Video Games for Collection Exploration: Games for and out of Data Repositories

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ABSTRACT
In this paper, we establish a link between video games and data collections. In particular, we examine video games as potential interfaces for collection exploration, i.e. as a platform for a more insightful and exploratory interaction with a repository. Furthermore, we question if a more structural relationship between the game and the collection is possible: Can we produce video games based on the structure of a repository? We explore these ideas on theoretical grounds and by means of a prototype game developed as a case study for a scientific image repository.

Categories and Subject Descriptors
H.5.2 **[User Interfaces]**: Graphical user interfaces (GUI).

General Terms
Human Factors, Theory, Experimentation

Keywords
video games, data collections, data exploration

1. GAMES *FOR* DATA REPOSITORIES: GAMING AS EXPLORATION
In most, well-maintained data collections there is a potential for discovery. Think of it: data collections create opportunities for processes that are considered stimulating for discovery, such as (serendipitous) encounters with valuable items or the establishment of insightful associations between items. But if there are treasures to lie hidden in data repositories, what tools do we need to discover them? We believe that, in interacting with data in repositories, there is a need for interfaces that challenge and engage the user to explore. To this end, we propose video games and gaming as a suitable platform for an interaction for exploration.

An interaction for collection exploration differs in focus and intention from regular search interfaces to collections. In particular, interfaces for exploration may require a shift from the query-based search and fact finding. Consider, for example, the exploratory search paradigm: The paradigm emerged in order to address different information needs, i.e. search processes of a high degree of uncertainty of the searcher [23], and as an attempt to facilitate learning and investigation [13]. An interaction for collection exploration requires a similar shift towards more open-ended activities but may be more related to browsing than to searching. Indeed, in information science literature, serendipitous encounters and associations are traditionally linked to (semi-directed or undirected) browsing or navigation in a hypertext-ed fashion [8]. As summarized in [26], browsing has a high degree of interactivity and can be understood as spatial movement across attention points.

We argue that video games can support such an open-ended interaction for collection exploration. To begin with, video games are closely related to navigation, as the notion space is a central aspect of gaming, both philosophically and technically [15]. Technically, gaming tasks often require navigation and wayfinding in virtual, usually three-dimensional, space. In fact, when information spaces are represented as three-dimensional spaces, navigation conventions from video games are applied for navigating these new spaces. This is the case with various representation of digital collections such as libraries [6, 16] or museums [3]. We embrace the idea of collections as spaces to be navigated and note that video games can support tasks relevant for exploration.

But most of all, next to supporting relevant tasks for exploration, video games can support the relevant emotional state for exploration. We believe that exploration requires a state of open-mindedness and even playfulness. Play itself is often related to creativity and learning [17] with (positive) affect said to stimulate the cognitive processes involved in creativity. [4] calls for support for creativity and play in information systems to promote serendipity and sagacity. And the HCI community is bringing into focus positive affect, fun [14] and playfulness [11] as desirable aspects of interaction design. Of course, playful interfaces need not be video games, but valuable lessons can be learned from video games [7, 12] as good video games have shown to be very successful in user engagement. At the same time, various fields are attempting to tap engagement and attraction to video games by appropriating gaming practices. For instance, the serious gaming industry is developing video games for a variety of utilitarian purposes [2, 21], while von Ahn's concept of 'games with a purpose' [22] attempts to convert human effort during play into productive (computation) work. From our viewpoint, we advocate

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that interfaces for collection exploration can be formed into video games to benefit from the positive effect of fun and play and to enhance user engagement and motivation.

2. GAMES *OUT OF* DATA REPOSITORIES: GAMING AS INFORMATION 'PERCEPTUALIZATION'

In the previous section, we described data collections as information spaces to be navigated in a playful and engaging manner. Still, simply exploring the content of a repository in virtual space is not sufficient towards a better understanding of the collection and its complexity. In this section, we discuss collection exploration as an investigation on the structure of the collection as a whole. We initiate our discussion from the standpoint of information visualization, however, we are aware that modalities other than visual perception may be worth exploiting. Eventually, we contemplate on the possibility of using video games as a type of 'executable' visualization or information 'perceptualization'.

