References & More Information

VR Interface Design Pre-Visualisation Methods
video located at: https://vimeo.com/141330081

1. Examples Pictured:
   Iron Man 2 (2010). [film] Jon Favreau.
   Iron Man 3 (2013). [film] Shane Beck.
   Matrix: Reloaded (2003). [film] The Wachowski Brothers.
   Minority Report (2002). [film] Steven Spielberg.
   Pacific Rim (2013). [film] Guillermo del Toro.
   Prometheus (2012). [film] Ridley Scott.
   Tron: Legacy (2010). [film] Joseph Kosinski.
   Avatar (2009). [film] James Cameron.
   Ender's Game (2013). [film] Gavin Hood.
   Guardians of the Galaxy (2014). [film] James Gunn.
   Oblivion (2013). [film] Joseph Kosinski.

2. Alger, M. (2015). *VR Interface Design Manifesto*. [presentation] https://vimeo.com/116101132

3. Medich, J. (2015). *What Would a Truly 3D Operating System Look Like?*. [blog] Leap Motion. http://blog.leapmotion.com/truly-3d-operating-system-look-like/

4. Abrash, M. (2014). *Oculus Connect Keynote*. [presentation] https://www.youtube.com/watch?v=knQSRTApNcs

5. Colgan, A. (2015). *Designing VR Tools: The Good, the Bad, and the Ugly*. [blog] Leap Motion. http://blog.leapmotion.com/designing-vr-tools-good-bad-ugly/

6. The concept that a more preferable environment contributes to an individual's happiness is self evident, in my opinion.

   Examples Pictured:
   Heavy Rain (2010). [video game] Quantic Dream: David Cage.
   The Sims 3 (2009). [video game] Electronic Arts.

7. I don't mean any disrespect to Doom & Quake as they were obviously enormous steps for video games and extremely popular as "killer apps" in their own right. I just mean to point out that productivity tools became the main reason the general public decided to buy PCs.

8. Examples pictured:

Google Image Search (2015). [software]
VLC (2015). [software] Mac. v 2.2.1.
Big Hero 6 (2014). [film] Don Hall, Chris Williams.
Amazon Kindle
123D Catch (2015). [website] Autodesk.
Photoshop (2014). [software] Adobe. v CC 2014.
Google Chrome (2015). [software] v 45.0.2454.85.
Reddit (2015). [website] reddit.com/r/oculus
Mac OS X (2015). [software] Apple. v 10.10.3.
Windows 8 (2014). [software] Microsoft.
Windows Media Player (2014). [software] Microsoft.
iOS 6 (2014). [software] Apple. v 6.1.6.
Miro Video Converter (2015). [software] Participatory Culture Foundation.
Android (2015). [software] Google.
Firefox (2015). [software] Mozilla. v 40.0.3.
Illustrator (2014). [software] Adobe. v CC 2014.
Cinema 4D (2014). [software] Maxon. v R16 Student.
Docs (2015). [software] Google.
Macbook Pro
Premiere (2014). [software] Adobe. v CC 2014.

9. Sutherland, I. E. (1968). *A head-mounted three dimensional display*. In Proceedings of the December 9-11, 1968, fall joint computer conference, part I, pp. 757-764. ACM. http://design.osu.edu/carlson/history/PDFs/p757-sutherland.pdf

Thacker, C., McCreight, E., Lampson, B., Sproull, R. and Boggs, D. (1979). *Alto: A personal computer*. Computer Structures: Principles and Examples, second edition, pp.549-572.
http://research.microsoft.com/en-us/um/people/blampson/25-Alto/25-Alto.pdf

Video sources (origins uncredited):
Ivan Sutherland - Head Mounted Display (1968).
https://www.youtube.com/watch?v=NtwZXGprxag

Xerox PARC Demo for Apple (1979).
https://www.youtube.com/watch?v=NxEmJu8OSug

It can also be said that Ivan Sutherland's "Sketchpad" (1963) or Douglas Engelbart's "On-line System" (1968) were GUIs, but I am referring to the window, icon, menu, pointer (WIMP) desktop style GUI for which Xerox PARC's Alto was first.

