RELATIONSHIPS IN SOCIAL NETWORKS REVEALED: A FACEBOOK APP FOR SOCIAL GRAPHS IN 3D BASED ON X3DOM AND WEBGL

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ABSTRACT

From the perspective of individual users, social networking platforms (SNPs) are meant to reflect their social relationships. SNPs should provide feedback allowing users to exploit the information they have entered. In reality, however, most SNPs actually hide the rich social network constructed by the users in their databases behind simple user interfaces. These interfaces reduce the complexity of a user's social network to a text-based list in HTML. This article presents results from a user study showing that 3D visualizations of social graphs can be utilized more effectively – and moreover – are preferred by users compared to traditional text-based interfaces. Subsequently, the article addresses the problem of deployment of rich interfaces. A social graph application for Facebook is presented, demonstrating how WebGL and HTML5/X3D can be used to implement rich social applications based on upcoming web standards.

KEYWORDS

3D Graph Visualization, Interaction, JavaScript, Social Networks, WebGL, X3D/X3DOM.

1. INTRODUCTION

Online social networking platforms (SNPs) are, as of 2010, very popular. Millions of users have entered their profiles and, at least, defined their relationships, if nothing else. This sensitive information is collected in large databases and it is in principle easy to digest by data mining. There exists a cornucopia of scientific tools to analyze and visualize social networking data (see Related Work) on a large scale. However, besides the ongoing highly relevant discussion about the potential misuse of this data by third parties, e.g. regarding privacy issues in the large, one aspect has, to our knowledge, been neglected by most platforms: individual users are not empowered to get a comprehensive overview of their social network in the small scale. Thus, the data entered by the users is only partially reflected back to them. Most social networking platforms simply lack presentations beyond serialized lists of first grade relationships. While this approach is suitable for finding special known entities in one’s social network, it does not provide a straight answer to questions like, e.g., which of one's friends are also friends or what common interests they share, and it makes it difficult to discover something new in the structure of the network.

From the different alternatives regarding the selection of features to present to users and the way they are presented, this paper argues to use graph-based representations for the basic relations expressed in the network. Research on social network analysis and graph-based systems in general has developed a rich set of tools and visualizations which could be used to fill this gap. Visualizing social networks as a graph emphasizes the structure of the data and allows for an intuitive exploration.

Graph-based visualizations for social networks can be dated back to the early 20th century. But why, to the knowledge of the authors, does not any of the current social networking platforms use graph-based visualizations? In this article, we investigate three possible reasons: (a) the tasks a typical user performs on such a platform do not require these visualizations; (b) graphs and especially 3D graphics are too difficult or abstract to be understood and handled by the common user; or (c) the required technology is difficult to deploy, e.g. it requires proprietary browser extensions, such as Flash or Silverlight. In fact, several

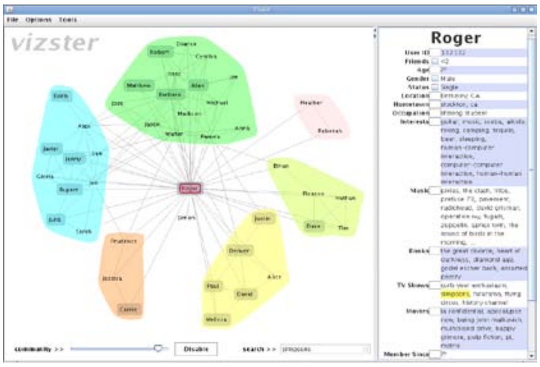

Figure 1: The standalone application Vizster allows end-users to interactively explore social networks in 2D.

