論文内容の要旨

博士論文題　Creating Immersive 3D User Interfaces for Professional 3D Design Work

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（論文内容の要旨）

With the advent of Virtual Reality (VR) and Augmented Reality (AR) technology in recent years, a new venue has been opened to provide more intuitive and efficient work environments for creating 3D designs and animations: immersive 3D User Interfaces (UIs) allow the user to enter into a three-dimensional work environment that engulfs him, instead of just looking at a flat PC workstation screen in front of him, which allows for a more natural and efficient way of interaction. However, most research in this area until now has not been focused on professional application and has failed to be adopted by professional artists. In order to bridge the gap between research prototypes and real-world adoption, more application-oriented research is required. In this work I present my ongoing research efforts focusing on the various factors and problems of immersive 3D user interfaces for 3D design as well as reflect on experiences from creating a prototype 3D user interface aimed at professional artists.

I have performed an analysis of the current work situation of 3D artists through both a survey and individual observation and analysis of the workflow. Through the survey, which 54 media professionals from around the world participated in, I found out details about their current workflow and situation. The individual observation of two artists who I recorded at work and then analyzed the video footage provides insight into what percentage of time artists spend on which subtask. I developed at prototype 3D UI aimed at professional design and performed a formative user study with eleven artists, which gives insights into the possibilities and limitations of current VR and AR technology and allowed me to improve the prototype. I have further performed two summative user studies through which I tried to find quantitative evidence for effects on work performance from 3D UI related human factors. One of this was the possible effect of positional head-tracking on task completion time on a 3D selection and transformation task. Previous research on this topic has been inconclusive and was performed with outdated technology. In my user study, I was not able to find any statistically significant effect from positional head-tracking on task completion time. The other study was the first direct comparison between AR and VR on 3D work performance in 3D interaction tasks. Surprisingly, this study showed significant advantages of AR work environments over VR work environments even in cases where prior known factors did not apply. Finally, I released my research prototype 3D UI to the public where it has been successfully adopted by 3D artists around the world. The lessons learned through this process are provided in the final chapter of this work.

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（論文審査結果の要旨）

平成 29 年 5 月 24 日に本博士論文の最終審査を行った．その結果，本博士論文は，提出者が独立した研究者として研究活動を続けていくための十分な素養を備えていることを示すものと認める．

KRICHENBAUER Maximilian Michael 君は，本博士論文において，３Ｄデザイン熟練者のための没入型三次元ユーザインタフェースを設計・開発する際のユーザインタフェース上の問題点について，いくつかの知見をまとめた．本論文の具体的な貢献を以下に示す．

１．国内外の３Ｄデザイン熟練者に対するアンケート調査を実施し，彼らの作業環境や作業スタイル，使用するインタフェースなどについての現状をまとめ，実際に使用されているユーザインタフェースとこれまでに提案されてきた先端的ユーザインタフェースの間の隔たりを明らかにした．

２．上記に基づき，３Ｄデザイン熟練者による３Ｄデザイン作業に関してのユーザインタフェースに対する要求仕様を明らかにした．

３．３Ｄデザイン熟練者の３Ｄデザイン作業のための没入型ユーザインタフェースを試作及び評価を行い，ユーザインタフェースに対するさらなる改良点などの見いだした．

４．没入型ユーザインタフェースを用いた３Ｄデザイン熟練者による３Ｄデザイン作業においては，従来重要と考えられてきた，頭部位置情報からのフィードバックに基づく視点位置変更が重要ではないことを明らかにした．

５．没入型ユーザインタフェースを用いた３Ｄデザイン熟練者による３Ｄデザイン作業において，バーチャルリアリティ環境と拡張現実環境の比較実験を実施し，拡張現実環境の優位性を明らかにした．

以上の成果から，本論文は，博士（工学）の学位論文として，三次元ユーザインタフェース分野においての学術的価値が十分に認められると判断した．