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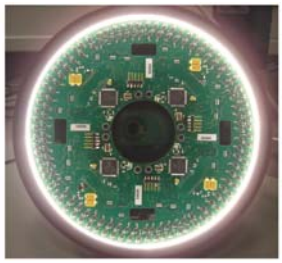
FIBREMAP -

Automatic Mapping of Fibre Orientation for Draping of Carbon Fibre Parts

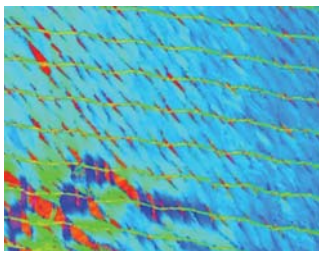


Introduction

The FibreMap project aimed at the development of an automatic quality control and feedback mechanism to improve draping of carbon fibres on complex parts. This mechanism could shorten process development times by 90% and allow automatic 100% quality control of fibre orientation.
During the project, a robotic scanning system was developed, that is able to accurately and automatically measure fibre orientation on each point of complex carbon fibre parts. This information is dense, complete and mapped in real-time onto a 3D model of the part.

Problem: Distortions in fibre orientation

The mechanical strength of a carbon fibre part depends on the arrangements of fibres all over the part. A deviation of few degrees in the orientation can weaken the part up to 10-20%. Draping simulation provides a prediction of the fibre angles on the 3D part. However, some problems or non-idealities in the production process can produce differences between simulation and real parts. FibreMap proposes the first automatic solution that provides a complete feedback of how fibres are arranged onto the real parts.
By means of a particular sensor that exploits the principles of photometric stereo, the orientation of the carbon fibre can be accurately measured at the level of single pixels.

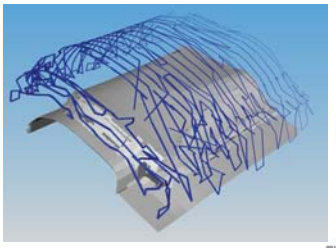


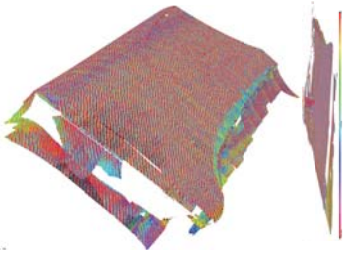
Coverage planning for surface scans

In the Fibremap project, the robot has the main task to precisely move the camera mounted on the TCP, all over the part to inspect. For this purpose, we developed a coverage planning algorithm that takes as input the 3D shape of a part and it provides as output a path for the robot and a list of positions where images need to be taken to fully scan the part The path also considers the properties of the sensor, and the kinematics and the dynamics of the robot to minimize the scanning time and avoid collisions in the workcell.

Fibre Angle Measurement

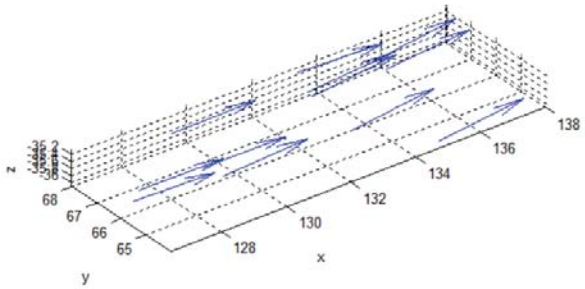
Fibre angle measurement uses a specific, patented sensor technology that is able to acquire a dense mapping of fibre angles from images acquired from a carbon fibre surface [1]. The accuracy of the sensor system could shown to be below 1°. In the FibreMap project, we developed the software to be able to measure fibre estimation when the sensor is moved at high speed over the part. Using accurate calibration and synchronisation mechanisms, the measured fibre angles are then projected in real-time on the 3D model of the part [2,3].





Accuracy

The robotic scanning system we developed is able to scan parts with different shape and complexity. The error in fibre orientation on the tangential plane is about 1°and is constant when the robot is moving at 2, 4 and 8 cm/s. The localization accuracy is below 3mm.



References
[1] S. Thumfart, W. Palfinger, Matthias Stöger, C. Eitzinger, Accurate Fibre Orientation Measurement for Carbon Fibre Surfaces, Proceedings of CAIP 2013, York, UK, Aug 27-29th, Part II, LNCS 8048, pp. 75-82, 2013.
[2] M. Munaro, M. Antonello, M. Moro, C. Ferrari, G. Clemente, E. Pagello, and E. Menegatti. FibreMap: Automatic Mapping of Fibre Orientation for Draping of Carbon Fibre Parts. In IAS-13 Workshop Proceedings: Workshop on ROS-Industrial in European Research Projects, pp. 272-275, Padova, Italy, 2014.
[3] M. Antonello, M. Munaro, and E. Menegatti. Efficient Measurement of Fibre Orientation for Mapping Carbon Fibre Parts with a Robotic System. In Proceedings of the 14th International Conference on Intelligent Autonomous Systems (IAS-14), Shanghai, July 2016.

The project is co-financed by the European Commission within the 7th Framework Programme for Research under Grant No. 608768