Kinesthetic Teaching is the most **Intuitive and Efficient** Way to Record Robot Learning Data in **Augmented Reality** Scenario!

A User Study on Augmented Reality-Based Robot Learning Data Collection Interfaces

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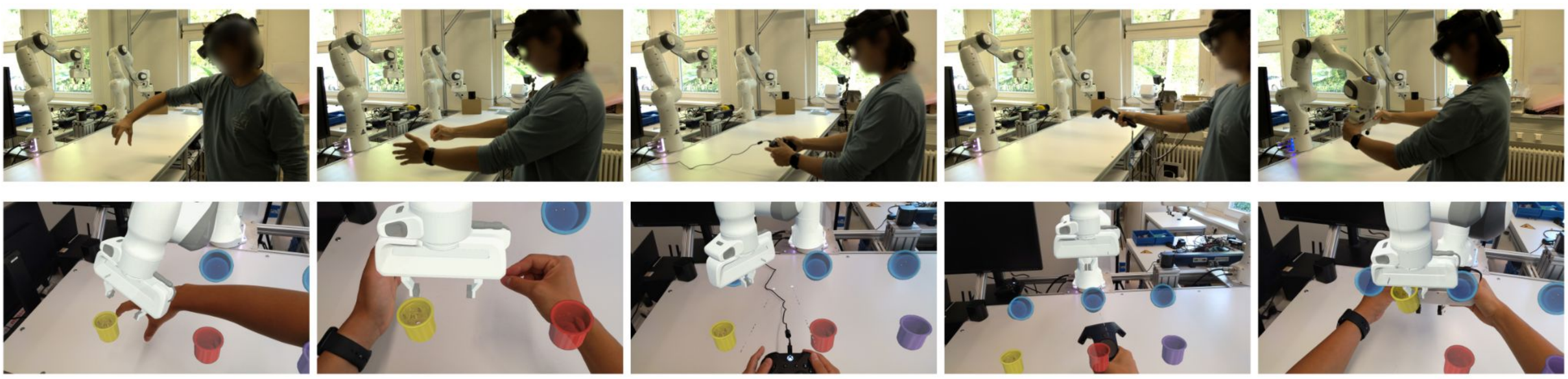
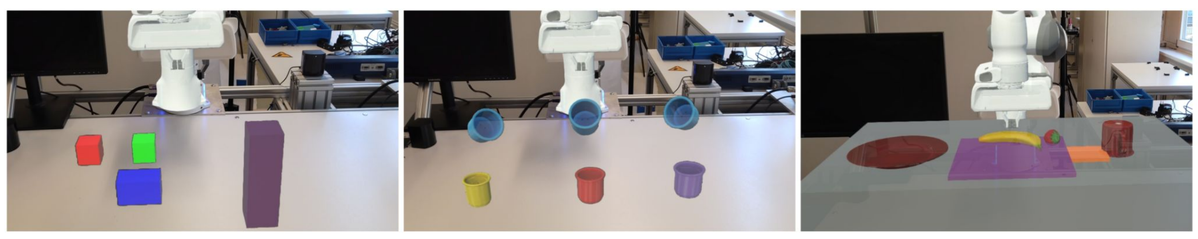
Five Augmented Reality-Based Interfaces for Evaluation



Hand Tracking (HT) | Virtual Kinesthetic Teaching (VK) | GamePad (GP) | Motion Controller (MC) | Kinesthetic Teaching (KT)

Virtual ⟵ ⟶ **Real**

Tasks for User Study



Box Stacking
Basic Pick and Place

Cup Inserting
Flexibility and Precision

Practical Manipulation
Comprehensive Manipulation

Procedure of User Study

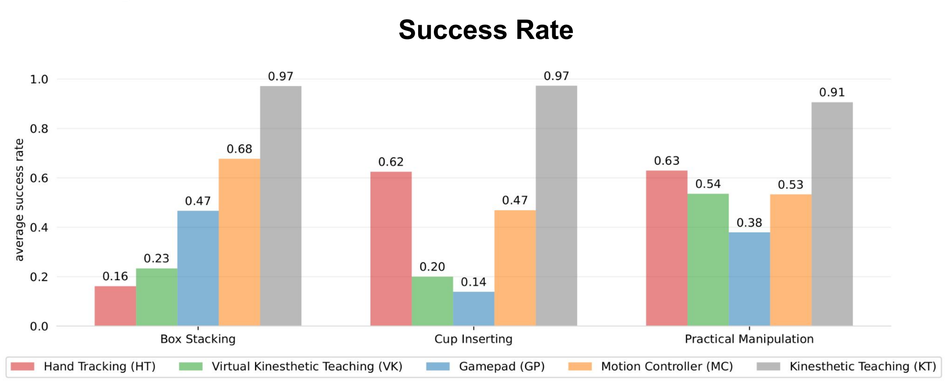
- **Background Questionnaire**
  - Investigate the participants' experience about robots, GamePad, AR devices.
- **Task Conduction**
  - Each participant conduct one task for three times.
  - **Success Rate**, **Task Completeness**, and **Task Completion Time** were recorded.
  - Participants need to finish task within time limit.
- **Interface Assessment Questionnaire**
  - Six scales from **UEQ+** including **Attractiveness**, **Efficiency**, **Perspicuity**, **Dependability**, and **Novelty** to evaluate the usability of each interface.