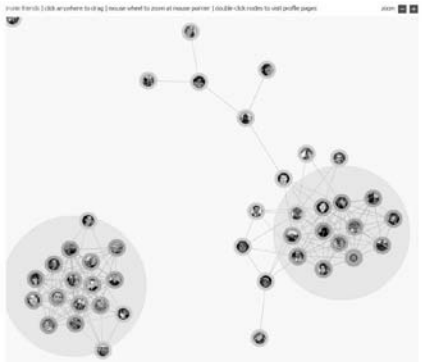

Figure 2: The Facebook app SocialGraph highlights clusters of friends in 2D as a single feature.

implementations of social graph visualizations exist as apps or social widgets based on Flash. The use of Flash, however, restricts the use of such visualizations primarily to the desktop, as support for Flash is not common on mobile devices (see e.g. the discussion Apple vs. Adobe in 2010 (Copeland 2010)). Mobile devices on the other side are at the heart-beat of any SNP, as at the time being the networks live primarily from their immediacy.

We address (a) and (b) by presenting results of a small user study, where we tested a basic user interface using a 3D social graph, showing that users prefer the graph version over the list-based HTML interface in certain tasks. Users are also generally faster when using the graph. Motivated by these results, we focus on the development of an interactive 3D social graph for Facebook, in which we put forward the idea of using emerging technologies, such as WebGL defined by the Khronos Group (Khronos 2009) and X3DOM, a DOM-based integration model for HTML5/X3D (Fraunhofer IGD 2010b). These technologies will be part of tomorrow's browsers and do not require proprietary extensions.

2. RELATED WORK

The visualization of social network data as graphs has a long tradition in the field of social network studies in social sciences. Freeman (Freeman 2000) reviews the evolution of techniques for visualizing social network data as graphs, starting as early as the beginning of the 20th century. Shape, color, position and the size of nodes can be identified as the main features for presenting distinct views on the data. However, the presentation of still images of a network is not always suitable if one has to extract meaningful data out of a network, especially with today's social networks being very complex with a lot of different attributes connecting the individual nodes. Perer and Shneiderman (2006) stress the importance of adequate mechanisms for interactive exploration of social network data. They present a rank-by-feature framework that enables network analysts to systematically detect certain patterns in the structure of a network. In (Perer & Shneiderman 2009) they present their findings of several case studies evaluating their SocialAction framework. SocialAction provides a combination of visualizations and a toolkit for social network analysis mainly designed for researchers. They conclude that researchers can benefit from tools that integrate visualization and tools for exploration of networks.

While tools for scientific usage are common and researchers are provided with powerful tools for network analysis there is still a lack of sufficient tools for end-users of social networks to gain a deeper insight in the structures underlying the data they are providing to the social network. Heer and Boyd try to address this problem with their Vizster tool (Heer & Boyd 2005) (Fig.1). Vizster combines the visualization of the social network with tools for exploration designed for end-users. They evaluated Vizster in two settings concluding that the possibility of the interactive exploration encourages users to playfully examine their networks in more detail.

In (Spritzer & Freitas 2008), a physics-based method of interactively manipulating networks is presented. A magnet metaphor is used in the MagnetViz tool to provide users with means to cluster nodes based on certain attributes. In (Bluhm et al. 2009) we presented a similar tool for the interactive exploration of Last.fm in 3D, both on the desktop and in an immersive Virtual Reality installation.

A disadvantage of the presented tools is that they are standalone applications which are not integrated into the SNP. One of the rare examples of tools that embed into SNPs is SocialGraph (Phillips et al. 2010), a Flash application on Facebook, which uses a force-based layout to arrange personal friends in a 2D plane (Fig. 2). The single special feature of SocialGraph is the identification of clusters of friends, which are highlighted by circles. Thus SocialGraph provides a unique benefit over the web interface, as it allows the users to clearly identify the social groups they are a part of. Interaction is nevertheless restricted to moving around nodes.

Until now there were only limited possibilities for the use of 3D graphics in browsers which might be a reason for the lack of 3D visualizations of social networks in the world wide web. In (Behr et al. 2009) an open source framework is presented that builds on top of WebGL, therefore no additional plugins are needed in recent browsers as is still the case with Flash or Java among others. In contrast to WebGLU (DeLillo 2009), X3DOM is capable of directly integrating declarative X3D scenes into the HTML5 DOM tree, enabling the use of advanced JavaScript technologies, such as Ajax or JQuery, to interact with the 3D content. For a more detailed discussion of WebGL frameworks refer to (Behr et al. 2010).

