Interaction Geography in a Museum

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Abstract
This paper outlines our use of space-time visualization as part of an emerging approach to studying human interaction and mobility in interior spaces that we call "interaction geography". We describe how we have used this approach in a museum setting. Findings and discussion show how interaction geography draws from space-time visualization research to advance professional design practice in a museum. We conclude by discussing limitations and the need for future research to further develop this early work.

Author Keywords
Interaction geography; space-time visualization; time geography; design research; interaction analysis; interaction design; museum studies

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Introduction
This paper outlines our use of space-time visualization as part of an emerging approach to studying human interaction and mobility in interior spaces that we call interaction geography. We describe how we have used this approach in a museum setting using empirical data collected during IRB approved research funded by the National Science Foundation at a nationally renowned museum located in the mid-South region of the United States [33, 34, 35]. This data includes 1) 22 case studies of complete museum visits that captured continuous, multi-perspective audio/video records of visitor mobility and interaction and 2) audio/video and post-surveys from professional development and design sessions with museum professionals.

We begin by reviewing relevant work in space-time visualization research and museum studies. We then illustrate how interaction geography and specifically, a dynamic visualization environment we have developed and call the *Interaction Geography Slicer (IGS)*, draws from space-time visualization research to describe museum visitor's interaction and mobility in museum gallery spaces. Subsequently, we show how we have used interaction geography and the Interaction

Geography Slicer (IGS) in one professional design and development session with museum curators, educators, archivists and designers. We conclude by discussing limitations and the need for future research to further develop this early work.

Relevant Work

Two bodies of research concerning space-time visualization and museum studies inform this work. We describe these in order.

Space-time visualization is an established area of research and design [1, 2, 7, 9, 24]. Moreover, it is a rapidly growing area of research due to new technologies [10, 12, 18, 20], new forms of urban mobility [26, 27], open data resources [13] and the increasing need to gain insights and reveal patterns from complex data [2, 11, 25]. We draw from space-time visualization research concerning time geography [15] and the use and advancement of the space-time cube and space-time cube operations such as space flattening [5, 21]. Moreover, we also draw from the visualization and analysis of movement [3, 4, 6], the use of flow maps by expert and non-expert audiences [27, 28, 31] and early attempts to visualize movement and interaction in interior environments [14, 17, 38].

With respect to museum studies, our work is informed by two particular trends along with methods used in museum studies. The first trend is that museums and archival collections are redefining their mission, from curating and conserving collections to engaging the public in conversations about the meaning of archival material in relation to broader societal themes [30]. The second trend is that studies of visitor behavior are shifting away from understanding gallery exhibits as a fixed curriculum that visitors succeed or fail at understanding, and towards a view of visitor learning as an "enacted curriculum" [23]. Likewise, we draw from methods of conversation, interaction and mobility analysis used in museum studies [16, 18, 29, 36, 37] as well as design based research methods that provide empirically driven ways to build, test and refine designs in educational settings [8].

Interaction Geography Slicer (IGS)

Figure 1 shows a museum gallery space that features exhibits of renowned American Roots, Bluegrass and Country musicians (e.g. Hank Williams, Bill Monroe, Maybelle Carter, Earl Scruggs, Crystal Gayle).

Figure 1: A Museum Gallery Space

Figure 2 is a snapshot from a dynamic visualization environment we have developed and call the *Interaction Geography Slicer (IGS)* to support multi-modal analysis of interaction and mobility that moves continuously through space and over time. The figure shows the simultaneous movement and conversation of a family of five whom we call the "Bluegrass Family" (a mother, her two young sons, their sister and her fiancé) in the museum gallery space shown in Figure 1.

