

CONTROL 2026

Final programme and book of abstracts

Welcome to

**15th United Kingdom Automatic Control Council (UKACC)
International Conference on Control**

**CONTROL 2026, Newcastle upon Tyne, United Kingdom,
23–25 June 2026**

On behalf of the organising committee, we extend a warm welcome to participants attending the 15th United Kingdom Automatic Control Council (UKACC) International Conference on Control (CONTROL 2026), held at Newcastle University's Frederick Douglass Centre, Newcastle upon Tyne, UK, from 23–25 June 2026.

CONTROL 2026 is the 15th edition of the UKACC International Conference on Control, the biennial conference of the United Kingdom Automatic Control Council, the UK national member organisation of the International Federation of Automatic Control (IFAC). Following the previous conference held in Winchester in 2024, this year's event brings together researchers, practitioners, industry representatives, and students from across the control community for three days of discussion, collaboration, and exchange.

The conference is jointly hosted by the Automatic Control Engineering (ACE) Network and UKACC, marking the first time that ACE has co-hosted the UKACC Control Conference. ACE is an EPSRC-funded network (2024–2026) that brings together leading researchers and industrial partners working across automation and control engineering. The network aims to strengthen collaboration across academia and industry while addressing key societal challenges including AI and data, clean growth, future mobility, and the ageing society. Through interdisciplinary research and engagement, ACE seeks to support the continued advancement of control engineering and automation within the UK and beyond.

CONTROL 2026 will feature plenary talks from internationally recognised researchers, invited sessions, and opportunities for networking and discussion across the wider control community. The conference also provides an opportunity for participants to contribute to ongoing conversations shaping the future direction of the ACE Network and the wider field of automatic control engineering.

Newcastle upon Tyne is a vibrant and historic city in the North East of England, well known for its industrial heritage, cultural landmarks, and welcoming atmosphere. Situated on the banks of the River Tyne, the city combines historic architecture with a lively modern centre and is home to several iconic landmarks including the Tyne Bridge, Grey Street, and Newcastle Castle, from which the city takes its name. We hope you will enjoy both the conference and your stay in Newcastle.

We would like to thank all members of the organising committee, session organisers, reviewers, sponsors, and contributors for their efforts and continued support in making CONTROL 2026 possible.

Control 2026 Organising Committee

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Automatic Control Engineering Network

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Keynote Speakers



Prof Pramod Khargonekar

Control meets AI: Automation, Autonomy, and Intelligent Machines

Day: Tuesday 23 June 2026

Abstract

It is not an exaggeration to say that we are witnessing dramatic developments in machine learning and artificial intelligence technologies. Control theory has had and continues to have common goals and intersections with machine learning and artificial intelligence. A major intellectual and technological challenge for the future is how we can the best of what these

various fields can offer. In this talk, I will address this question in the setting of cyber-physical systems (CPS). I will describe notions of cognitive CPS as well as Physical AI. I will discuss how we may think about concepts of automation, autonomy, and they can offer guidelines on the future of intelligent machines.

Biography

Pramod Khargonekar was Chair of the Department of Electrical Engineering and Computer Science from 1997 to 2001 and held the position of Claude E. Shannon Professor of Engineering Science at the University of Michigan. From 2001 to 2009, he was Dean of the College of Engineering and Eckis Professor of Electrical and Computer Engineering at the University of Florida till 2016. After serving briefly as Deputy Director of Technology at ARPA-E in 2012-13, he served the head of the Directorate of Engineering at the National Science Foundation from 2013 till June 2016. He was Vice Chancellor for Research and Distinguished Professor of Electrical Engineering and Computer Science at the University of California, Irvine, from 2016 to 2025, where he is currently Distinguished Professor of Electrical Engineering and Computer Science.

Khargonekar' research has spanned fundamental control theory and applications to manufacturing, energy systems, climate change mitigation, adaptation, and resilience. He is currently working on the integration of AI and ML into cyber-physical-human systems. In his leadership roles, he has enabled science and engineering research communities to pursue important multidisciplinary research aimed at major societal problems. He has received numerous honors and awards including IEEE Control Systems Award, IEEE Baker Prize, IEEE Control Systems Society Bode Lecture Prize, IEEE Control Systems Society Axelby Award, NSF Presidential Young Investigator Award, AACC Eckman Award,

Distinguished Alumni and Distinguished Service Awards from IIT Bombay, and Inaugural Hall-of-Fame Inductee, Electrical and Computer Engineering Department, University of Florida. He is a Fellow of IEEE, IFAC, and AAAS.



Prof Miroslav Krstić

Feedback Linearization in Infinite Dimension: From Exact to Machine-Learned

Day: Wednesday 24 June 2026

Abstract

Feedback linearization (FL), matured in the early 1980s, is arguably the most foundational concept in nonlinear feedback control. FL is a prerequisite for advancing nonlinear control from structural analysis to robust and adaptive design. In infinite dimension, however, FL cannot proceed through conversion to Brunovsky form, since such a

transformation diverges. I first present a methodology that yields a convergent transformation to a linear canonical form for hyperbolic PDEs with Volterra-operator nonlinearities. Alas, this exact construction relies on infinite sums, infinitely nested spatial integrations, and the offline solution of infinitely many feedback-gain PDEs posed on domains of increasing dimension. In a sequence of subsequent advances, I first establish robustness of the infinite-series FL under finite truncation, and then introduce neural operators (machine learning) that rigorously eliminate the nested spatial integrations and even bypass the offline PDE solving. Finally, I ask: what if the PDE's functional parameters are unknown and estimated through online system identification? I show that, with an offline-learned transformation from plant parameter functions to gain functions, the nonlinear PDE can still be adaptively stabilized. In summary, machine learning—with plant-to-gain mappings approximated offline and deployed jointly with online plant learning—enables both practical implementation and theoretical guarantees for control of nonlinear PDEs.

Biography

Miroslav Krstic is a professor and serves as senior associate vice chancellor for research at UC San Diego. He is the recipient of the IEEE Brockett Award and Bode Prize, ASME Oldenburger Medal, SIAM Reid Prize, Bellman Award, and other recognitions, including the Chestnut prize and several IFAC TC awards. He is a member of the Serbian Academy of Sciences and Arts, fellow of IEEE, IFAC, SIAM, ASME, AIAA, and other societies, and was a Distinguished Visiting Fellow of the Royal Academy of Engineering. Krstic is the current editor-in-chief of IEEE Transactions on Automatic Control, a former EiC of Systems & Control Letters, and former senior editor in Automatica. He is a coauthor of 19 books and several hundred papers on various nonlinear, adaptive, and infinite-dimensional control subjects.