10. *Vrui on Oculus Rift with Razer Hydra and Kinect* (2013). [video] okreylos.
https://www.youtube.com/watch?v=IERHs7yYsWI

More information on the VRUI project at UC Davis:
http://idav.ucdavis.edu/~okreylos/ResDev/Vrui/

11. *Classic 3D User Interaction Techniques for Immersive Virtual Reality Revisited* (2010). [video] Bielefeld University.
https://www.youtube.com/watch?v=KaNE4946LDk

Renner, P., Dankert, T., Schneider, D., Mattar, N. and Pfeiffer, T. (2015). *Navigating and Selecting in the Virtual Supermarket: Review and Update of Classic Interaction Techniques.*
http://www.techfak.uni-bielefeld.de/~tpfeiffe/pubs/2010_-_Renner_et_al_Navigation_and_Selection_in_the_Virtual_Supermarket.pdf

12. *MiddleVR for Unreal in a Cave* (2015). [video] MiddleVR.
https://www.youtube.com/watch?v=REfLUtqELjU

More information on MiddleVR:
http://www.middlevr.com/

13. Sherman, W. and Craig, A. (2003). *Understanding Virtual Reality*. San Francisco, CA: Morgan Kaufmann, pp.310-325.

Example pictured:
The Future of Design (2013). [video] SpaceX.
https://www.youtube.com/watch?v=xNqs_S-zEBY

14. Stoakley, R., Conway, M., Pausch, R. (1995). *Virtual Reality on a WIM: Interactive Worlds in Miniature*. University of Virginia.
http://www.cs.cmu.edu/~stage3/publications/95/conferences/chi/paper.html

15. AltSpace VR (2015). [software].
http://altvr.com/

16. Maddix, K. (2015). *Big Data VR Challenge – Winners!*. [blog] Masters of Pie.
http://www.mastersofpie.com/big-data-vr-challenge-winners/

17. Tiltbrush (2015). [software].
http://www.tiltbrush.com/

18. The idea of associating persistent menu items or actions with body parts is to take advantage of motor memory in relation with proprioception.

19. Examples pictured
Borderlands 2 (2012). [video game]
DiRT (2007). [video game]

20. Wall-E (2008). [film] Andrew Stanton.

21. Oculus Rift DK2: https://www.oculus.com/en-us/dk2/
Leap Motion controller: https://www.leapmotion.com/

22. Oculus Utilities for Unity 5 (2015). [software]
https://developer.oculus.com/downloads/game-engines/0.1.0-beta/Oculus_Utilities_for_Unity_5/

I'm getting these numbers from the Oculus Unity integration package, in which the cameras' field of view is 106.09° vertically and 94.16° horizontally for the DK2. I realize that it is marketed colloquially as having about a 100° field of view, but I assume this is just an estimated median between the two that is easier to refer to.

For content and ergonomics, I would prefer to err on the side of safety and go with the smaller circular diameter.

23. Chu, A. (2014). *VR Design: Transitioning from a 2D to a 3D Design Paradigm*. http://alexchu.net/Presentation-VR-Design-Transitioning-from-a-2D-to-a-3D-Design-Paradigm

24. The older Oculus best practice guide recommended permanent elements not be closer than 50cm (http://www.roadtovr.com/oculus-rift-best-practices-guide-virtual-reality-recommended-age/)

That distance has more recently been updated to 75cm (https://developer.oculus.com/documentation/intro-vr/latest/concepts/bp_app_ui/)

The reality of this near area is tricky, as it's a sort of gradient of discomfort. Within that nearest meter, how much strain is too much strain is a matter of opinion.

25. Ankrum, D. R. (1999). *Visual Ergonomics in the Office - Guidelines*. Occupational Health & Safety. pp. 68. http://office-ergo.com/wp-content/uploads/2010/12/Monitor-Placement-and-Lighting-Ankrum-DR.-19991.pdf

26. Hoffman, D., Girshick, A., Akeley, K. and Banks, M. (2008). *Vergence-accommodation conflicts hinder visual performance and cause visual fatigue*. Journal of Vision, 8(3), pp.33-33. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2879326/

27. "The current optics of the DK2 Rift are equivalent to looking at a screen approximately 1.3 meters away." https://answers.oculus.com/questions/41/how-do-i-find-a-comfortable-distance-zone-of-comfo.html

28. *NVIDIA's Light-field Glasses Prototype demo @ Siggraph 2013 (2013)*. [video] electrictv. https://www.youtube.com/watch?v=deI1IzbveEQ

Lanman, D. and Luebke, D. (2013). *Near-Eye Light Field Displays*. NVIDIA Research. https://research.nvidia.com/sites/default/files/publications/NVIDIA-NELD_0.pdf

29. G. Wetzstein, D. Lanman, M. Hirsch, R. Raskar. (2012). *Tensor Displays: Compressive Light Field Synthesis using Multilayer Displays with Directional Backlighting*. Proc. of SIGGRAPH 2012 (ACM Transactions on Graphics 31, 4). http://web.media.mit.edu/~gordonw/TensorDisplays/

