Optical Tracking of Finger Positions

A new method for interaction in virtual worlds

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Position of AR/VR in industry

■ **VR: Fully established tool in**
  - Automotive (Europe only?)
    - All automotive producers
    - Most Tier-1 suppliers
  - Aerospace industry

■ **AR/MR catching up**

■ **Mainly used for**
  - Design review
  - Digital Mock-Up (DMU)
  - Ergonomics
  - Assembly
  - Customer presentations
Industrial AR/VR applications

- Design Review
  - DMU
  - Data Visualization

- Indirect Interaction:
  - Menus, Selection
  - Navigation

- Assembly, Buildability,
  - Ergonomic studies
  - Mixed Mockup

- Direct interaction:
  - Grab / Manipulate
  - Navigation
Why Fingertracking?

- **Normal data gloves**
  - 6DOF sensor at wrist
  - Strain gages for backward kinematical approach
  - Glove over full hand to guide strain gages
  - External cables required

- **Problems**
  - 6D Errors propagate over long lever
  - Different finger/hand sizes
  - Gloves used over longer period are not hygienic
  - Ergonomics: Weight & Cables
The new approach

- **Initiated by VW**
  - An ergonomic device for ergonomic / assembly studies

- **Design goals**
  - Precise positions for finger tip
  - Reliable measurement
  - Light-weight
  - No external cables

- **Developed in cooperation of**
  - Volkswagen AG
  - Technische Universität München
  - A.R.T.
First tests: passive markers

- **First prototype**
  - 3DOF marker at finger tip
  - 6DOF target at back of hand

- **Problems**
  - Marker identification
  - Marker size
  - Merging markers
  - Marker pollution
Active markers

- **Infrared LEDs**
  - Pulsing for efficient power usage: Only emit when camera CCD active
  - Synchronized by modulated flash
  - Multiple flash groups possible

- **Addressable**
  - Enable / disable LED per frame
  - Sequentially switch between LEDs

- **Robust**
  - No performance degrading when soiled with fat
  - Mechanically robust

- **Small**
  - LED with diffusor sphere is <2mm
Active markers in finger tracking

- **Principle**
  - Thimbles with LEDs on finger tips
  - 6DOF target on back of hand
  - Finger tip LEDs flash sequentially
  - Target LEDs flash in every frame

- **Advantages**
  - Finger markers small
  - All markers robust against soiling
  - No merging markers for fingers

- **Disadvantage**
  - Fingers tracked with 1/3 tracking frequency
Calculating finger positions

- Normal fingers (index/middle)
  - 3 joints: 2 hinge joints and 1 ball joint
  - 4 degrees of freedom
  - Unique solution possible when last joint and tip given (no external forces)
  - Measure back of hand (6DOF) + tip (3DOF)

- Special: the thumb
  - Saddle joint instead of ball joint
  - Higher flexibility in movement
  - Requires additional information:
    - measure line instead of tip position
Finger marker positions

- **At the fingertip**
  - Unique solutions for equations
  - Good usability in VR
  - Problem: Touching objects in AR

- **Under the fingertip**
  - Unique solutions for equations
  - Usability in AR and VR bad

- **On top of finger tip**
  - Best for usability both in VR and AR
  - **BUT**: no unique solutions
Ambiguous finger positions
The finger tracking can/must be calibrated to the user’s hand

- Movement of fully extended fingers
- Finger length of index and middle fingers are radius of finger marker arc movement
- Centers are the base joint positions
- Phalanx length ratios are assumed to be constant
- Thumb length is calculated from finger lengths
Software

- **Plug-In for DTrack**
  - Simple Calibration
  - Multiple calibrations can be saved
  - Selection of calibration by name

- **Data sent out by Ethernet**

- **Compatible with all other tracking objects**
  - Flystick
  - Measurement Tool
  - Other targets
State of the A.R.T.

- **A.R.T. Fingertracking**
  - 2 Hands
  - Active Markers
  - 3 Finger --> 2 x 1 Marker, 1 x 2 Marker
  - No external Cables (Battery, IR Sync)
  - Hygienic, no glove
  - Changeable Thimbles in different sizes
  - Plug-In for DTrack
  - Simple calibration
  - Multiple Users possible / fast changing between users
  - Weight: 55g / 1.94 oz (including battery and thimbles)
State of the A.R.T.

- Active Markers
- Dial Syncgroups + Intensity
- Sync receiver
- Status LEDs
- 2 Thumb-Markers
- On/Off switch
- Rechargable Battery
Applications

- **Direct interaction**
  - Operating virtual switches / dials / levers / tools
  - Better Human-Computer interfacing

- **Other possibilities**
  - Navigation in VR/AR Szene
  - Intuitive system operation / gesture recognition

- **Software integration**
  - Virtual Design 2 (VD2)
  - Others planned or in work (Maya, …)
  - Source code for data receiver integration available

- **Support by A.R.T. available – just ask!**
Improvements planned or in work

- **Five fingers**
  - Use all fingers for interaction

- **Open finger tips**
  - Find a way to get the finger tips free for touching real objects

- **Tactile feedback**
  - Get tactile feedback from the application to the finger tips
Thanks for your attention!

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