UNIVERSITÄT SIEGEN

Real-time motion tracking for human and robot in a collaborative assembly task

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FAMS Fertigungsautomatisierung und Montage

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Motivation

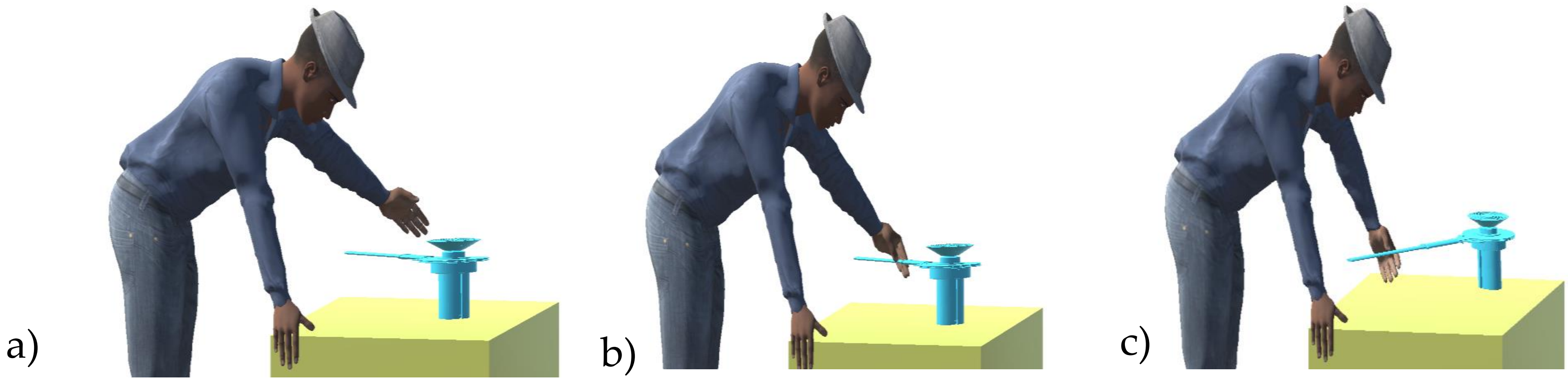


Fig. 1 Motion planning: a)reach, b)grasp c)apply force

Fig. 2 Robot control: i) Real-time robot control using ROS-Industrial, ii) Virtual simulation and visualization for pick and place operation

[ii] Source: https://rosindustrial.org/news

Introduction

- How is the human-robot collaboration in assembly operations?
- Is a physical human-robot collaboration safe?
- How is the disribution of motions in assembly tasks? E.g., pick– reach – join – apply force.
- Does accurate motion tracking improve collaboration of human and robots?

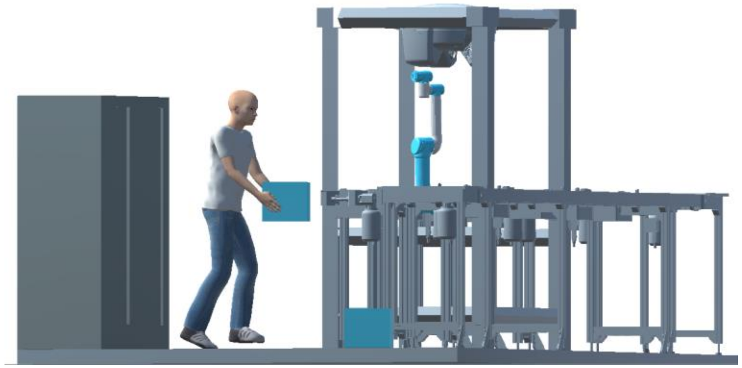


Fig. 3 Physical interaction modeling

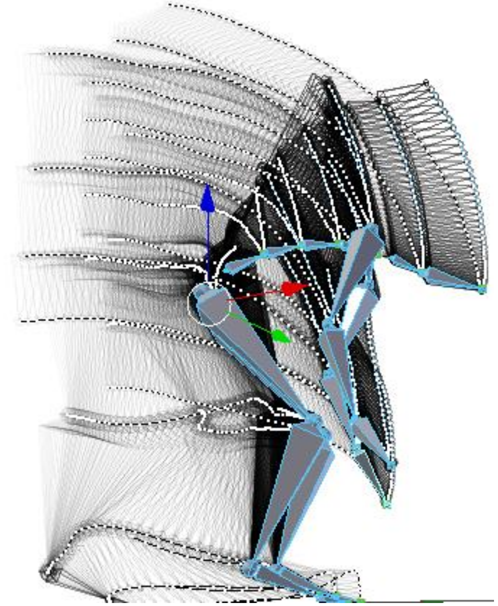


Fig. 4 Motion tracking and visualization

Objective

- In this work, our task is to **investigate a method to implement a simplified and decentralized motion tracking using a consistent file exchange format both for human and robot models in real-time using low-cost motion capturing systems**.