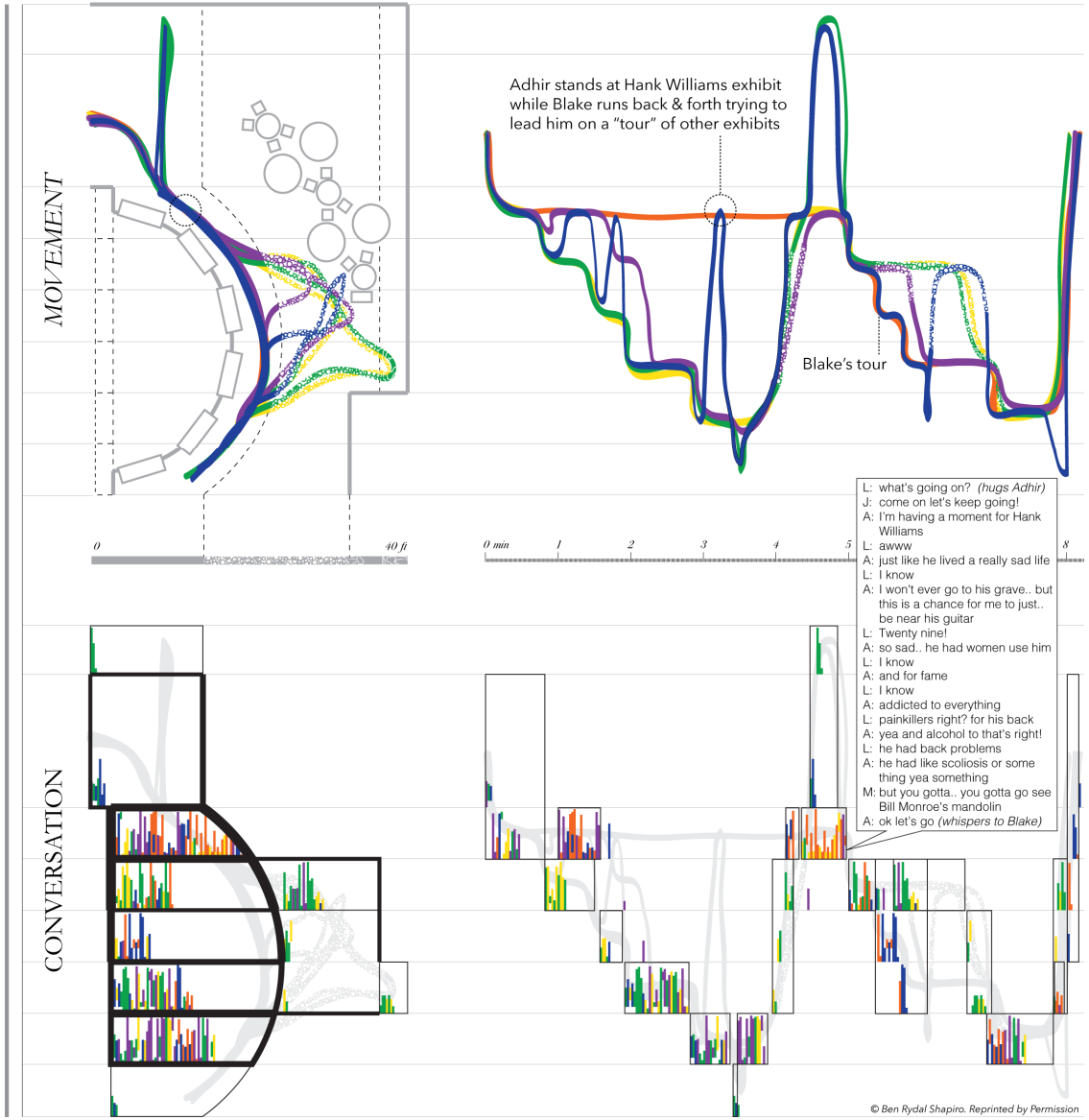

Figure 2: Snapshot from *Interaction Geography Slicer (IGS).* A family's movement and conversation in a museum gallery is shown across a "floor plan display" and "timeline display". Color designates individual family members:

Mom Lily 20 Jeans 10 Adhir 25 Blake 6 (age)

The top half shows movement and the bottom half shows conversation. The Y-axis on the timeline display corresponds to the vertical dimension of the floor plan display. Movement line pattern corresponds to the horizontal dimension of the floor plan display. Conversation organizes transcribed talk colored by speaker in space and time and groups topically related talk into conversation "boxes". Thicker boxes on the floor plan display show repeated conversations in the same area of space. *Software is written and will be made available by Ben Rydal Shapiro using JavaScript & p5.js. Source: Copyright © by Ben Rydal Shapiro. Reprinted by permission.*

Figure 2 shows how the IGS applies widely used techniques of space-time visualization particularly concerning the space-time cube [15, 21], space flattening [5] and the visualization of movement [3, 4, 25] to study the sequential and spatial organization of movement and conversation. For instance, in the previous figure we highlight the efforts of a 6-year-old boy Blake (the blue movement path moving up and down on the timeline display) to lead another family member Adhir (the straight orange movement path on the timeline display) on a tour of other exhibits in the gallery space. We also note how their intertwined paths at minutes 5-6 indicate that Blake is finally successful.

Figure 2 also hints at a larger set of possibilities to dynamically use space-time visualization to study museum visitor's interaction and mobility made possible by the IGS. For example, the figure provides some illustration of how users can select and read conversation. The conversation that is shown (e.g. selected by a user) in Figure 2 is a conversation between Adhir and his fiancé Lily about the painful life of Hank Williams that reveals why Adhir stood in silent "reverence" for five minutes at Hank William's exhibit.