3. GRAPH-BASED USER INTERFACES FOR SOCIAL NETWORKS

When advocating the use of 3D graph interfaces for SNPs, at least two issues are crucial: (a) the interface should actually help the user, or at least be more fun to use, and (b) the interface should be easy to use. Both issues are addressed by recapitulating the results of a user study done for an interactive graph-based 3D desktop-browser called SONAR for the SNP Last.fm (Bluhm et al. 2009). The original paper is published in German; hence we give a conclusive summary.

3.1. Evaluation of a 3D Social Graph as a User Interface

Previously, we presented SONAR, *Social Networks in Virtual Reality*, an interactive 3D graph visualization of the enriched social network defined by Last.fm (Bluhm et al. 2009). SONAR is targeted at desktops and immersive Virtual Reality installations. Its implementation is based on X3D and the additional functionality for immersive set-ups provided by the instantreality framework (Fraunhofer IGD 2010a). The tool allows the user to literally immerse into the social network and interactively explore the relationships between users, their favorite music and artists, or similar artists. This allows users to get a deeper understanding of their relationships and to identify patterns, which in the case of the music network Last.fm might lead to the discovering of new interesting artists. We used this application as tested to see, whether a 3D interface for social graphs can be understood by novice users and if such an interface can provide advantages over the text-based web interface.

In a user study, 16 participants between 20 and 30 years, students at Bielefeld University and active users of SNPs, were asked to perform several typical tasks, such as exploration or search, using the native web-based frontend of Last.fm and SONAR (Bluhm et al. 2009). Both applications were tested on the desktop. Typical tasks were like (1) "Is A a friend of B?", targeting at direct relationships that are typically presented on a single page, (2) "User A likes song B, find a similar song.", which requires the user to do a straight exploration into the depth of the network (that is, following up to two page transitions on the web frontend), or (3) "Find three mutual friends of users A and B.", requiring the users to follow at least two relations in parallel. The tasks were designed to be of increasing complexity regarding the overview of the structure of the local network excerpt required to solve the tasks. It was expected that tasks of category (1) were in favor of the text-based interface whereas tasks of category (3) were clearly in favor of the graph-based interface.

It turned out, that in all types of tasks users were more efficient in terms of time-on-task using the 3D graph visualization of SONAR than with the web-based frontend (Fig. 3). In addition to performance measures, the users were also asked which tool they preferred for each group of tasks. For tasks like (1), 69% preferred the web-based frontend over SONAR, but for (2) 75% preferred SONAR and for tasks like (3) all participants preferred SONAR (Fig. 4). When asked directly, 83% of the users also believed that they performed overall faster using SONAR.

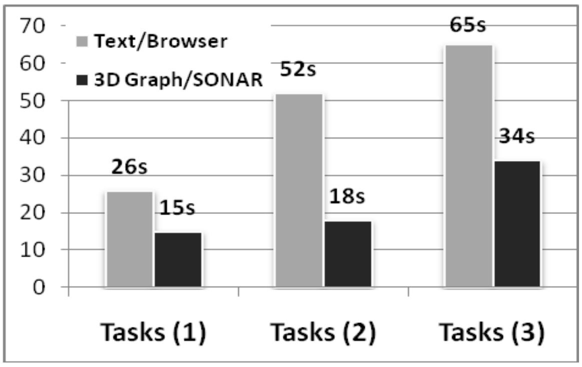

Figure 3: Time-on-task for the different task groups. All tasks were processed faster using the 3D graph.

