Interaction Techniques in VR

Workshop for interactive VR-Technology for On-Orbit Servicing

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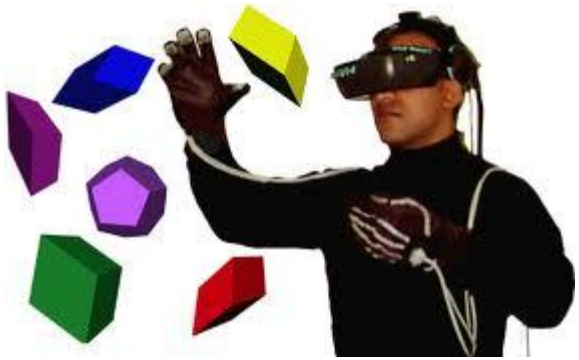
Outline

- 3D Interaction Techniques: Basic Terminologies
- 3D Interaction Techniques and Interface Components
- Factors influencing 3D Interaction Technique Design
- Evaluation of 3D Interaction Techniques: Evaluation Methods
- 3D UI Evaluation Approaches

- “Interacting with Force Sensitive Thin Deformable Virtual Objects (VR-OOS)”

3D Interaction Techniques: Basic Terminology

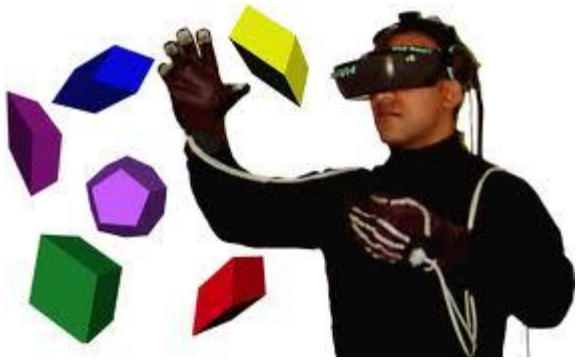
- Interaction Task: What a User wants to do
- 3D Interaction: User Interaction Tasks are performed directly in a 3D spatial Context.
- User Interface (UI): The medium through which the Communication between Users and Computers takes place.
- 3DUI: A UI that involves 3D Interaction



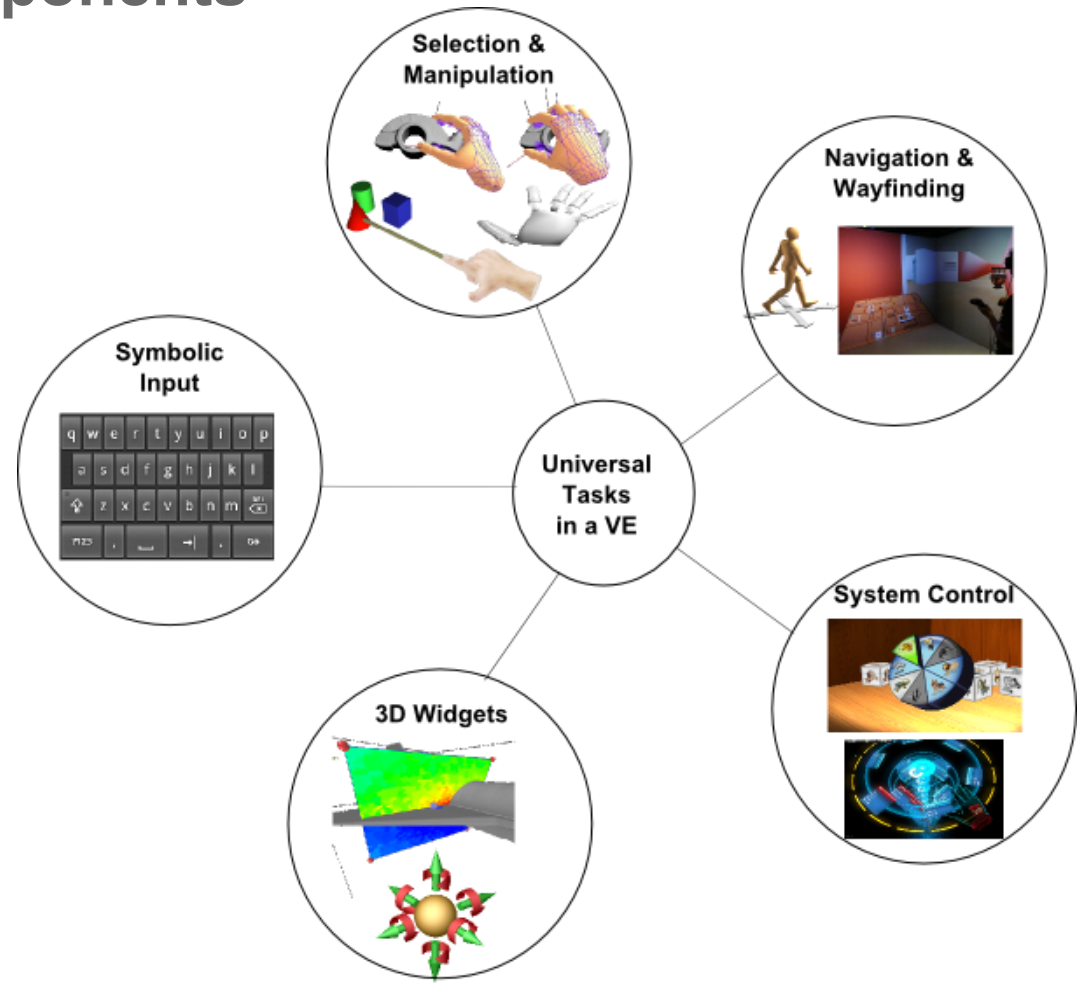
3D Interaction Techniques: Basic Terminology

