LINK-SIC — Industrial Robotics Projects

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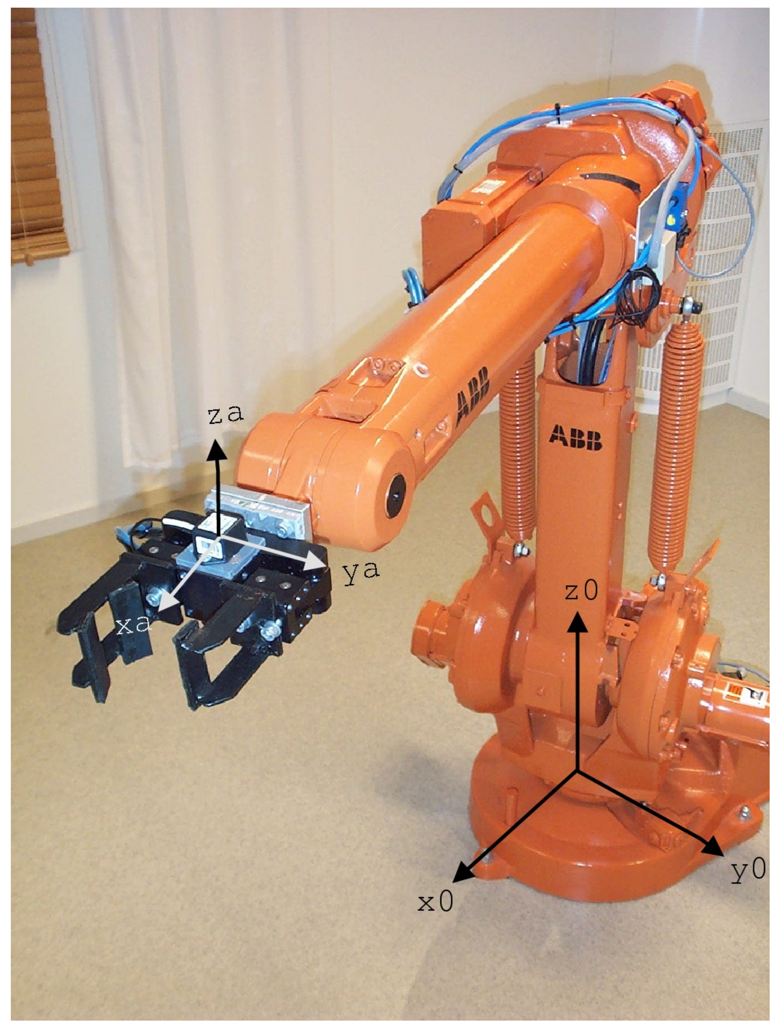
Sensor Fusion

Today, standard robot control is based only on sensors measuring the angles of the motor shafts. There is no measurement feedback from the arm structure, which is separated from the motor shafts by compliant bearings and compliant speed reducers with high friction and nonlinear stiffness.

Aim: Obtain better estimates of the robot tool position and orientation by adding sensors to the arm structure, for example accelerometers and gyroscopes.

Methods to fuse measurements from several sensors are well developed, but have not been applied to industrial robots in any larger extent.



Activities:

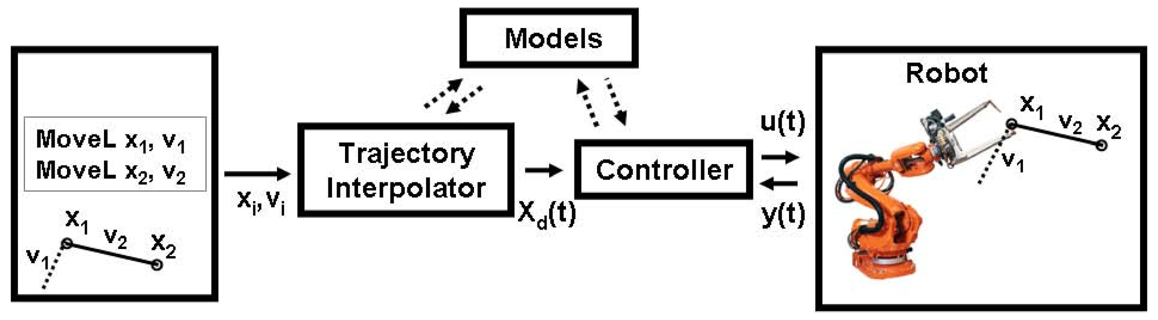
- Compare existing sensor fusion methods applied to industrial robots.
- Study optimal sensor locations as well as the number of sensors.
- Computational complexity is of vital importance due to model size and high bandwidth.

