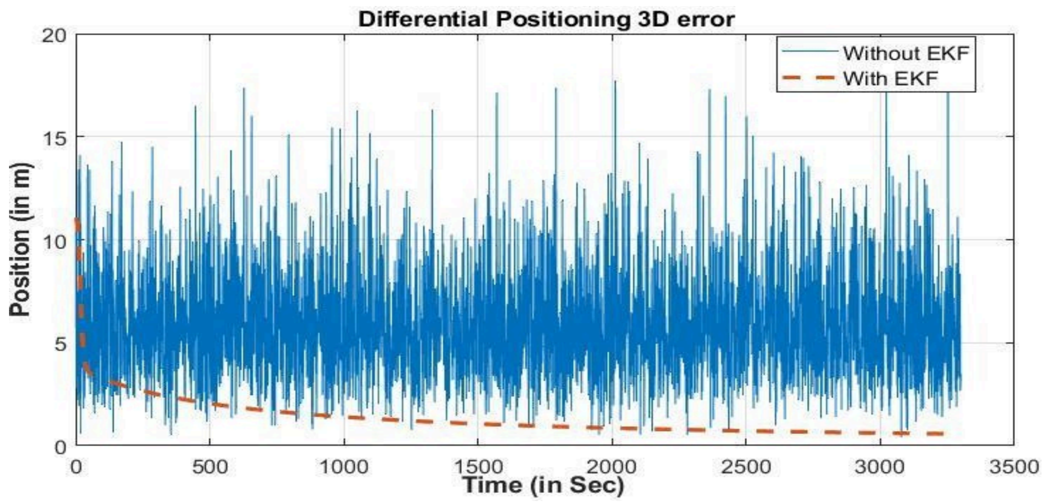
Lunar Differential Positioning Architecture with Extended Kalman Filter

Ashish K.Shukla [(1)], Kevla Merja[(1)*], Dev Desai[(2)], Isha Jani[(3)], Shweta Shah[(2)]
(1) Space Applications Centre, ISRO, Ahmedabad, India, e-mail: ashishs@sac.isro.in; kevlamerja412@gmail.com
(2) Sardar Vallabhbhai National Institute of Technology, Surat, India, devdesaiyt@gmail.com, snshah@eced.svnit.ac.in
(3) Leelaben Dashratbhai Ramdas Patel Institute of Technology & Research, Gandhinagar, India janiisha10@gmail.com

Abstract: In this paper we have proposed Differential Positioning Architecture for lunar surface. We have carried out differential positioning and highlighted the importance and the best possible way to setup a Lunar Reference Station (LRS) for lunar surface. We have simulated the scenario in System Tool Kit (STK) for lunar data generation and introduced 3m Gaussian Noise Error in the data. We have specifically selected Elliptical Lunar Frozen Orbit (ELFO) due to its better stability and visibility. We have also worked out the methodology to establish LRS equipped with pseudolite sensor with Laser Retroreflector Array (LRA) on lunar lander. Differential Positioning is done using Extended Kalman Filter (EKF) and 1.2 m accuracy is achieved.

Keywords: LRA, Differential Positioning, Lunar Reference Station, EKF

Introduction: Establishment of Lunar Reference Station(LRS) which is an essential component of differential positioning architecture is a major challenge. Furthermore, lack of proper Orbit Determination and Time Synchronisation (ODTS) system and reference frame conversion error also pose complexity. Therefore, in this work, we have proposed Laser Altimeter (LA) & LRA based method in which LA on lunar orbiter communicates with LRA deployed on lunar lander. This is used to compute position of the lander equipped with LRA from minimum three range measurements from different orbiter locations. To get accurate position of orbiter we propose to use on-board GNSS receiver that receives GNSS signals from earth. Once LRS location is known, any rover in the vicinity of the LRS can receive pseudo-range and other necessary data to perform differential positioning. To further increase the positional accuracy, we have applied Extended Kalman filter (EKF) on rover position.



Results and Discussion: EKF is implemented to estimate the position of the rover in differential mode. A comparison of position accuracy with & without EKF is illustrated in Figure below. It can be observed from the plot that the 3D position accuracy of the rover is 5.94 meter without EKF while using EKF on differential positioning, a much improved position accuracy of 1.29 meter is achieved.

Conclusion: Lunar Differential Positioning is attempted with a new approach to establish the reference station using Laser Altimeter On-board Lunar Orbiter and Laser Retro-reflector Array (LRA) on the lunar lander with pseudolite sensor. Double differencing in pseudo-range measurements is done for estimating Relative Baseline Vector which is further used to calculate the absolute position of the rover by applying EKF which shows a significant improvement in positional accuracy.

* *Kevla Merja is a contract engineer at SAC, ISRO*

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