Designing the Optimal Augmented Reality Experience

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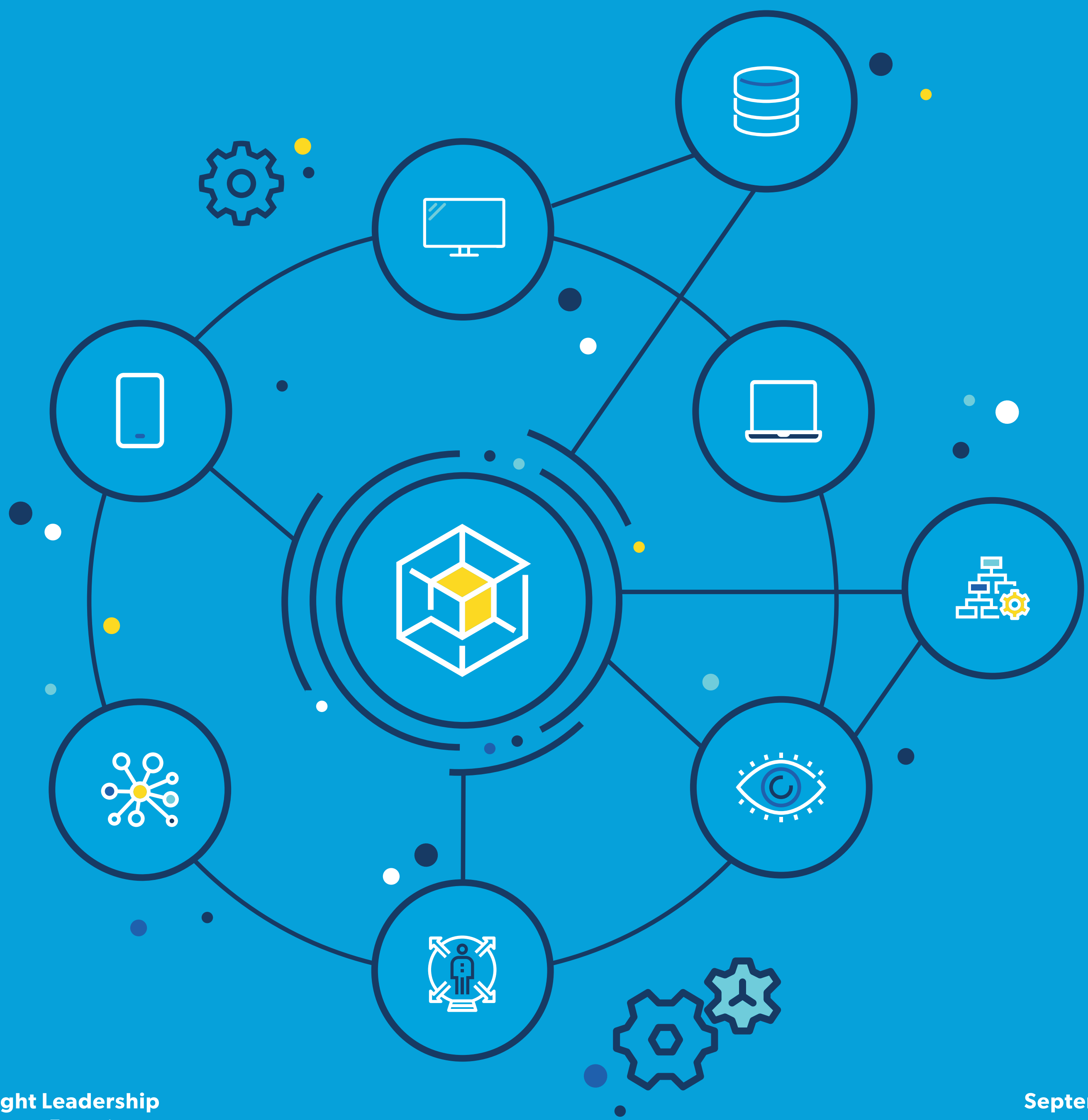

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Augmented Reality (AR) is a technology that superimposes computer-generated images onto a user's view of the real world allowing them to see the digital graphic in an approximation of what it would look like if it were actually there. While the AR features implemented on apps such as Instagram can be entertaining — such as making a tiger appear in your home — AR has found useful applications across a wide range of industries such as hospitality, healthcare, and manufacturing. It can be used to create virtual guest experiences, help physicians understand the functioning of a new medical device, simulate the production process on a factory floor, and more. Whether for entertainment or education, the development of these experiences is complex, and requires a disciplined approach based on best-practice techniques.

