ReflectiveHUD: Designing Spatial Interaction History

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Abstract
We present our design exploration of ReflectiveHUD: a tree-like immersive interaction history visualization for spatial tasks. While linear interaction history models such as undo and redo are ubiquitous, only a few nonlinear history models exist. We are interested in designing a nonlinear history model for complex spatial tasks. Our work-in-progress report the findings from a design study exploring what people see as effective nonlinear interaction history representations in spatial tasks. We explored as one of the study conditions, ReflectiveHUD, an interaction history representation that allows users to effectively revisit different temporal trajectories in their interaction history.

Author Keywords
Interaction History; Design Study; Time Design; Temporospatial Visualization; Undo.

ACM Classification Keywords
H.5.2. User Interfaces: User-centered design.

Introduction
The design of many systems today enables rolling back and re-trying things if user's interaction did not work out as expected the first time. Such awareness and control of user's interaction history is generally possible through linear models such as undo/redo or nonlinear models including branching timelines (Figure 1).

Related Work

Interaction history is often logged via actions or state modeling. For modelling user actions, the Command design pattern [11] is often used. Alternatively, application (or object) state can be saved or restored as needed (see [6] for a survey).

Oftentimes, linear history models fail to preserve subsequent user actions after performing an undo, with the exception of The Selective Undo technique [1] that allows users to select and undo only specific operations from the past. While most usage of the nonlinear models is in simple tasks, games are one-exception. For example, Final Fantasy XIII-2 [4] features, "Gate Matrix", a tree-like visualization for supporting nonlinear level access. Tom Clancy's The Division, features Echoes as spatial 3D holograms of previous actions allowing the player to revisit the past [10]. We follow the gaming approach and attempt such exploration in our study.

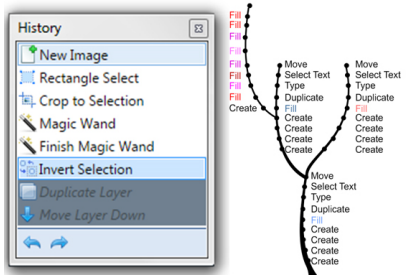

Figure 1: An example of capturing image edits in a linear history list (left), or in a nonlinear branching tree (right).

While the basic linear undo/redo model [6], often represented as a list of history items, is more common because of its simplicity, few nonlinear branching models (e.g., tree/graph) are gaining more popularity [3] particularly within non-spatial tasks such as image or text editing scenarios. However, most of the nonlinear approaches do not address the unique challenges of interaction history in complex spatial tasks and are often abstract (e.g., [7] and [9]), utilizing simple encoding of user actions using text [8] or static image thumbnails (e.g., [5] and [2]). Therefore, we focus on exploring nonlinear interaction history representations in spatial tasks and argue that having improved representations would increase users' awareness and control of their interaction history.

Many of today's tasks are spatial, involving (temporal) interactions that occur within physical or 3D virtual space. Examples of such tasks include walking from one location to another, exploring complex 3D data in immersive environments, designing an artifact, etc. The inherent availability of context space in such tasks affords more freedom when designing interaction, for instance, in collaborative scenarios where sharing space is common as well as when performing actions that require a large spatial area. Within an immersive mining simulation scenario, for example, a user may explore mining data with the goal of finding an optimal subset of the data. Therefore, the user must try different 3D interactions that filter the data. In such a context, presenting the user's interaction history as an abstract branching structure or a basic list of history items, similarly to non-spatial scenarios, would limit the user's awareness of his or her interaction history, a limitation that would leave little support for exploration, learning, and creativity. Therefore, it would be important in such immersive spatial environments to capture and present users' interactions in a flexible way.

Design Study

We conducted a two-part design study as a design critique focused on exploring what makes an effective nonlinear interaction history representation in spatial tasks. We explored two conditions in our study, an abstract tree visualization as our baseline condition, and the condition we termed ReflectiveHUD (RH) involving a set of enriched tree-like interaction history visualizations. We conceptualized RH using inspirations from games that explored innovative interaction history representations (e.g., [4] and [10]).

In the first part of the study, we aimed at gathering people's initial reaction to nonlinear interaction history representations. Then, we conducted the second part of the study, utilizing some of the first part's findings, to gather a more focused feedback on the RH condition and explore design variations of the RH representation.

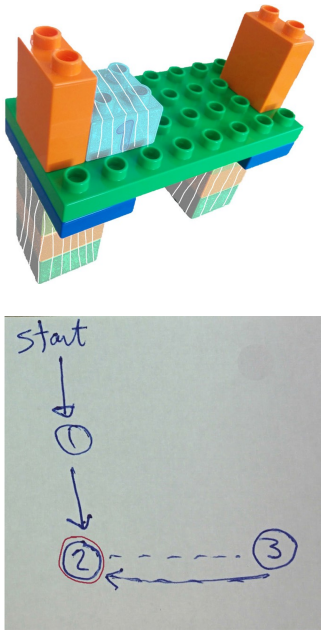

Figure 3: The interaction history sketches when the user performs an undo after completing three steps of the Lego task. (Top: the RH sketch utilizes hatched transparency for the Lego parts that were removed after the undo, Bottom: the abstract-tree sketch involves numerical text to indicate user steps with solid/dotted lines for active/disregarded interaction paths and with a red outline for the current step).

Protocol

We recruited six student participants (1 M / 5 F) for the first study part and another different six participants (4M / 2F) for the second part, all from a local university with background in design, HCI, and visualization.

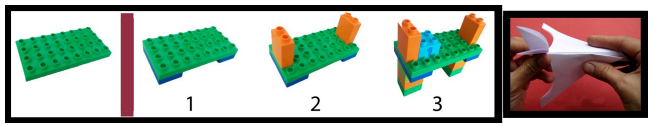

Figure 2: Sketches of the first three steps of the Lego task (left), and the desired outcome for the Origami task (right).

