2012 16th International Conference on Information Visualisation

ArchiBrain: A Conceptual Platform for the Visualization of Collaborative Design

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***Abstract*— The network effects of the digital age have made it easier for individuals to collaborate with others to produce meaningful content from the bottom up. Architectural and urban design could benefit from these new forms of distributed collaboration, since they have the potential to introduce a wealth of knowledge and creativity in the design process. In this paper, we present a prototype online platform called 'ArchiBrain' that is built around a 'project-tree' visualization of individual design contributions, which provides participants with a structured overview of the design process they are collaborating in. Our evaluation study provides the first indications that this visualization platform is able to increase the intrinsic motivation for designers to contribute in a collaborative manner, provides a clear overview over the design process, and can help directing collaborative efforts by highlighting the most popular design proposals.**

Keywords- social production; collaborative design; visualization; co-design; participative design; feedback

I. Introduction

The network effects of the digital age have made the sharing and producing of information, knowledge and culture more efficient and effective. Recent phenomena such as social media, blogging, crowdsourcing and the open source movement have shown that it is now easier than ever for individuals to connect and collaborate with others to produce meaningful content from the bottom up. These new modes of 'social production' typically occur between loosely connected and geographically distributed individuals, who tend to cooperate with each other without relying on either market signals or managerial commands [1].

Contemporary architectural and urban design problems are often confronted with complex, cross-disciplinary challenges that can only be tackled by a creative team possessing a variety of backgrounds and experiences. Therefore, design problems could benefit enormously from these new open forms of distributed collaboration and participation, since they have the potential to introduce a cross-disciplinary wealth of knowledge and creativity to the design process. For instance, Maher et al. state that *"collective design is possible because we can easily communicate and share ideas, digital models and files on the Internet"* [2]. Indeed, during the last two decades, the architectural design and planning process have become radically digitalized, making it easier for architects and designers to share Computer Aided Architectural Design (CAAD) files and project images through various file-sharing services and social networks. However, to organize a creative collaboration between geographically distributed designers over the web, one needs to take into account specific issues inherent to the process of designing:

- Chunking design problems in separately problems is not always possible. The solvable aspects of a design problem are often ill-defined and tend to co-depend on each other. Though designers may focus on individual or detailed aspects of a larger design problem, the according decisions should always be consistent with the overarching concept of the design solution. Therefore, contributors require some sort of overview of the design process to become aware of where their contributions fit in with the 'big picture'.
- Most design problems are wicked and ill-behaved [3]: they tend to generate more than one solution, as designing the 'right' answer is influenced by the individual experiences and subjective opinions of the designer(s). Therefore, collaborative design should leverage these inherent differences by encouraging a constructive discussion between participants.

We hypothesize that some of the issues of web-based, participative design can be overcome by visualizing the collaborative design process in real-time. We thus present ArchiBrain: a prototype online platform built around a 'project-tree', a time-based visualization of the design contributions that offers a structured overview of the actual state of the collaborative process. We evaluated its efficacy by studying its impact on three distinct levels:

- *Impact on motivation.* To what extent does online the platform provide incentives for designers to contribute to an overall design solution?
- *Impact on awareness.* How effective is the platform at providing participating designers with a clear overview over the design process?
- *Impact on social dynamics.* To what extent do social media features like voting and ranking enhance the creative interaction between designers?

The results of this study could be particularly useful for current and future web platforms that aim to facilitate creative and open design collaborations between geographically distributed individuals – ranging from

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DOI 10.1109/IV.2012.72

designers to any stakeholder such as actual inhabitants or policy makers – by providing insights into the efficacy of visualizing a collaborative design process to all participants during the design itself.

