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FRACTIONAL LANGEVIN MODELS FOR HUMAN MOTION TRACKING IN RECURSIVE BAYESIAN ESTIMATION ALGORITHMS

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The source motion for the human tracking task for a single coordinate component x can be modelled as Langevin process [1]:

$$\frac{d^2x}{dt^2} + \beta_x \frac{dx}{dt} = F_x(t), \tag{1}$$

where β_x is a rate constant and $F_x(t)$ is so-called thermal excitation process. This corresponds to the discrete process with discretization step ΔT in state-space form:

$$\begin{bmatrix} x_k \\ \dot{x}_k \end{bmatrix} = \begin{bmatrix} 1 & \Delta T \\ 0 & a_x \end{bmatrix} \begin{bmatrix} x_{k-1} \\ \dot{x}_{k-1} \end{bmatrix} + \begin{bmatrix} 0 \\ b_x \end{bmatrix} F_{x_k}. \tag{2}$$

Here $a_x = \exp(-\beta_x \Delta T)$, $b_x = \bar{v_x}\sqrt{1-a_x^2}$, $\bar{v_x}$ - is the steady-state RMS velocity and F_{x_k} being drawn from $\mathcal{N}(0,1)$, where a standard model of source dynamics [4] is obtained for $\beta = 0$. Here (1) can be seen as a special case of generalized Langevin equation with a special choice on retarded effect of frictional force [2]. In this work we propose to extend the source dynamics model [4] with the fractional versions of Langevin equation [3]. We report on construction of approximations for Bayesian Recursive Estimators, such as Kalman Filters, for developed fractional-order models and compare their performance to some conventional adaptive and non-adaptive filtering schemes based on integral-order models for human motion tracking. Additionally, the performance with respect to different approximation schemes of fractional-order operators is analyzed.

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