

Computer Engineering Department

Robotics Laboratory

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Research Theme

Anthropomorphic Force-Reflective Master-Slave System

Motivation

- A light, anthropomorphic, back-drivable, transmission mechanism for telerobotics
- Fidelity and sensitivity to small force/torque feedback magnitudes
- Effective mechanisms, transparency, compactness, and low cost.

Approach

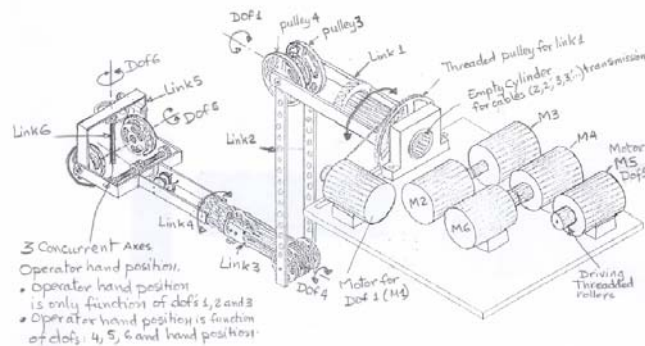


Figure 1: Anthropomorphic, 6 dof arm, without the driving cables

1. *Multiple Loop Transmission*

- Multiple Cable Pulley Loop mechanism (simplicity, maintainability)
- Each CPL is an independent system and can be locally maintained.
- A loop starts with a threaded roller at motor shaft
- Embedding the wire in the thread eliminates slippage
- Both ends of the rope are wrapped around the driven wheel
- Wire is wrapped 2 times to provide an acceptable range of motion
- In the final wrap, the rope is restrained from any slippage
- Pre-tensioning the wire is done independently for each loop
- High-speed, low tension cable until the last transmission stage where a high tension is used at the link level

2. *Backdrivable Mechanism*

- Low gear, light mechanism, minimal friction
- Decoupled rotative joints with no backlash due to the pre-tensioning
- Reducers are placed as close as possible to driven links.

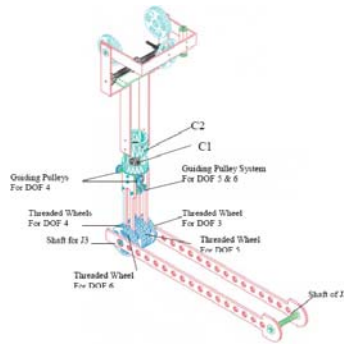


Fig. 2: Decoupled structure

3. Motor Grounding

- a. All motors are grounded to improve arm dynamics.
- b. Low friction cable routing structure within the first link for uncoupling (dof 1 and 4)
- c. The motor-link transmission is based on cable-pulley arrangement.

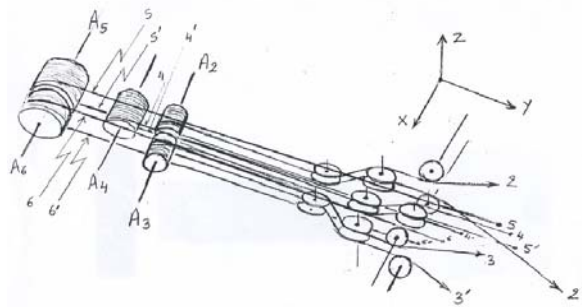


Figure 2: Threaded driving rollers and guiding system

4. Kinesthetic Force Feedback

- a. Anthropomorphic: direct position-force mapping to human arm
- b. Improved motion mapping: hand center at 3 concurrent rotation axes
- c. Low friction, low inertia, uncoupled dofs (3 Kgs arm weight)
- d. Kinematic model: rendering Cartesian position, display force, mapping hand to remote tool.

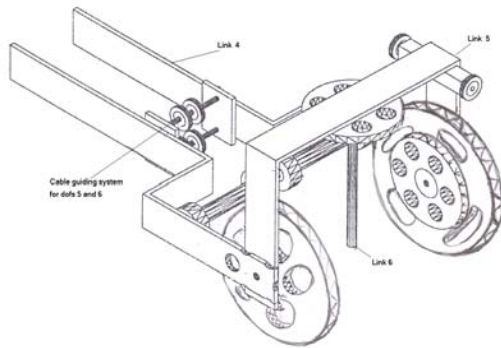


Figure 3: Hand center at the concurrency center of last three dofs