II. Background

The original definition of social visualization describes the enriching of social, electronic communication by making its rich and salient qualities visible in easily accessible and understandable ways [4]. Current development in social visualization aims to democratize the representation of information by: 1) opening up advanced data acquisition and visualization methods to lay audiences, and 2) integrating powerful social communication features within or alongside the visualizations. Accordingly, social visualization offers non-expert people the chance to increase their understanding of complex information by the power of collective and collaborative efforts [5]. Several projects from different disciplines have demonstrated how social visualization can positively impact collaboration and participation. In the field of open source software development, CodeSaw [6] showed how the visualization of code repositories and project communication can influence contributor motivation by providing insight into the patterns of collaboration within an open software community. DiMicco et al. [7] studied the effect of a shared display showing user contributions on group participation during collaborative tasks. The Netscan visualization [8] indicates how visualization can be used to provide a clear overview of the structure of online threaded conversations and patterns of participation within these conversations to reveal hidden structures and emergent social dynamics.

Several online platforms that focus on facilitating collaborative design have been developed in recent years, such as OpenArchitectureNetwork.org [9] and OpenIdeo.com [10]. Both aim to create web-based collaborative design communities, but have not yet explored the potential of visualization as the means of organizing and encouraging design collaboration. Research in CAAD has also focused on how computer applications and tools can positively stimulate, cause or assist collaborative design [11]. For instance, Phase[X] [12] was an online collaborative design studio which encouraged students to collaborate by elaborating on each other's designs in a series of sequential, evolutionary design phases. The use of visualization in this field has often focused on analyzing the data related to the design process after its completion [13, 14], rather than to actually support or organize it. At least one exception is the Studio-WikiTecture [15] project, which used a tree-shaped diagram of submitted design proposals to represent a collaborative, architectural design process within the virtual world platform 'Second Life'. While this project became an important inspiration for our own platform, it does however contain some restrictions that are inherent to operating within the medium of a proprietary 3D virtual world, such as the difficulty of integrating commonly used design file formats, and a significant learning curve towards participation.

III. Development of ArchiBrain

ArchiBrain was implemented as a prototype, yet fully working, website. Through the knowledge gathered via several pilot tests, this platform was refined in an iterative way.

A. *Concept Definition*

ArchiBrain aims to enable anyone to propose a design project, and to allow others to collaborate on finding appropriate design solutions in a distributed and asynchronous manner. The main elements of the platform are:

- The *project-tree* provides users with an organized overview of all preliminary proposals (represented in the tree as circular thumbnails) that have been submitted, and acts as the main navigational interface of the design project. The tree also visualizes the feedback from the community on each proposal, such as the number of comments and an average approval rating. A project-tree is created by defining an assignment description (the left-most sphere in the project-tree). Participating designers can then submit a number of design proposals on which the design community can then build alternative proposals. (Figure 1)
- A *proposal* is a short blog post written by a participant to describe a submitted design proposal. Such a post can contain images of a design proposal, some explanatory text, and the digital design file(s). These files provide other participants with the opportunity to create successive proposals by building upon the design files of previous ones. Each proposal can be rated by other participants, who can also leave comments to discuss what they like or dislike about the proposal.

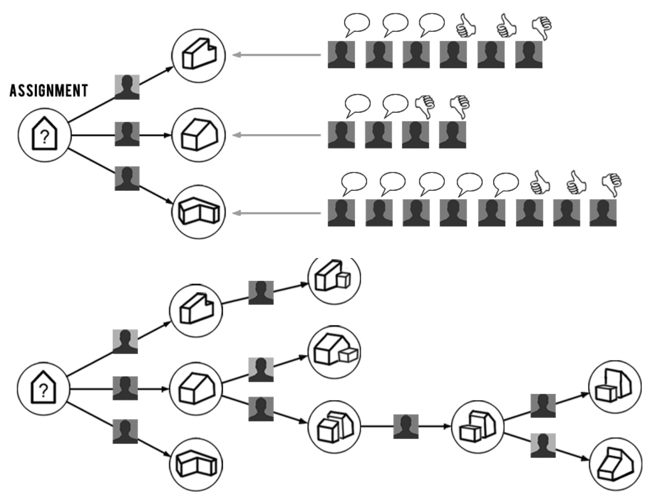

Figure 1. Every project-tree starts with an assignment. Contributors make a first set of design proposals on which the design community can give feedback via comments and ratings. (top) Contributors can edit each other's proposals (tree grows from left to right). The resulting project-tree is a diagram that shows how the collective design evolves over time. (bottom)

We propose that the ArchiBrain concept provides a collaborative platform for exploring multiple alternative design ideas to a given problem. The project-tree visualization is meant to help designers keep an overview over the proposals that have been made so far, the structural relations between them, and the feedback that they received so far. This overview could be used to better evaluate which proposals are relevant to work on or not, which is particularly useful when a multitude of alternative proposals compete against each other simultaneously.

