

Localization and Monitoring of Vehicles supported by Inertial Sensors

Martin Lindfors
martin.lindfors@liu.se

DESCRIPTION

This PhD project investigates how cheap sensors, such as inertial sensors, can be used to monitor wheeled vehicles. One aspect is to estimate the wheel speed of the vehicle, and use this in an odometric navigation system. Another is to localize a vehicle using an acoustic sensor network. Field tests data are obtained from NIRA Dynamics and FOI.

BACKGROUND AND MOTIVATION

Autonomous vehicles are foreseen to become an important component of everyday life in the future. In order to bring autonomous technology to more markets, it is desirable to use inexpensive, yet informative, sensors in the place of expensive sensors used today. Such sensors include inertial measurement units (IMUs) and microphones.

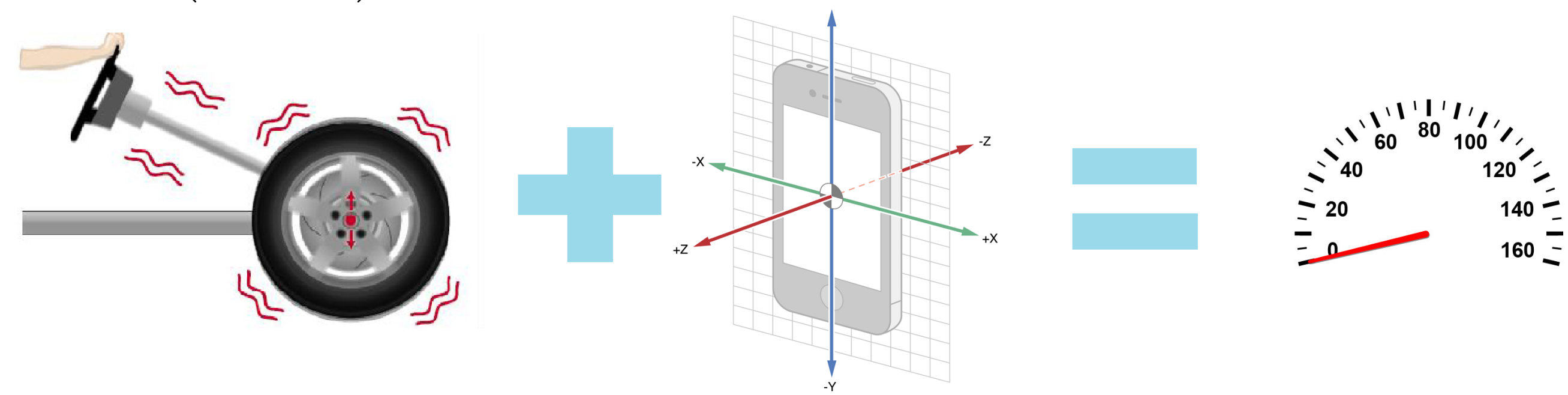


Figure 1: Using accelerometers and wheel vibrations to estimate wheel speed.

METHODS AND PRELIMINARY RESULTS

Area 1:

- New variant of Rao-Blackwellized point mass filter

$$p(x_t | \mathbb{Y}_t) = p(x_t^k | x_t^p, \mathbb{Y}_t) p(x_t^p | \mathbb{Y}_t) \\ \approx \sum_{i=1}^N w_{t|t}^i \mathcal{N}(x_t^k | \hat{x}_{t|t}^{k,i}, P_{t|t}^{k,i}) \delta(x_t^p - x_t^{p,i}).$$

- Dynamic model for harmonics
- Estimate Campbell diagram, use for estimation

Area 2:

- Apply above methods to acoustics
- Higher fidelity harmonics tracking than previous methods
- Varying source frequency model to exploit this fidelity

RESEARCH GOAL AND QUESTIONS

Extract useful information in novel ways from inexpensive sensors such as IMUs and microphones, mainly using harmonics tracking.

- Area 1: Use wheel vibrations measured by accelerometers to estimate wheel speed.
 - What harmonics tracking methods to use?
 - What preprocessing is required?
 - In which cases is wheel speed estimation feasible?
- Area 2: Extract engine speed from acoustic measurements in a microphone array, and use this to localize a vehicle using the Doppler effect.
 - What differences apply from the accelerometer case above?
 - Which methods are best here?
 - How much of a difference do they make for localization performance?

