Can Videogame Players Inform Better Scientific Visualization?

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Abstract
We sought to explore how knowledge of videogames could inform the design of complex digital interfaces for bioinformatics visualization tools. *Aquaria* is an open-source web resource for visual exploration of protein structures. We present the results of a series of workshops conducted with participants who have expertise in videogame design and development. We report on emerging themes relating to how videogames might inform improvements in the design of Aquaria and other bioinformatics visualization tools. Future work is described.

Author Keywords
Videogame expertise; Visualization; Design

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
Videogames commonly present large amounts of information in an engaging and intuitive format. Based on this observation, we sought to explore how knowledge of videogames and videogame design could inform the design of a complex non-game interface, initially in the context of bioinformatics visualization. In this way, we aimed to improve the design of an

Aquaria:
As noted in the main body of the paper, Aquaria is designed primarily to make specialized information about protein structures accessible to the broader molecular biology community. In contrast to most structure viewers, the interface is organized around the 1D protein sequence (essentially a string of characters over an alphabet of 20 amino acids). Structures appear in response to the query, with key components highlighted.

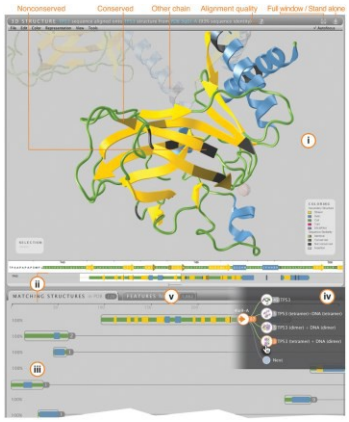

Figure 2 from O'Donoghue et. al. (2015, figure 1) shows the layout and highlighting of the structure.

An introductory video may be viewed at:
http://bit.ly/2aejCLF

interface for 3D visualization but also to provide important initial understanding of how videogames expertise might be adapted for other domains.

Aquaria

Aquaria[1] (see Figures 1 and 2) is an open web resource for visualisation and exploration of protein structures (O'Donoghue et al., 2015). Tens of thousands of protein structures and associated metadata are available through the Protein Data Bank[2] (PDB), but the PDB is geared to the needs of specialist researchers. Aquaria augments these data with tens of millions of model structures. In addition, Aquaria aims to simplify and streamline access to the wealth of structural information available, making it accessible to the general molecular biology community, allowing biologists to gain functional insight from protein structures. Users may retrieve structures related to a particular protein, map sequence-based features, use colour and shading to highlight functional components, and use a 3D viewer to select preferred orientation.

Research Aims

Our primary aim was to gain insights into ways that interface and interaction design of Aquaria might be improved from the perspective of participants with extensive experience with videogames. It may also be that insights generated specifically with Aquaria in mind can inform the design of similar tools. To follow up on this idea, the main developer of Aquaria (O'Donoghue), and an Aquaria user (Baldi) were included in the project as well as in drafting this manuscript. Our secondary aim was to begin exploring the extent to which videogame knowledge might be usefully applied in other domains and provide initial insight regarding useful methods for approaching this question.

[1] http://www.aquaria.ws/

[2] http://www.rcsb.org/pdb

Figure 1: Screenshot of the Aquaria interface

Related Work

Somewhat surprisingly, there is a relative dearth of research directly exploring how knowledge of videogame design can inform interaction and interface design in other domains (cf. gamification below). Dyck and colleagues (2003) observed that game design emerged as a relatively separate field from existing software design. They analysed (then) current videogame interfaces and sought to identify ideas that could be applied more generally to user interfaces.

Based on fourteen videogames, they established four strong themes with possible application in broader HCI: effortless community, learning by watching, deep customisability, and fluid system-human interaction. Given changes in videogame interfaces in the last

decade and our specific interest in 3D visualization software we sought to build on this work.

More recently, Kosmadoudi et al (2013) considered possible improvements to Computer Aided Design (CAD) software using more intuitive user interface design from videogames. While acknowledging their differing goals, the work identified a number of features of videogames with potential application in CAD software (including GUI immersion and information complexity, and knowledge structures with communication strategies). More specifically, they observed that features of videogame user interfaces, such as contextual menus and customizable interfaces had begun to appear in 3D design and modelling tools.

Gamification

Our aims and approach are very close to the concept of gamification "*the use of game design elements in non-game contexts*" (Deterding, Dixon, Khaled, & Nacke, 2011; see Seaborn & Fels, 2015 for a review). However, while gamification can refer to various design features and mechanics in games (e.g., rewards, leaderboards, avatars) our primary focus in the current study was the design of the interface and mode of interaction. That said, we agree that our approach could be considered to be a form of gamification.

