SnapperGPS A Small, Low-Cost, Low-Power Wildlife Tracking System
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Motivation

- Biologists and conservationists use global navigation satellite systems (GNSS), e.g., the GPS, to track animals and study their behaviour.
- Existing tracking devices are often expensive ($100–$10,000) and require heavy batteries for long-term deployments.
- This prohibits studies with many animals and is our motivation for developing SnapperGPS.

SnapperGPS aims at being a cheap, small, and low-power tracking solution.
Its core idea is to make the hardware as simple and as energy-efficient as possible.
We achieve this by doing as little signal acquisition and processing on the device as possible.
Instead, SnapperGPS provides a web service that processes the signals in the cloud.
This allows us to build a bare-bone receiver for <$30 that runs for >10 years on a coin cell.

Snapshot GNSS

Traditional GNSS
- Spends seconds or minutes
  - acquiring satellites,
  - tracking satellites,
  - decoding data from the satellites (signal transmission times, satellite orbits, …),
  - calculating receiver-satellite distances from signal travel times, and
  - estimating the receiver position from its distances to multiple satellites;
- Carries out all steps on the device;
- Consumes significant time and energy and requires complex hardware.

Snapshot GNSS [4], e.g., SnapperGPS
- Captures short 12-millisecond satellite signal snapshots from time to time;
- Samples the signals with a very low resolution to reduce hardware complexity and the amount of captured data;
- Stores the raw signal snapshots until the tag is recovered;
- Uploads the raw data to our cloud service after recovery;
- Calculates the track of the animal in the hind-sight in the cloud.

Robust Algorithms

- The main challenge for the cloud segment is to estimate a location from a satellite signal snapshot that is too short to decode a signal transmission timestamp.
- Instead, snapshot GNSS uses the phase of the periodic code that each satellite broadcasts to extract information about the signal travel time and hence the receiver-satellite distance.
- SnapperGPS takes the particular challenge that the hardware records signals at a much lower resolution than any existing system, which produces outliers.
- To robustly solve the code-phase-based positioning problem, we implement three alternative approaches based on probabilistic models [1]
  - The first one adds a Bayesian satellite selection strategy to the traditional non-robust least-squares approach to satellite navigation.
  - The second one employs a mixture model and maximum-likelihood estimation to jointly solve the outlier detection and the final positioning problem.
  - The third one directly estimates the location that has most likely caused the observed raw signal snapshot. The likelihood is optimised using a tailored branch-and-bound algorithm [2].

Web Application

- We implemented all algorithms in an open-source back-end of a public web application.
- Via the website, you can configure your receiver, upload raw data, and calculate tracks.

Conclusions

SnapperGPS is a small, low-cost and low-power wildlife tracking system. It comprises a purpose-built receiver and robust algorithms that are implemented in a cloud-based web application. It will soon be available to the public and the entire hardware and software stack will be made open source to encourage innovation.

We have demonstrated that SnapperGPS can be used in the field to track wildlife. In particular, SnapperGPS has been used to track nesting loggerhead sea turtles on the island of Maic in the 2021 nesting season.

References