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HYBRID DESIGN TOOLS IN A SOCIAL VIRTUAL REALITY USING NETWORKED OCULUS RIFT: A FEASIBILITY STUDY IN REMOTE REAL-TIME INTERACTION

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ABSTRACT

Hybrid Design Tool Environments (HDTE) allow designers and engineers to use real tangible tools and physical objects and/or artifacts to make and create real-time virtual representations and presentations on-the-fly. Manipulations of the real tangible objects (e.g., real wire mesh, clay, sketches, etc.) are translated into 2-D and/or 3-D digital CAD software and/or virtual instances. The HDTE is equipped with a Loosely Fitted Design Synthesizer (NXt-LFDS) to support this multi-user interaction and design processing. The current study explores for the first time, the feasibility of using a NXt-LFDS in a networked immersive multi-participant social virtual reality environment (VRE). Using Oculus Rift goggles and PC computers at each location linked via Skype, team members physically located in several countries had the illusion of being co-located in a single virtual world, where they used rawshaping technologies (RST) to design a woman's purse in 3-D virtual representations. Hence, the possibility to print the purse out on the spot (i.e. anywhere within the networked loop) with a 2-D or 3D printer. Immersive affordable Virtual Reality (VR) technology (and 3-D AM) are in the process of becoming commercially available and widely used by mainstream consumers, a major development that could transform the collaborative design process. The results of the current feasibility study suggests that designing products may become considerably more individualized within collaborative multi-user settings and less inhibited during in the coming 'Diamond Age' [1] of VR, collaborative networks and with profound implications for the design (e.g. fashion) and engineering industry. This paper presents the proposed system architecture, a collaborative use-case scenario, and preliminary results of the interaction, coordination, cooperation, and communication with immersive VR.

INTRODUCTION

The ever expanding social media networks, either public or professional, are the driving force behind the rapid growth in interconnected networks. As members of a network communicate with each other they create an interactive network. The growth of such a network has a virtuous or 'Snowball effect' (Fig. 1) [2]. Every new actor to an established network will increase the number of potential contacts and profitable interactions significantly [3]. The potential power of these networks increases exponentially with the number of users.

Many social networks are predominantly formed through informal contacts, often weak connections between people who consult collaborative before determining a view on an issue or choice. When people interact collectively, form opinions, share knowledge or develop activities, the network becomes increasingly more powerful. Often people take part in a number of networks, again these become linked and are mutually reinforcing [3]. Gladwell states that many social networks are dominated by 'mavens', people that are often part of more discussion and newsgroups on the Internet and have access to many information sources.