- Interaction Technique: Method allowing User to accomplish a Task via the User Interface.
  - Includes both hardware (input/output devices) and software components.

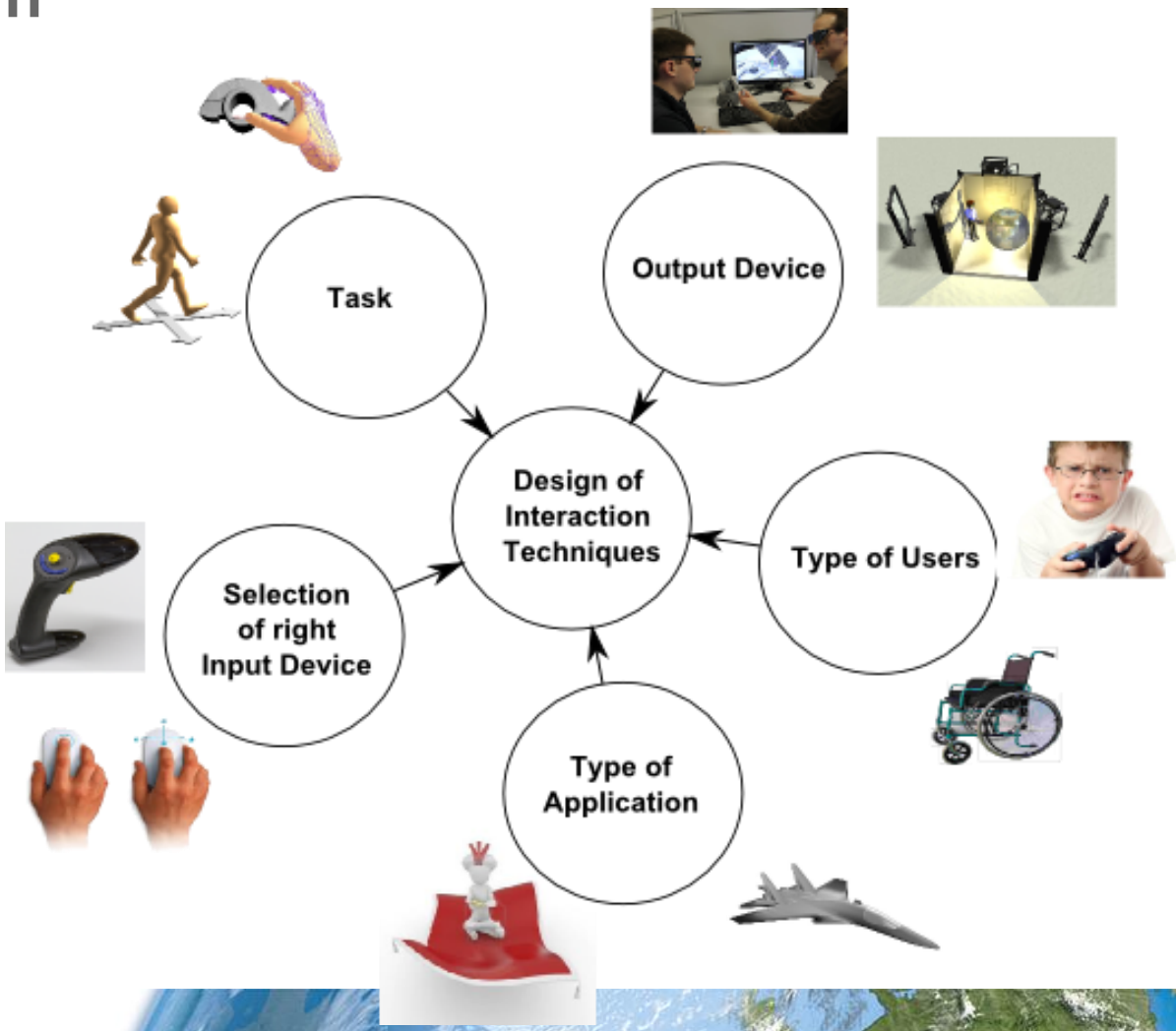
- Usability: Characteristics of an Artifact that affect User's use of the Artifact.