ROADMAP & MILESTONES

- A conference paper on wheel speed estimation from wheel vibrations has been presented at IV'16.
- A journal article on the same subject is being written for IEEE Transactions on Vehicular Technology.
- A conference paper on acoustic Doppler tracking is being written for FUSION'17.
- Further work:
 - Use wheel speed estimation for map aided localization using only an IMU.
 - Multiple harmonics tracking for vehicle surveillance.
 - More flexible trajectory model.

FIGURES

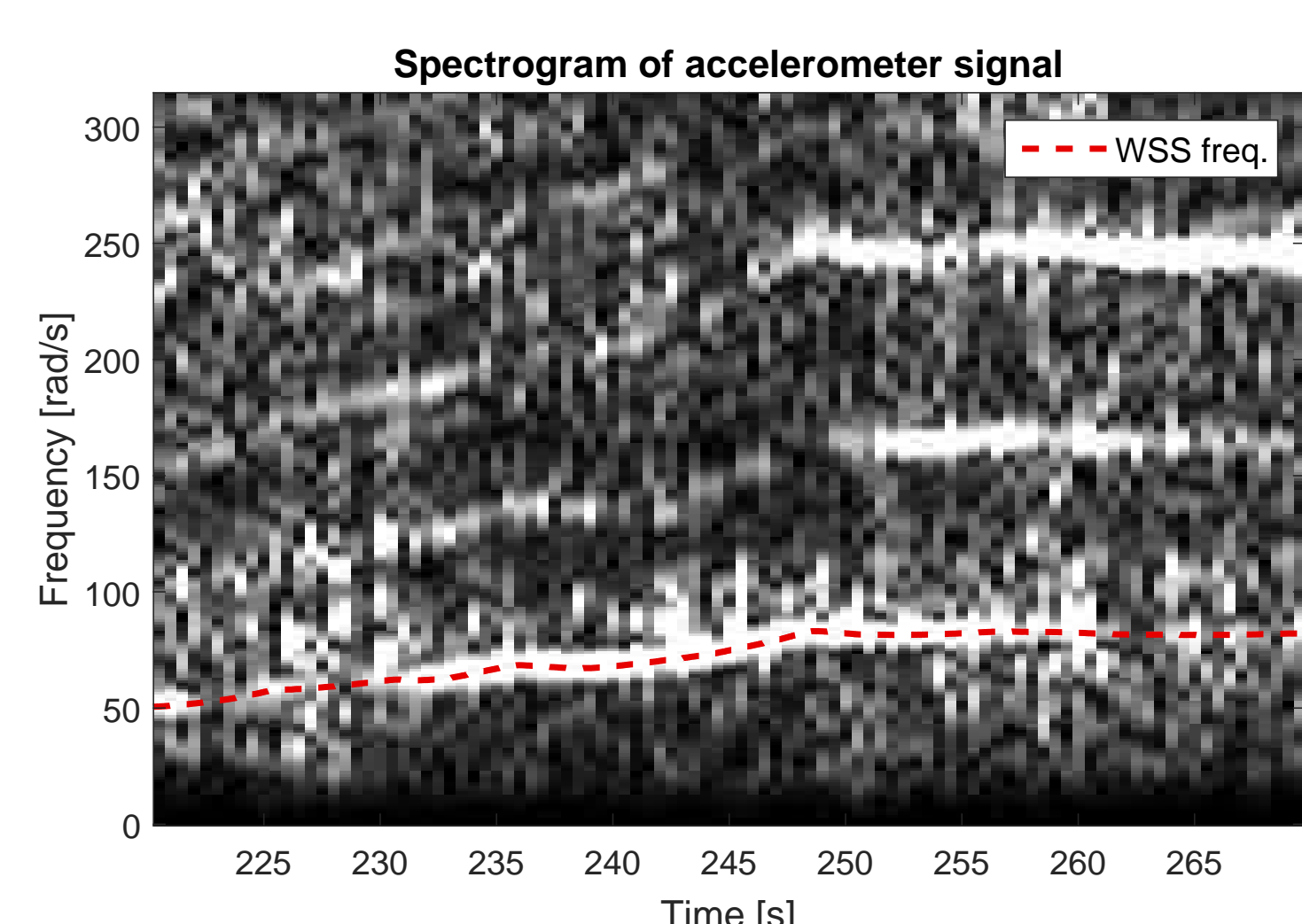


Figure 2: Spectrogram of accelerometer measurements, with true wheel speed annotated.

