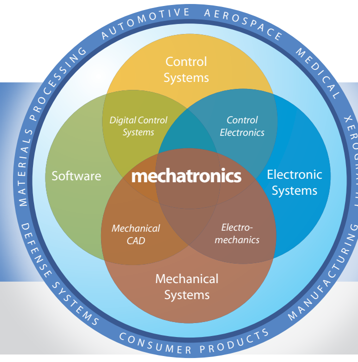
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS AND SOFTWARE



So You Want to Build an H-Bot?

The H-Bot is conceptually simple; it's the design of the controls that make it amazing.

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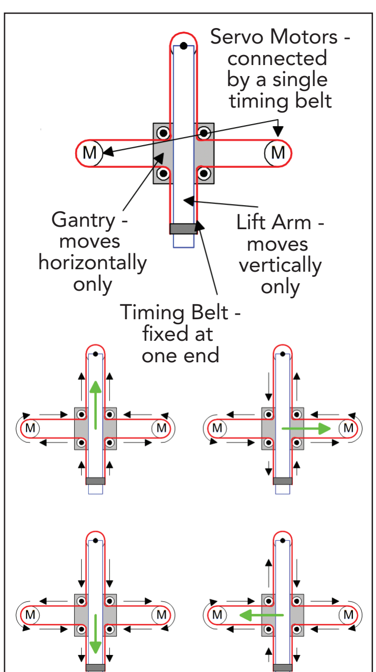
MODERN ROBOTICS IS BASED on modularity. Instead of using one six-axis robot for all applications, the mechatronics engineer is designing a robot for each particular application. This approach places more emphasis on model-based design and system integration.

The H-Bot is an example of such a robot. This two-dimensional robot is used extensively in many industrial applications, e.g., pick-and-place, sorting, gluing and inspection. It is easy to manufacture as it consists of two motors, a timing belt and two rails mounted perpendicular to each other. Despite its dynamic simplicity, friction, backlash and compliance throughout the mechanism are impediments to accurate positioning and represent system design challenges.

As in any coordinated-motion system, the computation of the position command to each motor of the H-Bot is just as important as the control scheme employed to control the robot. The successful combination of these two aspects will lead to accurate positioning, but that means different things depending on the application. In point-to-point applications, such as a pick-and-place system, moving to the target position accurately is the main concern, while in a tracking application, such as a gluing system, a low position-following error is required.



The control system for motion applications is typically a cascade control system that consists of position, velocity and current loops, all typically proportional-integral. Additional features such as velocity feedforward to reduce position-following error and acceleration feedforward to reduce velocity-following error are also usually part of the control architecture.

The position command computation is usually not well understood. Its complexity depends on the shape of the path the robot needs to follow. Paths with sharp corners, such as a square shape, are in general one of the most challenging paths to accurately reproduce with the actual machine. The challenge resides in accurately following sharp corners. Poor implementation of the calculation of the position command causes an overshoot on the corner which yields imperfections in the actual product.

Here's one approach to mitigate this effect and produce perfect corners for a square shape with an H-Bot: Each side of the square becomes a segment on the motion profile defined by the geometry of a square projected on X and Y axes. Thus, the profile X-axis and Y-axis in the Cartesian space is obtained. The inverse kinematics of the robot is then employed to obtain the position profile at the motor shafts. The synchronization between axes is obtained by a master axis. The motion profile of this master axis plays a key role to create perfect corners. This profile is defined in four segments as well that start and end at each corner of the square shape. To reduce machine vibration, wear and noise, a smooth profile — such as a fifth-order polynomial profile — needs to define the motion of the master axis from corner to corner.

Complete details on the design and construction of an H-Bot, including modeling, analysis, control design and experimental validation, can be found at **www.multimechatronics.com**. **DN**

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