A Novel AI-Based GPS Anti-spoofing System with Subspace Differential Direction-of-Arrival Estimation and Deep Learning Against Dynamic Spoofers

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Many critical systems, including financial, banking, telecom and nuclear weapons, rely on the Global Positioning System (GPS) for synchronization of clocks that is essential for their operation. Malicious actors intending to disrupt these systems employ sophisticated GPS spoofing techniques that mimic legitimate GPS transmissions so closely making it difficult for even the most advanced anti-spoofing methods to detect them. This project designs a novel artificial intelligence (AI)-based GPS anti-spoofing technique that relies only on the physical attributes unique to a signal originated at an orbiting satellite. It uses a multi-element antenna array receiver to estimate the instantaneous signal direction-of-arrival (DOA) using a subspace-based statistical signal processing algorithm termed the root-MUSIC. Time-series of the estimated differential DOAs of signals are input to a convolutional neural network deep-learning classifier that learns the embedded signatures unique to the trajectories of signal sources to separate authentic and spoofed GPS signals. A software implementation of the designed system using actual GPS orbital data demonstrated over 96% accuracy even against dynamic airborne spoofers. A hardware implementation, using a 4-element antenna array, an RF-transceiver and a microprocessor, was shown to detect spoofed signals with above 93% accuracy. Unlike existing methods, this AI-based anti-spoofing system does not require knowledge of receiver’s location and orientation or manual thresholds making it suitable for moving platforms. The proposed technique is expected to counter even the most advanced spoofers since it is difficult to exactly replicate the differential DOA of a satellite even by an airborne transmitter.

Awards Won:

Third Award of $1,000

American Statistical Association: Certificate of Honorable Mention

Arizona State University: Arizona State University ISEF Scholarship

Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category

University of Arizona: Renewal Tuition Scholarship

K. Soumyanath Memorial Award: First Award of $3,000

K. Soumyanath Memorial Award: $1,000 will be awarded to the winner's school.