TelePreview: A User-Friendly Teleoperation System with Virtual Arm Assistance for Enhanced Effectiveness

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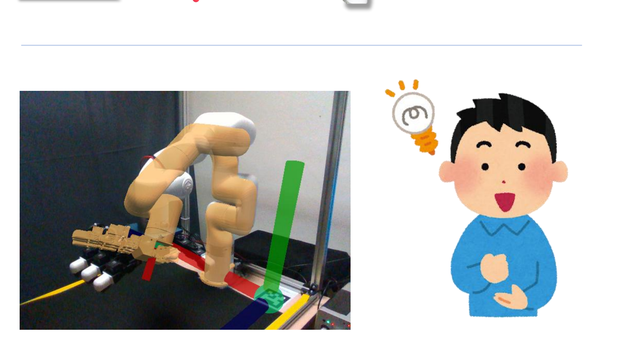
ICRA ATLANTA 2025
IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION

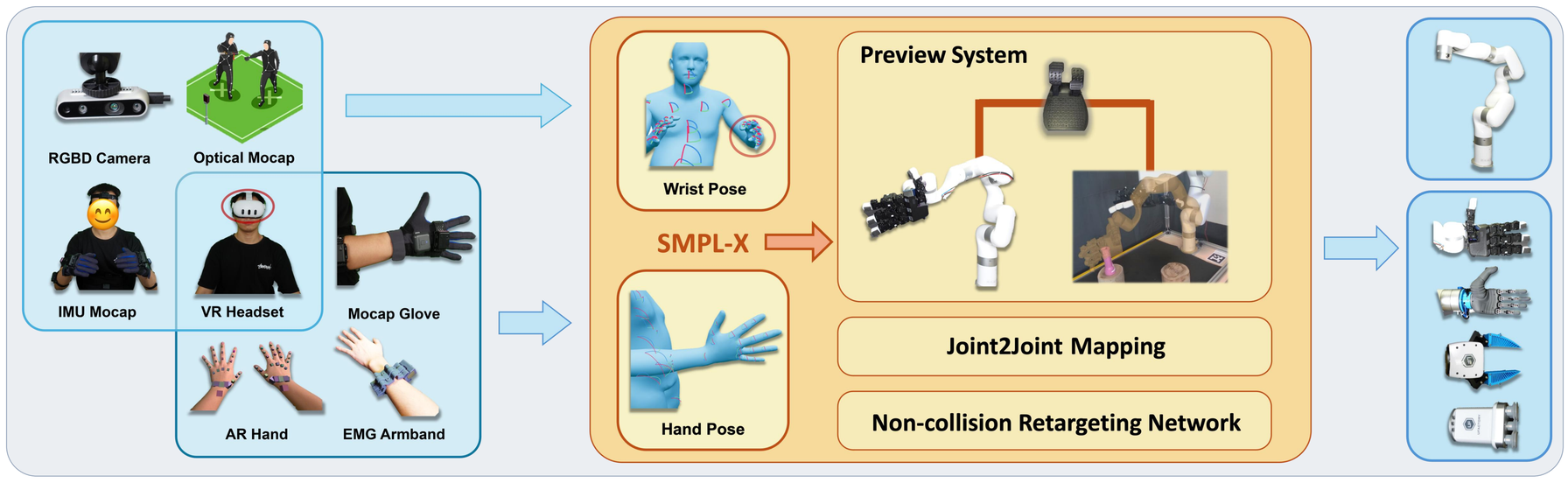
Motivation

Teleoperation serves as a powerful method for collecting on-robot data essential for robot learning from demonstrations. The intuitiveness and ease of use of the teleoperation system are crucial for ensuring high-quality, diverse, and scalable data.

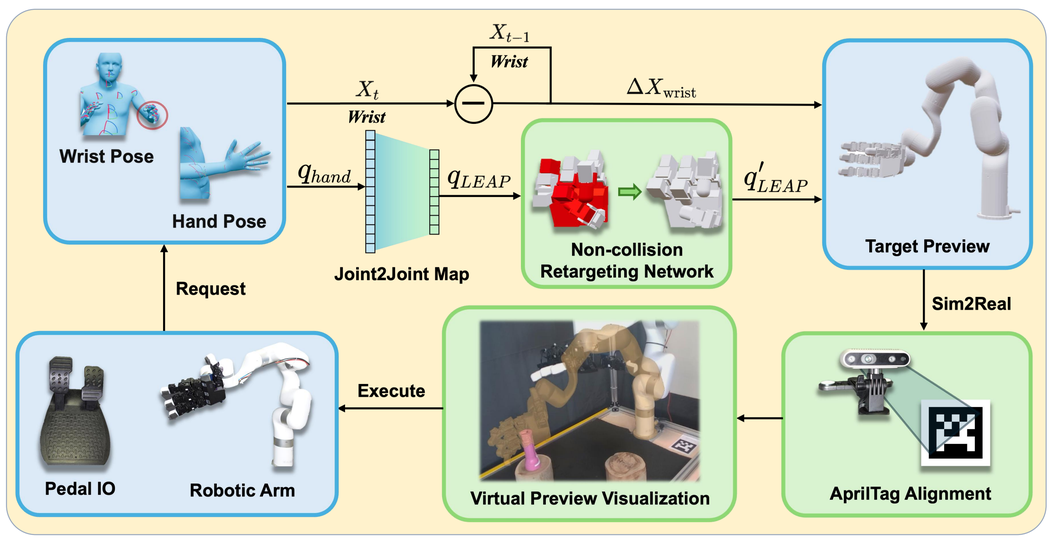
However, Teleoperation systems lack intuitive feedback to help operators understand how their commands will translate into robot actions.