Prof Naira Hovakimyan

Ontological Robustness for Certification of Autonomous Systems

Day: Thursday 25 June 2026

Abstract

Learning-based control paradigms have seen many success stories with autonomous systems in recent years. A typical architecture in these systems involves layers for perception, planning and control, wherein each of these layers uses different tools and metrics for assessing robustness and performance. For

example, the planners — that use vision-based sensors to update the navigation and motion planning — operate largely relying on distributionally robust stochastic optimal control, whereas the low-level controller can be a deterministic controller with its conventional gain and phase (time-delay) margin.

We present a new analysis framework for addressing this ontology challenge inherent to autonomous systems. We derive distributional robustness guarantees for deterministic L1 adaptive controllers that can be used by any stochastic planner without facing a language barrier. The combined planner-controller framework can serve as foundation for development of certificates for V&V of learning-enabled systems. An overview of different projects at our lab that build upon this framework will be demonstrated to show different applications.

Biography

Naira Hovakimyan received her MS degree in Applied Mathematics from Yerevan State University in Armenia. She got her Ph.D. in Physics and Mathematics from the Institute of Applied Mathematics of Russian Academy of Sciences in Moscow. She is currently W. Grafton and Lillian B. Wilkins Professor of Mechanical Science and Engineering and the Director of AVIATE Center of UIUC. She has co-authored two books, eleven patents and more than 500 refereed publications. She is the 2011 recipient of AIAA Mechanics and Control of Flight Award, the 2015 recipient of SWE Achievement Award, the 2017 recipient of IEEE CSS Award for Technical Excellence in Aerospace Controls, and the 2019 recipient of AIAA Pendray Aerospace Literature Award. In 2014 she was awarded the Humboldt prize for her lifetime achievements. In 2015 and 2023 she was awarded the UIUC Engineering Council Award for Excellence in Advising. In 2024 she was recognized as the winner of the College Award for Excellence in Translational Research, and in 2025 she was recognized for Excellence in Graduate Student Mentoring. She is Fellow of AIAA, IEEE, ASME, IFAC, and senior member of National Academy of Inventors. She has been named a Distinguished Lecturer for IEEE CSS for 2026-2028. She is a co-founder and chief scientist of Intelinair. Her work in robotics for elderly care was featured in the New York Times, on Fox TV, CNBC, and her recent NASA ULI award on flying cars led her to a live interview on Cheddar Innovates and many other media platforms. Her research interests are in control and optimization, autonomous systems, machine learning, neural networks, game theory, and their applications in aerospace, robotics, mechanical, agricultural, electrical, petroleum, biomedical engineering, and elderly care.

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General Information

Speaker Information

The lecture hall will be equipped with a projector and desktop computer. Presenters are encouraged to use their own laptops; however, we recommend using the breaks between sessions to check that there are no compatibility issues before your presentation.

Abstract presentations are allocated 15 minutes in total, consisting of 12 minutes for the presentation and 3 minutes for questions and discussion. Presenters are kindly asked to keep to time to ensure the smooth running of the programme.

If your laptop has a standard HDMI port, you should be able to connect directly using the HDMI fly lead provided in the room. If your laptop does not have an HDMI port, please bring your own adapter (for example, USB-C to HDMI or Mini DisplayPort/Thunderbolt to HDMI).

Badges

All registered participants will receive a personal badge on first arrival at the conference. Please wear this badge when attending sessions.

Wifi

Eduroam is available across Newcastle University. If you do not have access to eduroam, connect to the Wi-Fi network called "WiFi Guest".

1. Open a browser
2. It should automatically take you to the login page
3. Choose:
 - create an account, or
 - log in if you already have a Sky/The Cloud account
4. Once registered, you'll be connected.

Attendance Certificates

These will be available on request to all registered participants via the registration desk at the venue.

Mobile Phones

In fairness to the speaker and audience, please switch off or adopt the silent mode during presentations.

Social events

The conference will have an informal dinner and networking session from 5-7pm in the Atrium of the Frederick Douglas Centre.

Venue and Safety Information

The conference will take place at the Frederick Douglass Centre, Newcastle University, Newcastle Helix, NE4 5TG. The venue is fully accessible and includes lifts, accessible toilets, hearing loops, and quiet/private spaces.

Please take normal precautions with personal belongings throughout the event and do not leave valuables unattended. In the event of an emergency, please follow instructions from conference staff and venue personnel.

If you require assistance during the conference, please speak to a member of the organising team or venue staff.

Photography may take place during the conference for promotional and documentation purposes.

Conference Programme

Day 1 – Tuesday 23 June 2026: ACE Forum

Time	Programme
09:00 – 09:30	Registration & Coffee
09:30 – 09:45	Welcome – ACE Director
09:45 – 10:30	Keynote 1: Prof Pramod Khargonekar Title: Control meets AI: Automation, Autonomy, and Intelligent Machines
10:30 – 11:00	ACE Key Recommendations
11:00 – 11:30	Coffee Break
11:30 – 12:45	Panel: From Research Challenges to Real-World Impact
12:45 – 13:45	Networking Lunch
13:45 – 14:45	Plenary Session: Building the ACE Community
14:45 – 15:00	Coffee Break
15:00 – 16:00	Interactive NetworkPlus Missions Session
16:00 – 16:30	Closing Reflections
16:30	Close

Day 2 – Wednesday 24 June 2026: UKACC Conference

Time	Programme
08:30 – 09:00	Registration & Coffee
09:00 – 09:15	Welcome – UKACC Chair & Organising Committee

