Tech's Strategic Energy Institute (SEI) Faculty Council, Spring 2014 – 2017

- Assisting Georgia Tech's SEI to build bridges with oil and gas companies in the upstream sector, 2013-present
- Assisting Georgia Tech to build strong programs with Saudi Aramco; this effort resulted in a professional Master's Degree in Sustainable Power Systems and a professional Master's degree in Cyber Security among other collaboration programs, 2011 – 2017.
- Together with OIE, developed, maintained, and advised a students' exchange program with KFUPM where up to 30 Junior/Senior level students spend the fall semester on campus taking engineering courses and getting involved in cultural activities, 2009-present. The program morphed into OIE's TECHsplore that has been a model for such hosting of non-degree seeking UG students.
- Developed preparatory program to scholarship awardees from the United Arab Emirates (UAE) who are funded by the Emirates Nuclear Engineering Company.
- Assisted Georgia Tech and Boeing to design offset programs with Saudi Arabia
- Member of the ECE Student/Faculty committee, 2005-07
- Member of the Center for Signal and Information Processing (CSIP), 2003 - present
- Member of the Georgia Tech Broadband Institute (GTBI), 2004 - present
- Undergraduate Mentor, several ECE undergraduate students, spring 2007 – present
- Member of the Student Awards Selection Committee, School of ECE, 2008, 2009, 2011
- Participated in the Georgia Tech Broadband Institute IAB meetings – 2004 – 2009 (poster sessions and roundtables)

C. OTHER CONTRIBUTIONS

- February 09, 2016: participated in a GT CETL Faculty workshop on "*Innate Associations and Faculty Perceptions of Competence Workshop*"
- Served as a mentor at the promotion materials review "speed dating" workshop (GT ADVANCE), February 18, 2016

D. COMMUNITY CONTRIBUTIONS

- Served as a mentor for the non-profit organization, U-Beyond Mentorship, to mentor high school students who are interested in STEM.
- Because the President of U-Beyond Mentorship and emphasized our presence in Clarkston where many immigrants and refugees reside. I repeatedly gave seminars to Clarkston High School students and helped them understand the pathway to higher education.

VI. HONORS AND AWARDS

- Dean's honor list in all semesters of undergraduate studies
- Highest GPA Achievement Award from IEEE, 1996
- Highest GPA Achievements Award from Advanced Electronics Company, 1996
- B.S. with highest honor (GPA: 4.0/4.0) from King Fahd University of Petroleum & Minerals, 1997
- The ECE Outstanding Graduate Teaching Assistant Award at Georgia Tech, 2001
- The Center for Signal & Image Processing Service Award at Georgia Tech, Spring 2003
- The Center for Signal & Image Processing Research Award at Georgia Tech, Spring 2003
- Co-author of the paper "Bit allocation for textured 3D models" that has been among the best 15% accepted papers at *the IEEE Inter. Conf. on Image Processing*, 2004
- Top 10% Paper Award, IEEE MMSP, 2012
- The ECE Outstanding Junior Faculty Member Award, 2008
- IEEE Senior Member, 2010
- Voted as CEO and President of U-Beyond Mentorship, a non-profit organization focusing on mentorship, leadership, and networking, 2016-18
- Won the competition to host the first IEEE SPS Video and Image Processing (VIP) Cup 2017
- Paper on CVS was one of the most downloaded articles on Elsevier Signal Processing: Image Communication, October 2016.
- Received the 2017 Steven A. Denning Global Engagement Award
- McCarty Chair Professorship, 2021 – present
- Ph.D. Student Motaz Alfarraj was awarded the GTA Excellence Award, 2017
- Ph.D. Student Can Temel was awarded the GRA Excellence Award and the Sigma Xi Best Thesis Award, 2017
- Ph.D. Student Zhen Wang was awarded the CSIP Outstanding Research Award, Fall 2017
- Ph.D. Student Motaz Alfarraj was awarded the CSIP Outstanding Service Award, Spring 2018
- Ph.D. Student Amir Shafiq was awarded the CSIP Outstanding Research Award, Spring 2018
- Ph.D. Student Yazeed Alaudah was awarded the CSIP Outstanding Research Award, Fall 2018
- Selected among the 2018 Faces of Inclusive Excellence at Georgia Tech, 2018
- Recognized by several students through CETL as a Great Teacher
- Best Paper Award, *IEEE ICIP* 2019 (out of 960 papers)
- Best Video Presentation of a Special Session Paper, *IEEE ICIP* 2020