3D Interaction Techniques and Interface Components



Factors influencing 3D interaction technique Design



Evaluation of 3D Interaction Techniques/3DUI: Evaluation methods

- Cognitive Walkthrough:
  - Evaluating a UI based on stepping through common Tasks
- Heuristic or Guidelines based Evaluation:
  - Usability experts evaluate a UI design by applying relevant Design Guidelines
- Formative evaluation:
  - Observational, Empirical Evaluation
  - Asses User Interaction by placing User in Task based Scenarios
- Summative Evaluation:
  - A statistical Comparison of two or more Configurations
- Interview/Demo:
  - Gathering Information by talking directly to the Users
- Post-hoc Questionnaire:
  - Collect subjective data using a written set of questions

3D UI Evaluation approaches

- Well suited to produce Application specific usable Interface or Interaction Techniques

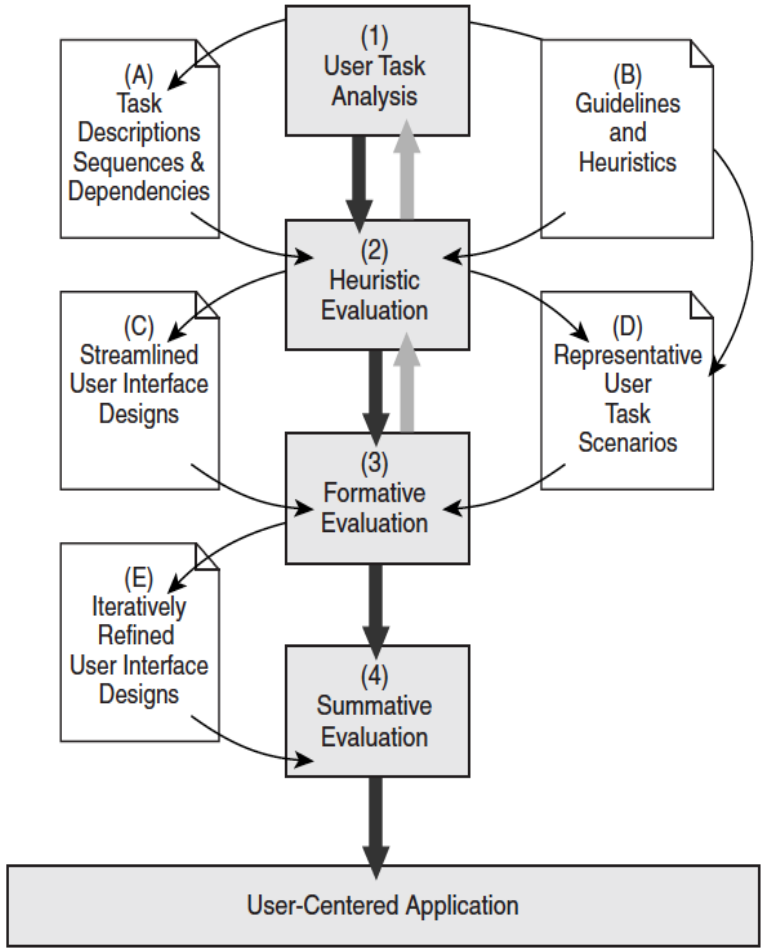
- User Task Analysis: detailed Task Descriptions, shapes User Task Scenario, Information Flow and more

- Heuristic: Guidelines based Evaluation

- Formative Evaluation: User centered Evaluation to ensure that Design meets stated Goals or Objectives

- Summative Evaluation: Assessment and statistical Comparison of two or more Configurations

Sequential Evaluation Approach



Interacting with Force Sensitive Thin Deformable Virtual Objects in VROOS

- User Task: Selection and Manipulation