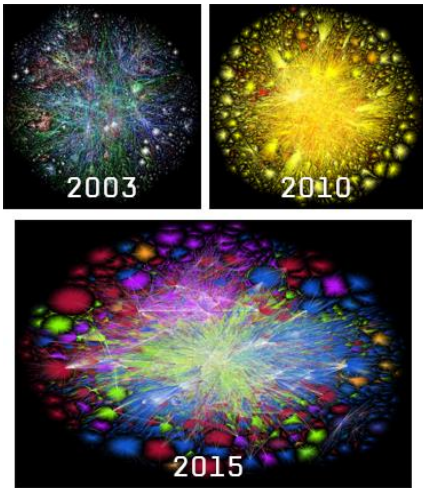

FIGURE 1. The Internet and its exponential growth

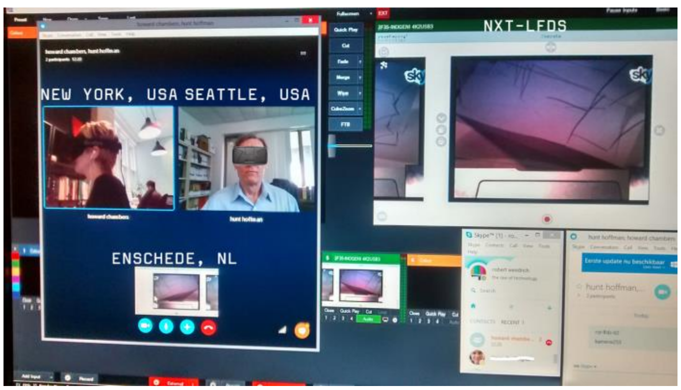

FIGURE 2. Collaborative connected network system

The mavens who are active in a given topic cluster, often have an informal hierarchy, some of them eventually emerge as informal leaders of the group. These people, Gladwell calls them ‘connectors’, play a coordination role and maintaining extensive contacts with other social networks. Connectors gather people and play a decisive role in controlling and monitoring network activity. Their reporting can induce others to modify their behavior. The search for the critical moments that change can bring is just a small step. In this context Gladwell speaks of the ’80/20 rule’ (Pareto), that indicates that 20 percent of people often determine 80 percent of the decisions (Fig. 2) [4]. In this feasibility study we connect social-network, VR and HDTE for remote collaborative design processing and interaction.

HYBRID DESIGN TOOL ENVIRONMENTS

Hybrid Design Tools Environments (HDTE) afford designers and engineers to use real tangible tools and physical objects and/or artifacts to make and create real-time virtual representations on-the-fly [5, 6]. Manipulations of the real objects (e.g, real wire mesh, or clay, sketches, etc) are translated into 2-D and /or 3D digital CAD software and virtual instances. The HDTE is equipped with a NXt-Loosely Fitted Design Synthesizer (NXt) to support this multi-user interaction and design processing [7, 8, 9]. The current study explores for the first time, the feasibility of using rawshaping in a networked multi-participant social virtual reality environment to remotely teach a new user how to use and interact with the rawshaping interface and hybrid design tool (HDT) (Fig. 3).

FIGURE 3. Multiple hybrid design tool environments

Consequently, a design-task is executed with the HDT to iteratively design, generate and create a virtual artifact (i.e. design of a woman’s purse). The presented socio-technical system for collaborative learning (e.g. design, engineering, communication), allows multiple users to view, interact, communicate, iterate, and collaborate on the design task in real-time mixed reality (MR). The users have various networked life-feeds and channels (i.e. audio, 2-D visual displays, 3-D VR headsets) that affords them to choose and decide on-the-fly (real-time) what suits them best in terms of views, presentation and representation.

A full account of all the HDTE and HDT methods, data acquisition, data analysis and evaluation, and results of testing and experimentation would be too lengthy for inclusion here, we refer to its primary documentation [7, 10, 11, 12, 13, 14].

SYSTEM ARCHITECTURE

Methods used in HDTE setup; using Oculus Rift goggles [15], Smartphones, Mac and PC computers at each location linked via Skype [16], four team members physically located in several countries had the illusion of being co-located in a single virtual world, where they used rawshaping technologies to design a woman’s purse, and printed out the purse with a 3-D printer. The setup employs the Oculus Rift Head Mounted Display (HMD) in conjunction with various skype audio- and video feeds to establish the networked real-time infrastructure. The HMD allows for full immersion, it lets the user view and navigate three-dimensional (3-D) virtual reality environments. The Rift provides high-resolution (960x1080 pixels per eye) stereoscopic images with 100º field of view (FOV).

