Between Pages and Reality: Exploring a Book Metaphor for Unfolding Data-driven Storytelling in Immersive Environments

Weizhou Luo* Mark Abdelaziz† Julián Méndez* Rufat Rzayev*‡

Interactive Media Lab Dresden
TUD Dresden University of Technology, Germany

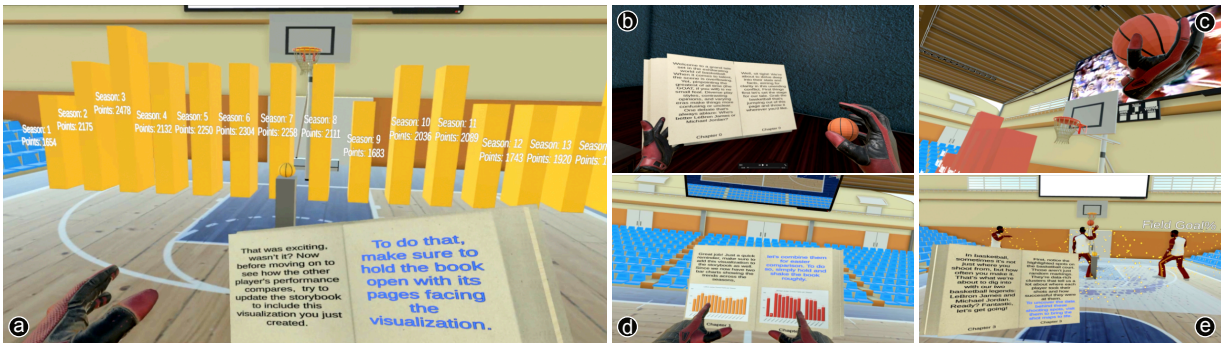

Figure 1: (a) Our *StoryBook* metaphor enables immersive data-driven storytelling by featuring pagination, textual narration, data visualizations, and interactive elements. Concepts were developed to allow interactions between *StoryBook* and the environment, such as (b) extracting interactive elements and (d) inserting visualizations for comparison. In an exemplary VR data story about basketball players, users engage in the narrative by (c) basketball shooting and (e) examining players' scoring areas.

Abstract

Storytelling is an effective way to communicate information to people with different backgrounds and literacy. Immersive technologies like virtual reality (VR) have great potential for presenting engaging narratives and multimodal content in innovative ways. However, it is essential to ensure that the presentation and interaction possibilities are comprehensible to broad audiences. Drawing inspiration from the traditional role of books in preserving stories, we introduce *StoryBook*, a conceptual metaphor for interacting with and unfolding immersive data stories. Through analogical reasoning, we mapped existing concepts of physical books to interact with a VR storytelling process. *StoryBook* provides a familiar and intuitive way of navigating, inserting, and extracting story elements in VR, akin to page-flipping, bookmarking, or note-taking with a real book. We developed a prototype and conducted initial user feedback sessions, showcasing the potential of our concepts. Our contribution provides insights into the design and interaction of data-driven stories in immersive environments.

Index Terms: Data-driven Storytelling, Immersive Environments.

1 Introduction & Background

Data storytelling is the process of creating and communicating narratives using data and visualizations to effectively explain and present insights to reach a broad or targeted audience [2]. It facilitates simplifying complex information, allowing the audience to engage with the content and make decisions [4]. By incorporating immersive technology, such as virtual reality (VR), data storytelling can enhance the understanding of complex data sets by offering an immersive experience and interaction with data and narration in natural and intuitive ways. It can heighten the audience's sense of presence and involvement, making them feel like active participants in the narrative [2]. However, transitioning traditional storytelling to immersive environments necessitates a rethinking of storytelling techniques. The exploratory and open nature of immersive environments requires new methods to guide users through the narrative and prevent them from becoming disoriented. Additionally, these systems must be designed to accommodate a diverse audience, ensuring that they can understand and engage with the content.

We present the *StoryBook* metaphor to interact with and unfold immersive data stories. Metaphors can support users in understanding unfamiliar systems by referencing familiar objects [3]. In our case, *StoryBook* serves as a central interface, guiding an interactive process, facilitating the storage of story elements, and actively contributing to the unfolding narrative experience. Unlike prior works on tangible books (e.g., [1]), we directly mapped physical book characteristics into virtual *StoryBook*. Users can advance the story by *reading* and turning pages, they can transit between the 2D pages and 3D world by *extracting* or *inserting* narrative elements, such as visualizations, and they can make *bookmarks* and *annotations* to take optional notes. To illustrate the potential of *StoryBook*, we developed a VR prototype using a data story about basketball players. Moreover, we conducted a preliminary study to get initial feedback about the concept. In summary, our contributions are designing and implementing a novel immersive storytelling concept for unfolding a data story in VR using a physical book metaphor.

2 StoryBook Concepts for Narrative Progression

StoryBook mimics a familiar reading experience that enables users to interact with and unfold data-driven narratives. Users can turn the pages to experience the story at their own pace. Moreover, users can bring the story to life instead of just imagining it by transitioning 2D elements into the 3D world. Inversely, the data-driven nature of these stories benefits from abstracting and storing 3D world elements as 2D charts, similar to sketching or storing photos in a

*e-mail: [weizhou.luo, julian.mendez2, rufat.rzayev]@tu-dresden.de
†e-mail: markmichealhp@gmail.com
‡Also with ScaDS.AI Dresden/Leipzig, Germany

notebook. We thus developed the following concepts.

