POPULAR SCIENTIFIC ABSTRACT

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Model Based Programming of Fiber Ply Pick and Drape Processes

Advanced composite materials are common in industries such as aerospace, automotive, and wind turbine. Due to improvements in the manufacturing of composite materials, they are becoming cheaper, allowing for more widespread use. These materials are attractive because they are stronger than steel and lighter than aluminum. The carbon fiber material is woven into thin plies that are imbued with a resin, such as epoxy. Each ply has a thickness of 0.1-0.2mm, and to build a component, multiple plies are stacked on top of each other until the desired thickness is achieved. A single component can consist of hundreds of fiber plies. Currently, there is a lack of automated solutions, meaning that the fiber plies have to be placed onto a form manually. Manually placing the plies onto a form is a complex and time consuming process. As salaries in Denmark are relatively high, the competitiveness of Danish manufacturers is reduced. The FlexDraper project was conceived to automate this process.

The FlexDraper project is an international project that was created to automate the fiber ply layup process. The project partners are specialists within the fields of robotics, computer vision, and composites. The proposed solution consists of a robot tool made up of a grid of suction cups, along with camera systems to monitor the layup process. The suction cups are attached to linear actuators such that the height of the suction cups above the form can be individually controlled. The suction cups are mounted with passive joints to the linear actuators, which in turn are attached to the tool via a passive joint. The suction cups are connected to each other with interlinks, allowing the suction cups to align themselves to the form the plies are being placed on. The presence of the interlinks and the passive joints makes the control of the tool more difficult, as the robot position and the actuator extensions do not fully define the suction cup positions.

The subject of this thesis is the mathematical modelling of the FlexDraper tool. We create models that can predict the positions and orientations of the individual suction cups given the actuator extensions and the robot position, which are the only parameters that can be controlled in the cell. Using the mathematical model, we derive a method that uses the prediction model to find optimal suction cup placements on the form such that the fiber ply can accurately be placed. The precision of the models and the control method are verified in the thesis.
At the time of writing fully automated test layups are being performed and commercialisation of the system are underway.