Posture Estimation and Optimization in Ergonomically Intelligent Teleoperation Systems

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WHY ERGONOMICS IS A CONCERN IN TELEOPERATION?

Work-related musculoskeletal disorders:

- The second largest cause of disabilities worldwide
- Main contributor: awkward postures
- Continuous data collection and ergonomic assessment of human posture is tedious

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Teleoperation:

- Remotely control the **follower** robot using a **leader** robot
- An example of physical-HRI
- Teleoperation improves the ergonomics by the ability to design the remote workspace optimally

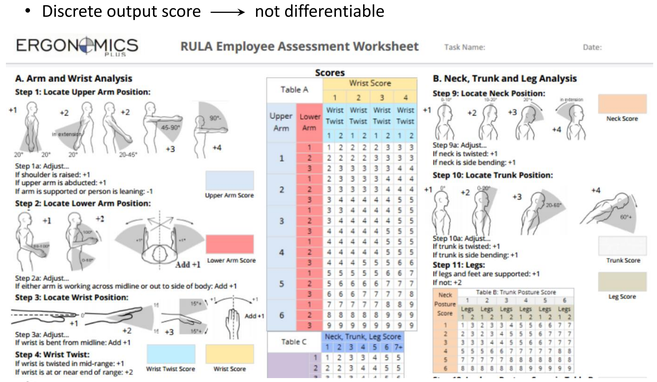
Da Vinci robot, by Intuitive Surgical

Still high rate of injuries among human teleoperator!

ERGONOMIC RISK ASSESSMENT

RULA risk assessment:

- RULA is the most common posture-dependent risk assessment tool
- Discrete output score ⟶ not differentiable

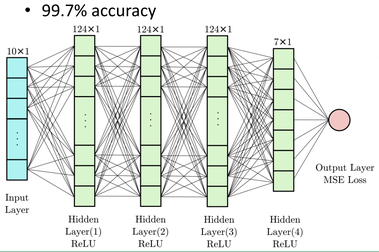


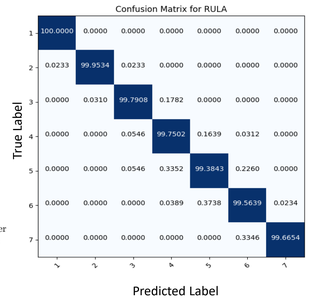
Courtesy of Ergonomics Plus

Learned a **continuous** & **differentiable** neural network model for RULA

Learning RULA score:

- 5-layer neural networks
- Regression with discrete labels
- 99.7% accuracy





SCAN ME

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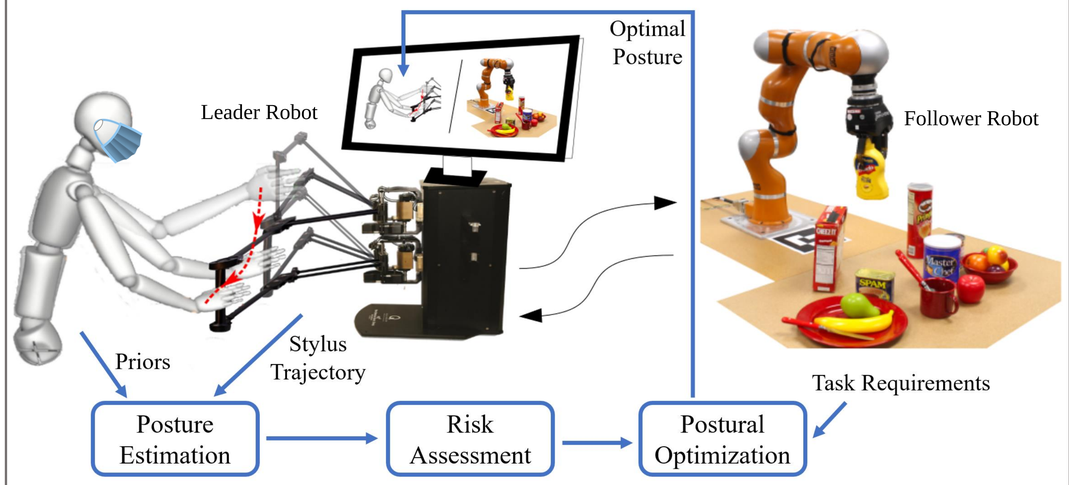
PIONEERS WORKSHOP 2021

ROBOTICS CENTER
THE UNIVERSITY OF UTAH

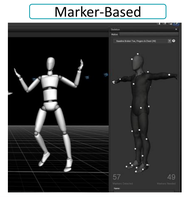
ERGONOMICALLY INTELLIGENT TELEOPERATION SYSTEMS

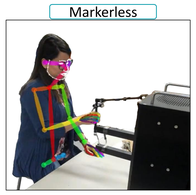


3D POSTURE ESTIMATION SOLELY FROM THE LEADER ROBOT

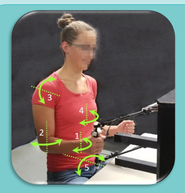
Vison-based posture estimation:

