International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.7 January - February – 2023
DOI:10.46647/ijetms.2023.v07i01.032 ISSN: 2581-4621

An overview of the design and development of lunar rover (Chandrayaan-2) for space applications

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Abstract

The paper gives an brief overview of the design and development of lunar rover (Chandrayaan-2) for space applications. The Moon has always been the center of attention for mankind, more than any other heavenly body in More than any other heavenly body in the night sky, the Moon has long been the focus of human interest. The Moon has always presented mankind with a challenge to learn more about it and to marvel at its wonders because it bears the early history of the solar system. We can uncover the early evolution of the solar system and that of planet Earth by having a better understanding of the Moon. With the 2008 launch of the Chandrayaan-1 orbiter mission to the Moon, India's planetary exploration program was launched by the Indian Space Research Organization (ISRO). India launched Chandrayaan-2, its second lunar exploration mission, nearly twelve years after its first lunar exploration mission. Chandrayaan-2, India's most technologically advanced aircraft, is on an unprecedented mission. The South Polar Region of the Moon will be studied by India's second lunar trip, which will draw on nearly ten years of scientific and Engineering advancement. A major accomplishment for both India and humanity, Chandrayaan-2 was the first mission ever to be sent to the southern pole of the moon. Both the high cold and constant darkness in this area make it extremely unsafe and have a bad impact on missions. India faced a tremendously difficult assignment as a result, and the entire world was interested in its outcome. Chandrayaan-1's eleven remote-sensing scientific instruments from ISRO, NASA, and ESA have made important discoveries, such as the identification of a water signature, the discovery of spinel minerals, lunar lava tubes, signs of recent volcanism, impact-triggered boulder movements, and the detection of sputtered atomic oxygen and backscattered helium on the lunar surface. Three components made up Chadrayaan-2: an orbiter, a lander, and a rover. 2019 saw the launch of this mission. During this mission, the Orbiter was successful in reaching the moon's orbit, but communication with the Lander was lost, which caused Lander to perform poorly and crash with the Pragyan rover and other scientific equipment. The work given here is a mini-project that is taken up as a part of the curriculum completed by electronics and communication engineering students in the second year of the electronics & communication engineering department at Dayananda Sagar College of Engineering in Bangalore.

Keyword

Planetary Exploration, Lunar Orbit Insertion, Orbiter Craft, Lander Craft, Lunar Rover, Soft Landing, Landing Sites, Craters.

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1. Introduction

The Moon is the largest and brightest celestial object present in the night sky. As the only natural satellite of the Earth, it has been a subject of study to scientists and researchers all over the world. The exploration of the Moon began with Luna 1, a first flyby mission launched by the Soviet Union in January 1959. Although Luna 1 did not reach the Moon's surface and flew within about 5,995 km from it [1]. On September 13, 1959, Luna 2 became the first spacecraft to land on the lunar surface making an impact. Whereas Luna 9 became the first spacecraft to achieve a controlled soft landing on the lunar surface and Luna 10 became the first spacecraft to orbit around the Moon. On October 22, 2008 India participated in the race of lunar exploration with the launch of Chandrayaan-1, ISRO began India's first planetary exploration mission of India [2].

With the Indian as well as International payloads on-board, Chandrayaan collected very important data during its mission of ten months. The most significant findings from Chandrayaan1 includes, discovery of presence of hydroxyl (OH) and water (H2O) molecules on the lunar surface and enhanced abundance towards the polar region, validating the global lunar magma ocean hypothesis, signatures of water ice present under the permanently shadowed regions near the poles, detection and mapping of reflected solar wind protons and identification of mini-magnetosphere, possible existence of water molecules in lunar environment, presence of Magnesium, Aluminum, Silicon and Calcium at several locations on the lunar surface, discovery of new rock types with unique chemical composition and radiation environment en-route and around the Moon (VSSC, 2019) [3]. After the success of Chandrayaan-1, The launch of Chandrayaan-2 took place atop a GSLV MK-III M1 on July 22, 2019 at 2:43 PM Indian Standard Time (IST) from the Second Launch Pad (SLP) at the Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. The launch of GSLV MK-III M1 is captured [4]. The Chandrayaan-2 spacecraft to the Moon is a composite module mission consisting of Orbiter, Lander and Rover. Chandrayaan-2 is planned to be launched onboard Geosynchronous Satellite Launch Vehicle (GSLV) in the summer of 2019. The Orbiter will carry the combined stack up to moon till the Lunar Orbit Insertion (LOI) [5]. The combined stack is then inserted into a lunar orbit of 100 km x 100 km. The Lander with the Rover is then planned to be separated from the Orbiter for soft-landing on a site near south polar lunar surface. The overall objective of Chandrayaan-2 is to build on the successes of the Chandrayaan-1 mission, testing new technologies and conducting experiments on the moon. The rover will collect samples from the lunar surface and analyze them on site, relaying data to Earth via the orbiter. The orbiter will map the contents of the surface down to a depth of a few tens of meters and carry out a detailed study of the lunar exosphere [6].