  - Delicate Task of Removing the protective multi-layer Insulation Foil from Virtual Satellite
  - Familiarize User with the Scenario and Train
  - The User has to apply a gentle Force while moving the Sensitive Foil

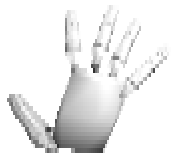
Requirement and Guidelines to be satisfied

- Enables control of a subtle Force applied on the Foil
- Ensure correct Transfer of Training
- Transfer: Ability to apply what is previously learned from one Task to another
    - In VEs, correct transfer of Skills and Knowledge from VE to Real World
- Natural and Intuitive Simulation of Physical Interaction (incl. imp psychomotor tasks)

Proposed Interaction Techniques

- Virtual Hand Metaphor
  - Recommended for manipulation tasks

- Find natural and intuitive Mappings between the Interaction Technique and the Input Devices and satisfy the Task/Application Requirements



- Two different Devices and 3 different Interaction Mappings
  - One using a standard Flystick

  - Two novel approaches using finger tracking device
    - High level manipulation precision -> permit grasp and manipulation by fingers
    - Finger tracking with Distance Measurement
    - Finger tracking with Direct Force Input

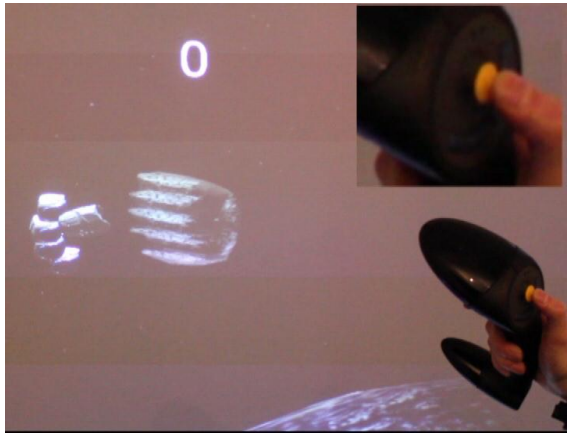
Flystick Method

- Device: A.R.T. Flystick2
  - 6 DOF
  - 6 Buttons
  - 1 Joystick (x/y-Axis; 200 different Values; Range: -1.0 .. 1.0; Step Size: 0.01)

