UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC. and GOOGLE LLC
Petitioners

v.

SPACETIME3D, INC.
Patent Owner

Case IPR2023-00343[1]
Patent No. 9,304,654 B2

DECLARATION OF SCOTT SCHAEFER IN SUPPORT OF PATENT OWNER'S RESPONSE

[1] Google LLC, which filed a petition in IPR2023-00579, has been joined as a petitioner in this proceeding.

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I, Scott Schaefer, declare as follows:

I. INTRODUCTION

1. I have personal knowledge of the facts and opinions set forth in this declaration, and if called upon to do so, I would testify competently thereto.

2. I am over the age of eighteen (18) and competent to make this Declaration.

3. I have been retained by Patent Owner SpaceTime 3D, Inc. to provide assistance, analysis, and opinions regarding IPR2023-00343 and U.S. Patent No. 9,304,654 B2 ("the '654 patent") as an expert in the field of computer science, and particularly in the area of 2D and 3D graphics and graphical user interfaces. Attached hereto as Appendix A is a true and correct copy of my *curriculum vitae* describing my background and experience.

4. I have been asked to evaluate the validity of the '654 patent in light of the assertions found in Petitioners Apple Inc. and Google LLC's (collectively, "Petitioners") Petition for *Inter Partes* Review of U.S. Patent No. 9,304,654 B2 Under 35 U.S.C. §§ 311-319 And 37 C.F.R. § 42 ("Petition"). (*See* Paper 2) To this end, below are my opinions, and their underlying bases, regarding the person of ordinary skill in the art at the time of the claimed inventions ("POSITA"); the fields of graphical user interfaces ("GUI"), including two dimensional ("2D") and three dimensional ("3D") spaces or environment; the '654 patent; claim construction; the

prior art of record; and the validity of the '654 patent, including why the prior art does not render the '654 patent obvious and why a person of ordinary skill would not have been motivated to make the prior art combinations asserted by Petitioner.

II. BACKGROUND AND QUALIFICATIONS

A. Education and Experience

5. I received a B.S. in Computer Science and Mathematics in 2000 from Trinity University. Afterwards, I attended Rice University and received an M.S. in Computer Science in 2003 and a Ph.D. in Computer Science in 2006. After graduating from Rice University, I began a faculty position at Texas A&M University in 2006 as an Assistant Professor. I was promoted to Associate Professor in 2012 and to Full Professor in 2016. I served as the person in charge of accreditation for our Computer Science degree from 2013-2017. I became Associate Department Head of the Department of Computer Science & Engineering in 2017 and I was appointed Department Head in 2019, a role in which I have served since that time. In 2019 I was awarded the Eppright Professorship in Engineering and was named the holder of the Lynn '83 and Bill Crane '84 Department Head Chair in 2020.

6. I have been awarded multiple awards for my teaching and research activities. I was named a member of the 2008 DARPA Computer Science Study Panel. I was awarded the Gunter Enderle Award in 2011 for my research. In 2012,

I received an NSF CAREER Award for my research work. My research was subsequently recognized in 2015 when I was named the Herbert H. Richardson Faculty Fellow by the College of Engineering. I was also awarded the 2019 TEES Research Impact Award to recognize significant contributions and impact in the area of research. In addition to these awards, I have received multiple best paper awards for my research in the past.

7. I have received multiple teaching awards from the Computer Science & Engineering department for teaching excellence over the years. In 2017, I was awarded the Distinguished Achievement Award in Teaching at the College level. In 2019, I was awarded the Distinguished Achievement Award for Teaching at the University level, one of the highest university honors that is awarded.

8. In addition to my academic experience, I have worked for a number of companies in different capacities. Before becoming involved in academia, I was employed by Southwest Research Institute to work on radio direction finding algorithms for the U.S. Navy in 1999-2000. I worked at WholeBrain Media on early mobile development from 1997-1999 including network communications. At Rare Medium, I performed what is now called full stack development and developed e-commerce platforms for various companies in 2000. I spent time at SensAble Technologies in 2003 developing implicit modeling algorithms for their haptic feedback system. In 2004, I was also employed by a startup company called Mok3

that was developed out of MIT to work on core computer vision algorithms for their image-based modeling software. This product constructed 3D models from sets of photographs of objects. I wrote the code that computed correspondences between images and ran a nonlinear optimization to align the images in 3D so that a virtual model of the object could be reconstructed. I was also employed by Microsoft Research as an intern in 2005 and subsequently as a visiting researcher in 2006 where we worked on a number of surface modeling methods in computer graphics. My work at Microsoft Research motivated the inclusion of what is now called the tessellator unit in DirectX 11, which is an application programming interface ("API") that governs the relationship between multimedia hardware. Every graphics card produced since 2009 has been influenced by my work there.

9. My research broadly lies in the field of computer graphics, though I have worked in many areas of Computer Science as is evidenced by my background. For example, I have researched and published extensively on topics from sampling methods used for rendering to how to represent surfaces and volumes in computer-generated images. My research has been implemented by a number of companies including Microsoft, Pixar, Adobe, and Nvidia. In addition, my work on architectural optimization to create surfaces out of small numbers of discrete panels was used to design and construct a ski lift in Switzerland.

10. In addition, I have served as an Associate or Guest Editor for a number of journals including Graphical Models, The Visual Computer, Computer Aided Design, Computer Aided Geometric Design, Transactions on Visualization and Computer Graphics, Computer Graphics and Applications, and ACM Transactions on Graphics. In addition to this service I have served as papers chair for most major computer science conferences in my area. I also serve on the steering committee of the Geometric Modeling and Processing conference.

11. In terms of instruction, I teach and have developed courses on a variety of topics in Computer Science. I have taught courses in computer graphics, geometric modeling, game development, data structures and algorithms, as well as both our lower level and upper-level undergraduate seminar courses. I also created the Computer Game Development course at Texas A&M University. Besides teaching, I previously served as the faculty advisor for the Texas A&M E-Sports Student Group.

B. Materials Considered

12. My analysis in this Declaration is based on my knowledge and experience. Based on my above-described qualifications in Section II.A, the Patent Trial and Appeal Board should consider me to be an expert in the field. Also, based on my experiences, I understand and know of the capabilities of persons of ordinary

skill in this field at the time of the claimed inventions ("Critical Date"), i.e., September 13, 2005.

13. As part of my independent analysis for this Declaration, I have considered the following: the '654 Patent (EX1001) and its prosecution history (EX1002) and that of the parent applications resulting in U.S. Patent Nos. 7,735,018 (EX2003) and 8,881,048 (EX2004); the background knowledge/technologies that were commonly known to persons of ordinary skill; my own knowledge and experience gained from my work in the field; my experience in teaching and advising others in this field; and my experience working with others involved in this field. In addition, I have reviewed and analyzed the Petition (Paper 2), the publications and materials listed on Petitioners' updated exhibit list (Paper 10), including the Declaration of Henry Fuchs (EX1003), the Patent Owner's Preliminary Response (Paper 6), Petitioners' reply (Paper 7), Patent Owner's sur-reply (Paper 8), the publications and materials listed in Patent Owner's preliminary response, its sur-reply and this Response, as well as the Board's Order Granting Institution (Paper 11).

C. Compensation

14. I am being compensated at my normal hourly rate for my time spent on this proceeding and for expenses incurred as a result of my role as an expert. My compensation is not in any way contingent on my performance, the result of this

proceeding, or any of the issues involved therein. I have no financial interest in the outcome of this case.

III. LEGAL PRINCIPLES REGARDING VALIDITY

15. I am not an attorney. For purposes of this report, I have been informed by counsel of the following legal standards that apply to the issues I address in this report.

A. Validity Generally

16. I understand that the claims of an issued patent are presumed to be valid. The basis for the presumption of validity is the fact that the allowed claims went through a rigorous examination process at the U.S. Patent Office.

17. I understand that Petitioners have the burden of proving invalidity by a preponderance of the evidence, and that the burden of proof never shifts to the plaintiff to prove the validity of the '654 patent.

B. Priority Date

18. I understand that an inventor establishes priority of an invention by conceiving of the invention and reducing the invention to practice.

19. I understand that a patent application may establish priority of invention when it supports all elements of the asserted claims.

C. Anticipation

20. I understand from counsel for Patent Owner that invalidation by anticipation occurs only when a single alleged prior art reference discloses each and every limitation of the claim at issue, either expressly or inherently. In other words, every limitation of the claim must identically appear in a single prior art reference for the reference to anticipate that claim. I also understand that all elements of the claim must be disclosed in the reference as they are arranged in the claim.

21. I understand that to be considered anticipatory, the prior art reference must be enabling and must describe the patentee's claimed invention sufficiently to have placed it in possession of a person of ordinary skill in the field of the invention.

22. I understand that the Petitioners did not assert, and the Board has not instituted, any grounds of unpatentability pursuant to Section 102.

D. Obviousness

23. It has further been explained to me by counsel for Patent Owner that a claim is obvious pursuant to 35 U.S.C. § 103 if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. As such, I understand that a claim is valid unless the differences between the claimed invention and the prior art are such that the subject matter as a whole would have been obvious

at the time the invention was made to a person having ordinary skill in the art to which the claimed invention pertains.

24. It has further been explained to me by counsel for Patent Owner that the following factors are used to make an obviousness determination: (i) the scope and content of the prior art; (ii) the level of ordinary skill in the art; (iii) the differences between the claimed invention and the prior art; and (iv) objective or secondary considerations of nonobviousness. Any relevant objective factors or secondary considerations of non-obviousness, which may include commercial success of a product using the invention, if that commercial success is due to the invention; long-felt need for the invention; evidence of copying of the claimed invention; industry acceptance; the taking of licenses under the patent by others; initial skepticism; failure of others; and praise of the invention.

25. I understand that when a patentee can demonstrate commercial success, usually shown by significant sales in a relevant market, and that the successful product is the invention disclosed and claimed in the patent, it is presumed that the commercial success is due to the patented invention. I also understand that courts may find the commercial success of the infringer and other members of the industry persuasive even though the patentee was not successful with a product covered by the patent.

26. I understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. But multiple prior art references or elements may, in some circumstances, be combined to render a patent claim obvious. I understand that I should consider whether there is an "apparent reason" to combine the prior art references or elements in the way the patent claims. Requiring a reason for the prior art combination protects against the distortion caused by hindsight. Along the same lines, one cannot use the asserted patent as a blueprint to piece together the prior art in order to combine the right ones in the right way as to create the claimed inventions. To determine whether such an "apparent reason" exists to combine the prior art references or elements in the way a patent claims, it will often be necessary to look to the interrelated teachings of multiple patents, to the effects of demands known to the design community or present in the marketplace, and to the background knowledge possessed by a person having ordinary skill in the art.

27. It has further been explained to me by counsel for Patent Owner that the motivation to combine must be more than mere conclusory statements and that a generic motivation to combine known elements is insufficient to establish obviousness. I understand that the motivation to combine prior art references must be identified in the Petition.

28. I understand that when the prior art "teaches away" from combining prior art references or certain known elements, discovery of a successful means of combining them is less likely to be obvious. A prior art reference may be said to "teach away" from a patent when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the patent or would be led in a direction divergent from the path that was taken by the patent.

29. I understand that in developing opinions as to whether or not certain claimed subject matter would have been obvious, each claim of a given patent should be considered in its entirety and separately from any other claims. In so doing, it is my further understanding that while I should consider any differences between the claimed invention and the prior art, I should also assess the obviousness or non-obviousness of the entirety of a claim covering an alleged invention, not merely some portion of it.

IV. PERSON OF ORDINARY SKILL IN THE ART

30. I understand that my interpretation of the patent claims and my validity analysis must be undertaken from the perspective of a hypothetical person of ordinary skill in the art at the time of the claimed inventions or POSITA. In determining the characteristics of a hypothetical person having ordinary skill in the art of the asserted patents at the time of the claimed inventions, I considered several things, including the type of problems encountered in the art, the solutions to those

problems, the rapidity with which innovations are made, the sophistication of the technology, and the education level and experience of people working in the field. It has further been explained to me by counsel for Patent Owner that the relevant timeframe is in or around September 13, 2005.

31. Based on my experience, it is my opinion that a person of ordinary skill in the art at the time of the invention of the Asserted Patent would have had a Bachelor's Degree in Computer Science or a related field, and two years of experience working in the field of computer graphics or graphical user interfaces or GUIs. An individual with less technical education but more experience, or vice versa, could also qualify as a person of ordinary skill in the art.

32. Given my education and professional experience described above and in my *curriculum vitae*, I am in a position to opine on the understanding of a person of ordinary skill in the art of the '654 patent.

V. THE '654 PATENT

A. Description of The Patented Invention

33. The '654 Patent provides "an improved three-dimensional graphical user interface." According to the specification, "[b]ecause the 3D GUI creates the illusion of infinite space in 3D, it can create a visual history of the user's computing session, whereby the user can visit past visual computing events (or a snapshot in

time) by simply navigating to previously recorded states or viewpoints." APPLE1001 at 5:6-11.[2]

34. However, there are times when it is difficult to operate in 3D space. For example, "[i]n certain cases it may be difficult to interact with a file, document, application, desktop or other output within a 3D virtual space." *Id*. at 21:18-22. "This can be the case if the end user is occupying an unfavorable viewpoint in the virtual space." *Id*. As such, the claimed invention allows the user to interact with active applications in 2D space while displaying images of open applications in 3D space, thereby making it easier for the user to identify and switch between open applications.

1. Each Image in 3D Space Must Include an Object (e.g., Window) and Application-Specific Data (e.g., its Contents)

35. The claimed invention does not start in 3D space. For example, Claim 1 of the '654 Patent provides for a GUI where (1) a user provides at least first,

[2] Note that my citations to non-patent literature throughout this Declaration refer to the page number added to the exhibit (and not the original page number of the document). For patents or patent publications, I've used the column/line numbers or paragraph numbers, respectively. Unless indicated otherwise, I have added all emphasis (bold/italics/underline) in any quoted text.

second, and third inputs, (2) corresponding first, second, and third applications are then opened by (a) generating objects having application-specific data, (b) displaying the objects (including application-specific data) on the display device, and (c) allowing the user to modify the application specific data by interacting with a corresponding object. Thus, ***the claims require that active applications including objects and application-specific data are first opened and displayed on the display device***.

36. Then, to enable switching from one open application to another, the GUI *generates* <u>*images of the objects*</u> *(e.g., a window)* <u>*and application-specific data*</u> *(e.g., data)* and displays the images in 3D space, with the image of the application that was last opened or interacted with being displayed in the foreground. APPLE1001 at 37:59–38:18. When the user interacts with a particular image, the corresponding object and application-specific data (as previously displayed) is displayed in 2D space, where the object *replaces* the plurality of images in 3D space, and the user can resume modifying the application-specific data (*e.g.*, where the user left off prior to the generation of images). *Id*. at 38:19-35. In other words, the images identify both the open applications (*i.e.*, the objects) and where the user last left off in each one (*i.e.*, the application-specific data). This allows the user to not only switch from one application (e.g., Microsoft Word) to another (e.g., Internet Explorer), but to one having particular content (*e.g.*, Netflix webpage).

37. When the user interacts with a particular image, the corresponding object and application-specific data (as previously displayed) is displayed (again) in 2D space, where the object *replaces* the plurality of images in 3D space, and the user can resume modifying the application-specific data (*e.g.*, where the user left off prior to the generation of images). *Id*. at 38:19-35.

38. Thus, the applications (including application-specific data) must be opened and displayed before the images can be generated. The images in 3D space allow the user to switch from one open application having specific content to another. Once an image is selected, the images are replaced by the corresponding objects, corresponding to an application, in 2D space (*i.e.*, the previously displayed object and application-specific data), allowing the user to pick up where they last left off.

2. Chronological Presentation of Images in 3D Space

39. With respect to the 3D space, not only are the images of open applications displayed, but they are displayed in an order of use (last opened or interacted with) so that "the user can visit past visual computing events (or snapshots in time) by simply navigating to previously recorded states or viewpoints." APPLE1001 at 5:6-13.

40. As discussed, a feature of the '654 Patent is to provide "a visual history of the user's computing session." *Id*. at 5:6-11; *see also* EX2001 at [42-43]. To this

end, the specification provides that "depth (z) … is also known as time" and that "[t]his notion of expressing depth or time in a visual computing metaphor is important for the creation of a visual history of the end user's computer sessions." APPLE1001 at 2:14-24. By plotting images of applications in 3D space, where the application *that was* <u>*last*</u> *opened or interacted with* is displayed in the foreground, the application *that was* <u>*previously*</u> *opened or interacted with* is displayed in a background, and so forth, "the 3D GUI can function as a visual chronological history of the user's computing session." *Id*. at 5:6-13.

41. This can be seen in Figures 16B and 20 of the '654 Patent (reproduced below), where "an end user selects the helper application called Yahoo! Search … [which] plots the search result in a unique 3D stack 560, which is represented by in the timeline 340 by an icon 562." *Id*. at 12:42-53. "An end user can select another helper application called Yahoo! Image Search … [which] plots the search results in its own unique 3D stack 570 … whereby another icon 572 representing stack 570 is added to the timeline (to the right of the last icon 562)." *Id*. at 12:54-65. "[S]hould an end user create a web-browser page within the virtual space … the new webpage would be drawn in its own 3D stack 580 … [and] would add another icon 582 to the timeline (to the right of the last icon 572)." *Id*. at 12:66-13:8.