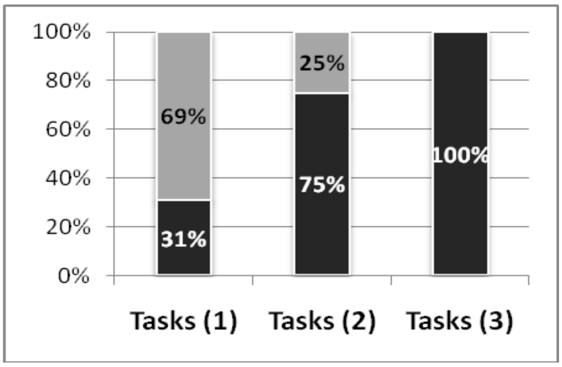

Figure 4: Preferences for the text-based browser (grey) or the 3D graph (black). Users preferred the browser over SONAR only for the standard tasks (1).

The participants of the study were novices to 3D social graphs. Hence, the results for the 3D graph visualization in the study suggest that the 3D graph visualization can easily be understood and be used purposefully, thus addressing issue (b). The fact that the 3D graph visualization is also preferred over the web-based presentation for tasks were the structure of the social network is highly relevant also suggests that, (a), such a visualization is suited for typical tasks which are expected to be performed on a SNP.

3.2 Overt and Covert Structures of Facebook's Social Graph

Friendship is the constructing relationship of the popular Facebook social network. Users create and manage individual profiles on Facebook. They can express their relationship to other users by linking their profiles, which is a reliable declaration as both participants have to agree upon the relation. This friendship-relation is rather static, once accepted it would not change until the relation is revoked. Note also, that the friendship relation not necessarily coincides with a friendship in the real world. It could also express family relations, relations between co-workers or business contacts, among others. However, they are at least two sources of information made available by Facebook which are more conclusive about the relationships: **communication events** and evidences of **real-life encounters**.

Besides the structure-giving friendship-relation, Facebook supports **communication events** which can be interpreted as relations. For example, users can directly exchange messages or they can upload images (authorship-relation), identify and tag other users on photos or comment images. Comments are a universal tool provided by Facebook, nearly everything can be commented by other users, be it messages, entries on the pinboard, photos, events or comments themselves. As the friendship-relation offers only a weak qualification of the link between users, the number and kind of social interactions which can be observed on Facebook, might provide a more thorough picture of the actual relationship between individuals and groups. The mining of the real social network from these interactions is currently a hot research topic.

All of these communication events happen in the virtual environment constructed by the social networking platform. The users not necessarily have met in real life. Another service offered by Facebook provides also an index for **real-life encounters**: users can upload photos and identify other users who are depicted on a photo by tagging them. The presence of two users on one or more photos constructs a relation *have-met-in-real-life*, weighted by the number of occurrences. This relation, however, has to be considered with care. If there is no photo showing a specific pair of users, this does tell nothing about the *have-met-in-real-life* relation. A second way to identify whether two users have met in real-life is to consider the event-management pages provided by Facebook. Events, such as parties, can have individual pages on Facebook which can be used, e.g. for organizational purposes. Among other things, users can be invited to events and they can state whether they have participated at the event or not.

However, as stated earlier, there is a lack of convenient tools for users to explore and make use of these overt and covert information to their full extend.

4. A 3D SOCIAL GRAPH APP FOR FACEBOOK

In the following, issue (c) of deploying rich 3D visualizations on the web is addressed. WebGL and X3DOM are recent technologies which promise a smooth integration between interactive 3D content, the HTML-DOM and JavaScript. This is demonstrated by highlighting the interaction between HTML/X3D, JavaScript and the Facebook server on selected features of a Facebook App for 3D social graphs (Mattar & Pfeiffer 2010).

4.1 Communication Flow

Facebook does not host third-party applications on their servers. Therefore an additional server is needed for applications. This makes it necessary to authenticate the user with an API provided by Facebook. Once this has been done and the user is properly authenticated, the user agent requests an application from within Facebook, Facebook responds with its so called Facebook chrome (Facebook's user interface) and an embedded iframe for the application. The application is delivered by the application host and rendered into the iframe by the user agent. Subsequent JavaScript API requests are conducted by the user agent and handled by the Facebook server. Figure 5 shows the communication flow between the user agent and the servers in detail.