Primary reason for sensor fusion is to improve the other three areas, for example to enable:

- Improved control robustness to errors in the dynamic models.
- Better control performance, for example increased stiffness in applications with large tool forces such as material removal, or improved ILC with reduced tool position errors compared to only using motor measurements.
- Increased model accuracy during identification.
- Enhanced robustness and accuracy of robot diagnosis and fault detection.

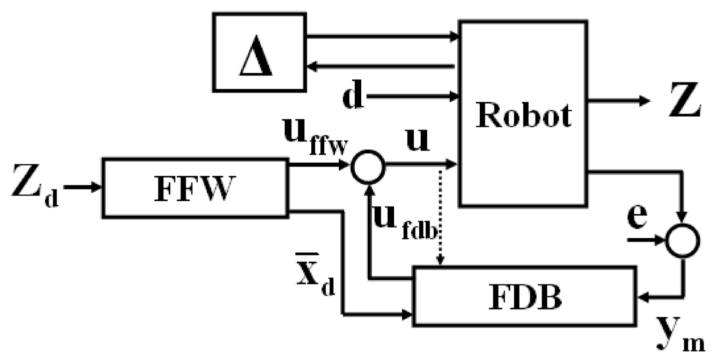
Control

Within this area, the results from the previous two areas (identification and sensor fusion) will used for improved control performance.



Activities:

- **Iterative Learning Control based on sensor fusion** of motor measurements and arm sensors. ILC enables the robot to reach an accuracy close to the repeatability level by compensating systematic errors when performing the same motion.
- **Improved stiffness, robustness, and path accuracy by using additional sensors** will be studied for different control strategies and different sensor locations.
- **Feedback and feedforward control without additional sensors** is challenging when the model complexity is increased, and many of the control strategies suggested in literature are therefore not applicable. For example, feedforward control requires the solution of a high-index DAE (Moberg, 2007). This problem will be studied to find out how far one can reach without using additional sensors.