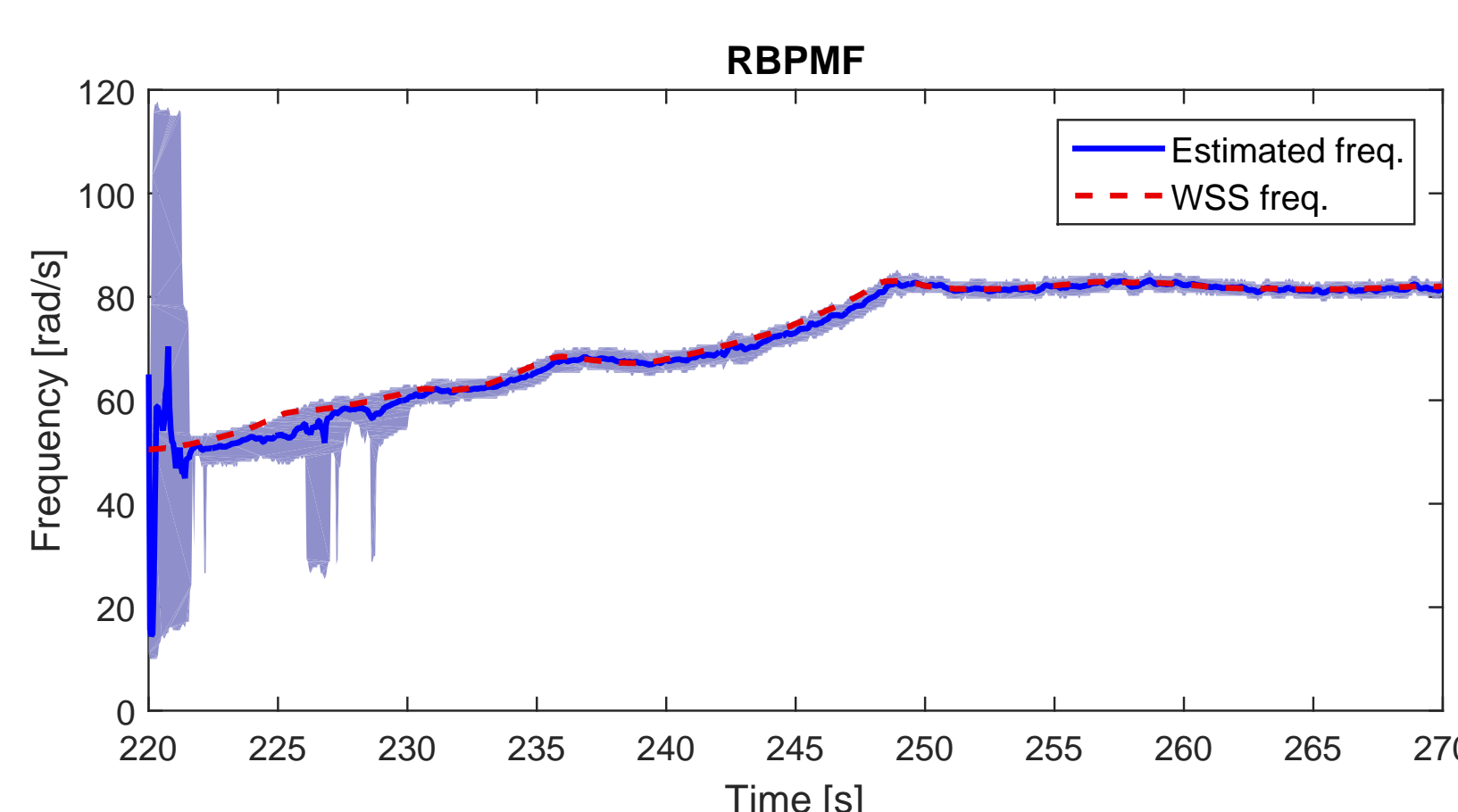


Figure 3: Posterior distribution of wheel speed using Rao-Blackwellized point mass filter.