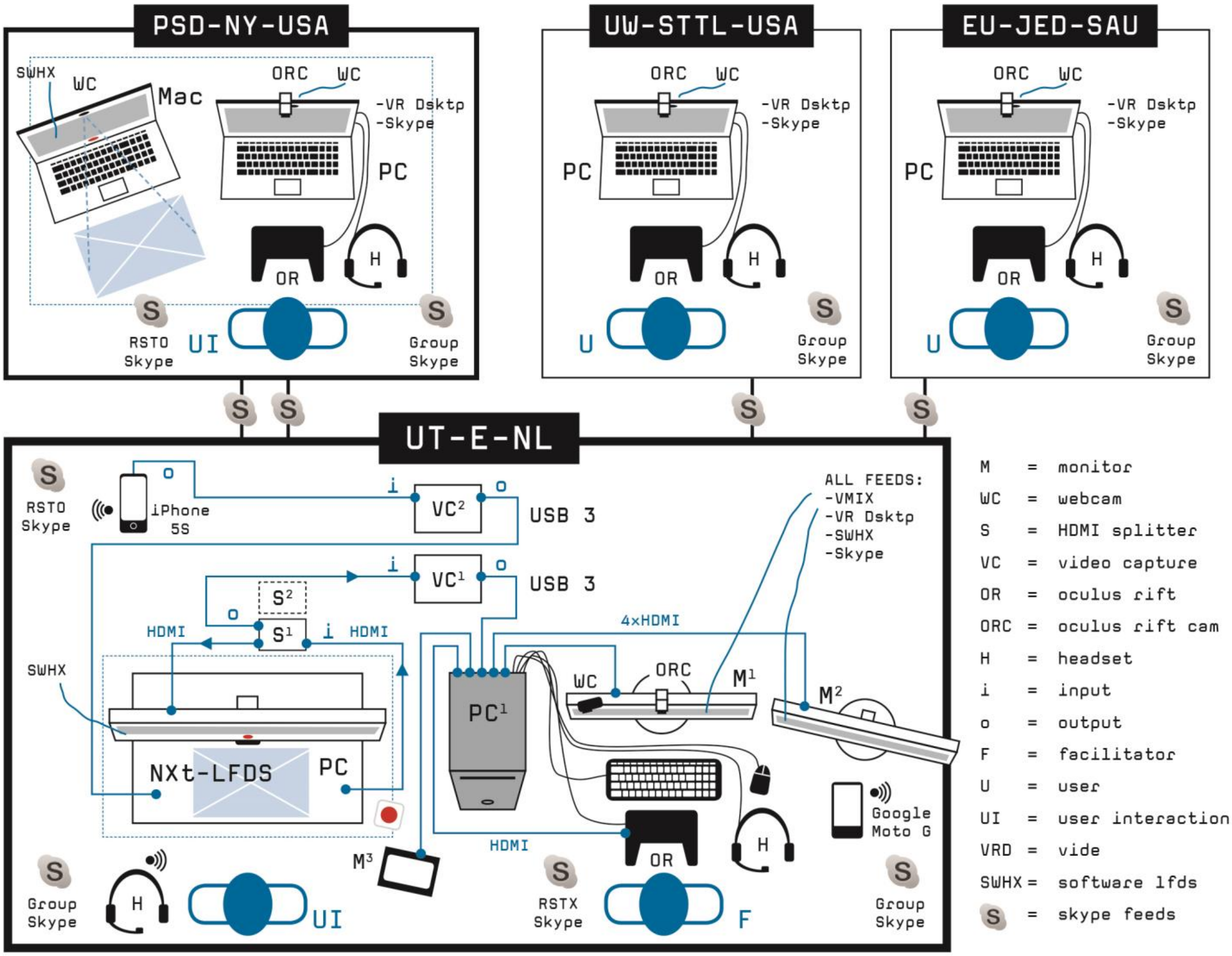

FIGURE 4. System architecture diagram

The overall system is comprised of three primary components: visualization using Oculus Rift (OR) for viewing the 3-D environment; the NXt hybrid design tool for iterative design processing; and the Skype communication feeds (i.e. audio, video) (Fig. 4) (Fig. 5).

The PC^1 contained a 3.4 GHz Core i7 4GB 1 TB CPU and a GTX970 4GB XLR8 Graphics card in order to get the OR running at 60 - 75 frames per second. The other laptops in the VRE-System were standard Mac and PC's equipped with HMD's. On the PC^1 and other laptops we installed Virtual Desktop [17], and Oculus Rift-Runtime for Windows [18]. The visualization and production of live video was done through vMix Live Production software [19]. For the multi-located collaborative user group feeds (i.e. audio and video) we used group-call for Skype. In addition, we used a separate Skype video-feed (i.e. via Smartphone) that streamed the virtual iterative design content generated in New York (NY) simultaneously (very low latency) synchronized with the HDTE tool software (i.e. SWHX) [20] in the Netherlands (NL) (Fig. 6).