Towards an interaction to support exploration, and, eventually, discovery, ideas and methods from the field of information visualization are relevant. Note that the primary goal of information visualization is to gain insight on data, by exploiting our visual perception capacities. In the context of information visualization, exploration of an information space is related to activities that allow forming a mental model of this space, such as navigation and browsing [20]. Similarly, [25] suggests that one of the processes involved in gaining insight with visualizations is the formulation of a mental model of the data. According to [26], information visualization can be beneficial for information retrieval as it can capture useful information that is aggregated across items, on the macro-level of the collection. In line with the aims of information visualization, we state that collection exploration should involve a better understanding of the collection and its structure as a whole rather than looking at individual entries only. For the purposes of this paper, structure can emerge by simply modeling the collection as a network of interconnected entities.

Typically, structure as in a set of entities and their relations is abstracted to a graph. The graph, i.e. a set of vertices and edges, is in fact a non visual representation. For the purposes of information visualization, this graph is usually visualized as a node-link diagram by means of graph drawing algorithms such as the ones surveyed in [5]. The node-link diagram is not the only possible graph visualization (see e.g. matrix representations [19]) but it is the most prominent and a great amount of research is dedicated in improving graph layouts in terms of both efficiency and user satisfaction. On the other hand, interactivity has allowed for interactive graph visualizations that enable exploration and direct manipulation (see [9] for a survey). Interactivity and navigation, e.g. across the graph and its available paths, are essential for constructing a mental model of the graph.

We have already discussed video games in relation to navigation. If graph structures have nodes to be visited and paths to be traversed, graph structures could as well constitute a game space to be navigated. But playing a video game is not only about spatial skills: it involves a variety of challenges that activate a plethora of cognitive processes. Can we exploit these processes towards a better understanding of the structure of the collection? We observe that several common games, particularly abstract strategy board games, can be described and analyzed mathematically as graphs. In reverse, we question whether game logic can be devised out of existing graph structures, such as the connections in a data collection. Essentially, we introduce a more structural relationship between the game and the collection and pronounce that the underlying (graph) structure of the collection should be truly incorporated into the game. To this end, structure must be properly mapped to game logic and mechanics. For example, features of the graph could be utilized to control the progress of the game, to decide upon its outcome or to score the user actions. Such a game would confront the player with the structure of the repository during game time and would require the player to actively interact and reason with the encoded structure for the needs of the game. Eventually, the game becomes a form of 'executable' information visualization that materializes connections rather than visualizing them.

3. A CASE STUDY: ONTO-FROGGER

We have designed and implemented a prototype game in order to investigate the suggested link between video games and collection exploration. Our case study is based on a scientific imaging database maintained by our research group.

3.1 Background

The Cyttron Scientific Image Database (for) Exchange (CSIDx) is a multi-modal imaging database for microscopy data from the life sciences [10]. As imaging in different modalities and resolutions is a regular practice for biological research, integration of imaging techniques can assist researchers in a more comprehensive examination of a biological phenomenon and in critically combining findings and observations. Entries in CSIDx are composite entities of image data, i.e. pixel data captured from the imaging scanner, plus semantic information, as users are required to annotate their images with ontology terms from various life science ontologies. We exploit these annotations to establish connections across images. In particular, we model the repository as a (undirected) graph in which every annotated image is a node. Nodes are connected with an edge when they share an annotation term. The resulting graph constitutes the semantics of our database: A gaming activity for CSIDx should support navigation across the interconnected images and familiarize players with the derived structure.

3.2 Design phase

Our concept phase was initially stirred to games of some graph traversing resemblances. Still, we diverted from strictly mathematical graph games in favor of games that support spatial navigation. Early on, we decided to adjust an existing game concept instead of starting from scratch and devising an entirely new one. Appropriating a known game could increase our possibilities for a successful final product thanks to a tested gameplay and a familiar look.

We have taken the classic arcade game Frogger (Konami Industry Co. Ltd, 1981) [1] as a first vehicle for our own game concept. Frogger's concept (Figure 1) seemed to be a suitable candidate due to its (implicit) path traversing qualities. The game is an arcade action game based on mechanic skill (timing of jumping) but its interactivity can be formally narrowed down to dodging,

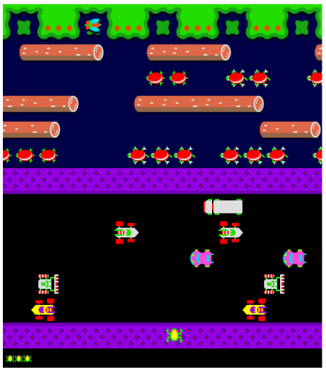

Figure 1: Frogger-like gameplay. On the bottom half of the screen, the frog needs to cross over a busy highway, by avoiding passing-by traffic. On the top half, the frog needs to cross a river by jumping on floating objects such as logs and turtles (Frogger clone implemented by neave.com).

