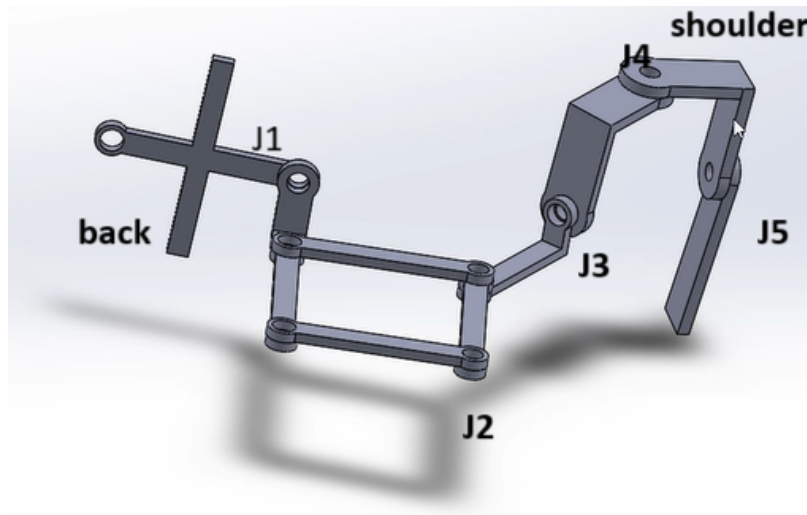


Understanding the Harmony Exoskeleton Robot and Its Degrees of Freedom

The **Harmony Exoskeleton Robot** is a device designed to help with upper-body rehabilitation by mimicking natural human movements. It has **14 degrees of freedom (DOF)**, which means it can move in 14 different ways to match the complex motions of the shoulder, elbow, and wrist. This flexibility allows the exoskeleton to adapt to a wide range of tasks while remaining comfortable for the user.

Shoulder Joint: Degrees of Freedom and Physical Realization



The **shoulder joint mechanism** in the Harmony exoskeleton is particularly notable for its design, offering **five active degrees of freedom (5-DOF)**. These DOFs are split as follows:

- **Three DOFs for Ball-and-Socket Motion:**
 - **Forward and Backward Movement:** Like swinging your arm forward to pick something up or backward to throw (**J5**).
 - **Side-to-Side Movement:** Lifting your arm away from your body or bringing it back down (**J3**).
 - **Twisting Movement:** Rotating your arm around the vertical axis (**J4**).

These movements are created using three **rotating joints** that work together to mimic how the human shoulder rotates.

- **Two Translational DOFs for Shoulder Girdle Motion:**
 - **Up and Down:** Raising or lowering the shoulder (**J1**).
 - **Forward and Backward:** Moving the shoulder slightly forward or pulling it back (**J2**).

These motions are achieved using a **parallelogram linkage** (a system of linked bars) in conjunction with a rotating joint. The parallelogram mechanism ensures smooth translational movement by shifting the ball-and-socket joint along the natural trajectory of the shoulder girdle.

Design Considerations

The Harmony exoskeleton's shoulder joint is built to match human movements as closely as possible. The placement of the joints and the use of the parallelogram mechanism ensure that the robot's movements match the user's natural arm and the shoulder motions.