The iterative content designed and generated by the NY-user (UI-NY) on the NXt were coordinated and facilitated through an audio-cue "Capture," given in NY and actuated (i.e. push on red capture button) by the user in NL (UI-NL) (Fig. 7). The user-interaction between the two interactors appeared to be fluid, in sync, clear in communication, and showed that coordination, cooperation, and collaboration on distance is possible by facilitation of multi-modalities (Fig. 8).

The user located in NY was a first time user of the NXt user-interface (UI) and tool features. She needed very little time to understand, learn how to use, and grasp the workings of the interface, interaction modalities, and system features. This is an indication of the apparent intuitive qualities of the NXt, by which the user feels at ease and comfortable in using the software capabilities. We noticed some concurrent dislocation constraints during the physical bi-manual interaction and wear of the HMD. Occasionally, users had to move-up the HMD's in order to figure out the exact position/location of the hands in relation to the workspace (Fig. 9).

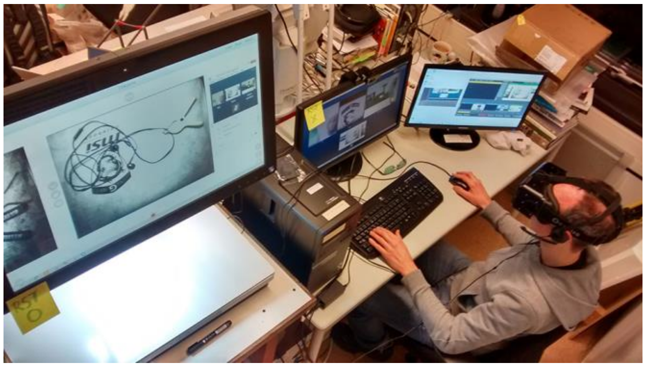

FIGURE 5. Setup system infrastructure UT-E-NL

FIGURE 6. Multiple skype feeds test

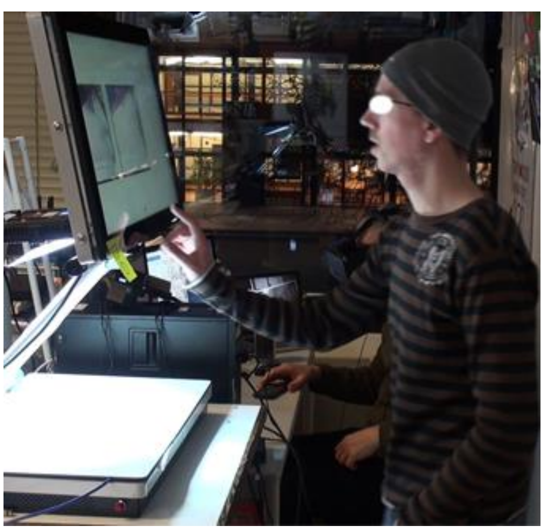

FIGURE 7. Multi-located networked user interaction with NXt (foreground) and OR 3-D (background)

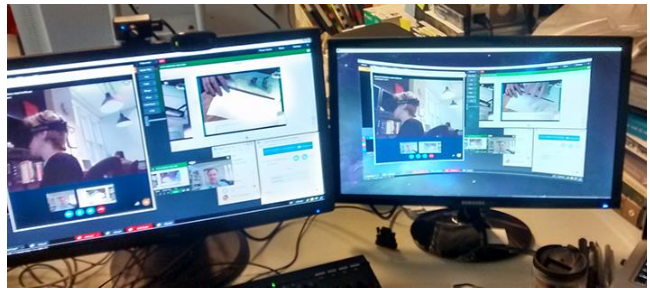

FIGURE 8. Multi-located networked user interaction (on left), OR 3-D goggle view (on right)