09:15 – 10:00	Keynote 2: Prof Miroslav Krstic Title: Feedback Linearization in Infinite Dimension: From Exact to Machine-Learned
10:00 – 10:30	Coffee Break
10:30 – 12:00	Abstract Presentations Session 1 — Fundamental advances in control, optimisation, and learning-based control methods
12:00 – 13:30	Lunch & Poster Viewing
13:30 – 15:00	Abstract Presentations Session 2 — AI, Robotics & Autonomous Decision-Making
15:00 – 16:00	Coffee Break
16:00 – 16:30	Siemens Talk- Michal Zlotek Title: Scaling AI on the Edge: High-Performance Control with Software-Defined Automation
16:30- 17:00	Talk by Prof Daniel Coca Direct Data-Driven Identification of the Finite-Horizon GPC Law
17:00 – 19:00	Conference Dinner & Networking (Ground Floor Atrium)
17:00 – 18:00	UKACC AGM- Seminar Room 2.14 (UKACC Group Members welcome)
19:00	Close

Day 3 – Thursday 25 June 2026: UKACC Conference

Time	Programme
09:00 – 09:30	Arrival Refreshments
09:30 – 10:15	Keynote 3: Prof Naira Hovakimyan Title: Ontological Robustness for Certification of Autonomous Systems
10:15 – 10:45	AI in Publishing Talk :Dr. Sneha Rhode Gupta (Wiley)
10:45 – 11:00	Coffee Break
11:00 – 12:30	Abstract Presentations Session 3 — Applications of Control in Engineering Systems
12:30 – 14:00	Lunch & Poster Competition Final Judging
14:00 – 14:45	Session 4 — Control in Education
14:45-15:00	Quanser Director of Engineering- Peter Martin Title: Durable Skills for Controls Engineers: Feedback from Industrial Engineers to Help Students and New Graduates Succeed
15:00 – 16:00	Awards & Closing Remarks
16:00	Conference Close

Oral Presentations

Session 1- Fundamental Advances in Control, Optimisation, and Learning-Based Control Methods

Reference Number: p_8288

Offset-free Tracking Data-Driven Predictive Control

Authors: Lucca Heinze Faro, Yuanbo Nie, Paul Trodden

Abstract

Although data-driven predictive control (DDPC) has risen in interest in recent years, offsetfree tracking within this framework is still not widely understood. An incremental-input formulation for offsetfree DDPC is presented in [1], which increases the system order and thus the size of the optimal control problem (OCP).

In this work, a novel formulation based on a disturbance model is presented, which does not result in an increased OCP.

Reference Number: p_8356

Spillover-Free Boundary Control of PDEs via L^2 Residue Separation

Author: Anton Selivanov

Abstract

Modal decomposition is a classical approach to controlling PDEs, whereby a finite number of dominant modes are stabilised and the remaining highly damped modes are truncated. While effective in practice, such truncation may induce spillover, as neglected dynamics can degrade performance or even destabilise the closed-loop system.

This talk will present a novel constructive framework for spillover avoidance: the L^2 residue separation method. The approach systematically decouples controlled and residual dynamics, providing rigorous performance guarantees without compromising implementability.

Reference Number: p_8037

Entropic Wasserstein Robust Control

Authors: André Bertolace, Konstantinos Gatsis, Kostas Margellos

Abstract

Wasserstein distributionally robust control typically treats model ambiguity as risk and designs against worst-case disturbance laws, which can be overly conservative and structurally unrealistic in data-driven settings where uncertainty is mainly epistemic. We

propose an entropy-regularized Wasserstein robust control framework that smoothly interpolates between worst-case DRO and a “least-informative” endpoint obtained by maximizing conditional entropy. This yields a tunable family of robust controllers and, in the maximum-entropy limit under quadratic transport, an explicit disturbance model given by Gaussian smoothing of the nominal distribution.

Reference Number: p_ 2708

Safety Controller Synthesis of Time-Delayed Polynomial Systems: A Data-Driven Krasovskii-Based Approach

Authors: Omid Akbarzadeh, Mohammad, Hossein Ashoori, Amy Nejati, and Abolfazl Lavaei

Abstract

We develop a data-driven framework for the synthesis of robust Krasovskii control barrier certificates (RKCBC) and corresponding robust safety controllers (R-SC) for discrete-time input-affine uncertain polynomial systems with unknown dynamics, while explicitly accounting for unknownbut- bounded disturbances and time-invariant delays using only observed input–state data. The challenge of safety synthesis for such systems stems from two main factors: first, the system’s mathematical model is unavailable; and second, the safety conditions should explicitly incorporate the effects of time delays on system evolution during the synthesis process, while remaining robust to unknown disturbances. To address these key challenges, we develop a data-driven framework based on Krasovskii control barrier certificates, extending the classical CBC formulation for delay-free systems to explicitly account for time delays by aggregating delayed components within the barrier construction. The proposed framework relies solely on input–state data collected over a finite time horizon, enabling the direct synthesis of RK-CBC and RSC from observed trajectories without requiring an explicit system model.

Reference Number: p_ 5483

Multipliers for Lur’e systems with periodic excitation

Authors: William P. Heath, Sayar Das and Joaquin Carrasco

Abstract

Dynamic multipliers can be used to guarantee the stability of Lur’e systems with slope-restricted nonlinearities when the excitation has finite energy. They give no guarantee that the closed-loop system has finite incremental gain. We give examples with periodic excitation where the closed-loop response apparently has a subharmonic or chaotic response. We revisit a class of multipliers that can guarantee a unique, attractive and period-preserving solution when the excitation has a specific frequency. Their phase limitations are inherited from those of discrete-time multipliers. The multipliers cannot be used at all frequencies unless the circle criterion can also be applied; this is consistent with known results about dynamic multipliers and incremental stability.

Reference Number: p_4504

Performance Analysis of Model Predictive Control with Multiple Constraint Horizons

Authors: Allan Andre do Nascimento, Han Wang, Antonis Papachristodoulou, Kostas Margellos

Abstract

We consider a nonlinear Model Predictive Control (MPC) formulation where two distinct constraint horizons with different types of state constraints are present. In the first one, a number of predicted states are subject to a controlinvariant set constraint, while the remaining predicted states within the prediction horizon are constrained to a less restrictive set. This formulation provides a theoretical generalization of partially constrained MPC, and enables explicit closed-loop sub-optimality analysis with heterogeneous constraints.

Using relaxed dynamic programming, we obtain computable upper and lower bounds for the closed-loop cost, including explicit expressions for related sub-optimality parameters as functions of prediction/constraint horizons and its associated decay rate parameters. The resulting framework provides relevant design information on the trade-off between estimation quality and computational burden.

