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The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Mehrad Ghasem Sharabiany**

The public defense will take place on **Wednesday 28th January 2026 at 5 pm** in room **I.0.01** (Building I, VUB Main Campus)

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CONTINUOUS-TIME NONLINEAR SYSTEM IDENTIFICATION BY LINEARIZATION

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Abstract of the PhD research

The physical world is governed by physical laws, and these laws are typically expressed as differential equations. Therefore, it is natural to expect that mathematical models abstracting the real world would also take the form of (nonlinear) differential equations—and indeed, they often do. However, this expectation does not hold when it comes to models derived from data by system identification techniques. In contrast, the field of system identification is dominated by discrete-time models. There are compelling reasons for this preference. First, data are inherently stored in a digitized (sampled) format. Second, the computers that construct and simulate these models are digital. Most importantly, discrete-time models offer simplicity and robustness, especially in the presence of measurement noise, since they are built from time-delayed input-output signals rather than requiring the estimation of derivatives or integrals. Therefore, the dominance of discrete-time models in system identification is hardly surprising. On the other hand, the parameters and signals in continuous-time (CT) models (ODE models) typically have physical interpretations, which can be particularly valuable in certain fields such as fault diagnosis. Additionally, CT models are well-suited to modern high-rate (and probably variable-rate) sampling data acquisition tools which render signals that are nearly continuous. So, continuous-time models are getting more attention in recent years.

The problem of derivatives in (direct) continuous-time algorithms are dealt with by applying dynamical linear filters, like modulating functions, that transform differential equations to algebraic equations. However, the application of these linear filters is limited to predefined structures and block-oriented models. In this thesis, a novel multi-step continuous-time nonlinear system identification framework is proposed that utilizes linearization around a large signal as starting point of the identification. Therefore, well-established linear tools for CT modeling (LTV models here), that can exploit dynamical linear filters for identification, can be used. Then, established methods in conservative (gradient) field are employed to convert the estimated linear model into a nonlinear one. This converted nonlinear model is then used as an initial estimate within the (Generalized) OE or EIV frameworks to refine the nonlinear model using noisy input–output data. Also, part of the thesis is dedicated to nonparametric estimation of required quantities like noise variance, nonlinear distortion and large signal for periodic large signals.