New algorithm brings real-time precision to navigation systems

GA, UNITED STATES, August 26, 2025 /EINPresswire.com/ -- In an era where autonomous systems demand pinpoint accuracy, navigation algorithms face a tough trade-off between precision and speed. Traditional methods struggle with noisy signals and computational bottlenecks, slowing their adoption in real-world applications. The newly developed Optimized iSAM (OiSAM)-Factor Graph Optimization (FGO) algorithm rewrites this equation. By combining an optimized incremental smoothing approach with adaptive re-linearization, the method slashes processing time while preserving high-level accuracy. Tested against leading benchmarks, OiSAM-FGO cut optimization time by over 50% yet matched state-of-the-art performance, far outpacing traditional Kalman filters. The advance brings navigation systems closer to the elusive goal of being both fast and fault-tolerant.

The vehicle trajectories. a The Awesome GINS Dataset which was collected in an open-sky industrial area in Wuhan. b The second dataset which was collected in a suburban area in the Optics Valley of China, Wuhan.

Global Navigation Satellite Systems (GNSS) power today's location services but falter in cities, where tall buildings block signals. Inertial Navigation Systems (INS), meanwhile, fill short-term gaps but drift over time. Fusing the two has become standard, yet common algorithms like the Extended Kalman Filter cannot fully handle nonlinear dynamics or exploit historical data. Factor Graph Optimization (FGO) emerged as a breakthrough, offering global optimization and multi-sensor flexibility. Its drawback, however, is heavy computational demand that overwhelms embedded hardware. Because of these persistent challenges, researchers have been compelled to pursue new approaches that enhance efficiency without undermining accuracy.

A research team from the Institute of Microelectronics, Chinese Academy of Sciences, together with the University of Chinese Academy of Sciences, has unveiled Optimized iSAM (OiSAM)-FGO, a novel algorithm that brings real-time efficiency to GNSS/INS integration. Published (DOI: 10.1186/s43020-025-00173-w) on August 11, 2025, in Satellite Navigation , the work introduces an optimized incremental smoothing and adaptive re-linearization framework. In rigorous trials on real-world datasets, OiSAM-FGO not only preserved state-of-the-art precision but also halved

computation time, delivering a critical upgrade for intelligent transportation and autonomous navigation.

The study tackles the long-standing trade-off between accuracy and efficiency in factor graph optimization. At its core lies OiSAM, an improvement on incremental smoothing and mapping that focuses calculations only on essential non-zero elements, reducing complexity from quadratic to linear scale. Complementing this is the Adaptive Joint Sliding Window Re-linearization (A-JSWR) strategy, which smartly decides when to re-linearize—balancing periodic updates with sudden state changes. Together, they form the OiSAM-FGO framework, capable of delivering high accuracy under real-time constraints.

Testing was performed on the well-known Awesome GINS (GNSS+ INS) Dataset and additional field data from Wuhan, China. In head-to-head comparisons with OB-GINS—the current state-of-the-art FGO method—and Extended Kalman Filter baselines, OiSAM-FGO proved its worth. Optimization time dropped by more than 50%, with overall efficiency gains exceeding 20% across scenarios, while accuracy in position, velocity, and attitude remained on par with OB-GINS and far beyond Extended Kalman Filter (EKF). Even in challenging conditions, the algorithm maintained robustness, with only minor fluctuations in yaw estimation. These results highlight OiSAM-FGO's ability to combine the precision of advanced graph optimization with the speed demands of real-world navigation.

"Bringing factor graph optimization out of theory and into practice has been a long-standing challenge," explained lead author Zhichao Yang. "With OiSAM-FGO, we've shown it is possible to retain the benefits of global optimization while stripping away much of the computational burden. This means resource-limited platforms—from embedded automotive systems to portable robotics—can now access levels of navigation accuracy once thought too expensive in terms of processing power. Our results mark a step closer to real-time, reliable navigation across diverse environments".

The new carries wide-ranging implications. For autonomous driving, aerial drones, mobile robotics, and smart transport systems, OiSAM-FGO opens the door to faster and more reliable navigation without requiring costly hardware upgrades. By reducing processing and memory demands, the algorithm helps conserve power and lower system costs—vital advantages for embedded devices. Looking ahead, the framework could be extended to multi-sensor platforms incorporating Light Detection and Ranging (LiDAR) or cameras, broadening its use in complex urban landscapes. With OiSAM-FGO, navigation systems are set to become more efficient, accessible, and adaptable to the future of intelligent mobility.

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