- Mapping Real Hand → Virtual Hand:
  - Back of Hand Identical
  - Joystick‘s Y-Axis move Fingers
    - Up: Open Hand
    - Neutral: Just before closed
    - Down: Close Hand + Apply Force

- Force Applied:

$$F = \begin{cases} 0 & , y \geq 0 \\ -y & , y < 0 \end{cases}$$



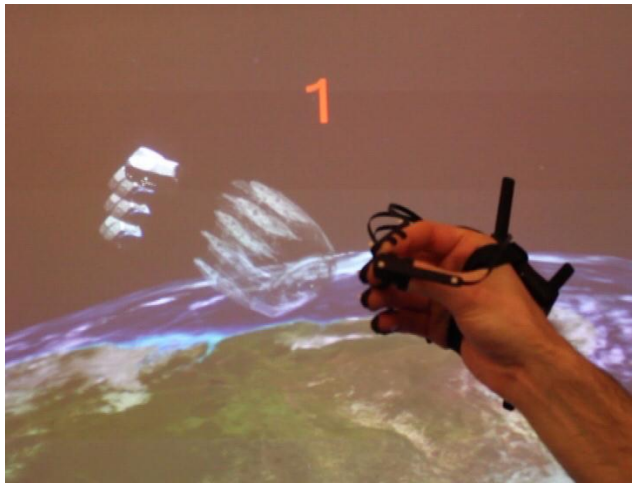
Distance Method

- Device: A.R.T. Fingertracking
  - Position and Orientation of Back of the Hand and all five Finger Tips

- Mapping Real Hand → Virtual Hand:
  - While User‘s Hand still open for 3cm, Virtual Hand is just before closed
  - Force applied by further Closing the User‘s Hand, linearly mapped on Euclidian Distance between Thumb and Finger

- Force Applied:

$$F = \begin{cases} 0 & ,d \geq 3cm \\ 1 - d/3cm & ,d < 3cm \end{cases}$$



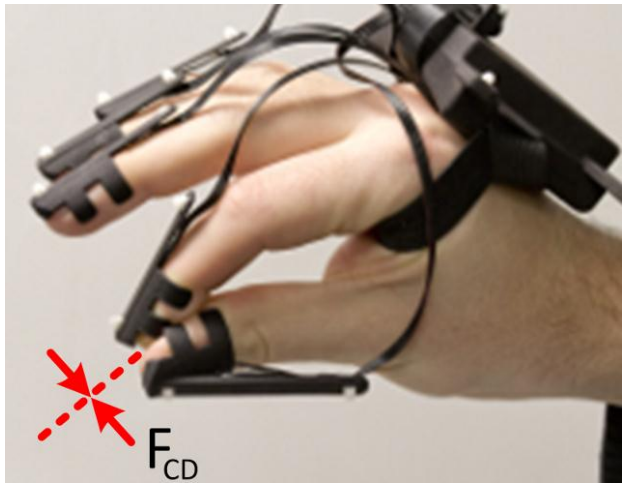
Pinching Method

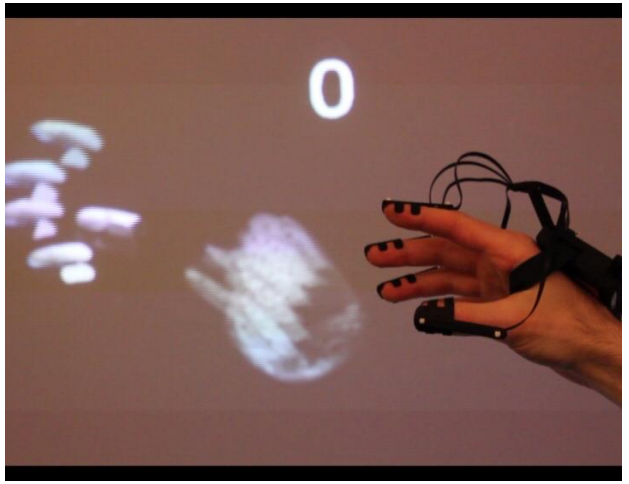
- Device: A.R.T. Fingertracking-CD (CD = Collision Detection)
  - Standard A.R.T. Fingertracking Device equipped with Electrodes around the Finger Tips Measuring the Skin Resistance between Finger and Thumb
  - 5 Bit Analog-Digital Converter (32 different Values; Range: 0 .. 1; Step SIze: 0.033)