42. As can best be seen in Figure 20, this creates "a historical visual chronology of the user's computing session" (*id*. at 19:54-55), with the most recently

opened application, web-browser (580) (or image thereof) being displayed in the foreground of the 3D space, and images of the previously opened applications (Yahoo! Image Search (570) and Yahoo! Search (560)) being displayed in the background of the 3D space.

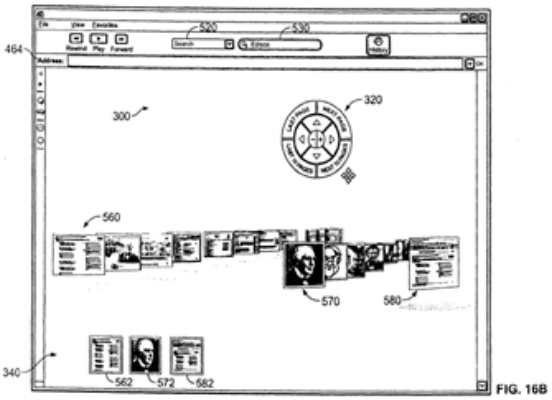


Figure 16B

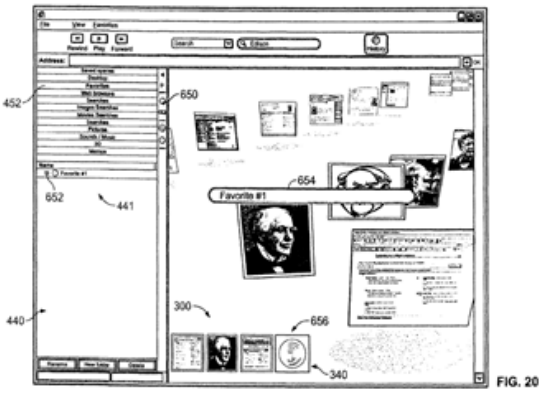


Figure 20

43. The ordering in 3D space (including the timeline) can then be changed based on input from the end user, referred to as a "visual event." "[E]ach new action, initiated as a result of input from the end user or otherwise initiated by programmatic access, that results in a visual event, is … plotted as an icon on the dynamic timeline linear map 340," where "[a] 'visual event' refers to a change in appearance in the 3D virtual space." *Id.* at 11:50-66.

44. This can be seen in Figures 13A and 13B (reproduced below). In Figure 13A, the Microsoft Word application (490) is presented in the foreground, with a

Yahoo! Search application (492) being presented in the background. However, as discussed in Figure 2, a "user input" (22) results in "recalculating geometry" (24) and "redraw[ing] [the] scene" (26), thereby moving the Yahoo! Search application (492) to the foreground, as shown in Figure 13B. In other words, the "input from the end user" on, or the "programmatic access" of, the Yahoo! Search application (492) moves the application to the foreground of the 3D space. *Id*. at 11:50-66.

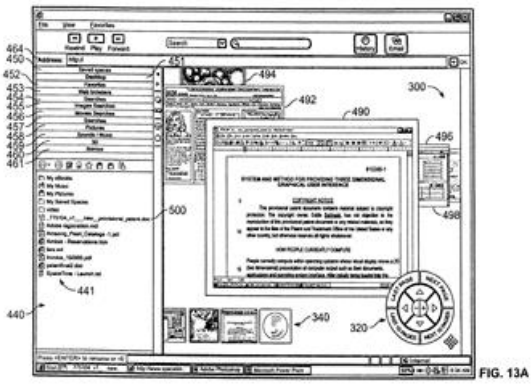


Figure 13A

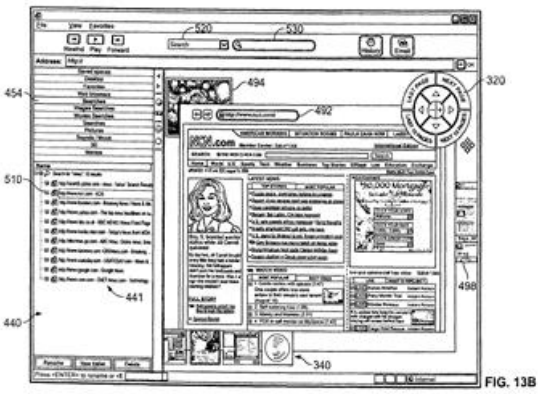


Figure 13B

45. Such a feature is recited in Claim 1 of '654 Patent where the images are displayed in 3D space "in an order based on a last time that said user one of (i) opened said first application and interacted with said first object, (ii) opened said second application and interacted with said second object, and (iii) opened said third application and interacted with said third object, such that a first one in said order is displayed in a foreground of said three-dimensional space, a second one in said order is presented is displayed in a background of said three-dimensional space, behind at

least said first one in said order, and a third one in said order is displayed in a background of said three-dimensional space, behind at least said second one in said order." *Id*. at 38:5-18.

46. By displaying the most recently used application (or an image thereof) in the foreground of the 3D space and the other applications (or images thereof) in the background of the 3D space in the order that they were used, "it can create a visual history of the user's computing session, whereby the user can visit past visual computing events (or a snapshot in time) by simply navigating [along the z-axis] to previously recorded states." *Id*. at 25:52-56; *see also id*. at 2:62-63 and 22:13-14 ("This way, the 3D GUI lets one travel back (visually) in computing time.").

47. It is important to note that the ordering is not based on the creation or editing of *application-specific data* (*e.g.*, a document, etc.), but *the opening or last interaction with a specific application*. Thus, ***the claimed invention orders images in 3D space based on the most recently used applications — not the most recently used documents***.

48. The foregoing features are particularly advantageous in ultra-mobile personal computer ("UMPC") devices. By interacting with individual, active applications in 2D space and navigating through images of applications in 3D space (*i.e.*, a non-conventional technique that exploits the fact that images of applications can be more easily manipulated in 3D space than active applications), the claimed

invention improves the functionality of the UMPC devices (*e.g.*, smartphones) by requiring less power, minimal (or reduced) processing, and smaller screen sizes. EX2001 at [5-12] and [41-43]; EX2014 at [50].

B. Prosecution History Of The '654 Patent

49. During prosecution of the '654 Patent, the Examiner considered and cited several prior art references that are virtually identical to the prior art relied upon by Petitioners. The prosecution histories of the '654 Patent and its parents, the '048 and '018 Patents, were discussed in detail in the Patent Owner's Preliminary Response. *See, e.g.*, Paper 6 at 11-20. Of critical importance are the prior art rejections made in various office actions.

50. During prosecution of the '018 Patent, the Examiner rejected the claims for being unpatentable over Gottesman et al. (U.S. Publication No. 2003/0164827) (EX2005) and Freeman et al. (U.S. Patent 6,725,427) (EX2006). EX2003 at 87-123. Gottesman provides "[a] system and method for presenting search and/or data query results within a virtual three-dimensional environment." EX2005 at Abstract. The 3D environment may include a plurality of containers (*see* Figure 1A at 220A and 220B, reproduced below), where "[each] container may be rendered in the virtual three-dimensional environment." *Id*. at [0031].

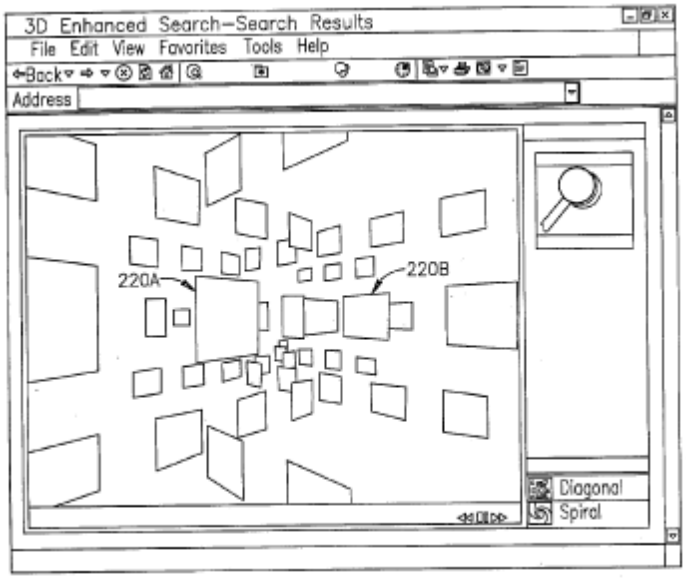


Figure 1A of Gottesman

51. A different three-dimensional ("3D") graphical user interface ("GUI") is disclosed in Freeman, where a "stream" of documents are presented in 3D space. *See*, *e.g.*, Figure 1 (reproduced below).

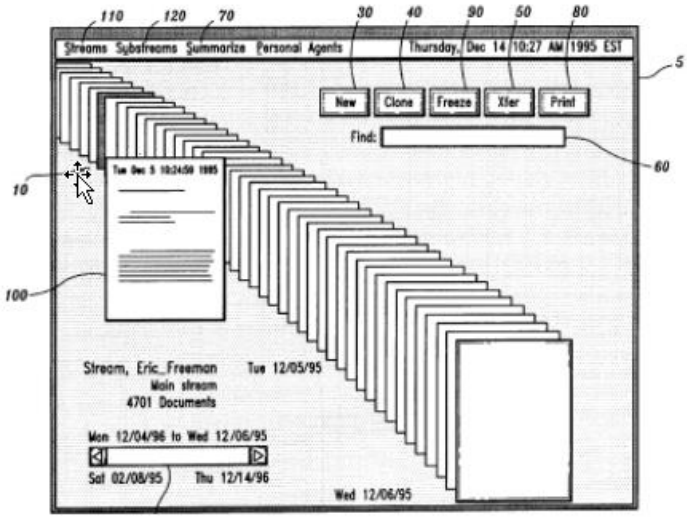


Figure 1 of Freeman

52. During prosecution of the '048 Patent, the Examiner rejected the claims over Gottesman and Prager et al. (U.S. Patent No. 6,768,999) (EX2007). EX1004 at 69-87, 124-143, and 174-192. Prager is similar to Freeman in that it discloses a 3D space that includes a "stream" where "glance views" can be used to display additional information on documents in the stream. This can be seen in Figure 1 (reproduced below).

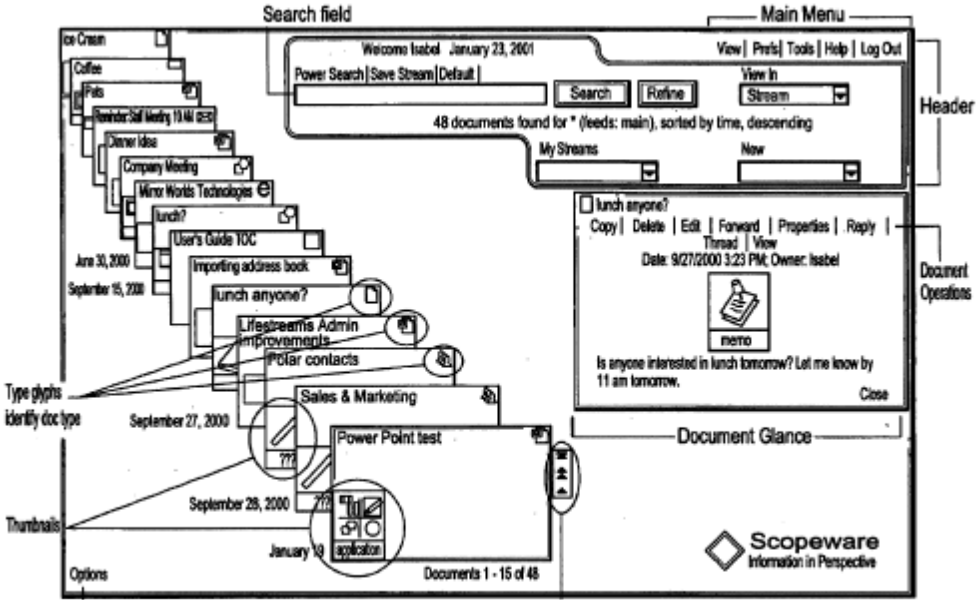


Figure 1 of Prager

53. In an Amendment dated June 27, 2014, SpaceTime3D canceled the pending claims (Claims 1-66), and added new Claims 67-86. *Id*. at 52-62. While the new claims were similar to the previous claims (*e.g.*, where objects are presented in 3D space), they further provided that the user can interact with the first image in

3D space, resulting in the images in 3D space being "replaced" by "the rendered first webpage" within a 2D space where the webpage can be interacted with to acquire (and display) additional information.

54. During an interview, additional amendments were agreed upon to place the claims in condition for allowance. *Id*. at 23-31. In particular, Claim 82 (issued Claim 14) was amended to include the step of "replacing the first and second images within the 3D space with a window within a two-dimensional (2D) space in response to receiving the interaction, wherein the window includes the first webpage." *Id*. Clearly, the Examiner believed that the "replacing" step was critical to the allowance of the '048 Patent.

55. SpaceTime3D then filed a continuation, which resulted in the '654 Patent. Before a first Office Action could issue, SpaceTime3D filed a Preliminary Amendment, cancelling the originally filed claims and adding new Claims 67-86. APPLE1002 at 213-227. Claims 67-86 were similar to the claims that were allowed in the '048 Patent, with the exception of (1) reciting "applications" instead of "webpages," where each application is configured to generate "an object" having "application-specific data," and (2) the images are presented as "a timeline," with the images being presented in an order in which each application was opened or interacted with. *Id*.

56. In the Remarks section of the Preliminary Amendment, SpaceTime3D stated that "[w]hile the pending claims are different in scope than those allowed in the Parent Application (*i.e.*, Serial No. 12/751,879) [the '048 Patent], the[y] are similar in that they include features that were considered allowable subject matter by the Examiner in the Parent Application. For this reason, the Applicant believes that the pending claims (*i.e.*, Claims 67-88) [sic] are in condition for allowance." *Id*.

57. In response, the Examiner contacted SpaceTime3D's counsel, and suggested amendments that would place the claims in condition for allowance. *Id*. at 8-21. Those amendments, which were entered by way of an Examiner's Amendment, provided that the images were presented "<u>in a three-dimensional space</u>," and that, in response to interacting with an image in 3D space, "replacing said plurality of images <u>within said three-dimensional space</u> with one of said first, second, and third objects corresponding to said one of said plurality of application <u>within a two-dimensional space</u> in response to said first interaction, receiving a second interaction by said user with said one of said first, second, and third objects, <u>within said two-dimensional space</u>." *Id*.

58. In allowing the claims, the Examiner stated that "[t]he following is an examiner's statement of reasons for allowance: The present invention teaches ***converting outputs*** of a plurality of applications ***into a plurality of images*** displayed in a three-dimensional space, ***replacing the plurality of images with the output of***

the first application in a two-dimensional space in response to the first user interaction with the first image, and modifying the first application-specific data in response to the second user interaction with the output." *Id*. This together with the Examiner's amendment emphasizes, yet again, the importance of the "replacing" step in the claimed invention. It also emphasizes that the images are of "outputs" of the applications and that an interaction on an image replaces the image with "the output" (*i.e.*, the previous output, thereby allowing the user to resume where they last left off).

VI. CLAIM CONSTRUCTION

59. I am informed that claim terms are construed under the standard provided by the U.S. Court of Appeals for the Federal Circuit in *Phillips v. AWH Corp*., 415 F.3d 1303 (Fed. Cir. 2005) (en banc); 35 C.F.R. § 42.100(b). I am informed that under this standard claim terms are presumed to have their ordinary and customary meaning in light of the patent's specification as understood by a person of ordinary skill in the art at the time of the invention, unless (1) the patentee acts as its own lexicographer by setting out a definition in the specification, or (2) the patentee disavows the full scope of a claim term in either the specification or during the prosecution of the patent.

60. The parties agreed upon the following constructions, which I understand are derived from the *Markman* Order issued by the District Court in

SpaceTime3D, Inc. v. Samsung Elecs. Co., Ltd., et al., No. 2:19-cv-00372-JRG (E.D. Tex.). EX2011. I have applied these constructions in my analysis below.

Term or Phrase	Agreed Upon Construction
"3D space"	"a virtual space defined by a three-dimensional coordinate system"
"2D space"	"a finite graphical area defined by a two-dimensional coordinate system"

61. For the purposes of this IPR, the remaining terms should be interpreted as they would have been understood by a person having ordinary skill in the art considering the context of the claims themselves, the specifications, the figures, the prior art, and the prosecution history. Consistent with these constructions and interpretations, I have considered the claims in light of their ordinary meaning to one skilled in the art and consistent with my experience in the relevant field given its ordinary and customary meaning as they would be understood by a POSITA in the context of the '654 Patent's specification and prosecution history. One such term is "replacing." This term is not a term of art. Indeed, Petitioners' expert confirmed that he also interpreted "replacing" as having its ordinary meaning. A person of ordinary skill in the art having read the specification and applying the proper interpretation would have understood that "replacing" means to "take the place of." *See e.g.*, EX2018; *see also* APPLE1001 at 2:24-27, 35-39; 18:44-54; 26:17-31; 38:25-29.