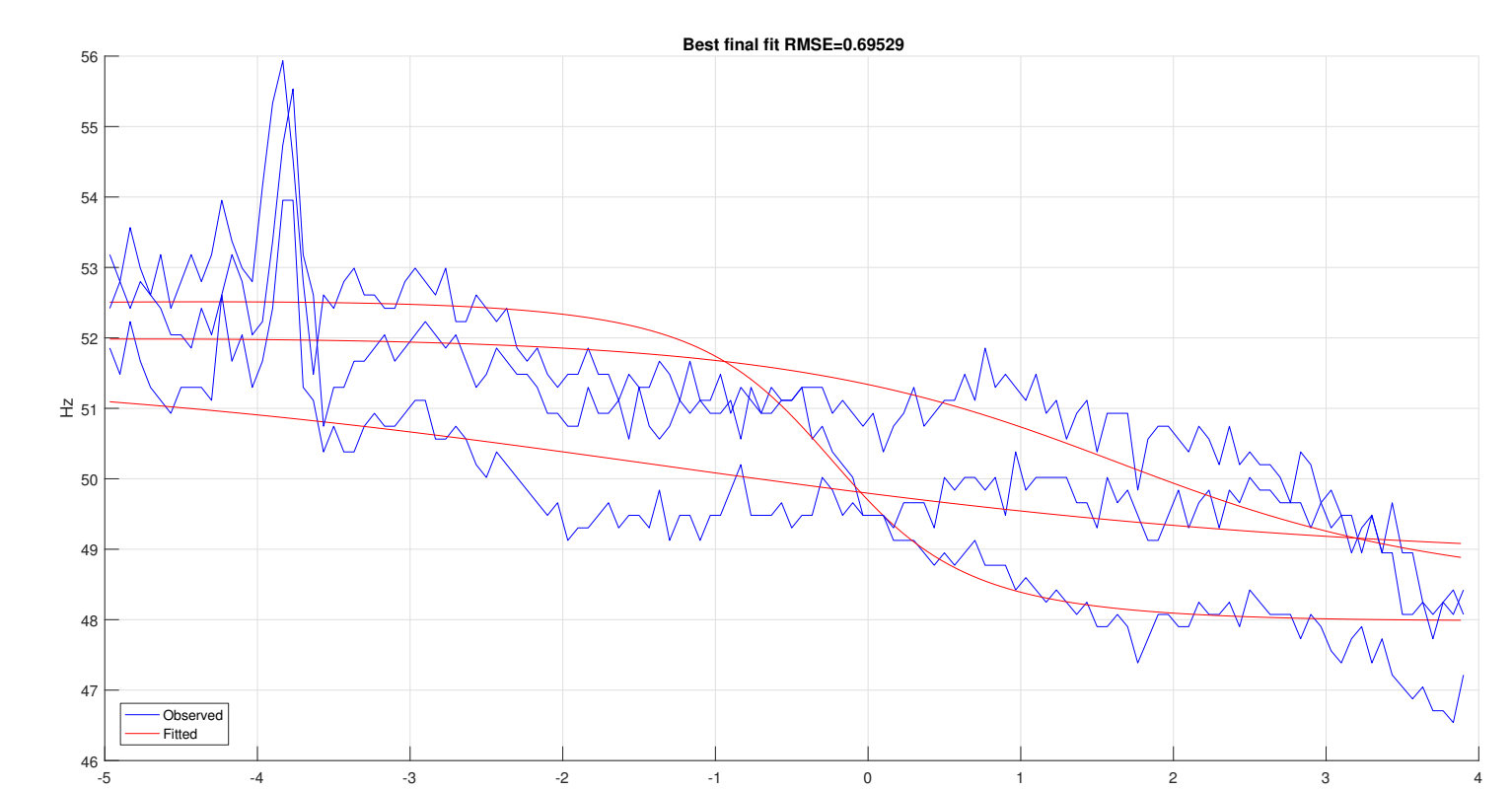


Figure 4: Comparison of pure Doppler frequency shift, assuming constant engine speed, with engine speed variations.