Design Patterns for Situated Visualization in Augmented Reality: Supplementary Material

Benjamin Lee [iD], Michael Sedlmair [iD], and Dieter Schmalstieg [iD]

1 INTRODUCTION

This supplementary document provides further insights from our survey, which applied a codebook of 10 situated visualization design patterns to a corpus of 293 papers. Please refer to Sections 3.1 and 3.2 in the main manuscript for full details about the survey's scope and methodology.

It is important to reiterate that the survey primarily serves as the theoretical and literary basis for our 10 situated visualization design patterns. Thus, this supplementary document goes into further detail as to how each design pattern has been used in the literature, rather than identifying research gaps and opportunities. For more in-depth and comprehensive literature surveys, particularly for the identification of research gaps and opportunities, we refer to a recent 2022 survey by Bressa et al. [23] on situated visualization, and a very recent 2023 survey by Shin et al. [231] on situated analytics. Note that almost all in-text citations in this document are non-exhaustive.

2 CORPUS CHARACTERISTICS

The vast majority of papers in the corpus originate from the visualization and augmented reality (AR) research communities, including ISMAR, VR, TVCG, and CHI. It includes full papers as well as short papers, workshop papers, and posters, such as those from ISMAR-ADJUNCT and CHI EA.

Figure 1 shows the number of papers that were published in each year in our corpus. As to be expected, there is a noted increase in papers roughly around 2019, in part due to the inclusion of numerous immersive analytics papers. It is important to stress however that these counts should not be used as an indication of research interest in situated visualization, due to our convenience sampling of papers as described in the original manuscript. Nevertheless, the corpus contains a fair balance of papers throughout the past 2+ decades, which we believe provides a consistent view of how the AR and visualization fields have used situated visualization. The only notable outlier in our corpus in terms of publication year is the paper on cutaways and ghosting by Feiner and Seligmann [56], which was included due how well it demonstrates the so-called "X-ray lens" design.
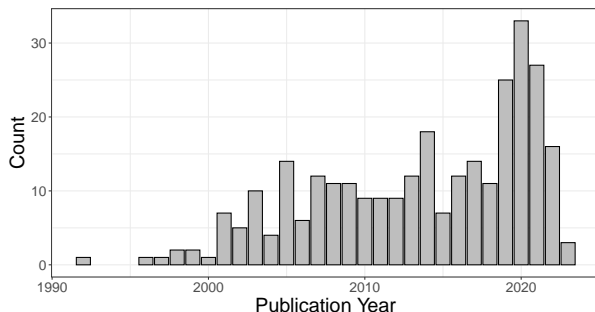

Fig. 1: Number of papers published per year in our corpus.

• *Benjamin Lee and Michael Sedlmair are with University of Stuttgart. E-mail: first-name.last-name@visus.uni-stuttgart.de*
• *Dieter Schmalstieg is with Graz University of Technology and University of Stuttgart. E-mail: schmalstieg@tugraz.at*
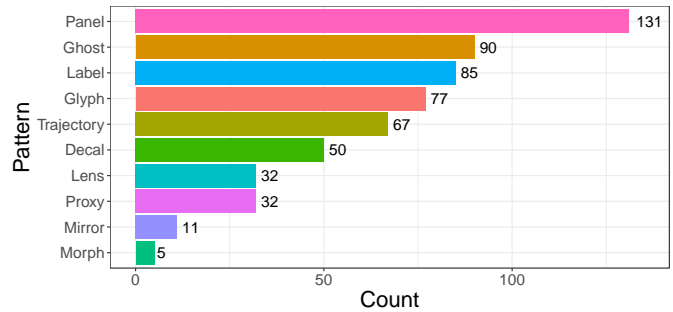

Fig. 2: Ranked frequency of each pattern in our survey. A paper may be assigned to more than one pattern.

3 POPULARITY AND USAGE OF PATTERNS

Table 1 lists the 10 patterns and provides references to the papers which were assigned to each of them. Figure 2 provides a visual representation of the same data as the table, but sorted by frequency. In contrast to Section 3 of the original manuscript which sought to define the patterns, this section aims to provide further insight into the ways in which each pattern is used in our corpus (roughly sorted by frequency).

Panels are clearly the most used pattern in our corpus. This is not surprising, as it is a flexible, intuitive, and straightforward method of displaying information to the user. Panels are usually text-based (e.g., to show instructions/documents to the user [117, 186, 281], to show WIMP-style user interfaces [94, 130, 162]). With the growth of immersive analytics, it is now common to use panels to show abstract data visualizations (e.g., [58, 113, 184, 254]), as they are an obvious means to do so—particularly for 2D visualizations.

Labels are also a popular pattern as they are a simple and effective method of embedding information onto physical referents, with the majority of research using it as such. Labels can not only show static information (e.g., names of locations [13, 69]), but also show dynamically updating values based on the state of the referent and/or user's input (e.g., for measurement [195], for 3D manipulation [108]). As mentioned in the original manuscript, the placement of labels is a research challenge in and of itself, with myriad considerations such as clutter, label crossing, and overlap with other labels and salient areas [69].

Ghosts are a unique pattern in that they are virtual objects that appear to be part of the actual physical scene, and thus serve to complement it. Given the interlink between AR and 3D graphics, it is unsurprising that ghosts are frequently used. Ghosts can stand on their own without being fixed to any physical referent (e.g., as an autonomously moving virtual agent [7, 11], for factory planning [86], to visualize full-body movements at discrete steps [31]). Likewise, ghosts can also be affixed to a physical referent. A straightforward example are ghosts which indicate where on the referent a physical component should be attached in manual assembly (e.g., [92, 238, 295]). Another example is spatially superimposing the ghost onto the referent, such that the user believes they are instead holding the ghost (e.g., [89, 257]). From an information visualization perspective, ghosts have been used to facilitate unit visualizations, with each data point being represented as a 3D object (e.g., [4, 37]). Ghosts can also provide further context to aid in the posthoc analysis of spatio-temporal data (e.g., an avatar representation of the user at a given point in time [149], virtual representations of

pre-existing objects [24]).

Glyphs are another common pattern. While glyphs can be used to encode some data directly on the physical referent (e.g., for immersive analytics [26, 37, 213]), they are most popularly used to either highlight some part of the referent (e.g., using a floating marker [20, 109, 130]) and/or to indicate where some action should be performed (e.g., where to push [117, 233], where to drill/insert [45, 80, 92, 110]). Glyphs can also be combined with the trajectory pattern as an arrow to denote a particular direction or path the action needs to be taken (e.g., rotate an object clockwise or counter-clockwise [30, 245, 281], look or move in the specified direction [171, 185]). Note that these glyphs and trajectories may also be freely drawn by a user (e.g., during remote assistance as annotations [43, 63, 162, 176], for sketching [62, 134, 209]).

Trajectories, as mentioned earlier, are typically used with glyphs to show directions, whether they be provided by the system or drawn by a user. They may indicate a path which an object (or the user) should directly follow (e.g., for drones [296], for navigation [139, 201, 229]). Trajectories are also obvious candidates for posthoc analysis of spatio-temporal data, particularly that of physical movements (e.g., [24, 94, 149]). Trajectories can also simply be used as regular trajectories and visual links as per information visualizations (e.g., [127, 194, 213]). They may also be used to connect and draw links between multiple referents (e.g., in networks [26, 52, 84, 228], along different points of space [174, 201, 289]), or between a referent and another visualization pattern (e.g., panels [276, 294], labels [69, 203, 252]).

Decals are comparatively less common than other patterns. This may be for a number of reasons, from the need to accurately detect and track the referent's surface, to the possibility of the decal occluding the underlying referent. Nevertheless, decals have been used in a wide range of physical scales: large scale (e.g., in agriculture [114, 289], building acceptance [210, 227, 297], environmental monitoring [259, 260]); medium scale (e.g., in rooms [149]); and small scale (e.g., on tabletops [2], on human faces [205]). Decals can show continuous field data (e.g., of physical movements [149], of crop yields [114]), can be used similarly to panels embedded on the referent (e.g., affinity diagramming with post-it notes [240]), and can provide more visual guidance to facilitate a given task (e.g., a virtual grid on a table [2, 35], a virtual target [80], overlaid textures to indicate selection [108]).

Proxies are similar to ghosts in that they appear as virtual 3D objects, but dissimilar in that they are replications of the referent itself (i.e., digital twin). As such, proxies are used comparatively little as the user can oftentimes already see the referent itself. As stated in the original manuscript, proxies are generally used to visualize referents that are too large in scale or are difficult to acquire (e.g., buildings [70, 251], human organs [104, 222]). Because proxies are inherently virtual, they can be freely manipulated by the user without physical constraints for myriad purposes (e.g., to explore intricate parts of the referent [79, 248, 249], for zooming [91], for scaling [128], for shopping and try-on [42, 99]). A proxy can also be used to indicate the desired state that the referent should be in (e.g., after product assembly [92, 143, 283]). Of course, proxies are perhaps most commonly used for navigation (e.g., as 3D worlds-in-miniature [107, 129, 170, 174, 184, 200, 267], as 2D top-down maps [237, 289]).

Magic Lenses fulfill a niche in that they are mainly used to reveal the internal structure of referents. As with proxies (and to some extent morphs and mirrors), this typically requires a digital twin of the referent in order to accurately visualize and position the contents revealed by the lens. Lenses can be used when it is important to look inside of a referent (e.g., to understand structures without occlusion [56, 102, 156], for surgery [45, 75], for maintenance [160, 215]). It can also be used to look directly through referents as though they were transparent (e.g., while driving [190], for occluded interaction [55, 140, 158]). Lenses may either reveal a portion of the referent when viewed through a specified region of space (e.g., [102, 120, 144, 156]), or be always visible to the user (e.g., [101, 216]). A compelling form of lens is to utilize a flashlight metaphor for shining AR visuals onto referents (e.g., on cultural artifacts in museums [204], on human bodies [34]). Another compelling use of lens is to leverage a physical handheld lens to enable tangible interaction of AR objects [120].

Mirrors are one of the two underutilized patterns. A likely reason is that mirrors require the user to look at a 2D plane that is separate from the original referent, increasing the level of spatial indirection which makes it harder to perform some physical task. That said, mirrors are perfectly suited in applications where the user needs to see their own face or body (e.g., [3, 22, 161, 205, 286]), just like an actual mirror. Mirrors can also be used in place of head-mounted AR displays (e.g., using projectors [14, 17], using a monitor [198, 233, 283]), which may be beneficial if wearing a head-mounted display is impractical.

Morphs are the rarest pattern found in the literature. While manipulating the appearance of a referent can resolve issues like occlusion (e.g., explosion diagrams [105], diminished reality [165]), it may be problematic when the user still requires awareness of the physical structure of the referent—particularly when they need to touch and manipulate it. Therefore, most works that modify the appearance of a referent would keep to salient augmentations like ghosts, or preserve the outer structure of the referent while revealing the internal structure using a magic lens.

4 PATTERN USAGE OVER TIME

Figure 3 shows the frequency that each individual pattern appeared in our corpus per year. Glyph, ghost, trajectory, label, and panel all clearly see a spike in usage in 2019 and beyond. Of course, this is in part due to the increase in the total number of papers included in the corpus from those years. That said it is interesting to see that the other five patterns did not see similar increases. As mentioned in Section 2, this may simply be the result of the manner in which the corpus was generated. Nevertheless, this does point towards some patterns being more relevant to so-called modern-day situated visualization than others. Panels are more likely to be used to display 2D visualizations and user interfaces (e.g., [58, 184, 213, 276]), ghosts benefit from 3D models being easier to create and more readily accessible (e.g., [4, 37]), and trajectories being used more in analytical contexts of spatio-temporal data (e.g., [24, 94, 149]).
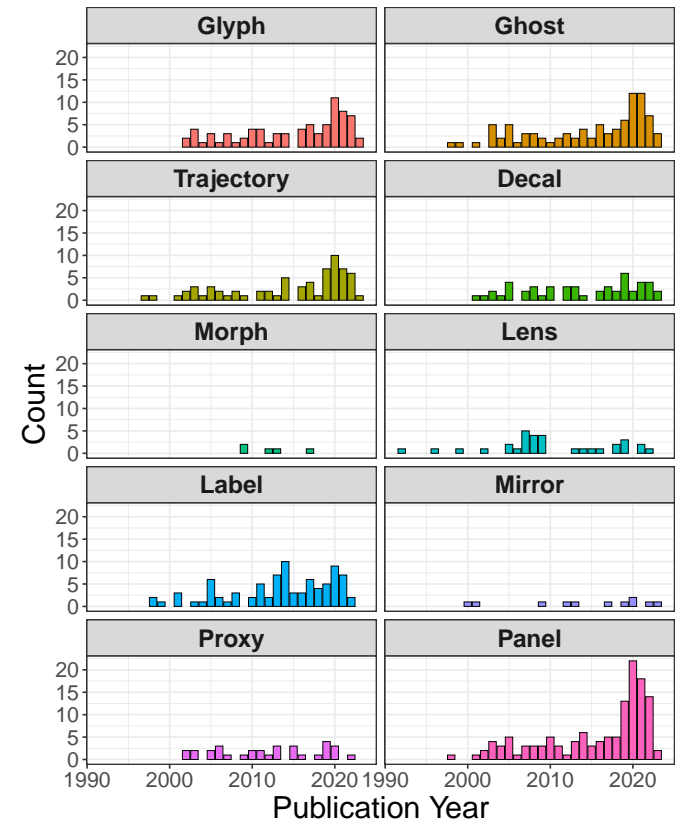

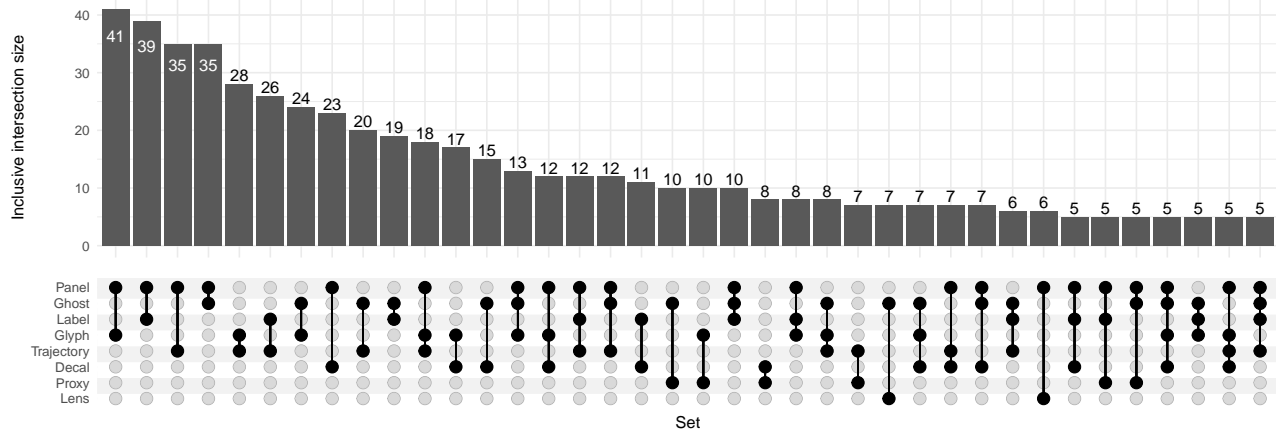Fig. 3: Number of papers per year in our corpus, faceted by pattern.

