Pseudolite based Rover Navigation for Future Interplanetary Missions: An AI-based Approach

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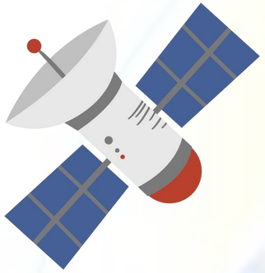
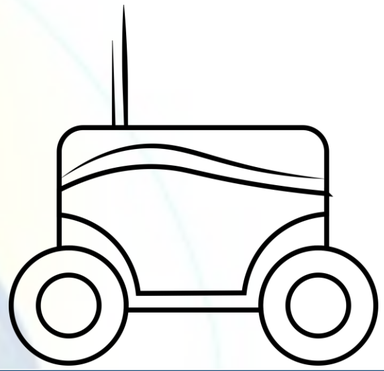
Introduction

- In the absence of any Lunar navigation system, navigation using Ground Based Pseudolite transceivers is one of the possible options.
- In navigating with the help of pseudolites on lunar surface, first the position of the pseudolite itself must be known.
- AI based path planning has been implemented to provide navigation support to the rover.
- The AI-based path planning algorithm has two modules:

✓ straight line motion module

✓ boundary-to-follow module.

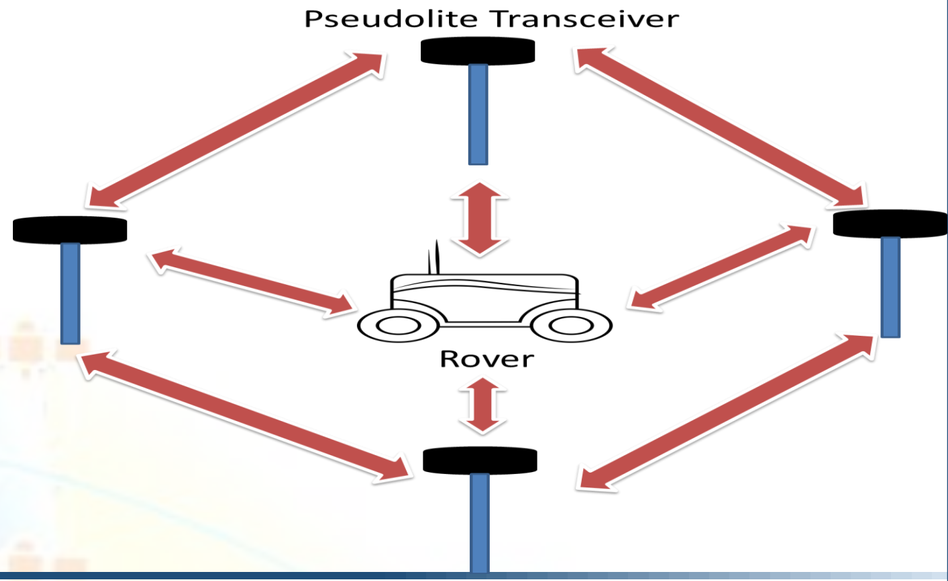




Pseudolite System for Lunar Navigation

- Pseudolite relative Self-Positioning using Bi-directional Ranging is used due to non-availability of absolute locations of Pseudolite transceivers

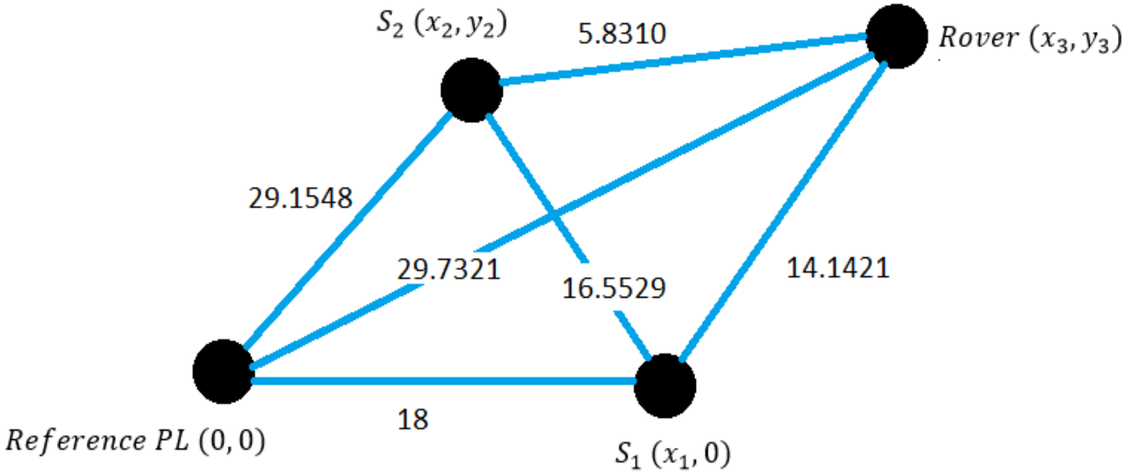
$$\nabla\Delta\phi_{i,j}^{i,j} = 2\left|\left|p^i - p^j\right|\right| + \nabla\Delta N_{i,j}^{i,j} + \nabla\Delta b_{i,j}^{i,j} + \nabla\Delta v_{i,j}^{i,j}$$



