Novel Approach to Calculation of Bike Route Distance Using Concept of Fractal Dimension

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Fractals, known for their non-integer dimensions, help describe intricate natural phenomena, like the coastline paradox. These principles may be applied to human-made processes like bike routes, where GPS faces challenges due to meandering routes and signal noise. This research aims to improve bike route distance calculations using fractal concepts in GPS data. Equipped with an odometer and GPS, a cyclist navigated diverse meandering routes, yielding 81,705 GPS points. The total distance for each route was calculated using different scales. Examining length-scale dependencies determined fractal dimensions for different meandering levels. While a highly meandering route had a fractal dimension of 1.23, a lesser meandering had 1.08. Then, distances were extrapolated to smaller scales toward true lengths based on scale and fractal dimension dependencies. For 32 bike routes, the GPS mean error relative to odometer distance was 7.2% (max 20.2%, SD 4.6%), whereas the fractal approach showed a mean error of only 0.4% (SD 2.3%). This indicates a more precise and accurate process than existing GPS applications. This research introduces a novel fractal approach for GPS distance tracking with broader implications beyond cycling because the algorithm can use noisy signal data to find accurate distance values. By using the fractal-like qualities inherent in large-scale inaccurate data, the algorithm extrapolates more accurate distances. Industries such as aerospace, defense, and logistics, which heavily depend on accurate distance tracking in the presence of signal noise, can benefit significantly. This method not only enhances distance tracking for cyclists but also offers a promising solution for various applications grappling with GPS signal-based distance measurement challenges.

Awards Won:
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category,