- Mapping Real Hand → Virtual Hand:
  - Real Hand = Virtual Hand

- Force Applied:

$$F = F_{CD}$$



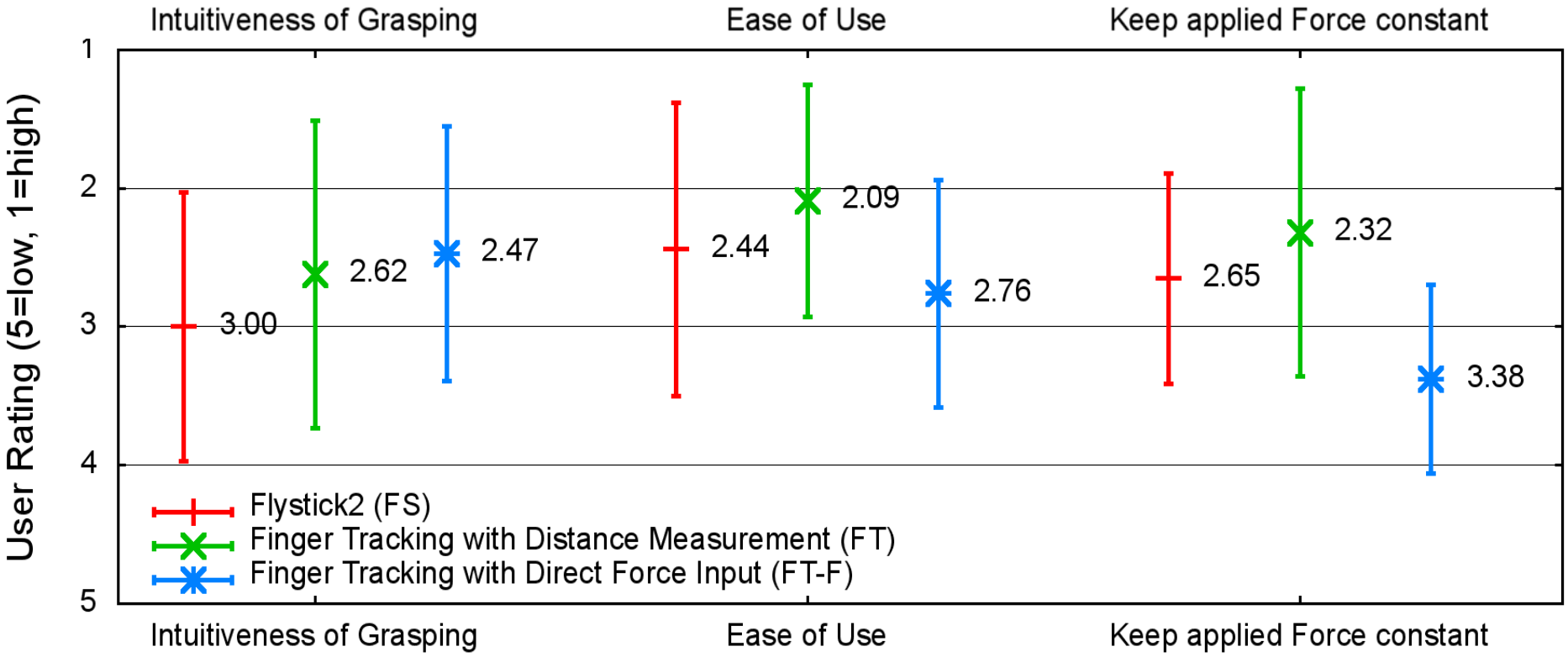


Measures