We cannot devote adequate attention in this paper to the full and still emerging possibilities of the IGS. However, it is important to note that the IGS supports the visualization and analysis of five streams of audio and video collected in this example from small cameras worn by each member of the family as part of this research. Moreover, the IGS supports floor plan or map rotation, which allows users to study whether interpretations in one floor plan view hold up over changes in orientation and scale in other floor plan views. Likewise, it supports multiple 3D space-time visualization views. In addition, many of the decisions that inform the design of the IGS aim to make space-time visualization more useful to new audiences that are particularly concerned with people's conversation and interaction [32]. Lastly, Figure 3 below illustrates the kinds of comparative analysis that can be explored using the IGS. Namely, the figure compares the mobility of four different families/groups including the Bluegrass Family in three different museum gallery spaces. All displayed information is set to the same spatial and temporal scales. The Taylor Swift Family did not visit the Hall of Fame Rotunda Gallery space and thus we substituted a floor plan of the entire museum.

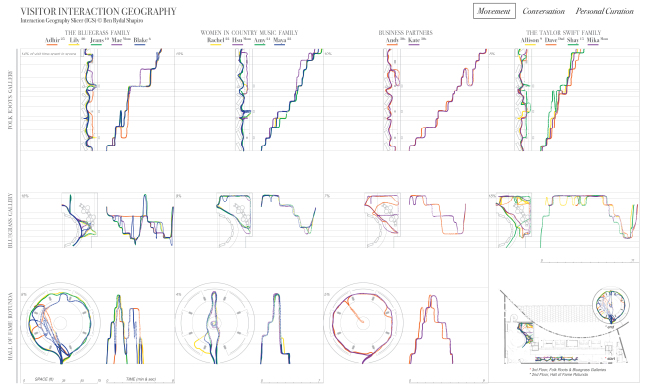

Figure 3: Small multiples of family mobility from Interaction Geography Slicer (IGS). *Source: Copyright © by Ben Rydal Shapiro. Reprinted by permission.*

Using Interaction Geography to Advance Professional Design Practice

Figure 4 below introduces our use of interaction geography and the IGS during one professional design and development session with museum professionals.