62. I understand that the Petitioners have asserted that, based on the Samsung's Court's construction of 3D space, in determining the presence of a 2D or 3D space, it is irrelevant whether the objects themselves are 2D or 3D and that what is important is the space in which the objects reside. Thus, for example, a 2D application (or image thereof) can exist in 3D space. By way of another example, Claim 1 requires that the images in 3D space are replaced with a corresponding application "within a two-dimensional space." APPLE1001 at 38:25-29. While an image may appear two dimensional, that does not define the space in which the image exists. I agree with Petitioners' position and it is my opinion that a POSITA would have understood that while an image may appear two dimensional, that does not define the space in which the image exists.

VII. OVERVIEW OF PETITIONERS' PRIMARY REFERENCES

A. Anthony

63. In Grounds 1A and 2A, Petitioners rely on Anthony (APPLE1007). Anthony is similar to prior art 3D GUIs that were considered during prosecution, where everything takes place in 3D space. *See supra,* Section V.B (discussing Gottesman, Freeman and Prager).

64. As shown in Figure 4 (reproduced below), files or folders are presented in a "dynamic timeline" in a 3D environment, where the items are placed "in some logical order using an attribute shared by each of the items." APPLE1007 at [0011].

One item in the group (*e.g.*, a file or a folder) is designated by the user (*e.g.*, by clicking on it) as "a focal group" and "is displayed at a primary point of focus in the GUI." *Id.*; *see also id*. at [0066] ("the focal group 509 may be placed in the front and center of the GUI view"). "The remainder of the groups are displayed on either side of the focal group based on their ordering … such that … [they] appear to be less prominent to the user than the focal group." *Id*. at [0011] and [0012].

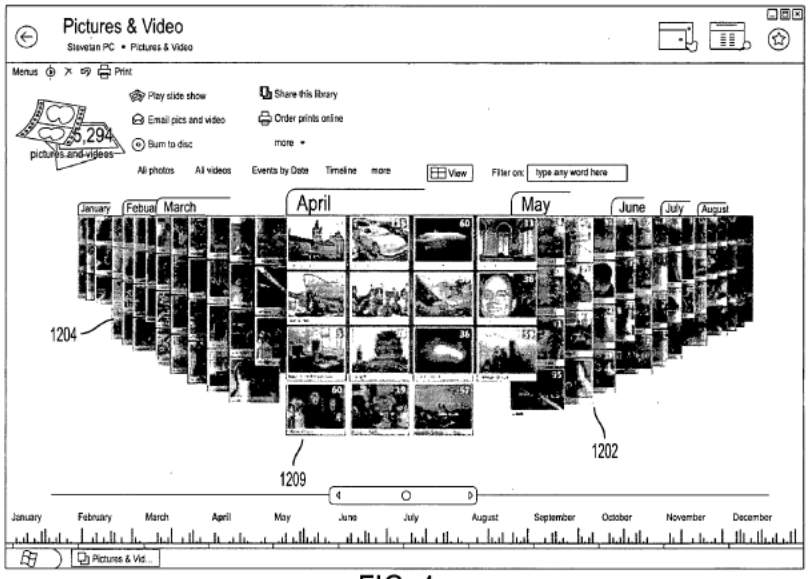


FIG. 4

65. In Figure 4, the focal group are digital pictures that were taken in April. "When the user selects a new focal group [*e.g.*, May, as shown in Figure 12A], the system may initiate a series of steps to animate the process of changing focus from one group of icons to another." *Id*. at [0059]. In other words, "the GUI is updated to reflect the view from the conceptual camera's position." *Id*. at [0060]. "[T]he

conceptual camera provides for a 'zooming' effect that ***allows the focal group 509 to always remain fully visible in the foreground***, more prominently displayed, while ***the non-focal groups recede to the background***, less prominently displayed on either side of the focal group, according to the ordering attribute." *Id*. at [0050] (emphasis added).

66. In Anthony, ***the dynamic timeline is <u>three-dimensional</u>*** and is ***presented exclusively <u>in a 3D environment</u>***. *See*, *e.g.*, *id*. at [0043] ("[T]hree dimensional (3D) graphics technology may be used to provide the dynamic timeline view in a 3D environment."). If the user clicks on a non-focal group, it is animated to the foreground of the 3D space (becoming the focal group). *See*, *e.g.*, *id*. at [0059] ("When the user selects a new focal group, the system may initiate a series of steps to animate the process of changing focus from one group of icons to another."). If the user double-clicks on the focal group, then the item is presented in the 3D environment, either by "attempt[ing] to open the file" (*e.g.*, if the item is a file) or presenting the item on a new timeline (*e.g.*, if the item is a folder). *See*, *e.g.*, *id*. at [0047]. Either way, all objects are presented in 3D space. In fact, the only mention of 2D GUIs in Anthony is in the prior art, all of which are criticized. *See*, *e.g.*, *id*. at Figures 2 and 3 and [0004-0008] ("Although these techniques [used with 2D GUIs] are useful in organizing smaller grouping of files and folders, as the number of files increases, these techniques become less and less effective.").

67. Petitioners acknowledge the exclusive 3D nature of Anthony and only cites to this reference for its disclosure of a timeline in a 3D space where items are displayed chronologically. However, in the claimed invention, it is the images of the *applications and their content (objects with application-specific data)* that are arranged based on the last time the applications were opened or interacted with. In Anthony, the timeline is *not for applications*, but *for files*. Anthony points out that with the advent of digital cameras, hundreds if not thousands of digital photograph images may be stored on a computer and that it can be very difficult to view, find and select a particular image. *Id*. at [0003-0004]. The solution in Anthony is to present the images (or folders containing images) in a "dynamic timeline," where the items are arranged chronologically, or "using a date of creation or date of edit attribute as the ordering attribute." *Id*. at [0042]; *see also id*. at Figure 3 (showing that files can be arranged by name, type, size, or date).

68. Thus, while Anthony may allow a user to quickly find a file from thousands of files, in contrast the claimed invention allows a user to quickly switch from one application to another, where each *application* is (a) presented in the order in which *it was last opened or used* and (b) presented so that the user can see where they last left off (by capturing images of the application-specific data).

69. Petitioners argue that Anthony is not limited to images but can also be used to arrange other files chronologically, including "Excel spreadsheets." Pet. at

13. While it is true that the timeline in Anthony can be used to display other files (*i.e.*, Excel files), it does so based on the last time the *file* was opened or edited—not the last time the *application* (*e.g.*, Excel) was opened or interacted with. It would make no sense to present applications in an order that they were created. Users rarely, if ever, care about when applications were created or last used. Instead, users are looking for recent files (*e.g.*, files that were last created, edited, or saved). Thus, ordering applications as claimed would appear random and have little if any value to the user.

70. A POSITA would have understood that Anthony discloses that *files are presented in a 3D timeline* and arranged based on an ordering attribute. The *open applications, however, are identified on the taskbar*. *See, e.g.*, APPLE1007 at Figure 4 (bottom left corner). This is because the number of open applications is negligible compared to the number of files stored on the computer. As such, a POSITA would not have used the 3D timeline of Anthony to present open applications in the order in which they were last used. Not only would this be duplicative of the taskbar, but those skilled in the art would have understood that Anthony teaches that the "[prior art] techniques are useful in organizing smaller groupings of files and folders." *See also* APPLE1007 at [0008].

B. Hanggie

71. Hanggie (APPLE1006) describes a "3D compositing desktop window manager" for presenting content in a 3D space, including content that was originally configured for presentation in a 2D space. *Id*. at [0001]. Such content may include, for example, content for "Microsoft Windows® XP … [which] employs the 2-dimensional Graphics Device Interface (GDI) graphics rendering engine to render the display." *Id*. at [0008]. Hanggie *transforms* this content using a "3D compositing desktop windows manager" referred to as a "CDWM," which "uses advanced textures, lighting, and 3D transformations" to present the content in a 3D environment. *Id*. at [0012] and [0025].

72. "In order to draw the window in 3D, the CDWM may define the window anatomy using various components, including a base content object and one or more child content objects." *Id*. at [0057]. As shown in Figure 3 (reproduced below), [t]he frame or base content 303 of the window 301 may host child content including buttons 305 (e.g., used to restore, maximize, minimize, close the window, etc.), and indicative icon 307, scrollbars 309, menu bar 311, and window caption text 313." *Id*. at [0058].

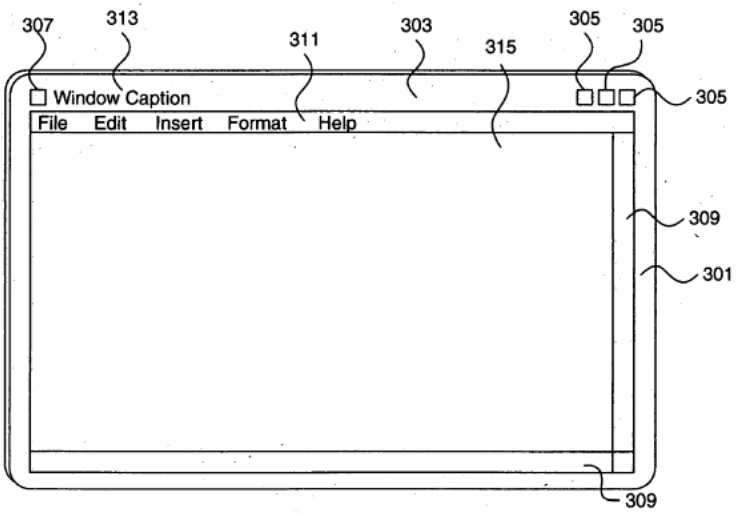


FIG. 3

73. Hanggie provides that both the window and its contents are active in 3D space. To this end, Hanggie provides:

> ***The CDWM maps mouse hit-test points*** relative to application-defined, content-local, 3D coordinates, ***and delivers mouse event notifications to the application***. … Examples of system-managed content objects ***include the application indicative icon, frame buttons (e.g., minimize, restore, close), caption text, and certain menu bars***. Application-managed content objects include those content object(s) to which the application renders its primary visual output, e.g., ***text by a word processor, numeric grid by a spreadsheet application, or images by a photo editing application***.

Id. at [0060]. Thus, not only can the window be interacted with in 3D space (*e.g.*, to maximize the window, to minimize the window, to close the window, etc.), but so too can its contents (*e.g.*, to alter text in a Word® document, to alter numeric entries in an Excel® document, etc.). As such, Hanggie operates exclusively in 3D space.

74. Hanggie does provide that there are times when its CDWM (*i.e.*, 3D transformation) should not be used. First, "in systems that do not have the video hardware necessary to efficiently perform the processor intensive calculations required for desktop compositing (e.g., in systems with low video memory, or with no 3D acceleration hardware) the CDWM and/or the operating system may allow the user to select whether the composite or legacy drawing mode should be used." *Id*. at [0092]. Second, legacy drawing mode may also be selected "based on power-conservation conditions. For example, when a portable device is disconnected from AC power source and switches to battery power, the operating system, may enforce legacy drawing mode." *Id*.

75. However, a POSITA would not be motivated to switch from 3D to 2D when the user maximizes a window. Hanggie discloses various lighting effects that are advantageous to rendering windows whether or not the window is maximized including the use of diffuse reflections (*Id*. at [77]), specular reflections (*Id*. at [78]), reflectivity (*Id*. at [79]), and refraction (*Id*. at [80]). Simply maximizing a window

would not motivate a POSITA to disable the CDWM (3D rendering) and all of these effects. Moreover, Hanggie describes at length the benefits of transparency (*Id*. at [93]) or simulated frosted glass, which "provides a rich user experience that makes a GUI of the present invention more desirable." *Id*. at [94]. Moreover, the frosted glass "aids the user to understand window layer order in a multi-window environment." *Id*. at [95]. "[T]he physically modeled distortion of the background" "allows the user to immediately distinguish between background and foreground content." *Id*. at [95]. In addition, "frosted glass makes it easier for a user to read and/or view content on the screen." *Id*. at [96]. Even a maximized window will have windows behind it in a multi-window environment and thus benefit from the frosted glass effect described by Hanggie as well as other rendering effects. Therefore, a POSITA would not be motivated to return to 2D rendering and thus a 2D space in the case of a maximized window and forego all of the other benefits of 3D rendering described by Hanggie.

76. Even if a POSITA would have been motivated to switch from 3D to 2D as Petitioners contend (they would not), the claimed inventions require much more than Hanggie discloses. For example, Claim 1 requires (1) the opening and displaying of active applications, including objects and application-specific data, (2) generating and displaying images of the objects and application-specific data in 3D space, and, in response to an interaction on a particular image, (3) replacing the

images with the corresponding active application (or the object and application-specific data as previously presented) in 2D space, where the application-specific data can be further modified.

77. In Hanggie, regardless of whether the system is operating in CDWM or legacy drawing mode (3D or 2D), the windows are always active. Hanggie gives the appearance of 3D by using "3D graphics and animation, shadows, transparency, advanced lighting techniques and other rich visual features on the desktop." APPLE1006 at [0026]. However, both the window (*e.g.*, object) and its contents (*e.g.*, application-specific data) are always active.

78. This can be seen in Figure 3 (reproduced above), where an exemplary 3D window (301) includes buttons (305), scrollbars (309), and menu bars (311), all of which can be interacted with in 3D space. *Id*. at [0058]. It also includes a "primary content object area 315" (*id*.), or "[a]pplication-managed content objects including those content objects to which the application renders its primary visual output, e.g., text by a word processor, numeric grid by a spreadsheet application, or images by a photo editing application" (*id*. at [0060]). The user can interact with the content (or application-specific data) by "mapp[ing] mouse hit-test points relative to application-defined, content-local, 3D coordinates, and deliver[ing] mouse event notifications to the application." *Id*. Thus, while the selection of CDWM or legacy drawing mode may determine whether windows are displayed in 3D or 2D space, ***it***

does not result in "replacing" images of open applications with active applications as claimed.

79. Petitioners argue that the "frame buttons" in Hanggie—specifically the "maximize" button—enables "selection between 2D and 3D viewing mode." Pet. at 25. First, a POSITA would have understood that this is not true as maximizing a window merely results in the window being enlarged in 3D space—it does not switch from a 3D space to a 2D space as Petitioners contend. Second, those skilled in the art would not have found it obvious to implement Hanggie's method of switching to 2D as doing so would eliminate (or disable) many of the advantages touted in Hanggie (*e.g.*, various lighting effects, reflections, refractions, transparency, etc.). Finally, even if a POSITA would have been motivated to switch from CDWM to legacy drawing mode in response to window being maximized, *e.g.*, to save power, this still would not result in the claimed "replacing" feature.

80. As discussed above, in the claimed invention, an application is opened and a corresponding object having application-specific data is generated and displayed on a display device, where the user can interact with the object to modify the application specific data. For example, if the user opens the application Microsoft Word®, a Word® document (application-specific data) in a window (object) having a window bar (*e.g.*, maximize, minimize, etc.) and a menu bar (*e.g.*, file, edit, view, etc.) would be displayed on the display device. *An image of the*

object <u>*and*</u> *application-specific data would then be captured* and presented (along with other images corresponding to other applications and their application-specific data) in 3D space. Interacting with the image in 3D space would result in replacing the image in 3D space with the Word® document in the window in 2D space, allowing the user to (again) interact with the object to modify the application-specific data.

81. In Hanggie, clicking on the "maximize" button does not result in the claimed *"replacing"* <u>*an image of the application*</u> *(object and application-specific data) in 3D space with* <u>*an active version of the application*</u> *in 2D space*. As discussed in Section V, the Examiner only allowed the '048 Patent (*i.e.*, the parent patent) after the claims were amended to include the "replacing" step (EX2004 at 17-31), and only allowed the '654 Patent after the claims were amended to provide that what is being "replaced" is "said plurality of images within said three-dimensional space with one of said first, second, and third object corresponding to said one of said plurality of applications within a two-dimensional space" (APPLE1002 at 8-21).

82. With respect to the above-identified Word® example, switching from 3D to 2D requires ***replacing*** an ***<u>image</u> of the Word® application (object and application-specific data)*** with an ***<u>active version</u> of the Word® application***. In Hanggie, the window is merely being enlarged, or maximized, and (at best)

displayed in 2D space. As such, Hanggie fails to disclose "replacing" anything with anything, let alone an image with an active application as claimed.

83. Not only does Hanggie not disclose the claimed invention, but it actually teaches away. Hanggie provides that a reversion to legacy drawing mode may be accomplished automatically "based on power-conservation conditions." *Id*. at [0092]. Thus, to reduce power consumption, Hanggie teaches disabling the CDWM (3D), whereas the claimed invention generates and displays images in 3D space, as images are easier to manipulate, skew, etc., in 3D space than the actual active applications. In other words, Hanggie displays active applications in 2D space, where the claimed invention displays images of open applications in 3D space.

C. Matthews

84. In Grounds 1B and 2B, Petitioners rely on U.S. Patent Publication No. 2006/0107229 ("Matthews"), but only with respect to dependent claims 6, 9, 14, and 18. APPLE1008. Matthews discloses a 3D GUI that "utilizes a three-dimensional transformation to move a presently displayed work area, for example a desktop with open windows, revealing a background presentation area behind it." *Id*. at Abstract.

