Registration form

Name:
Affiliation:
Address:
E-mail:
Phone:

Supervisor (for students):

Registration rates

Regular:

- ○ early (until April 7, 2023) — ILS 530
- ○ late (after April 7, 2023) — ILS 590

Student (full-time graduate students only):

- ○ early (until April 7, 2023) — ILS 280
- ○ late (after April 7, 2023) — ILS 330

Method of payment

- ○ Wire transfer, bank requisites:
  - beneficiary: איגוד ישראלי לבקרה אוטומטית
  - bank: Leumi (10)
  - branch: 705
  - account: 13186472
- ○ Charge to institutional account
- ○ On-site payment (cash or checks only)

Filled registration forms are to be e-mailed to

mira.aran.iaac@gmail.com

with a proof of transfer, if applicable

טופס הרשמה

שם:
מקום עבודה:
כתובת:
דוא"ל:
טלפון:

מנחה (עבור סטודנטים):

דמי הרשמה

רישום מלא:

- ○ מוקדם (עד 7 באפריל 2023) — ₪530
- ○ מאוחר (לאחר 7 באפריל 2023) — ₪590

רישום סטודנט (סטו' לתארים מתקדמים בזמן מלא בלבד):

- ○ מוקדם (עד 7 באפריל 2023) — ₪280
- ○ מאוחר (לאחר 7 באפריל 2023) — ₪330

אמצעי תשלום

- ○ העברה בנקאית, פרטי הבנק:
  - מוטב: איגוד ישראלי לבקרה אוטומטית
  - בנק: לאומי (10)
  - סניף: 705
  - חשבון: 13186472
- ○ לחיוב תקציב מוסדי שמספרו
- ○ תשלום במקום (המחאה או מזומן בלבד)

את הטופס יש לשלוח לכתובת הדוא"ל

mira.aran.iaac@gmail.com

עם אישור העברה, אם רלוונטי

איגוד ישראלי לבקרה אוטומטית

National Member Organization of IFAC and IAIN

Invitation to IAAC guest workshop

Algorithmic Nonlinear Control: The Circuit Approach

to be held in **VERT Lagoon**, Netanya
on Monday, April 17, 2023 (Nisan 26, 5783)

Speaker:
Rodolphe Sepulchre (KU Leuven & University of Cambridge)

Organizer: **Christian Grussler** (Technion)

We are grateful to the organizations below, whose support makes holding IAAC events possible

- Applied Materials Israel Ltd.
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Foreword פתח דבר

System theory is the child of two parents: circuit theory, that led to the input-output representation of systems as operators, and mechanics, that led to the state-space representation of systems. The Kalman–Yakubovich–Popov lemma is a key bridge between the two traditions, and it has underpinned much of the development of today's algorithmic linear robust control theory. Such a bridge is lacking in nonlinear control. The input-output theory, originated by Zames in 1960, has known a development somewhat disconnected from the state-space approach, that has increasingly dominated the field over the last forty years.

Motivated by novel applications of soft robotics, smart materials, neuromorphic engineering, and spike-based computation, the workshop will present recent research efforts aimed at reviving the "circuit approach" of system theory in the algorithmic age of control.

Passivity is the core concept of linear circuit theory. It underlines both a physical and algorithmic theory of interconnection. Monotonicity, the incremental form of passivity, will be shown to play the analog role in nonlinear circuits. The workshop will explore how to ground a physical and algorithmic theory of nonlinear systems in the state-space free concept of monotonicity.

The workshop will be presented by **Rodolphe Sepulchre**, who is a professor of engineering at KU Leuven and at the University of Cambridge. He is a fellow of IFAC (2020), IEEE (2009), and SIAM (2015). In 2008, he received the IEEE Control Systems Society Antonio Ruberti Young Researcher Prize. He was elected at the Royal Academy of Belgium in 2013. Professor Sepulchre is the recipient of the 2020 IEEE Axelby Best Paper Award and (co-) authored the monographs *Constructive Nonlinear Control* (1997, with M. Jankovic and P. Kokotovic) and *Optimization on Matrix Manifolds* (2008, with P.-A. Absil and R. Mahony). He is Editor-in-Chief for the *IEEE Control Systems Magazine* since 2020. Parts of the workshop will be co-presented by Dr. **Tom Chaffey** from the University of Cambridge.

Christian Grussler (Technion), Workshop Organizer

Program תכנית

08:15–09:00	Registration
09:00–09:05	Opening
09:05–10:35	*Why nonlinear circuits?* – *engineering motivations* – *current limitations of nonlinear control* – *the mixed-feedback amplifier* – *input-output vs. state-space representations* – *incremental vs. non-incremental properties*
10:35–11:00	Coffee / tea break
11:00–12:30	*Drawing a circuit behavior* presented by Dr. T. Chaffey – *graphical tools for system analysis* – *from Nyquist plots to Scaled Relative Graphs*
12:50–14:00	Lunch
14:00–15:30	*Computing a circuit behavior* presented by Dr. T. Chaffey – *algorithmic tools for system analysis* – *monotone and mixed monotone operators*
15:30–15:45	Coffee / tea break
15:45–17:15	*Learning a circuit behavior* – *data fitting and regularization* – *system representations in reproducing kernel Hilbert spaces*
17:15–17:30	Discussion & Closing

Description תיאור

The workshop will be divided into four lectures.

1. The first lecture will motivate the circuit approach by describing the current limitations of nonlinear control in applications ranging from neuromorphic engineering to soft robotics. We will revisit the external and internal descriptions of a nonlinear system and the key role of incremental input-output properties in system analysis. We will analyse key limitations that arise from assuming a nonlinear state-space representation at the onset.
2. The second lecture will introduce the concept of the scaled relative graph as a nonlinear generalisation of the Nyquist plot of a linear time invariant system. We will discuss the central role of graphical tools for system analysis and explore the potential of the scaled relative graph with respect to classical graphical tools from nonlinear control.
3. The third lecture will show how to compute the behavior of a nonlinear circuit modelled as interconnections of monotone elements. We will show that this approach leverages a large body of literature on large-scale convex optimisation and we will discuss the advantages of this approach with respect to the traditional simulation of a circuit. The special case of nonlinear RLC circuits will be examined in detail.
4. The fourth lecture will show how the circuit approach opens new avenues in data-driven learning of nonlinear systems. We will present efficient representations of input-output operators in reproducing kernel Hilbert spaces, showing how the classical regularised least-square paradigm allows to regularise the data fitting with external system properties.