Methodology

Three design workshops were undertaken, each with two participants with expertise in video game interfaces (a total of six participants). The expertise of participants extended to experience designing videogames, teaching undergraduate courses about videogame design and development, and publishing academic work in the fields of player experience and game design. Workshop durations ranged from 90 minutes to 2 hours. Workshops began by providing introductory knowledge to the field of molecular biology and protein structure, followed by a demonstration of the Aquaria interface. Participants were then encouraged to either repeat a process similar to the demonstration, or to freely explore the interface while discussing it: how it could be improved, and how it related to games or other similar systems. Topics from previous workshops were mentioned to new participants to encourage further discussion and insights from a broader set of participants.

Additionally, two of the workshop facilitators were experts in videogame design and computer-human interaction but largely naïve regarding biology and protein structure and the Aquaria tool. Inspired by the "engaged researcher" paradigm (Third, 2016), these facilitators acted as semi-informed participants, both asking questions and contributing to the conversation with the goal of initiating and developing ideas presented by the participants.

Workshops were video recorded and later reviewed and coded for themes. One coder did an initial review of the recordings, noting all concepts discussed, and then refined these themes through discussion with other experts (in bioinformatics, game design and computer-human interaction). The final step was a second review of the recordings to further refine the more prominent and topics and extract representative quotes.

Results and Discussion

In the following discussion [P1], [P2] etc. are used to denote comments made by participants and [F1], [F2] to refer to comments made by the facilitators.

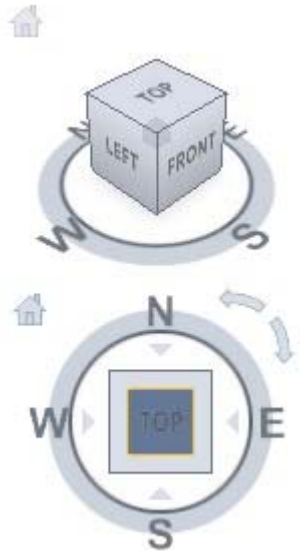

Figure 3. The “ViewCube” used in 3D Studio Max.

Orientation and Movement

Orientation and movement of the 3D structural view was a significant theme of discussion and insight that emerged during the workshops. These discussions emerged from parallels to game design and 3D modelling software, partially in relation to paradigms of exploration in video games, and partially in relation to control systems common in games.

Parallels to game design and 3D modelling software emerged in the first workshop, and some of these discussions centered on the method of rotation and panning to orient and move in three dimensional environments. In the second workshop, participants discussed how they felt these systems of mouse-controlled and keyboard shortcut orientation were unintuitive, and very difficult for newcomers.

"*Feels like a 3D modelling tool.*" [P5]

Building upon these discussions, participants in the second workshop drew similarities to 3D Studio Max, and suggested an element of its interface that they felt was more intuitive and could be adapted to Aquaria. This feature, called the ‘ViewCube’ (see Figure 3), is an interactive icon in the top right hand corner that can be used to rotate the view through a set of orthographical options. This was highlighted as an intuitive and easy way for beginners to learn to explore and orient the three-dimensional view, as opposed to less clear keyboard shortcuts and mouse controls used in Aquaria. As pointed out by both developer and user of Aquaria, there is an example of a molecular graphics software (VMD, Humphrey et al., 1996) that indeed adopted a similar solution: a 3D axes orientation representation to facilitate users orienting in the viewport. Contrary to the ViewCube, the VMD 3D axes does not drive any change in orientation, but simply rotate with the protein represented in the viewport.

In one workshop, it was suggested that some form of default orientation could be applied, and this orientation could be utilised to allow for further exploration in a similar manner to the system used in several CAD software tools.

"*Yeah, 3D Studio Max has a really nice interface on the right hand corner [..] which you click and rotate to certain views, and there's a reset button which takes you back to the original view.*" [P1]

In spite of the superficial similarity between Aquaria and game design or CAD software, molecules do not have an intrinsic orientation or canonical co-ordinate system. Exploration is unrestricted but lacks intrinsic guidance, and this is not provided by the tool.

[F1] *"Did you want a default orientation for this?"*
[P2] *"I think that's what I was thinking about with the silhouette. In the corner have a sort of greyed out silhouette of the protein, and when you click it, it returns to the default."*

Identifying the best default orientation for any given protein is something that Aquaria developers are actively perusing by performing user studies on Amazon Mechanical Turk (Heinrich et al., 2016). The combination of a ViewCube like feature and a default orientation was considered a great input to improve user experience for Aquaria.