- In this context, we implemented digital models for both human and robot that applies a kinematic model to control the movement of the human and robot skeletons.

- We combined robot joint motions and human motion in a single intuitive graphical interface to track motions using sensory systems easily.

i. Human motion modeling

(a) (b) (c)

Fig. 5 Tracker assignment and orientation alignment for human motion tracking using HTC Vive trackers (9 trackers are used): (a) Trackers fixed on human body parts; (b) a digital human model (c) a skeleton control and joint locations.

ii. System configuration and interfacing

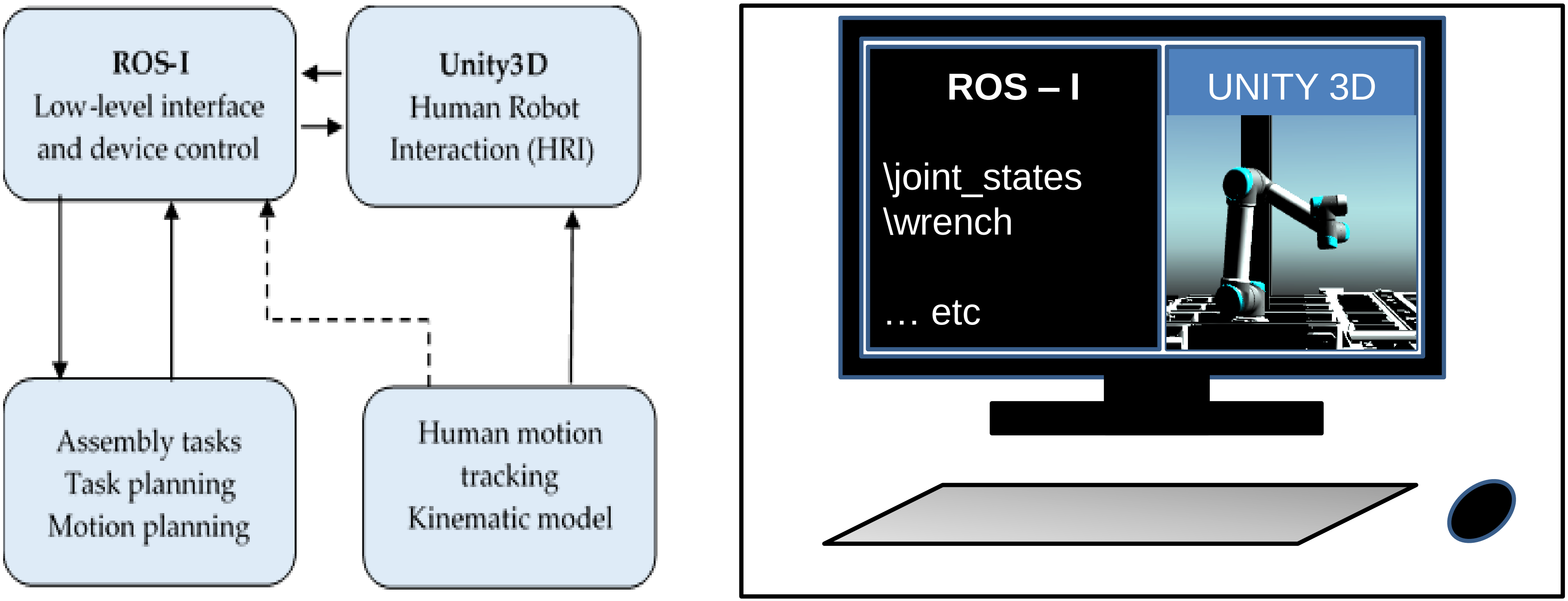
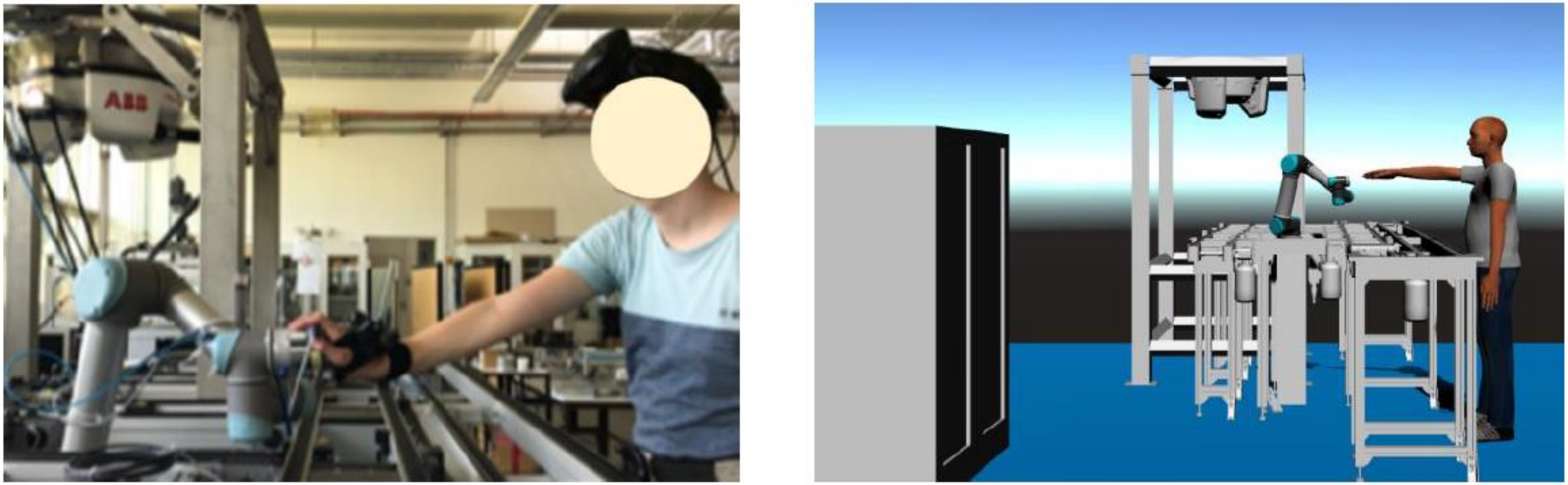