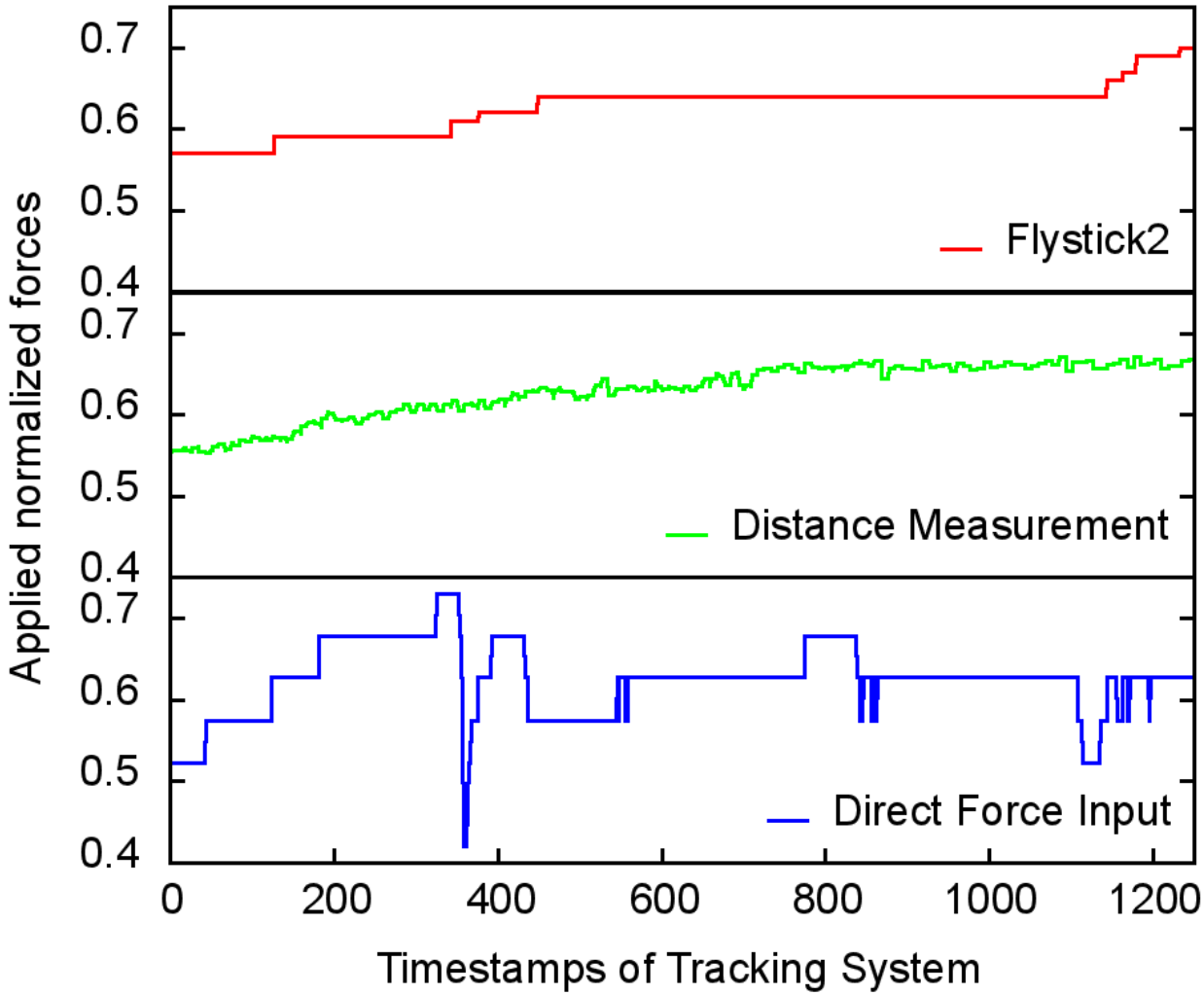
- Summative User Study
  - Quantitative Part: Measure applied Force over Time
  - Qualitative Part: Questionnaire (12 Questions)

