
CARACOL
RAMICoS
WHITE PAPER
RAMICoS - Intelligent Control System for Robotic Large Scale Additive Manufacturing System
July 2023

THE PROJECT

- INTRODUCTION
- OBJECTIVES
- EXECUTION
- RESULTS

CARACOL

Integrating monitoring and automation systems into LFAM machinery

- **Quality** represents one of the greatest challenges for AM technologies: always ensuring the required functional performance and a high level of accuracy finishing of the final products.

- **Monitoring and automation systems are enabling factors to enhance productivity** of innovative production technologies such as Additive Manufacturing, as they **ensure stability, repeatability and efficiency**

- **A wide range of sensors installed on the machinery** detects possible threats and unexpected behaviors, performance issues or non-compliance problems is in a fully automated way. By using AI and algorithms, data are extracted, stored, and displayed in real-time insightful visualization.

- In this scenario, Caracol developed the **project *RAMICoS - Intelligent Control System for Robotic Large Scale Additive Manufacturing System***, financed by the Ministry of Economic Development, **in collaboration with MADE Competence Centre and Politecnico di Milano**, the company aimed to achieve several objectives by the end of 2023.

OBJECTIVES

A set of target actions to achieve by the end of 2023

- Identifying common problems occurring during the printing process of Robotic LFAM Systems, defining and characterizing the related defects generated affecting the deposition of the extruded material.

- Identifying the types of sensors and their correct placement, to gather the appropriate data from process monitoring and control.

- Carrying out testing and trial sessions to assess the effectiveness of the proposed sensors' integration.

- Carrying out a trial session to mitigate the risks related to material quality issues, with regard to fibre-reinforced polymers.

- Identifying a data collection and analysis system, capable of detecting and tracking anomalies while providing insights to support the company's decision-making process.

EXECUTION

Project Stages

Phase 1: State of the Art of Process Monitoring and Market Analysis

- In the very first phase, the main process problems and observed behaviours have been identified. The potential hardware and software solutions have been studied, also considering what is already present on the market as far as LFAM and Additive Manufacturing solutions are concerned.

Phase 2: Monitoring System Preparation

- The proper sensors and acquisition system have been selected, purchased, and installed, with the main purpose of collecting data while the system is printing.

Phase 3: Experimental Campaigns and Data Elaboration

- Different experiments have been carried on to build a vast dataset and to test the most suitable in-situ monitoring algorithms, aimed at automatically identifying process anomalies.

Phase 4: Mock-up Realization

- A first proof-of-concept has been realized, showing the capabilities of the monitoring system for the visualization of data on complex shapes, as well as for the early identification of process flaws.

RESULTS

From defect mapping to automatic flaw detection

- The most critical defects for LFAM have been identified, as well as the process characteristics that might signal their presence.

- The in-situ monitoring architecture has been designed and implemented, enabling the collection of a large typology of signals during each printing process.

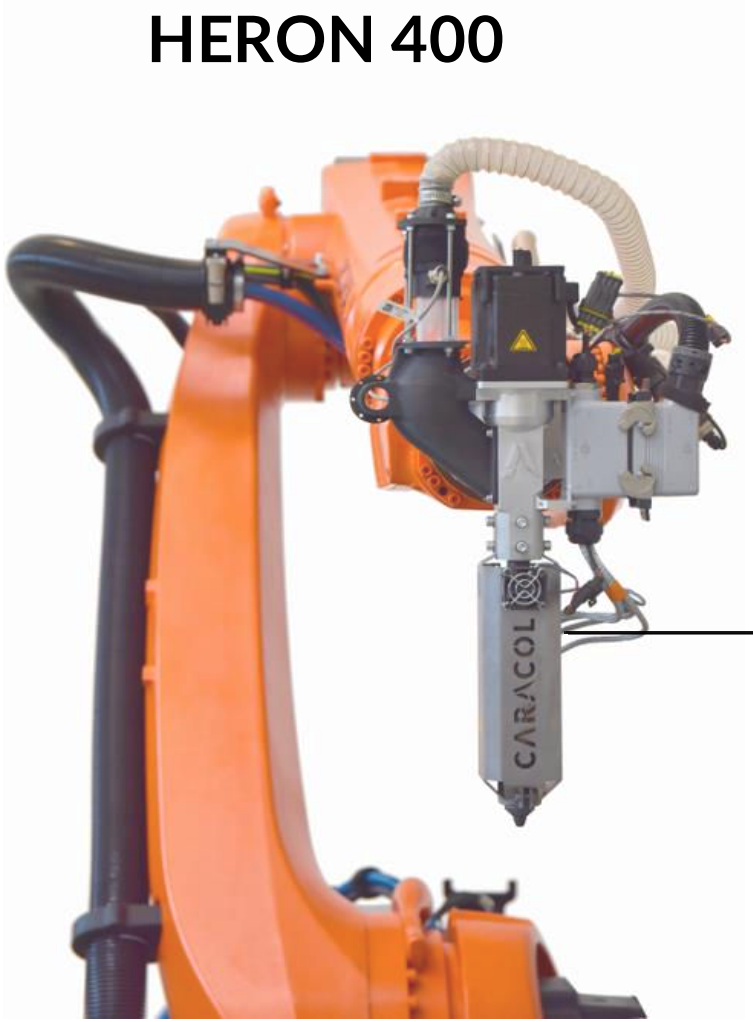
- The first dataset allowed the creation of a digital twin, which maps the quality index onto the part geometry, highlighting the position and frequency of process anomalies.