Reading Users start the immersive story by opening the two-sided book and turning to the first page. Aside from audio narrations, narrative elements such as text, images, charts, and empty spaces (for insertion) are presented on the pages, providing a blueprint for the story. To progress, users flip the page from right to left with a fingertip pinch (or trigger pressing) and can revisit previous content by flipping back. The thickness of the book indicates the amount of remaining content. Users can pause the storytelling by closing the book, which suspends ongoing animations in the immersive environments, allowing them to delve into details. To quickly advance or rewind the narrative, users can perform a full hand flip from the edge of the book to turn multiple pages at once.

Extraction Users can transit elements confined in the 2D pages of the book into the 3D virtual world. The real-world equivalent of this experience is akin to reading a passage or seeing a picture in a book, and imagining it coming to life around you. However, VR allows us to materialize our imagination. For instance, themed objects can dynamically alter the environment to reflect their significance within the story. In our exemplary story, extracting a basketball icon could transform the space into a court (see Fig. 1b), and shooting the extracted basketball could generate 3D bars showing the scores achieved by professional basketball players per season (see Fig. 1a&c). This turns the storytelling process into a participatory and co-creative experience. Data visualizations especially benefit from 2D to 3D transitions, as one can visceralize 2D content by revealing additional 3D properties [5]. For instance, a scatter plot depicting basketball player scoring locations can be extracted from the book and overlaid onto a virtual court (see Fig. 1e), supporting direct spatial understanding, and a specific scoring animation can be replayed to experience a data point in its visceral form.

Insertion Inverse to extraction, insertion allows users to move elements from the 3D world into the 2D book world. For instance, after experiencing a 3D visualization, the user can incorporate this visualization into the book, similar to the practice of sketching and storing photos. The unique ability to extract these elements back into the real world can also be used to replay parts of the story. Furthermore, users can edit objects within the book with greater control by applying familiar data visualization techniques such as comparing and filtering. For example, two 3D bar charts can be inserted back into the book and transformed into 2D bar charts that are either juxtaposed (see Fig. 1d) or superimposed for easier comparison.

Placement As a virtual component, *StoryBook* can be flexibly placed in 3D space and quickly accessed by users. Namely, it is possible to fix the book to any position in mid-air and quickly invoke it regardless of distance (e.g., by gesturing). When the immersive environment requires full attention, users can also place the book in a virtual pocket beside their waist, allowing them to engage with the content without the book obstructing their view.

Bookmark and Annotation For quick access and easy reference to essential information, users can tear out pages of interest and keep them accessible within the virtual space. A semi-transparent page can indicate where the original page was removed. Users can also add annotations, such as sticky notes, to these pages. To overview all notes, the book can spread out all pages in a spiral for simultaneous viewing, enabling faster navigation.

3 Prototype and Initial Feedback

We developed a proof-of-concept prototype using Unity3D and SteamVR on a PC with an Nvidia 3060 graphics card and the HTC VIVE PRO headset for an immersive experience. We adapted a story about a performance comparison of two professional basketball players (based on James vs Jordan[1] by Bry & Vuillemot) and implemented essential concepts (see the video figure in the supplementary material). During the storytelling process, users can immerse themselves in the story by being in a basketball arena and advancing the story by interacting with the *StoryBook* (see Fig. 1). They can progress through the story by turning pages, experience the narration by listening to the audio or reading from the book, extract statistics about the basketball players from the book by materializing the visualizations onto the virtual environment, and insert visualizations into the book for safekeeping and analysis. Additional interaction methods were also explored, such as book shaking to join visualizations. We designed the *StoryBook* like a physical book featuring realistic page-flipping animations with a placement characteristic described in the previous section. Moreover, we recorded an audio narration in addition to the textual one on the pages. The prototype was developed using freely available assets.

We conducted a preliminary study with 11 participants (4 males, 7 females) with a mean age of 25 (SD = 4.76) for initial feedback. Participants were informed of the study's objectives, completed consent and demographic forms, familiarized themselves with the VR setup, engaged in think-aloud experiments while their activity was recorded, and concluded with brief interviews. Overall, participants enjoyed the familiar metaphor of *StoryBook* and its immersive, participatory experience. In particular, they valued the control over narrative progression and the ability to explore data nonlinearly and in 3D space, supporting data comprehension. However, the insertion mechanic received mixed feedback. While participants found it interesting, they experienced issues with unintentional triggering of the interaction and confusion about what could be inserted. We plan to use the feedback to enhance the prototype.

4 Conclusion

We propose *StoryBook*, a narrative control metaphor in VR that allows users to interact with data and narrative elements for a seamless storytelling experience. Our proof-of-concept prototype and initial user study showed that *StoryBook* is promising for story progression and data comprehension, which is beneficial in the exploratory nature of immersive environments. The prototype is available in Github[2] to support further research. Also, we will conduct user studies investigating different facets of immersive data storytelling, such as the impact of transitioning content between pages and reality on the storytelling experience.

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