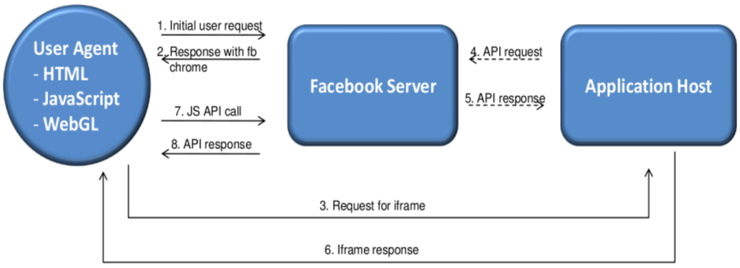

Figure 5: Communication between the User Agent (Browser), the application host and the Facebook server.

4.2 Integrating HTML5 and X3D: X3DOM

The visualization is realized based on X3D (Web3D 2008) using the HTML-Profile (Behr et al. 2009). For the embedding of the 3D scene which holds the interactive social graph, the X3DOM integration model (Behr et al. 2010) is used. Fraunhofer IGD provides a reference implementation based on JavaScript (Fraunhofer IGD 2010b) under the MIT/GPL dual license. The project is hosted on sourceforge.net for everyone to contribute. Using X3DOM, the 3D scene can be declared directly in the HTML-DOM tree (Fig. 7).

4.3 Constructing a Live Graph

The visualization of the social graph is constructed in real-time and asynchronous by retrieving and analyzing relevant data from the Facebook servers. This is all done in JavaScript (Fig. 6). If, for example, a new friend is detected, the according visualization (Fig. 7) is constructed by directly manipulating the embedded DOM tree (Fig. 7).

The X3DOM implementation monitors the DOM for changes and mirrors them in the scenegraph which is internally constructed and hidden behind the high-level X3D API. This way, X3DOM can optimize the declarative specification of the scenegraph given by the programmer and create a scenegraph which is optimized for performance, tailored to the WebGL implementation or, if available, a special purpose X3D plugin.

```
function addUserCB(user_infos) {
    var user42 = document.createElement("Transform");
    var user42_shape = document.createElement("Shape");
    var user42_box = document.createElement("Box");
    ...;
    user42.appendChild(user42_shape);
    document.getElementById("users").appendChild(user42);
}

FB.Facebook.apiClient.users_getInfo(uid, infos_req, addUserCB);
```

Figure 6: JavaScript-Code for creating a new friend node.

```
<html>
 <body>
  <x3d>
   <scene>
    <Group id="users">
     <Transform DEF="user42">
      <Shape>
       <Box size="2 2 1"> </Box>
       ...
      </Shape>
     </Transform>
    </Group>
   </scene>
  </x3d>
 </body>
</html>
```

Figure 7: Snippet of DOM tree with embedded X3D and its WebGL visualization on the bottom right.

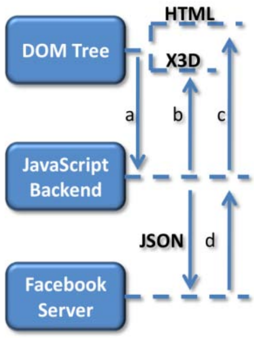

Figure 8: Interaction between HTML, X3D, JavaScript backend and the Facebook Server.

4.4 Interaction

As a starting point, the social graph application reveals the relationship between the user and the first-grade relationships, the friends that have been registered by the user. From that point on, users can interactively explore their social network. In the following, we present selected examples. On the one hand, these examples are selected to demonstrate useful applications of social graphs. On the other hand, each example also demonstrates a technical aspect of the integration of HTML5 and X3D. One such aspect has already been presented above, with the on-the-fly modification of the declarative X3D scenegraph based on asynchronous requests to the Facebook database. The flow of control and modification is hinted at in the title of each example.

