Multi-view VR system for co-located multidisciplinary collaboration and its application in ergonomic design

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ABSTRACT

In co-located collaborative environment for product design, new groupware of multi-view system allows multiple experts to have individual visual information. A co-located multi-view VR system and a multidisciplinary task have been created and studied. Results show that using multi-view VR system achieves a better effectiveness and user performance. Then, an application for collaborative ergonomic design is explored and an industrial multidisciplinary scenario is realized with proposed system.

CCS CONCEPTS

• **Human-centered computing → Interaction paradigms**; *Collaborative interaction*;

KEYWORDS

Multi-view VR, Multidisciplinary collaboration, Ergonomics

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1 INTRODUCTION

In industry, multidisciplinary experts have trends to work collaboratively during product development. For co-located synchronous collaborative design activities, such as project review and decision-making, experts from different domains must discuss, negotiate, and compromise to reduce multidisciplinary differences [Tang et al. 2006]. E.g. in automobile industry, the ergonomic analysis of the drivers posture and visual fields in a car cockpit is one important stage for design optimization. An ergonomist often deals with anthropometric measurements beside a designer. During the simultaneous collaborative measuring activity, they concern about different professional information.

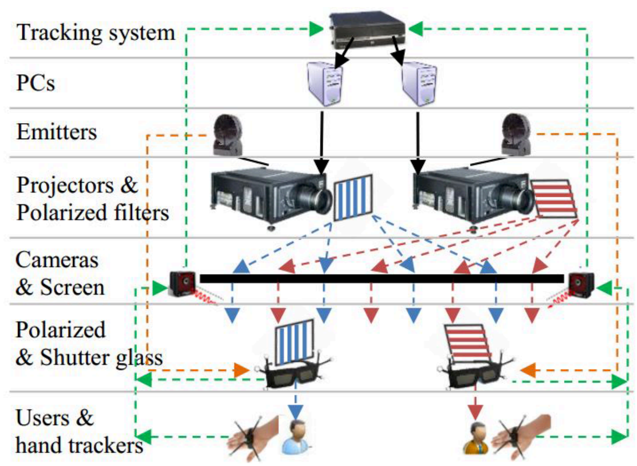

Figure 1: Proposed multi-view VR system for co-located multidisciplinary collaboration.

Multi-view system is a visual-perception interface which allows users to see simultaneously multiple images with a unique shared medium [Wu and Zhai 2013]. However, current co-located collaborative VR system adopts several mono-view devices to display multidisciplinary tasks to different users, e.g. two users collaborate in virtual world while they are displayed separately by a CAVE and a screen [Kemeny 2014]. In this poster, we aim to present a multi-view VR system for co-located multidisciplinary collaboration and its application for automobile ergonomic design activity. In the next section, the configuration of proposed system is presented, followed by an experimental study.

Table 1: Measurements during the experiment. (*: p<0.05 significant; **: p<0.01 highly significant)

Condition	I(Max 5)	U(Max 5)	CS(Max 5)	FT(s)	PCT(s)	PCT/FT(%)	HCT(s)	HCT/FT(%)	Error
TMVSs	3.95	3.26	3.86	563.74	39.94	8.82	172.47	37.08	1.46
DVS	4.53*	3.7*	3.95	451.4**	10.67**	2.51**	136.15*	31.45	0.8*

2 SYSTEM ARCHITECTURE AND EXPERIMENTAL STUDY

Figure 1 shows the architecture of proposed multi-view VR system. Each high brightness digital video projector can provide an individual 3D view because of its 120Hz refresh rate. An emitter sends a synchronized signal to its corresponding shutter glasses, which allows users two eyes to receive alternating images. Meanwhile, polarized filters with orthogonal directions are positioned at the exit of the lenses of projectors and before users glasses so that two users cannot see each others content. An experimental study of this multi-view VR system is conducted with a co-located multidisciplinary task for two users. A player and a helper must collaborate to go through a maze. Their multidisciplinary objectives and limitations are different:

- *Player*: to go through the maze, collecting coins and avoiding invisible bombs.
- *Helper*: to guide the player with information that only he can see: Highlighted outlets at every intersection; Bombs.

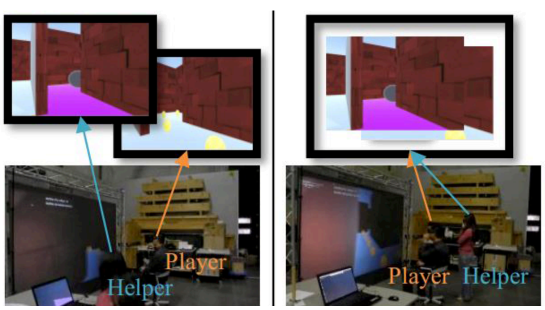

Figure 2: Experimental conditions: Mono-view systems (Left); Multi-view system (Right).

This experiment is carried out under two conditions, shown in Figure 2: Two mono-view systems (TMVSs) and Double-view system (DVS). Results (in Table 1) show that:

- *Effectiveness*: using DVS, Finish Time (FT), Players communication time (PCT) and Helpers communication time (HCT) are shorter; Less Error and less Ratio of players communication time to finish time (PCT/FT) are realized.
- *User performance*: users have more involvement (I) and positive comments on the usability (U) and Collaboration Satisfaction (CS) of DVS.

In summary, users achieve the multidisciplinary collaboration task more efficiently (faster speed, more concentration, and less error) with multi-view VR system.

3 ERGONOMIC SCENARIO

In automobile industry, the analysis of drivers field of view (FOV), which involves designers and ergonomists, is often realized with a virtual mock up in CAVE [Kemeny 2014]. Two steps are often followed: 1. Verbalization: The ergonomist questions the designer: what blocks the lower visual field? The designer responds: the dashboard. 2. Geometry analysis: Anthropometric measurements and a post-processing geometric calculation will be launched by ergonomist to verify if the dashboard limits the lower visual field.

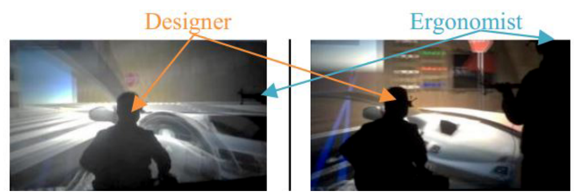

Figure 3: Designer view (Left): A-pillar blocks a part of red street sign; Ergonomist view (Right): A shadow covers the part of red street sign which cant be seen by designer.

We propose a scenario that combines Verbalization & Geometry analysis for a co-located synchronous ergonomic evaluation using multi-view system. The ergonomist can realize at once which object blocks the lower visual field by several tools developed, which consist: 1. displaying a snapshot of drivers FOV on a virtual screen; 2. darkening objects out of FOV (in Figure 3); 3. calculating the value of FOV; 4. highlighting the part that blocks the lower visual field and displaying the bottom edge of FOV on it. These tools may help ergonomist increase the reliability of designers answers and save the time for post-processing.

4 CONCLUSIONS

In this poster, we propose a multi-view VR solution for co-located multidisciplinary collaboration. The effectiveness and user behaviors are studied through an experiment. A scenario of an industrial application of collaborative ergonomic design is then realized. In the future, scenarios of co-located multidisciplinary collaboration will be presented in multi-view CAVE system and evaluated by different experts during product development.

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