Trade-off adjustment between resolution and bandwidth in low frequency force measurement with magnetic springs

Research framework

In micro and nano force measurement using rigid macroscopic force-displacement transducers connected to magnetic springs, the under-damped and long transient response due to the transducers mass inertia can not be neglected for time-varying force measurement. It is thus necessary to deconvolve the transducer displacement to correctly estimate the unknown input force, which leads to a trade-off between the resolution and the bandwidth of the force sensor.

Proposed approach

The deconvolution approach implemented is based on a discrete Kalman filter with an uncertain *a priori* model to represent the unknown micro-nano force to be estimated. This model is a discretized Wiener process including a parameter which is a power spectral density whose value has to be adjusted by the end-user.

The main advantage of this approach is that the end-user can directly control with this parameter the unavoidable trade-off that exists between the wished resolution on the estimated force (aka its standard deviation) and the force sensor bandwidth (correlated to the response time of the estimation).

This approach is computationally cheap and makes possible the extension of the sensor bandwidth beyond the low natural resonant frequency of the macroscopic force-displacement transducer (up to x3 extension possible with low noise displacement sensors). It also takes into account the dynamic behavior imposed by the mass inertia.

Major article: E. Piat, J. Abadie, S. Oster, Nanoforce estimation based on Kalman filtering and applied to a force sensor using diamagnetic levitation, Sensors and Actuators: A Physical, 2012, 179:223-236.

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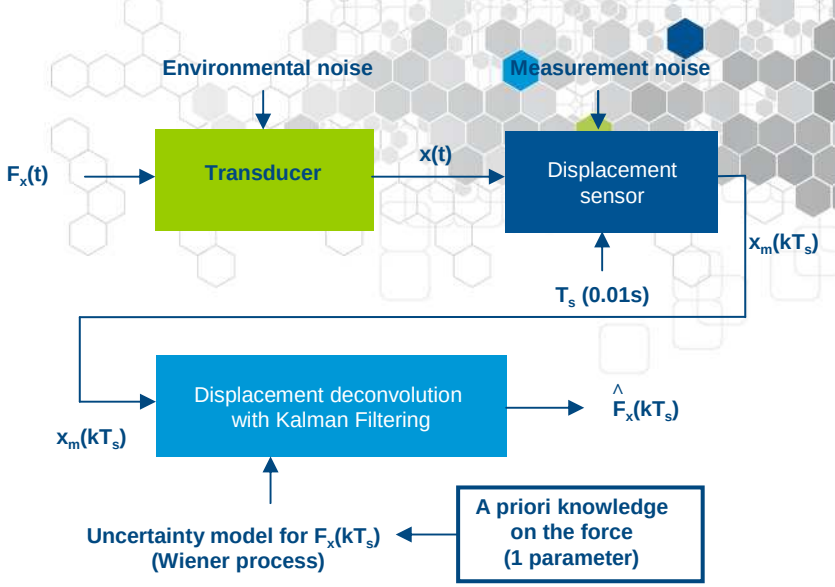
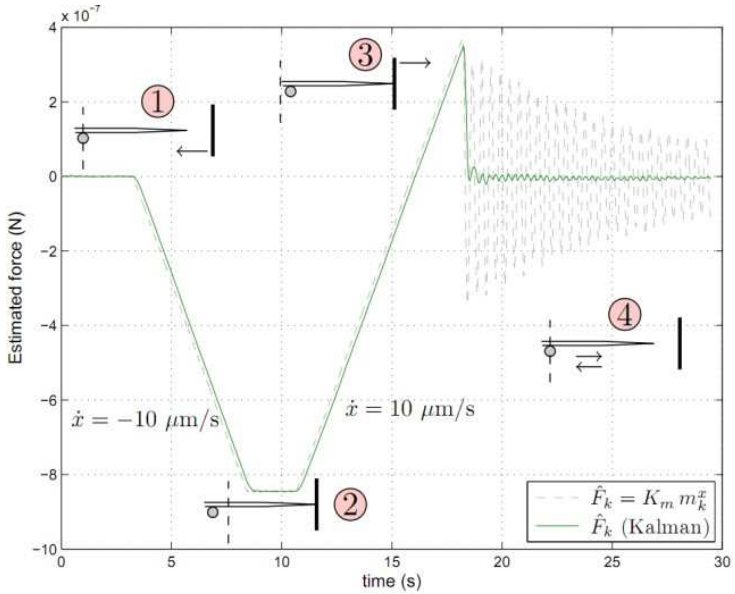


Deconvolution of the transducer displacement with an parametric adjustment of the trade-off between the resolution and response time of the force estimation



Experimental pull-off force measurement (without and with deconvolution)

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