85. Petitioners rely on Matthews only for its disclosure of a 3D space that includes a desktop (dependent Claims 6 and 14) and a web browser (dependent Claims 9 and 18). However, because this reference is only being cited with respect

to dependent claims, it has been explained to me that if Grounds 1A and 2A (involving Anthony and Hanggie) relating to the independent claims are denied, then so too must Grounds 1B and 2B (further involving Matthews) because a dependent claim cannot be found to be obvious when the claim from which it depends is found to be nonobvious.

VIII. THE CLAIMS OF THE '654 PATENT ARE NOT OBVIOUS

A. Petitioners Fail To Show That The Asserted Prior Art Teaches Or Suggests All Elements Of The Challenged Claims

1. Combining Anthony and Hanggie Does Not Disclose The Claimed Limitations (Grounds 1A and 2A)

86. Grounds 1A and 2A are Petitioners' only challenge to the independent claims of the '654 Patent, *i.e.*, Claims 1, 10, and 19. Therein, Petitioners argue that Hanggie discloses the claimed "replacing" feature, and only relies on Anthony for its disclosure of arranging items chronologically in 3D space.

87. As discussed above, a critical feature of the invention is how open applications are presented to the user in 3D space and how the user then interacts with a particular application in 2D space. In the '018 Patent, this was done by mapping interactions on an image of a webpage in 3D space to a rendered version of the webpage (off screen). The '654 and '048 Patents provide for a different sequence of events—events involving the opening and displaying a plurality of

applications (objects and application-specific data), allowing the user to modify the application-specific data, displaying images of the open application and application-specific data in 3D space, and replacing the plurality of images with a single, active application in 2D space, where the application is selected based on the interaction with one of the plurality of images in 3D space.

88. A POSITA would have understood that it was customary in GUI design for everything to occur in one space. By way of example, in Microsoft Windows®, everything occurs on a single desktop GUI. The same is true for Anthony and Hanggie, where everything occurs on a single 3D GUI. There is no switching from one space to another. These GUIs are generally designed for personal computers (PCs) having unlimited power and relatively powerful processors (*e.g.*, Pentium). However, on mobile devices, having relatively small displays, limited battery life, and limited processing power, it is neither feasible nor efficient to present a plurality of active webpages in a 3D space where items are skewed, manipulated, etc.

89. Thus, SpaceTime3D did what was counterintuitive—going from a 3D environment, where only images are presented, to a 2D environment, where only one active application is presented for interaction. Switching environments allows the user to go from a first environment (a 3D space) where a user can navigate through a plurality of images of applications and select a particular one, to a second environment (a 2D space) where the user can interact with an actual, live version of

the selected application. Not only does this require going from a 3D space to a 2D space, it also requires the actual, active application to "replace" the plurality of images.

90. Those skilled in the art would have appreciated that the image that is displayed in 3D space is not just an image of the application but ***an image of <u>its associated object</u> (e.g., a window) <u>and application-specific data</u> (e.g. the window's content)*** as previously opened and displayed on the display device. That way ***when the user is scrolling through the images in 3D space, <u>the user can see both the open applications and where they last left off on each application</u>***. For example, Claim 1 provides "generating a plurality of images … wherein said first image is an image of at least a portion of a first object generated by said first application and having first application-specific data." APPLE1001 at 37:59-38:4.

91. The same is true for the corresponding application that is displayed in 2D space. The interaction with an image does not result in the corresponding application being opened but displaying the previously opened version of the application including the application-specific data, so that the user can resume where they last left off. To this end, Claim 1 provides "replacing said plurality of images within said three-dimensional space with one of <u>said</u> first, second, and third objects corresponding to <u>said</u> one of said plurality of applications within a two-dimensional space … receiving a second interaction … and modifying <u>said</u> one of <u>said</u>, first,

second, and third application-specific data in response to said second interaction." APPLE1001 at 38:25-35 (emphasis added). A POSITA would have understood that the use of the term "said" refers to the first, second and third images of at least a portion of a first, second and third objects generated by said first, second and third applications and having application-specific data.

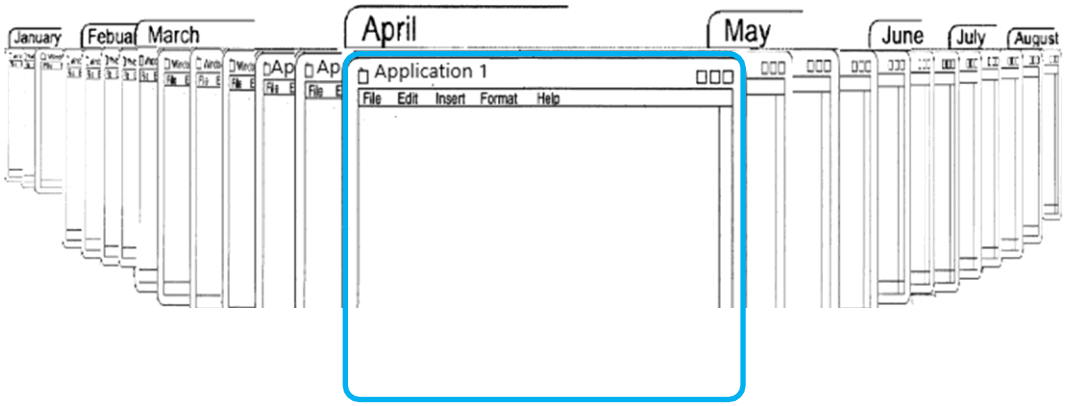
92. By displaying "said … object" in 2D space and allowing the user to modify "said … application-specific data" (*i.e.*, the object and application-specific data that was displayed on the display device prior to the image being generated), the user can pick up where they last left off. As such, the claimed invention is not merely a way to open an application or a file but to switch from one open application to another to allow the user to resume "where the user last left off [with] the items that were output … staged just as they were [prior to switching applications]." APPLE1001 at 20:32-38.

2. Anthony and Hanggie do not Disclose the Claimed Chronological Order Where Images are Displayed Based on When the Application was Opened or Interacted With

93. Petitioners rely on Anthony for its disclosure of displaying items in a 3D space based on an "ordering attribute." In one embodiment, the selected "ordering attribute" is chronological, "e.g., by using a date of creation or date of edit attribute as the ordering attribute." APPLE1007 at [0042]. However, as Petitioners

point out, it is "*data objects*" (*e.g.*, digital photograph images, etc.) that are arranged based on the ordering attribute, not applications. Pet. at 23-24.

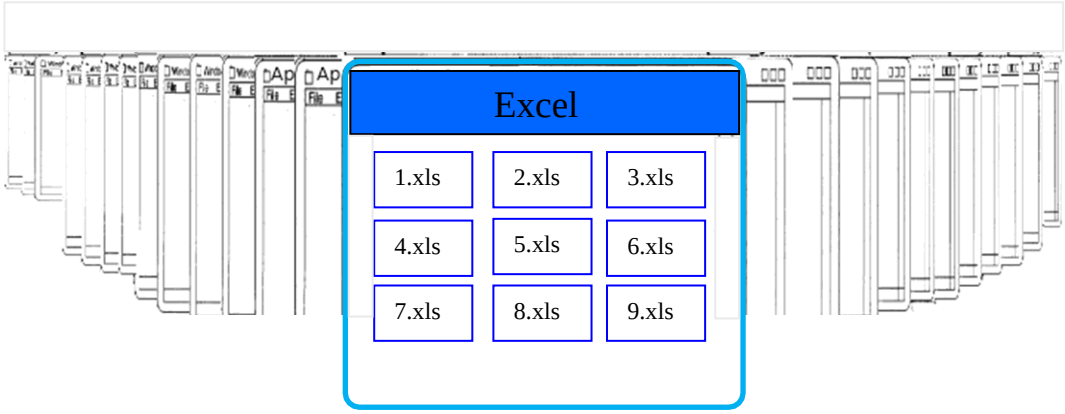
94. Petitioners argue that "a POSITA would have understood and found it obvious that a plurality of application windows could be organized and represented within Anthony's timeline" (Pet. at 24) and provided an *annotated* version of Figure 4 from Anthony, replacing the plurality of photographs from different time periods with individual applications (Pet. at 25) (reproduced below).



Petitioners' Annotated Version of Figure 4

95. As discussed above, the 3D timeline in Anthony is for "displaying files and folders." APPLE1007 at Abstract. While Anthony does provide that "file type" can be an ordering attribute (*id*. at [0042] and [0049]), this attribute would allow the user to locate "files or folders" for a particular application. Thus, a POSITA would have understood that a more accurate annotation of Figure 4 according to Anthony's

teaching would be as follows, thereby allowing a user to more easily locate files or folders for a particular application.



Patent Owner's Annotated Version of Figure 4

96. While the individual files or folders (*e.g.*, 1.xls, 2.xls, etc.) within the application (*e.g.*, Excel, etc.) may be ordered by name, size, date, etc. (*see id.* at Figure 3), a POSITA would have understood that this would not result in the claimed invention where individual applications are displayed in an order based on a last time that each application was opened or interacted with by the user and that it would also not be an obvious modification. First, those skilled in the art would have understood that doing so would not "allow the user to more easily … find a desired file or folder." *Id*. at Abstract. In this case, the ordering would not be dependent on folders or files but applications. While an application may open a file, it would not help finding a particular file and applications typically do not open folders as part of their

application specific data. Even if they did, ordering by when an application was opened or interacted with would not have any relationship to finding a particular folder.

97. Second, displaying an "application window," as Petitioners suggest, would not allow the user to view the application where the user last left off. In Anthony, once a file is located, "double-clicking the file will cause the system to attempt to open the file." APPLE1007 at [0047]. In contrast, in the claimed invention, the applications are already opened and populated with application-specific data. This is important as the user should be able to determine in 3D space which applications are open and where the user last left off.

98. Finally, Anthony teaches that the taskbar is sufficient to illustrate open applications. *See, e.g.*, APPLE1007 at Figure 4 (bottom left corner). Thus, while a POSITA purportedly may have been motivated to use the 3D timeline to display stored files based on application type (as shown in Patent Owner's annotation version of Figure 4, above), the applications themselves would not be arranged in the order in which they were last used. Those skilled in the art would have understood that Petitioners' argument to the contrary is merely another example of impermissible hindsight.

99. Those skilled in the art would have understood that it would make no sense, nor would it be obvious, to use the 3D timeline to present open applications

in an order in which they were last used. Support for this can be found in Anthony, where *saved files are presented in a 3D timeline*, whereas *open applications are presented on the taskbar*. *See, e.g.*, APPLE1007 at Figure 4 (bottom left corner); This is due to the number of open applications (relatively small) versus the number of stored files (relatively large). Not only would the modification suggested by Petitioners be duplicative of the taskbar, but, according to Anthony, "[prior art] techniques are [sufficient] in organizing smaller groupings of files and folders." APPLE1007 at [0008].

100. A POSITA would have understood that Hanggie cannot make up for this deficiency in Anthony because it does not disclose any order for displaying items in 3D space, let alone the claimed order. For this reason alone, the combination of Anthony and Hanggie as set forth in Grounds 1A and 2A does not render Independent Claims 1, 10, and 19 obvious.

3. Anthony and Hanggie do not Disclose "Replacing" Images of Both Objects (*e.g.*, Windows) and Application-Specific Data (*e.g.*, the Windows' Contents)

101. There is no dispute that Anthony does not disclose or suggest a 2D space or going from a 3D space to a 2D space. Instead, Petitioners argue that this feature is disclosed in Hanggie. According to Petitioners, Hanggie teaches "control buttons, with the buttons for enabling selection between 2D and 3D viewing modes." Pet. at 25. In particular, Petitioners argue that the "control buttons" allow the user

to "close, minimize, maximize, or restore a window" and that clicking on the "maximize" button "would result in Anthony's user interface switching from a 3D timeline view … to a 2D view of the maximized window." *Id*. at 26-27.

102. The claims, however, require more. They do not merely require going from 3D to 2D but "replacing" *a plurality of images* in 3D space with *an active application* in 2D space, where the images include *both objects and application-specific data*. However, a POSITA would have understood that Hanggie does not generate images but displays active applications in 3D space. In fact, this is why the window shown in Figure 3 of Hanggie can be "maximized," *i.e.*, because it is active. But it is not just the window that is active of Hanggie—so too is the content (*e.g.*, application-specific data). Petitioners' expert agrees. EX1003 at ¶ [111] ("As is known in the art, in response to a user entering a key on a keyboard when interacting with a Microsoft® Word® application window, application-specific data, such as the text content in the window is modified to reflect the input key."); EX2016 at 31:4-40:5, 40:7-42:18, 43:11-45:5, 47:12-51:13, and 70:5-71:16 (testifying regarding the functionality of control buttons 305 in context of Dr. Fuchs' self-generated composite figure of Hanggie Fig. 3 and Anthony Fig. 4).

103. As discussed above in Section VII, Hanggie describes a "3D compositing desktop window manager" for presenting content in a 3D environment. APPLE1006 at [0001]. "In order to draw the window in 3D, the [3D compositing

desktop window manager] may define the window anatomy using various components, including a base content object and one or more child content objects." *Id*. at [0057]. As shown in Figure 3 (reproduced below), "[t]he frame or base content 303 of the window 301 may host child content including buttons 305 (e.g., used to restore, maximize, minimize, close the window, etc.), and indicative icon 307, scrollbars 309, menu bar 311, and window caption text 313." *Id*. at [0058].

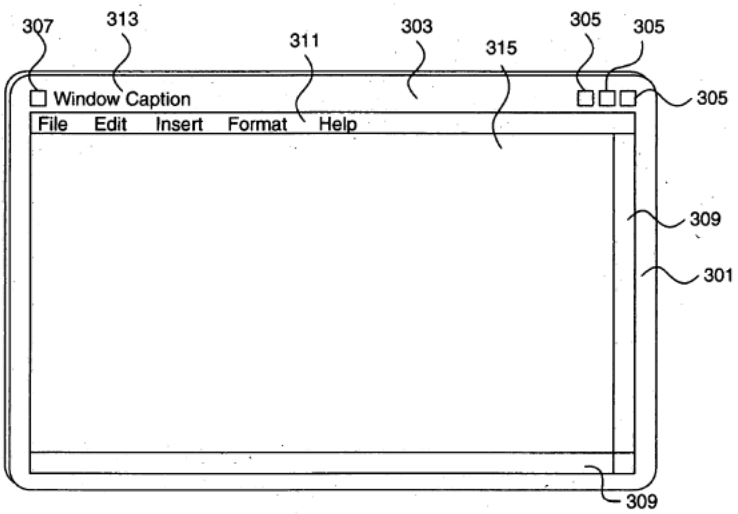


FIG. 3

104. A POSITA would have understood that Hanggie provides that not only can the window be interacted with in 3D space (*e.g.*, by minimizing, maximizing, scrolling, etc.), but so too can the contents of the window (*e.g.*, "text by a word processor, numeric grid by a spreadsheet, or images by a photo editing application"). APPLE1006 at [0060]. Petitioners' expert agreed. EX2016 at 47:12-51:13; EX1003 at ¶ [111]. This is accomplished by "map[ping] mouse hit-test points relative to

application-defined, content-local, 3D coordinates, and deliver[ing] mouse event notifications to the application." As such, a POSITA would have understood that Hanggie does not disclose presenting a plurality of images in 3D space, but a plurality of active windows. EX2016 at 72:9-14 ("In a combination, Anthony-Hanggie's system, which I refer to as "HAC," the control button 305 could well be used -- would have been used by a POSITA to do some form of maximize or minimize or delete, and I talk about that in a number of different places.").

105. While Hanggie teaches that a window can be "maximized" or enlarged, a POSITA would have understood that this does not constitute presenting an application in 2D space as Petitioners contend.

106. Petitioners acknowledge this but argues that a POSITA would have been motivated to modify Hanggie as it would have been "beneficial to switch from a 3D mode to a 2D mode to reduce graphics processing and thereby conserve battery power." Pet. at 27. As noted, I disagree that a POSITA would have been motivated in light of Hanggie because the displaying images, as recited in the claimed method, does not require the processor and memory intensive resources that displaying active applications such as those disclosed in Hanggie. *See*, *e.g.*, APPLE1006 at [0007], [0009], [0092]. Even if this was true (it is not), a POSITA would have understood that it would not have resulted in "replacing" a plurality of images with an active

application as claimed because the applications are always active in Hanggie, *i.e.*, in Hanggie there are no images in 3D space to replace.