4.4.1 Search (HTML → X3D)

To allow quick access to a specific friend in the social graph a search box is presented to the user. JavaScript is used to query the friend list (Fig. 8 path a), retrieved from Facebook (Fig. 8 path d), and the user is assisted with an auto-suggestion feature while he types. Additional visual feedback is provided to the user by highlighting nodes with an id partly matching the search string (Fig. 9). A JQuery statement is used to trigger the highlighting of the nodes:

```
$("Transform[id^='"+search_string+"']").each(function() {highlight($(this)[0], true)});
```

On a successful search request the X3D-part of the DOM tree is altered from within the JavaScript backend (Fig. 8 path b): the viewpoint of the 3D scene is panned in order to bring the requested user into focus.

In this case an additional UI element was added to the web page (Fig. 9). The integration of this feature into an existing search field is possible, due to the fact that the HTML and X3D part of the DOM tree can interact. This enables one to make use of existing HTML-/CSS-based UI frameworks and therefore allows a seamless integration of 2D and 3D UI elements into the look-and-feel of a web page.

4.4.2 Who's on which picture (X3D ↔ HTML)

In Facebook users can upload pictures and tag themselves and friends on the pictures. However, Facebook does not offer a convenient method to gain an overview of how tagged friends relate to each other in one's network. In our application the user can click on a node in the 3D graph (Fig. 8 path a) and a context menu is displayed in 3D (Fig. 8 path b) and in HTML (Fig. 8 path c). One of the menu items enables the user to view tagged pictures for the selected node. By using Facebook's API the tagged pictures of the associated person and all of the assigned tags are retrieved (Fig. 8 path d). The pictures are then presented in a small gallery using the standard HTML *img*-tag (Fig. 9). As the user hovers over a picture, all friends tagged in the picture are highlighted in the graph. For this purpose a JavaScript callback is assigned to the *mouseover*-event of the *img*-elements.