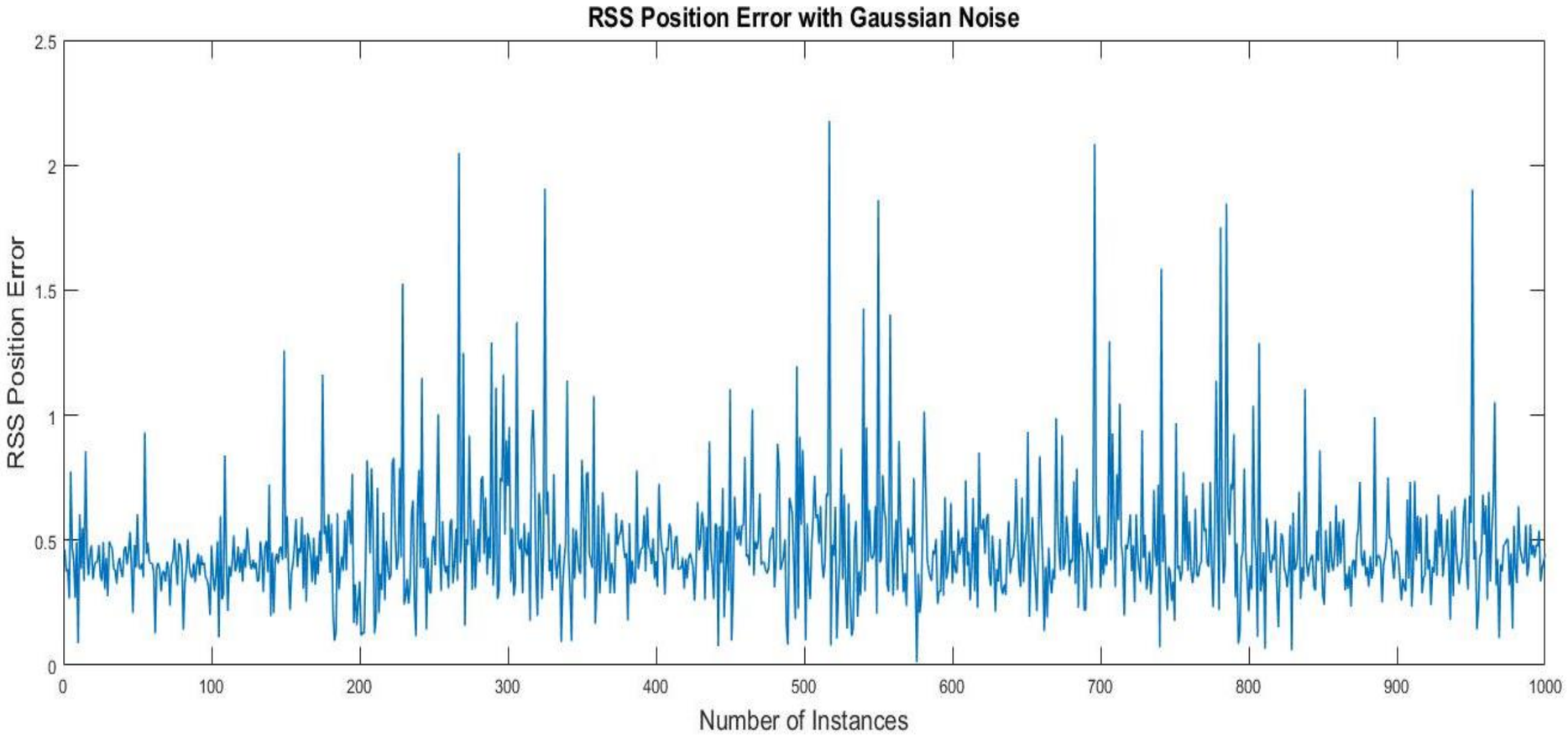
- After double differencing, Receiver & transmitter clock biases are eliminated.
- Finally, rover positioning using bidirectional ranging from remaining pseudolite transceivers is done.