Fig. 4: An UpSet plot [40, 137] showing the frequency of set combinations between the 10 patterns with the intersect mode (i.e., a set can overlap with other sets). Only sets with a degree of two or higher, and with five or more members are shown.

5 COMMON PATTERN COMBINATIONS

Figure 4 shows an UpSet plot [40, 137] of the frequency of different combinations of the 10 patterns used in our corpus. Note however that, as mentioned in the original manuscript, multiple patterns were assigned to a paper regardless of whether or not the patterns were used simultaneously. For instance, a paper that would demonstrate the use of panels in one prototype and glyphs in another prototype was coded identically to one that used both together.

The 1st to 4th most popular sets are all a combination of panel with another pattern (glyph, label, trajectory, ghost), with panel + decal coming at 8th. This is unsurprising given that these are the most popular patterns (Figure 2). Even so, this demonstrates the raw versatility that the panel pattern has—even if boring from a novelty perspective. Whenever some information needs to be displayed, be it text, a data visualization, or even a user interface, a panel can be used.

The most popular set which does not include a panel is glyph + trajectory. As mentioned, the two typically go hand. An arrow may point the user to move or look in a specific direction, or be used to highlight some part of the referent which the user should perform some task on. Trajectories can also easily connect multiple glyphs together, akin to a network (e.g., [26, 52]) or a chain of waypoints to follow (e.g., [201, 289, 296]).

Trajectory + label is the next most popular non-panel set. This is mainly the use of labels combined with leader lines (e.g., [69, 77, 139, 151, 163, 188, 203, 252]), which count as trajectories connecting the label to the referent. Otherwise, the use of this set is merely coincidental, with the system offering trajectory and label views separately from each other (e.g., [58, 77, 127]).

The first set utilizing three patterns is panel + glyph + trajectory. This is effectively a combination of the previous two sets (glyph + trajectory, trajectory + label). A clear use of this set is for navigation, whereby glyphs are used to represent key points of interest, labels provide further information about these points, and trajectories show a guide path between each point (e.g., [139, 201]).

None of the sets in Figure 4 include the mirror nor morph patterns. This is to be expected given their already low total occurrences in the corpus. The only noteworthy combinations here involve mirror, which has been combined with glyph, ghost, and panel (i.e., [3, 161, 205, 233, 283, 286]). In these instances, the mirror mostly acts to facilitate the AR experience without the use of head-mounted display, and thus can theoretically be combined with any other pattern.

6 SURVEY CONCLUSIONS AND LIMITATIONS

This survey provides further insight as to how the patterns have been used by the papers contained within our corpus. It is not indicative of the entire fields of AR and (situated) visualization, and thus we do not discuss nor provide recommendations for research directions. What we can conclude is that our patterns are expressive enough to cover a wide range of different applications, designs, and use cases. We hope this survey would serve as a starting point for both researchers and situated visualization designers to classify existing work and express new ideas.

Pattern	Image	References	Count
Glyph		[20, 24, 26, 30, 31, 37, 39, 42, 43, 45, 47, 51–53, 78, 79, 85, 87, 90, 92, 94, 107, 109, 110, 113, 116, 117, 119, 123, 125, 127, 130, 142, 147, 149, 154, 161, 162, 169–173, 176, 185, 186, 189, 194, 195, 199–201, 205, 207–209, 213, 222, 224, 225, 232, 233, 238, 245, 247, 255, 262, 272, 278, 280, 281, 286, 288, 289, 293, 294, 296]	77
Ghost		[1, 4, 7–11, 18, 20, 28, 30–32, 37, 38, 50, 51, 53, 58, 61, 64, 67, 68, 71, 73, 81, 86, 89, 92–94, 97, 101, 103, 106, 110, 119–121, 127, 128, 134, 138, 143, 149, 150, 152, 155, 160, 164, 180, 185, 188, 189, 192–194, 203, 205, 208, 215, 224, 225, 227, 230, 233–238, 241, 244, 246, 247, 253, 257, 266–268, 271, 272, 274, 276, 283, 284, 286, 291, 292, 295]	90
Trajectory		[24, 26, 30, 32, 33, 37, 47, 52, 58, 60, 62–64, 69, 73, 74, 76, 77, 84, 94, 95, 109, 112, 116, 120, 127, 133–135, 139, 149, 151, 162–164, 170, 174, 175, 186, 188, 194, 199, 201–203, 209, 213, 222, 224, 226, 228, 229, 242, 245, 252, 255, 256, 263, 267, 274, 276, 279, 281, 286, 289, 294, 296]	67
Decal		[1, 2, 9, 20, 21, 32, 35, 49, 51, 53, 57, 68, 70, 80, 90, 91, 95, 98, 100, 108, 114, 124, 125, 129, 141, 142, 149, 159, 172, 186, 189, 194, 200, 201, 205, 210, 218, 220, 227, 239–241, 253, 259, 260, 278, 280, 289, 295, 297]	50
Morph		[105, 165, 207, 251, 260]	5
Magic Lens		[22, 34, 45, 47, 55, 56, 75, 101–103, 106, 120, 140, 144, 156–158, 160, 190, 194, 204, 206, 214–219, 222, 223, 242, 264]	32
Label		[6, 9, 12, 13, 15, 28, 29, 33, 35, 36, 38, 51, 58, 63, 69, 70, 72, 74, 77, 79, 81–84, 86, 88, 96, 108–110, 112, 113, 115, 118, 124, 126, 127, 131, 136, 139, 145, 151, 163, 167, 168, 174, 175, 177–179, 181, 182, 184, 185, 188, 195, 201–203, 221, 226, 228, 236, 237, 240–243, 246, 250–252, 258, 259, 263, 265, 269, 272, 274, 276, 278, 282, 285, 290, 293]	85
Mirror		[3, 14, 16, 17, 22, 161, 198, 205, 233, 283, 286]	11
Proxy		[9, 42, 70, 79, 91, 92, 99, 104, 107, 128, 129, 143, 145, 153, 170, 174, 184, 192, 193, 200, 213, 222, 237, 248, 249, 251, 253, 260, 267, 272, 279, 289]	32
Panel		[3, 5, 8, 15, 19, 24, 25, 27, 32, 38, 39, 41, 43, 44, 46–48, 51, 53, 54, 58, 59, 65, 66, 72, 73, 77, 78, 81, 82, 84, 91–96, 98, 100, 111, 113, 114, 117, 119, 120, 122, 124, 125, 127, 130–132, 134, 135, 145, 146, 148, 149, 152, 155, 162, 166, 170, 172, 174, 179–184, 186–188, 191–197, 199, 201, 202, 205, 209, 211–213, 216, 217, 220–222, 225, 228, 229, 233, 237, 238, 240, 243, 245, 254, 260–263, 265, 266, 269, 270, 272–278, 280–283, 287–290, 292–295]	131

Table 1: Table of results from our survey ($N = 293$). A paper may be assigned to more than one pattern.

REFERENCES

[1] M. F. Alam, S. Katsikas, O. Beltramello, and S. Hadjiefthymiades. Augmented and virtual reality based monitoring and safety system: A prototype IoT platform. *Journal of Network and Computer Applications*, 89:109–119, July 2017. doi: 10.1016/j.jnca.2017.03.022

[2] J. Alves, B. Marques, M. Oliveira, T. Araújo, P. Dias, and B. S. Santos. Comparing Spatial and Mobile Augmented Reality for Guiding Assembling Procedures with Task Validation. In *2019 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC)*, pp. 1–6, Apr. 2019. doi: 10.1109/ICARSC.2019.8733642

[3] F. Anderson, T. Grossman, J. Matejka, and G. Fitzmaurice. YouMove: Enhancing movement training with an augmented reality mirror. In *Proceedings of the 26th Annual ACM Symposium on User Interface Software and Technology*, UIST '13, pp. 311–320. Association for Computing Machinery, New York, NY, USA, Oct. 2013. doi: 10.1145/2501988.2502045

[4] A. Assor, A. Prouzeau, P. Dragicevic, and M. Hachet. Exploring Augmented Reality Waste Data Representations for Eco Feedback. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI EA '23, pp. 1–4. Association for Computing Machinery, New York, NY, USA, Apr. 2023. doi: 10.1145/3544549.3583905

[5] B. Bach, R. Sicat, J. Beyer, M. Cordeil, and H. Pfister. The Hologram in My Hand: How Effective is Interactive Exploration of 3D Visualizations in Immersive Tangible Augmented Reality? *IEEE Transactions on Visualization and Computer Graphics*, 24(1):457–467, Jan. 2018. doi: 10.1109/TVCG.2017.2745941

[6] B. Bach, R. Sicat, H. Pfister, and A. Quigley. Drawing into the AR-CANVAS: Designing embedded visualizations for augmented reality. In *Workshop on Immersive Analytics, IEEE Vis*, 2017.

[7] I. Barakonyi, T. Psik, and D. Schmalstieg. Agents that talk and hit back: Animated agents in augmented reality. In *Third IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 141–150, Nov. 2004. doi: 10.1109/ISMAR.2004.11

[8] I. Barakonyi and D. Schmalstieg. AR puppet: Animated agents in augmented reality. First Central European International Multimedia and Virtual Reality Conference, pp. 35–42, 2004.

[9] I. Barakonyi and D. Schmalstieg. Augmented Reality Agents in the Development Pipeline of Computer Entertainment. In F. Kishino, Y. Kitamura, H. Kato, and N. Nagata, eds., *Entertainment Computing - ICEC 2005*, Lecture Notes in Computer Science, pp. 345–356. Springer, Berlin, Heidelberg, 2005. doi: 10.1007/11558651_34

[10] I. Barakonyi and D. Schmalstieg. Augmented reality agents for user interface adaptation. *Computer Animation and Virtual Worlds*, 19(1):23–35, 2008. doi: 10.1002/cav.220

[11] I. Barakonyi, M. Weilguny, T. Psik, and D. Schmalstieg. MonkeyBridge: Autonomous agents in augmented reality games. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology*, ACE '05, pp. 172–175. Association for Computing Machinery, New York, NY, USA, June 2005. doi: 10.1145/1178477.1178500

[12] J. Baumeister, S. Y. Ssin, N. A. M. ElSayed, J. Dorrian, D. P. Webb, J. A. Walsh, T. M. Simon, A. Irlitti, R. T. Smith, M. Kohler, and B. H. Thomas. Cognitive Cost of Using Augmented Reality Displays. *IEEE Transactions on Visualization and Computer Graphics*, 23(11):2378–2388, Nov. 2017. doi: 10.1109/TVCG.2017.2735098

[13] B. Bell, S. Feiner, and T. Höllerer. View management for virtual and augmented reality. In *Proceedings of the 14th Annual ACM Symposium on User Interface Software and Technology*, UIST '01, pp. 101–110. Association for Computing Machinery, New York, NY, USA, Nov. 2001. doi: 10.1145/502348.502363

[14] H. Benko, R. Jota, and A. Wilson. MirageTable: Freehand interaction on a projected augmented reality tabletop. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '12, pp. 199–208. Association for Computing Machinery, New York, NY, USA, May 2012. doi: 10.1145/2207676.2207704

[15] J. D. H. Bezerra and C. T. de Souza. smAR2t: A Models at Runtime Architecture to Interact with the Web Of Things using Augmented Reality. In *Proceedings of the XXXIII Brazilian Symposium on Software Engineering*, SBES '19, pp. 124–129. Association for Computing Machinery, New York, NY, USA, Sept. 2019. doi: 10.1145/3350768.3353818

[16] C. Bichlmeier, S. M. Heining, M. Feuerstein, and N. Navab. The Virtual Mirror: A New Interaction Paradigm for Augmented Reality Environments. *IEEE Transactions on Medical Imaging*, 28(9):1498–1510, Sept. 2009. doi: 10.1109/TMI.2009.2018622

[17] O. Bimber, L. M. Encarnacao, and D. Schmalstieg. Augmented Reality with Back-Projection Systems using Transflective Surfaces. 2000.