Session 2- AI, Robotics & Autonomous Decision-Making

Reference Number: p_2780

Embodied Opinion Dynamics for Safety-Critical Motion Control in Dynamic Environments

Authors: Zhiqi Tang, Yu Xing

Abstract

This paper proposes a novel adaptive control framework that embeds nonlinear opinion dynamics within the dynamical sensorimotor layers of an automated vehicle governed by second-order nonholonomic bicycle kinematics. The framework enables an ego vehicle to perform adaptive decision-making and achieve safe motion control under interaction uncertainty with non-cooperative neighbouring agents. We consider a representative case study in which an ego vehicle autonomously attempts to merge into a lane occupied by human driven or automated vehicles whose intentions are unknown. Within the proposed frame work, the ego vehicle adaptively selects and executes merging versus non-merging behaviours in response to changing environmental conditions. Formal safety guarantees, as well as equilibrium and stability analyses of the closed-loop system, are provided. Numerical simulations further demonstrate the effectiveness of the proposed approach.

Reference Number: p_3706

Risk-Aware Autonomous Driving with Hybrid-MDP Prediction and Chance-Constrained MPC

Authors: Siyuan Li, Chengyuan Liu, Jiye Yang and Wen-hua Chen

Abstract

This extended abstract presents a hierarchical decision-making framework for autonomous driving under interaction uncertainty. Surrounding vehicles are modelled by a hybrid Markov decision process (HMDP) that couples discrete manoeuvre evolution with stochastic continuous dynamics, producing a set of multi-branch predictions. These forecasts are incorporated into a decision-making framework that integrates an ego HMDP with model predictive control (MPC), jointly optimising manoeuvre selection and trajectory feasibility in a receding-horizon manner. Probabilistic safety is enforced through chance constraints over the planning horizon, yielding risk-bounded planning with a tunable confidence level. Simulation case studies on highway overtaking, where a target-lane rear vehicle exhibits longitudinal mode uncertainty, illustrate anticipative and risk-tunable decisions under interaction uncertainty.

Reference Number: p_7206

Cooperative Control with Relative Distance Estimation under Limited Field-of-View Constraints

Authors: Songlin Ma, Thien-Minh Nguyen, Dean Connor, Cuebong Wong and Allahyar Montazeri

Abstract

Due to the absence of relative localisation systems, most robust formation control methods are validated only in numerical simulations. Ultra-Wideband (UWB) provides inter-robot distance measurements even under non-line-of-sight (NLOS) conditions.

However, there aren't many options available in physics simulation platforms. In this paper, a scalable UWB model with a Gazebo-based simulator is presented with considering four propagation characteristics (line-of-sight, soft NLOS, diffraction and reflection in hard NLOS) and corresponding received signal strength. By using the designed models, the UWB plugin can be easily deployed on different types of robots for multi-robot relative localisation.

Reference Number: p_2487

Multi-UAV Cooperative Search and Rescue under Intermittent Communication

Authors: Yi Gou, Sabyasachi Mondal, Venkatraman Renganathan and Antonios Tsourdos

Abstract

Multi-UAV cooperative search has significant value in numerous scenarios. However, in reality, UAV swarms often face communication constraints. This study investigates how intermittent communication influences the multi- UAV search. We adopt a Boustrophedon leader-follower formation control strategy combined with a distributed decision-making algorithm to build a cooperative search system that adapts to intermittent communication. The architecture includes perception, control and task layers, integrated environment simulation, communication management, coordination/decision-making, formation control and path planning. By comparing simulations under ideal communication and intermittent-communication scenarios, we analyse the differences in how outages impact multi-UAV cooperation. The results show that with ideal communication the formation is well maintained, overall coordination is better, paths are smoother, and coverage efficiency is higher. Under intermittent communication, link breakages prevent followers from sensing targets and formation states in real time; trajectories exhibit oscillations, leading to increased path redundancy, reduced smoothness and degraded formation integrity, decreasing the team's responsiveness. Even so, with an appropriate state machine controller and task adaptation, the system sustains the search function, ultimately achieving about 80% area coverage and 100% survivor discovery, demonstrating the effectiveness and robustness of the proposed method under communication constraints.

Reference Number: p_1163

Intention-Aware Safe Motion Planning in Uncertain Traffic

Authors: Qidong Zhou, Jian Zhou, Pian Yu and Yulong Gao

Abstract

Safe motion planning for autonomous vehicles is often hindered by the unpredictable control and behavioural intentions of surrounding vehicles. This paper proposes an efficient, intention-aware motion-planning strategy that learns and integrates these uncertainties into online predictions via analytical forward reachability analysis.

By capturing both low-level control inputs and high-level behavioral intentions, the framework improves the feasibility and safety of ego-vehicle decision-making. The method's effectiveness is validated through distributed multi-vehicle planning tasks and real-world traffic dataset case studies.

Reference Number: p_4715

Integrated UAV Guidance Algorithm from Low-Level Control to High-Level Mission Planning

Authors: Jongrae Kim, Nabil Shaukat, Saikat Dutta

Abstract

To address the growing need to protect critical infrastructure from malicious drone attacks, we present an air-defence system architecture that deploys groups of fixed-wing Uncrewed Aerial Vehicles. The system integrates a low-level target-tracking algorithm with a high-level mission planner to ensure coordinated and efficient operation. We prove that the cost function arising from the min-max formulation of the optimal target-tracking problem is convex, enabling the problem to be solved efficiently in real time. The reinforcement-learning-based mission planner then assigns each UAV to a target, maximising the safety and coverage of the protected region.

Session 3- Applications of Control in Engineering Systems

Reference Number: p_7543

Emotion from Motion: Bio-inspired Iterative Learning Control for Character Animation Tasks

Authors: Daniel Hobson, Bing Chu, Xiaohao Cai

Abstract

Conveying emotion through movement is an important component of compelling storytelling, but creating suitable animations is hard and requires significant time from skilled artists. Producing convincing animations in real-time (e.g. driving animatronic systems) is even harder; in this case, the puppeteer essentially needs to solve the inverse kinematic problem – often on unfamiliar hardware – in order to send commands that produce desired motion.

