

# The role of modelling and parameter identification for controlling robotic and biological systems

## Abstract

Mathematical models are widely employed to describe phenomena in diverse domains, as natural or social sciences, or engineering. While model-less approaches (i.e., machine learning techniques) may neglect an explicit knowledge of the laws behind the system under study, the implementation of advanced control strategies (i.e., optimal or robust control) requires more effort with respect to model-based approaches, which, conversely, need a reliable and identifiable mathematical model.

Having the symbolic structure of the model representing the considered system, a crucial process consists in the identification of the intrinsic model parameters for the actual observed system, in order to have algebraic or differential equations able to reliably describe the process under study.

In robotics, a dynamic model is the relationship between joint motion (positions, velocities and accelerations) and applied joint torques. The knowledge of accurate dynamic models is of fundamental importance for many robotic applications, such as for planning minimum energy trajectories, when regulating force or imposing a desired impedance control at the contact, or when implementing strategies for the sensorless detection and isolation of unexpected collisions. By means of a dynamic observer of the unknown actuation faults (a.k.a. the residual vector), it is possible to retrieve an estimation of the external disturbances, thus unforeseen collisions. Furthermore, when a collision is sensed, possible countermeasures may be taken, as reaction maneuvers like human reflexes. Moreover, human-robot collaboration strategies in industrial settings are also achieved by means of the residual vector: for instance, the orientation of a workpiece held by the end-effector of a manipulator can be changed by simply pushing or pulling the robot structure, while preserving its position.

Beyond robotics, parameters identification is a critical issue even in biomedical contexts: for instance, the tuning of artificial pancreas devices for insulin-resistant patients. A recently published mathematical model accurately describing human glucose homeostasis is exploited to generate virtual patients: in particular, the glycemic profile of a healthy patient, together with the identified insulin-resistant patient parameters, can be successfully used to tune an external controller infusing insulin by subcutaneous injections.

## Short Bio

Claudio Gaz is a Post-Doc researcher at the Department of Computer, Control and Management Engineering (DIAG) of Sapienza Università di Roma (Italy), where he received a Master Degree in Control Engineering with the highest mark in 2011 and a Ph.D. in Automation and Operational Research in 2016. He received in 2019 the French national qualification as *maître de conférences* for the class 61 (*Génie informatique, automatique et traitement du signal*). His main interests are

mathematical modeling, parameter identification and control of robotics and biological systems. In particular, he dealt with the dynamic parameters identification of well-known manipulators, such as the KUKA LWR, the Universal Robots UR10, the Kinova Jaco Arm 2 and the Franka Emika Panda. He was a visiting researcher at Airbus (Airbus Group) in Suresnes (France) and at the German Aerospace Center (DLR) in Oberpfaffenhofen (Germany). He is currently collaborating also with the Italian National Research Council (CNR-IASI) on issues concerning the control of glycemia for insulin-resistant patients.