How to Self-Position Using Bidirectional Ranging

- Firstly, each pseudolite transmitter position should be known for the rover positioning.
- Hence, a relative frame of reference within the pseudolite network has been worked out.
- The three sub-objectives of this module are:
- Assume a reference point as (0,0).
- Make a reference axis
- Get ranges to compute the position of remaining pseudolites using bidirectional ranging.



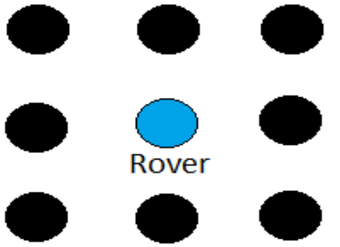
Rover Positioning Simulation Results



- Rover positioning using bidirectional ranging was done after introducing Gaussian Noise in the simulated data.
- RMS position error: 0.49 m.

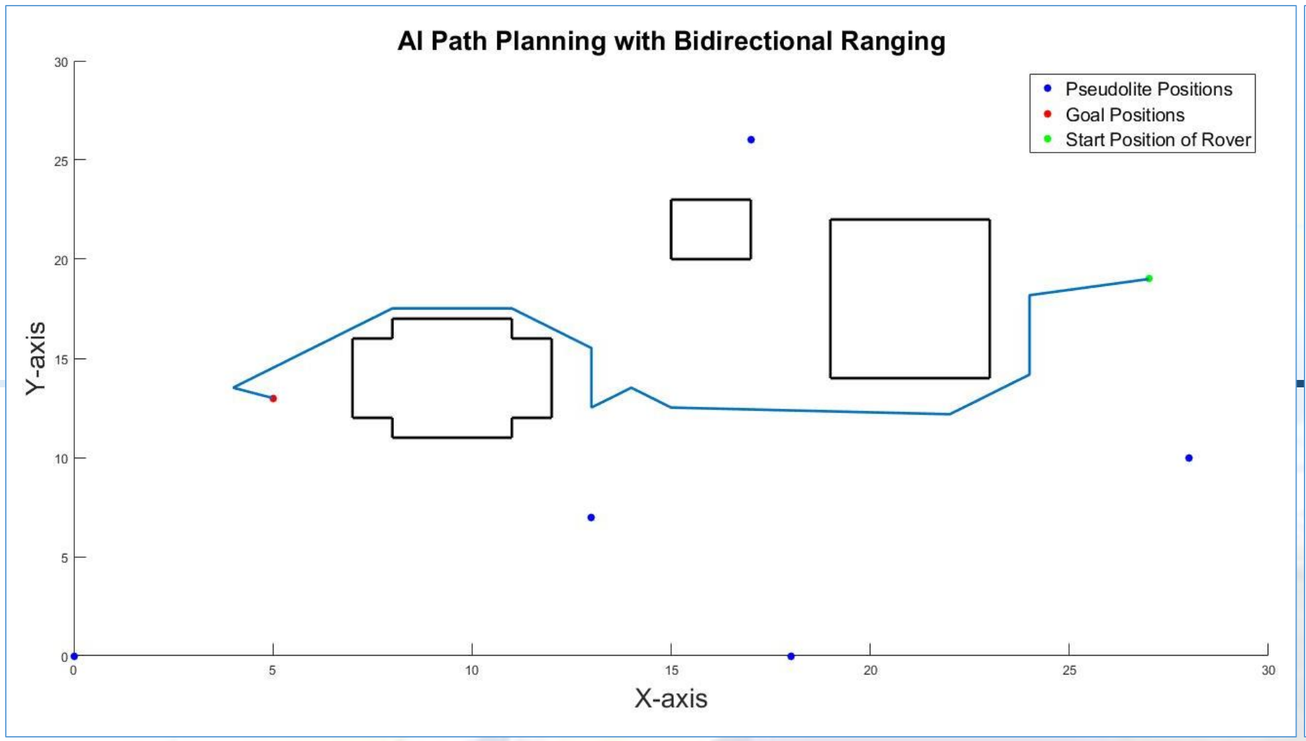
AI Based Rover path planning with Bidirectional Ranging