Furthermore, bespoke trajectories must be crafted for each action a character performs, whereas we seek a method to encode the desirable character-driven, emotive properties of a unique character into a controller, and then apply this to a generic reference trajectory instead. This approach is much more in line with the real structure of biological motion controllers and is achieved using an iterative learning control scheme, resulting in motion with consistent emotive performance across any target trajectory.

Reference Number: p_4104

Wind Disturbance Rejection and Fault Recovery for Quadplane Trajectory Tracking Using a Supertwisting Observer

Authors: Zaidan Zyadat, Nadjim Horri, Thomas Statheros

Abstract

This paper presents a combined wind disturbance rejection and actuator fault compensation control strategy for the longitudinal quadplane trajectory tracking. A super twisting sliding mode observer is formulated to estimate lumped uncertainties, consisting of wind disturbances on all longitudinal gust channels and an additive elevator fault. A Dryden continuous gust model is used for the simulation analysis. The estimated perturbations are compensated in the control loop to ensure robust trajectory tracking across the vertical takeoff and landing, forward flight modes and the transitioning modes between them. The super twisting sliding mode observer algorithm provides finite time convergence with smooth flight mode transitions.

Simulation results demonstrate accurate trajectory tracking under moderate wind conditions in the presence of an additive actuator fault. The super twisting observer-based compensation is combined with two benchmark controllers, a linear quadratic regulator and a H_∞ controller, without loss of generality. The observer-based corrections improve the tracking accuracy-energy trade-off in both cases. The super twisting observer-based H_∞ controller outperforms the observer-compensated linear quadratic regulator in terms of tracking accuracy for similar energy consumption, which is attributed to increased robustness to observer estimation errors. Simultaneous fault and wind disturbance compensation presents benefits for safety-critical unmanned aerial vehicle operations under windy conditions.

Reference Number: p_3160

Local Plug-and-Play Compatible Stability Conditions for AC Grids

Authors: Liam Hallinan, Ioannis Lestas

Abstract

The rise of renewable generation in AC power systems introduces a need to reduce centralisation when analysing small-signal grid stability. In this extended abstract, we present a decentralised and distributed framework for stability analysis based entirely on local subsystem analysis. The framework takes the form of quadratic constraints on local subsystems that, when satisfied across the network, collectively imply that the generalised Nyquist criterion holds for the entire grid. The proposed approach offers increased flexibility compared to alternative methods, and can be used as a foundation for grid codes that enable plug-and-play functionality.

Reference Number: p_1097

Privacy Oriented Coalition Formation for Energy Distribution

Authors: Luke Rickard, Paola Falugi, Eric C. Kerrigan

Abstract

The evolution of renewable technologies has prompted the need for radical shifts in the way energy is distributed. In this work, we consider employing coalitional control, an exciting technique that investigates agents joining together in coalitions (groups of agents), within

which agents freely cooperate. In order to form these coalitions, agents must share some information about themselves to permit calculations on the potential gains from forming different coalitions.

We develop a novel technique for bottom-up coalition formation that preserves agents' privacy during coalition formation, explicitly addressing privacy concerns overlooked in the existing literature. Specifically, we limit the amount of information that agents are required to share to enhance agents' privacy and reduce computational complexity, while guaranteeing increased profit compared to agents working individually.

Reference Number: p_8019

ILC for Stroke Rehabilitation: Can Current Approaches Cope with Trial-Varying Initial Conditions?

Authors: Lucy Hodgins, Chris T. Freeman, Zehor Belkhatir

Abstract

Iterative learning control (ILC) has been widely used in rehabilitation, having recently succeeded in obtaining target postures of the hand and wrist. However, it is not designed to deal with the trial-varying initial conditions or disturbances that often occur in biological systems. This paper validates the application of ILC in this context, and shows its equivalence to a particular form of feedback controller. Experimental results then highlight the benefits of this approach. This work provides valuable insight into principled control design within the rehabilitation setting.

Reference Number: p_3065

Distributed Control in Agriculture

Authors: William Rohde, Fulvio Forni

Abstract

In the agricultural industry, there is an essential need for sustainable intensification, which is to achieve an increase in productivity per unit of land area without unsustainable harm to agricultural land or excessive chemical use. Per-plant control of crop growth could increase yields and reduce excess applications of chemical inputs. We present an iceberg lettuce case study, where we used a distributed controller based on an average consensus protocol to assign per-plant fertiliser rates based on observations of crop growth.

This decreased variance in the mass of harvested crop while maintaining the mean mass. For iceberg lettuce, this increases yield (as it results in more crop reaching grower specifications) without using additional fertiliser. In a trial of 900 plants, this resulted in an increase in yield of 3.1–5.7%, suggesting that per-plant level control during crop growth is a viable strategy for sustainable intensification.

Session 4- Control in Education

Reference Number: p_7423

Review of the control101 toolbox

Authors: John Anthony Rossiter

Abstract

The control101 toolbox (Rossiter, 2024) was first released in 2023 and at that time had a limited range of resources. In the past three years a number of additions have been made, so the purpose of this extended abstract is to review and summarise the current status.

The intention is to help attendees evaluate the current status of the toolbox and thus better discern how this might be utilised in their own teaching.

Reference Number: p_9115

BatteryZoo: Yet Another Toolbox for Battery Modelling, Estimation, and Control

Authors: Paing Hmu Ko, Yuanbo Nie, and Ross Drummond

Abstract

Battery modelling and control software remain fragmented across cell libraries, parameter estimation, ageing analysis and application specific optimisations. This paper presents the BatteryZoo, a MATLAB toolbox that couples a battery database (“Zoo”) with unified estimation (“Field Biologist”), control (“ZooKeeper”) and ageing (“Veterinarian”) modules, leading to a pipeline from cell data to identified models and constrained optimisation.

Reference Number: p_ 6896

Enhancing Resilience and Fairness in Microgrid Energy Management: A Convex Optimization Approach

Authors: Haochen Tao, Lysandros Tziiovani, Stelios Timotheou, and Francesca Boem

Abstract

Due to the increasing complexity of Microgrids systems, guaranteeing their resilience to faults and robustness to uncertainties is becoming more and more important and challenging. This paper presents a computationally efficient microgrids Energy Management System resilient to faults in the grid. The constrained Model Predictive Control-based framework proposes a proactive scheduling method under normal operations and an outage management solution under grid faults. To reduce the computation time, a convex optimization approach is proposed together with an iterative

bisection penalty-tuning algorithm. A fairness constraint is also implemented to ensure equitable load curtailment in the case of outages. Validation on a modified IEEE 33-bus system shows comparable performance to mixed-integer programming with lower computation time and fairer service.