B. *Prototype Development*

Our prototype platform was implemented and offered under the domain *www.archibrain.org*. The platform was built with the Drupal 6 Content Management System [16] following current best practices as elaborated in 'Using Drupal' [17]. Each proposal is formatted on a separate bookmarkable webpage, here called the *proposal page.* The project-tree visualization was developed with Processing [18], and was embedded at the top of each proposal page as an interactive Java-applet. This applet parses the necessary data needed to draw the tree from a set of XML-lists, which summarize all submitted proposals and comments, votes, and thumbnail-images related to these proposals. Figure 2 shows the final version of the proposal page as it was used during the evaluation study. It contains the following elements:

- *Project-tree visualization (top).* The visualization acts as the main navigation tool to browse through the different proposals (represented as circles) and their comments (smaller bubbles located around the circles). Hovering over a specific circle displays additional information on the according proposal. Selecting it enlarges the thumbnail, while double-clicking take the user to the specific proposal page. Users can select certain 'parameters' to reveal extra layers of information: one can highlight the most recent comments, filter the proposals and comments by author, or correlate the surface area of the spheres with the average rating of that proposal.
- *Proposal (middle)*. This area consists of a title, a set of images and the textual description. The sidebar contains the like/dislike rating system, project meta-data (e.g. author, postdate) and the attached design files. At the top right, there is a 'create child proposal' button, which invites the reader to create a new proposal that builds upon the ideas of the shown proposal.
- *Comments section (bottom).* This section shows the feedback by the design community on the proposal. Comments can include images and files to support a more visual style of feedback other than just text.

C. *Design Rationale*

The prototype website underwent several iterations during development based on the results from two separate

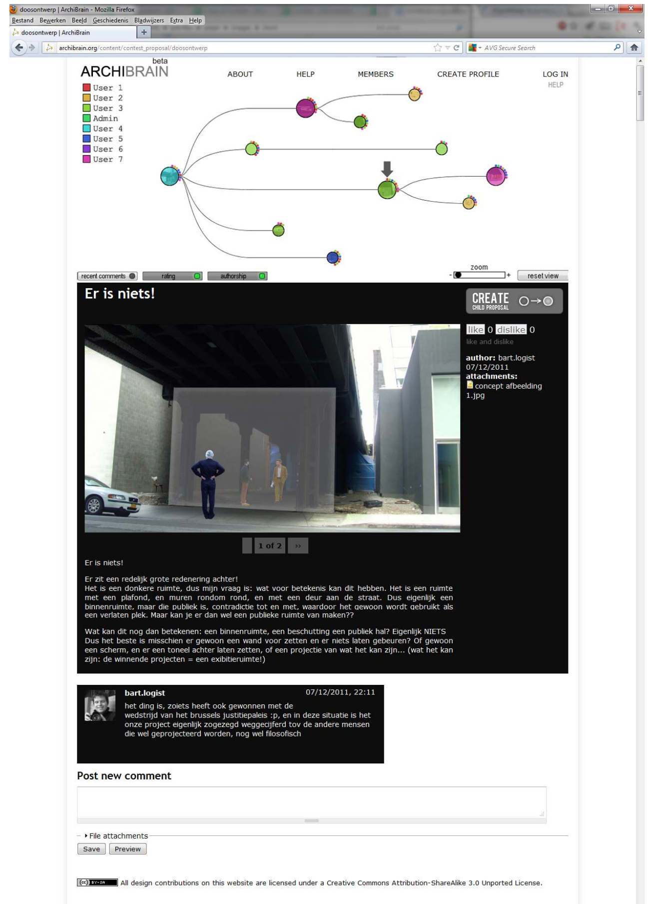

Figure 2. An example proposal page with the project-tree visualization at the top, the proposal information in the middle and the comment section at the bottom. The arrow indicates the proposal that is currently being viewed.

pilot evaluation tests. Figure 3 shows the state of the project-tree as used during the first pilot-test, Figure 4 during the second pilot test. The following list reveals the most important design decisions made during development.