30. Alger, M. (2015). *HMD resolution and maximum depth perception*. [blog] http://mikealgermovingimage.tumblr.com/post/127113260256/hmd-resolution-and-maximum-depth-perception

31. "Tracking degrades when arms are held directly away from the body (i.e. elbows straight)"
Leap Motion Release Notes. v 2.3.1.
https://developer.leapmotion.com/documentation/python/supplements/SDK_Release_Notes.html

"The Leap Motion controller tracked my hand quite well whenever my hands were within two thirds arm distance in front of my face..."
Part 2 of 30 x Oculus Rift Games (2015). [video] OculusHut. 08:40.
https://youtu.be/j4OEJbY2kxE?t=8m40s

32. This is based on my own experience. The tracking's fidelity degrades significantly when the hands or arms cross. I assume this is because Leap Motion's software uses the infrared silhouette to build the skeleton and mesh used for collisions and when the silhouettes cross, it has a harder time distinguishing between the shade of grey of one hand and the other. Other tracking methods or upcoming improvements may allow UI to be placed on or around tracked hands.

33. Examples pictured:
Leap Motion Image Hand Grid Shader Test (2015). [video] hecomi.
https://www.youtube.com/watch?v=BRhyEZaB8LM

Planetarium (2015). [software] Leap Motion.
https://developer.leapmotion.com/gallery/planetarium

Hovercast (2015). [software] Aesthetic Interactive.
https://github.com/aestheticinteractive/Hover-VR-Interface-Kit

34. VR OS Utopia Exhibition (2015). [software] Alger, M.
http://mikealgermovingimage.tumblr.com/post/122833583691/this-is-a-screen-recording-of-the-app-im-showing

35. Widgets (2014). [software] Leap Motion.
https://developer.leapmotion.com/gallery/widgets

36. Alger, M. (2015). *HMD Button Design for AR and VR*. [blog]
http://mikealgermovingimage.tumblr.com/post/117567194441/hmd-button-design-for-ar-and-vr

37. The top 500 sites on the web (2015). [website] Alexa.
http://www.alexa.com/topsites

I used Alexa for the most common web applications. Information on most commonly used smartphone and PC applications is less public, so I used several lists from Google searches claiming to be definitive for recent years despite having different results. The goal was just to get a comprehensive list of common applications to estimate common user tasks.

More information:
Alger, M. (2015). *User Tasks*. [blog]
http://mikealgermovingimage.tumblr.com/post/112271424946/user-tasks

38. Valve and HTC Vive: http://www.htcvr.com/

No, I don't think people would likely use a Leap Motion controller for one hand and only one Vive controller in the other, but it does work nicely as a keyboard-and-mouse interaction style for the example.

39. Examples pictured:

How to 3D body scan with Artec Eva (2014). [video] Artec 3D.
https://www.youtube.com/watch?v=MiQmYPsFi48

Artec Studio 9 User Guide (2014). v 9.2.
http://artec-group.com/sw/ug/ug.pdf

40. Examples pictured:

Leap Motion controller: https://www.leapmotion.com/product/vr
Valve and HTC Vive HMD and controllers: http://www.htcvr.com/
iPad and iPhone: http://www.apple.com/ipad/
Oculus Touch: https://www.oculus.com/en-us/rift/

41. Collet A., Chuang M., Sweeney P., Gillett D., Evseev D., Calabrese D., Hoppe H., Kirk A., Sullivan. S. (2015). *High-quality streamable free-viewpoint video*. ACM Transactions on Graphics, 34(4)
http://research.microsoft.com/en-us/um/redmond/projects/fvv/

42. Examples pictured:
Google Glass: https://www.google.com/glass/start/
Oculus Rift DK1: https://www1.oculus.com/order/dk1/
OSVR: http://www.razerzone.com/osvr
3D Head: http://www.beverlyhills3d.com/
Oculus Rift DK2: https://www.oculus.com/en-us/dk2/
Samsung Gear VR: http://www.samsung.com/global/microsite/gearvr/
Microsoft Hololens: https://www.microsoft.com/microsoft-hololens/en-us
HTC Vive: http://www.htcvr.com/
Oculus Rift (aka CV1): https://www.oculus.com/en-us/rift/

43. Kreylos, O. (2015). *On the road for VR: Microsoft HoloLens at Build 2015, San Francisco*. [blog] Doc-Ok.org.
http://doc-ok.org/?p=1223

Microsoft Hololens Hands-On Impressions (2015). [video] Tested.
http://www.tested.com/tech/concepts/523767-microsoft-hololens-hands-impressions/

Microsoft has not yet detailed specifications for the hololens head mounted display. However, much can be extrapolated from the technologies in use and the experiences of others. It is very possible that a later consumer version may have higher resolutions, wider fields of view, and/or ways to display black pixels with varying opacity, but the current demo version appears to have the properties explained in the video.

