Teleoperation of a Humanoid Robot Using a Motion-Tracking Suit

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Vrije Universiteit Amsterdam

PROBLEM

- Traditionally: joysticks, keyboards, or complex coding
    - Challenges: non-intuitive that require significant learning and practice

- Natural human body movements as inputs -> more intuitive approach [1]
- Motion-tracking suits and vision-based systems
    - A gap in research exists in their comparative performance

[1] K. Darvish, L. Penco, J. Ramos, R. Cisneros, J. Pratt, E. Yoshida, S. Ivaldi, and D. Pucci, "Teleoperation of Humanoid Robots: A Survey," arXiv:2301.04317 [cs.RO], 2023.

RESEARCH QUESTION

"In terms of usability and motion accuracy, how does a motion-tracking suit system perform relative to a 2D vision-based system in the context of real-time teleoperation of a humanoid robot?"

METHODOLOGY & IMPLEMENTATION

MOTION DATA CAPTURE

Utilize a Perception Neuron 32 motion-tracking suit to capture motion data.

DATA PROCESSING

Process the captured motion data in the corresponding software Axis Neuron to obtain BVH data. Use socket programming to Python module.

JOINT ANGLE MAPPING

Process joint angles in the corresponding head, shoulders, elbow, and hand modules.

ROBOT INTERFACE

Map the processed values to the NAO robot for teleoperation using NAOqi.

EVALUATION

JOINT COMPARISON

- Four positions
- Reference robot vs. Controlled robot
- Mean Square Error

PARTICIPANT EXPERIMENT

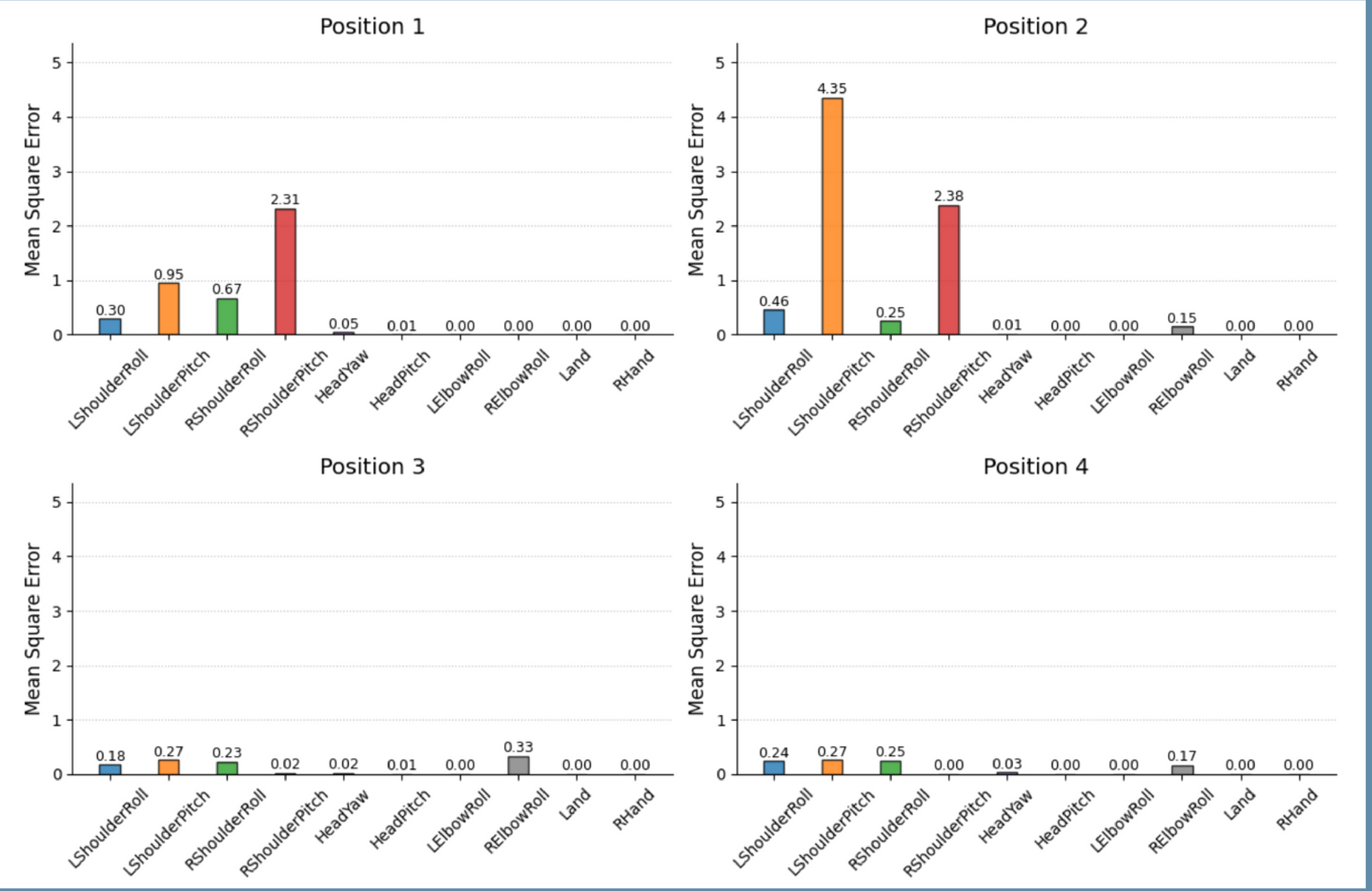
- 10 participants
- Motion-tracking suit vs 2D Video-based [2]
- Reference robot
- Five tasks + free mode
- Questionnaire
- Wilcoxon score and IQR