- *Drawing the tree.* We noticed that the relations between proposals and the order by which proposals are submitted influence the overall readability of the tree. Therefore, our drawing algorithm draws proposals in chronological order from left to right.
- *Referencing other proposals.* We introduced the concept of 'references', which are represented in the project-tree as grey arrows. References allow designers to relate to up to three additional proposals, to indicate that the according ideas have been incorporated into their new proposal. References are visible when hovering over a proposal, as shown in Figure 4.

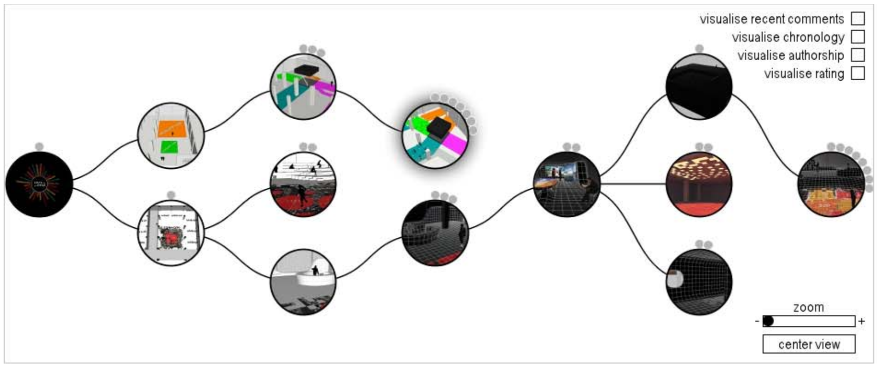

Figure 3. The first version of the project-tree used during the first pilot-test. Proposal are represented by interconnected spherical thumbnails with comment 'bubbles' around them.'

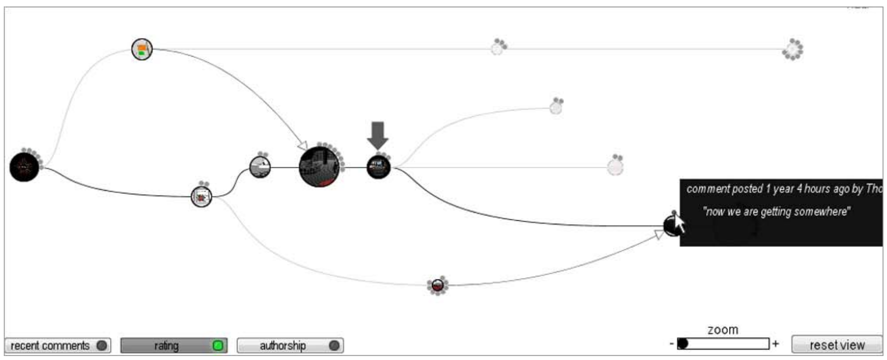

Figure 4. The version of the project-tree as used during the second pilot test. Several new elements were introduced since the first version, such as the ability to reference more than one proposal, an updated drawing algorithm that places proposals in chronological order, and an arrow that indicates which proposal is being viewed.

- *Proposal 'family history' clarity.* When hovering over a proposal, all the references and proposals that came before it are revealed, highlighting all historical steps that influenced that proposal.
- *Rating and visualizing popularity.* The initial five-star rating system proved inefficient at identifying popular proposals, since most proposals received an unrepresentative amount of votes and the average value tended to hover in the middle (i.e. 2.5). Our second pilot test indicated that popularity was best indicated by the number of comments a proposal received as well as the number of 'child proposals' that came from it. The final version of our platform swapped the five-star rating for a binary like/dislike rating system in order to encourage more decisive voting. To factor in how the number of comments and children could be better highlighted, a ranking algorithm was added which placed branches with many offspring, recent comments and references at the top of the screen.

