

Data Efficient Action Learning for Optimising Execution of Industrial Assembly Tasks with Binomial Outcomes

Popular abstract of PhD thesis by Lars Carøe Sørensen

Automation of small batch production has recently caught increasingly interest in the assembly industry. However, the long set-up time, the rather static deployment, and the use of specialized equipment all make today's automation approaches and solutions cost-ineffective for small batch production, where each product is produced in a rather low number. The automation of small batch production demands the setup to be flexible and easily adjustable to new tasks, both in terms of hardware and software. A consequence of using general purpose hardware equipment such as generic gripper fingers is that uncertainties are introduced into the process. These process uncertainties may lead to unacceptably many failed assembly attempts which all require intervention by the operator.

This thesis investigates how process optimisation utilising machine learning algorithms can be applied for small batch production in an industrial assembly context to make automation profitable using industrial robot arms. The ultimate goal is to equip the robot with the ability to self-adjust its motion towards the best solution with no or only initial interference from an operator. This is done by automatic tuning of a set of predefined motion parameters given for each assembly task. The aim is that this can contribute to a reduced set-up time and consequently facilitate the applicability of robot automation to small batch production in industrial assembly. However, the process uncertainties need to be considered during the optimisation to compensate for these in the motion of the robot.

Overall, we propose to use a machine learning method and statistical methods to make robots profitable in small batch production. The intention is that the number of evaluations needed, and thereby the robot set-up time, can be reduced by iteratively making a statistically founded choice of which robot motion to try out next. Hence, the process uncertainties are taken into account during the optimisation by our statistical approach which thereby secures the most robust solution.

We show how kernel smoothing techniques that generalise the outcome of a robot motion to alike motions can be used to reduce the number of evaluations needed, and we clarify the importance of using a proper statistical estimate to obtain an applicable solution. The performance of the methods is analysed on a mathematical function, but also using dynamic computer simulations which realistically mimic the real industrial assembly tasks. Moreover, real-world experiments are used to either test the solution obtained in simulation, to continue learning, or to learn the task from scratch. We restrict the evaluation of a robot motion to be either success or failure to simplify the robotic setup and thereby keep cost down.