ENGLISH SUMMARY

The thesis envisions a future where humans and robots collaborate as teammates in manufacturing space for execution of tasks conventionally considered irrelevant to automation. The success of human-robot collaboration depends on the ease of integrating and reconfiguring robots as teammates considering constraints of a manufacturing space. The goal of the thesis is to build knowledge and develop tools and techniques for a simple, easy and natural integration and reconfiguration of robots in manual manufacturing systems.

The author of the thesis hypothesizes that industrial assembly - the process of joining parts and components into functional products - carries a high potential for human-robot teaming. Industrial assembly, during the past century, has seen a progress from conveyor belt assembly lines to lean assembly cells comprising of small flexible human teams. But one thing has remained constant in assembly – the humans. Due to the complex nature of assembly work the manufacturing rationalization efforts for automation have largely remained away from assembly systems making it the most labor, cost and time intensive process in a manufacturing value chain.

When integrating robots in a team-oriented and semi-structured environment – such as assembly - several questions need to be answered in design, development and operation constituting both the technical and social facets. The research presented in the thesis is made in cooperation with a manufacturing company interested to increase the level of automation in its manual assembly cells by the use of human-robot collaboration.

The thesis explores manual assembly cells for their human-robot automation potential. A structured design method is documented for developing HRC production systems. Distribution of assembly tasks between human and robot is discussed. Flexible feeding of assembly parts is explored. Human-robot virtual simulation models as digital prototype are developed for validation of the design of human-robot production system. Digital twins as simulation models with a lifecycle approach are explored for their usefulness in dealing operational complexity of human-robot manufacturing team.

A human-robot assembly cell – AssemBot – is designed and developed to demonstrate that human-robot collaborative systems result in less human-effort and increase productivity. The results support the hypothesis that human-robot teams can be enabled in assembly cells for variant oriented manufacturing.