ESTABLISHING BEST PRACTICES FOR AR INTERFACE DESIGN

Best practices for interface design are crucial tools for designers and developers, who utilize these tools on a regular basis in order to guide interface design and optimize a user experience. While the guidelines, and subsequent techniques, for 2D interface design have been refined over many years thanks to the excellent work of the Nielsen-Norman Group (NNG) and others' efforts, the guidelines for extended reality (ER) and augmented reality (AR) experiences have not.

In order to take a deep dive into AR design, we started with the Nielsen-Norman Group's classic heuristics, which Oxford defines as "an approach to problem solving or self-discovery that employs a practical method," and evaluated which heuristics were most applicable to AR and how best to apply them to AR interface design.

AESTHETIC AND MINIMALIST DESIGN

AR overlays are particularly susceptible to information overload, so special care should be taken to show only relevant and useful information.

ERROR PREVENTION AND HANDLING

Systems that rely on live data from a variable environment will inevitably be "buggier." They, therefore, need more robust error handling and careful consideration regarding the avoidance of errors.

VISIBILITY OF SYSTEM STATUS

AR applications have incredible potential to be used in a variety of environments. Feedback systems must be designed with this in mind. Applications intended to be used on a factory floor may benefit from haptic rather than aural feedback, for example.

Of all of the research that's been conducted into XR-specific heuristics, i.e, "Extended Reality" (XR) technologies including VR (Virtual Reality) and AR (augmented Reality), we found this article to be the most thorough and useful: Heuristic Evaluation of Virtual Reality Applications by Alistair Sutcliffe and Brian Gault. Sutcliffe and Gault used NNG's heuristics as a foundation, then adapted, expanded, and applied them to the design of a virtual environment.

Sutcliffe and Gault used the below heuristics to efficiently evaluate the usability of two virtual reality applications, and we found them particularly useful in our development of a prototype for an AR retail shopping aid.

NATURAL ENGAGEMENT
Interaction should approach the user's expectation of interaction in the real world as much as possible. Ideally, the user should be unaware that the reality is virtual. Interpreting this heuristic will depend on the naturalness requirement and the user's sense of presence and engagement.

COMPATIBILITY WITH THE USER'S TASK AND DOMAIN
The virtual environment (VE) and behavior of objects should correspond as closely as possible to the user's expectation of real-world objects, their behavior, and affordances for task action.

NATURAL EXPRESSION OF ACTION
The representation of the self/presence in the VE should allow the user to act and explore in a natural manner and not restrict normal physical actions. This design quality may be limited by the available devices. If haptic feedback is absent, natural expression inevitably suffers.

CLOSE COORDINATION OF ACTION AND REPRESENTATION
The representation of the self/presence and behavior manifested in the VE should be faithful to the user's actions. Response time between user movement and update of the VE display should be less than 200 Millis to avoid motion sickness problems.

REALISTIC FEEDBACK
The effect of the user's actions on virtual world objects should be immediately visible and conform to the laws of physics, as well as the user's perceptual expectations.

FAITHFUL VIEWPOINTS
The visual representation of the virtual world should map to the user's normal perception, and the viewpoint changes by head movement should be rendered without delay.

NAVIGATION AND ORIENTATION SUPPORT
The user should always be able to find where they are in the VE and return to known, preset positions. Unnatural actions such as fly-through surfaces may help, but these must be judged in a trade-off with naturalness (see heuristics 1 and 2).

CLEAR ENTRY AND EXIT POINTS
The means of entering and exiting from a virtual world should be clearly communicated.

CONSISTENT DEPARTURES
When design compromises are used, they should be consistent and clearly marked, e.g., cross-modal substitution and power actions for navigation.