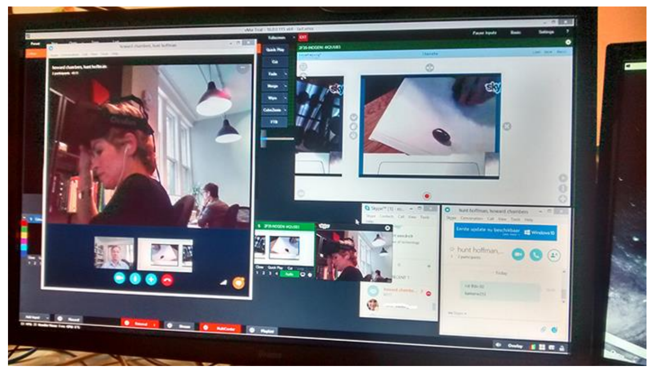

FIGURE 9. Dislocation constraint HMD during UIA

GLOBAL COLLABORATIVE LEARNING AND VIRTUALIZATION

Remote real-time collaboration with socio-technical systems and dialogue tools aimed at promoting collaborative learning and deepening the space of debate and producing epistemic interactions is in the interest of designers, engineers and educators around the globe [21]. This calls for enabling more platforms for real-time collaborations between teams and networks. Design processes can be seen as an integration of a technical, cognitive and social process, and such a process is clearly multidisciplinary [22]. Therefore, it is essential to facilitate global knowledge sharing and communication among individuals and groups. The design and development of collaborative learning systems have had an effect on the emergence of some significant trade-offs related to the means of dialogue, the coordination of action and dialogue, the self-regulation/metacognition of students/users, and the analysis and meta-analysis tools for teachers/industry as well as the differences between 'problem-solving oriented systems' and 'wide community systems' [23].

Global virtualized collaborative learning could be viewed as a pedagogical method that can stimulate students/users to discuss information and problems from different perspectives, to elaborate and refine these in order to re-construct and co-construct (new) knowledge or to solve problems. In such situations, externalization, articulation, argumentation, and negotiation of multiple perspectives are considered the main mechanisms that can promote collaborative learning [23, 24].

For global industry and manufacturing enterprises, collaborative networks are recognized as a very important instrument for survival of organizations in periods of turbulent socio-economic changes [25]. The National Research Council [26] identified six grand challenges for industry, manufacturers, and education, representing gaps in existing practices:

1. Achieve concurrency in (all) operations.
2. Integrate human and technical resources to enhance workforce performance and satisfaction.
3. "Instantaneously" transform information gathered from a vast array of diverse sources into useful knowledge for making effective decisions.
4. Reduce production waste and product environmental impact to "near zero".
5. Reconfigure manufacturing enterprises rapidly in response to changing needs and opportunities.
6. Develop innovative manufacturing processes and products with a focus on decreasing dimensional scale.

These challenges require new organizational structures, new educational models and frameworks, new business models, new design , production and management models, new theories, new processes, new socio-technical systems, novel theories and technologies that allow educational systems and industries/companies to face-up to the dynamic and continual oscillating changes evoked by hyper-globalization, hyper-connectivity and hyper-mediation.

PRELIMINARY RESULTS OF DESIGN TASK

FIGURE 10. NXt GUI and user in interaction

The NXt-LFDS software records all the iterations and virtual instances of the design process, the captured iterations are either saved as individual instances or merged stacks of virtual instances [27]. The merged stacks are considered 3-D end results of single or multiple user-interaction.

In this collaborative networked design task and setup, the user interaction (Fig. 10) lasted 37 minutes in total; the user made 96 iterative steps with a total of 22 merged stacks (Fig. 11). The results show promise in the use of remote interaction modalities and tool features over long distance with a real-time connected VRE. However, the overall quality and tangible outcome could be debated, the results are interesting enough to share and trigger the imagination and spur the need for more research, testing and experimentation.