Framework



Workflow



Framework Overview: TelePreview includes (1) diverse input devices (e.g., RGB-D, IMU suits, VR/AR, EMG) to capture motion; (2) a processing pipeline using SMPL-X, joint mapping, and non-collision retargeting to generate robot-ready poses; and (3) support for various robot platforms.

Workflow: User wrist and hand poses are mapped to robot joints via SMPL-X-based processing. A visual preview ensures safe, accurate execution. AprilTag calibration aligns virtual and real robots.

Contribution

Interactive Visual Assistance: A preview interface improves teleoperation accuracy and usability for all users.
Low-Cost System: High-performance setup using inertial mocap and gloves for under $1,000.
Easy Hardware Adaptation: Adapts to new devices by tuning a few interpretable parameters.

Experiments

Task	TelePreview	Open Teach [1]	AnyTeleop [3]	Telekinesis [32]
Pick & Place	**1.0**	0.8	**1.0**	0.9
Hang	**0.9**	-	-	-
Pour	**1.0**	0.8	0.7	0.7
Box Rotation	**1.0**	-	0.6	0.6
Cup Stacking	**1.0**	-	0.7	0.3

TABLE I: **Real Robot Teleoperation Results** We mark tasks they did not attempt or do not support with "-". Success rates for Open Teach [1] reflect expert performance.

Task	Success Rate			Average Success Execution Time (s)		
	w/o preview	w/ preview	Difference ↑	w/o preview	w/ preview	Difference ↓
Pick & Place	0.6	1.0	**+0.4**	23.56±4.65	13.55±3.17	**-10.01**
Hang	0.6	1.0	**+0.4**	29.30±8.18	30.83±3.65	+1.53
Pour	0.9	0.8	-0.1	43.20±6.73	36.13±5.86	**-7.07**
Box Rotation	0.6	0.8	**+0.2**	30.47±14.08	19.12±3.32	**-11.35**
Cup Stacking	0.5	1.0	**+0.5**	31.54±6.04	18.91±1.29	**-12.63**

TABLE II: Effect of Preview Assistance on New User Performance.

End-Effector	w/o Preview	w/ Preview	Improvement
LeapHand (16-DoF) [10]	23.6 ± 4.7	13.6 ± 3.2	-10.0
Parallel-jaw Gripper (1-DoF)	16.8 ± 1.7	14.2 ± 1.4	-2.6
Vacuum Gripper (binary)	15.2 ± 1.9	13.7 ± 1.3	-1.5

TABLE III
GENERALIZABILITY ACROSS END-EFFECTORS.

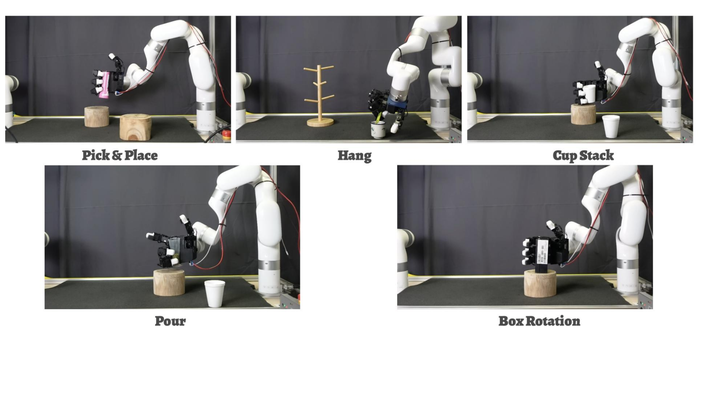


Table I — Performance vs. Baselines:
TelePreview achieves near-100% success on fine-grained tasks, outperforming OpenTeach, AnyTeleop, and Telekinesis—especially on complex tasks like **Hang**, where others failed.
Table II — New User Benefit:
Preview mode boosts success rates and reduces execution time for novices. In **Cup Stacking**, success rose from 50% to 100%, and time dropped by 12.6s.
Table IIII — Hardware Adaptability:
TelePreview improves performance across various end-effectors, with the largest gain on a 16-DoF robotic hand—showing strong generalizability to new platforms.

Conclusion

TelePreview offers a low-cost, high-precision teleoperation system with visual preview. It outperforms existing methods, helps new users succeed faster, and generalizes well across hardware—making advanced teleoperation more accessible and reliable.

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