Hand-Based Interaction on a Millimeter Scale in Virtual and Augmented Reality

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ABSTRACT

Interaction with mixed-reality systems is often performed using input devices or simple gestures. A promising alternative concept for interacting with mixed-reality systems is hands-free interaction on a millimeter scale where a precise tracking of small finger movements is utilized for interaction. However, because of technological challanges, this field has not been researched sufficiently yet.

Fig. 1

DESIGNING HAND-BASED INTERACTION

One of our research focuses is hand-based interaction. We are especially interesed in interacting on a millimeter-scale in which the hand becomes an universal input device that unites different concepts of human-computer interaction research such as *On-Body Interaction*, *Tangbile Interaction*, *Microgestures* and *Natural Interaction*. A vast quantity of hand tracking devices exist, mostly glove-based or camera-based systems. However, from product videos and presentations it is not always visible how adequate the tracking quality is for intended prototype system and many devices we examined in our prototyping and desinging of systems (depictured in fig. 1) provide hand tracking only to a limited degree. The limits of utilized technology do also limit our prototyping and inhibit new approaches to interaction. It is important to be aware of this.

From our point of view, a universal rating system for hand tracking devices is missing that allows the selection of appropriate devices for prototypes and experiments. Further, it could help exposing current technological flaws to guide futuer developments. In the future, we plan to accumulate context-dependent features and applications to develop such a universal rating system for hand tracking devices.

LEVELS OF TRACKING CAPABILITIES

When using a finger tracking devices the **level** of tracking capabilities should be kept in mind as these influence (and in worst case, limit) our ideation in prototyping of experimental systems:

(I) **Events**: Only specific actions such as static or dynamic gestures are recognized. They can be defined as complex movement, for example the bloom-gesture of Microsofts‘ Hololens or simple movement such as stretching out one finger. They are not registered in 3D space and are utilized in a binary way, for example as clicking technique.

(II) **3D Input**: For 3D-input, the hand’s position in tracking space is combined with simple events. For example, a tap and hold of thumb and index (a pinch gesture) can be used to indicate a drag and drop action to move virtual objects in 3D-space as manipulation task.

(III) **Partial Tracking**: The hand is held in a certain interaction pose (for example slightly pronated in front of a head mounted display, or above an interaction device) and only parts of the hand are tracked with high accuracy. For example, thumb, index and middle finger are tracked as continuous movements that control basic controls or precise positions on the hand are utilized as specific inputs Some commercially available systems such as Leap Motion, Oculus Quests‘ experimental finger tracking or some simple data gloves provide partial tracking as it is sufficient for many applications.

(IV) **Full Tracking**: A full tracking of a single hand in 3D-space. All joint angles are tracked accurately and can be utilized for interaction. The hand model approximates a user’s hand to provide a millimeter-scale accuracy of finger tips and other universally specifiable points for interaction. Many systems seem to aim at this level but are limited due to external factors or complexity of tracking.

(V) **Universal Tracking**: Support for special features such as multi-hand and multi-user, on-body and on-object interaction that allow novel mixed-reality systems. Current commercially available system often fail at these tasks.

KEY FEATURES OF FINGER TRACKING DEVICES

It is critical to identify key factors of finger tracking as they determine which system can be created (and about which systems we think).

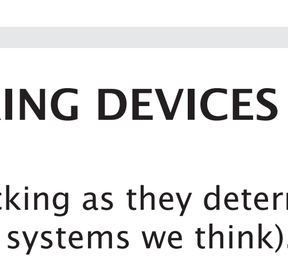
[A] Accuracy and precision: Divergence of tracked positions and real-world position, tracking of contact points on skin, coverage of whole movement space (angles of joints).

[M] Precise hand model: The Fitting of the virtual hand to the users‘ hand shape, adjust finger lengths and diameter of hand.

[C] Comfort: Instrumentation of hands, restriction of movements, time needed to initialize tracking, inhibition of tactile perception.

[T] Technology: Basic features of tracking devices such as latency, noise, drift, technology-related limitations (e.g. IR tracking, tracking space).

[D] Distribution: Mobility, price.



Possible visualization as spider graph.

TAKE AWAY

- Keep in mind that prototyping is today still limited by the capabilities of most tracking devices. Hence, promising approaches for interaction techniques and applications are unfortunately discarded.

- Think ahead: In five or ten years the tracking capabilities may be much more advanced. We can already start designing new interaction techniques today that can be implemented in the future.

- We need a rating system for hand tracking devices!