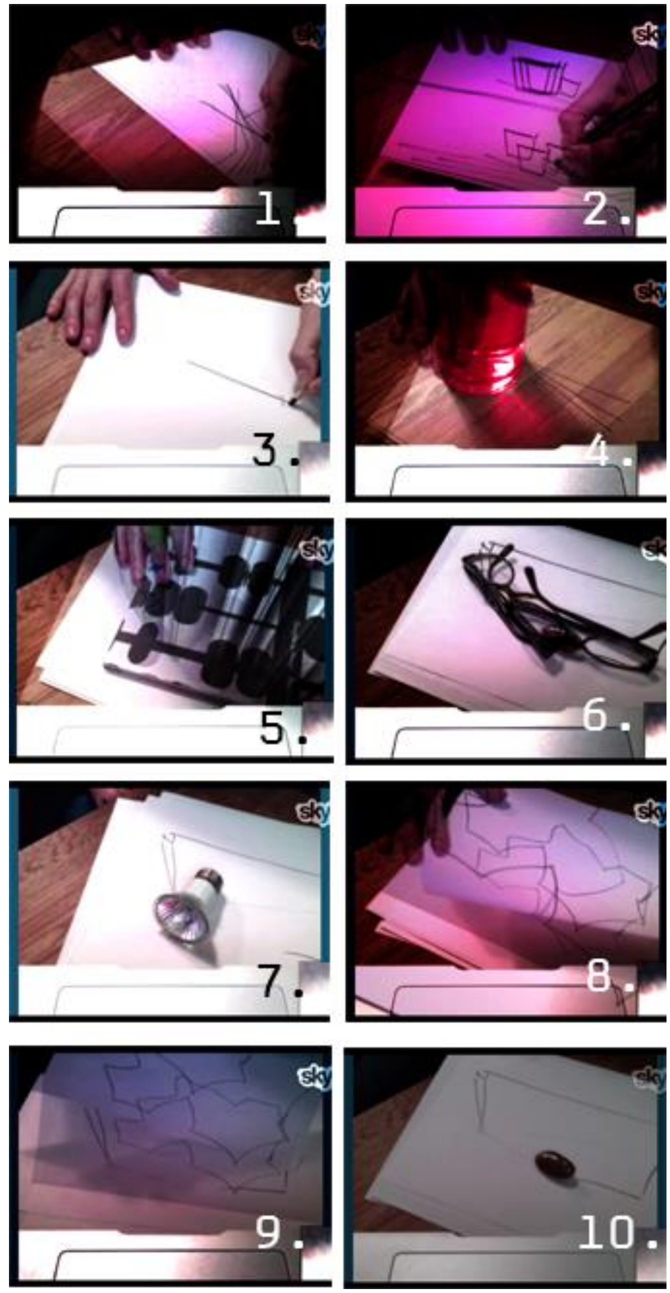

FIGURE 11. Preliminary end results of design task

CONCLUSION

Immersive Virtual Reality technology (and 3D printers) are in the process of becoming commercially available and widely used by mainstream consumers, a major development that could transform the design process. The results of the current feasibility study suggests that designing products may become considerably more individualized and less inhibited during the coming "Diamond Age" [1] of virtual reality, with profound implications for the design (e.g. fashion) and engineering industry and manufacturing and production enterprises.

Future Directions; The designer was able to see her hands and the real objects she was manipulating in the NXt-software, via a video feed from a camera pointed at her desk. One disadvantage of immersive (occlusive) VR is that the designer can feel but cannot directly see objects in the real world except through the camera. The designer viewed this as a limitation. A see through augmented reality display (e.g., via Magic Leap or via a head mounted camera on the Oculus Goggles) might work better.

The current version of rawshaping software (i.e. SWHX) is not compatible with Oculus Rift Direct Mode. New rawshaping software programmed in Unity will allow a more immersive VR experience. For more information visit vimeo.com, type rawshaping technology for videos on hybrid design tools (HDT), experimentation, testing, blended spaces, user experience (UX), user engagement (UE), user interaction interfaces (IxD), and various other cyber-physical modalities.

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