[2] M. B. Kucuk, "Humanoid Robot Control from Human Joint Angles via 2D Camera," B.S. thesis, Dept. Computer Science, Vrije Universiteit, Amsterdam, Netherlands, 2022.

RESULTS
DEMO

RESULTS
JOINT COMPARISON

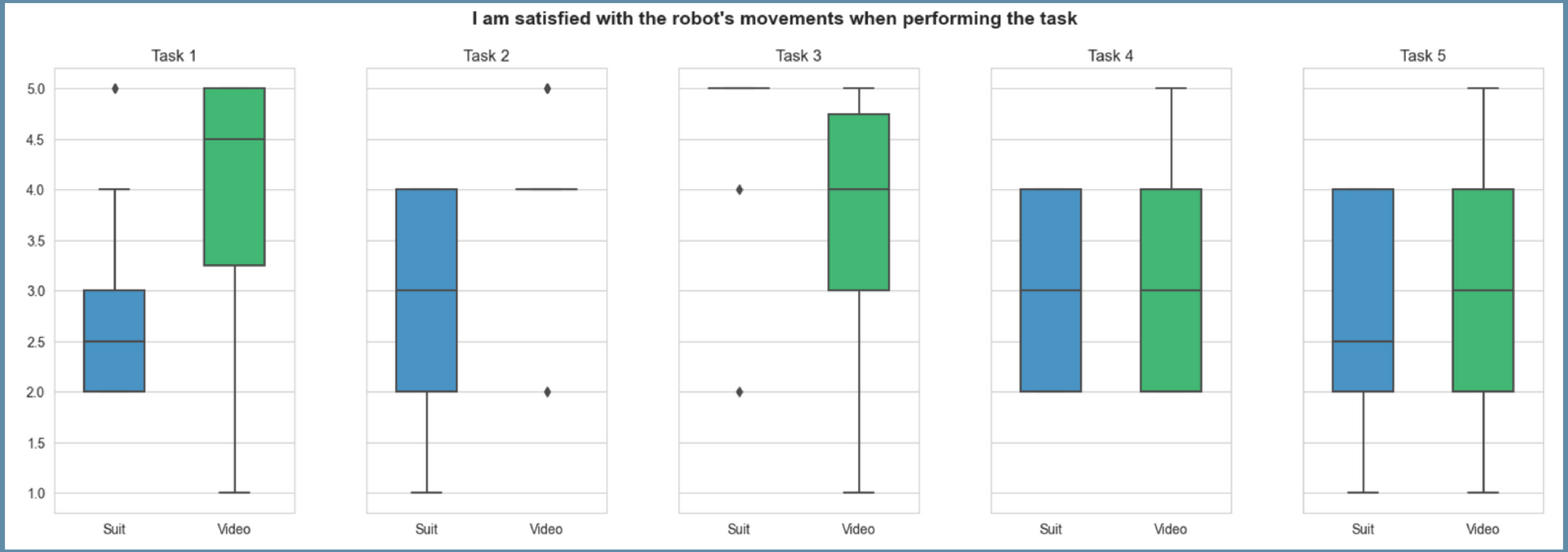
- Position 1: Arms to the side
- Position 2: Arms to the front
- Position 3: Head turned left
- Position 4: Head turned downwards