Abstracts (Poster Sessions)

Reference Number: p_3874

Hierarchical Model Predictive Control for Multi-Feeder Distribution Systems Using AC Flexibility Envelopes

Authors: Sary Yehia, Alessandra Parisio

Abstract

The growing penetration of flexible buildings and distributed energy resources in active distribution networks requires scalable coordination mechanisms that respect network constraints. This work proposes a hierarchical model predictive control (MPC) framework for multi-feeder systems that preserves AC feasibility while incorporating time-coupled building dynamics. Buildings compute local admissible power trajectories, which are aggregated at feeder level into network-constrained flexibility envelopes at the point of common coupling (PCC). A system-level MPC then coordinates feeder injections using these envelopes, avoiding a centralized nonlinear AC-MPC formulation. Preliminary results suggest that the proposed approach enables effective coordination across feeders while maintaining tractable computational requirements. The framework provides a promising direction for scalable, network-aware predictive coordination in active distribution systems.

Reference Number: p_3882

Wearable Smart Insole Based Estimation of Three Dimensional Ground Reaction Forces via Spatio Temporal Attention Fusion

Authors: Jin Luo, Ziwei Wang, Liucheng Guo

Abstract

Accurate 3D ground reaction force (GRF) estimation traditionally requires expensive, lab-restricted force plates. This study proposes a wearable alternative. We fuse data from smart insoles containing an eighteen-channel pressure array and a sixaxis IMU. The model processes these modalities using parallel 1D convolutional encoders. Spatial attention targets specific plantar regions. Temporal self-attention models kinematic sequences within a sliding window. A recurrent layer then fuses these features to regress 3D GRFs. The proposed framework achieved a 3.58% average NRMSE and an R2 of 0.68. This improves upon a dual-stream attention baseline, which had a 3.90% NRMSE and an R2 of 0.65. Mediolateral force is highly variable and difficult to infer from pressure sensing alone. For

this specific force component, our method reached 1.74% NRMSE and an R^2 of 0.45. This performance exceeds both the baseline and an LSTM reference model.

Reference Number: p_4197

Adaptive Predefined-Time H_∞ Control for Uncertain Stochastic Systems with Stochastic Disturbances and Input Saturation

Authors: Tianliang Zhang, Xiushan Jiang, Kang Li, Yu-Hong Wang, and Weihai Zhang

Abstract

This paper investigates the adaptive predefined-time H_∞ control for nonlinear stochastic systems. We first prove a sufficient condition about practical predefined-time stochastic stabilization (PPTSS) with H_∞ constraint. We consider a system that consists of unknown dynamics and input saturation constraints, and introduce an auxiliary variable system to overcome input saturation issues. By combining fuzzy logic systems with adaptive backstepping techniques, we propose a novel adaptive predefined-time H_∞ control scheme that enables PPTSS and H_∞ performance constraints to be achieved simultaneously.

Reference Number: p_4332

Optimal Flow Formations using Reinforcement Learning

Authors: Junjie Zhang, Eric C. Kerrigan, Georgios Rigas

Abstract

Aerodynamic drag reduction in vehicle platoons depends strongly on unsteady wake interactions between bluff bodies, which are difficult to exploit using fixed-spacing or model-based control strategies. We investigate a reinforcement learning framework for dynamic spacing control in a two-member platoon of square cylinders, with the objective of reducing the drag on the downstream body by actively interacting with the upstream wake. The controller interacts directly with a two-dimensional direct numerical simulation at Reynolds number $Re = 100$. Each agent observes pressure signals sampled in the wake of the downstream body and adjusts the inter-body spacing in real time based on local flow information. The learned policy exhibits oscillatory spacing modulation synchronized with vortex shedding, enabling favorable wake-body interactions. Compared to a fixed-spacing baseline, the optimal policy achieves up to a 5.06% reduction in the mean drag coefficient of the downstream body. These results demonstrate that multi-agent reinforcement learning can discover physically interpretable, feedback-based strategies for exploiting unsteady wake dynamics in platooning configurations

Reference Number: p_4595

Closed-loop compensation of excitable dynamics in a living neural circuit

Authors: Thiago B. Burghi, Kyra Schapiro, Harry Wang, Eve Marder, Timothy O’Leary

Abstract

This work addresses the problem of closedloop control of living neurons in vitro, using intracellular recordings. Our main result is the design of a nonlinear, model-based, data-driven controller that compensates for perturbations of the membrane dynamics induced by external physiological inputs such as organic neuromodulators. Solving this task is challenging: living neurons in intact circuits are difficult to model, and quantifying the effect of neuromodulators in real time remained an open problem until the present work. To predict neuronal responses under varying neuromodulatory conditions, we introduce modulatory inputs into a data-driven model architecture designed for rapid identification of membrane dynamics. Using data collected under nominal and neuromodulated conditions, we estimate model parameters during an electrophysiology experiment and validate real-time model predictions against incoming measurements. To reject neuromodulatory perturbations, we employ the validated model in a simple yet effective nonlinear controller-observer scheme. While our results are demonstrated in a testbed neural circuit within the crab Stomatogastric Ganglion, our ideas pave the way for principled closed-loop compensation of dysfunctional excitable states in more complex nervous systems.

Reference Number: p_4719

Iterative solution of unicycle optimal control problem

Authors: Gleb Merkulov, Vladimir Turetsky and Tal Shima

Abstract

A finite-horizon optimal control problem for a non-linear unicycle vehicle with constant linear velocity is considered. The cost functional consists of the squared norm of a final position and the integral control effort term with penalty coefficient α . Thus, both the miss distance and the control are soft-constrained. By changing the state variables, the dynamics become mixed linear/bilinear. For the latter, the optimal control problem is solved numerically by iterating the bilinear equations and solving a linear-quadratic control problem at each iteration step. The convergence is studied both analytically and numerically. L2-convergence margins are derived, which do not hold for small α . However, in the weighted angular norm, the convergence condition is independent of $\alpha > 0$, as supported by numerical results.

