Optical tracking of finger positions

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Abstract

Assembly simulations and ergonomical studies are major fields for Virtual and Augmented Reality in industry. Both applications require direct object manipulation as the essential interaction method. Finger tracking is a tool, which allows to recognize finger positions without disturbing gloves and cables.

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1 Introduction

Today, virtual and augmented reality are accepted tools for the development process in the European automotive industry. Many applications are available, where utilizing VR or AR methods can significantly reduce efforts and costs, especially assembly and ergonomic studies. Both kinds of studies require interaction schemes, which are as close to the natural interaction as possible to achieve valid results.

Real-world (not virtual) interaction usually means interacting with the hands. To achieve a good virtual simulation, VR and AR interaction therefore has to offer a possibility to measure finger positions.

2 Design issues

2.1. Goals

Designing a finger target has to fulfill several requirements:

- Finger tip position must be measured precisely
- The system must be physically robust and reliable
- Optimal usability: low weight, no external cables, no glove

2.2. Difficulties

Several major problems occur when using optical tracking for fingertip positions:

- Size: The space usable for tracking devices along the finger is limited by the finger size.
- Identification: Single markers usually cannot be identified in optical tracking systems
- Marker merging: markers too close to each other, e.g. when picking an object, may not be visible to the camera as individual objects
- Robustness: passive markers loose their efficiency when being soiled, especially when grabbing on it.

2.3. Solution

Active markers allow to solve both the size and robustness problem: passive markers need a certain minimal size to reflect enough light back to the camera, where active markers produce their own light and thus can be much smaller. Furthermore, the performance of active markers does not significantly degrade when being soiled with fat.

Therefore, a design with active markers was chosen. Active markers require a power supply. Power-efficient active markers have to be stroked instead of continuously driven, thus needing synchronization with the cameras. Highly efficient lightweight rechargeable batteries, available from digital cameras and mobile phones, and IR synchronization can be used to still maintain the usability requirements.

Optical tracking systems usually identify objects by *bodies*, i.e. solid combinations of four or more markers. This is easily possible for a hand, but not for an individual finger. On the other hand, using only single markers for each finger looses the identification possibility. Furthermore, single markers at the fingertips risk merging with gestures like picking an object.

To overcome this problem, the markers at the fingertips are sequentially switched on, so in each frame only one of the fingers is visible to the camera. This reduces the individual framerate by a factor of three, but eliminates both the identification and the merging problem.

3 Fingertracking hardware

The fingertracking hardware consists of a hand target to determine the hand position in 6D and Markers for the fingertips. The thumb requires two markers due to its higher flexibility of movement.

Figure 1: Finger tracking hardware.

All markers used for finger tracking are active markers, i.e. LEDs emitting infrared pulses synchronized to the camera by IR sync signals.

The hand target contains all electronics, a rechargeable battery (standard camera battery) and LEDs for two different target geometries fro left and right hand. Still the complete system weighs only 60g (2.1 oz) per hand including the fingertip markers and cables.

4 TECHNICAL DATA

The finger tracking works with a frequency of 60Hz for the hand measurement and 20Hz for the fingertips. The accuracy in a typical setup is better than 1mm for both the hand and the finger tip positions. A calibration procedure allows measuring the hand sizes, so the software automatically calculates the positions of the finger phalanxes.

5 COMPARISON WITH EXISTING HARDWARE

Currently there are several different data gloves commercially available. Essentially they look very similar and are based on the same principle: a glove containing measurement devices in the fingers to determine finger positions plus a wrist-mounted tracking device to measure the hand position in 6 dimensions.

From the glove a cable leads either to a box creating the final data or to a belt-clip box transmitting the data vi Bluetooth® or other wireless connection to a base station.

Several disadvantage arise from this method:

- The 6DOF position is measured at the wrist and the finger position is then calculated based on relative measurement. Small angular errors in the measurement of the back of the hand propagate along a large lever to the finger tips.
- The measurement of the finger bending requires a closed glove, which is being regarded as unpleasant by most users for longer usage
- The cables required to connect the glove and its master box reduce the usability
- The weigth of glove and cables is disturbing

6 CONCLUSION AND FUTURE WORK

The finger tracking hardware is a new method for data glove operation in systems with optical tracking. It combines high finger position accuracy and good usability by a wireless, lightweight device.

In the future, a tactile feedback will be integrated into the finger tips to allow using the sense of touch in virtual simulations.

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