Simulation of a robotic arm for multi-directional 3D printing

Kevin Castelli*, **Hermes Giberti**†

* Dipartimento di Ingegneria Industriale e dell'Informazione
Università di Pavia
via Ferrata 5, 27100, Pavia, Italy
email: kevin.castelli@unipv.it

† Dipartimento di Ingegneria Industriale e dell'Informazione
Università di Pavia
via Ferrata 5, 27100, Pavia, Italy
email: hermes.giberti@unipv.it

ABSTRACT

Additive Manufacturing (AM), in the last decades, has aroused great interest among people and researchers thanks to its flexibility and versatility, making it the most widespread solution for prototyping and one-off production. One of the advantages of AM is that it can build complex shapes that with Subtractive Manufacturing would not have been feasible. AM technologies, on the other hand, are a direct evolution of subtractive ones and this can be seen from the exploitation of the same machines, but also of the same machining strategy (layer based approach). This represents a constraint to the potentiality of AM to build 3D object in three dimensional space (multi-directional printing) and not just an approximation by 2D features (unidirectional printing). Therefore, new solutions and novel building strategies are being researched. Industrial robots have been used to this end. Integration is required to perform 3D printing task, from the outline of the working cell to the definition of the control strategy. The flexibility given by systems with more than 3 Degrees of Freedom (Dofs) increases the complexity of the design of the working cell, of the tool and of the trajectories that prevent the collision with the piece. Simulation is a safe and indispensable tool to carry out this task.
In this context, the following article describes the assessment of suitable control architectures for the realization of a Fused Deposition Modeling (FDM) printer based on a 6 Dofs robotic arm. Off-line programming (using the software released by the manufacturer for better compliance with the physical robot system) is preferred to validate the robot behavior in order to avoid wastes and damage to the machine. One additional advantage of the simulation is the possibility to easily exchange virtual subsystem with the real ones to asses them individually.
For each identified control strategy, that easily integrate the extruder with the robotic system, the results obtained will be shown for paths generated for conventional 3D printing as well as for multi-directional printing. The focus is put on the obtained position and speed profiles, two of the several aspects that yield a minimization of the error between designed and manufactured object, but strictly concern the robotic system in itself. Simulation results are then compared to the acquisitions on the physical system.

REFERENCES

[1] Zhang, G.Q., Spaak, A., Martinez, C., Lasko, D.T., Zhang, B., Fuhlbrigge, T.A. *Robotic Additive Manufacturing Process Simulation towards Design and Analysis with Building Parameter in Consideration*. 2016 IEEE International Conference on Automation Science and Engineering (CASE)

[2] Evjemo, L.D. et al.*Additive manufacturing by robot manipulator: An overview of the state-of-the-art and proof-of-concept results* 2017 22nd IEEE International Conference on Emerging Technologies and Factory Automation