Reference Number: p_5205

Iterative Learning Control of a Peristaltic Pump for Ultra-Low Flow-Rate Pulsation

Authors: Gosuke Kuriyama and Kentaro Hirata

Abstract

This note presents a method for suppressing the flow-rate pulsation of peristaltic pumps using Iterative Learning Control (ILC). The nonlinear state-space model derived for the pump exhibits a structure that differs from those commonly reported in the literature. To address this, we first provide a mathematical proof of error convergence in a discretetime setting. Based on this result, pump performance can be improved in a completely model-free manner. Experimental results obtained using a newly developed pump with an improved mechanism demonstrate that the proposed approach achieves ultra-low flow-rate pulsation.

Reference Number: p_5409

TERA: A Unified Taylor Model Enabled Reachability Analysis Framework

Authors: Salma Iraky and Andrew Sogokon

Abstract

Reachability analysis of safety-critical systems requires computing rigorous enclosures of all possible state trajectories. Taylor Model (TM)-based methods have proved effective at mitigating the so-called wrapping effect which leads to overly conservative enclosures of reachable sets. However, existing tools are often hard to extend or focused on narrow system classes (e.g. deterministic systems modelled by ODEs, or hybrid systems). We develop TERA: a Python-native framework for TM-based reachability analysis of continuous, hybrid and stochastic systems within a single symbolic-numeric workflow. TERA is free and opensource, enabling rapid prototyping of reachability analysis techniques with rigorous enclosures. At present, our implementation is able to compute tight reachable set overapproximations for non-linear ODEs and hybrid systems on difficult benchmark problems, and already supports analysis of continuous-time stochastic systems. Our goal is to develop a robust open-source Python infrastructure for rigorous reachability analysis supporting a broad class of systems, including stochastic hybrid systems.

Reference Number: p_ 5422

Pointing Error Budget, Contributing Factors, and Mitigation Strategies for Attitude Control of a LEO SAR Satellite

Authors: Semsettin Numan SOZEN, Yusuf ACAR, Mustafa Yavuz OZTURK, Cagatay YAVUZYILMAZ

Abstract

High-resolution Synthetic Aperture Radar (SAR) satellites impose stringent attitude pointing requirements, typically expressed as Absolute Pointing Error (APE) and Relative Pointing Error (RPE), where even small violations directly degrade azimuthal image resolution and geolocation accuracy. Meeting these requirements in a Low Earth Orbit

(LEO) environment is a significant control engineering challenge, as the Attitude and Orbit Control System (AOCS) must simultaneously reject a range of disturbances originating from both internal hardware imperfections and external environmental torques.

This paper systematically identifies and quantifies the primary contributors to pointing error in a LEO SAR satellite. On the actuator side, non-ideal reaction wheel dynamics are shown to generate structured micro-vibrations that manifest directly as high-frequency RPE violations. On the sensor side, the low update rate of star trackers (typically 2–4 Hz) combined with their measurement noise creates a rate estimation problem: angular velocity derived from discrete, noisy quaternion measurements amplifies high-frequency content, causing the controller to over-command the reaction wheels and inject additional jitter into the control loop. Environmental disturbances, including gravity gradient torques, solar radiation pressure, and misalignment of the electric propulsion thruster, further contribute steady-state pointing offset and momentum accumulation in the reaction wheels.

To address these contributors, a layered mitigation architecture is proposed. An Extended Kalman Filter (EKF)-based sensor fusion scheme, blending star tracker attitude measurements with gyroscope angular rate data, is implemented to provide smooth, high-bandwidth attitude estimates and reduce sensor-induced jitter by eliminating noisy rate derivation. For steady-state disturbance rejection, the baseline PID controller is augmented with an integral term and a model-based Disturbance Observer (DOB), effectively cancelling both constant and slowly-varying torque disturbances. Numerical simulations are conducted for a representative SAR imaging scenario (60-second fixed inertial hold), comparing an idealised actuator model against a high-fidelity non-linear reaction wheel model incorporating friction and torque ripple.

Results demonstrate that the proposed augmented control architecture reduces attitude jitter by a factor of 2–4 compared to a baseline PID controller operating on ideal actuator assumptions, and eliminates the steady-state pointing offset introduced by thruster misalignment. The findings provide quantitative evidence that realistic component-level modelling and multi-layer mitigation strategies are essential for meeting SAR mission pointing requirements in operational LEO environments.

Reference Number: p_ 5429

Recursive Passive NFIR Operators for Nonlinear Identification and Data-Driven Control

Authors: Zixing Wang, and Fulvio Forni

Abstract

We propose a new class of passive nonlinear recursive finite-impulse-response (FIR) operators, obtained by combining FIR filters with nonlinear lifting functions. The lifting enables computationally light passivity constraints derived from frequency-domain sampling. Feedback from the operator output is also used to define the lifting. This gives the

operator more expressivity while leaving passivity guarantee intact. The benefits makes the proposed operator well suited to modelling and controlling physical plants such as electromechanical systems.

Reference Number: p_ 5576

C* Controller Design for Longitudinal Stabilisation of Blended Wing Body Aircraft

Authors: Yating Qi, James Whidborne, Linghai Lu

Abstract

The C* controller is a longitudinal flight control architecture that shapes a pilot-oriented response from a weighted combination of load factor and pitch rate. Where load factor feedback dominates at higher speeds, pitch rate feedback dominates as speed reduces, providing improved handling quality across the flight envelope. C* control has been widely adopted in conventional civil aircraft, however, its systematic application to unconventional, unstable, low-static-margin configurations such as the Blended Wing Body (BWB) aircraft remains less explored. Due to the absence of a conventional tailplane, BWB exhibits reduced or negative static margin, leading to longitudinal instability and increased sensitivity to control inputs, particularly during approach conditions. This work presents a C* controller design for a 6-DoF BWB longitudinal model trimmed and linearised at approach condition. An inner pitch-rate feedback stability augmentation system is first tuned to stabilise and damp the short-period dynamics, followed by an outer-loop PI-based C* controller designed using frequency-domain loop shaping. The augmented flight control system just achieves a level 1 handlingquality criteria. These preliminary results demonstrate that C* architecture can be systematically adapted to low-static-margin BWB configurations through structured controller design.

