FibreMap: Automatic Mapping of Fibre Orientation for Draping of Carbon Fibre Parts

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1 Project idea and objectives

The FibreMap project[1] aims at the development of an automatic quality control and feedback mechanism to improve draping of carbon fibres on complex parts. There is a strong need in the automotive industry for automatic systems that perform quality control and improve draping processes in order to allow high production volumes. As illustrated in Fig. 1, the technology that is being developed in the project will include a new sensor system for robust detection of fibre orientation combined with a robotic system to scan complex parts. This is based on a new technology that uses reflection models of carbon fibre to solve the problems encountered with earlier vision-based approaches. The data coming from the inspection system will be fed into draping simulation to improve the accuracy of the processes. Draping is the process of placing woven carbon material on typically complex 3D parts (preforms) with the goal of having the fibres oriented along specific directions predicted by finite element calculations. This is done to maximize the strength-to-weight ratio of the part.

There is a strong trend in the automotive industry towards lightweight parts to increase fuel efficiency, also considering the needs of electrical vehicles. Setting up the draping process for a complex part takes up to 50 preforms for trial-and-error improvements. Current production processes are thus not yet adequate to cover the expected volumes of several 100.000 parts per year. The project aims at shortening process development times by 90% and allowing automatic 100% quality control of fibre orientation. The industry-led consortium consists of European key partners in draping simulation, manufacturing of carbon parts for the automotive industry, sensor developers and robotic experts. It is complemented by a group of European car manufacturers that are linked to the project as associated partners.

The FibreMap project started in September 2013 and it will last for three years.

[1] http://fibremap.eu.

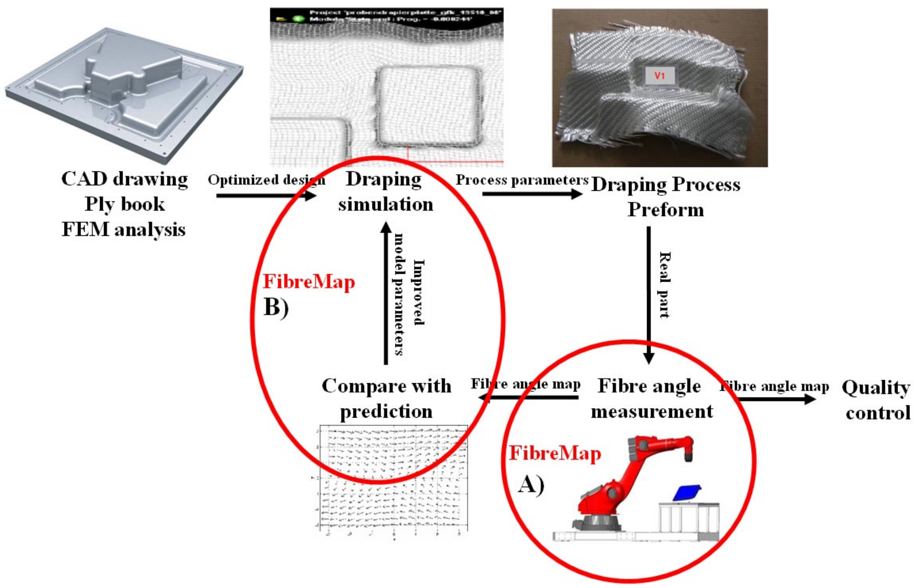
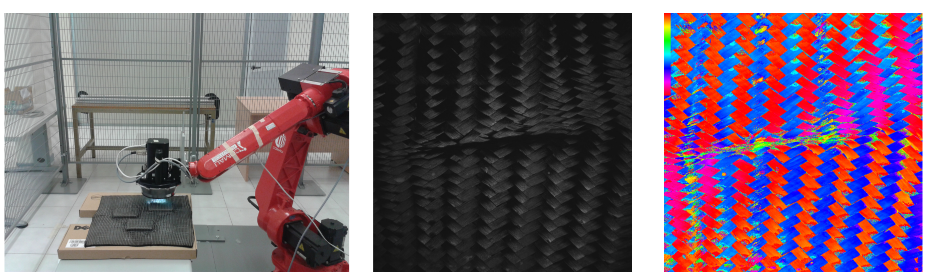


Fig. 1. System overview for the FibreMap project.



(a) Part scanning

(b) Raw image

(c) Color-coded fibre orientations

Fig. 2. Example of (a) scanning of a carbon fibre part, (b) a raw image acquired with the sensor and (c) the estimated fibre orientations coded with colors.

2 ROS benefit for the project

This project will benefit from the adoption of ROS for two main reasons. The former consists in using ROS communication infrastructure, which exploits TCP messaging in JSON/YAML format. This choice allows for fast encoding/decoding of messages, human readability and standardized inter-machine communication.

The second benefit will derive from the exploitation of ROS-Industrial package for extrinsic calibration[2]. This package provides a generic tool for calibrating sensors to a known reference frame and will allow to produce robot-sensor calibration software, without the need for using robot-specific software and allowing to produce new software which could work on every robot.

3 Contribution to ROS-I

During the project, a demonstrator will be set up based on a Comau Smart5-Six robot[3]. This robot will be able to optimally scan complex parts and trigger image acquisition. For controlling the robot, we aim to adopt ROS-Industrial *hardware-agnostic* philosophy to develop a software interface that could work for most robots. In that case, only a specific-library provided by the manufacturer of the robot would be needed, so that the real robot movement could be perfectly simulated. We are also interested in developing a robot driver for Comau robots which could be compliant with ROS-Industrial specifications and contributing it back to ROS.

4 Use cases

The demonstrator of the project will be based on scanning a complex carbon fibre part with a manipulator carrying a specific sensor which is able to estimate fibre orientations. Thanks to ROS-Industrial approach, most of the software developed for this project should be directly applicable to other robots. In Fig. 2(a), an example of robot scanning a carbon fibre part is reported, together with (b) a raw image of the part as acquired from the sensor and (c) a color-coded representation of the estimated fibre angles.

5 Conclusion and future works

We presented the FibreMap project, that aims at the development of an automatic quality control and feedback mechanism to improve draping of carbon fibres on complex parts. For this project, ROS-Industrial is useful both for its low-level communication capabilities and for its high-level packages like the one

[2] industrial_extrinsic_cal: `http://wiki.ros.org/industrial_extrinsic_cal`.
[3] `http://www.comau.com/ita/offering_competence/robotics_automation/products/low_medium_robots/Pages/smart_5_six.aspx`.

for robot-sensor extrinsic calibration. As a by-product of the demonstrator development, we expect to contribute back to ROS-Industrial an open source driver for Comau robots.

6 Acknowledgements

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