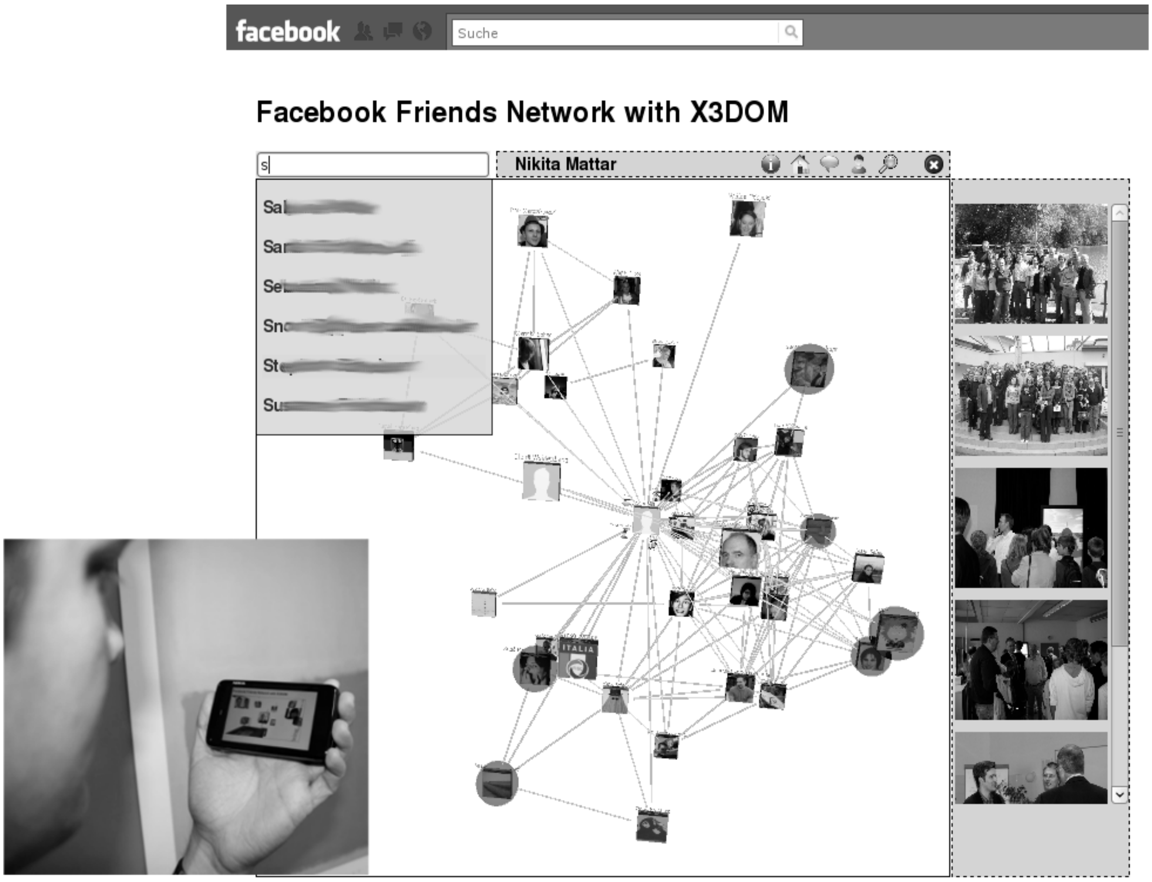

Figure 9: Left: Viewing the App on a mobile WebGL-enabled device (Nokia N900). Right: The 3D social graph is augmented by a div-overlay with search suggestions stacked on top. Corresponding nodes are highlighted with a sphere in the graph. Image gallery with tagged pictures for a user is shown on the right.

As it might be interesting to see if certain friends are tagged together on pictures, the user is furthermore able to filter shown pictures by selecting multiple friends in the 3D graph. Only pictures are shown where all of the selected nodes are tagged on.

4.4.3 Layouting (X3D)

The layouting of the graph is done using a simple force-based layouting algorithm. The layout algorithm is time consuming and thus the recently developed WebWorker threads are used to run the algorithm in the background whenever the UA offers this functionality. The background thread, however, does not have direct access to the DOM tree and is thus also not able to read or update the current positions of the nodes in the graph. The relevant information has to be exchanged via messages between the main thread with DOM access and the background thread doing the layout. This ensures at the same time a synchronous update of the 3D scenegraph.

5. CONCLUSION

SNPs, like Facebook, have a rich structure which in most cases is not apparent to the user (see 3.2). Presenting such information in a conclusive way which allows for an exploration of the rich structure of the social network (including overt and covert information) would make SNPs more transparent to the user. This would, on the one hand, enable the users to use the SNP more efficiently and, at the same time, provide a clear feedback regarding the private details disclosed by communicating over the platform. An open question is how the underlying data of SNs can be prepared and presented to provide valuable information to the end-user. In 3.1 we presented results of a small user study showing that even the mere presentation of direct connections in a 3D graph offers an advantage over list-based interfaces.

While the small number of participants in the presented study is sufficient for this kind of usability tests, it does not allow us to draw further conclusions about the advantages of an interactive graph-based visualization. On Facebook, however, a large user-base is available without the restriction to a certain group of participants (undergraduates) as it was the case in our study. Thus, the SNP allows for an extensive evaluation of different aspects (e.g. A-B tests) of applications like the one presented on a large scale.

Successful 3D apps based on WebGL which are distributed on SNPs such as Facebook, could be an important driving force to foster the adoption of 3D technology on the web. The use of web technology furthermore promises to bridge the gap between applications on desktop computers and mobile devices, as technologies like WebGL are ported to mobile devices as well (Fig. 9) and no proprietary plugins are needed.

In this article, we have presented an application using the HTML5/X3D integration model X3DOM and provided examples for different techniques to create interactive graphics that are supported by X3DOM. Overall, the team of WebGL and X3DOM makes creating interactive 3D applications feel quite WWW-ish, an argument which could make this Web3D technology appealing to a broad range of new users.

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