RESULTS
PARTICIPANT EXPERIMENT

- Task 1: Arms to the side, up, down
- Task 2: Arms to the front, up, down
- Task 3: Head movements
- Task 4: Elbows flex/extend
- Task 5: Arms and elbows

Task	Wilcoxon Statistic	p-value
Task 1	8	0.0825312
Task 2	0	0.0157641
Task 3	3	0.0310325
Task 4	16	0.77283
Task 5	21.5	0.904436



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- Task 1: Arms to the side, up, down
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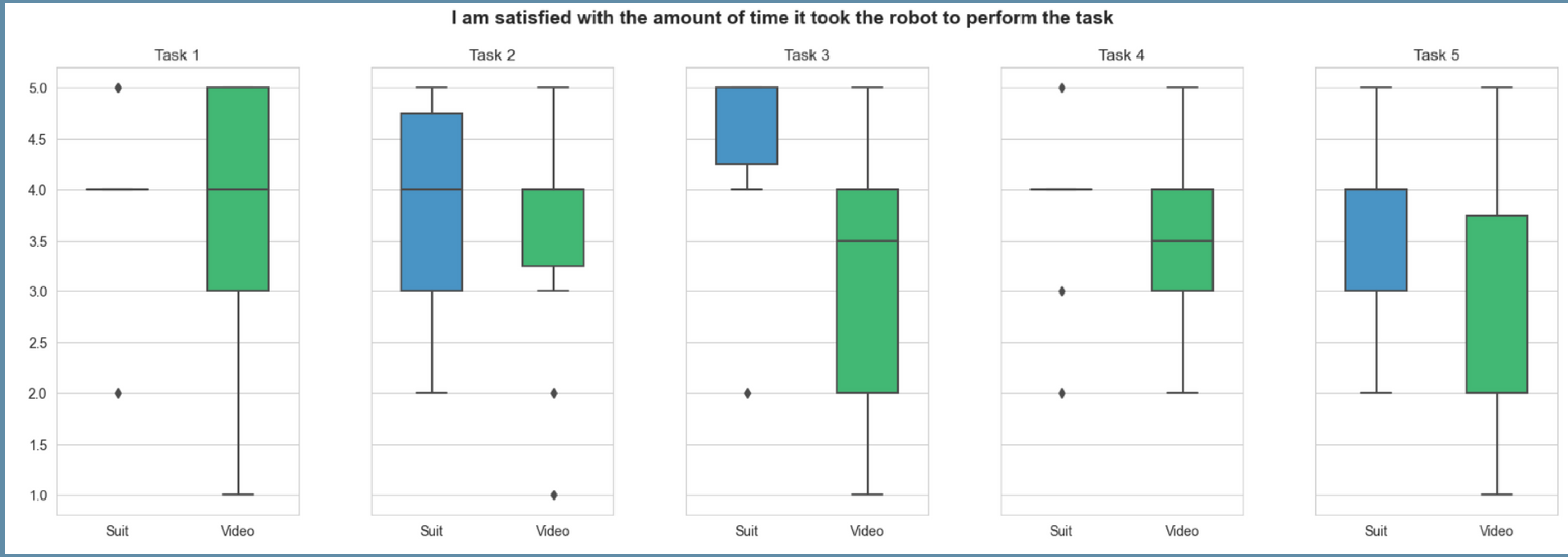
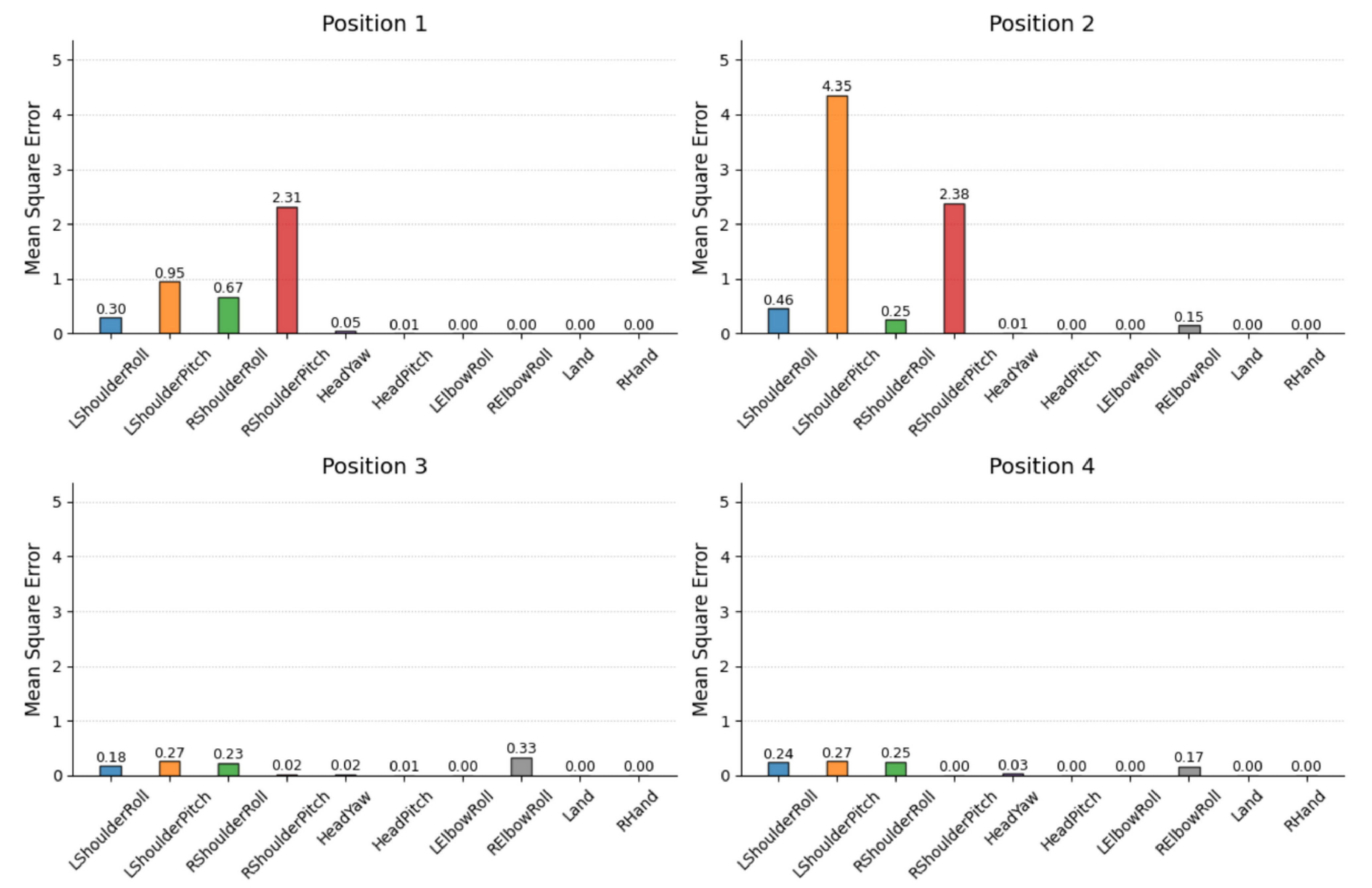
Task	Wilcoxon Statistic	p-value
Task 1	15.5	0.719264
Task 2	17.5	0.941627
Task 3	3.5	0.0200419
Task 4	11.5	0.350642
Task 5	6	0.0457979