SUPPORT FOR LEARNING
Active objects should be cued, and if necessary, explain themselves to promote learning of VEs.

CLEAR TURN-TAKING
Where system initiative is used, turn-taking should be clearly signaled with conventions established.

SENSE OF PRESENCE
The user's perception of engagement and being in a "real" world should be as natural as possible.

Figure 1: Heuristic evaluation of virtual reality applications - Alistair Sutcliffe and Brian Gault (Interacting with Computers: The Interdisciplinary Journal of Human-Computer Interaction)

WHAT WE DISCOVERED

As we designed, built, and tested this prototype, we uncovered other best practices and opportunities for further study. For example, users unexpectedly expressed preferences for using the application in both portrait and landscape mode in testing. This desire for choices should be accounted for in AR application layout design, in general. We plan to conduct several studies of user behavior to uncover other AR best practices, including interactive element affordances, CX prototyping capabilities, and onboarding experiences. The results of these investigations will be covered in future posts.

In addition to general usability heuristics, we discovered a set of ergonomic guidelines that are very useful in determining the placement of AR elements in virtual space. The standard reach of a human arm, the angles of direct and peripheral vision, and the maximum distance of legibility all play roles in determining the best placement for interactable and visible objects in 3D virtual spaces. We have included a handy cheat-sheet below for reference and we will be building an AR-viewable reference in our next post to illustrate these concepts in their realized form.

VIRTUAL ENVIRONMENT ERGONOMIC LAYOUT DIAGRAMS

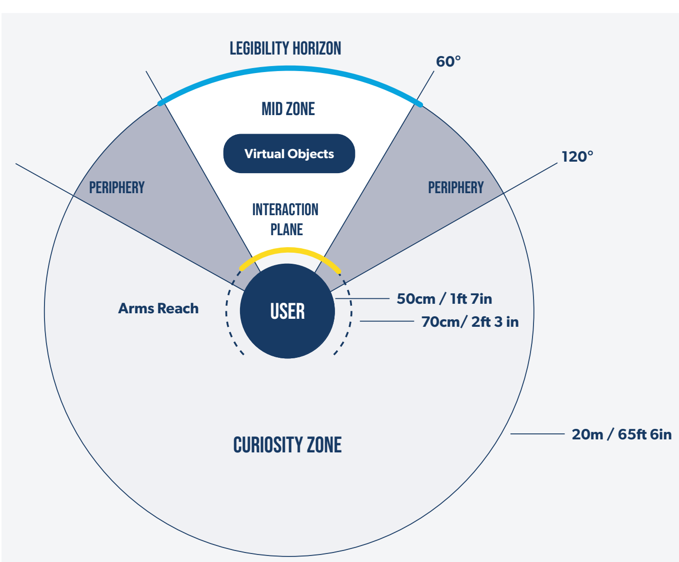


Figure 2 (above): Top-down view of ideal object placement (Original Illustration by Jacob Payne 2017)

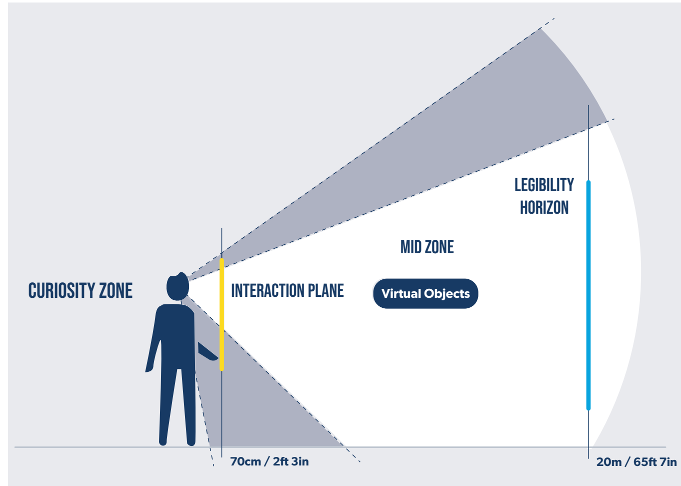


Figure 3 (above): Side-view of ideal object placement (Original Illustration by Jacob Payne 2017)

The diagrams above and to the left illustrate the ideal placement of interactable and readable elements in a virtual environment based on standard ergonomic measurements of humans. A user should have around 50 centimeters of "personal space" to avoid feeling cramped. Our normal vision forms a 60-degree cone from our eyes and our peripheral vision extends to 120 degrees. Objects intended for immediate interaction should live within the 60-degree cone and within arm's reach at around 70 centimeters.