[18] O. Bimber, L. M. Encarnação, and D. Schmalstieg. The virtual showcase as a new platform for augmented reality digital storytelling. In *Proceedings of the Workshop on Virtual Environments 2003*, EGVE '03, pp. 87–95. Association for Computing Machinery, New York, NY, USA, May 2003. doi: 10.1145/769953.769964

[19] Ó. Blanco-Novoa, P. Fraga-Lamas, M. A. Vilar-Montesinos, and T. M. Fernández-Caramés. Creating the Internet of Augmented Things: An Open-Source Framework to Make IoT Devices and Augmented and Mixed Reality Systems Talk to Each Other. *Sensors*, 20(11):3328, Jan. 2020. doi: 10.3390/s20113328

[20] J. Blattgerste, P. Renner, B. Strenge, and T. Pfeiffer. In-Situ Instructions Exceed Side-by-Side Instructions in Augmented Reality Assisted Assembly. In *Proceedings of the 11th PErvasive Technologies Related to Assistive Environments Conference*, PETRA '18, pp. 133–140. Association for Computing Machinery, New York, NY, USA, June 2018. doi: 10.1145/3197768.3197778

[21] L. Bonanni, C.-H. Lee, and T. Selker. Attention-based design of augmented reality interfaces. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '05, pp. 1228–1231. Association for Computing Machinery, New York, NY, USA, Apr. 2005. doi: 10.1145/1056808.1056883

[22] F. Bork, L. Stratmann, S. Enssle, U. Eck, N. Navab, J. Waschke, and D. Kugelmann. The Benefits of an Augmented Reality Magic Mirror System for Integrated Radiology Teaching in Gross Anatomy. *Anatomical Sciences Education*, 12(6):585–598, Nov. 2019. doi: 10.1002/ase.1864

[23] N. Bressa, H. Korsgaard, A. Tabard, S. Houben, and J. Vermeulen. What's the Situation with Situated Visualization? A Survey and Perspectives on Situatedness. *IEEE Transactions on Visualization and Computer Graphics*, 28(1):107–117, Jan. 2022. doi: 10.1109/TVCG.2021.3114835

[24] W. Büschel, A. Lehmann, and R. Dachselt. MIRIA: A Mixed Reality Toolkit for the In-Situ Visualization and Analysis of Spatio-Temporal Interaction Data. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1–15. ACM, Yokohama Japan, May 2021. doi: 10.1145/3411764.3445651

[25] W. Büschel, A. Mitschick, T. Meyer, and R. Dachselt. Investigating Smartphone-based Pan and Zoom in 3D Data Spaces in Augmented Reality. In *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services*, MobileHCI '19, pp. 1–13. Association for Computing Machinery, New York, NY, USA, Oct. 2019. doi: 10.1145/3338286.3340113

[26] W. Buschel, S. Vogt, and R. Dachselt. Augmented Reality Graph Visualizations. *IEEE Computer Graphics and Applications*, 39(03):29–40, May 2019. doi: 10.1109/MCG.2019.2897927

[27] S. Büttner, M. Prilla, and C. Röcker. Augmented Reality Training for Industrial Assembly Work - Are Projection-based AR Assistive Systems an Appropriate Tool for Assembly Training? In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–12. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376720

[28] A. Butz, T. Hollerer, S. Feiner, B. MacIntyre, and C. Beshers. Enveloping users and computers in a collaborative 3D augmented reality. In *Proceedings 2nd IEEE and ACM International Workshop on Augmented Reality (IWAR'99)*, pp. 35–44, Oct. 1999. doi: 10.1109/IWAR.1999.803804

[29] G. Caggianese, V. Colonnese, and L. Gallo. Situated Visualization in Augmented Reality: Exploring Information Seeking Strategies. In *2019 15th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)*, pp. 390–395, Nov. 2019. doi: 10.1109/SITIS.2019.00069

[30] Y. Cao, X. Qian, T. Wang, R. Lee, K. Huo, and K. Ramani. An Exploratory Study of Augmented Reality Presence for Tutoring Machine Tasks. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–13. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376688

[31] Y. Cao, T. Wang, X. Qian, P. S. Rao, M. Wadhawan, K. Huo, and K. Ramani. GhostAR: A Time-space Editor for Embodied Authoring of Human-Robot Collaborative Task with Augmented Reality. In *Proceed-*

ings of the 32nd Annual ACM Symposium on User Interface Software and Technology, UIST '19, pp. 521–534. Association for Computing Machinery, New York, NY, USA, Oct. 2019. doi: 10.1145/3332165. 3347902

[32] Y. Cao, Z. Xu, F. Li, W. Zhong, K. Huo, and K. Ramani. V.Ra: An In-Situ Visual Authoring System for Robot-IoT Task Planning with Augmented Reality. In *Proceedings of the 2019 on Designing Interactive Systems Conference*, DIS '19, pp. 1059–1070. Association for Computing Machinery, New York, NY, USA, June 2019. doi: 10.1145/3322276. 3322278

[33] R. Castle, G. Klein, and D. W. Murray. Video-rate localization in multiple maps for wearable augmented reality. In *2008 12th IEEE International Symposium on Wearable Computers*, pp. 15–22, Sept. 2008. doi: 10. 1109/ISWC.2008.4911577

[34] W. M. Chang, M. B. Horowitz, and G. D. Stetten. Intuitive intraoperative ultrasound guidance using the Sonic Flashlight: A novel ultrasound display system. *Neurosurgery*, 56(2 Suppl):434–437; discussion 434– 437, Apr. 2005. doi: 10.1227/01.neu.0000156551.66538.6a

[35] J. Chastine, K. Nagel, Y. Zhu, and M. Hudachek-Buswell. Studies on the Effectiveness of Virtual Pointers in Collaborative Augmented Reality. In *2008 IEEE Symposium on 3D User Interfaces*, pp. 117–124, Mar. 2008. doi: 10.1109/3DUI.2008.4476601

[36] D. Chen, S. Tsai, C.-H. Hsu, J. P. Singh, and B. Girod. Mobile augmented reality for books on a shelf. In *2011 IEEE International Conference on Multimedia and Expo*, pp. 1–6, July 2011. doi: 10.1109/ICME.2011. 6012171

[37] Z. Chen, Y. Su, Y. Wang, Q. Wang, H. Qu, and Y. Wu. MARVisT: Authoring Glyph-Based Visualization in Mobile Augmented Reality. *IEEE Transactions on Visualization and Computer Graphics*, 26(8):2645– 2658, Aug. 2020. doi: 10.1109/TVCG.2019.2892415

[38] S. Chidambaram, H. Huang, F. He, X. Qian, A. M. Villanueva, T. S. Redick, W. Stuerzlinger, and K. Ramani. ProcessAR: An augmented reality-based tool to create in-situ procedural 2D/3D AR Instructions. In *Designing Interactive Systems Conference 2021*, DIS '21, pp. 234–249. Association for Computing Machinery, New York, NY, USA, June 2021. doi: 10.1145/3461778.3462126

[39] K. Chintamani, A. Cao, R. D. Ellis, and A. K. Pandya. Improved Tele-manipulator Navigation During Display-Control Misalignments Using Augmented Reality Cues. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*, 40(1):29–39, Jan. 2010. doi: 10.1109/TSMCA.2009.2030166

[40] J. R. Conway, A. Lex, and N. Gehlenborg. UpSetR: An R package for the visualization of intersecting sets and their properties. *Bioinformatics*, 33(18):2938–2940, Sept. 2017. doi: 10.1093/bioinformatics/btx364

[41] M. Cordeil, B. Bach, A. Cunningham, B. Montoya, R. T. Smith, B. H. Thomas, and T. Dwyer. Embodied Axes: Tangible, Actuated Interaction for 3D Augmented Reality Data Spaces. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–12. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376613

[42] E. Cruz, S. Orts-Escolano, F. Gomez-Donoso, C. Rizo, J. C. Rangel, H. Mora, and M. Cazorla. An augmented reality application for improving shopping experience in large retail stores. *Virtual Reality*, 23(3):281– 291, Sept. 2019. doi: 10.1007/s10055-018-0338-3

[43] D. Datcu, S. G. Lukosch, and H. K. Lukosch. Handheld Augmented Reality for Distributed Collaborative Crime Scene Investigation. In *Proceedings of the 2016 ACM International Conference on Supporting Group Work*, GROUP '16, pp. 267–276. Association for Computing Machinery, New York, NY, USA, Nov. 2016. doi: 10.1145/2957276. 2957302

[44] S. Davari, F. Lu, and D. A. Bowman. Validating the Benefits of Glance-able and Context-Aware Augmented Reality for Everyday Information Access Tasks. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pp. 436–444, Mar. 2022. doi: 10.1109/VR51125.2022. 00063

[45] C. Dennler, N. A. Safa, D. E. Bauer, F. Wanivenhaus, F. Liebmann, T. Götschi, and M. Farshad. Augmented Reality Navigated Sacral-Alar-Iliac Screw Insertion. *International Journal of Spine Surgery*, 15(1):161– 168, Feb. 2021. doi: 10.14444/8021

[46] S. Di Verdi, D. Nurmi, and T. Hollerer. ARWin - a desktop augmented reality Window Manager. In *The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings.*, pp. 298–299, Oct. 2003. doi: 10.1109/ISMAR.2003.1240729

[47] K. R. Dillman, T. T. H. Mok, A. Tang, L. Oehlberg, and A. Mitchell. A Visual Interaction Cue Framework from Video Game Environments for Augmented Reality. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, pp. 1–12. Association for Computing Machinery, New York, NY, USA, Apr. 2018. doi: 10. 1145/3173574.3173714

[48] S. DiVerdi, T. Hollerer, and R. Schreyer. Level of detail interfaces. In *Third IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 300–301, Nov. 2004. doi: 10.1109/ISMAR.2004.38

[49] K. Dorfmuller-Ulhaas and D. Schmalstieg. Finger tracking for interaction in augmented environments. In *Proceedings IEEE and ACM International Symposium on Augmented Reality*, pp. 55–64, Oct. 2001. doi: 10. 1109/ISAR.2001.970515

[50] C. Du, Y.-L. Chen, M. Ye, and L. Ren. Edge Snapping-Based Depth Enhancement for Dynamic Occlusion Handling in Augmented Reality. In *2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 54–62, Sept. 2016. doi: 10.1109/ISMAR.2016.17

[51] N. A. M. ElSayed, B. H. Thomas, K. Marriott, J. Piantadosi, and R. T. Smith. Situated Analytics: Demonstrating immersive analytical tools with Augmented Reality. *Journal of Visual Languages & Computing*, 36:13–23, Oct. 2016. doi: 10.1016/j.jvlc.2016.07.006

[52] B. Ens, F. Anderson, T. Grossman, M. Annett, P. Irani, and G. Fitz-maurice. Ivy: Exploring Spatially Situated Visual Programming for Authoring and Understanding Intelligent Environments. In *Proceedings of the 43rd Graphics Interface Conference*, GI '17, pp. 156–162. Canadian Human-Computer Communications Society, Waterloo, CAN, Jan. 2017.

[53] B. Ens, S. Goodwin, A. Prouzeau, F. Anderson, F. Y. Wang, S. Gratzl, Z. Lucarelli, B. Moyle, J. Smiley, and T. Dwyer. Uplift: A Tangible and Immersive Tabletop System for Casual Collaborative Visual Analytics. *IEEE Transactions on Visualization and Computer Graphics*, 27(2):1193– 1203, Feb. 2021. doi: 10.1109/TVCG.2020.3030334

[54] B. M. Ens, R. Finnegan, and P. P. Irani. The personal cockpit: A spatial interface for effective task switching on head-worn displays. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 3171–3180. ACM, Toronto Ontario Canada, Apr. 2014. doi: 10.1145/2556288.2557058

[55] O. Erat, W. A. Isop, D. Kalkofen, and D. Schmalstieg. Drone-Augmented Human Vision: Exocentric Control for Drones Exploring Hidden Areas. *IEEE Transactions on Visualization and Computer Graphics*, 24(4):1437– 1446, Apr. 2018. doi: 10.1109/TVCG.2018.2794058

[56] S. K. Feiner and D. D. Seligmann. Cutaways and ghosting: Satisfying visibility constraints in dynamic 3D illustrations. *The Visual Computer*, 8(5):292–302, Sept. 1992. doi: 10.1007/BF01897116

[57] H. S. Ferdous, T. Hoang, Z. Joukhadar, M. N. Reinoso, F. Vetere, D. Kelly, and L. Remedios. "What's Happening at that Hip?": Evaluating an On-body Projection based Augmented Reality System for Physiotherapy Classroom. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, pp. 1–12. Association for Computing Machinery, New York, NY, USA, May 2019. doi: 10.1145/3290605. 3300464

[58] P. Fleck, A. Sousa Calepso, S. Hubenschmid, M. Sedlmair, and D. Schmalstieg. RagRug: A Toolkit for Situated Analytics. *IEEE Transactions on Visualization and Computer Graphics*, pp. 1–1, 2022. doi: 10.1109/TVCG.2022.3157058

[59] C. D. Flick, C. J. Harris, N. T. Yonkers, N. Norouzi, A. Erickson, Z. Choudhary, M. Gottsacker, G. Bruder, and G. Welch. Trade-offs in Augmented Reality User Interfaces for Controlling a Smart Environment. In *Proceedings of the 2021 ACM Symposium on Spatial User Interaction*, SUI '21, pp. 1–11. Association for Computing Machinery, New York, NY, USA, Nov. 2021. doi: 10.1145/3485279.3485288

[60] A. Fuhrmann, H. Loffelmann, and D. Schmalstieg. Collaborative augmented reality: Exploring dynamical systems. In *Proceedings. Visualization '97 (Cat. No. 97CB36155)*, pp. 459–462, Oct. 1997. doi: 10. 1109/VISUAL.1997.663921

[61] R. Gal, L. Shapira, E. Ofek, and P. Kohli. FLARE: Fast layout for augmented reality applications. In *2014 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 207–212, Sept. 2014. doi: 10.1109/ISMAR.2014.6948429

[62] D. Gasques, J. G. Johnson, T. Sharkey, and N. Weibel. PintAR: Sketching Spatial Experiences in Augmented Reality. In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*, pp. 17–20. ACM, San Diego CA USA, June 2019. doi: 10.1145/3301019

.3325158

[63] S. Gauglitz, B. Nuernberger, M. Turk, and T. Höllerer. In touch with the remote world: Remote collaboration with augmented reality drawings and virtual navigation. In *Proceedings of the 20th ACM Symposium on Virtual Reality Software and Technology*, VRST '14, pp. 197–205. Association for Computing Machinery, New York, NY, USA, Nov. 2014. doi: 10.1145/2671015.2671016

[64] M. Gervautz and D. Schmalstieg. Anywhere Interfaces Using Handheld Augmented Reality. *Computer*, 45(7):26–31, July 2012. doi: 10.1109/MC.2012.72

[65] N. Ghouaiel, J.-M. Cieutat, and J.-P. Jessel. Adaptive augmented reality: Plasticity of augmentations. In *Proceedings of the 2014 Virtual Reality International Conference*, VRIC '14, pp. 1–4. Association for Computing Machinery, New York, NY, USA, Apr. 2014. doi: 10.1145/2617841.2620695

[66] D. Goldsmith, F. Liarokapis, G. Malone, and J. Kemp. Augmented Reality Environmental Monitoring Using Wireless Sensor Networks. In *2008 12th International Conference Information Visualisation*, pp. 539–544. IEEE, London, UK, July 2008. doi: 10.1109/IV.2008.72

[67] M. Golparvar-Fard, F. Peña-Mora, and S. Savarese. Application of D4AR - A 4-Dimensional augmented reality model for automating construction progress monitoring data collection, processing and communication. *Journal of Information Technology in Construction (ITcon)*, 14(13):129–153, June 2009.