- Main Focus
  - Task Performance
  - Ease of Use
  - Intuitiveness
  - Preference of Interaction Method

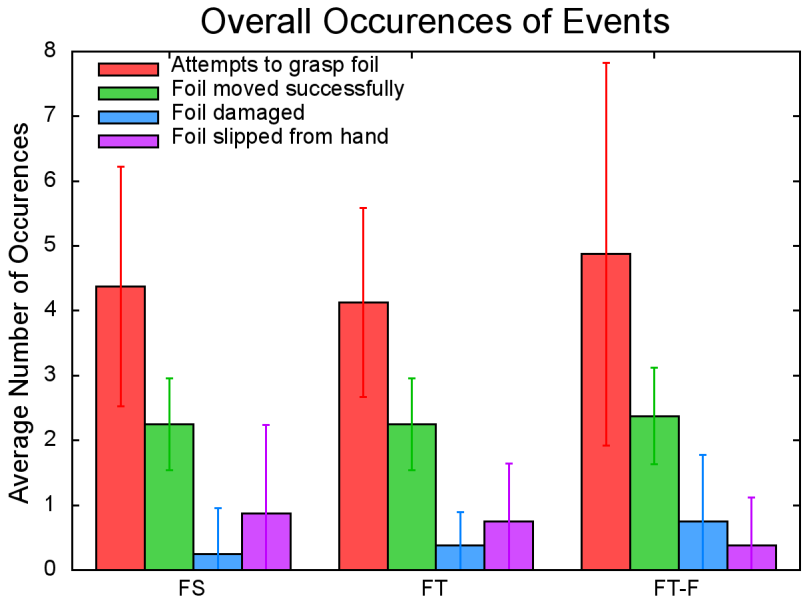
Results (I) - Questionnaire



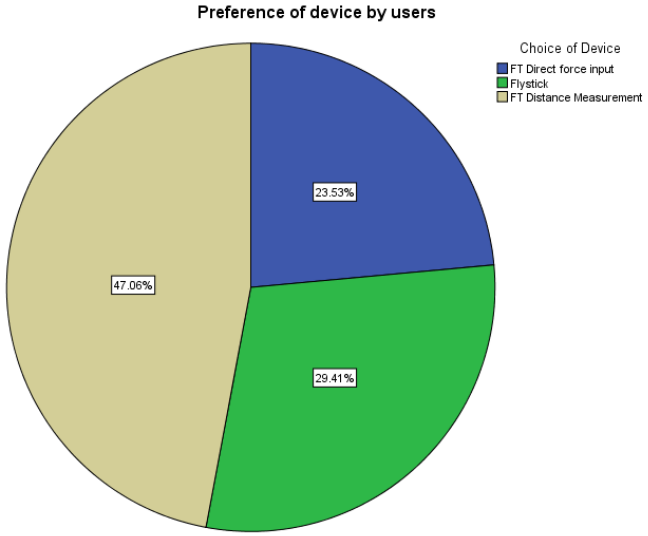
Results (II) – Applied normalized Forces



Results (III)



- **Task Performance:**
  Performance of Direct Interaction Methods using Fingertracking and Indirect Interaction Method using the Tracked Joystick is comparable.



- **Preference of Device:**
  - ~47% prefered Flystick2
  - ~70% prefered Direct Interaction Methods
  - If the Range of Fingertracking with Collision Detection would have been bigger, ~70% would use the Pinching Method for solving the task again.

Conclusion

- **Purpose:**
  Explore the potential and benefits of direct and indirect interaction methods for the specific task of grasping and manipulating a thin force sensitive deformable virtual object within an immersive VE.

- **Challenge:**
  Find an appropriate interaction method that trains the user about the fact of gently grasping and moving it without damaging it, while still supporting all other object interactions required in the training simulator.

- **Conclusion:**
  Finger tracking as a direct interaction method is suitable for this task.

Thank you!
Questions?