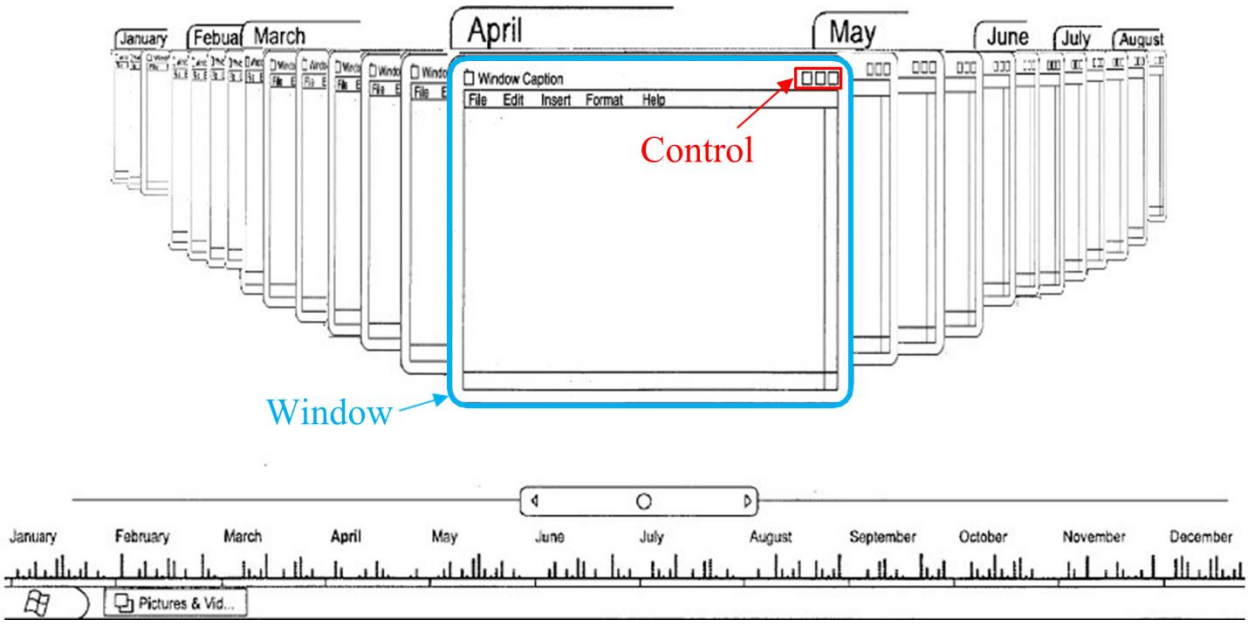
107. Even if maximizing resulted in the active window being displayed in 2D space, a POSITA would have understood that there is no "replacing" occurring, let alone replacing an image with an active application as claimed.

108. This is true regardless of whether the claimed combination is Anthony in view of Hanggie (Ground 1A) or Hanggie in view of Anthony (Ground 2A) (collectively "HAC"), as Petitioners are relying exclusively on Hanggie's "maximizing" button for switching to from 3D to 2D. *See* Petition at 27 ("[T]he POSITA would have found it obvious to implement the maximize control button such that manual user selection of that button would result in Anthony's user interface switching from a 3D timeline view … to a 2D view of the maximized window.") and 33 ("[T]he POSITA would have found it obvious to implement Hanggie's maximize control button such that manual user selection of that button would result in Hanggie's user interface switching from a 3D timeline view, to a 2D view of the maximize window.").

109. Of critical importance to the claimed invention, and therefore Petitioners' argument of obviousness, is the images that are generated, displayed in 3D space, and replaced in response to an interaction. As discussed above, ***each image includes include both an object*** (e.g., a window that typically includes a title

bar (e.g., maximize, minimize, etc.) and a menu bar (e.g., file, edit, view, etc.)) ***and application-specific data*** (e.g., the window's contents). ***In Petitioners' combination, however, <u>the image does not include the window (or object) as claimed</u>—evidence of this is the fact that the user can click on the maximize button, the minimize button, the close button, etc***.

110. Dr. Fuchs provided several illustrations of the argued combination, including "the combined figure shown below, [where] the focal group of windows in Anthony's Fig. 4 are replaced by the window shown in Hanggie's Fig. 3." APPLE1003 at [63]. According to Dr. Fuchs, "each window has a window caption and control buttons, consistent with the Hanggie's teachings." *Id*. He confirmed during his deposition that these control buttons remain active in the argued combination could be interacted with to, for example, maximize the window, close the window, etc. EX2016 at 72:9-14 ("In a combination, Anthony-Hanggie's system, which I refer to as "HAC," the control button 305 could well be used -- would have been used by a POSITA to do some form of maximize or minimize or delete, and I talk about that in a number of different places.").



111. A POSITA would have understood that if the window in Dr. Fuchs' proposed combination was an image as claimed, then the user would not be able to maximize the window, minimize the window, close the window, etc., through the control buttons on the window. This is why the claimed invention switches from an (inactive) image of the application in 3D space to an (active) application in 2D space to allow the user to interact with the object and modify the application-specific data. ***By definition, <u>because the user can interact with the control buttons</u> on the window, <u>the window (object) is not an image as required by the Challenged Claims.</u>***

112. For example, Claim 1 requires the first image to include "the first object" (*e.g.*, the window) and "the application-specific data." Petitioners acknowledge that the window is the claimed object. *See, e.g.*, Pet. at 42 ("Thus, in

HAC, the application window (***'object'***) is displayed in said 2D space on a fixed resolution display.") (emphasis in original). Petitioners then argue, however, that this same window is an image. *See, e.g.*, Pet. at 52 ("It would have been obvious to a POSITA that upon '***receiving a first interaction from [the] user with one of [the] plurality of images corresponding to one of said plurality of applications***,' e.g., through user selection of the maximize button for a window, HAC's computer would have allowed the user to view the window in a 'maximize' capacity such that it occupies all or almost all parts of the computer display.") (emphasis in original). Petitioners cannot have it both ways. If the user can interact with the maximize button, then the image does not include the object (window) and the interaction from the user is not with the image. If the image includes the object (window), then the user would not be able to maximize the window as argued by Petitioners.

113. The logic (or illogic) of Petitioners' argument stems from their expert, Dr. Fuchs, who opines that "[a] POSITA would have found it obvious to implement Hanggie's maximize control button such that manual user selection of that button would result in Anthony's user interface switching from a 3D timeline view to a 2D view of the maximized window." APPLE1003 at [68]. Again, a POSITA would have understood that the mere fact that the user can interact with Hanggie's control buttons on the window illustrates that the window is not *an image* as required by the claims. Petitioners' expert agreed that the window is interactive. EX2016 at 72:9-14

(confirming that Hanggie's window and its control buttons remain active in the proposed combination with Anthony).

114. A POSITA would have understood that this feature (imaging both objects and application-specific data) is not only required by the claims, but paramount to the purpose of the invention. Once an application has been opened and displayed, including generating an object (*e.g.*, a window) having application-specific data (*e.g.*, data), images of the same (*i.e.*, both the object and the application-specific data) are generated and displayed in 3D space. This allows the user to not only see which applications are open (hence the object), but where the user last left off (hence the application-specific data). The user can then interact with a particular image, resulting in the images being replaced with the previously opened application (*i.e.*, "<u>the</u> object" and "<u>the</u> application-specific data"). As such, in order to allow the user to identify open applications and to see where they last left off in 3D space, the image must include both the object (*e.g.*, the window) and the application-specific data (*e.g.*, its contents).

115. There are other flaws with Petitioners' argument, including motivation to combine. A POSITA would have understood that it is the active nature of the applications in Hanggie that requires increased processing and memory, which results in greater power consumption, and provides the motivation (as argued by Dr. Fuchs) to switch from 3D to 2D. *See, e.g.*, APPLE1006 at [0007] (describing the

"CPU intensive calculations" for desktop compositing), [0009] ("desktop compositing is a memory intensive process"), and [0092] (by disabling CDWM "the video graphics processing unit (GPU) is less active and thus consumes less power."). In other words, active applications are extremely difficult to manipulate in 3D space, requiring additional power, more processing, etc. *See e.g.* EX2001 at [37 and 41]. Hanggie teaches that in systems that do not have the necessary video hardware, or to reduce power consumption, the system should switch from active applications in 3D space to active applications in 2D space. APPLE1006 at [0092].

116. In contrast, a POSITA would have understood that such motivation is not relevant to the claimed inventions because images are much easier to manipulate in 3D space than active applications; replacing the active applications with images would itself reduce power consumption, thereby eliminating the need to switch to 2D space. *See e.g.* EX2001 at [37 and 41]. For applications with animations, images of the object would not have to be sent continuously to the GPU, which is often a bottleneck in 3D graphics. For other applications, displaying images does not require mapping inputs to the object from 3D space, which would result in fewer computations and, again, fewer images sent to the graphics processing unit ("GPU") when the application specific data is changed.

117. To put it another way, the claimed inventions of the '654 Patent provide for a different solution to reduce power than Hanggie's use of a 2D Legacy mode to

display active applications, *i.e.*, display *images* of open applications in 3D space. *See e.g.* EX2001 at [41]. Thus, a POSITA would have understood that Hanggie's method involving displaying active applications in 2D space teaches away from the claimed invention's method of displaying *images* in 3D space to conserve power.

118. A POSITA would have understood that Anthony also teaches away from the claimed invention. First, Anthony criticizes the prior art's teaching of displaying items in 2D space. *See, e.g.*, APPLE1007 at [0006] ("Although the use of thumbnails [in 2D space] provides the user with a visual indication of the contents of each file, in a folder that contains many files, it may still be difficult to locate a desired file."). This alone would dissuade a POSITA from modifying or combining Anthony with any method of replacing items in 3D space with 2D space. Second, as discussed above, Anthony's "thumbnail" approach does not suffer from the intensive processing and memory requirements as Hanggie, and thus provides no motivation (or need) modify Anthony in light of Hanggie in order to switch from 3D to 2D space.

119. A POSITA would have understood that Anthony's approach is also quite different from the claimed invention. For example, the claims require that if you interact with any image in 3D space (foreground or background), the images are replaced with a corresponding active application. In Anthony, however, if you interact with an item in the background (*e.g.*, a non-focal group), the item moves to

the foreground (*e.g.*, becoming the focal group). *See*, *e.g.*, APPLE1007 at [0059] ("When the user selects a new focal group, the system may initiate a series of steps to animate the process of changing focus from one group of icons to another."). And if you interact with an item in the foreground, "the system [will] attempt to open the file" in 3D space. *Id*. at [0047]. In the claimed invention, however, the applications are already opened. As such, the images are replaced with "<u>the</u> object" and "<u>the</u> application-specific data" (as previously displayed). Plus, they are presented in 2D space, not in the 3D space taught in Anthony.

120. The Board relied on numerous incorrect and unsupported statements by Petitioners that it would have been obvious to convert the 3D window disclosed in Hanggie into a 2D window. *See*, *e.g.*, Decision at 40 ("Petitioner asserts that 'using the maximize button to switch to a 2D viewing of the window' would have been obvious.") and 51-52 ("Petitioner *modifies* the teachings of Hanggie and combines them with Anthony such that when a user selects the maximize button for a 3D window in Anthony's timeline, the maximized window is displayed *as a 2D window* to 'allow the user to more intuitively and easily interact with the window.'") (emphasis in original).

121. However, a POSITA would have understood that it is not the object (*e.g.*, window) that is 2D but the space in which the object is presented. As the Samsung Court stated in the *Markman Order*, "[i]t is true that 'objects' may be

displayed in the 3D space, but the term at issue is 'spaces,' and not the term 'objects.'" EX2011 at 16. In response to the argument that Petitioners are making (*i.e.*, that a 2D window satisfies the claim language), the Court stated "Defendants' construction improperly conflates 'space' with 'objects by requiring that a '2D space' is a virtual space in which displayed objects (not the space) have only height and width, while a '3D space' is a virtual space in which displayed objects (again not the space) have height, width, and depth." *Id*. "The Court agrees that a 3D space may be populated with an 'object,' but an 'object' does not define a 3D space. Instead, a 3D space is defined by the characteristics of the space." *Id*. at 17.

122. Thus, Petitioners' mischaracterization of the of the claimed invention appears to stem from Petitioners' expert, Dr. Fuchs, who admitted that he did not take into account the Court's *Markman* Order in rendering his opinions. EX2016 at 63:24-64:10; EX1003 at [34].

123. According to the claims, for each application, an object is generated having application-specific data. In the context of applications, a POSITA would understand that the claimed object is akin to a window and the application-specific data is data (or content) that is displayed therein. Thus, for example, if a user were to open Microsoft Word®, the object would be the window, which includes a title bar (*e.g.*, maximize, minimize, close) and a menu bar (*e.g.*, file, edit, view, etc.). The application-specific data would be a particular Word document or file. The same

would be true for Microsoft Excel, where the object would be the window (*e.g.*, title bar, menu bar, etc.) and the application-specific data would be a particular Excel file. This is consistent with the claimed invention where the object (*e.g.*, window) is generated and displayed in response to opening an application and it includes application-specific data (*e.g.*, data) that can be modified by the user.

124. On the one hand, Petitioners assert that both the window (the object) and its content (the application-specific data) are active and can be interacted with, with the user *interacting with the window* (or the title bar) to maximize the window and *interacting with its conten*t, thereby modifying the application-specific data. *See, e.g.*, Decision at 40 ("Petitioner asserts that 'using the maximize button to switch to a 2D viewing of the window' would have been obvious"); and 37-38 ("According to Petitioner, in Hanggie content related to the applications can include 'e.g., text by a word processor, numeric grid by a spreadsheet application, or images by a photo editing application,'" and "when using a word processor application or spreadsheet application, it is well known that a user can interact with the application and edit text and images in the application window.").

125. On the other hand, with respect to generating a plurality of images, the Board relied on Petitioners and their expert assert that a POSITA would have generated three windows, where each "window is *an image of at least a portion of an object* (e.g., 2D window) generated by the respective application and having

respective application-specific data (e.g., application data, application content object.”).” Decision at 34 (emphasis in original).

126. Again, Petitioners cannot have it both ways—if the window and its title bar (with maximize button) is active, then it is not an image, and (a) the image does not include the object as claimed and (b) the interaction is not on the image. Alternatively, if the window and its title bar (with maximize button) is an image, then it cannot be interacted with by the user to maximize the window, as Petitioners contend. This is because those skilled in the art understand that an image of a window would not include any ability to modify the application-specific data—hence the reason the claims replace the images with the active application in response to the interaction, as this is the only way the user can then interact with the application (*e.g.*, to modify its application-specific data).

127. Further, if only images of the object and the application-specific data are presented in 3D space, then there would be no motivation to switch to 2D space, as the motivation stems from the intensive processing and memory requirements associated with displaying active applications in 3D space.

128. As the Board noted, Patent Owner argues that “when Anthony’s dynamic timeline displays inactive images in 3D in the form of *inactive* application windows with control buttons, it would have been obvious to a person of ordinary skill in the art that ‘selection of a maximize button corresponding to a particular

application window would cause that window to *replace* the [inactive] image previously displayed in 3D with a 2D window that is *active* to receive user inputs.'" Decision at 50 (emphasis in original) (citing Petition at 35-54).

129. There are several problems with this argument. First, a POSITA would have understood that the control buttons are part of the window. Thus, if the window is *inactive* (as it is merely an image), then so too are the buttons, thereby preventing "selection of a maximize button." Further, a POSITA would have understood that if the window and its contents are *inactive* (as it is merely an image), then there would be no motivation to switch from 3D to 2D space because displaying images do not require the intensive processing and memory requirements of displaying active applications in 3D. Finally, a POSITA would have understood that if the window is *active* (allowing selection of a maximize button) and only its contents are inactive (or imaged), then the image would not include both the object and the application-specific data as claimed.

130. In light of the foregoing, it is my opinion that Petitioners have failed to show that Anthony and Hanggie, either alone or in combination, discloses each and every feature of Independent Claims 1, 10 and 19. The same is true for Dependent Claims 2-5, 7-8, 11-13, or 15-17 because not only do these claims depend from the foregoing independent claims, but they also include features that are not disclosed in or suggested by Anthony and Hanggie.

131. For example, Claim 8 requires that, when replacing the plurality of images with an active application, further "enlarging a size of at least said one of said plurality of images before replacing said one of said plurality of images with said one of said first, second, and third objects, thereby simulating movement of said one of said plurality of images in a z-axis of said display." Petitioners merely argue that this would be obvious because "maximizing a window involves enlarging the size of the window (image) until it covers most if not all the display area of the display screen." Pet. at 65-66. Again, it is not a *window* that is enlarged in Claim 8 (and Claim 17), but the *selected image*. This underscores the flaw in Petitioners' arguments concerning the independent claims.

4. Combining Anthony, Hanggie, and Matthews Does Not Disclose The Claimed Limitation (Grounds 1B and 2B)

132. In Grounds 1B and 2B, Petitioners argue that Claims 6, 9, 14, and 18 are obvious over Anthony and Hanggie (HAC) in view of Matthews. First, it should be pointed out that Grounds 1B and 2B do not address any independent claim. As such, if the Board denies Grounds 1A and 2A, at least with respect to Claims 1, 10, and 19, then as it has been explained to me, the Board also must deny Grounds 1B and 2B. Second, Matthews is only cited by Petitioners for its disclosure of two features: (1) "displaying a fourth image on said display device, said fourth image being an image of a desktop having at least one other application" and (2) "where

each one of said plurality of applications comprises a web browser application." In addition, a POSITA would have understood that it doesn't make up for the deficiencies of Anthony and Hanggie, as discussed above with respect to Claim 1. In fact, Petitioners do not argue that it does, but only that it teaches the features of Dependent Claims 6, 9, 14, and 18. Because of this, and the serious flaws with Grounds 1A and 2A, a POSITA would have understood that the combination of prior art set forth in Grounds 1B and 2B does not render obvious Dependent Claims 6, 9, 14, and 18.

