博士論文（要約）

A Study on Interactive Image Display with 2D MEMS Scanner and its Applications to Free Space Optics
(二次元ＭＥＭＳスキャナによるインタラクティブ画像ディスプレィとその自由空間光通信応用に関する研究)

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We will soon have tremendous number of mobile devices communicating each other and sometimes interacting with human beings. In such a situation, we foresee two problems. One is that radio frequency communication will suffer from bandwidth limitation when the density of the devices increases, and the other problem is that small devices have no space for information display or touch sensor to interact with users. We solve these problems by using the free space optics (FSO) and by using a projection display with gesture recognition function. Our system is based on the re-use of the reflected or scattered light while controlling the projected laser beam by a microelectromechanical systems (MEMS) scanner. Here, we construct two systems, which are interactive display combining a distance finding system to a projection display and the FSO with object tracking capabilities.

Firstly, interactive display uses a laser scanning display for image display and the triangulation method for range finding. The laser used for display is scattered by an object and comes back to the system, to be detected by the position sensitive detector. Based on this signal, we calculate the distance to the scattering point, while the laser is scanned for projecting image. As a result, we obtain 3D profile of the area that the display is lightening. We analytically model the light detection and ranging (LIDAR) system and also experimentally measure the signal. The calculation and experimental data agrees well to each other in a range from 20 cm to 60 cm distance. As a demonstration of real-time interactive display, we show a system measuring distance from the laser scanning display (LSD) to a user's palm and projecting the measured data on it. We also demonstrate an interactive display controlled by the viewer's hand gesture, in which the pages are flipped in forward or backward direction according to the direction of the waved hand in front of the LSD system.

The system that we call FSO with tracking capability is constructed with a stationary active optical terminal or active optical terminal (AOT) that spatially scans a laser beam to search for and track a remote passive optical node or passive optical terminal (POT). The AOT in this work is equipped with a MEMS optical scanner to scan a collimated beam of two wavelengths 532~nm and 635~nm. Two lenses are installed around the MEMS optical scanner to enhance the deflection angle without blurring the focus. The relative position of the remote POT to the laser beam spot, i.e., beam position error, is known by investigating the light reflected from the corner cube reflector using the quadrant photodiode (QPD). We also enable the bi-directional data transmission, even when the devices are moving. Finally, we experimentally evaluate the performance of the control and communication systems.

Moreover, we discuss on several issues about this work. Firstly, we discuss on the error and noise in the interactive display, followed by the solutions for the issues. After that, we discuss on the miniaturization of this work. MEMS scanner requirement is shown for targeting the specification of the MEMS scanner suitable for both systems, i.e. interactive display and FSO with tracking capabilities. Finally, we discuss on the field of view (FOV) of the POT which was the main reason of the tracking failure during the demonstration.

The system has the advantage in the energy consumption respect, because it re-uses the scattered or reflected light from the shot laser for sensing. Also, this system can be applied for a temporal communication with a device or a person such as long-distance version of radio frequency identifier (RFID), smart dust or communication between aerial devices, apart from the data collection from the distributed sensors.