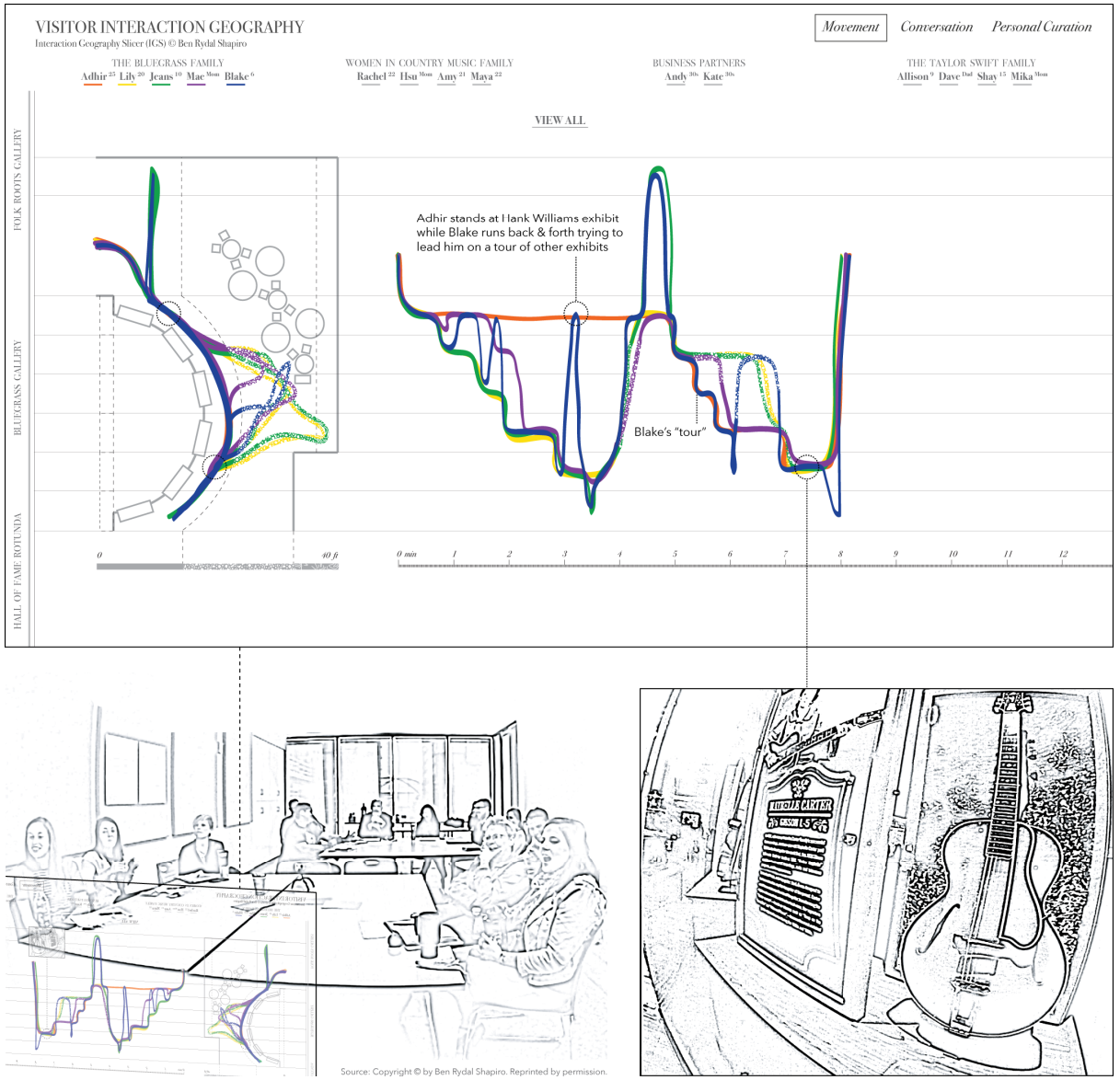

Figure 4: The bottom left image of the figure shows a group of museum curators, educators, archivists and designers using the *Interaction Geography Slicer (IGS)* to study how their visitors engage with exhibits in museum gallery spaces. Different visitor groups and gallery spaces can be selected and compared. The large top image provides a detailed view of what they are looking at, which is the movement of one family in one museum gallery space. The bottom right image displays video (from a camera worn by family member Lily) selected by a museum curator at a point in space and time when the family is gathered together at an exhibit dedicated to Maybelle Carter. *Software is written and will be made available by Ben Rydal Shapiro using JavaScript & p5.js. Source: Copyright © by Ben Rydal Shapiro. Reprinted by permission.*

Our analysis of video records and post surveys from multiple sessions in this museum including the one shown above illustrates three primary contributions of methods (e.g. the IGS) and concepts (e.g. "engagement contours" [33]) of interaction geography.

Contribution 1: We found methods and concepts of interaction geography allowed museum professionals to "see" their visitors in very new ways and challenged idealized models of museum visitors as relatively passive consumers of intended design. For example, prior to our work many museum curators, educators and designers at this museum viewed young children's rapid movements in museum gallery spaces as childish behavior that prevented real engagement and learning. The previous figure captures the moment when they are vividly confronted by Blake's rapid movement (e.g. running back and forth) to lead Adhir on a tour of other exhibits. Though initially shocking, this moment created what we understood as a shift in the perspective of museum professionals to see young children's rapid movements and family's "interaction geographies" as very intentional and opportunities for design.

Contribution 2: We found methods and concepts of interaction geography provide ways for museum professionals to ask questions currently important to museum studies and to ask new types of questions. For example, in our design sessions museum professionals used interaction geography as an approach to study how adults coordinate young children's attention and observation not only at single exhibits as is typically the case [23, 30] but also, at times, repeatedly across multiple exhibits and gallery spaces. Moreover, we found interaction geography offers ways to ask new questions such as how young children manage their families as interpretive resources in museum gallery spaces [33]. We feel these possibilities advanced professional design practice in this museum.

Contribution 3: We found that methods and concepts of interaction geography could provide a powerful means to support evidence-based design decisions in this museum and to do so collaboratively across multiple museum departments. For example, museum professionals indicated how this work could provide a much needed way to not only learn about their visitors but also to gather evidence on visitor activity that could inform future, more expansive and equitable design decisions. Likewise, museum professionals indicated that the visual and interactive nature of our work could provide ways for different museum departments to work together in new ways.

Conclusion & Future Work

This paper outlined our use of space-time visualization as part of an emerging approach to studying human interaction and mobility in interior spaces that we call interaction geography. Many more studies are needed to address inherent limitations in this early work, which draws from one exploratory study. Future research should further refine and generalize the visualization techniques, software and concepts introduced in this paper across different types of interior spaces and also conduct additional user test cases to study how people understand and use interaction geography and the IGS.

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