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Fused filament fabrication applied to structural components of small drones

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The Fused Filament Fabrication (FFF) technology is commonly employed in rapid prototyping. 3D home desktop printers are usually used to produce non-structural objects. However, when the mechanical stresses are low, the FFF technology can also be successfully employed to produce structural objects, not only in prototyping phase but also in the production of series structural elements. The innovative idea of the present work is the application of the FFF technology, implemented in desktop 3D printers, for the production of components for aeronautical use, especially for unmanned aerial systems.

For this aim, the architecture and preliminary design of an innovative multirotor Unmanned Aerial Vehicle (UAV) is presented. This UAV is able to easily and quickly change its configuration: the principal structure is made of an universal and general plate, combined with a circular ring, in order to create a rail guide able to host the arms, in a variable number from 3 to 8, and the legs. The proposed UAV is inexpensive because of the few universal pieces needed to compose the platform for the creation of a kit. This modular kit allows to have a modular drone with different configurations. These configurations consider different numbers of arms, numbers of legs, numbers of rotors and motors, and landing capabilities.

The 3D printing technology is introduced to produce all the structural elements of the UAV. For this reason, all the components are designed to be produced via the FFF technology by means of desktop 3D printers. Therefore, an universal, dynamic and economic multi-rotor UAV has been developed and produced. Customization is combined with the concept of additive manufacturing, as all components are designed to be produced in FFF. This approach does not limit the application scenarios of the drone, but it is a further step in the direction of customization, as it allows continuous upgrades over time. After the definition of the most severe conditions for the structure, a structural validation of its performance must be conducted. The functional use of FFF-produced parts is challenging due to the anisotropic behaviour of the parts. However, some structural elements are thin-walled and they can be printed with a 100% linear infill. A simplified approach could be an analogism with unidirectional composites, whose 2D testing procedures and methodologies are well known. A finite element analysis of some elements of the frame is conducted, using shell elements to discretize the geometry. A proper definition of their mechanical response is possible because the constitutive model is not a priori isotropic but it reflects the behaviour of the finished parts. The tensile strength variability in the material reference system is high: a component-by-component comparison proves the design to be adequate and measured to the surrounding conditions even if it remarks the absence of a defined failure criterion.