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Author: Mr. Ravan Akhundov
Azerbaijan State Oil and Industry University (ASOIU), Azerbaijan

Mr. Fakhri Amanov
Azerbaijan State Oil and Industry University (ASOIU), Azerbaijan

SELF-REPLICATING MACHINES

Abstract

Self-replicating machines, capable of autonomously creating copies of themselves utilizing raw materials in the environment, present a concept dating back centuries. However, the first substantial proposal emerged in the 1950s by mathematician John von Neumann. This paradigm gains significance in the context of space exploration, a field fraught with challenges and expenses. Traditional space systems lack maintenance capabilities post-launch, necessitating spare parts from Earth or tolerating failures. The vision of self-replicating machines, or von Neumann probes, offers a potential solution. These probes feature basic elements such as propulsion, sensing, intelligence, memory, resource harvesting, and a maintenance system. For galactic exploration, these spacecraft aim to replicate themselves, contributing to an expanded understanding of the universe. While early concepts, like Project Daedalus in the 1970s, proposed colossal spacecraft, recent studies focus on more practical, partially self-replicable probes. An innovative 2020 paper suggests probes with up to 70Practical applications extend beyond interstellar exploration, including lunar factories envisioned by NASA in the 1980s. These factories, featuring autonomous robotic systems, aim to utilize lunar resources for building structures before human arrival. Furthermore, self-replicating machines align with the In-Situ Resource Utilization (ISRU) concept, emphasizing the extraction and utilization of local resources for space missions. ISRU holds promise for producing building elements, spare parts, and propellants, crucial for missions to Mars and beyond. Notably, the Sabatier reaction, converting CO2 from Martian atmospheres into methane, demonstrates the potential for self-replicating systems to contribute to propellant production. While challenges persist, such as the maturity of artificial intelligence for spacecraft autonomy and the need to import complex electronic components, ongoing research aims to address these limitations. As technology advances, the realization of self-replicating machines emerges as a transformative approach for sustainable space exploration, opening new frontiers in our quest to understand and utilize the cosmos.