[68] R. Grasset, J.-D. Gascuel, and Schmalstieg. Interactive mediated reality. In *The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings.*, pp. 302–303, Oct. 2003. doi: 10.1109/ISMAR.2003.1240731

[69] R. Grasset, T. Langlotz, D. Kalkofen, M. Tatzgern, and D. Schmalstieg. Image-driven view management for augmented reality browsers. In *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 177–186, Nov. 2012. doi: 10.1109/ISMAR.2012.6402555

[70] L. Gruber, S. Gauglitz, J. Ventura, S. Zollmann, M. Huber, M. Schlegel, G. Klinker, D. Schmalstieg, and T. Höllerer. The City of Sights: Design, construction, and measurement of an Augmented Reality stage set. In *2010 IEEE International Symposium on Mixed and Augmented Reality*, pp. 157–163, Oct. 2010. doi: 10.1109/ISMAR.2010.5643564

[71] L. Gruber, D. Kalkofen, and D. Schmalstieg. Color harmonization for Augmented Reality. In *2010 IEEE International Symposium on Mixed and Augmented Reality*, pp. 227–228, Oct. 2010. doi: 10.1109/ISMAR.2010.5643580

[72] J. Grubert, M. Heinisch, A. Quigley, and D. Schmalstieg. MultiFi: Multi Fidelity Interaction with Displays On and Around the Body. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, CHI '15, pp. 3933–3942. Association for Computing Machinery, New York, NY, USA, Apr. 2015. doi: 10.1145/2702123.2702331

[73] J. Grubert, T. Langlotz, S. Zollmann, and H. Regenbrecht. Towards Pervasive Augmented Reality: Context-Awareness in Augmented Reality. *IEEE Transactions on Visualization and Computer Graphics*, 23(6):1706–1724, June 2017. doi: 10.1109/TVCG.2016.2543720

[74] U. Gruenefeld, A. E. Ali, W. Heuten, and S. Boll. Visualizing out-of-view objects in head-mounted augmented reality. In *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pp. 1–7. ACM, Vienna Austria, Sept. 2017. doi: 10.1145/3098279.3122124

[75] C. Gsaxner, A. Pepe, J. Wallner, D. Schmalstieg, and J. Egger. Markerless Image-to-Face Registration for Untethered Augmented Reality in Head and Neck Surgery. In *Medical Image Computing and Computer Assisted Intervention – MICCAI 2019: 22nd International Conference, Shenzhen, China, October 13–17, 2019, Proceedings, Part V*, pp. 236–244. Springer-Verlag, Berlin, Heidelberg, Oct. 2019. doi: 10.1007/978-3-030-32254-0_27

[76] R. Guarese, P. Andreasson, E. Nilsson, and A. Maciel. Augmented situated visualization methods towards electromagnetic compatibility testing. *Computers & Graphics*, 94:1–10, Feb. 2021. doi: 10.1016/j.cag.2020.10.001

[77] R. Guarese, J. Becker, H. Fensterseifer, M. Walter, C. Freitas, L. Nedel, and A. Maciel. Augmented Situated Visualization for Spatial and Context-Aware Decision-Making. In *Proceedings of the International Conference on Advanced Visual Interfaces*, AVI '20, pp. 1–5. Association for Computing Machinery, New York, NY, USA, Oct. 2020. doi: 10.1145/3399715.3399838

[78] S. Guven and S. Feiner. Authoring 3D hypermedia for wearable augmented and virtual reality. In *Seventh IEEE International Symposium on Wearable Computers, 2003. Proceedings.*, pp. 118–126, Oct. 2003. doi: 10.1109/ISWC.2003.1241401

[79] S. Guven and S. Feiner. Visualizing and navigating complex situated hypermedia in augmented and virtual reality. In *2006 IEEE/ACM International Symposium on Mixed and Augmented Reality*, pp. 155–158, Oct. 2006. doi: 10.1109/ISMAR.2006.297807

[80] F. Heinrich, L. Schwenderling, F. Joeres, K. Lawonn, and C. Hansen. Comparison of Augmented Reality Display Techniques to Support Medical Needle Insertion. *IEEE transactions on visualization and computer graphics*, 26(12):3568–3575, Dec. 2020. doi: 10.1109/TVCG.2020.3023637

[81] S. Henderson and S. Feiner. Exploring the Benefits of Augmented Reality Documentation for Maintenance and Repair. *IEEE Transactions on Visualization and Computer Graphics*, 17(10):1355–1368, Oct. 2011. doi: 10.1109/TVCG.2010.245

[82] S. J. Henderson and S. K. Feiner. Augmented reality in the psychomotor phase of a procedural task. In *2011 10th IEEE International Symposium on Mixed and Augmented Reality*, pp. 191–200, Oct. 2011. doi: 10.1109/ISMAR.2011.6092386

[83] B. Herbert, M. Billinghurst, A. Weerasinghe, B. Ens, and G. Wigley. A generalized, rapid authoring tool for intelligent tutoring systems. In *Proceedings of the 30th Australian Conference on Computer-Human Interaction*, OzCHI '18, pp. 368–373. Association for Computing Machinery, New York, NY, USA, Dec. 2018. doi: 10.1145/3292147.3292202

[84] B. M. Herbert, W. Hoff, and M. Billinghurst. Usability Considerations of Hand Held Augmented Reality Wiring Tutors. In *2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 277–282. IEEE, Recife, Brazil, Nov. 2020. doi: 10.1109/ISMAR-Adjunct51615.2020.00078

[85] B. M. Herbert, G. Wigley, B. Ens, and M. Billinghurst. Perceptions of Integrating Augmented Reality into Network Cabling Tutors. In *2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 231–236, Nov. 2020. doi: 10.1109/ISMAR-Adjunct51615.2020.00068

[86] D. Herr, J. Reinhardt, G. Reina, R. Krüger, R. V. Ferrari, and T. Ertl. Immersive Modular Factory Layout Planning using Augmented Reality. *Procedia CIRP*, 72:1112–1117, 2018. doi: 10.1016/j.procir.2018.03.200

[87] J. Hertel and F. Steinicke. Augmented Reality for Maritime Navigation Assistance - Egocentric Depth Perception in Large Distance Outdoor Environments. In *2021 IEEE Virtual Reality and 3D User Interfaces (VR)*, pp. 122–130, Mar. 2021. doi: 10.1109/VR50410.2021.00033

[88] R. Hervás, J. Bravo, J. Fontecha, and V. Villarreal. Achieving Adaptive Augmented Reality through Ontological Context-Awareness applied to AAL Scenarios. *JUCS - Journal of Universal Computer Science*, 19(9):1334–1349, Jan. 2013. doi: 10.3217/jucs-019-09-1334

[89] A. Hettiarachchi and D. Wigdor. Annexing Reality: Enabling Opportunistic Use of Everyday Objects as Tangible Proxies in Augmented Reality. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, pp. 1957–1967. Association for Computing Machinery, New York, NY, USA, May 2016. doi: 10.1145/2858036.2858134

[90] F. Heyen and M. Sedlmair. Augmented reality visualization for musical instrument learning. In *Extended Abstracts for the LateBreaking Demo Session of the 23rd Int. Society for Music Information Retrieval Conf.* ISMIR, Bengaluru, India, 2022.

[91] T. N. Hoang and B. H. Thomas. Augmented Viewport: An action at a distance technique for outdoor AR using distant and zoom lens cameras. In *International Symposium on Wearable Computers (ISWC) 2010*, pp. 1–4, Oct. 2010. doi: 10.1109/ISWC.2010.5665865

[92] L. Hou, X. Wang, L. Bernold, and P. E. D. Love. Using Animated Augmented Reality to Cognitively Guide Assembly. *Journal of Computing in Civil Engineering*, 27(5):439–451, Sept. 2013. doi: 10.1061/(ASCE)CP.1943-5487.0000184

[93] G. Huang, X. Qian, T. Wang, F. Patel, M. Sreeram, Y. Cao, K. Ramani, and A. J. Quinn. AdapTutAR: An Adaptive Tutoring System for Machine Tasks in Augmented Reality. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, pp. 1–15. Association for Computing Machinery, New York, NY, USA, May 2021. doi: 10.1145/3411764.3445283

[94] S. Hubenschmid, J. Wieland, D. I. Fink, A. Batch, J. Zagermann, N. Elmqvist, and H. Reiterer. ReLive: Bridging In-Situ and Ex-Situ

Visual Analytics for Analyzing Mixed Reality User Studies. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI '22, pp. 1–20. Association for Computing Machinery, New York, NY, USA, Apr. 2022. doi: 10.1145/3491102.3517550

[95] S. Hubenschmid, J. Zagermann, S. Butscher, and H. Reiterer. STREAM: Exploring the Combination of Spatially-Aware Tablets with Augmented Reality Head-Mounted Displays for Immersive Analytics. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1–14. ACM, Yokohama Japan, May 2021. doi: 10.1145/3411764.3445298

[96] K. Huo, Y. Cao, S. H. Yoon, Z. Xu, G. Chen, and K. Ramani. Scenariot: Spatially Mapping Smart Things Within Augmented Reality Scenes. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, pp. 1–13. Association for Computing Machinery, New York, NY, USA, Apr. 2018. doi: 10.1145/3173574.3173793

[97] J. Iglesias, D. Gómez, A. M. Bernardos, and J. R. Casar. An Attitude-Based Reasoning Strategy to Enhance Interaction with Augmented Objects. In *2012 Sixth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing*, pp. 829–834, July 2012. doi: 10.1109/IMIS.2012.29

[98] D. Jo and G. J. Kim. ARIoT: Scalable augmented reality framework for interacting with Internet of Things appliances everywhere. *IEEE Transactions on Consumer Electronics*, 62(3):334–340, Aug. 2016. doi: 10.1109/TCE.2016.7613201

[99] D. Jo and G. J. Kim. IoT + AR: Pervasive and augmented environments for "Digi-log" shopping experience. *Human-centric Computing and Information Sciences*, 9(1):1, Jan. 2019. doi: 10.1186/s13673-018-0162-5

[100] N. Joshi, M. Lakier, D. Vogel, and J. Zhao. A Design Framework for Contextual and Embedded Information Visualizations in Spatial Augmented Reality. pp. 12 pages, 7479, 2022. doi: 10.20380/GI2022.24

[101] S. Junghanns, G. Schall, and D. Schmalstieg. Employing location-aware handheld augmented reality to assist utilities field personnel. Proc. 5th International Symposium on LBS & TeleCartography (LBS 2008), pp. 95–99, Nov. 2008.

[102] D. Kalkofen, E. Mendez, and D. Schmalstieg. Interactive Focus and Context Visualization for Augmented Reality. In *2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 191–201, Nov. 2007. doi: 10.1109/ISMAR.2007.4538846

[103] D. Kalkofen, E. Mendez, and D. Schmalstieg. Comprehensible Visualization for Augmented Reality. *IEEE Transactions on Visualization and Computer Graphics*, 15(2):193–204, Mar. 2009. doi: 10.1109/TVCG.2008.96

[104] D. Kalkofen, B. Reitinger, P. Risholm, A. Bornik, R. Beichel, D. Schmalstieg, and E. Samset. Integrated medical workflow for augmented reality applications. Proceedings of MICCAI Workshop on Augmented Environments for Medical Imaging and Computer-Aided Surgery (AMI-ARCS'06), 2006.

