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

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A fractal is a mathematical object with non-integer dimensions, characterized by self-similar patterns repeating at different scales. They help describe intricate natural phenomena, like the coastline paradox, in which length increases as scales decrease. These principles may be applied to human-made processes like bike routes, where GPS faces challenges in meandering routes and signal loss. This research aims to improve bike route distance calculations using hybrid-fractal concepts in GPS data. Equipped with an odometer and GPS, a cyclist navigated diverse meandering routes. The new method only calculated distance with different scales on selected sections with anti-correlation between turning angle and speed. Examining selected length-scale dependencies determined fractal dimensions for different meandering levels. Low meandering routes had an average fractal dimension of 1.05, and highly meandering 1.15. Distances were extrapolated to smaller scales toward true length based on hybrid scale and fractal dimension dependencies. The hybrid fractal approach achieved a mean error of 0.3% (max 5.7%, SD 2.2%) relative to odometer distance—reducing the mean distance error by 24 times and SD by 2 times compared to current GPS application. This research introduces a novel hybrid fractal approach for GPS distance tracking with broad applicability beyond cycling because the algorithm can use data in larger scales and still find accurate distances based on fractal dimension. Because of the ability to use this large-scale, inaccurate data, a hybrid fractal approach is a promising solution for fields that have issues with GPS signal loss like aerospace, defense, and wildlife biology, which depend on accurate distance tracking in the presence of meandering and GPS signal issues.

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