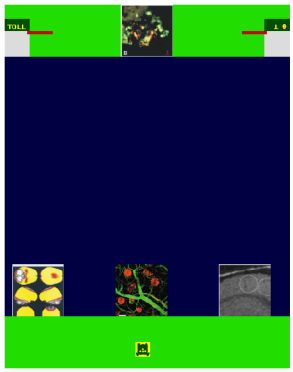

Figure 2: Onto-Frogger (2009), active area upon game start. The frog needs to cross the river by jumping on floating image tiles using the target image as a guide. The target image is inaccessible behind the toll station as no coins have been collected yet.

i.e. the avoidance of moving objects, and obstacle course, i.e. the traversing of a difficult path [24]. Simply put, the game requires the player to execute a valid trajectory in game space. In addition, an analogy with Frogger could lower the entry threshold for our users: The game's popularity and familiar look should help our users to quickly comprehend the new game while its simple controls and minimal storyline should allow even the non-gamer to immediately start playing.

3.3 Onto-Frogger: The game

Onto-Frogger, our prototype game, is a single-player, arcade style game. It borrows the game settings of the classic arcade Frogger but enhances the original action-based gameplay to include images and their annotations. In particular, the game focuses on the user annotations with ontology terms and on the connections implied by these annotations. The result is a crossover between an action/platform and a puzzle solving game.

In Onto-Frogger (Figure 2), the player needs to reach a target image on the other side of a river. Arriving at the opposite bank requires the player to land successfully on image tiles, i.e. without getting drowned, and to collect enough coins on the way in order to pass the toll station on the other side. Coins are to be found on image tiles that share annotations with the target image: every coin is an annotation term shared with the target. The objective of the game is to jump on appropriate image tiles that grant sufficient coins and to collect as many coins as possible in order to achieve a high score. Collecting multiple unique annotations (golden coins) is rewarded more points than collecting multiple instances of the same annotation (silver coins). As such, the scoring system attempts to stimulate a conscious investigation of the available choices instead of mechanic response. Technically, the so-called 'coin terms' are edges to the target image: making a successful trajectory directly relates to visiting neighbors of the target node which can be understood as the target's immediate context in the repository.

4. DISCUSSION/ FUTURE WORK

Onto-Frogger is a prototype and experiment that allowed us to tackle an unexplored territory, i.e. producing games for and out of data collections. As such, it raises more questions than it can actually answer. But it is useful in terms of identifying difficulties and downfalls and in terms of setting our agenda for further research. For the most part, the major challenges can be grouped as issues of 1) evaluation and 2) (lack of) framework. In effect, how are we to verify our theoretical claims on video games for collections (evaluation) and how can we secure suitable games for a given dataset (framework)?

Definitely, Onto-Frogger (and any other game for collection exploration) is a challenging product to evaluate, due to both its hybrid character and its aims. To date, we have conducted evaluations on the game interface and the clarity of the game rules (as supported by interface elements). In our experience, standard HCI techniques proved to be very supportive for the development of the game. Yet, for a complete examination of Onto-Frogger as a video game, more input is needed in terms of user satisfaction and perceived fun and challenge. On the other hand, the game is ultimately an invitation for exploration. A game for collection exploration should be evaluated in respect to the effect of its use. This challenge is similar to the ones faced by information visualization displays suggested to promote insight: Evaluating the impact of such products is a cumbersome task (see e.g. [18]), mainly due to the nature of the creative processes to be stimulated.

Is, however, Onto-Frogger a good game concept for the given graph structure? The game makes indeed extensive use of the available connections which are an essential part of the game's 'reality'. The rules imposed were dictated by the features of our dataset, namely a very dense graph with short distances. As a result, Onto-Frogger evolved into a game that significantly deviates from its original inspiration and so it seems reasonable to question if the analogy with the original Frogger is still useful. In comparison to Frogger, Onto-Frogger is a fairly elaborate game and we wonder if this is an over-complication or a necessity to facilitate our data. Here, we already face a need for methodology: what are the structural elements of the graph that must be communicated and how are to be encoded in game elements? Onto-Frogger was the outcome of creative brainstorming together with a close inspection of our dataset. Technically, it focuses on the graph edges (presence of a connection) which are translated to the game interactivity of collection. With a number of features of the repository structure to be mapped and a number of game

elements to be exploited, we are curious if the process of mapping structure to gameplay can be formalized. Nevertheless, this would require a multidisciplinary effort with contributions from game design studies, human computer interaction, the graph community and cognitive sciences.

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