B. The Prior Art Relied Upon by Petitioners, Including the Combinations Thereof, are Very Similar to Prior Art Considered During Prosecution

133. Further evidence of non-obviousness can be found in the prosecution histories of the '018, '048, and '654 Patents. A POSITA would have understood that not only did the Examiner consider very similar prior art, but she also considered similar combinations to those presented in the Petition. Those skilled in the art would have understood that this is further evidence of the non-obviousness of the Challenged Claims.

134. During prosecution, SpaceTime3D distinguished its invention from several prior art references, including Sciammarella, Freeman, Prager, Kamiwada, and Iida—even amending the claims to further distinguish over the GUIs described therein. Here, Petitioners are arguing that the '654 Patent is invalid over Anthony

and Hanggie (Grounds 1A and 2A) (*i.e.*, the only grounds that address the independent claims). But the USPTO already considered and allowed the '654 Patent over references that are virtually identical to these references.

135. For example, Petitioners are citing Anthony for its disclosure of a 3D space having a plurality of items, where each item is arranged chronologically (*i.e.*, based in time). A POSITA would have understood that the same feature was disclosed in Sciammarella, Freeman, and Prager, where items are chronologically arranged in 3D space. For example, compare Figure 4 of Anthony to Figure 2 of Sciammarella (both reproduced below). Sciammarella, like Anthony, provides for a 3D GUI that presents a plurality of items in a "selected layout and order." *See, e.g.*, EX2008 at Figure 1 at 28d (showing that the user can "sort 28e" based on "time 28d"). In particular, Sciammarella provides that "[t]he order interface 28 is for ***selecting one of four different sequence orders*** that determine arrangement of the thumbnails 23 in the selected layout. ***The four orders include***: name of data object, type of data object, size of the date file, and ***time the file was stored***." *Id*. at [0053] (emphasis added).

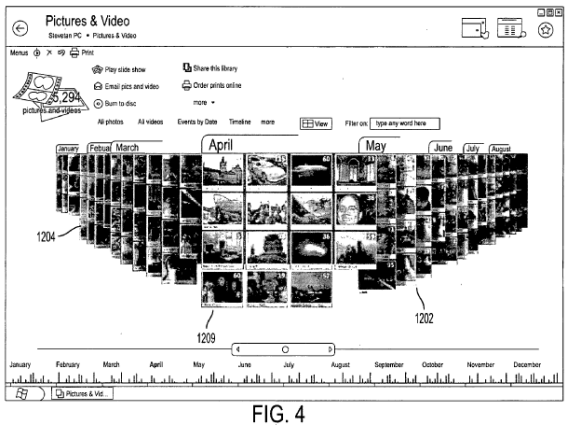


FIG. 4

Figure 4 of Anthony

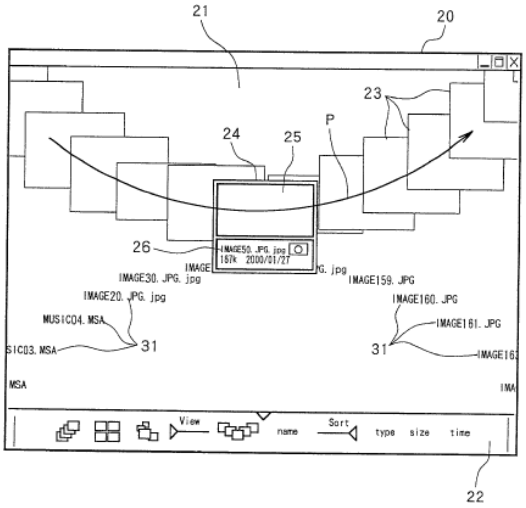


Figure 2 of Sciammarella

136. The items presented can include "digital image files, digital audio files, text files, executable programs, program files, and movie files," where the selected file is "the center-most, or focus, thumbnail 25." *Id*. at [0047-0050]. To edit an item in the 3D stack, "the user can select to launch an application related to the selected data object." *Id*. at [0090]. In response, the program manager "moves the launched application to the front [of the 3D space]." *Id*. Thus, like Anthony, the items in Sciammarella, which may represent different "files," are arranged chronologically, and can be edited in 3D space.

137. The same is true for Freeman and Prager, both of which are reproduced below. In Freeman, the documents (which may include "text, pictures, animations, software programs, or any other type of data") are "stored in one or more chronological ordered streams." EX2006 at Abstract.

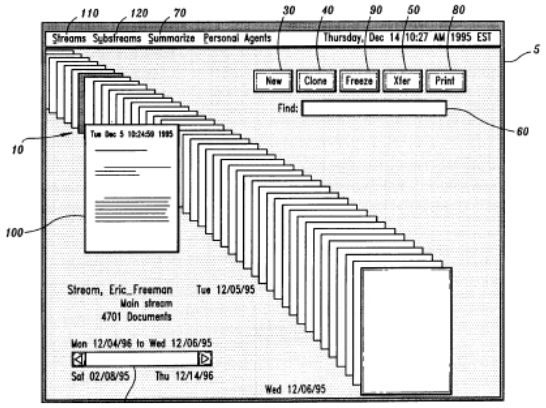


Figure 1 of Freeman

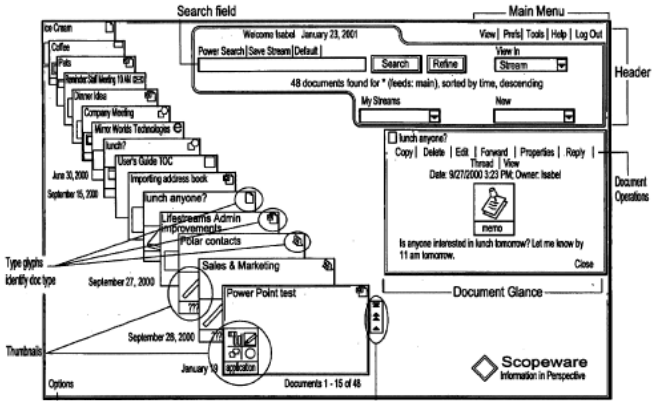


Figure 1 of Prager

138. In Freeman, a "stream" of documents are presented in 3D space. *See*, *e.g.*, *id*. at Figure 1 and 4:24 ("A 'stream' according to the present invention is ***a time-ordered sequence of documents*** that functions as a diary of a person or an entity's electronic life.") (emphasis added). The documents in the stream are "graphical representations" of the actual document, with the document on top of the stream (*i.e.*, the foremost document) being "live" or "active," so that it can be interacted with as traditionally done on a 2D desktop. *See*, *e.g.*, *id*. at 5:48-56.

139. Prager is similar to Freeman in that it discloses a 3D space that includes "a time-ordered stream" where "glance views" can be used to display additional information on documents in the stream. Like Freeman, the "stream" in Prager comprises a plurality of "document representations." *See*, *e.g.*, EX2007 at Figure 1. "[W]hen the user touches a document on the screen with the cursor, a summary of that document with a thumbnail vies [sic] appears immediately … [as] a dedicated

small window besides the receding parade of time ordered documents." *Id*. at 2:23-34. As shown in Figure 5 of Prager, "[i]f the user has clicked on a browse card to fix the glance view as a stationary window, the user can then select any of the visible and available document operations." *Id*. at 7:43–8:8. If a "document operation" is selected (*e.g.*, Copy, Delete, etc.), then "the system executes the selected operation (command) and the display reflects this at S511." *Id*. Thus, the 3D space includes both a stream having a plurality of "browser cards" in chronological order and a "document glance" for any selected "browser card," where the "document glance" can be interacted with to alter its contents.

140. Both Freeman and Prager were cited several times by the Examiner in rejecting claims in the parent patent applications. *See*, *e.g.*, EX2003 at 87-123 and EX2004 at 69-87, 124-143, and 174-192. However, a POSITA would have understood that the claims of the '654 Patent was ultimately allowed because the cited references, like Anthony, disclosed 3D GUIs that remained in 3D, *i.e.*, they never switched back-and-forth between 2D and 3D space, where an active application "replaces" a plurality of inactive images.

141. The Examiner also considered prior art that is very similar to Hanggie, where items are presented and can be edited in 3D space, where individual items can be maximized or enlarged (*e.g.*, to be viewed better, etc.). For example, U.S. Patent Publication No. 2001/0050687 ("Iida") was cited by the Examiner during

prosecution. EX2001 at 20. Iida discloses "a three-dimensional object display program designed to display merchandise and other physical objects in three-dimensional space so as to facilitate user selection." EX2009 at [0002]. To better view the merchandise, "[i]f there is input from the instruction input unit 21 to change the vantage point by for example advancing into or retreating from the three-dimensional space displayed, then the three-dimensional space data display unit 20 displays the three-dimensional space data from the new vantage point." *Id*. at [0050].

142. In particular, Iida provides that "space 68 can also be enlarged/reduced as needed." *Id*. at [0083]. This can be seen, for example, in Figures 13 and 14 (reproduced below), where "[t]he vantage point can be moved along the Z-axis by using buttons 75 and 76, so that the vantage point moves toward the front when the button 75 is depressed and the vantage point moves to the rear when the button 76 is depressed." *Id*. at [0090]. In Figure 14, "the vantage point movement button 75 has been pressed," thereby zooming out. *Id*. at [0092]. Zooming in can also be accomplished by depressing the vantage point movement button 76.

FIG.13

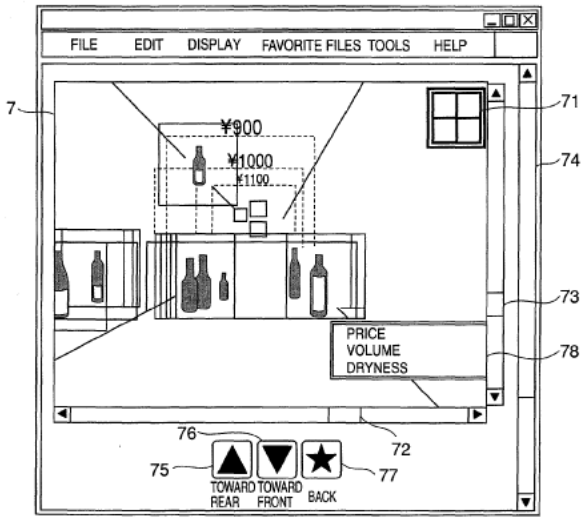


Figure 13 of Iida

FIG.14

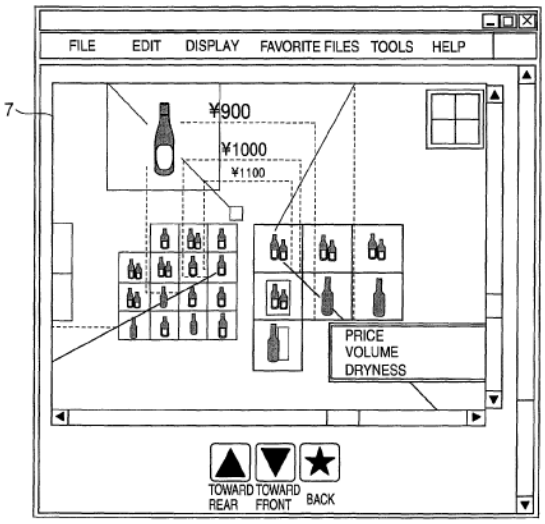


Figure 14 of Iida

143. Figure 15 (reproduced below) "shows a case in which the product in the center of the three-dimensional space screen 7 is selected and the product detail screen 8 is displayed." *Id*. at [0083]. As shown, a POSITA would have understood that the product detail page includes the same "frame buttons" that are present in Hanggie (*i.e.*, minimize, maximize, close). Thus, the user could also change their vantage point by, for example, maximizing the product detail page. Iida provides that if the vantage point changes, then "the three-dimensional display unit 20 redraws the three-dimensional space screen 7 according to the changed vantage point." *Id*. at [0091]; *see also id*. at Figure 12 at S45 ("Three Dimensional Space Redrawn Using Different Vantage Point"). Thus, a POSITA would have understood that the Examiner was aware of prior art that disclosed enlarging (or maximizing) a

window in 3D space, and that doing such does not constitute switching from 3D to 2D, but merely "redrawing the 3D space."

FIG.15

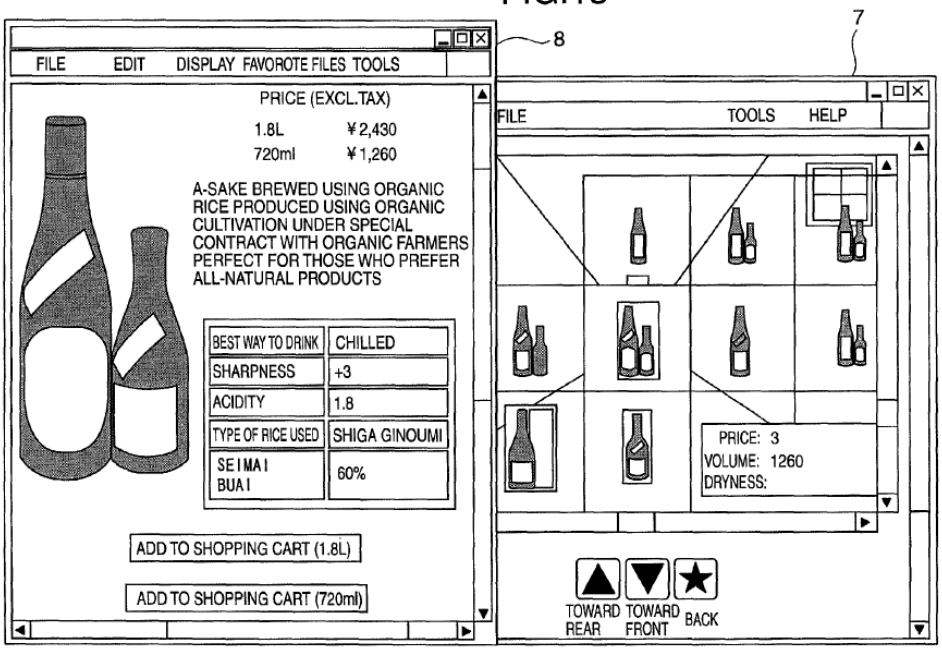
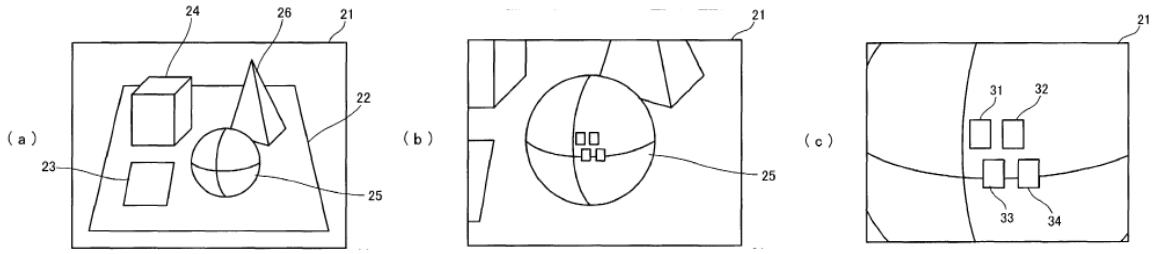


Figure 15 of Iida

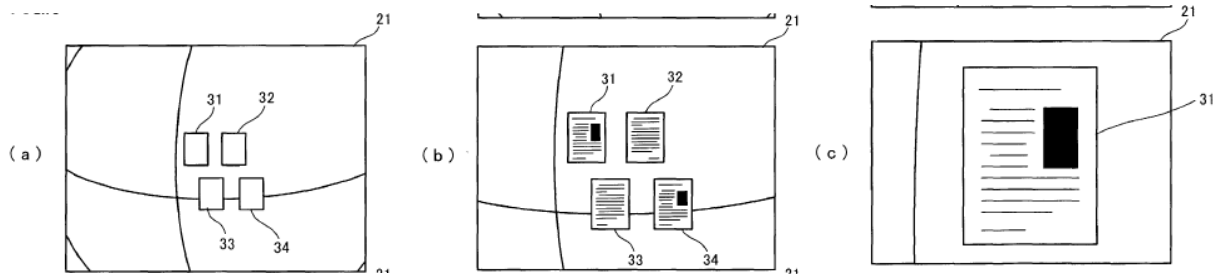
144. The same features were disclosed in U.S. Patent Publication No. 2003/0179231 ("Kamiwada"), which was cited by the Examiner during prosecution. EX2001 at 20. Kamiwada teaches a 3D GUI, or more particularly one where "a display is changed automatically while maintaining link relationship among information objects in a virtual three-dimensional space." EX2010 at Abstract. In Figures 4a-c (reproduced below), Kamiwada shows an example of "[w]hen the user conducts operation of the input device … so as to approach the sphere information

object 25, the display screen alters as shown in (a) through (c) of FIG. 4. Namely, the sphere information object 25 is enlarged (zoomed in), and the four information objects 31-34 located on the surface of the sphere become visible gradually." *Id*. at [0042]; *see also id*. at [0044] ("In the display shown in (c) of FIG. 4, the four information objects 31-34 are further enlarged (zoomed in), so that contents of their text are displayed.").



