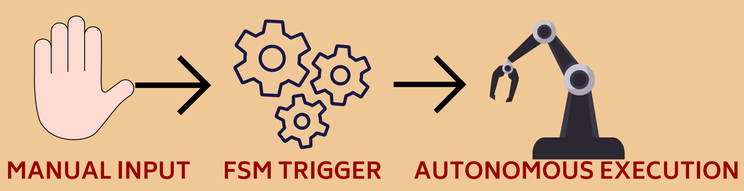
SHARED AUTONOMY IN ROBOTIC TELEOPERATION: ENHANCING HUMAN-CENTERED INTERACTION VIA NATURAL USER INTERFACES

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BACKGROUND & MOTIVATION

Human-Robot Interaction (HRI) increasingly relies on Natural User Interfaces (NUIs), such as gesture tracking, for intuitive control. However, continuous direct manipulation often causes tracking noise, poor precision, and high physical fatigue, commonly known as the "gorilla arm effect". Our research objective is to relieve the user's cognitive and physical burden by strategically transferring high-precision, time-sensitive tasks to the robot's onboard intelligence



METHODOLOGY & IMPLEMENTATION

The system was developed within the Webots simulation environment. For tracking and processing, the MediaPipe framework extracts wrist coordinates via a webcam, which are then smoothed by an Exponential Moving Average (EMA) low-pass filter to eliminate high-frequency jitter. Control is dictated by a 4-state Finite State Machine (FSM) implementing shared intelligence. The user provides manual guidance until a spatial threshold triggers autonomous grasping, bypassing user input. The robot then performs a protected transit to minimize failure risk and autonomously releases the object at the target.

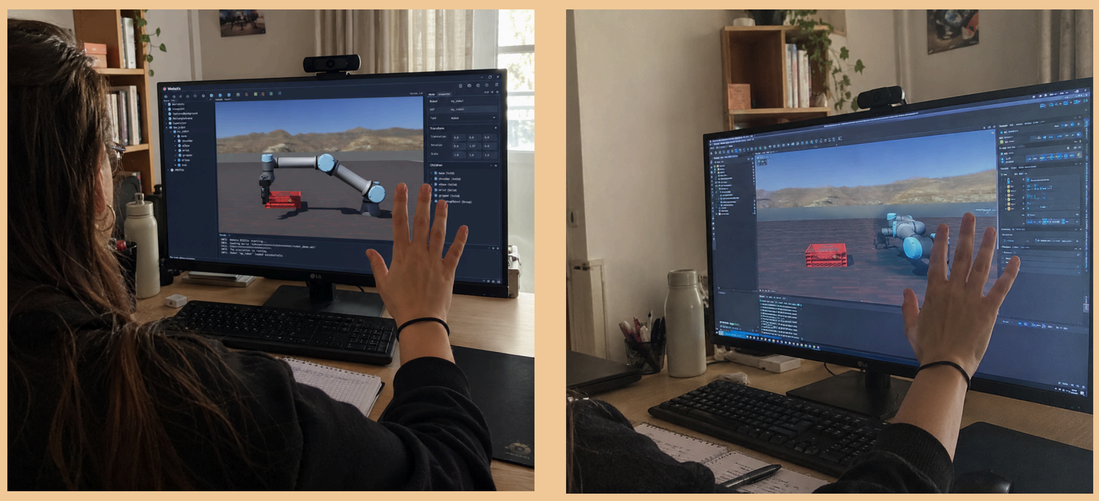
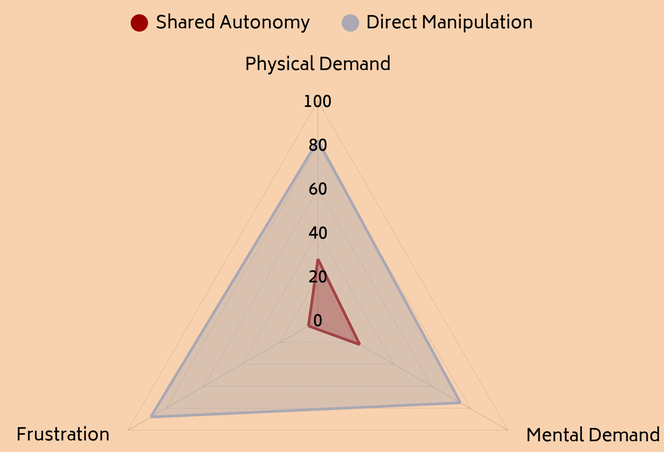
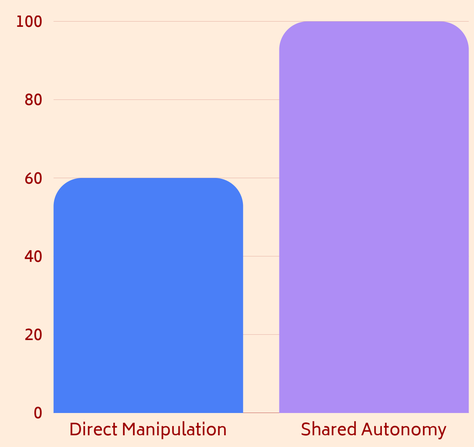