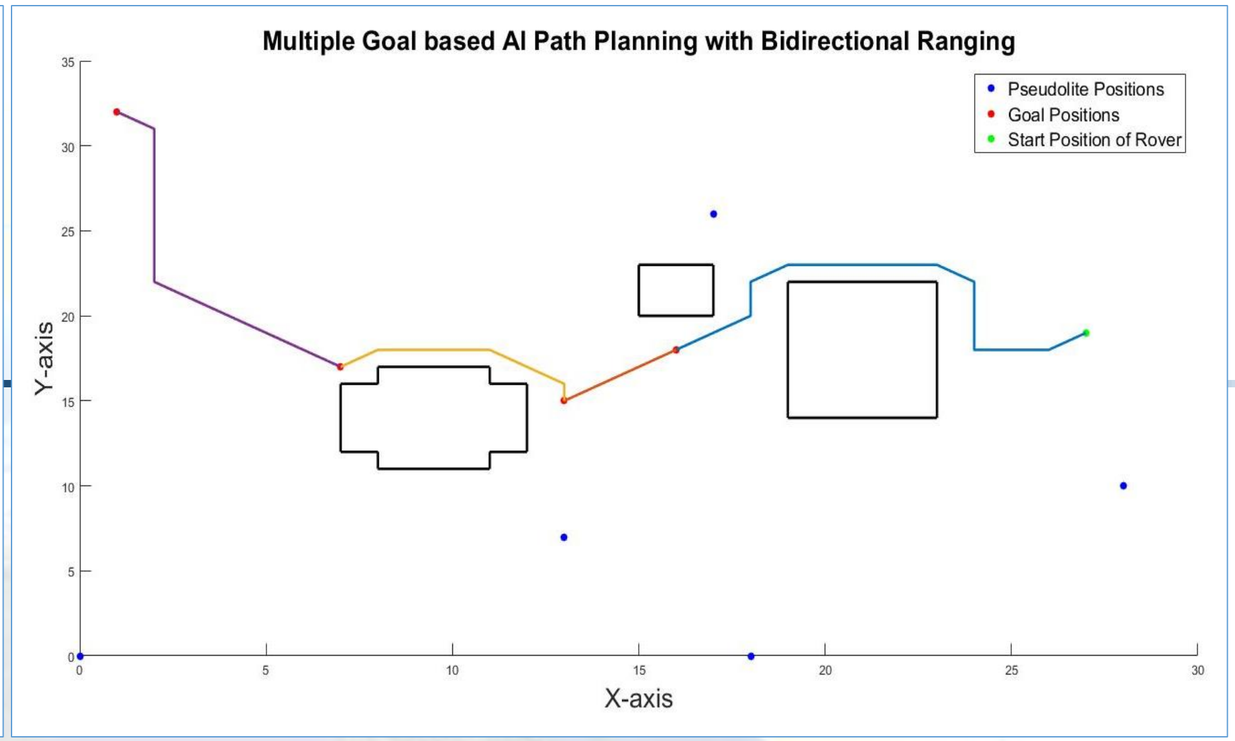
- AI based path planning is an improved version of traditional path planning algorithm in combination with bi-directional ranging.
- The AI Path planning module has simulated predefined percept sequences in the form of a 2D array which was not accessible to the rover.
- Rover had access to only the immediate 8 neighbouring cells at its current position.



8 neighbors of Rover's Current Position

Rover Path Planning with Single & Multiple Goals





Single and multiple goals were achieved by the rover.

Conclusion

- Pseudolite Based scheme for future interplanetary/Lunar missions is worked out using simulated data with AI based approach.
- Self-positioning of pseudolite and rover positioning was done using bidirectional ranging.
- The AI-based path planning was implemented in association with bidirectional ranging.
- In future, we aim at developing prototype hardware for the demonstration of the concept.


Thank You