44. *Microsoft Hololens* (2015). [website] Microsoft.
https://www.microsoft.com/microsoft-hololens/en-us

Microsoft HoloLens - Transform your world with holograms (2015). [video] Microsoft.
https://www.youtube.com/watch?v=aThCr0PsyuA

Microsoft HoloLens - Possibilities (2015). [video] Microsoft.
https://www.youtube.com/watch?v=aAKfdeOX3-o

Microsoft HoloLens demo onstage at BUILD 2015 (2015). [presentation] Microsoft.
https://www.youtube.com/watch?v=3AADEqLIALk

Minecraft Hololens demo at E3 2015 (2015). [presentation] Microsoft. https://www.youtube.com/watch?v=xgakdcEzVwg

Microsoft HoloLens: Partner Spotlight with Case Western Reserve University (2015) [video] Microsoft. https://www.youtube.com/watch?v=SKpKlh1-en0

45. This is the Oculus Rift DK2 Resolution and field of view of in-game cameras as previously described. (see 22.)

46. This interface previsualization was created for an upcoming product. However, I have omitted most of the interface and features at the request of the creators since it is still in development.

47. Alger, M. (2015). *Visual Design Methods for Virtual Reality*, pp 79-86. http://aperturesciencellc.com/vr/paper

Alger, M. (2015). *How to Make Your Head Into a Game Avatar*. [blog] http://mikealgermovingimage.tumblr.com/post/126459997751/how-to-make-your-head-into-a-game-avatar

A quick summary of these can be found in the appendix of the corresponding writeup. If I'm honest, I thought it would be fun to have an avatar and this was the process of comparing creation methods for myself.

48. Alger, M. (2015). *Visual Design Methods for Virtual Reality*, pp 46-49. http://aperturesciencellc.com/vr/paper

49. Alger, M. (2015). *Designing VR for Humans*. C-Base Raumstation, Berlin, Germany. http://www.meetup.com/Berlin-Virtual-Reality-Meetup/events/220294981/

50. Alger, M. (2015). *Take Care of Your Humans (with Virtual Reality!)*. Hemnes, Warsaw, Poland. http://www.meetup.com/GoMobile-with-Design/events/220210315/

51. Alger, M. (2015). *Murica VR Chat Environment*. [blog] http://mikealgermovingimage.tumblr.com/post/123603176478/someone-on-reddit-asked-for-a-fireworks

52. Alger, M. (2015). *Insider Notes from the HTC Vive VR Jam at London's Playhubs*. [blog] Road to VR. http://www.roadtovr.com/insider-notes-from-the-htc-vive-vr-jam-at-londons-playhubs/

53. Museum of Lies (2015). [video] https://vimeo.com/130581302

54. Gaming consoles are examples of computers that are constantly doing complex rendering, so it's definitely possible with current tech. What I was thinking of is how you won't have a video for your current desktop or many users would disable the "aero" transparency in Windows because it's taxing to performance including frame rate. Since VR has to maintain upwards of 75-90 frames per second, much of the complex multitasking we're used to may be curbed in these first years if it was being additionally represented as meshes and materials with lighting. It is still definitely possible, though.

55. Examples pictured:

Real-Time Archviz in Unreal Engine (Realistic 3D Interior VR): London Apartment - UE4Arch (2015). [video] CGriver.com https://www.youtube.com/watch?v=JOMRxZUQ-nI

Alger, M. (2015). *NSFW* [blog] http://thealphamike.tumblr.com/post/102232009319/nsfw

mOculus.io - Autodesk Maya in VR @ Grounded Vindaloop (2015). [video] https://www.youtube.com/watch?v=pJs7UEyEDhU

Tywin Lannister Sculpt Timelapse (2013). [video] Adam Fisher. https://www.youtube.com/watch?v=nUe2IHN_isU

Google Earth (2015). [software] v 7.1.5.1557. http://earth.google.com

The Future of Design (2013). [video] Space X. https://www.youtube.com/watch?v=xNqs_S-zEBY

6000 Moons (2015). [software] Bin Software. v0.8. http://binsoftware.com/moons/

Structure of a Volcano (2013). [video] 3D-Hub Player https://www.youtube.com/watch?v=tJ_mgONXyjQ

Titans of Space (2014). [software] Drash VR LLC.
http://www.titansofspacevr.com/

Field Trip (2015). [video] Mike Alger.
https://www.youtube.com/watch?v=lRlO_CFsFJY

Henry (2015). Oculus Story Studio.
https://storystudio.oculus.com/en-us/henry/