[105] D. Kalkofen, M. Tatzgern, and D. Schmalstieg. Explosion Diagrams in Augmented Reality. In *2009 IEEE Virtual Reality Conference*, pp. 71–78. IEEE, Lafayette, LA, Mar. 2009. doi: 10.1109/VR.2009.4811001

[106] D. Kalkofen, E. Veas, S. Zollmann, M. Steinberger, and D. Schmalstieg. Adaptive ghosted views for Augmented Reality. In *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 1–9, Oct. 2013. doi: 10.1109/ISMAR.2013.6671758

[107] M. Kalkusch, T. Lidy, N. Knapp, G. Reitmayr, H. Kaufmann, and D. Schmalstieg. Structured visual markers for indoor pathfinding. In *The First IEEE International Workshop Agumented Reality Toolkit,*, pp. 8 pp.–, Sept. 2002. doi: 10.1109/ART.2002.1107018

[108] S. Kasahara, R. Niiyama, V. Heun, and H. Ishii. exTouch: Spatially-aware embodied manipulation of actuated objects mediated by augmented reality. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction*, TEI '13, pp. 223–228. Association for Computing Machinery, New York, NY, USA, Feb. 2013. doi: 10.1145/2460625.2460661

[109] S. Kasahara and J. Rekimoto. JackIn: Integrating first-person view with out-of-body vision generation for human-human augmentation. In *Proceedings of the 5th Augmented Human International Conference*, AH '14, pp. 1–8. Association for Computing Machinery, New York, NY, USA, Mar. 2014. doi: 10.1145/2582051.2582097

[110] S. G. Kaya, B. Zhou, R. R. Arora, N. Zheutlin, G. Vanloo, and E. K. Eyigoz. Dynamic Content Generation for Augmented Technical Support. In *2021 IEEE International Symposium on Mixed and Augmented Reality*

Adjunct (ISMAR-Adjunct)*, pp. 441–446, Oct. 2021. doi: 10.1109/ISMAR-Adjunct54149.2021.00101

[111] H. Kim, T. Matuszka, J.-I. Kim, J. Kim, and W. Woo. Ontology-based mobile augmented reality in cultural heritage sites: Information modeling and user study. *Multimedia Tools and Applications*, 76(24):26001–26029, Dec. 2017. doi: 10.1007/s11042-017-4868-6

[112] S. Kim, G. A. Lee, and N. Sakata. Comparing pointing and drawing for remote collaboration. In *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 1–6, Oct. 2013. doi: 10.1109/ISMAR.2013.6671833

[113] T. Kim, B. Saket, A. Endert, and B. MacIntyre. VisAR: Bringing Interactivity to Static Data Visualizations through Augmented Reality. 2017. doi: 10.48550/ARXIV.1708.01377

[114] G. King, W. Piekarski, and B. Thomas. ARVino - outdoor augmented reality visualisation of viticulture GIS data. In *Fourth IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'05)*, pp. 52–55, Oct. 2005. doi: 10.1109/ISMAR.2005.14

[115] N. Kishishita, K. Kiyokawa, J. Orlosky, T. Mashita, H. Takemura, and E. Kruijff. Analysing the effects of a wide field of view augmented reality display on search performance in divided attention tasks. In *2014 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 177–186, Sept. 2014. doi: 10.1109/ISMAR.2014.6948425

[116] K. Kobayashi, K. Nishiwaki, S. Uchiyama, H. Yamamoto, S. Kagami, and T. Kanade. Overlay what Humanoid Robot Perceives and Thinks to the Real-world by Mixed Reality System. In *2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 1–2. IEEE, Nara, Japan, Nov. 2007. doi: 10.1109/ISMAR.2007.4538864

[117] J. Kong, D. Sabha, J. P. Bigham, A. Pavel, and A. Guo. TutorialLens: Authoring Interactive Augmented Reality Tutorials Through Narration and Demonstration. In *Proceedings of the 2021 ACM Symposium on Spatial User Interaction*, SUI '21, pp. 1–11. Association for Computing Machinery, New York, NY, USA, Nov. 2021. doi: 10.1145/3485279.3485289

[118] T. Köppel, M. Eduard Gröller, and H.-Y. Wu. Context-Responsive Labeling in Augmented Reality. In *2021 IEEE 14th Pacific Visualization Symposium (PacificVis)*, pp. 91–100, Apr. 2021. doi: 10.1109/PacificVis52677.2021.00020

[119] S. Krings, E. Yigitbas, I. Jovanovikj, S. Sauer, and G. Engels. Development framework for context-aware augmented reality applications. In *Companion Proceedings of the 12th ACM SIGCHI Symposium on Engineering Interactive Computing Systems*, EICS '20 Companion, pp. 1–6. Association for Computing Machinery, New York, NY, USA, June 2020. doi: 10.1145/3393672.3398640

[120] K. Krug, W. Büschel, K. Klamka, and R. Dachselt. CleAR Sight: Exploring the Potential of Interacting with Transparent Tablets in Augmented Reality. In *2022 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 196–205, Oct. 2022. doi: 10.1109/ISMAR55827.2022.00034

[121] T. Kymäläinen and S. Siltanen. Co-Designing Novel Interior Design Services that Utilise Augmented Reality: A Case Study. In F. V. Cipolla Ficarra, ed., *Advanced Research and Trends in New Technologies, Software, Human-Computer Interaction, and Communicability*, pp. 269–279. IGI Global, Hershey, PA, USA, 2014. doi: 10.4018/978-1-4666-4490-8.ch025

[122] W. S. Lages and D. A. Bowman. Walking with adaptive augmented reality workspaces: Design and usage patterns. In *Proceedings of the 24th International Conference on Intelligent User Interfaces*, IUI '19, pp. 356–366. Association for Computing Machinery, New York, NY, USA, Mar. 2019. doi: 10.1145/3301275.3302278

[123] D. Lange, T. C. Stratmann, U. Gruenefeld, and S. Boll. HiveFive: Immersion Preserving Attention Guidance in Virtual Reality. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–13. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376803

[124] T. Langlotz, T. Nguyen, D. Schmalstieg, and R. Grasset. Next-Generation Augmented Reality Browsers: Rich, Seamless, and Adaptive. *Proceedings of the IEEE*, 102(2):155–169, Feb. 2014. doi: 10.1109/JPROC.2013.2294255

[125] T. Langlotz, H. Regenbrecht, S. Zollmann, and D. Schmalstieg. Audio stickies: Visually-guided spatial audio annotations on a mobile augmented reality platform. In *Proceedings of the 25th Australian Computer-Human Interaction Conference: Augmentation, Application, Innovation, Collaboration*, OzCHI '13, pp. 545–554. Association for Computing

Machinery, New York, NY, USA, Nov. 2013. doi: 10.1145/2541016.2541022

[126] T. Langlotz, D. Wagner, A. Mulloni, and D. Schmalstieg. Online Creation of Panoramic Augmented Reality Annotations on Mobile Phones. *IEEE Pervasive Computing*, 11(2):56–63, Feb. 2012. doi: 10.1109/MPRV.2010.69

[127] R. Langner, M. Satkowski, W. Büschel, and R. Dachselt. MARVIS: Combining Mobile Devices and Augmented Reality for Visual Data Analysis. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1–17. ACM, Yokohama Japan, May 2021. doi: 10.1145/3411764.3445593

[128] F. Ledermann, I. Barakonyi, and D. Schmalstieg. Abstraction and Implementation Strategies for Augmented Reality Authoring:. In M. Haller, M. Billinghurst, and B. Thomas, eds., *Emerging Technologies of Augmented Reality*, pp. 138–159. IGI Global, 2007. doi: 10.4018/978-1-59904-066-0.ch007

[129] F. Ledermann and D. Schmalstieg. APRIL: A high-level framework for creating augmented reality presentations. In *IEEE Proceedings. VR 2005. Virtual Reality, 2005.*, pp. 187–194, Mar. 2005. doi: 10.1109/VR.2005.1492773

[130] G. A. Lee, S. Ahn, W. Hoff, and M. Billinghurst. Enhancing First-Person View Task Instruction Videos with Augmented Reality Cues. In *2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 498–508, Nov. 2020. doi: 10.1109/ISMAR50242.2020.00078

[131] J. Lee, J.-I. Kim, J. Kim, and J.-Y. Kwak. A Unified Remote Console Based on Augmented Reality in a Home Network Environment. In *2007 Digest of Technical Papers International Conference on Consumer Electronics*, pp. 1–2, Jan. 2007. doi: 10.1109/ICCE.2007.341516

[132] J. H. Lee, S.-G. An, Y. Kim, and S.-H. Bae. Projective Windows: Bringing Windows in Space to the Fingertip. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, pp. 1–8. Association for Computing Machinery, New York, NY, USA, Apr. 2018. doi: 10.1145/3173574.3173792

[133] T. Lee and T. Hollerer. Viewpoint stabilization for live collaborative video augmentations. In *2006 IEEE/ACM International Symposium on Mixed and Augmented Reality*, pp. 241–242, Oct. 2006. doi: 10.1109/ISMAR.2006.297824

[134] G. Leiva, J. E. Grønbæk, C. N. Klokmose, C. Nguyen, R. H. Kazi, and P. Asente. Rapido: Prototyping Interactive AR Experiences through Programming by Demonstration. In *The 34th Annual ACM Symposium on User Interface Software and Technology*, pp. 626–637. ACM, Virtual Event USA, Oct. 2021. doi: 10.1145/3472749.3474774

[135] G. Leiva, C. Nguyen, R. H. Kazi, and P. Asente. Pronto: Rapid Augmented Reality Video Prototyping Using Sketches and Enaction. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–13. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376160

[136] T. Leppänen, A. Heikkinen, A. Karhu, E. Harjula, J. Riekki, and T. Koskela. Augmented Reality Web Applications with Mobile Agents in the Internet of Things. In *2014 Eighth International Conference on Next Generation Mobile Apps, Services and Technologies*, pp. 54–59, Sept. 2014. doi: 10.1109/NGMAST.2014.24

[137] A. Lex, N. Gehlenborg, H. Strobelt, R. Vuillemot, and H. Pfister. UpSet: Visualization of Intersecting Sets. *IEEE Transactions on Visualization and Computer Graphics*, 20(12):1983–1992, Dec. 2014. doi: 10.1109/TVCG.2014.2346248

[138] C. Li, W. Li, H. Huang, and L.-F. Yu. Interactive augmented reality storytelling guided by scene semantics. *ACM Transactions on Graphics*, 41(4):91:1–91:15, July 2022. doi: 10.1145/3528223.3530061

[139] N. Li, A. S. Nittala, E. Sharlin, and M. Costa Sousa. Shvil: Collaborative augmented reality land navigation. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '14, pp. 1291–1296. Association for Computing Machinery, New York, NY, USA, Apr. 2014. doi: 10.1145/2559206.2581147

[140] K. Lilija, H. Pohl, S. Boring, and K. Hornbæk. Augmented Reality Views for Occluded Interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pp. 1–12. ACM, Glasgow Scotland Uk, May 2019. doi: 10.1145/3290605.3300676

[141] D. Lindlbauer and A. D. Wilson. Remixed Reality: Manipulating Space and Time in Augmented Reality. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, pp. 1–13. Association for Computing Machinery, New York, NY, USA, Apr. 2018.

doi: 10.1145/3173574.3173703

[142] C. Liu, S. Huot, J. Diehl, W. Mackay, and M. Beaudouin-Lafon. Evaluating the benefits of real-time feedback in mobile augmented reality with hand-held devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '12, pp. 2973–2976. Association for Computing Machinery, New York, NY, USA, May 2012. doi: 10.1145/2207676.2208706

[143] F. Loch, F. Quint, and I. Brishtel. Comparing Video and Augmented Reality Assistance in Manual Assembly. In *2016 12th International Conference on Intelligent Environments (IE)*, pp. 147–150, Sept. 2016. doi: 10.1109/IE.2016.31

[144] J. Looser, R. Grasset, and M. Billinghurst. A 3D Flexible and Tangible Magic Lens in Augmented Reality. In *2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 51–54, Nov. 2007. doi: 10.1109/ISMAR.2007.4538825

[145] C.-H. Lu. IoT-enhanced and Bidirectionally Interactive Information Visualization for Context-Aware Home Energy Savings. In *2015 IEEE International Symposium on Mixed and Augmented Reality - Media, Art, Social Science, Humanities and Design*, pp. 15–20, Sept. 2015. doi: 10.1109/ISMAR-MASHD.2015.20

[146] F. Lu, S. Davari, and D. Bowman. Exploration of Techniques for Rapid Activation of Glanceable Information in Head-Worn Augmented Reality. In *Symposium on Spatial User Interaction*, pp. 1–11. ACM, Virtual Event USA, Nov. 2021. doi: 10.1145/3485279.3485286

[147] F. Lu, S. Davari, L. Lisle, Y. Li, and D. A. Bowman. Glanceable AR: Evaluating Information Access Methods for Head-Worn Augmented Reality. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pp. 930–939, Mar. 2020. doi: 10.1109/VR46266.2020.00113

[148] W. Luo, A. Lehmann, Y. Yang, and R. Dachselt. Investigating Document Layout and Placement Strategies for Collaborative Sensemaking in Augmented Reality. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI EA '21, pp. 1–7. Association for Computing Machinery, New York, NY, USA, May 2021. doi: 10.1145/3411763.3451588

[149] W. Luo, Z. Yu, R. Rzayev, M. Satkowski, S. Gumhold, M. McGinity, and R. Dachselt. Pearl: Physical Environment based Augmented Reality Lenses for In-Situ Human Movement Analysis. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI '23, pp. 1–15. Association for Computing Machinery, New York, NY, USA, Apr. 2023. doi: 10.1145/3544548.3580715

[150] B. MacIntyre, J. Bolter, E. Moreno, and B. Hannigan. Augmented reality as a new media experience. In *Proceedings IEEE and ACM International Symposium on Augmented Reality*, pp. 197–206, Oct. 2001. doi: 10.1109/ISAR.2001.970538

[151] J. B. Madsen, M. Tatzgern, C. B. Madsen, D. Schmalstieg, and D. Kalkofen. Temporal Coherence Strategies for Augmented Reality Labeling. *IEEE Transactions on Visualization and Computer Graphics*, 22(4):1415–1423, Apr. 2016. doi: 10.1109/TVCG.2016.2518318

[152] T. Mahmood, W. Fulmer, N. Mungoli, J. Huang, and A. Lu. Improving Information Sharing and Collaborative Analysis for Remote GeoSpatial Visualization Using Mixed Reality. In *2019 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 236–247, Oct. 2019. doi: 10.1109/ISMAR.2019.00021

[153] D. Markov-Vetter, J. Mühl, D. Schmalstieg, E. Sorantin, and M. Riccabona. 3D augmented reality simulator for neonatal cranial sonography. In *International Journal of Computer Assisted Radiology and Surgery*, vol. 4, pp. 19–20. Springer, Berlin, Germany, June 2009.