DISCUSSION

JOINT COMPARISON

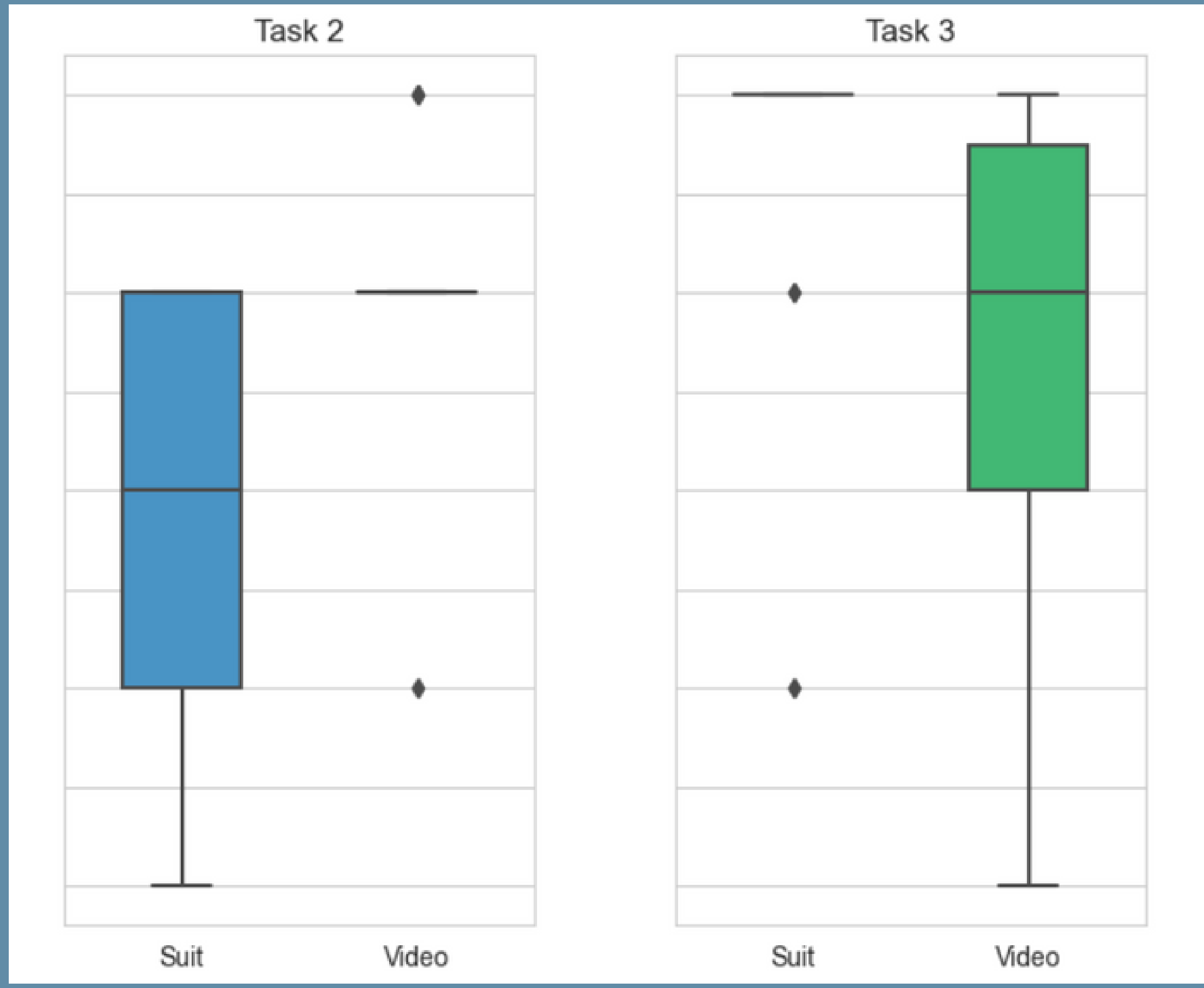
- Shoulder implement. issues in motion-tracking suit
- Possible reasons:
  - Axis modifications
  - Incorrect range parameters



