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題目(和文)	3D タッチとジェスチャー検出に基づき、ホログラフィックライトフィールドディスプレーとの直接なインタラクション
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	情報通信 情報通信	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（工学）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis presents the development of a 3D touchable interface using a holographic light field (LF) display. This interface is capable of registering the content and the position of the user, as well as detecting the gestures performed by the user. The thesis consists of 8 chapters.

Chapter 1 presents the introduction to this topic by explaining several 3D displaying techniques that have been proposed in the past. Within them, we point out the LF displaying technique based on Lippman's original proposal and state the motivation of this research, which uses a LF display to create an interface that mimics the real world in a more intuitive way.

Chapter 2 introduces several types of graphic user interfaces (GUIs) to properly classify this study. First, we introduce 2D aerial GUIs that reproduce 2D images in air and detect the interaction of the user in that plane. Next, autostereoscopic displays are introduced and the concept of a holographic optical element (HOE) is described. Techniques that extend the detection of the interaction to 3D are discussed, to provide an overview on GUIs that use 3D displays. Once that outlook on the existing GUIs is complete, the remaining challenges are described. Some of these challenges are the lack of modularity (i.e. difficulty of using developed parts of the proposed systems for some other purpose), the lack of registration between the user and the content, and the lack of modification of the displayed content in real time.

Chapter 3 covers the theoretical and technical details of the 3D LF display used for this study. Different from other LF reproducing approaches, this display is based on HOEs. Which permits to achieve a transparent screen that can be used for augmented reality (AR) applications. The fabrication of the HOE array and the calibration between the pixels of a projector and the center of the HOEs are detailed.

Scattered light detection, an important technique for the goal of this study, is treated in chapter 4. To detect scattered light in accordance with the movement of a user, this chapter opens with the technical details on how the LF images are updated in real time, so the LF can be reconstructed in the position the finger of the user moves to. Next, the detection of color is used to locate the position of a user in 3D using one RGB camera.

Color measurements provide information on the missing coordinate, that otherwise would be lost by the projection of a 3D image into a 2D sensor. Interaction examples using this technique and technical improvements to make color detection more robust, are detailed.

In chapter 5, we use the scattered light detection technique (although not the color-based 3D

tracking method) developed in chapter 4 to assign a color vector to a 3D position and combine this measurement with the readings of an infrared stereo-camera based system (Leap Motion controller, or LM controller) specialized in detecting features of the hand, such as the position of the fingers in 3D space. This combination of 3D information forms the basis of the estimation of an affine transformation that relates the LF space directly with the 3D positions of the user given by the LM. A method based on 2D Random Sample Consensus (RANSAC) algorithm and the fitting of a plane using Singular Value Decomposition (SVD), is proposed to provide a robust 3D measurement. The final result allows the spatial matching between the finger of the user and the LF. We also present proposals of GUIs that perform the proposed spatial calibration while the user operates them.

After accomplishing a method to match the 3D space of the LM controller and the space of the reproduced LF images, we detail some applications of the registered LF display in chapter 6. Some examples are real time free drawing, registered gestures to manipulate LF objects directly, and the development of evaluation tasks to assess the user experience. These tasks are screen unlocking, moving and placing LF boxes in a goal, and tracing a circle on top of a specified trajectory.

In chapter 7, to observe the effect of LF spatial registration in the performance of the user, we present an experiment using the 3 evaluation tasks mentioned in chapter 6. Each of the tasks is presented to the user with different degrees of spatial registration (not registered, registered with a displacement, and registered) and the Task Completion Time (TCT) for 11 users is measured. The results show a statistically significant difference in the TCT between the registered and the unregistered versions when the user combines gestures with the displacement of a LF image.

Finally, the conclusions of this study as well as the pending tasks and future research proposals are outlined in chapter 8.