[154] A. Marquardt, C. Trepkowski, T. D. Eibich, J. Maiero, E. Kruijff, and J. Schoning. Comparing Non-Visual and Visual Guidance Methods for Narrow Field of View Augmented Reality Displays. *IEEE transactions on visualization and computer graphics*, 26(12):3389–3401, Dec. 2020. doi: 10.1109/TVCG.2020.3023605

[155] N. Matsushita, D. Hihara, T. Ushiro, S. Yoshimura, J. Rekimoto, and Y. Yamamoto. ID CAM: A smart camera for scene capturing and ID recognition. In *The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings.*, pp. 227–236, Oct. 2003. doi: 10.1109/ISMAR.2003.1240706

[156] E. Mendez, D. Kalkofen, and D. Schmalstieg. Interactive context-driven visualization tools for augmented reality. In *2006 IEEE/ACM International Symposium on Mixed and Augmented Reality*, pp. 209–218, Oct. 2006. doi: 10.1109/ISMAR.2006.297816

[157] E. Mendez and D. Schmalstieg. Adaptive Augmented Reality Using Con-

text Markup and Style Maps. In *2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 267–268, Nov. 2007. doi: 10.1109/ISMAR.2007.4538860

[158] E. Mendez and D. Schmalstieg. Importance masks for revealing occluded objects in augmented reality. In *Proceedings of the 16th ACM Symposium on Virtual Reality Software and Technology*, VRST '09, pp. 247–248. Association for Computing Machinery, New York, NY, USA, Nov. 2009. doi: 10.1145/1643928.1643988

[159] D. Mogilev, K. Kiyokawa, M. Billinghurst, and J. Pair. AR Pad: An interface for face-to-face AR collaboration. In *CHI '02 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '02, pp. 654–655. Association for Computing Machinery, New York, NY, USA, Apr. 2002. doi: 10.1145/506443.506530

[160] P. Mohr, B. Kerbl, M. Donoser, D. Schmalstieg, and D. Kalkofen. Retargeting Technical Documentation to Augmented Reality. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, CHI '15, pp. 3337–3346. Association for Computing Machinery, New York, NY, USA, Apr. 2015. doi: 10.1145/2702123.2702490

[161] P. Mohr, D. Mandl, M. Tatzgern, E. Veas, D. Schmalstieg, and D. Kalkofen. Retargeting Video Tutorials Showing Tools With Surface Contact to Augmented Reality. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, CHI '17, pp. 6547–6558. Association for Computing Machinery, New York, NY, USA, May 2017. doi: 10.1145/3025453.3025688

[162] P. Mohr, S. Mori, T. Langlotz, B. H. Thomas, D. Schmalstieg, and D. Kalkofen. Mixed Reality Light Fields for Interactive Remote Assistance. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–12. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376289

[163] P. Mohr, M. Tatzgern, J. Grubert, D. Schmalstieg, and D. Kalkofen. Adaptive user perspective rendering for Handheld Augmented Reality. In *2017 IEEE Symposium on 3D User Interfaces (3DUI)*, pp. 176–181, Mar. 2017. doi: 10.1109/3DUI.2017.7893336

[164] P. Mohr, M. Tatzgern, T. Langlotz, A. Lang, D. Schmalstieg, and D. Kalkofen. TrackCap: Enabling Smartphones for 3D Interaction on Mobile Head-Mounted Displays. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pp. 1–11. ACM, Glasgow Scotland Uk, May 2019. doi: 10.1145/3290605.3300815

[165] S. Mori, S. Ikeda, and H. Saito. A survey of diminished reality: Techniques for visually concealing, eliminating, and seeing through real objects. *IPSJ Transactions on Computer Vision and Applications*, 9(1):17, June 2017. doi: 10.1186/s41074-017-0028-1

[166] S. Mori, Y. Kataoka, and S. Hashiguchi. Exploring Pseudo-Weight in Augmented Reality Extended Displays. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pp. 703–710, Mar. 2022. doi: 10.1109/VR51125.2022.00091

[167] A. Morrison, A. Mulloni, S. Lemmelä, A. Oulasvirta, G. Jacucci, P. Peltonen, D. Schmalstieg, and H. Regenbrecht. Mobile Augmented Reality: Collaborative use of mobile augmented reality with paper maps. *Computers and Graphics*, 35(4):789–799, Aug. 2011. doi: 10.1016/j.cag.2011.04.009

[168] A. Mulloni, A. Dünser, and D. Schmalstieg. Zooming interfaces for augmented reality browsers. In *Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services*, MobileHCI '10, pp. 161–170. Association for Computing Machinery, New York, NY, USA, Sept. 2010. doi: 10.1145/1851600.1851629

[169] A. Mulloni, H. Seichter, and D. Schmalstieg. Enhancing handheld navigation systems with augmented reality. Proc. Mobile Augmented Reality Workshop at MobileHCI2011, pp. 7–10, Aug. 2011.

[170] A. Mulloni, H. Seichter, and D. Schmalstieg. Handheld augmented reality indoor navigation with activity-based instructions. In *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services*, MobileHCI '11, pp. 211–220. Association for Computing Machinery, New York, NY, USA, Aug. 2011. doi: 10.1145/2037373.2037406

[171] A. Mulloni, H. Seichter, and D. Schmalstieg. User experiences with augmented reality aided navigation on phones. In *2011 10th IEEE International Symposium on Mixed and Augmented Reality*, pp. 229–230, Oct. 2011. doi: 10.1109/ISMAR.2011.6092390

[172] A. Mulloni, D. Wagner, and D. Schmalstieg. Mobility and social interaction as core gameplay elements in multi-player augmented reality. In *Proceedings of the 3rd International Conference on Digital Interactive*

Media in Entertainment and Arts, DIMEA '08, pp. 472–478. Association for Computing Machinery, New York, NY, USA, Sept. 2008. doi: 10.1145/1413634.1413718

[173] A. Nawab, K. Chintamani, D. Ellis, G. Auner, and A. Pandya. Joystick mapped Augmented Reality Cues for End-Effector controlled Teleoperated Robots. In *2007 IEEE Virtual Reality Conference*, pp. 263–266, Mar. 2007. doi: 10.1109/VR.2007.352496

[174] J. Newman, I. Barakonyi, A. Schuerzinger, and D. Schmalstieg. Wide area tracking tools for augmented reality. Advances in Pervasive Computing. Austrian Computer Society Press, 2006.

[175] J. Newman, D. Ingram, and A. Hopper. Augmented reality in a wide area sentient environment. In *Proceedings IEEE and ACM International Symposium on Augmented Reality*, pp. 77–86, Oct. 2001. doi: 10.1109/ISAR.2001.970517

[176] B. Nuernberger, K.-C. Lien, T. Höllerer, and M. Turk. Interpreting 2D gesture annotations in 3D augmented reality. In *2016 IEEE Symposium on 3D User Interfaces (3DUI)*, pp. 149–158, Mar. 2016. doi: 10.1109/3DUI.2016.7460046

[177] J. Orlosky, K. Kiyokawa, and H. Takemura. Management and manipulation of text in dynamic mixed reality workspaces. In *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 1–4, Oct. 2013. doi: 10.1109/ISMAR.2013.6671819

[178] J. Orlosky, K. Kiyokawa, T. Toyama, and D. Sonntag. Halo Content: Context-aware Viewspace Management for Non-invasive Augmented Reality. In *Proceedings of the 20th International Conference on Intelligent User Interfaces*, IUI '15, pp. 369–373. Association for Computing Machinery, New York, NY, USA, Mar. 2015. doi: 10.1145/2678025.2701375

[179] C. Parker and M. Tomitsch. Data Visualisation Trends in Mobile Augmented Reality Applications. In *Proceedings of the 7th International Symposium on Visual Information Communication and Interaction*, VINCI '14, pp. 228–231. Association for Computing Machinery, New York, NY, USA, Aug. 2014. doi: 10.1145/2636240.2636864

[180] N. Pereira, A. Rowe, M. W. Farb, I. Liang, E. Lu, and E. Riebling. ARENA: The Augmented Reality Edge Networking Architecture. In *2021 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 479–488, Oct. 2021. doi: 10.1109/ISMAR52148.2021.00065

[181] K. Pfeuffer, Y. Abdrabou, A. Esteves, R. Rivu, Y. Abdelrahman, S. Meitner, A. Saadi, and F. Alt. ARtention: A design space for gaze-adaptive user interfaces in augmented reality. *Computers & Graphics*, 95:1–12, Apr. 2021. doi: 10.1016/j.cag.2021.01.001

[182] H. Pohl, T.-S. Dalsgaard, V. Krasniqi, and K. Hornbæk. Body LayARs: A Toolkit for Body-Based Augmented Reality. In *Proceedings of the 26th ACM Symposium on Virtual Reality Software and Technology*, VRST '20, pp. 1–11. Association for Computing Machinery, New York, NY, USA, Nov. 2020. doi: 10.1145/3385956.3418946

[183] B. Pokrić, S. Krčo, and M. Pokrić. Augmented Reality Based Smart City Services Using Secure IoT Infrastructure. In *2014 28th International Conference on Advanced Information Networking and Applications Workshops*, pp. 803–808, May 2014. doi: 10.1109/WAINA.2014.127

[184] A. Prouzeau, Y. Wang, B. Ens, W. Willett, and T. Dwyer. Corsican Twin: Authoring In Situ Augmented Reality Visualisations in Virtual Reality. In *Proceedings of the International Conference on Advanced Visual Interfaces*, AVI '20, pp. 1–9. Association for Computing Machinery, New York, NY, USA, Oct. 2020. doi: 10.1145/3399715.3399743

[185] D. Pustka, M. Huber, C. Waechter, F. Echtler, P. Keitler, J. Newman, D. Schmalstieg, and G. Klinker. Automatic configuration of pervasive sensor networks for augmented reality. *IEEE Pervasive Computing*, 10(3):68–79, July 2011. doi: 10.1109/MPRV.2010.50

[186] X. Qian, F. He, X. Hu, T. Wang, A. Ipsita, and K. Ramani. ScalAR: Authoring Semantically Adaptive Augmented Reality Experiences in Virtual Reality. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI '22, pp. 1–18. Association for Computing Machinery, New York, NY, USA, Apr. 2022. doi: 10.1145/3491102.3517665

[187] R. Radkowski, J. Herrema, and J. Oliver. Augmented Reality-Based Manual Assembly Support With Visual Features for Different Degrees of Difficulty. *International Journal of Human–Computer Interaction*, 31(5):337–349, May 2015. doi: 10.1080/10447318.2014.994194

[188] I. Radu and B. Schneider. What Can We Learn from Augmented Reality (AR)? Benefits and Drawbacks of AR for Inquiry-based Learning of Physics. In *Proceedings of the 2019 CHI Conference on Human Factors*

in Computing Systems, CHI '19, pp. 1–12. Association for Computing Machinery, New York, NY, USA, May 2019. doi: 10.1145/3290605.3300774

[189] J. Rambach, A. Pagani, and D. Stricker. [POSTER] Augmented Things: Enhancing AR Applications leveraging the Internet of Things and Universal 3D Object Tracking. In *2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct)*, pp. 103–108, Oct. 2017. doi: 10.1109/ISMAR-Adjunct.2017.42

[190] F. Rameau, H. Ha, K. Joo, J. Choi, K. Park, and I. S. Kweon. A Real-Time Augmented Reality System to See-Through Cars. *IEEE Transactions on Visualization and Computer Graphics*, 22(11):2395–2404, Nov. 2016. doi: 10.1109/TVCG.2016.2593768

[191] C. Reichherzer, J. Fraser, D. C. Rompapas, and M. Billinghurst. Second-Sight: A Framework for Cross-Device Augmented Reality Interfaces. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI EA '21, pp. 1–6. Association for Computing Machinery, New York, NY, USA, May 2021. doi: 10.1145/3411763.3451839

[192] P. Reipschläger and R. Dachselt. DesignAR: Immersive 3D-Modeling Combining Augmented Reality with Interactive Displays. In *Proceedings of the 2019 ACM International Conference on Interactive Surfaces and Spaces*, ISS '19, pp. 29–41. Association for Computing Machinery, New York, NY, USA, Nov. 2019. doi: 10.1145/3343055.3359718

[193] P. Reipschläger, S. Engert, and R. Dachselt. Augmented Displays: Seamlessly Extending Interactive Surfaces With Head-Mounted Augmented Reality. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI EA '20, pp. 1–4. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3334480.3383138

[194] P. Reipschlager, T. Flemisch, and R. Dachselt. Personal Augmented Reality for Information Visualization on Large Interactive Displays. *IEEE Transactions on Visualization and Computer Graphics*, 27(2):1182–1192, Feb. 2021. doi: 10.1109/TVCG.2020.3030460

[195] B. Reitinger, P. Werlberger, A. Bornik, R. Beichel, and D. Schmalstieg. Spatial measurements for medical augmented reality. In *Fourth IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'05)*, pp. 208–209, Oct. 2005. doi: 10.1109/ISMAR.2005.53

[196] B. Reitinger, C. Zach, and D. Schmalstieg. Augmented Reality Scouting for Interactive 3D Reconstruction. In *2007 IEEE Virtual Reality Conference*, pp. 219–222, Mar. 2007. doi: 10.1109/VR.2007.352485

[197] G. Reitmayr and D. Schmalstieg. Mobile collaborative augmented reality. In *Proceedings IEEE and ACM International Symposium on Augmented Reality*, pp. 114–123, Oct. 2001. doi: 10.1109/ISAR.2001.970521

[198] G. Reitmayr and D. Schmalstieg. A wearable 3D augmented reality workspace. In *Proceedings Fifth International Symposium on Wearable Computers*, pp. 165–166, Oct. 2001. doi: 10.1109/ISWC.2001.962125

[199] G. Reitmayr and D. Schmalstieg. Data management strategies for mobile augmented reality. In *Proceedings of the International Workshop on Software Technology for Augmented Reality Systems*, pp. 47–52. IEEE Computer Society Press, 2003.

[200] G. Reitmayr and D. Schmalstieg. Location based applications for mobile augmented reality. In *Proceedings of the Fourth Australasian User Interface Conference on User Interfaces 2003 - Volume 18*, AUIC '03, pp. 65–73. Australian Computer Society, Inc., AUS, Feb. 2003.

[201] G. Reitmayr and D. Schmalstieg. Collaborative augmented reality for outdoor navigation and information browsing. Proceedings of the Symposium on Location Based Services and TeleCartography, Jan. 2004.

[202] G. Reitmayr and D. Schmalstieg. Semantic world models for ubiquitous augmented reality. Semantic Virtual Environments (SVE 2005), 2005.