- The dataset also underlined the possibility of using this tool to send automatic alarms when a part defect or a process failure arise

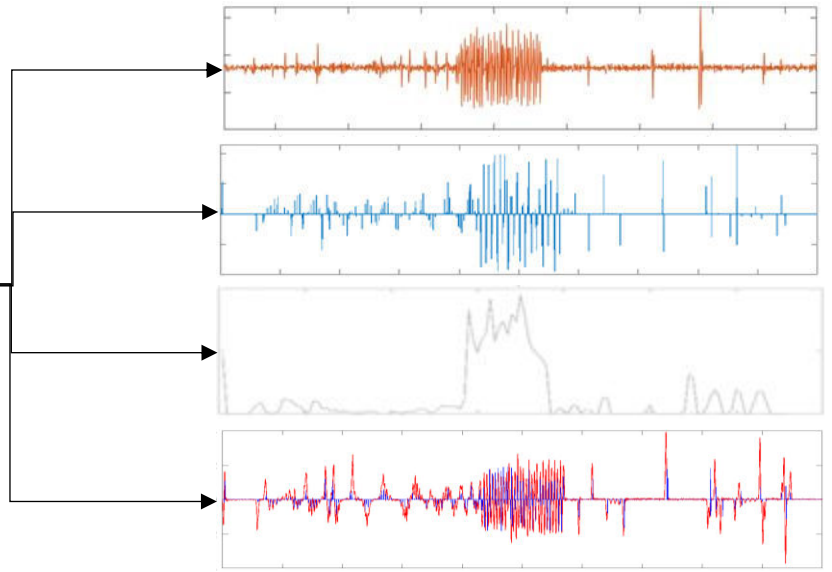
- This project paves the way towards further developments of monitoring tools and their integration within Caracol smart LFAM platforms.

