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A MODULAR NUCLEIC ACID EXTRACTION AND ANALYSIS SYSTEM FOR EXTRATERRESTRIAL EXPLORATION

Abstract

In an era where the exploration of extraterrestrial environments is becoming increasingly feasible, especially amongst private companies, the development of innovative tools for analyzing these distant worlds is paramount. Our project introduces an automated, nucleic acid-based soil sample analysis system initially developed for the international University Rover Challenge. This initiative seeks to propel forward the capabilities of robotics and engineering within the domain of life-detection. The primary objective was to design a system that is not only compact but also capable of extracting and analyzing nucleic acids (RNA and DNA) from soil samples within a constrained time frame of 30 minutes. These constraints address the critical limitations of size, weight, and power that are universally associated with space missions.

The methodology employed in the development of this system is characterized by an interdisciplinary approach, integrating mechanical durability, electronic efficiency, and software capabilities. The mechanical design is tailored to withstand the rigors of potential extraterrestrial environments, while the electronic subsystem is optimized for minimal power consumption. A Python-based software component enhances the system's usability, facilitating intuitive data processing and visualization for rapid analysis of nucleic acid extractions.

Preliminary results from field testing across different soil types have validated the system's efficacy in performing its functions within the targeted timeframe. These include purity via A260/A280 ratio and concentration. These findings underscore the system's potential utility in planetary exploration and astrobiology, where expedient and reliable onsite analysis of soil samples is of paramount importance.

In conclusion, the development of this automated nucleic acid-based soil sample analysis system exemplifies the transformative impact of academic competitions, such as the University Rover Challenge, on fostering innovations that bridge the gap between theoretical exploration and practical application. The project not only contributes to the technological advancements in space exploration but also highlights the critical role of interdisciplinary collaboration in solving the complex challenges of understanding and exploring extraterrestrial environments. The ongoing refinement and validation of the system through rigorous field tests aim to further solidify its applicability in real-world scenarios, thereby marking a significant stride toward its adoption in industrial and scientific endeavors beyond the confines of academic research.