Figures 4a-c of Kamiwada

145. "FIG. 5 shows an example of change in display when the viewpoint further approaches from the display 21 shown in (c) of FIG. 4 to one information object on the sphere information object 25." *Id*. at 0045; *see also id*. at Figures 5a-c, reproduced below. Kamiwada provides that this is an "example of change in display when user conducts operation approaching (zooming in) a specific information object using a point device (the input device 2) such as a mouse." *Id*. at [0046].



Figures 5a-c of Kamiwada

146. This "zooming" can be achieved manually (*e.g.*, step-by-step, as shown in Figures 4-5), or automatically (*e.g.*, by clicking on "document 1" in Figure 11, similar to the "frame button" in Hanggie). *See*, *e.g.*, *id*. at [0063]. Either way, a POSITA would have understood that Kamiwada makes it clear that even though the user is "zooming in" on a single 2D object, the object is still in 3D space. This is because, to allow "browsing" in 3D, "the relative positions of the information objects located in the virtual three-dimensional space [must be] maintained." *Id*. at [0065].

147. In short, a POSITA would have understood that the Examiner was aware of prior art that is virtually identical (in all material respects) to Hanggie, where an item in 3D space can be enlarged or maximized (*e.g.*, to be viewed better, etc.). Because the prior art cited by Petitioners is substantially the same as prior art considered by the Examiner during prosecution of the '654 Patent, the prior art Anthony, Hanggie and Matthews, individually or in combination, do not render obvious the claimed inventions for the same reasons the Examiner found over the cited prior art.

IX. CONCLUSION

148. In connection with the above, I have reviewed, had input into, and endorse as set forth fully herein the nonobviousness analysis in the accompanying Patent Owner's Response showing that each element of Claims 1-19 of the '654 Patent are not rendered obvious by the prior art references set forth therein. I reserve the right to amend and/or supplement the foregoing in accordance with applicable Court rules, orders, and procedures.

149. In signing this Declaration, I understand that the Declaration will be filed as evidence in a review proceeding before the Patent Trial and Appeal Board of the U.S. Patent and Trademark Office. I acknowledge that I may be subject to cross examination.

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

Dated: October 19, 2023

Dr. Scott Schaefer

Appendix A

Scott Schaefer

Professional Preparation

- B.S. Computer Science and Mathematics, Trinity University 2000
- M.S. Computer Science, Rice University 2003
  Thesis: Interpolatory Subdivision for Surfaces of Revolution
  Advisor: Joe Warren
- Ph.D. Computer Science, Rice University 2006
  Dissertation: Intuitive Methods for 3D Shape Deformation
  Advisor: Joe Warren

Appointments

- Department Head of Computer Science & Engineering, 9/2019-present
- Associate Department Head of Computer Science & Engineering, 9/2017-8/2019
- Full Professor, Texas A&M University 9/2016-present
- Associate Professor, Texas A&M University 9/2012-8/2016
- Assistant Professor, Texas A&M University 8/2006-8/2012
- Visiting Researcher, Microsoft Research 8/2006

Research Grants

- "Generalized Barycentric Coordinates," *National Science Foundation*, PI: Scott Schaefer, 6/1/2007-5/31/2010, $300,000.
- "Terrain and Surface Reconstruction Using Wavelets," *DARPA*, PI: Scott Schaefer, 2/1/2008-1/31/2009, $91,759.
- "Surface Reconstruction from Point Clouds Using Wavelets," *DARPA*, PI: Scott Schaefer, Co-PI: Guergana Petrova, 5/1/2009-4/30/2011, $499,747.
- "Fast Point Cloud Surface Reconstruction Algorithms," *National Science Foundation*, PI: Ron Devore, Co-PI: Scott Schaefer, Guergana Petrova, 9/1/2009-8/31/2012, $707,891.
- "CAREER: Parameterization and Tessellation for Computer Graphics," *National Science Foundation*, PI: Scott Schaefer, 6/1/2012-5/31/2017, $472,995.
- "TOP Proposal for Math Learning Tools", *Texas A&M University*, PI: Andre Thomas, Co-PI: Susan Pedersen, Paulo Lima-Filho, Scott Schaefer, 9/1/2014-8/31/2015, $100,000.
- "Automated Parametric Discretization Tool for High Fidelity Hypersonic Design Analysis", AFOSR SBIR Phase I, PI: HyPerComp Inc., subcontract: Scott Schaefer, 3/27/2018-1/2/2019, $150,000.
- "Automated Parametric Discretization Tool for High Fidelity Hypersonic Design Analysis", AFOSR SBIR Phase II, PI: HyPerComp Inc., subcontract: Scott Schaefer, 7/11/2019-10/15/2021, $150,000.

Awards

- Participant of the 2008 DARPA Computer Science Study Panel
- 2010 Computer Science & Engineering Undergraduate Faculty Teaching Excellence Award
- 2011 Computer Science & Engineering Undergraduate Faculty Teaching Excellence Award

- Best Paper Award (The Günter Enderle Award), Eurographics 2011 for "Wavelet Rasterization"
- NSF CAREER Award
- 2015 Herbert H. Richardson Faculty Fellow
- 2017 Association of Former Students Distinguished Achievement Award in Teaching – College Level
- Third Best Paper Award, SGP 2017 for "Isometry-Aware Preconditioning for Mesh Parameterization"
- 2017 Computer Science & Engineering Undergraduate Faculty Teaching Excellence Award
- 2018-2019 SEC Academic Leadership Fellow
- 2018-2019 TEES Research Impact Award
- 2019 Associate of Former Students Distinguished Achievement Award in Teaching – University Level
- Best Paper Award, SGP 2019 for "A Family of Barycentric Coordinates for Co-Dimension 1 Manifolds with Simplicial Facets"
- Eppright Professor in Engineering 2019-2020
- Lynn '84 and Bill Crane '83 Department Head Chair 2020-Present

Refereed Journal Publications

(All papers can be found at http://faculty.cs.tamu.edu/schaefer/research/)

1. A Subdivision Scheme for Hexahedral Meshes. Bajaj C., Schaefer S., Warren J., Xu G. *The Visual Computer*, Vol. 18, pp. 409-420, (2002).
2. Dual Contouring of Hermite Data. Ju T., Losasso F., Schaefer S., Warren J. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 19% acceptance), Vol. 21, No. 3, pp. 339-346, (2002).
3. Convex Contouring of Volumetric Data. Ju T., Schaefer S., Warren J. *The Visual Computer*, Vol. 19, pp. 513-525, (2003).
4. Recursive Turtle Programs and Iterated Affine Transformations. Ju T., Schaefer S., Goldman R. *Computers and Graphics*, Vol. 28, No. 6, pp. 991-1004, (2004).
5. Turtle Geometry in Computer Graphics and Computer-Aided Design. Goldman R., Schaefer S., Ju T. *Computer-Aided Design*, Vol. 36, No. 14, pp. 1471-1482, (2004).
6. Teaching Computer Game Design and Construction. Schaefer S., Warren J. *Computer-Aided Design*, Vol. 36, No. 14, pp. 1501-1510, (2004).
7. A Factored Approach to Subdivision Surfaces. Warren J., Schaefer S. *Computer Graphics & Applications*, Vol. 24, No. 3, pp. 74-81, (2004).
8. On C^2 Triangle/Quad Subdivision. Schaefer S., Warren J. *ACM Transactions on Graphics* Vol. 24, No. 1, pp. 28-36 (2005).
9. Dual Marching Cubes: Primal Contouring of Dual Grids. Schaefer S., Warren J. *Computer Graphics Forum*, Vol. 24, No. 2, pp. 195-201 (2005).
10. Mean Value Coordinates for Closed Triangular Meshes. Ju T., Schaefer S., Warren J. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 21% acceptance), Vol. 24, No. 3, pp. 561-566 (2005).
11. Image Deformation using Moving Least Squares. Schaefer S., McPhail T., Warren J. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 18% acceptance), Vol. 25, No. 3, pp. 533-540 (2006).

12. Barycentric Coordinates for Convex Sets. Warren J., Schaefer S., Hirani A., Desbrun M. *Advances in Computational and Applied Mathematics*, Vol. 27, No. 3, pp. 319-338 (2007).
13. A Unified, Integral Construction for Coordinates over Closed Curves. Schaefer, S., Ju T., Warren J. *Computer-Aided Geometric Design*, Vol. 24, No. 8-9, pp. 481-493 (2007).
14. Manifold Dual Contouring. Schaefer S., Ju T., Warren J. *Transactions on Visualization and Computer Graphics*, Vol. 13, No. 3, pp.610-619 (2007).
15. Approximating Catmull-Clark Subdivision Surfaces with Bicubic Patches. Loop, C. and Schaefer S. *ACM Transactions on Graphics*, Vol. 27, No. 1, pp. 8:1-8:11 (2008).
16. Nonlinear Subdivision Through Nonlinear Averaging. Schaefer S., Vouga E., Goldman R., *Computer Aided Geometric Design*, Vol. 25, No. 3, pp. 162-180 (2008).
17. Streaming Surface Reconstruction Using Wavelets. Manson J., Petrova G., Schaefer S. *Computer Graphics Forum* (Proceedings of the Symposium on Geometry Processing, 24% acceptance), Vol. 27, No. 5, pp. 1411-1420 (2008).
18. G^2 Tensor Product Splines over Extraordinary Vertices. Loop, C., Schaefer S. *Computer Graphics Forum* (Proceedings of the Symposium on Geometry Processing, 24% acceptance), Vol. 27, No. 5, pp. 1373-1382 (2008).
19. Exact Evaluation of Limits and Tangents for Non-Polynomial Subdivision Schemes. Schaefer S., Warren J. *Computer Aided Geometric Design*, Vol. 25, No. 8, pp. 607-620 (2008).
20. On the Smoothness of Real-Valued Functions Generated by Subdivision Schemes using Nonlinear Binary Averaging. Vouga E., Schaefer S., Goldman R. *Computer Aided Geometric Design*, Vol. 26, No. 2, pp. 231-242 (2009).
21. Non-uniform Subdivision for B-splines of Arbitrary Degree. Schaefer S., Goldman R. *Computer Aided Geometric Design*, Vol. 26, No. 1, pp. 75-81 (2009).
22. J-Splines. Rossignac J., Schaefer S. *Computer-Aided Design*, Vol. 40, No. 10-11, pp. 1024-1032 (2009).
23. Simplification of Articulated Meshes. Landreneau E., Schaefer S. *Computer Graphics Forum* (Proceedings of Eurographics, 23% acceptance), Vol. 28, No. 2, pp. 347-353 (2009).
24. Approximating Subdivision Surfaces with Gregory Patches for Hardware Tessellation. Loop C., Schaefer S., Ni T., and Castano I. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH ASIA, 25% acceptance), Vol. 28, No. 5, pp. 151:1-9 (2009).
25. Hair Meshes. Yuksel C., Schaefer S. and Keyser J. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH ASIA, 25% acceptance), Vol. 28, No. 5, pp. 166:1-7 (2009).
26. Isosurfaces Over Decompositions of Multiresolution Grids. Manson J. and Schaefer S. Computer Graphics Forum (Proceedings of Eurographics, 20% acceptance), Vol. 29, No. 2, pp. 377-385 (2010).
27. Parameterizing Subdivision Surfaces. He L., Hormann K., Schaefer S. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 26% acceptance), Vol.29, No. 4, pp. 120:1-6 (2010).
28. Triangle Surfaces with Discrete Equivalence Classes. Singh M. and Schaefer S. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 26% acceptance), Vol.29, No. 4, pp. 46:1-7 (2010).
29. Moving Least Squares Coordinates. Manson J. and Schaefer S. *Computer Graphics Forum* (Proceedings of the Symposium on Geometry Processing, 34% acceptance), Vol. 29, No. 5, pp. 1517-1524 (2010).
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32. Contouring Discrete Indicator Functions. Manson J., Smith J., Schaefer S. *Computer Graphics Forum* (Proceedings of Eurographics, 17% acceptance), Vol. 30, No. 2, pp. 385-393 (2011).
33. Wavelet Rasterization. Manson J., Schaefer S. *Computer Graphics Forum* (Proceedings of Eurographics, 17% acceptance), Vol. 30, No. 2, pp. 395-404 (2011).
34. Parameterization and Applications of Catmull-Rom Curves. Yuksel C., Schaefer S., Keyser J. *Computer-Aided Design*, Vol. 43, No. 7, pp. 747-755 (2011).
35. Positive Gordon-Wixom Coordinates. Manson J., Li K. and Schaefer S. *Computer Aided Design* (Proceedings of SIAM Conference on Geometric and Physical Modeling, 29% acceptance), Vol. 43, No. 11, pp. 1422-1426 (2011).
36. Hierarchical Deformation of Locally Rigid Meshes. Manson J. and Schaefer S. *Computer Graphics Forum*, Vol. 30, No. 8, pp. 2387-2396 (2011).
37. Encoding Normal Vectors Using Optimized Spherical Coordinates. Smith J., Petrova G., Schaefer S. *Computers & Graphics* (Proceedings of Shape Modeling International, 34% acceptance), Vol. 36, No. 5, pp. 360-365 (2012).
38. Progressive Encoding and Compression of Surfaces Generated from Point Cloud Data. Smith J., Petrova G., Schaefer S. *Computers & Graphics* (Proceedings of Shape Modeling International, 34% acceptance), Vol. 36, No. 5, pp. 341-348 (2012).
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40. Microstructure Based Models for Multi-Functional Material Systems. Sarzynski M., Schaefer S., Ochoa O. *Mechanics of Advanced Materials and Structures*, Vol. 19, No. 6, pp. 421-430 (2012).
41. Improving the Parameterization of Approximate Subdivision Surfaces. He L., Loop C. and Schaefer S. *Computer Graphics Forum* (Proceedings of Pacific Graphics, 20% acceptance), Vol.31, No. 7, pp. 2127-2134 (2012).
42. Analytic Rasterization of Curves with Polynomial Filters. Manson J. and Schaefer S. *Computer Graphics Forum (*Proceedings of Eurographics, 25% acceptance), Vol. 32, No. 2, pp. 499-507 (2013).
43. Mesh Denoising via L0 Minimization. Lei H. and Schaefer S. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 24% acceptance), Vol. 32, No. 4, pp. 64:1-8 (2013).
44. Cardinality-Constrained Texture Filtering. Manson J. and Schaefer S. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 24% acceptance), Vol. 32, No. 4, pp. 140:1-8 (2013).
45. Bilinear Accelerated Filter Approximation. Manson J. and Schaefer S. *Computer Graphics Forum* (Proceedings of the Eurographics Symposium on Rendering, 36% acceptance), Vol. 33, No. 4, pp. 33-40 (2014).
46. Selective Degree Elevation for Multi-Sided Bezier Patches. Smith J. and Schaefer S. *Computer Graphics Forum* (Proceedings of Eurographics, 27% acceptance), Vol. 34, No. 2 (2015), pp. 609-615.
47. Denoising Point Sets via L0 Minimization. Sun Y, Schaefer S., and Wang W. *Computer Aided Geometric Design* (Proceedings of Geometric Modeling and Processing, 24% acceptance), Vol. 35 (2015), pp. 2-15.
48. Bijective Parameterization with Free Boundaries. Smith J. and Schaefer S. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 25% acceptance), Vol. 34, No. 4 (2015), pp. 70:1-70:9.

49. Pyramid Algorithms for Barycentric Rational Interpolation. Hormann K. and Schaefer S. *Computer Aided Geometric Design*, Vol. 42 (2016), pp. 1-6.
50. Robust Mesh Denoising via Vertex Pre-filtering and L1-Median Normal Filtering. Lu X., Chen W., and Schaefer S. *Computer Aided Geometric Design*, Vol. 54 (2017), pp. 49-60.
51. Image Structure Retrieval via L0 Minimization. Sun Y., Schaefer S., and Wang W. *Transactions on Visualization and Computer Graphics*, Vol. 24, No. 7, pp. 2129-2139 (2017).
52. Isometry-Aware Preconditioning for Mesh Parameterization. Claici S., Bessmeltsev M., Schaefer S., and Solomon J. *Computer Graphics Forum* (Proceedings of the Symposium on Geometry Processing, 34% acceptance), Vol. 36, pp. 37-47 (2017).
53. k-Curves: Interpolation at Local Maximum Curvature. Yan Z., Schiller S., Wilensky G., Carr N., and Schaefer S. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH, 28% acceptance), Vol. 36, No. 4, pp. 129:1-129:7 (2017).
54. Simplicial Complex Augmentation Framework for Bijective Maps. Jiang Z., Schaefer S., and Panozzo D. *ACM Transactions on Graphics* (Proceedings of SIGGRAPH Asia, 25% acceptance), Vol. 36, No. 6, pp. 186:1-186:9 (2017).
55. Circle Reproduction with Interpolatory Curves at Local Maximal Curvature Points. Yan, Z., Schiller S., and Schaefer S. *Computer Aided Geometric Design*, Vol. 72, pp. 98-110 (2019).
56. A Family of Barycentric Coordinates for Co-Dimension 1 Manifolds with Simplicial Facets. Yan, Z. and Schaefer S. *Computer Graphics Forum* (Proceedings of the Symposium on Geometry Processing, 30% acceptance), Vol. 38, No. 5, pp. 75-83 (2019).
57. Low Rank Matrix Approximation for 3D Geometry Filtering. Lu X., Schaefer S., Luo J., Ma L., and He Y. *Transactions on Visualization and Computer Graphics*, Vol. 28, No. 4, pp. 1835-1847 (2022).