Experimental Campaigns and Data Elaboration

Sensor's integration on HERON 400

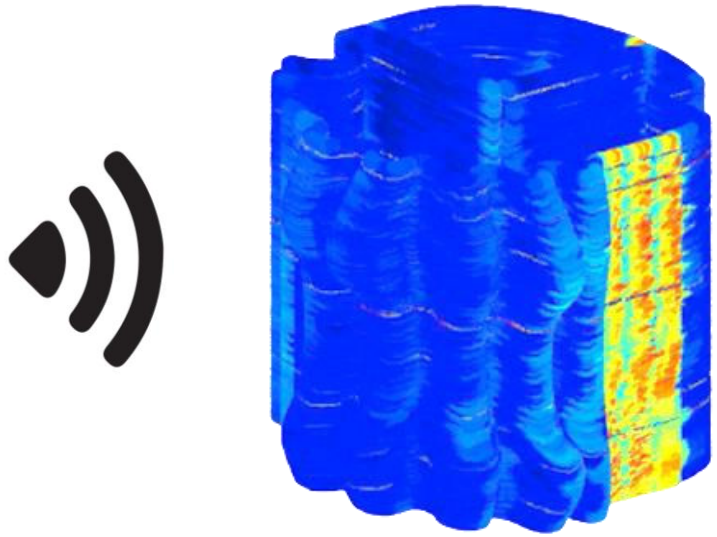


Continuous monitoring of parameters



DIGITAL TWIN

paving the way for
REAL TIME DETECTION
AND DEFECT SIGNALLING

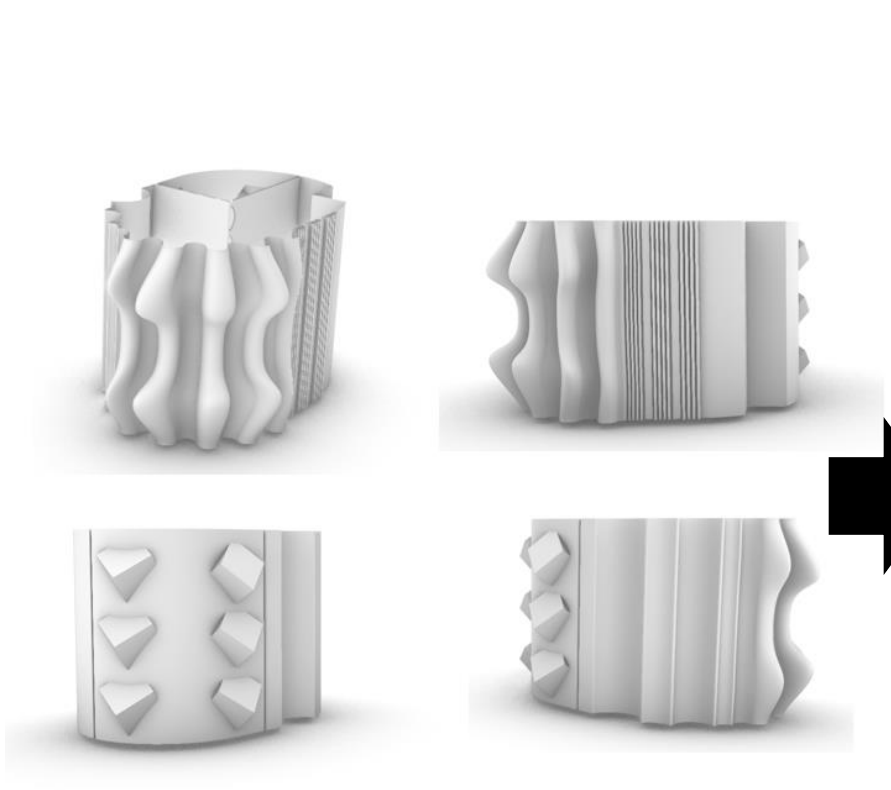


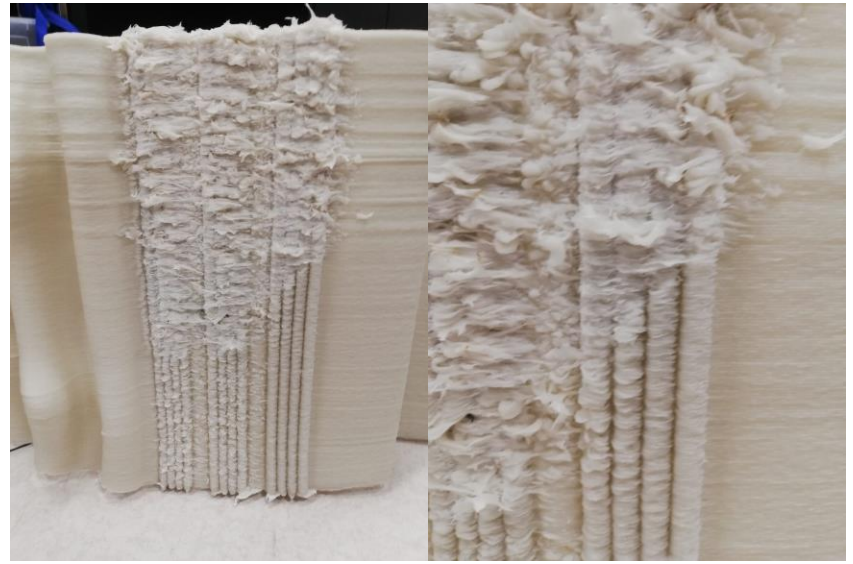
Experimental Campaigns and Data Elaboration

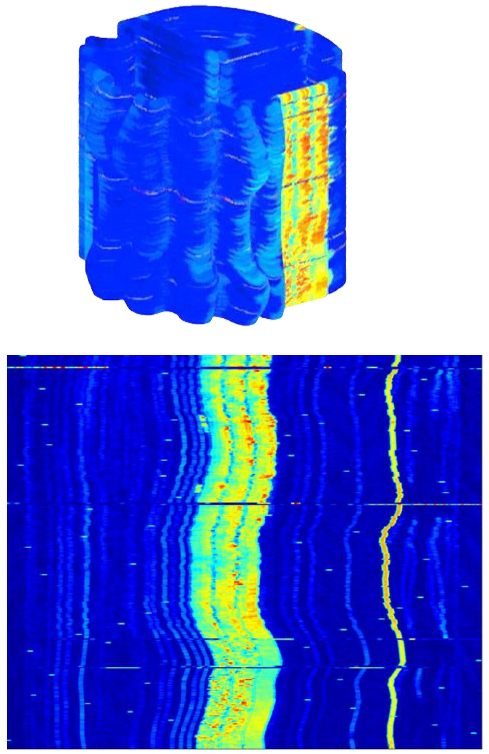
3D PRINTING OF A COMPLEX GEOMETRY

DEFECTS GENERATED ARTIFICIALLY

DATA COLLECTION AND ELABORATION







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