2021 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

CAREER: Situational Awareness Strategies for Autonomous Systems in Dynamic Uncertain Environments

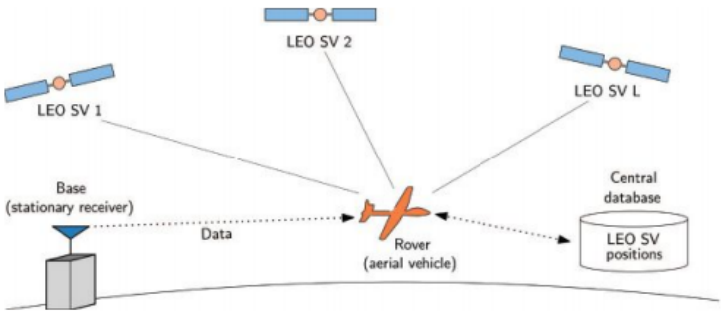
Award # 1929965 / Award Date: April 2018 / Zak Kassas, University of California, Irvine)

Challenge:

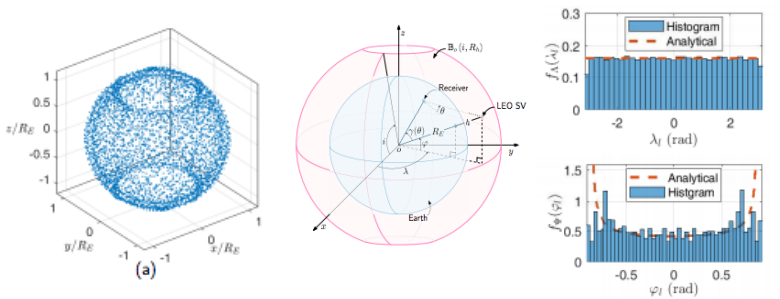
- Exploit signals transmitted by poorly known megaconstellation low Earth orbit (LEO) satellites with dynamic and stochastic states to achieve situational awareness

Solution:

- Developed a base/rover carrier-phase differential LEO (CD-LEO) framework to compensate for large uncertainties in LEO satellite states
- Developed stochastic geometry models for megaconstellation LEO satellites
- Developed an efficient integer least-squares approach to estimate carrier phase ambiguities



Differential Framework



Stochastic Geometry Models for Megaconstellation LEO satellites

Scientific Impact:

- Tractable theory to deal with high dynamic stochastic uncertainties in large-scale systems
- Computationally efficient approach to solve integer optimization problems (achieving 60% computational reduction over current state-of-the-art) with performance guarantees

Broader Impact:

- Enabled situational awareness for autonomous systems deployed in poorly known dynamic stochastic environment
- Enabled efficient exploitation of future megaconstellation LEO satellites (e.g., Starlink)
- Reduced UAV navigation error by 96% over current state-of-the-art
- Hosted 50 middle-school students for a day-long Game of Drones competition

Project info:
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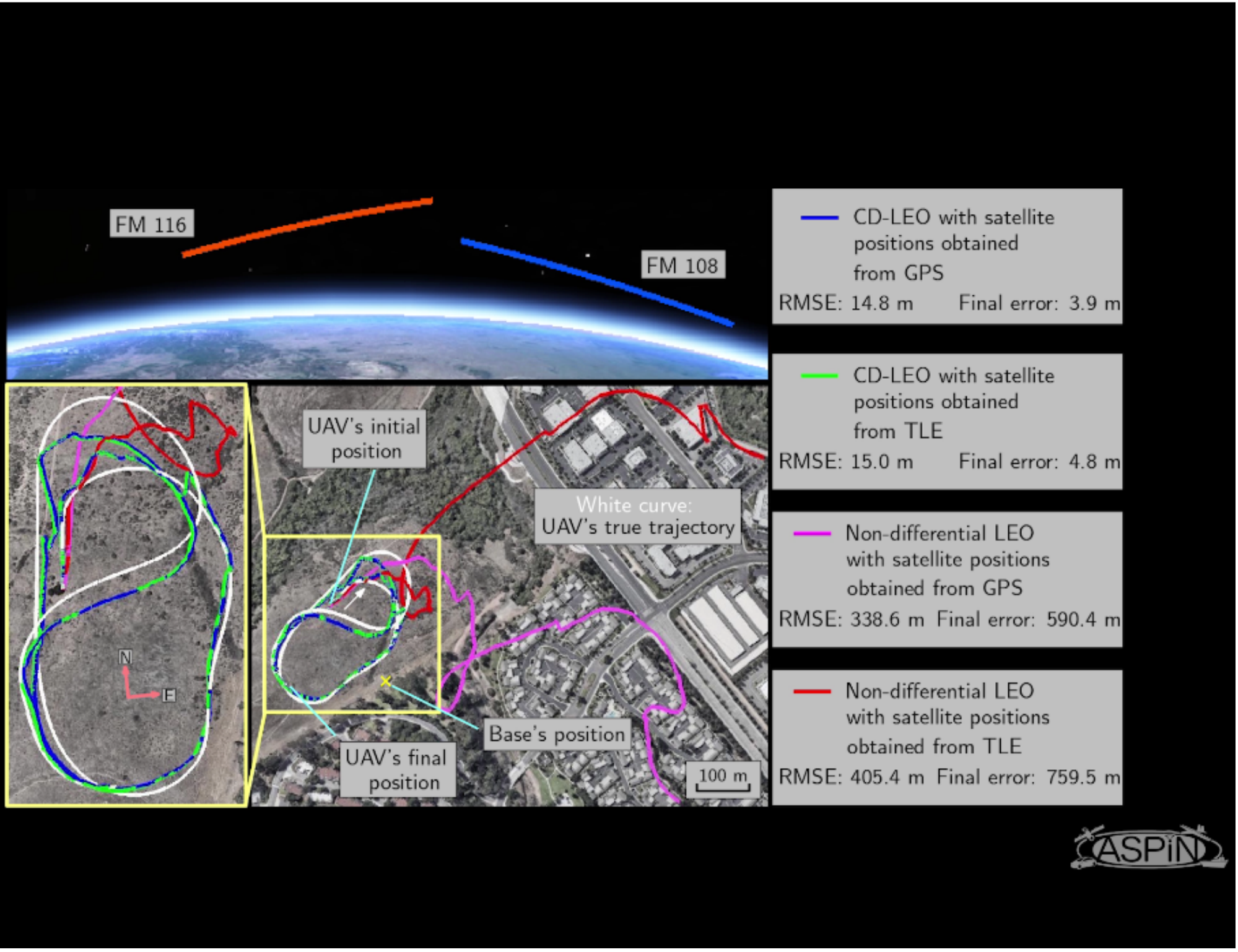
FM 116
FM 108
UAV's initial position
White curve: UAV's true trajectory
Base's position
UAV's final position
100 m
N
E
CD-LEO with satellite positions obtained from GPS
RMSE: 14.8 m Final error: 3.9 m
CD-LEO with satellite positions obtained from TLE
RMSE: 15.0 m Final error: 4.8 m
Non-differential LEO with satellite positions obtained from GPS
RMSE: 338.6 m Final error: 590.4 m
Non-differential LEO with satellite positions obtained from TLE
RMSE: 405.4 m Final error: 759.5 m
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