Gradient and Mass Estimation in a Vehicle Using Different Sensor Combinations

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INTRODUCTION

The aim of this project is to obtain accurate online estimation of vehicle mass and road gradient using an algorithm based on recursive least squares with an exponential forgetting factor. Velocity, torque and acceleration are measured for use in the algorithm.

VEHICLE DYNAMICS

The vehicle was modelled as:

$$m\ddot{x} = F_{engine} - mgsin\theta - C_{\mu}mgcos\theta$$

$$\begin{bmatrix}\dot{x}\\ \ddot{x}\end{bmatrix} = \begin{bmatrix}0 & 1\\ 0 & 0\end{bmatrix}\begin{bmatrix}x\\ \dot{x}\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}\begin{bmatrix}-g & F_{engine}\end{bmatrix}\begin{bmatrix}sin\theta + C_{\mu}cos\theta\\ 1/m\end{bmatrix}$$

$$\dot{\boldsymbol{x}} = A\boldsymbol{x} + B\boldsymbol{\varphi\Theta}$$

and the estimator as:

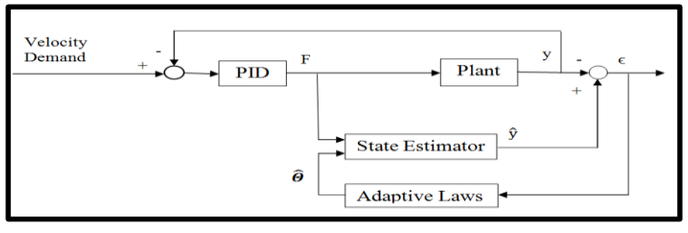
$$\dot{\hat{\boldsymbol{x}}} = A\hat{\boldsymbol{x}} + B\boldsymbol{\varphi}\hat{\boldsymbol{\Theta}}$$

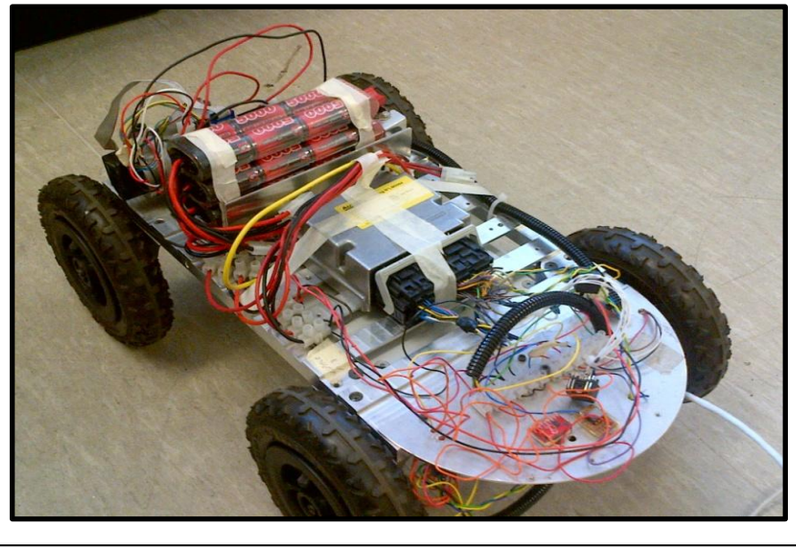
RECURSIVE LEAST SQUARES

RLS is based on minimising the sum of the squares of the difference between measured and estimated values. RLS is more sensitive to new data as it gradually "forgets" past data. Doing so, we obtain 2 pivotal update equations.

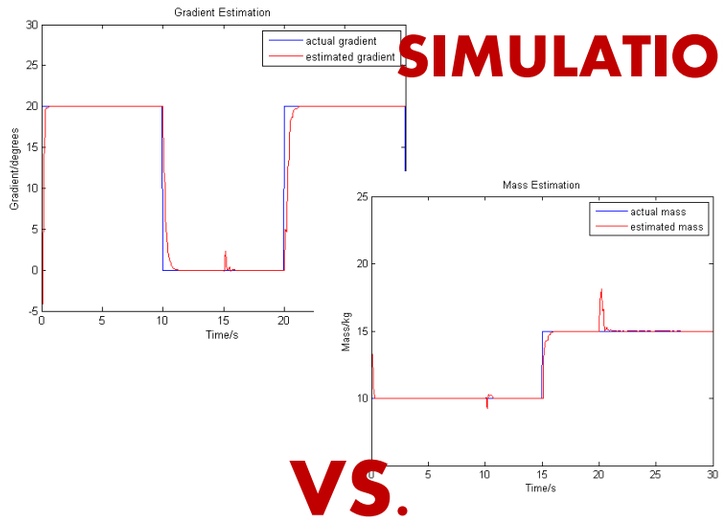
$$\dot{\hat{\boldsymbol{\Theta}}} = -\boldsymbol{P}(t)\boldsymbol{W}^{T}\epsilon$$

$$\dot{\boldsymbol{P}} = \lambda(t)\boldsymbol{P} - \boldsymbol{P}\boldsymbol{W}^{\boldsymbol{T}}\boldsymbol{W}\boldsymbol{P}$$

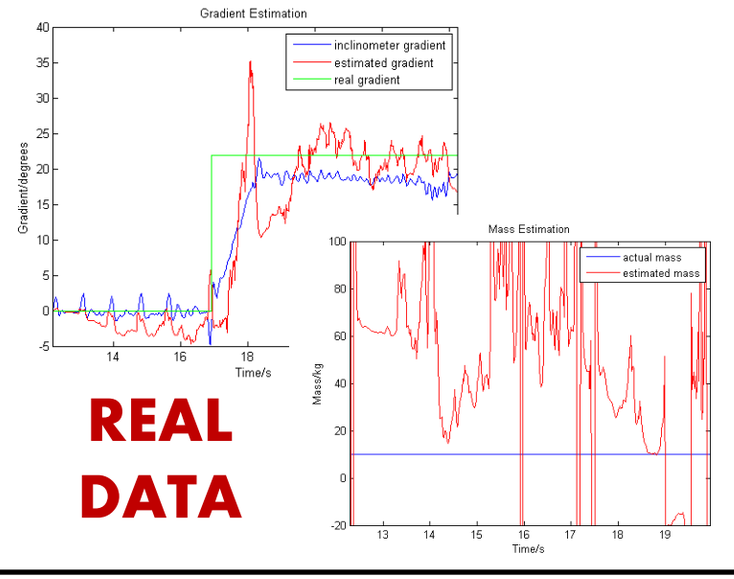




SIMULATION



VS.



REAL DATA

CONCLUSION

Simulation results prove promising but online estimates, especially mass, are still challenging. Persistent excitation should be investigated further.