Several suggestions for adapting the interface were based around hardware familiar from gaming. These

Figure 4. Messages left by players in ‘Dark Souls’

Figure 5. Collaborative Play in ‘Game and Wario’

included a controller such as that used with the Xbox One, touch screen interfaces as used on a tablet, and virtual reality headsets.

"*This would make a nice tablet app. Touch screen would be nice, zooming and pinching.*" [P5]

Collaboration and Social Features

Social engagement, communities and collaboration are significant features of many video games, and their potential application was discussed in all workshops.

Initial discussions focused on some form of social overlay or chat, where users could see who else was viewing a similar protein, and establish discussions based upon this shared interest and view. Parallels were also drawn to several video games, including ‘Dark Souls’ (Figure 4) which features the ability for players to leave notes for others in places of interest, and ‘Game and Wario’ (Figure 5) which features a collaborative puzzle solving element, which led to discussions of ‘solving’ issues surrounding proteins with collaboration, potentially in a gamified form.

""*Might be interesting to know what other people were looking at that protein, and to discuss with them.*" [F1] … "(nods)*…Like in World of Warcraft where you can set a checkpoint of a place of interest…*" [P4]

"*Each player* (in ‘Game and Wario’) *has to kind of solve their puzzle, to fire the cannon. I was just thinking, maybe in terms of social applications, there's something with … the whole binding thing where both sides are manipulating their sides of the structure and trying to piece them together.*" [P3] …."*Some kind of collaborative solving task?*" [F2]… “*Yeah, which kind of links to what we were saying before about objectives as well. Either identify or manipulate this sequence in a way that creates the sequence that creates bones or fights this type or cancer. … Showing how this information is relevant to other fields.*" [P3]

The principal aim of Aquaria is to reach a broader audience of biologists and scientists, making protein structure information more accessible. Including collaborative and community features could support broader, cross-disciplinary interaction, perhaps accelerating research in fields such as drug discovery. Overall these ideas were highly regarded as positives and inspired the possibility of a feature integration of Proteopedia (Hodis et al., 2008), a community curated encyclopedia for proteins, in Aquaria.

Playfulness and Provenance

Participants mentioned the potential value of bringing a sense of playfulness to Aquaria and relatedly, the ability to return to earlier states.

"*The interactivity is all based around visualisation of information, …, but there's no interactivity that's about kind of.. Experimenting or playing, or like you were saying, how things join together, can we take this thing to that thing and what happens when you do.*" [P1]

"*When you're being playful in a system, that's when things are at their best, that's when you're learning systems quite well. Like no-one opens Photoshop and starts playing around with the options really, but if you did you'd learn stuff really quickly.*" [P3]

To some extent opportunities for ‘play’ are more apparent with greater familiarity with the systems, and

there is potential for interactivity to be modelled effectively through onboarding. Indeed, this was a common suggestion during the workshops - that some process of on-boarding or a tutorial would be useful for novice Aquaria users.

The Onboarding concept as well as playfulness were both seen as very positive directions for future Aquaria development. While the design and implement of an effective onboarding strategy is not expected to be straightforward, its value was clear to the Aquaria team.

Multiple Perspectives

Participants discussed the value in multiplayer games of being able to see things for differing perspectives. This idea was connected with the ability, in complex production tools, to have multiple views of 3D models. The similarities drawn between Aquaria and these systems by the participants in the workshop led to the insight that this kind of highly customisable interface with optional multiple perspectives on the same system could be beneficial. One suggestion was the ability to open multiple views with different matching structures in each, allowing for easier comparison. The Aquaria team agreed that adding a multiple views feature would benefit a small but not insignificant fraction of users.

"*You can have multiple visualizations at the same time, like within the same scene.. Like you can have multiple perspectives.*" [P5] ..."*Maybe separate windows for viewing things*." [P6]

Future Work

This paper considered themes emerging from our initial analysis of the workshop data. These themes will shortly be analysed in more depth along with other themes excluded here due to space constraints. Just prior to submission we conducted a larger, combined workshop involving these workshop participants and experts in bioinformatics. While these data have yet to be analyzed, additional, complementary insights were generated and our future work will integrate these strands in greater detail.

Conclusions

Our participants' knowledge of video game environments has allowed numerous useful insights relating to Aquaria: more intuitive approaches to orientation and movement, the inclusion of social features to support collaboration, support for a sense of playfulness and provenance, and the possibility of multiple perspectives on the protein structure being observed. The vast majority of these ideas have been confirmed as useful for the further development of Aquaria by the tool developers, and we suggest that many of these insights are of value to developers of other complex visualization tools. Finally, our work provides initial empirical support for the utility of videogame expertise in the consideration of non-game interface and interaction design and similarly, the appropriateness of small iterative workshops as a methodology in this situation.

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