Fig. 6 System configuration for ROS-I and Unity3D based assembly process planning and control; Software framework (The dashed lines show an alternative configuration

iii. Experimental set-up and motion capturing



(a) (b)

Fig. 7 The concept for virtual simulation and real-time motion tracking for collaborative human-robot assembly tasks; (a) Experimental design for assembly tasks using human-robot collaboration; (b) Unity3D environment showing system configuration and practical realization.

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Table 1. Motion assignment and task descriptions

Motion type	Human	Robot
Reach	The human arm will reach to the robot tool center position	It moves from the home position to the desired position
Join	The human arm will move part two to align its orientation with part one.	It waits for joining processing
Apply force	A force will be applied to assemble the parts by force-fitting	It waits for joining processing
Release	The human hand releases the part	It waits for the process
Move	The human arm retracts back to the object position	It moves the assembled part to the handling area.

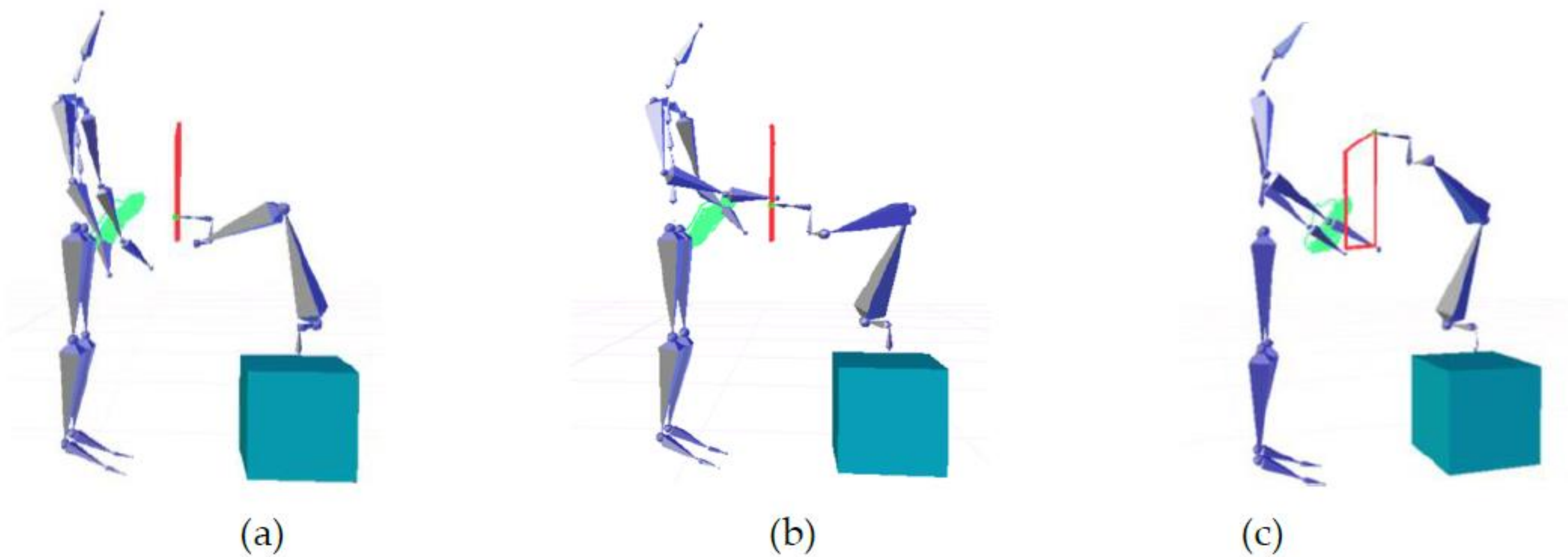
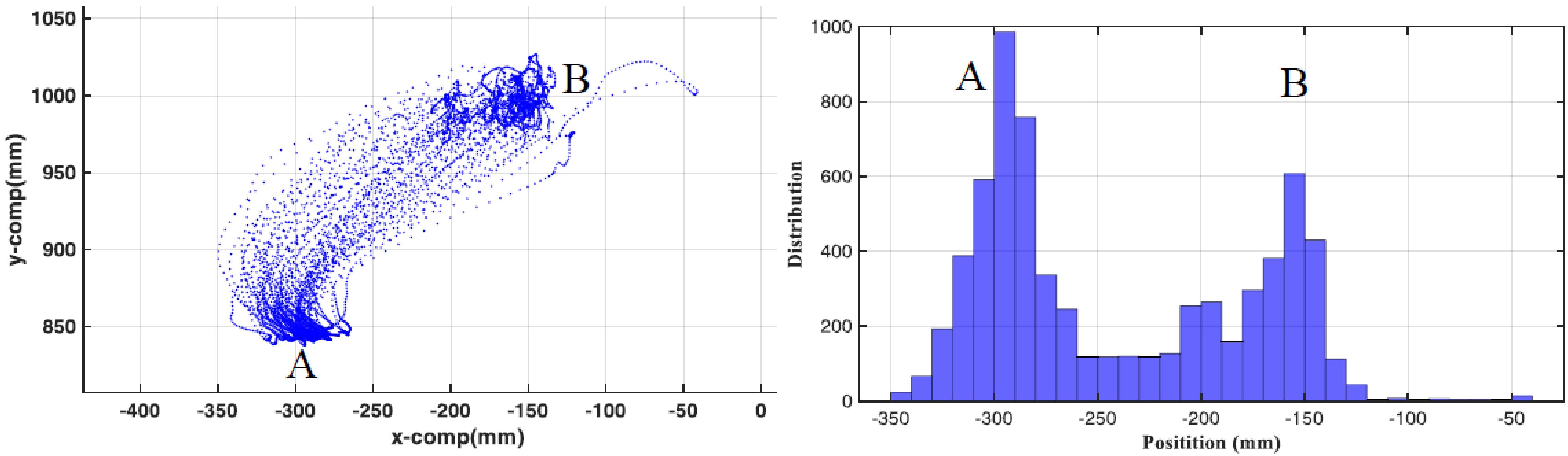


Fig. 8 Motion parameterization for human-robot collaboration; (a) Wait for the robot until it reaches the defined position; (b) The human arm extended to reach the robot tool center position; (c) The robot moves the object to the target position using a square path. The red color shows the robot path and the green lines show the wrist path.



(a) (b)

Fig. 9 Wrist path for 50 steps. (a) Projection of XY-components for human arm motion; (b) Distribution of the x-component

Discussion

Overall,

- Conceptual development for real-time motion tracking in assembly tasks, particularly for human-robot collaboration.
- Decentralized system control for a real-time process using ROS-I and Unity3D.

Our contribution is;

- A generic model controllers for human and robot motion tracking using a kinematic tree structure.
- A consistent motion capturing formats and exchanges are investigated.
- Similarly, the capability of low cost and commercially available gaming equipment such as HTC vive is tested.
- Lastly, a single operating system (i.e. Linux (Ubuntu 18.04)) is used to run both ROS-I and Unity3D systems. In this configuration a concept of an assembly process is described into ***reach – join – apply force – release – move*** motion types are defined to be executed by the human and robot.

A real-time robot control using input motion trackers will be considered in the future work.

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