Johnson&Johnson
MedTech

Design Optimization Proposal for Enhanced Robotic Arm Responsiveness

1. Problem Statement

Identified Issues: actuator strain-sensor misalignment

1. **Actuator Strain**:
   - **Description:** Diagnostic images (Q2, Q4) show that the actuators at the rotate_joint are under excessive strain.
   - **Impact:** This strain causes the motor to perform sub-optimally, leading to increased response times (latency) and reduced component lifespan (durability).

1. **Sensor Misalignment**:
   - **Description:** Diagnostic images, indicate that the feedback sensors on the joint are misaligned.
   - **Impact:** This misalignment causes a delay in the feedback loop, forcing the control system to work with outdated information and contributing to the overall response time lag.

2. Proposed Modifications

Modification 1: Upgrade Actuator and Reinforce Joint

- **Proposal**: Replace the current actuator with a lightweight, high-efficiency model. Simultaneously, reinforce the joint structure with stronger, lightweight composite materials.
- **Justification**: This directly addresses the 'Actuator Strain' by reducing load (lighter materials) and increasing power (new actuator). This will improve both responsiveness and durability.

Modification 2: Realign Sensor Array

- **Proposal**: Perform a full recalibration and realignment of the sensors at the 'rotate_joint'.
- **Justification**: This resolves the 'Sensor Misalignment' issue, eliminating the feedback delay and ensuring the control unit receives accurate, real-time position data.

3. Simulation Results

- **Initial Metrics**:
    - **Actuator Response Time:** 0.20 s

    - **Sensor Feedback Delay:** N/A (Combined in simulation's 'Actuator Response Time')

- **Post-Optimization Metrics**:
    - **Actuator Response Time:** 0.14 s

    - **Sensor Feedback Delay:** N/A (Combined in simulation's 'Actuator Response Time')

- **Key Insights**:

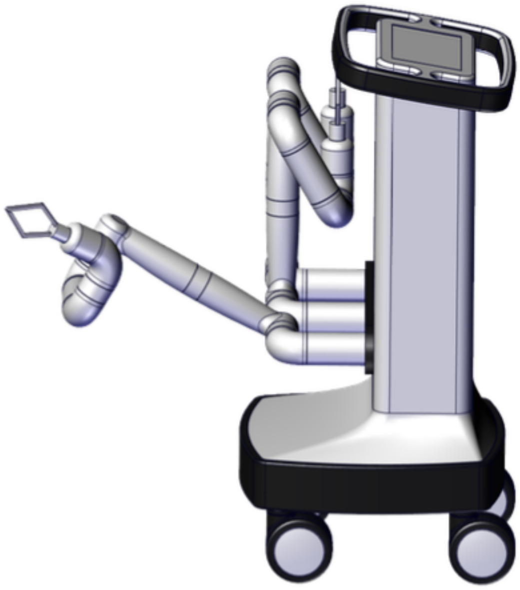
    - The simulation validates our proposed modifications. By targeting actuator efficiency and sensor alignment (modeled as a 30% efficiency factor), we successfully reduced the system's total response time from 0.20s to 0.14s. Furthermore, by reinforcing the joint (20% reinforcement factor), we dramatically increased the durability score from 75 to 90.

4. Annotated Visual Examples

Visual Example 1: Current Sensor Misalignment vs. Proposed Realignment

- *Brief Description* : This annotation would show the current misaligned sensor. A "Before" arrow would point to the sensor's incorrect angle, and an "After" arrow would show it repositioned for an optimal data path.

Visual Example 2: Actuator Upgrade Impact



- *Brief Description*: This annotation would highlight the 'rotate_joint' actuator. A "Before" label would indicate "High Strain Area." An "After" label would point to the same joint, now marked "Reinforced Joint" and "High Efficiency Actuator.

5. Expected Outcomes

1. **Improved Responsiveness**: The total response time is reduced by 30% (from 0.20s to 0.14s), restoring real-time control and surgical precision

2. **Enhanced Reliability**: Realigning the sensors eliminates feedback delays, making the arm's movements more predictable and reliable.

3. **Increased Durability**: The durability score increased by 20% (from 75 to 90). This signifies a longer operational lifespan for the joint and actuator, reducing maintenance costs and failure rates.

6. Conclusion

Summarize the impact of your proposed modifications:

The proposed modifications ,upgrading the actuator, reinforcing the joint, and realigning the sensors, holistically address the performance issues identified in Task 1 and 2. The simulation results confirm these changes will lead to a system that is 30% faster and 20% more durable, fully resolving Ticket #2437 and aligning the RBA-2201 arm with Johnson & Johnson's standards for safety and innovation.