The Chandrayaan-2 mission will help us gain a better understanding of the origin and evolution of the Moon by conducting detail topographical studies, comprehensive mineralogical and morphological analyses and a host other experiments on the lunar surface. The primary objective of the mission was to demonstrate the ability to soft-land a lander and operate a rover at the South Polar Region of the Moon. Whereas, the scientific goals of the mission include detailed study of topography, seismography, mineral identification and distribution, surface chemical composition, thermo-physical characteristics of top soil and composition of the tenuous lunar atmosphere.

Unfortunately, during its attempt on September 7, 2019 lander (Vikram) gets deviated from its intended trajectory starting at an altitude of 2.1 km above the lunar surface and had lost communication with the ground station [7]. Thus, Chandrayaan-2 will attempt more ambitious technical maneuvers that will put Indian space technology to the test. For the first time, ISRO will attempt to give a craft a controlled, or soft, landing. The agency has had to develop advanced systems that can guide the lander to a touch down and successfully deploy the rover. The Fig. 1 gives the view of the Chandrayan robot [8].

2. Objectives of The Project Work

- To demonstrate the ability of soft land and operate a robotic rover on on the lunar surface.
- To develop and demonstrate the key technologies for end to end lunar mission capability.

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- The Orbiter will observe the lunar surface and relay communication between Earth Station and Lander.
- To map the lunar surface and help to prepare 3D maps of it.
- To study the topology, mineralogy, surface chemical composition, elemental abundance, lunar explore by employing Image Processing Technique.
- To build an application to analyse the data obtained from Rover.

Fig. 1 : A view of the Chandrayan robot

3. Highlights of Chandrayaan 2

- Chandrayaan 2 fostered the findings of Chandrayaan 1 as reported by the ISRO.
- The mission targeted the "South Polar region" of the Moon which was completely unexplored.
- The mission focused on the extensive mapping of the lunar surface for studying variations in its composition and tracing the Moon's origin and evolution.
- Chandrayaan 2 was considered as a challenging mission as the South Polar Region of the Moon was totally unexplored by any space agency before.
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4. Challenges of Moon Landing

There are various challenges in moon landing like; trajectory accuracy, communication with deep space network, extreme cold & hot temperature variation, lunar dust, lumpy gravity, soft landing etc. some of the challenges involved in moon landing are mentioned here [9]. Communication with deep space network - Communication to the satellite from the ground station is very important [10]. It helps to control satellite during mission, send commands and new updates, give satellite location and its path, firing rocket engine and thruster. Indian deep space network is located at byalalu near the banglore (Karnataka) [11]. Usually most of the time lack of communication is responsible for the mission failure (ISRO, 2019a) [12].

Soft Landing - Soft landing was the main challenge in this mission and it was first time for India attempt a soft landing on lunar surface [13]. The soft landing was executed by performing the rough braking and fine braking maneuvers by firing the onboard engines and it takes extreme precision [14]. Lander was also capable to absorb shock impact without damaging onboard payload and systems (ISRO, 2019a). Extreme Temperature - There is no atmosphere on moon which causes temperature variation is extreme [15]. It takes 27.5 days to complete one rotation around its axis and also around the earth. Due to its rotation one side of moon remains 13.6 day in light which is called lunar day and another part remains in darkness for 13.6 days which is called lunar night [20 -22]. During the lunar day temperature can reach 260 F and in lunar night it can reach -280 F (ISRO, 2019a) [16].

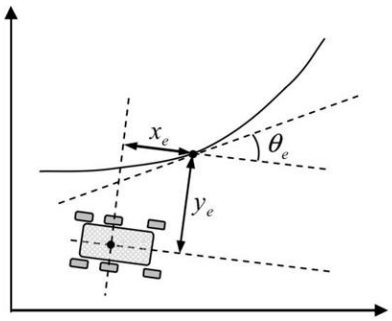

Fig. 2 : Description of the Path Following Problem

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The path tracking control problem is solved by designing the tracking control rule [V, W] and to converge the posture error to the origin [19]. That is to control the Rover to follow the reference Path [18]. The Fig. No. 2 gives the description of the path following problem [17].

5. Conclusion

It was a nation pride mission for India and it was the first time in the world when a nation launched mission to reach South Pole of the moon. Unfortunately landing on the moon of VIKRAM rover was not successful but this project achieved its 95 % success and objectives according to ISRO. Now ISRO has planned a new landing mission on the lunar surface with Chandrayaan-3.

6. Future Advancement

A brief review of the project that is going to be done in our work is presented in this paper in a nutshell. In November 2019, ISRO officials confirmed news about a new lunar Lander mission is being studied for launch in November 2020. New project is known as Chandrayaan-3 and it would be a re-attempt to achieve the landing capabilities on lunar surface. This Lunar Polar Exploration Mission is a joint venture of India with Japan which in 2024. In this mission, there would be no orbiter launching in lunar orbit. The proposed spacecraft would have a detachable propulsion system, a Lander and a rover.