IV. Evaluation Study

A. Pilot Studies

As mentioned before, the development phase was influenced by two pilot studies that were conducted prior to the main evaluation study. The pilot tests served as a means to root out possible technical problems as well as to identify unknown issues with our evaluation study methodology. For instance, the second pilot test was conducted with a group of architecture students who were asked to use the platform to collaborate on a design assignment over the course of three consecutive design sessions. Due to some technical difficulties during the last design session and various issues with controlling the laboratory environment, the results of this experiment were not fully representative and a separate study was required.

B. Main Evaluation Study Methodology

We conducted the main evaluation study with seven students and young professionals in the field of architecture and urbanism. Five were recent graduates and two were still students of a master-level architectural degree. Although this cohort was relatively small, the participants constituted a realistic user group, as everyone took part on a voluntary basis and took the initiative to use the platform for a real-life design competition scenario.

All participants had already used our website during the second pilot study and were therefore already familiar with all its functionalities. All participants were asked to fill in a background survey, to provide us with an idea of their familiarity with social media and their experience on sharing information or collaborating via the web. During a period of two and a half weeks, participants were asked to try to exchange design files and design ideas via the ArchiBrain platform. Five participants used the platform during this period to brainstorm design ideas for a real design competition during which they had to design an exhibition pavilion in New York [19]. All participants used the platform from their own homes and during their own spare time. Participants did not receive any reward for their participation. The evaluation period was divided into three consecutive design sessions, at the end of which the participants were asked to fill in an intermediate survey, which was used to track any changes in the motivation and perception of the design process. During the last session, two additional participants were invited to provide additional commentary and feedback on the design proposals that were being made. After the evaluation period, all participants were asked to fill in a final survey, which focused on the user experience of collaborating using the platform. In addition to the survey data, all interactions on the website were logged.

V. Results and Discussion

Over the course of the study, 10 design proposals were submitted and 87 comments were exchanged, which were all represented in real-time in the project-tree, as shown in Figure 2.

A. Impact on User Motivation

We set out to understand how the visualization could help motivate participants to collaborate in the context of a joint design. The analysis was based on 8 categories of user motivation, as defined by Maher et al. [2]. The following categories of user motivation appeared to be *positively* influenced by our platform.

Ideology. When asked on a five point Likert scale whether they felt like their design contributions helped improve the overall design, a vast majority of participants responded positively (average = 4.6, standard deviation = 0.49). When asked if their comments helped improve the design, respondents also reacted positively (av=4.14, sd = 0.64). In both cases, a statistical T-test shows that the average differs significantly from the mean of 3 (with 90% certainty).

Reward. When asked if seeing their proposals visualized in the project-tree felt rewarding (Likert), all participants responded positively (av=4.4, sd=0.49). A vast majority felt the same about their comments being visualized in the tree (av=4.2, sd=0.75). A statistical T-test shows that both averages differ significantly from 3 (with 90% certainty).

Recognition. In each intermediate survey, we asked the participants if they appreciated the feedback they received on their comments and their design proposals (Likert). Participants consistently responded positively (sesion 1: av=4.0, sd=0.0; session 2: av=4.0, sd=0.0; session 3: av=4.5, sd=0.5). We also asked whether they appreciated the adaptations made out of their proposals. Only after the second design session did a majority of participants respond positively (av=3.75, sd=0.43). We can assume that this occured because no adaptations of previously submitted proposals were made during the first session and only a few were made during the last.

Duty. In an open question we asked participants for their personal motivation to contribute to the evaluation study:

"[Archibrain] offered a useful tool for us to collaborate, something you wouldn't have at your disposal otherwise. It also formed a good way of tracking the different design proposals that were made" - Participant 3

"I liked [designing on Archibrain] because of the challenge of the design, and because [we didn't need to be in the same place] to meet with everybody." - Participant 2

The following categories of user motivation appeared to be *negatively* influenced by our platform.