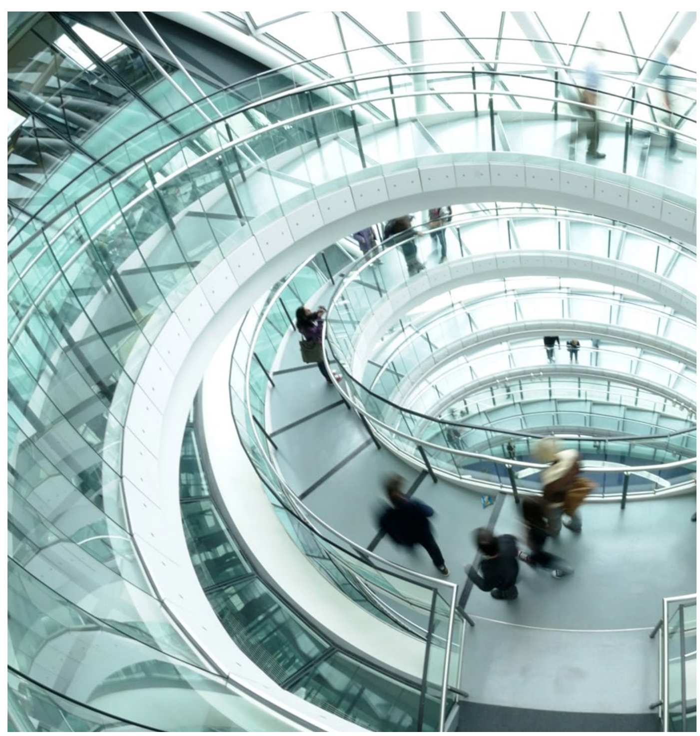
Objects indented for secondary interaction should live further out within that same cone, but no further than 20 meters. At longer distances, text gets difficult to read and objects hard to recognize. Finally, objects intended to be hidden and discovered can live behind the user or in their peripheral vision.

On the next page is a checklist to help you achieve good usability practices for any extended-reality application. As always, no set of rules replaces real testing, so allow ample time for that in your project's timeline.

AR DESIGN CHECKLIST

- [ ] Do the objects in your AR environment approximate their real-world counterparts?
- [ ] Does the virtual environment for your application approximate the real world?
- [ ] Can the user explore the virtual environment in a natural way? Does your application use haptic feedback to aid in this (e.g., grasping, object collision, etc.)?
- [ ] Is the delay between a user's action and the consequence of that action in the virtual environment less than 200 Millis?
- [ ] Are the effects of the user's actions visible immediately and do they conform to the laws of physics and other generally expected object behavior?
- [ ] Does the visual representation of the virtual world change with the user's orientation (e.g., head movement, device orientation, etc.)?
- [ ] Can users quickly re-orient back to a known point in the virtual environment in as natural a way as possible?
- [ ] Are the means of entering and exiting the virtual environment clearly communicated?
- [ ] Do virtual objects have educational content tied to them to help users understand what they are and what they do?
- [ ] Are conventions for user vs. system action turn-taking clearly established and consistently applied?
- [ ] Are objects intended for direct interaction located inside the interaction plane or the mid-zone in front of the user?
- [ ] Are objects and text intended for reading inside the legibility horizon in front of the user?
- [ ] Are controls that can cause changes to the virtual environment (e.g., clear, exit, etc.) located in an area that will not be accidentally accessed (e.g., above the user's head at arm's length, etc.)?

Use these guidelines to design ER and AR applications and products that are easier for your users to interact with and intuitively understand. Utilize this new technology to its fullest potential. And keep an eye on future content as we continue to further explore ER and AR best practices.



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