[203] J. Rekimoto. Matrix: A realtime object identification and registration method for augmented reality. In *Proceedings. 3rd Asia Pacific Computer Human Interaction (Cat. No.98EX110)*, pp. 63–68. IEEE Comput. Soc, Shonan Village Center, Japan, 1998. doi: 10.1109/APCHI.1998.704151

[204] B. Ridel, P. Reuter, J. Laviole, N. Mellado, N. Couture, and X. Granier. The Revealing Flashlight: Interactive Spatial Augmented Reality for Detail Exploration of Cultural Heritage Artifacts. *Journal on Computing and Cultural Heritage*, 7(2):6:1–6:18, June 2014. doi: 10.1145/2611376

[205] S. Rigling, X. Yu, and M. Sedlmair. "In Your Face!": Visualizing Fitness Tracker Data in Augmented Reality. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI EA '23, pp. 1–7. Association for Computing Machinery, New York, NY, USA, Apr. 2023. doi: 10.1145/3544549.3585912

[206] E. Samset, D. Schmalstieg, J. V. Sloten, A. Freudenthal, J. Declerck, S. Casciaro, Ø. Rideng, and B. Gersak. Augmented reality in surgical procedures. In *Human Vision and Electronic Imaging XIII*, vol. 6806, pp. 194–205. SPIE, Feb. 2008. doi: 10.1117/12.784155

[207] C. Sandor, A. Cunningham, U. Eck, D. Urquhart, G. Jarvis, A. Dey, S. Barbier, M. R. Marner, and S. Rhee. Egocentric space-distorting visualizations for rapid environment exploration in mobile mixed reality. In *2009 8th IEEE International Symposium on Mixed and Augmented Reality*, pp. 211–212, Oct. 2009. doi: 10.1109/ISMAR.2009.5336461

[208] C. Sandor and G. Klinker. A rapid prototyping software infrastructure for user interfaces in ubiquitous augmented reality. *Personal and Ubiquitous Computing*, 9(3):169–185, May 2005. doi: 10.1007/s00779-004-0328-1

[209] N. Saquib, R. H. Kazi, L.-Y. Wei, and W. Li. Interactive Body-Driven Graphics for Augmented Video Performance. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, pp. 1–12. Association for Computing Machinery, New York, NY, USA, May 2019. doi: 10.1145/3290605.3300852

[210] M. Sareika and D. Schmalstieg. Urban Sketcher: Mixed Reality on Site for Urban Planning and Architecture. In *2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 27–30, Nov. 2007. doi: 10.1109/ISMAR.2007.4538821

[211] M. Satkowski and R. Dachselt. Investigating the Impact of Real-World Environments on the Perception of 2D Visualizations in Augmented Reality. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, pp. 1–15. Association for Computing Machinery, New York, NY, USA, May 2021. doi: 10.1145/3411764.3445330

[212] M. Satkowski, W. Luo, and R. Dachselt. Towards In-situ Authoring of AR Visualizations with Mobile Devices. In *2021 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 324–325. IEEE, Bari, Italy, Oct. 2021. doi: 10.1109/ISMAR-Adjunct54149.2021.00073

[213] K. A. Satriadi, J. Smiley, B. Ens, M. Cordeil, T. Czauderna, B. Lee, Y. Yang, T. Dwyer, and B. Jenny. Tangible Globes for Data Visualisation in Augmented Reality. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI '22, pp. 1–16. Association for Computing Machinery, New York, NY, USA, Apr. 2022. doi: 10.1145/3491102.3517715

[214] G. Schall, H. Grabner, M. Grabner, P. Wohlhart, D. Schmalstieg, and H. Bischof. 3D tracking in unknown environments using on-line keypoint learning for mobile augmented reality. In *2008 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops*, pp. 1–8, June 2008. doi: 10.1109/CVPRW.2008.4563134

[215] G. Schall, E. Mendez, S. Junghanns, and D. Schmalstieg. Urban 3D models: What's underneath? Handheld augmented reality for subsurface infrastructure visualization. 9th International Conference on Ubiquitous Computing (UbiComp 2007), 2007.

[216] G. Schall, E. Mendez, E. Kruijff, E. Veas, S. Junghanns, B. Reitinger, and D. Schmalstieg. Handheld Augmented Reality for underground infrastructure visualization. *Personal and Ubiquitous Computing*, 13(4):281–291, May 2009. doi: 10.1007/s00779-008-0204-5

[217] G. Schall, E. Mendez, and D. Schmalstieg. Virtual redlining for civil engineering in real environments. In *2008 7th IEEE/ACM International Symposium on Mixed and Augmented Reality*, pp. 95–98, Sept. 2008. doi: 10.1109/ISMAR.2008.4637332

[218] G. Schall, B. Reitinger, E. Mendez, S. Junghanns, and D. Schmalstieg. Handheld geospatial augmented reality using urban 3D models. ACM CHI'07 Workshop on Mobile Spatial Interaction, 2007.

[219] G. Schall, D. Wagner, G. Reitmayr, E. Taichmann, M. Wieser, D. Schmalstieg, and B. Hofmann-Wellenhof. Global pose estimation using multi-sensor fusion for outdoor Augmented Reality. In *2009 8th IEEE International Symposium on Mixed and Augmented Reality*, pp. 153–162, Oct. 2009. doi: 10.1109/ISMAR.2009.5336489

[220] T. Schinke, N. Henze, and S. Boll. Visualization of off-screen objects in mobile augmented reality. In *Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services*, MobileHCI '10, pp. 313–316. Association for Computing Machinery, New York, NY, USA, Sept. 2010. doi: 10.1145/1851600.1851655

[221] D. Schmalstieg. Augmented reality techniques in games. In *Fourth IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'05)*, pp. 176–177, Oct. 2005. doi: 10.1109/ISMAR.2005.17

[222] D. Schmalstieg, A. Fuhrmann, G. Hesina, Z. Szalavári, L. M. Encarnação, M. Gervautz, and W. Purgathofer. The Studierstube Aug-

mented Reality Project. *Presence*, 11(1):33–54, Feb. 2002. doi: 10.1162/105474602317343640

[223] D. Schmalstieg and G. Schaufler. Sewing Worlds Together With SEAMs: A Mechanism to Construct Complex Virtual Environments. *Presence*, 8(4):449–461, Aug. 1999. doi: 10.1162/105474699566332

[224] D. Schmalstieg and D. Wagner. A handheld augmented reality museum guide. In *IADIS International Conference Mobile Learning 2005*, pp. 295–296, 2005.

[225] D. Schmalstieg and D. Wagner. Experiences with Handheld Augmented Reality. In *2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pp. 3–18, Nov. 2007. doi: 10.1109/ISMAR.2007.4538819

[226] D. Schmalstieg and D. Wagner. Mobile phones as a platform for augmented reality. Proceedings of the IEEE VR 2008 Workshop on Software Engineering and Architectures for Realtime Interactive Systems, pp. 43–44. Shaker Verlag, 2008.

[227] R. Schoenfelder and D. Schmalstieg. Augmented Reality for Industrial Building Acceptance. In *2008 IEEE Virtual Reality Conference*, pp. 83–90, Mar. 2008. doi: 10.1109/VR.2008.4480755

[228] R. Seiger, R. Kühn, M. Korzetz, and U. Aßmann. HoloFlows: Modelling of processes for the Internet of Things in mixed reality. *Software and Systems Modeling*, 20(5):1465–1489, Oct. 2021. doi: 10.1007/s10270-020-00859-6

[229] C. Shin, W. Lee, Y. Suh, H. Yoon, Y. Lee, and W. Woo. CAMAR 2.0: Future Direction of Context-Aware Mobile Augmented Reality. In *2009 International Symposium on Ubiquitous Virtual Reality*, pp. 21–24, July 2009. doi: 10.1109/ISUVR.2009.24

[230] J.-e. Shin, B. Yoon, D. Kim, and W. Woo. A User-Oriented Approach to Space-Adaptive Augmentation: The Effects of Spatial Affordance on Narrative Experience in an Augmented Reality Detective Game. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, pp. 1–13. Association for Computing Machinery, New York, NY, USA, May 2021. doi: 10.1145/3411764.3445675

[231] S. Shin, A. Batch, P. W. S. Butcher, P. D. Ritsos, and N. Elmqvist. The Reality of the Situation: A Survey of Situated Analytics. *IEEE Transactions on Visualization and Computer Graphics*, pp. 1–19, 2023. doi: 10.1109/TVCG.2023.3285546

[232] J. Shingu, E. Rieffel, D. Kimber, J. Vaughan, P. Qvarfordt, and K. Tuite. Camera pose navigation using Augmented Reality. In *2010 IEEE International Symposium on Mixed and Augmented Reality*, pp. 271–272, Oct. 2010. doi: 10.1109/ISMAR.2010.5643602

[233] L. R. Skreinig, A. Stanescu, S. Mori, F. Heyen, P. Mohr, M. Sedlmair, D. Schmalstieg, and D. Kalkofen. AR Hero: Generating Interactive Augmented Reality Guitar Tutorials. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 395–401, Mar. 2022. doi: 10.1109/VRW55335.2022.00086

[234] G. Somanath and D. Kurz. HDR Environment Map Estimation for Real-Time Augmented Reality. In *2021 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 11293–11301, June 2021. doi: 10.1109/CVPR46437.2021.01114

[235] M. Speicher, B. D. Hall, A. Yu, B. Zhang, H. Zhang, J. Nebeling, and M. Nebeling. XD-AR: Challenges and Opportunities in Cross-Device Augmented Reality Application Development. *Proceedings of the ACM on Human-Computer Interaction*, 2(EICS):7:1–7:24, June 2018. doi: 10.1145/3229089

[236] G. Speiginer and B. MacIntyre. Ethereal: A toolkit for spatially adaptive augmented reality content. In *Adjunct Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology*, UIST '14 Adjunct, pp. 113–114. Association for Computing Machinery, New York, NY, USA, Oct. 2014. doi: 10.1145/2658779.2658802

[237] G. Speiginer, B. MacIntyre, J. Bolter, H. Rouzati, A. Lambeth, L. Levy, L. Baird, M. Gandy, M. Sanders, B. Davidson, M. Engberg, R. Clark, and E. Mynatt. The Evolution of the Argon Web Framework Through Its Use Creating Cultural Heritage and Community–Based Augmented Reality Applications. In M. Kurosu, ed., *Human-Computer Interaction: Users and Contexts*, Lecture Notes in Computer Science, pp. 112–124. Springer International Publishing, Cham, 2015. doi: 10.1007/978-3-319-21006-3_12

[238] A. Stanescu, P. Mohr, D. Schmalstieg, and D. Kalkofen. Model-Free Authoring by Demonstration of Assembly Instructions in Augmented Reality. *IEEE Transactions on Visualization and Computer Graphics*, 28(11):3821–3831, Nov. 2022. doi: 10.1109/TVCG.2022.3203104

[239] M. Stranner, C. Arth, D. Schmalstieg, and P. Fleck. A High-Precision

Localization Device for Outdoor Augmented Reality. In *2019 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 37–41, Oct. 2019. doi: 10.1109/ISMAR-Adjunct.2019.00025

[240] H. Subramonyam, S. M. Drucker, and E. Adar. Affinity Lens: Data-Assisted Affinity Diagramming with Augmented Reality. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, pp. 1–13. Association for Computing Machinery, New York, NY, USA, May 2019. doi: 10.1145/3290605.3300628

[241] S. Sureshkumar, C. P. Agash, S. Ramya, R. Kaviyaraj, and S. Elanchezhiyan. Augmented Reality with Internet of Things. In *2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS)*, pp. 1426–1430, Mar. 2021. doi: 10.1109/ICAIS50930.2021.9395941

[242] J. Swan and J. L. Gabbard. Survey of User-Based Experimentation in Augmented Reality. 2005.

[243] Z. Szalavári, D. Schmalstieg, A. Fuhrmann, and M. Gervautz. "Studier-stube": An environment for collaboration in augmented reality. *Virtual Reality*, 3(1):37–48, Mar. 1998. doi: 10.1007/BF01409796

[244] T. Tahara, T. Seno, G. Narita, and T. Ishikawa. Retargetable AR: Context-aware Augmented Reality in Indoor Scenes based on 3D Scene Graph. In *2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 249–255. IEEE, Recife, Brazil, Nov. 2020. doi: 10.1109/ISMAR-Adjunct51615.2020.00072

[245] K. Tainaka, Y. Fujimoto, M. Kanbara, H. Kato, A. Moteki, K. Kuraki, K. Osamura, T. Yoshitake, and T. Fukuoka. Guideline and Tool for Designing an Assembly Task Support System Using Augmented Reality. In *2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 486–497, Nov. 2020. doi: 10.1109/ISMAR50242.2020.00077

[246] A. Tang, C. Owen, F. Biocca, and W. Mou. Comparative effectiveness of augmented reality in object assembly. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '03, pp. 73–80. Association for Computing Machinery, New York, NY, USA, Apr. 2003. doi: 10.1145/642611.642626

[247] M. Tatzgern, R. Grasset, D. Kalkofen, and D. Schmalstieg. Transitional Augmented Reality navigation for live captured scenes. In *2014 IEEE Virtual Reality (VR)*, pp. 21–26, Mar. 2014. doi: 10.1109/VR.2014.6802045

[248] M. Tatzgern, R. Grasset, E. Veas, D. Kalkofen, H. Seichter, and D. Schmalstieg. Exploring distant objects with augmented reality. In *Proceedings of the 5th Joint Virtual Reality Conference*, JVRC '13, pp. 49–56. Eurographics Association, Goslar, DEU, Dec. 2013. doi: 10.2312/EGVE.JVRC13.049-056

[249] M. Tatzgern, R. Grasset, E. Veas, D. Kalkofen, H. Seichter, and D. Schmalstieg. Exploring real world points of interest: Design and evaluation of object-centric exploration techniques for augmented reality. *Pervasive and Mobile Computing*, 18:55–70, Apr. 2015. doi: 10.1016/j.pmcj.2014.08.010

[250] M. Tatzgern, D. Kalkofen, R. Grasset, and D. Schmalstieg. Hedgehog labeling: View management techniques for external labels in 3D space. In *2014 IEEE Virtual Reality (VR)*, pp. 27–32, Mar. 2014. doi: 10.1109/VR.2014.6802046

[251] M. Tatzgern, D. Kalkofen, and D. Schmalstieg. Dynamic compact visualizations for augmented reality. In *2013 IEEE Virtual Reality (VR)*, pp. 3–6, Mar. 2013. doi: 10.1109/VR.2013.6549347

[252] M. Tatzgern, V. Orso, D. Kalkofen, G. Jacucci, L. Gamberini, and D. Schmalstieg. Adaptive information density for augmented reality displays. In *2016 IEEE Virtual Reality (VR)*, pp. 83–92, Mar. 2016. doi: 10.1109/VR.2016.7504691

[253] A. Tomkins and E. Lange. *Bridging the Analog-Digital Divide: Enhancing Urban Models with Augmented Reality*. Wichmann Verlag, DE, June 2020.