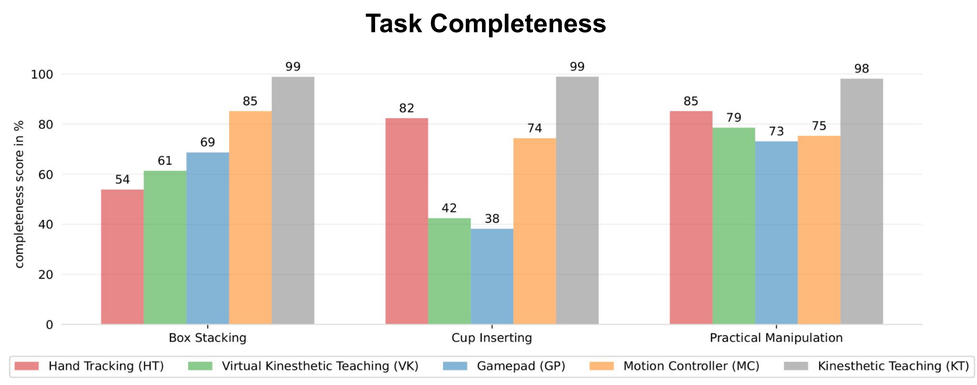
User Study Result

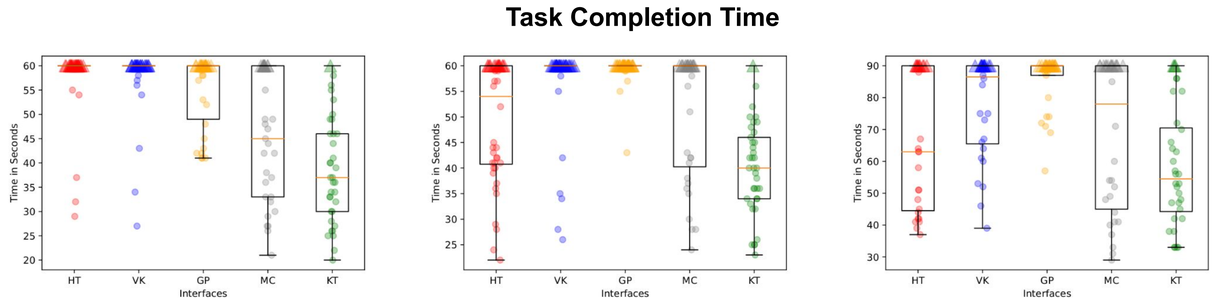
*from **35** participants and **483** valid human demonstrations collected from them*

- **Kinesthetic Teaching** emerged as the most potent interface for high-precision motion control and a consistently high success rate.
- **Motion Controller Interface** has proven to be both efficient and user-friendly.
- **Hand Tracking** exhibits substantial potential as an interface for robot interaction.
- **Virtual Kinesthetic Teaching** represents an innovative approach to robot interaction.
- **Gamepad** interface presents an economical option for robot data collection.

Objective Metrics via Task Performance

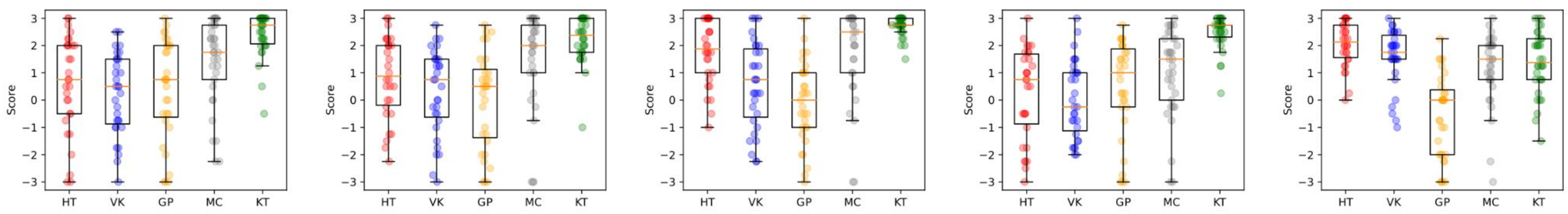






(a) Task 1 (b) Task 2 (c) Task 3

Subjective Metrics via Interface Assessment Questionnaire



(a) Attractiveness (b) Efficiency (c) Perspicuity (d) Dependability (e) Novelty

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Intuitive Robots Lab

Autonomous Learning Robots Lab

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