DISCUSSION

MOTION SATISFACTION

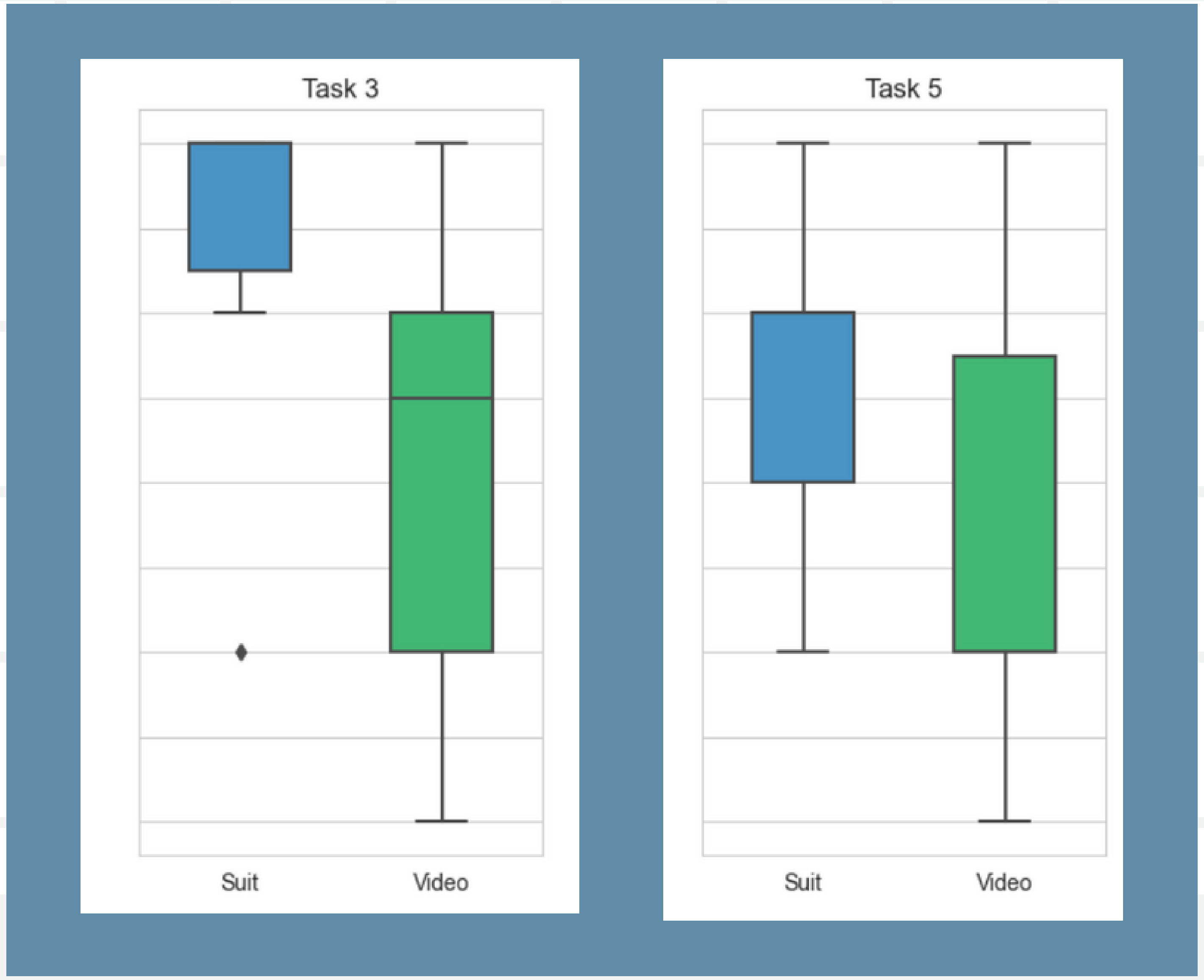
- Task 2: Lower scores in suit system → Shoulder issues
- Task 3: Consistent scores in suit system → Functional head joint
- Task 3: Inconsistencies in 2D system → Difficulties in head detection



DISCUSSION

LATENCY

- Task 3: High scores in suit system → Functional head joint
- Task 3: Wide scores range in 2D system → positioning time
- Task 5: Large ranges in both systems.



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- Superior motion satisfaction → 2D vision-based system
- Superior latency performance → Motion-tracking suit system

CONCLUSION

- Motion tracking suit offers shorter latency but faces challenges with shoulder joint interpretation
- The 2D vision-based system provides overall better motion satisfaction but struggles with head detection and latency
- No system is universally superior; performance depends on specific tasks and body parts
- The need to match system to application needs

FUTURE WORK

JOINT MAPPING

Further development of the joints to make the mirroring of movements more identical

FULL BODY WORK

Continue to implement entire body of NAO

INTERFACE

For the user experience, an interface to get a better grasp of the movements your performing

ADAPTATION FOR OTHER ROBOTS

Apply the system to other robots -> more applications possible

THANK YOU

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