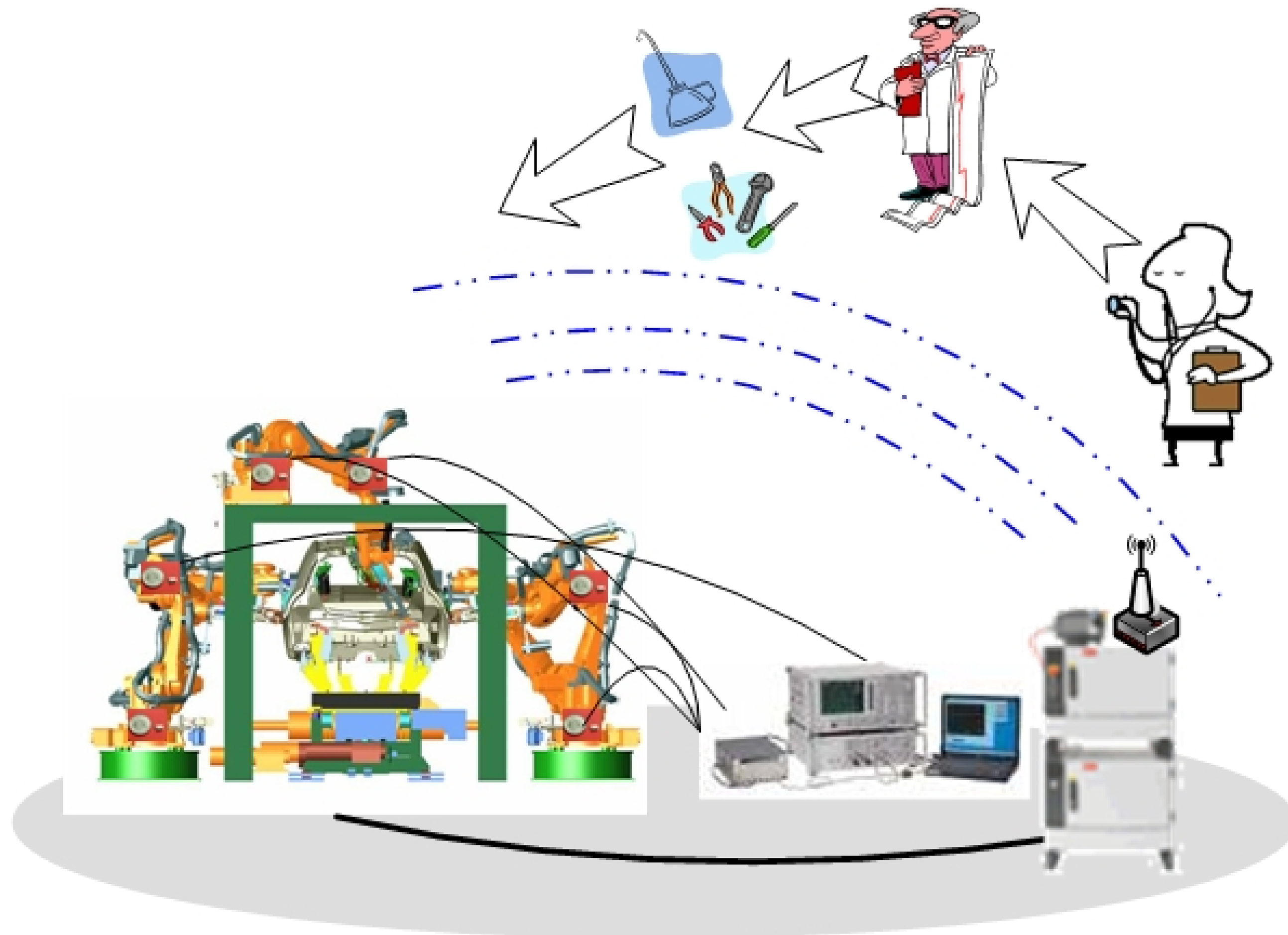
Diagnosis

Robotic-system faults are typically characterized by critical changes in the system parameters and can potentially result not only in the loss of productivity, but also in unsafe operation of the manipulator. Hence, **automated monitoring–diagnostics–prognostics** of the robotic manipulator and **effective accommodation** of such faults play a crucial role in the use of robotic manipulators as parts of an autonomous system.

The process of system fault characterization:

1. **Detection** deals with determining if a malfunction has occurred in the system.
2. **Diagnosis/ prognosis** considers the problem of isolating and/or identifying a fault.
3. **Accommodation** attempts to prevent a particular fault.

Once any malfunction at the system level, i.e. robot dynamic as a whole is detected, further analysis at the component level will be feasible.



Activities:

- **Develop a methodology for system fault characterization** of industrial robots using either the available signals individually or the group of the signals, **without interrupting the production cycles of any type**.
- Further analysis aiming at the **isolation and identification of the fault at the component level** and thus estimating the remaining lifetime of the component is also needed.
- The process of **developing the reference/ nominal/ footprint model** will be a challenging task due to the dynamic nature of the manipulator and nevertheless the environment on which the robot is acting,
- Since many faults in the actuator system give rise to increased friction, it is proposed to start developing **recursive friction identification** performed when the robot runs “customer defined” cycles.