References

[1] Duda, Kevin R., Michael C. Johnson, and Thomas J. Fill., "Design and analysis of lunar lander manual control modes", *2009 IEEE Aerospace conference*, pp. 1-16, IEEE, 2009.
[2] Acharya, Hardik, T. P. Srinivasan, and B. GopalaKrishna, "A new approach for terrain analysis of lunar surface by Chandrayaan-1 data using open source libraries", *2013 Fourth National Conference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG)*, pp. 1-4. IEEE, 2013.
[3] Aneesh, R.P., Dinakar Prasad Vajja, P. P. Pramod, PS Ajeesh Kumar, and Arun Peethambaran, "Spacecraft command and data system simulator for the payload chaste in Chandrayaan-2 mission", *2017 IEEE International Conference on Circuits and Systems (ICCS)*, pp. 97-102. IEEE, 2017.
[4] Calla, O. P. N., Shubhra Mathur, and Kishan Lal Gadri, "Possible Landing site for Chandrayaan-2 Rover", *2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, pp. 1-5. IEEE, 2016.
[5] Wan, Junlin, Hong Nie, Jinbao Chen, and Qing Lin, "Modeling and simulation of Lunar lander soft-landing using transient dynamics approach", *2010 International Conference on Computational and Information Sciences*, pp. 741-744. IEEE, 2010.
[6] Rui, Xu, Jiang Huiping, Tang Shengjing, Cui Pingyuan, and Yue Fuzhan, "Analyzing and designing of lunar rover motion controller", *2007 IEEE International Conference on Robotics and Biomimetics (ROBIO)*, pp. 1574-1579. IEEE, 2007.
[7] Harrison, Dan A., Robert Ambrose, Bill Bluethmann, and Lucien Junkin, "Next generation rover for lunar exploration", *2008 IEEE aerospace conference*, pp. 1-14. IEEE, 2008.
[8] Mark Williamson, "Analysis asian moon - Briefing in depth", *IEEE- Engineering & Technology*, vol. 3, no. 21, pp. 6-19, December 2008.
[9] Charles D. Brown, "Elements of spacecraft design", *AIAA*, 2002.
[10] Mehran Sarkarati and Mariella Spada, "Developing operational spacecraft simulators", *Proceedings of the DASIA 2008- Data systems in Aerospace*.
[11] Arnold Hanslmeier, "The Sun and Space Weather", *Springer*.
[12] James Joseph, "Papike text book Planetary Materials", *Mineralogical Society of America*, 1998.
[13] Dinakar Prasad Vajja, PP Pramod and PS Ajeeshkumar, "Design Document of Processing Electronics of ChaSTE Payload on Chandrayaan-2 Lander", *TR-SPL-CH2-ChaSTE-PE*, 2015.

DOI:10.46647/ijetms.2023.v07i01.032 ISSN: 2581-4621

[14] A.H.G. AL-DHAHER, "Development of Microcontroller/FPGA-based systemsInt", *J. Engng*, vol. 20, no. 1, pp. 52-60, 2004.
[15] MESA-introduction document round table conference on 2010 , *European Space Agency*.
[16] E. Marsch, H.-J. Fahr and K., *text book*: The Outer Heliosphere: The Next Frontiers.
[17] Dinakar Prasad Vajja, PP Pramod and PS Ajeeshkumar, "Electrical Interconnection Details (EID) of ChaSTE Payload on Chandrayaan-2 Lander", *TR-SPL-CH2-ChaSTE-EID*, 2015.
[18] R. Devi Priya, R. Sivaraj, Ajith Abraham, T. Pravin, P. Sivasankar and N. Anitha. "Multi-Objective Particle Swarm Optimization Based Preprocessing of Multi-Class Extremely Imbalanced Datasets". International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems Vol. 30, No. 05, pp. 735-755 (2022). Doi: 10.1142/S0218488522500209
[19] Dinakar Prasad Vajja, PP Pramod and PS Ajeeshkumar, "Interface Document for Processing Electronics and Frontend Electronics of ChaSTE Payload on Chandrayaan-2 Lander", *TR-SPL-CH2-ChaSTE-ID*, 2015.
[20] Chirag H B; Darshan M; Rakesh M D; Priyanka D S; Manjunath Aradya. "Prediction of Concrete Compressive Strength Using Artificial Neural Network". International Research Journal on Advanced Science Hub, 4, 11, 2022, 281-287. doi: 10.47392/irjash.2022.069
[21] PP Pramod, PS Ajeeshkumar, Vajja Dinakar Prasad and Vijaykumar S Nair, "Design and Development of Data Disseminator for BC Measurements for Remote ARFI Observatories", ISRO-VSS C-TR-0523–0-15, 2015.
[22] Honey Well, Temperature sensors HEL-700 Series Platinum RTD datasheet.