- Require extra sensor
- Setup & calibration
- Occlusion
- Sensitive to background light
- Sensitive to cloths
- Attach marker on body





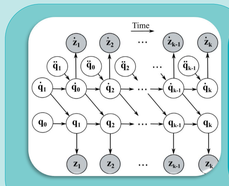
Use the **leader** robot as the **only** sensor for 3D posture estimation



Link Lengths Estimation

Circle Point Analysis

- Circular motion routines while holding the leader robot's stylus
- Estimate the radius of each motion



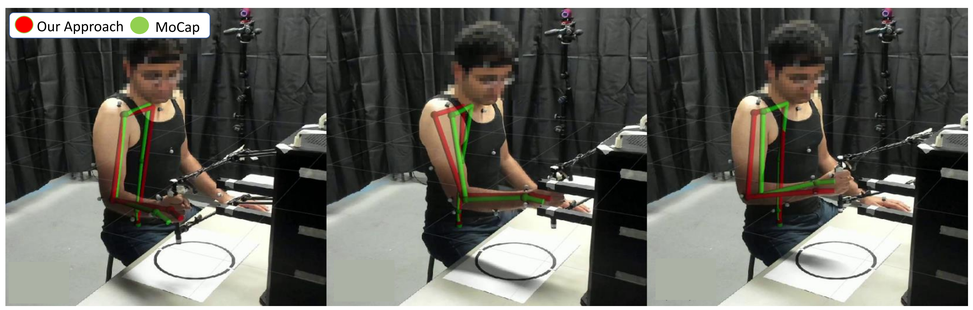
Joint Angles Estimation

Partially-Observable Dynamic System

- Particle filter for inference
- Pose-dependant range of motion
- Initialize around neutral posture

Posture estimation results:

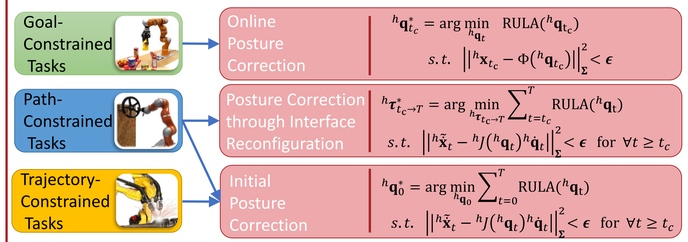
- Compared the posture estimation and RULA score from our approach vs. MoCap posture
- Less than 5deg median deviation and less than 15deg upper quartile deviation from Mocap
- %84 accuracy in RULA interpretation compared with Mocap



POSTURE OPTIMIZATION IN TELEOPERATION

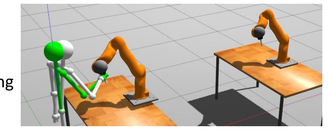
Optimal posture:

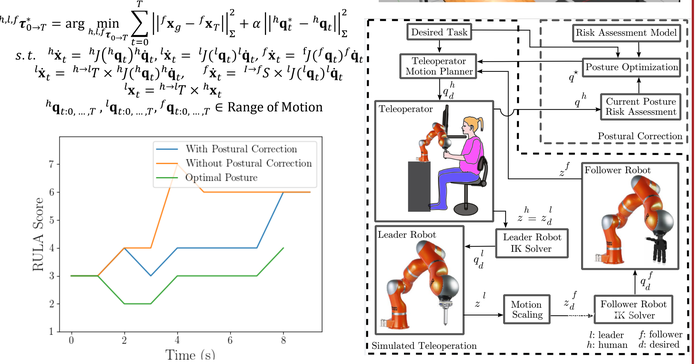
- Gradient-based solver: Sequential Quadratic Programming
- Gradient-free solver: Cross-Entropy Method



Teleoperation simulator:

- Simulation in Gazebo, including a human teleoperator simulator, and the robots
- Human teleoperator simulator:
  - Completes the teleoperation tasks
  - Applies the postural correction
  - Optimization planner with replanning

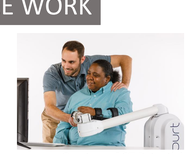




OTHER APPLICATIONS & FUTURE WORK

Applications:

- Other p-HRI tasks
- VR systems using pose of controllers
- Drivers holding steering wheel
- Assistive rehabilitations & exoskeletons



Courtesy of OT Potential

Courtesy of Facebook

Future work:

- Conduct a human subject study to evaluate our posture optimization methods
- Postural correction through motion rate control
- Compare the effectiveness of visual feedback vs. feedback through the leader robot

Courtesy of Honda Research Inst.

Peternel et al.2017

REFERENCES

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