# A GPS-aided Inertial Navigation System for the Pedelec

(Master's thesis)

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## Motivation

Regarding the congested traffic in cities, especially at busy times, a Pedelec (Pedal Electric Cycle) poses an alternative to the automobile traffic to reach the desired destination promptly as it assists the rider's pedaling with an electromotor. Often navigation systems based on the Global Positioning System (GPS) are used to aid the driver in finding the route through an urban area. In these regions, buildings and trees pose obstacles to the GPS, which dampen and refract the signals and consequently heavily influence the accuracy of these estimations. Therefore, the use of additional sensor technology is inalienable in order to provide a reliable and more precise position estimation in an urban environment.

## State of the art

More accurate estimates of vehicle states by combining GPS and an inertial navigation system (INS) have been subject of research in various fields of applications, for instance, aircraft, submarines, spacecraft and guided missiles. In this work, the conventional approaches used in practice are evaluated and tailored to the domain of Pedelecs.

## Objective

The goal of this work is the creation of a low-cost GPS-aided inertial navigation system for the Pedelec using an Android smartphone.
A combination of both, GPS and INS, allows for smoother positioning and velocity estimates between each measured sample. Especially in areas where GPS may lose its signal the INS can continue to estimate the Pedelec position and angle.
As the sensor fusion of GPS and INS is, in general, a nonlinear filtering problem, a statistical approach is used and implemented. Furthermore, a dynamic bicycle model that represents the underlying state space for the sensor fusion needs to be created.
This work should serve as a baseline system on which further improvements to the localization and mapping of the Pedelec should be made and evaluated.
If time permits, a hybrid approach is examined that contains both discrete and continuous state space representations in order to alleviate the disadvantages and time inherent assumptions and combine the benefits of both models, for example, by combining hidden Markov models and nonlinear dynamical systems.

## Approach

Explorative prototyping is done using MATLAB to evaluate the feasibility of the approaches. Subsequently, these approaches are developed targeting the Android architecture.

First, a dynamic vehicle model of the bicycle has to be created. On the basis of this model, a particle filtering algorithm is implemented and evaluated. Furthermore, a hybrid approach will be applied and used to assess the minimization of the error in heading direction.

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