Fun. In the final survey we inquired if participants enjoyed working on the platform. Although most enjoyed the overview the project-tree provided to them, some participants pointed out that the asynchronous collaboration hindered an enjoyable workflow.

"It is nice to have the process in a visual synthesis, but the fact you had no real time discussion and had to wait long for new proposals made it frustrating and slow." - Participant 2

Social. All participants reported in the final survey that they enjoyed receiving feedback from other designers (Likert, av=4.4, sd=4.9). However, when asked in the intermediate surveys if they felt like being part of a team, the response was neutral (sesion 1: av=3, sd=1; session 2: av=3, sd=1; session 3: av=3.5, sd=1.12). A possible explanation for this result could be found in the asynchronous nature of the collaboration, which sometimes meant participants had to wait for creative feedback for longer periods of time.

The survey questions that polled user motivation based on the categories '**Career**' (participation that may lead to an advance in the individuals career) and '**Challenge**' (participation that provides a sense of personal achievement through acquiring additional knowledge or skill) did not gather notable or relevant results, mainly due to neutral responses to our survey questions.

B. Impact on Overview

We set out to understand to what extent our platform, and in particular the project-tree visualization, provided a useful representation of the collaborative design process. When asked in the final survey if they felt like they had a good overview of the different proposals that were made during the design process (Likert), a vast majority of participants responded positively (av=4, sd=1.07). A statistical T-test showed that this average differs significantly from 3 with 90% certainty). To check whether the project-tree helped them with this, participants were asked in an open question whether they felt the project tree was a correct representation of the design process. Most responded positively:

"Yes: you can see what projects are being worked on, you can see the timeline in it. Everything was clear." – Participant 3

"Yes, you can see which concepts were abandoned, and which ideas [were elaborated]" - Participant 1

One participant mentioned that the references to other proposals were sometimes unclear, since you could only view them for one proposal at a time once you scroll over it.

"…it is only a pity you only see the connection with one project unless you click on a proposal." – Participant 2

C. Impact on Social Dynamics

We aimed to understand how our platform and project-tree visualization helped designers give and interpret creative feedback. Participants mostly ignored the like/dislike system, as most felt this rating system was far too simplified to effectively evaluate a design project. Instead, most participants praised the use of comments for giving feedback:

"The effect of the votes hardly made a difference, but the comments were essential - even more important than the proposals. The proposals trigger the discussion, but the comments are needed to explore the concept and because there were many collaborators you always had different angles on one proposal." - Participant 2

One participant noted that he mainly looked at a proposal's offspring as an indication of its success:

"...didn't think about rating: if a proposal didn't have children it wasn't good, that's rating enough for me" - Participant 1

These comments tend to support one of our preliminary conclusions from our second pilot study that the popularity and relevance of a design proposal is primarily influenced by the number of comments and offspring it has received. We had taken this issue into account by implementing a ranking algorithm, which placed proposals with a high number of offspring, references and recent comments, higher up on the page (the upper branches of the tree). This effect was noted by most participants:

"I noticed that the most important discussions came on top of the tree. [By doing this], the tree filtered the important [designs] for me, so I could focus my attention only on the important designs." – Participant 3

VI. Conclusion

In this paper, we aimed to understand how the visualization of a distributed, asynchronous, and participative design process helps to organize collaboration in the context of design. We therefore presented ArchiBrain: an online prototype platform with a 'project-tree' visualization that provides designers with an overview over the design process and helps them evaluate feedback from other designers.

We conducted an evaluation study with a voluntary group of recent architecture graduates, who used the platform to collaborate on a joint submission for a design competition. The study indicated that our platform tends to increase the motivation for designers to contribute to a shared design process in several different ways. The visualization provides a useful overview over the collaborative design process, which allows the identification of promising design proposals. While certainly not replacing face-to-face contact, our results indicate that a common, shared visualization can support asynchronous distributed collaboration between designers. By facilitating these new forms of social visualization, a more widespread creative collaboration between designers can be encouraged.

