Robotics and Additive Manufacturing

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Additive Manufacturing (AM) is a technology that allows to build components from scratch, thus eliminating typical issues encountered in subtractive technologies (i.e. definition of the to-be-manufactured component, referencing it to the machine working coordinate system, ad hoc tool path generation, holding device, interaction forces, etc.). Conventional 3D printing strategies are based on the superimposition of flat layers, although they give acceptable results for the realization of design components and simple geometries (2.5D objects) with fast building time, they intrinsically carry few drawbacks, that are: additional material for support structure of overhanging features, anisotropy of the final object, surface roughness (staircase effect).

The possibility to overcome these drawbacks could improve this technology, making it a valid alternative to conventional technologies for the realization of mechanical, structural and esthetical components.

All these disadvantages can be reconducted to the lack of additional Degrees of freedom (Dofs) to define, in space, the position of the tool center point (TCP): for instance, the staircase effect could be eliminated by the addition of a single layer, perpendicular to the building direction, to cover the hull; the anisotropy of the material could be mitigated by adding reinforcement, or by reorienting the building direction, so that the extruded wire are directed as the applied loads; support structure could be eliminated if the system were able to adjust the building direction to match the overhang.

Therefore, a feasible solution could be the introduction of industrial robots, one or more, with at least 3 Dofs (i.e. robotic arms, PKM machines). A Robot arm (6 Dofs) can be used to deposit on differently oriented planes in order to build features that can act as reinforcement, customize existing builds, reconstruct damaged parts and remove the necessity for wasteful extrusions to generate supports. The integration of other tools, like milling bits and collaborative devices, could improve the resulting object by reducing the post-processing operations and the lead time.

The research will lead to the definition of an improved 3D printing system (both hardware and software) for the realization of components tailored to the mechanical and geometrical specifications. The result will be a compact working cell integrating both additive and subtractive tools to output ready-to-use objects in a collaborative environment so that the personnel may safely interact with the system to create an optimal result.

The proposed research has as main objective the validation and the characterization of robotic system for AM. The main points, that need to be addressed, are:

- Integration of the different components (robot, extruder, heating devices and other machining tools)
- Definition and assessment of unconventional 3D printing strategies
- Tool path generation for these approaches
- Selection of the optimal process accounting for functionality, precision and cost.
- Integration of additional robot, machines or personnel (collaborative solution) to carry out specific task.

Since robot-based 3D printers can find their application in different fields (for instance: large scale components manufacturing, reconstruction, customization of basic components, aerospace, automotive, engineering and design), suitable case studies need to be investigated exploiting different materials and AM technologies.