FIGURE 1: USER INTUITIVELY CONTROLLING THE WEBOTS SIMULATION VIA MEDIAPIPE HAND GESTURE TRACKING

EXPERIMENTAL EVALUATION & RESULTS

A within-subjects experiment (n=4) compared Level 2 Direct Manipulation against Level 3 Shared Autonomy in a pick-and-place task. In terms of efficiency, shared autonomy reduced the Task Completion Time (TCT) by 63.1%, dropping from 56.4s to 20.8s. Reliability also vastly improved, with the task success rate increasing from 60% to a perfect 100%. Furthermore, NASA-TLX evaluations revealed drastic reductions in user workload: physical demand dropped from 82 to 28, mental demand from 75 to 22, and frustration from 88 to a near-zero score of 5 out of 100.





IMPACT & FUTURE DIRECTIONS

Shifting the human role from a micro-manager to a macro-supervisor significantly enhances both system efficiency and user comfort, demonstrating a sustainable approach to human-centered design. Future work will explore adaptive autonomy, utilizing Machine Learning to dynamically adjust robot autonomy based on real-time signal jitter and user fatigue inference. Additionally, we aim to integrate multi-modal semantic fusion by combining LLMs for voice-command disambiguation with gestural tracking.

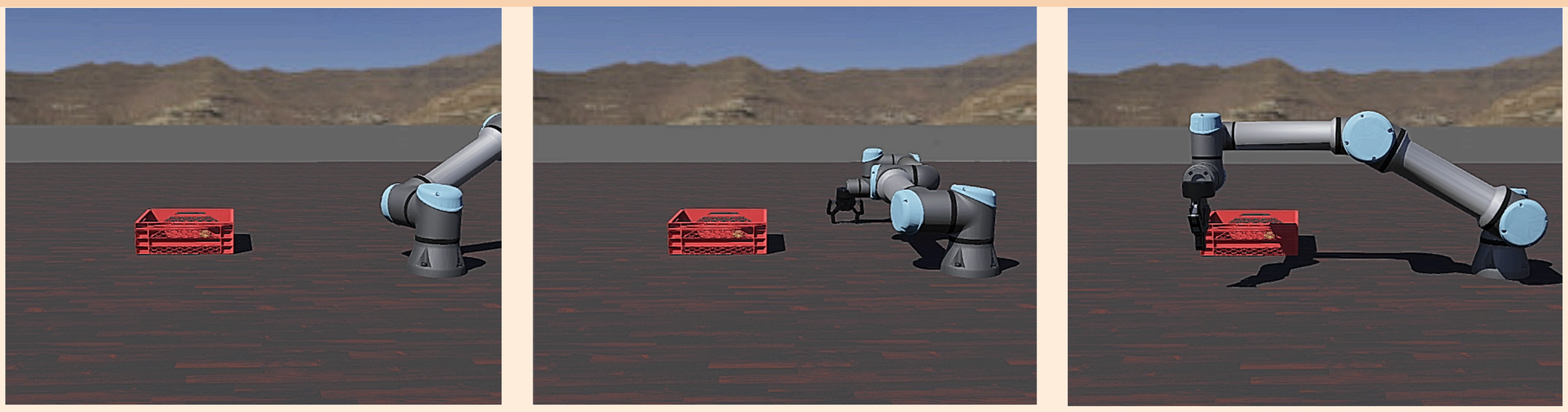


FIGURE 2: SEQUENCE OF THE AUTONOMOUS GRASPING AND PROTECTED TRANSIT PHASES

SCAN TO EXPLORE: REPORT, VIDEO & PROFILE