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58. A Factored Interpolatory Subdivision Scheme for Quadrilateral Surfaces. Schaefer S., Warren J. *Curves and Surface Fitting: Saint Malo 2002*, pp. 373-382.
59. Smooth Geometry Images. Losasso F., Hoppe H., Schaefer S., Warren J. *ACM SIGGRAPH/Eurographics Symposium on Geometry Processing 2003*, pp. 138-145 (35% acceptance).
60. Adaptive Vertex Clustering Using Octrees. Schaefer S., Warren J. *Proceedings of SIAM Geometric Design and Computing 2003*, pp. 491-500.
61. Smooth Subdivision of Tetrahedral Meshes. Schaefer S., Hakenberg J., Warren J. *ACM SIGGRAPH/Eurographics Symposium on Geometry Processing 2004*, pp. 151-158 (29% acceptance).
62. Lofting Curve Networks using Subdivision Surfaces. Schaefer S., Warren J., Zorin D. *ACM SIGGRAPH/Eurographics Symposium on Geometry Processing 2004*, pp. 105-116 (29% acceptance).
63. Dual Marching Cubes: Primal Contouring of Dual Grids. Schaefer S., Warren J. *Proceedings of Pacific Graphics 2004*, pp. 70-76 (19% acceptance).
64. Subdivision Schemes and Attractors. Schaefer S., Levin D., Goldman R. *ACM SIGGRAPH/Eurographics Symposium on Geometry Processing 2005*, pp. 171-180 (25% acceptance).
65. A Geometric Construction of Coordinates for Convex Polyhedra using Polar Duals. Ju T., Schaefer S., Warren J., Desbrun M. *ACM SIGGRAPH/Eurographics Symposium on Geometry Processing 2005*, pp. 181-186 (25% acceptance).

66. Freeform Curves on Spheres of Arbitrary Dimension. Schaefer S., Goldman R. *Proceedings of Pacific Graphics 2005*, pp. 160-162 (36% acceptance).
67. Example-Based Skeleton Extraction. Schaefer S. and Yuksel C. *ACM SIGGRAPH/Eurographics Symposium on Geometry Processing 2007*, pp. 153-162 (28% acceptance).
68. Exact Evaluation of Non-Polynomial Subdivision Schemes at Rational Parameter Values. Schaefer S. and Warren J. *Proceedings of Pacific Graphics 2007*, pp. 321-330 (22% acceptance).
69. On the Parameterization of Catmull-Rom Curves. Yuksel C., Schaefer S. and Keyser J. *SIAM/ACM Joint Conference on Geometric and Physical Modeling 2009*, pp. 47-53 (28% acceptance).
70. Suggestive Hatching. Singh M. and Schaefer S. *Computational Aesthetics 2010*, pp. 25-32 (38% acceptance).

Book Chapters

71. Multi-Sided Patches via Barycentric Coordinates. Schaefer, S. In Generalized Barycentric Coordinates in Computer Graphics and Computational Mechanics. Ed. Hormann, K. and Sukumar, N. CRC Press, 2017. 135-146.

Technical Reports

72. Dual Contouring: "The Secret Sauce". Schaefer S. and Warren J. Rice University Technical report TR 02-408.
73. Barycentric Coordinates for Convex Sets. Warren J., Schaefer S., Hirani A., Desbrun M., Rice University Technical Report.
74. Approximating Catmull-Clark Subdivision Surfaces with Bicubic Patches. Loop C. and Schaefer S. Microsoft Research Technical Report, MSR-TR-2007-44.
75. Circumcentric Dual Cells with Negative Area. Dyer R. and Schaefer S. Simon Fraser University Technical Report, CMPT2009-6.

Conference and Invited Talks

1. Interpolatory Subdivision for Surfaces of Revolution, talk at SIAM Conference on Geometric Design and Computing, Sacramento, CA (November 2001).
2. Dual Contouring of Hermite Data, paper presentation at ACM SIGGRAPH, San Antonio, TX (July 2002).
3. A Factored Approach to Tri/Quad Subdivision, talk at SIAM Conference on Geometric Design and Computing, Seattle, WA (November 2003).
4. Adaptive Vertex Clustering Using Octrees, talk at SIAM Conference on Geometric Design and Computing, Seattle, WA (November 2003).
5. Building Smooth 3D Deformations using Tetrahedral Subdivision, talk at Second Annual Workshop of Deformable Modeling ITR, Houston, TX (March 2004).
6. Smooth Subdivision of Tetrahedral Meshes, paper presentation at ACM SIGGRAPH/Eurographics Symposium on Geometry Processing, Nice, France (July 2004).
7. Lofting Curve Networks Using Subdivision Surfaces, paper presentation at ACM SIGGRAPH/Eurographics Symposium on Geometry Processing, Nice, France (July 2004).
8. A Geometric Construction of Coordinates for Convex Polyhedra using Polar Duals, paper presentation at ACM SIGGRAPH/Eurographics Symposium on Geometry Processing, Vienna, Austria (July 2005).

9. Mean Value Coordinates for Closed Triangular Meshes, talk at TexGraph, College Station, TX (May 2005).
10. Mean Value Coordinates for Closed Triangular Meshes, paper presentation at ACM SIGGRAPH, Los Angeles, CA (August 2005).
11. Approximating Catmull-Clark Patches, talk at TexGraph, College Station, TX (May 2006).
12. A Simple Approach to Nonlinear Subdivision, talk at Curves and Surfaces, Avignon, France (June 2006).
13. Image Deformation using Moving Least Squares, paper presentation at ACM SIGGRAPH, Boston, MA (August 2006).
14. Approximate Catmull-Clark Patches, invited talk at Trinity University, San Antonio, TX (November 2006).
15. Mean Value Coordinates for Closed Shapes, invited talk at Trinity University, San Antonio, TX (February 2007).
16. Example-Based Skeleton Extraction, paper presentation at ACM SIGGRAPH/Eurographics Symposium on Geometry Processing, Barcelona, Spain (July 2007).
17. Exact Evaluation of Non-Polynomial Subdivision Schemes at Rational Parameter Values, paper presentation at Pacific Graphics, Maui, HI (October 2007).
18. Barycentric Coordinates for Closed, Convex Curves, talk at SIAM Conference on Geometric Design and Computing, San Antonio, TX (November 2007).
19. Manifold Dual Contouring, talk at the Dagstuhl Workshop on Geometric Modeling, Dagstuhl, Germany (May 2008).
20. Approximate Catmull-Clark Patches, paper presentation at ACM SIGGRAPH, Los Angeles, CA (August 2008).
21. Simplification of Articulated Meshes, talk at the Workshop on Computational Mathematics of Discrete Surfaces, Banff, Canada (February 2009).
22. Suggestive Hatching, paper presentation at Computational Aesthetics, London, UK (June 2010).
23. Approximating Subdivision Surfaces for Hardware Tessellation, talk at Curves and Surfaces, Avignon, France (June 2010).
24. Scales and Scale-Like Structures, paper presentation at ACM SIGGRAPH/Eurographics Symposium on Geometry Processing, Lyon, France (July 2010).
25. Parameterization of Subdivision Surfaces, paper presentation at ACM SIGGRAPH, Los Angeles, CA (July 2010).
26. Surface Reconstruction and Compression, talk at the DARPA GRID II Workshop, Washington, D.C. (August 2010).
27. Approximating Subdivision Surfaces for Hardware Tessellation, invited talk at Washington University, St. Louis, MO (October 2010).
28. Approximating Subdivision Surfaces for Hardware Tessellation, invited talk at Texas State University, San Marcos, TX (December 2010).
29. Surface Reconstruction using Discrete Indicator Functions, talk at the IAMCS Workshop on Visualization in Biomedical Computation, College Station, TX (February 2011).
30. Exact Evaluation of Non-polynomial Subdivision Schemes at Rational Parameter Values, talk at the Approximation Theory Conference, Nashville, TN (May 2011).
31. Construction and Manipulation of Discrete Indicator Functions, talk at the Dagstuhl Workshop on Geometric Modeling, Dagstuhl, Germany (May 2011).
32. Computer Graphics, invited talk at Trinity University, San Antonio, TX (September 2011).

33. Parameterization Aware MIP-Mapping, invited talk at University of Lugano, Lugano, Switzerland (September 2012).
34. Approximate Catmull-Clark Surfaces and their Parameterization, talk at the New Trends in Subdivision Workshop, Milan, Italy (September 2012).
35. Generalized Barycentric Coordinates, talk at the Workshop on Algebraic Geometry and Geometric Modeling, Banff, Canada (January 2013).
36. Rasterization and Back Again: Aliasing and Computer Graphics, invited talk at KAUST, Saudi Arabia (April 2013).
37. Mesh Denoising via L0 Minimization, talk at the Dagstuhl Workshop on Geometric Modeling, Dagstuhl, Germany (May 2014).
38. Cardinality Constrained Texture Filtering, invited talk at Trinity University, San Antonio, TX (September 2014).
39. Cardinality Constrained Texture Filtering, invited talk at Hong Kong University, Hong Kong, China (October 2014).
40. Aliasing in Solid and Geometric Modeling, Keynote talk at SPM 2014, Hong Kong, China (October 2014).
41. Bijective Parameterization with Free Boundaries. Keynote talk at Curves and Surfaces 2016, Tonsberg, Norway (June 2016).
42. Digital Taxidermy: Bijective Parameterization with Free Boundaries. Invited talk Lehigh University, Bethlehem, PA (December 2018).
43. Bijective Parameterization with Free Boundaries. Keynote talk at Shape Modeling International 2019, Vancouver, CA (June 2019).
44. Digital Taxidermy: Bijective Parameterization with Free Boundaries. Invited talk Rice University, Houston, TX (September 2019).
45. Generalized Barycentric Coordinates. Invited talk at Oberwolfach, Germany (February 2022).
46. On Bezier and Barycentric Coordinates. Keynote lecture at the CSF Workshop on Generalized Barycentric Coordinates in Computer Graphics and Computational Mechanics. Switzerland (June 2022).

Teaching Experience

- CPSC 689: “Special Topics in Surface Deformation and Reconstruction” (Fall 2006)
- CPSC/CSCE 441: “Computer Graphics” (Spring 2007, Fall 2008, Fall 2009, Spring 2011, Spring 2012, Fall 2013, Spring 2014, Fall 2014, Fall 2016, Fall 2017)
- CPSC/CSCE 645: “Geometric Modeling” (Fall 2007, Spring 2009, Fall 2010, Spring 2013, Fall 2015)
- CPSC/CSCE 489: “Computer Game Development” (Spring 2008, Spring 2009, Spring 2010, Fall 2011, Fall 2013)
- CSCE 221: “Data Structures and Algorithms” (Summer 2013, Spring 2015, Spring 2017, Fall 2018)
- CSCE 181: “Introduction to Computing” (Fall 2014, Spring 2015, Fall 2015, Spring 2016, Fall 2017, Spring 2018, Fall 2018, Spring 2019)
- CSCE 481: “Seminar” (Fall 2016, Spring 2017)

Reviewer/Referee Experience

- ACM SIGGRAPH

- ACM Transactions on Graphics
- IEEE Visualization
- Eurographics
- SIGGRAPH ASIA
- The Visual Computer
- Computer-Aided Design
- Symposium on Geometry Processing
- Computer Aided Geometric Design
- Journal of Zhejiang University SCIENCE
- Graphical Models (GMOD)
- Journal of Virtual Reality and Broadcasting
- EuroVis
- Eurographics Symposium on Rendering
- Computer Graphics Forum
- Computers & Graphics
- International Journal of Image and Graphics
- Journal of Computing and Information Science
- Advances in Computational Mathematics
- Computers Graphics and Applications
- IEEE/ACM Transactions on Computational Biology and Bioinformatics
- International Journal of Computer Applications in Technology
- Mathematical and Computer Modeling
- SIAM Journal of Mathematical Analysis
- International Symposium on Visual Computing
- Shape Modeling International
- Pacific Graphics
- ACM Symposium on Solid and Physical Modeling
- Algorithms
- IEEE Pacific Visualization
- Journal of Computer Science and Technology
- ASME International Design Engineering Technical Conference
- Abstract and Applied Analysis
- Journal of Mathematics and the Arts
- Journal of Computers
- ACM Symposium on Computational Geometry
- Eurographics Workshop on High Performance Graphics
- IEEE Transactions on Multimedia
- International Journal of Advanced Robotic Systems
- IEEE Scientific Visualization
- Computing Surveys
- International Journal of Image and Graphics

Editorial Positions

- Associate Editor, Graphical Models (GMOD), 2010-present
- Associate Editor, The Visual Computer, 2010-2016
- Associate Editor, Computed Aided Design, 2015-present
- Associate Editor, Transactions on Visualization and Computer Graphics, 2016-2020

- Associate Editor, ACM Transactions on Graphics, 2017-2020
- Guest Editor, Computer Aided Design, 2010-2013, 2015
- Guest Editor, Computer Aided Geometric Design, 2010-2012
- Guest Editor, Computers & Graphics, 2020-2021

Program Committees

- Program co-chair of Geometric Modeling and Processing (2010)
- Program co-chair of the Symposium on Geometry Processing (2011)
- Program co-chair of Shape Modeling International (2012)
- Program co-chair of Solid and Physical Modeling (2015, 2016)
- Conference co-chair of Geometric Modeling and Processing (2018)
- ACM SIGGRAPH Papers Committee (2011, 2012, 2016)
- ACM SIGGRAPH Asia Papers Committee (2011, 2017)
- ACM SIGGRAPH Unified Jury (2009, 2010, 2013, 2014)
- ACM SIGGRAPH Conflict of Interest Coordinator (2019, 2020)
- Eurographics Short Papers (2012)
- Symposium on Geometry Processing (2008, 2009, 2010, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022)
- Pacific Graphics (2007, 2011, 2012, 2014)
- ACM Symposium on Solid and Physical Modeling (2008, 2010, 2014, 2017, 2020, 2022)
- SIAM/ACM Joint Conference on Geometric and Physical Modeling (2009, 2011, 2013, 2021)
- Shape Modeling International (2009, 2010, 2011, 2013, 2014, 2015)
- Sibgrapi (2011)
- Computational Aesthetics (2011, 2012, 2013, 2014)
- International Symposium on Visual Computing (2007, 2008, 2009, 2010, 2011, 2012, 2013)
- Geometric Modeling and Processing (2012, 2015, 2016, 2019, 2020, 2021, 2022)
- Computer Graphics International (2013)
- Sketch-Based Interfaces and Modeling (2013, 2014)
- Non-Photorealistic Animation and Rendering (2013, 2014)
- Eurographics (2015)

University Service

- Library Committee (2006-2007)
- Undergraduate Curriculum Committee (2007-2008, 2013-2019)
- Computer Science Advisory Committee (2008-2009, 2013-2016, 2017-2019)
- Computer Engineering Coordinating Committee (2014-2019)
- Visualization Joint Committee (2014-2019)
- Undergraduate Recruiting Committee (2008-2009)
- Undergraduate Student Awards Committee (2009-2010, 2011-2013, 2017-2019)
- Web Advisory Committee (2010-2011)

- Visualization Faculty Search Committee (2011-2012)
- University Honor Council (2013-2019)
- College of Engineering Awards Committee (2013-2015)
- Faculty Advisor for Texas A&M E-Sports Student Group (2012-2020)
- Faculty Advisor for Texas A&M Science Fiction Association Student Group (2017-2018)
- CSCE ABET Coordinator (2013-2017)
- CSCE Faculty Search Committee (2014-2015)
- Chair of the CSCE APT Faculty Search Committee (2016-2017)
- Chair of the Undergraduate Curriculum Committee (2015-2017, 2018-2019)
- Engineering Science Curriculum Committee (2016-2017)
- Associate Department Head for Academics (2017-2019)
- CSCE APT Faculty Search Committee (2017-2019)
- CSCE Faculty Awards Committee (2017-2018)
- CSCE Graduate Awards Committee (2017-2019)
- Chair of the Computing Fundamentals Task Force (2017-2018)
- Broadening Participation Taskforce Member (2018-2019)
- Graduate Advisory Committee (2017-2019)
- Graduate Fee Oversight Committee (2018-2019)
- CoE Undergraduate Advising Task Force (2022)
- Department Head Steering Council Member (2022-present)
- Operations Assessment University Committee (2023)
- Petroleum Engineering Department Head Search Committee Chair (2023-present)

Postdoctoral Scholars and Students

Postdoctoral Scholars Sponsored

- Kuiyu Li, 2010-2011, Intel.

PhD Students

- Mayank Singh, PhD 2011, University of Wisconsin La Crosse.
- Eric Landreneau, PhD 2011, Blizzard Entertainment.
- Josiah Manson, PhD 2014, Activision Research.
- Lei He, PhD 2014, Microsoft.
- Jason Smith, PhD 2016, Schlumberger.
- Zhipei Yan, PhD 2021, ByteDance.
- Anshul Mendiratta, current PhD student.

Masters Students

- Deepak Garg, MS 2013, Pimco.