[254] W. Tong, Z. Chen, M. Xia, L. Y.-H. Lo, L. Yuan, B. Bach, and H. Qu. Exploring Interactions with Printed Data Visualizations in Augmented Reality. *IEEE Transactions on Visualization and Computer Graphics*, pp. 1–11, 2022. doi: 10.1109/TVCG.2022.3209386

[255] C. Ulbricht and D. Schmalstieg. Tangible augmented reality for computer games. In *Proceedings of the Third IASTED International Conference on Visualization, Imaging, and Image Processing*, pp. 950–954. Acta Press, 2003, 2003.

[256] E. Umlauf, H. Piringer, G. Reitmayr, and D. Schmalstieg. ARLib: The augmented library. In *The First IEEE International Workshop Agumented*

Reality Toolkit,, pp. 2 pp.–, Sept. 2002. doi: 10.1109/ART.2002.1106996

[257] A. E. Unlu and R. Xiao. PAIR: Phone as an Augmented Immersive Reality Controller. In *Proceedings of the 27th ACM Symposium on Virtual Reality Software and Technology*, VRST '21, pp. 1–6. Association for Computing Machinery, New York, NY, USA, Dec. 2021. doi: 10.1145/3489849.3489878

[258] K. Uratani, T. Machida, K. Kiyokawa, and H. Takemura. A study of depth visualization techniques for virtual annotations in augmented reality. In *IEEE Proceedings. VR 2005. Virtual Reality, 2005.*, pp. 295–296, Mar. 2005. doi: 10.1109/VR.2005.1492802

[259] E. Veas, R. Grasset, I. Ferencik, T. Grünewald, and D. Schmalstieg. Mobile augmented reality for environmental monitoring. *Personal and Ubiquitous Computing*, 17(7):1515–1531, Oct. 2013. doi: 10.1007/s00779-012-0597-z

[260] E. Veas, R. Grasset, E. Kruijff, and D. Schmalstieg. Extended Overview Techniques for Outdoor Augmented Reality. *IEEE Transactions on Visualization and Computer Graphics*, 18(4):565–572, Apr. 2012. doi: 10.1109/TVCG.2012.44

[261] S. Veigl, A. Kaltenbach, F. Ledermann, G. Reitmayr, and D. Schmalstieg. Two-handed direct interaction with ARTootKit. In *The First IEEE International Workshop Agumented Reality Toolkit,*, p. 2. IEEE, Darmstadt, Germany, 2002. doi: 10.1109/ART.2002.1106984

[262] C. Venezia and M. Marengo. Context Awareness Aims at Novel Fruition Models: Augmented Reality May be the Killer Application for Context Awareness. In *2010 IEEE/IFIP International Conference on Embedded and Ubiquitous Computing*, pp. 392–396, Dec. 2010. doi: 10.1109/EUC.2010.65

[263] L. Ventä-Olkkonen, M. Posti, O. Koskenranta, and J. Häkkilä. Investigating the balance between virtuality and reality in mobile mixed reality UI design: User perception of an augmented city. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*, NordiCHI '14, pp. 137–146. Association for Computing Machinery, New York, NY, USA, Oct. 2014. doi: 10.1145/2639189.2641201

[264] J. Viega, M. J. Conway, G. Williams, and R. Pausch. 3D magic lenses. In *Proceedings of the 9th Annual ACM Symposium on User Interface Software and Technology*, UIST '96, pp. 51–58. Association for Computing Machinery, New York, NY, USA, Nov. 1996. doi: 10.1145/237091.237098

[265] A. Villanueva, Z. Zhu, Z. Liu, K. Peppler, T. Redick, and K. Ramani. Meta-AR-App: An Authoring Platform for Collaborative Augmented Reality in STEM Classrooms. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–14. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376146

[266] D. Wagner, T. Pintaric, F. Ledermann, and D. Schmalstieg. Towards Massively Multi-user Augmented Reality on Handheld Devices. In H. W. Gellersen, R. Want, and A. Schmidt, eds., *Pervasive Computing*, Lecture Notes in Computer Science, pp. 208–219. Springer, Berlin, Heidelberg, 2005. doi: 10.1007/11428572_13

[267] D. Wagner and D. Schmalstieg. First steps towards handheld augmented reality. In *Seventh IEEE International Symposium on Wearable Computers, 2003. Proceedings.*, pp. 127–135, Oct. 2003. doi: 10.1109/ISWC.2003.1241402

[268] D. Wagner and D. Schmalstieg. Handheld Augmented Reality Displays. In *IEEE Virtual Reality Conference (VR 2006)*, pp. 321–321, Mar. 2006. doi: 10.1109/VR.2006.67

[269] T. Wang, X. Qian, F. He, X. Hu, K. Huo, Y. Cao, and K. Ramani. CAPturAR: An Augmented Reality Tool for Authoring Human-Involved Context-Aware Applications. In *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*, UIST '20, pp. 328–341. Association for Computing Machinery, New York, NY, USA, Oct. 2020. doi: 10.1145/3379337.3415815

[270] X. Wang, L. Besançon, D. Rousseau, M. Sereno, M. Ammi, and T. Isenberg. Towards an Understanding of Augmented Reality Extensions for Existing 3D Data Analysis Tools. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1–13. ACM, Honolulu HI USA, Apr. 2020. doi: 10.1145/3313831.3376657

[271] X. Wang, S. K. Ong, and A. Y. C. Nee. A comprehensive survey of augmented reality assembly research. *Advances in Manufacturing*, 4(1):1–22, Mar. 2016. doi: 10.1007/s40436-015-0131-4

[272] S. Werrlich, A. Daniel, A. Ginger, P.-A. Nguyen, and G. Notni. Comparing HMD-Based and Paper-Based Training. In *2018 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 134–142, Oct. 2018. doi: 10.1109/ISMAR.2018.00046

[273] G. White, C. Cabrera, A. Palade, and S. Clarke. Augmented Reality in IoT. In X. Liu, M. Mrissa, L. Zhang, D. Benslimane, A. Ghose, Z. Wang, A. Bucchiarone, W. Zhang, Y. Zou, and Q. Yu, eds., *Service-Oriented Computing – ICSOC 2018 Workshops*, Lecture Notes in Computer Science, pp. 149–160. Springer International Publishing, Cham, 2019. doi: 10.1007/978-3-030-17642-6_13

[274] M. Whitlock, G. Fitzmaurice, T. Grossman, and J. Matejka. AuthAR: Concurrent Authoring of Tutorials for AR Assembly Guidance. pp. 9 pages, 16039. Canadian Human-Computer Communications Society / Société canadienne du dialogue humain-machine, 2020. doi: 10.20380/GI2020.43

[275] M. Whitlock, J. Mitchell, N. Pfeufer, B. Arnot, R. Craig, B. Wilson, B. Chung, and D. A. Szafir. MRCAT: In Situ Prototyping of Interactive AR Environments. In *Virtual, Augmented and Mixed Reality. Design and Interaction: 12th International Conference, VAMR 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part I*, pp. 235–255. Springer-Verlag, Berlin, Heidelberg, July 2020. doi: 10.1007/978-3-030-49695-1_16

[276] M. Whitlock, D. A. Szafir, and K. Gruchalla. HydrogenAR: Interactive Data-Driven Presentation of Dispenser Reliability. In *2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 704–712, Nov. 2020. doi: 10.1109/ISMAR50242.2020.00101

[277] C. A. Wiesner, M. Ruf, D. Sirim, and G. Klinker. 3D-FRC: Depiction of the future road course in the Head-Up-Display. In *2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 136–143, Oct. 2017. doi: 10.1109/ISMAR.2017.30

[278] W. Willett, Y. Jansen, and P. Dragicevic. Embedded Data Representations. *IEEE Transactions on Visualization and Computer Graphics*, 23(1):461–470, Jan. 2017. doi: 10.1109/TVCG.2016.2598608

[279] J. Wither, Y.-T. Tsai, and R. Azuma. Indirect augmented reality. *Computers & Graphics*, 35(4):810–822, Aug. 2011. doi: 10.1016/j.cag.2011.04.010

[280] W. Woo. CAMAR: Context-aware mobile augmented reality in smart space. *Proc. of IWUVR*, Jan. 2009.

[281] L.-C. Wu, I.-C. Lin, and M.-H. Tsai. Augmented reality instruction for object assembly based on markerless tracking. In *Proceedings of the 20th ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, I3D '16, pp. 95–102. Association for Computing Machinery, New York, NY, USA, Feb. 2016. doi: 10.1145/2856400.2856416

[282] W. Xie, Y. Liang, J. Johnson, A. Mower, S. Burns, C. Chelini, P. D'Alessandro, N. Weibel, and J. P. Schulze. Interactive Multi-User 3D Visual Analytics in Augmented Reality. *Electronic Imaging*, 32(13):363-1–363-6, Jan. 2020. doi: 10.2352/ISSN.2470-1173.2020.13.ERVR-363

[283] M. Yamaguchi, S. Mori, P. Mohr, M. Tatzgern, A. Stanescu, H. Saito, and D. Kalkofen. Video-Annotated Augmented Reality Assembly Tutorials. In *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*, UIST '20, pp. 1010–1022. Association for Computing Machinery, New York, NY, USA, Oct. 2020. doi: 10.1145/3379337.3415819

[284] W. Yii, W. H. Li, and T. Drummond. Distributed visual processing for augmented reality. In *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 41–48, Nov. 2012. doi: 10.1109/ISMAR.2012.6402536

[285] S. You and U. Neumann. Fusion of vision and gyro tracking for robust augmented reality registration. In *Proceedings IEEE Virtual Reality 2001*, pp. 71–78, Mar. 2001. doi: 10.1109/VR.2001.913772

[286] X. Yu, K. Angerbauer, P. Mohr, D. Kalkofen, and M. Sedlmair. Perspective Matters: Design Implications for Motion Guidance in Mixed Reality. In *2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 577–587, Nov. 2020. doi: 10.1109/ISMAR50242.2020.00085

[287] T. Zachariah and P. Dutta. Browsing the Web of Things in Mobile Augmented Reality. In *Proceedings of the 20th International Workshop on Mobile Computing Systems and Applications*, HotMobile '19, pp. 129–134. Association for Computing Machinery, New York, NY, USA, Feb. 2019. doi: 10.1145/3301293.3302359

[288] J. Zhang, Y. Sheng, W. Hao, P. P. Wang, P. Tian, K. Miao, and C. K. Pickering. A context-aware framework supporting complex ubiquitous scenarios with Augmented Reality enabled. In *5th International Conference on Pervasive Computing and Applications*, pp. 69–74, Dec. 2010.

doi: 10.1109/ICPCA.2010.5704077

[289] M. Zheng and A. G. Campbell. Location-Based Augmented Reality In-situ Visualization Applied for Agricultural Fieldwork Navigation. In *2019 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 93–97, Oct. 2019. doi: 10.1109/ISMAR -Adjunct.2019.00039

[290] M. Zheng, X. Pan, N. V. Bermeo, R. J. Thomas, D. Coyle, G. M. P. O'hare, and A. G. Campbell. STARE: Augmented Reality Data Visualization for Explainable Decision Support in Smart Environments. *IEEE Access*, 10:29543–29557, 2022. doi: 10.1109/ACCESS.2022.3156697

[291] B. Zhou and S. Güven. Fine-Grained Visual Recognition in Mobile Augmented Reality for Technical Support. *IEEE Transactions on Visualization and Computer Graphics*, 26(12):3514–3523, Dec. 2020. doi: 10. 1109/TVCG.2020.3023635

[292] F. Zhu and T. Grossman. BISHARE: Exploring Bidirectional Interactions Between Smartphones and Head-Mounted Augmented Reality. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pp. 1–14. Association for Computing Machinery, New York, NY, USA, Apr. 2020. doi: 10.1145/3313831.3376233

[293] J. Zhu, S. K. Ong, and A. Y. C. Nee. An authorable context-aware augmented reality system to assist the maintenance technicians. *The International Journal of Advanced Manufacturing Technology*, 66(9):1699–1714, June 2013. doi: 10.1007/s00170-012-4451-2

[294] Z. Zhu, Z. Liu, T. Wang, Y. Zhang, X. Qian, P. F. Raja, A. Villanueva, and K. Ramani. MechARspace: An Authoring System Enabling Bidirectional Binding of Augmented Reality with Toys in Real-time. In *Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology*, UIST '22, pp. 1–16. Association for Computing Machinery, New York, NY, USA, Oct. 2022. doi: 10.1145/3526113.3545668

[295] V. Zogopoulos, E. Geurts, D. Gors, and S. Kauffmann. Authoring Tool for Automatic Generation of Augmented Reality Instruction Sequence for Manual Operations. *Procedia CIRP*, 106:84–89, Jan. 2022. doi: 10. 1016/j.procir.2022.02.159

[296] S. Zollmann, C. Hoppe, T. Langlotz, and G. Reitmayr. FlyAR: Augmented Reality Supported Micro Aerial Vehicle Navigation. *IEEE Transactions on Visualization and Computer Graphics*, 20(4):560–568, Apr. 2014. doi: 10.1109/TVCG.2014.24

[297] S. Zollmann, D. Kalkofen, C. Hoppe, S. Kluckner, H. Bischof, and G. Reitmayr. Interactive 4D overview and detail visualization in augmented reality. In *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pp. 167–176. IEEE, Atlanta, GA, USA, Nov. 2012. doi: 10.1109/ISMAR.2012.6402554