We asked all participants to perform scripted spatial tasks. Prior to performing the tasks, the concept of interaction history was introduced through an example of undo/redo within the MS Word application. Following each task, a short interview was conducted to elicit participants' feedback about history representations and their usage in this task. After completing all tasks, participants were interviewed about how they perceived the nonlinear interaction history visualization, their feedback on the various design encodings that were explored in the RH representation, and their overall experience. Each Participant was compensated $20 (CAN) for the study session that lasted one hour.

Tasks

The tasks used in our study were: (1) finding a Santa Claus object hidden in the lab space, (2) making a flapping rabbit Origami object, and (3) building a (predesigned) Lego construct. We scripted the tasks to simplify generating content for the history representation.

The first task focused on spatial exploration of the lab space. Each participant was asked to physically walk and search the lab following the experimenter instructions to fulfil the task goal of finding the Santa object in the lab. At certain locations, participants were instructed to turn and continue the searching either to the left or to the right, with the shown interaction history representation reflecting that change.

In the second task, the goal was to make a flapping rabbit Origami object (Figure 2 bottom). The scripted instructions deliberately involved wrong steps (e.g., incorrect cut, unsuitable choice of colors, etc.) and ways to resolve them, allowing participants to rewind time and have another chance to fix the problem.

For the last task, we asked each participant to build a Lego shape. The scripted instructions simulated how a user may refine the construction by changing his or her mind at certain interaction points. For instance, the user was guided to arrange the Lego blocks, one after the other, in a certain way, but later realized that it will not lead to the desired final shape, and thus was guided to roll back and try a different arrangement.

The participants were guided by (either hand- or computer- drawn) static paper sketches reflecting specific instructions for each of the study tasks. Additional sketches were used simulating what the interaction history would look like at each step of the tasks. For example, Figure 2 (Left) shows some of the sketches that were made for the (first three steps of the) Lego task. Figure 3 shows the associated history representation sketches (utilizing the RH and the abstract tree) after the third step of the Lego task.

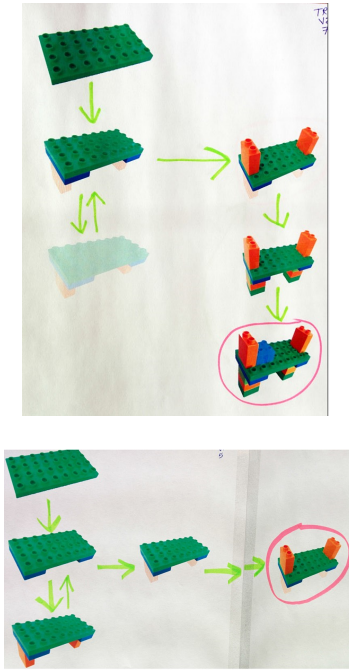

Figure 4: Two design variants of the RH sketches for the Lego task, reflecting interaction branches using directed arrows and with the most recently captured snapshot having a red outline. (Top: a tree that utilizes some transparency for the user disregarded branches, Bottom: a tree that clones branching points without the use of transparency).

In the first part of the study, participants performed all the three tasks. In the second part, however, only the Origami and Lego tasks were considered and the abstract representation was omitted towards our focus on exploring different RH design aspects such as transparency, layout, and arrangement. Figures 4 and 5 show an example of the two design variants that were used with each task.

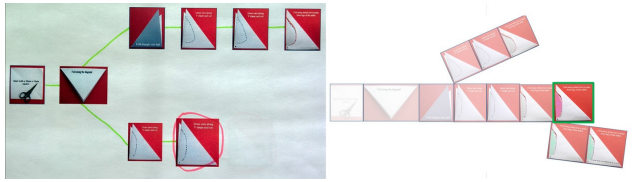

Figure 5: Two design variants sketches of the RH for the Origami task. (Left: an organized tree-like structure showing previews of user actions over time, Right: a transparency-based history visualization highlighting the main interaction branch as always expanding horizontally to the right with disregarded branches fanning out over time).

Results and Discussion

Our initial analysis of the gathered critique data focused on understanding how our participants perceived the nonlinear interaction history representations, and their preference on the RH design variants we explored.

All participants found the nonlinear interaction history representations to be useful and preferred the RH representation to the abstract one. The participants' preference for the nonlinear representation (including RH) since it preserves previous alternative interactions, and provides a clear idea of what have been tried before. Two participants specifically linked the choice of the history representation to the simplicity/complexity of the task and of one's workflow. As P6 expressed, "*this [RH] representation is better for navigation tasks and for being oriented in space, while the abstract graph is better for less spatial tasks like planning*". All participants favored the visual history representation especially if the task is visual. As P6 puts it, "*I prefer [nodes with] graphics because it is easier to follow the history, because you don't need to recreate the history in mind, because the history is there*".

Participants' opinions on line connectivity varied. Two participants found lines unnecessary as they can get in the way. However, most participants preferred having some line connectivity especially if the representation layout would change dramatically. Those who favored having lines added that lines should be dotted, thinner, or transparent when showing disregarded branches, and should be solid, opaque, or thicker for the active path. Concerning transparency, four participants agreed it could be helpful, if it is consistently applied to nodes as opposed to having it fade over time.

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Conclusion

We presented our early design of nonlinear interaction history representation for spatial tasks, reflecting on a preliminary design study. We highlight one of our study conditions, the ReflectiveHUD: a tree-like interaction history visualization allowing users to effectively revisit different temporal trajectories in their interaction history.

We are currently exploring more design variants of the ReflectiveHUD representation, as well as considering its realization in an immersive surgical simulation context.

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