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SELF-REPLICATING 3D PRINTED SATELLITES

Abstract

Satellites are, inherently, space-based robots. Thus, many advances in the realm of robotics can also be applied, fully or in-part to the production, configuration, testing and other aspects of satellites. This paper is concerned with one particular development: 3D printing-based self-replicating robots. The concept facilitates a variety of benefits for terrestrial robots, such as being able to configure robots for a goal not known a priori, allowing for adaptive missions. Adaptiveness, along with the use of in-situ resources, are also benefits which may drive the consideration of this technology for planetary exploration missions. For in-space craft, several of these benefits apply and an additional benefit is present. This paper presents a framework for the use of 3D printing-based self-replicating satellites and discusses potential applications for their use.

Prior work has discussed the efficacy of in-space 3D printing. Systems have been presented for attaching to objects, dividing objects into parts and scheduling the printing process and the technical and logistical challenges of printing in a vacuum have been considered. In most cases, this work was concerned with printing structures much larger than the printing spacecraft. In this case, the spacecraft will print another craft of a similar size to itself which may or may not also have 3D printing capabilities. In each instance, current and projected future mission needs are assessed to determine if printing a craft at all is warranted and, if so, to determine what configuration of craft to print.

Printing the craft in-space facilitates bringing materials into orbit in a raw form that has less structural constraints and will require less volume. Craft printed in orbit also benefit from being able to be structurally designed for microgravity (instead of terrestrial gravity and launch forces). Space debris, of compatible material types, may be able to be harvested and reused (as could printed craft, should their configuration no longer be needed).

The paper begins with a review of prior work in the field of self-replicating robots and related fields such as self-assembly, robot autonomy, evolvable hardware, and the automated manufacturing of robots. Then, a detailed framework for the system is presented and the potential space-based applications that self-replicating robot systems could be used for are discussed and its efficacy for these applications is evaluated. The paper concludes with a discussion of planned future work and a description of the pathway to the implementation of this type of a system.