Kinesthetic Teaching for Robotic Assembly

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In the recent years we are experiencing a rise in the number of collaborative robots, the so-called *cobots*, in the industry. The robots can make it more cost effective to manufacture products in Denmark. Traditionally, robot programmers needs knowledge about programming languages and interfaces specific to the manufacturer.

An easier and more accessible method of programming is called *programming by demonstration*, which requires little to no programming experience. With the inbuilt force-torque sensor and gravity-compensated controller of cobots, one can program the robot by dragging it around to teach it a particular trajectory or a particular motion. This is known as kinesthetic teaching.

While kinesthetic teaching in free space is easy, it becomes more challenging for in-contact operations such as gluing or assembly processes. The dynamics of both the environment as well as the human dynamics has an influence on the kinesthetic teaching and can be described as uncertainties.

These uncertainties can often be described by a number of parameters that can vary with time. Parameters describing the normal direction of a curved surface or the stiffness of a human arm both exhibits this.

This thesis is about estimation of time-varying parameters and its usage practical applications. The thesis also investigates estimation of non-Euclidean parameters as well as system safety.