Further work in this area will explore how different design phases could be better organized and represented within the project-tree to allow for a more structured design process, and how a better notification system for new content could streamline the collaboration experience and help designers keep track of the comments and adaptations made on their proposals. Furthermore, we want to look into how different project-trees can relate to one another to create a wider network of creative exchange within the ArchiBrain platform.

Acknowledgments

The authors would like to thank the participating designers who contributed their time in our pilot tests and evaluation study. After the study was over, they continued work on the competition submission (in collaboration with the author), and actually won an honorable mention in the design competition as a result.

References

[1] Y. Benkler, "The Wealth of Networks: How Social Production Transforms Markets and Freedom", Yale University Press, 2006, pp. 60.

[2] M. L. Maher, M. Paulini, P. Murty, "Scaling Up: From Individual Design to Collaborative Design to Collective Design", Proc. Design Computing and Cognition DCC'10, 2010, pp. 581-600.

[3] H. Rittel, "Some Principles for the Design of an Educational System for Design", DMG-DRS Journal, Vol. 7, April - June 1973, pp. 151-152.

[4] J. Donath, K. Karahalios, F. Viegas, "Visualizing Conversation", Annual Hawaii International Conference on System Sciences, 1999.

[5] M. Wattenberg, K. Jesse, M. Matt, "ManyEyes: a Site for Visualization at Internet Scale", IEEE Transactions on Visualization and Computer Graphics 13, 2007, pp. 1121-1128.

[6] E. Gilbert, K. Karrie; "Using Social Visualisation to Motivate Social Production", Transactions on Multimedia, Vol. 11, IEEE, April 2009, pp. 413-421.

[7] J. M. Dimicco, A. Pandfolio, W. Bender, "Influencing group participation with a Shared Display", Proc. CSCW '04 ACM conference on Computer supported cooperative work, ACM, 2004, pp. 614-623.

[8] M. A. Smith, A. Fiore, "Visualization Components for Persistent Conversations", Proc. SIGCHI conference on Human factors in computing systems, ACM, 2001, pp. 136-143.

[9] Open Ideo , Viewed May 01, 2012

url: http://www.openideo.com/
[10] Open Architecture Network, Viewed May 01, 2012 url: http://openarchitecturenetwork.org/
[11] H. Achten, J. Beetz, "What Happened to Collaborative Design?", Proc. 27th eCAADe conference, Istanbul, Turkey, 2009, pp. 357-366.
[12] U. Hirschberg, M. Engeli (editor), "Phase (X)", In: "Bits and Spaces: architecture and computing for physical, virtual, hybrid realms, 33 projects by architecture and CAAD, ETH Zurich", Bïrkhäuser Publishers for Architecture, Basel, Switzerland, 2001.
[13] T. Dorta, A. Lesage, E. Perez, J.M. Christian Bastien, "Signs of Collaborative Ideation and the Hybrid Ideation Space", Proc. Design Creativity 2010, Springer, 2010, pp. 199-206.
[14] S. Abdelhosen, T. El-Khouly, "Representing Reflective Practice in a Remote Design Collaboration Process", Proc. 3rd Conference of International Association of Societies of Design Research, IASDR, 2009, pp. 1317-1326.
[15] S. Chase, R. Schultz, J. Brouchould, "Gather around the Wiki-Tree", Proc. 26th eCAADe Conference Proceedings, ISBN, 2008, pp. 809-816.
[16] Drupal 6 Content Management System, Posted September 28 2003, Viewed March 13, 2012, url: http://drupal.org/project/drupal
[17] A. Byron, A. Berry, N. Haug, J. Eaton, J. Walker, J. Robbins, "Using Drupal - Choosing and Configuring Modules to build Dynamic Websites", O'Reilly, Sebastopol, 2009 (¹2008).
[18] Processing, Viewed March 13, 2012, url: http://processing.org/download/
[19] Under the Railroad, design competition hosted by anonymous.d, New York, competition ended Jan 9th, 2012, url: http://www.anonymousd.com