Reference Number: p_ 5666

Scalability of Region of Attraction Estimation for Quadrotor Dynamics: From 3-State Cascade to 6-State Rigid Body Models

Authors: Sorachat Chuenwongaroon, Argyrios Zolotas, Dmitry Ignatyev

Abstract

This paper compares Sum-of-Squares (SOS) optimisation and Physics-Informed Neural Network (PINN) Lyapunov methods for quadrotor Region of Attraction (ROA) estimation. For a 3-state subsystem, both SOS (degree-6) and PINN produce expanded, non-ellipsoidal ROA estimates. However, for a 6-state planar model, computational limits restrict SOS to conservative degree-2 estimates. In contrast, the PINN approach scales efficiently to 6D, generating a much larger non-convex ROA candidate, validated via 500,000-point dense sampling. Due to Satisfiability Modulo Theories (SMT) verification bottlenecks, the neural ROA estimates rely on this dense empirical validation. These results define the scalability

frontier where algebraic synthesis fails and learning-based methods become necessary for aerospace stability analysis.

Reference Number: p_ 5867

Energy-Efficient Full-Vehicle Active Suspension Control with Coordinated Pump-Orifice Actuation and Physical Limit Constraints

Authors: Yi-Yuan Li, Farid Esa, Efstathios Siampis

Abstract

This paper presents a hierarchical control framework for a hydraulic suspension system with coordinated pump-orifice actuation on a full-vehicle model. The upper layer employs model predictive control (MPC) to generate suspension force references for vehicle heave, roll, and pitch regulation. The lower layer executes these commands via an optimal control allocation strategy that coordinates a semi-active orifice and an active hydraulic pump while accounting for hydraulic dynamics and suspension physical limits. Actuator-induced force bounds are fed back to the MPC layer to ensure feasible force generation. Energy efficiency is embedded in the allocation strategy, prioritising the low-energy orifice over the higher-energy pump. By integrating vehicle-level control with energy-aware allocation, the framework improves ride performance, reduces power consumption, and protects system components under realistic operating conditions.

Reference Number: p_ 5961

An Online Data-Driven Linear Quadratic Regulator for Switched Linear Systems

Authors: Liting He, Thulasi Mylvaganam

Abstract

We propose an online, data-driven linear quadratic regulator for unknown, switched, discrete-time linear systems. More precisely, we develop a method to detect (potential) switches, occurring at unknown times, and utilise this to trigger a data recollection and control redesign phase in an online fashion. Differently from alternative online techniques that typically require collecting data continuously, often via the injection of “probing inputs” in the form of noise that may deteriorate control performance, the proposed framework is aimed at collecting data and redesigning the controller only when necessary, resulting in a reduction of data requirements and computational burden. The proposed approach is validated via simulation studies.

Reference Number: p_ 6569

Development of multi-level precipitation-reactive control of wind turbines for blade life extension

Authors: Edmondo Minisci, M. Sergio Campobasso, C. James Taylor

Abstract

Atmospheric precipitation-induced leading edge erosion of wind turbine blades increases maintenance costs and reduces power and energy yield. Precipitation- Reactive Control (PRC) curtails rotor speed during erosive precipitation events, alleviating erosion but incurring curtailment-induced power and energy yield losses. Initial PRC assessments using a single curtailment level point to promising results, but higher PRC performance is desirable to accelerate field deployment. This presentation will describe a novel multi-level PRC algorithm based on multi-objective optimisation, aiming to achieve significantly higher blade life extensions and lower energy yield losses over the single-level curtailment method. The case study used for demonstration is the Lancaster Hazelrigg site, hosting an operational 2.3 MW wind turbine and a UK Met Office weather station. The presented optimisation of the multi-level PRC algorithm uses synchronous co-located measured time-series of wind speed and rain droplet size distribution recorded over a reference period of one year.

Reference Number: p_ 6868

Distributed gradient-free resource allocation of multi-agent Systems

Authors: Wenyan Tang, Jia Wu, Hongwei Zhang, Kang Li

Abstract

This paper proposes a distributed gradient-free algorithm of multi-agent systems (MASs) for solving resource allocation problem. This proposed algorithm is suitable for scenarios where gradients are difficult or impossible to be obtained. The sufficient conditions that guarantee the MASs achieving the solution of resource allocation problem are given. Finally, simulations verify the feasibility of the proposed algorithm.

Reference Number: p_ 6894

Linear Model Predictive Control Step as an Implicit Neural Differential Equation Layer

Authors: Nikilesh Ramesh, Ross Drummond, Pablo R. Baldivieso-Monasterios , Yuanbo Nie

Abstract

The solution to multi-parametric quadratic programmes from linear model predictive control (L-MPC) problems are shown to have an analytic representation in terms of a continuous-time neural ordinary differential equation. This formulation of the L-MPC presents new opportunities for analysis, i.e. using contraction theory, and connections to learning theory. For example, it could enable learning L-MPC formulations from data using either imitation or reinforcement learning.

Reference Number: p_ 6896

Enhancing Resilience and Fairness in Microgrid Energy Management: A Convex Optimization Approach

Authors: Haochen Tao, Lysandros Tziiovani, Stelios Timotheou, and Francesca Boem

Abstract

Due to the increasing complexity of Microgrids systems, guaranteeing their resilience to faults and robustness to uncertainties is becoming more and more important and challenging. This paper presents a computationally efficient microgrids Energy Management System resilient to faults in the grid. The constrained Model Predictive Control-based framework proposes a proactive scheduling method under normal operations and an outage management solution under grid faults. To reduce the computation time, a convex optimization approach is proposed together with an iterative bisection penalty-tuning algorithm. A fairness constraint is also implemented to ensure equitable load curtailment in the case of outages. Validation on a modified IEEE 33-bus system shows comparable performance to mixed-integer programming with lower computation time and fairer service.

Reference Number: p_ 6931

Control for powered-two wheeler stability assistance and autonomy: development of a test platform

Authors: James Fleming, Qusay Hawari, Luca Bassani, Stefano Lovato, Guitao Yang, Roberto Lot

Abstract

Powered Two-Wheelers (PTWs) have complex lateral dynamics characterised by multiple modes (e.g. capsize, weave, and wobble) with natural frequencies, damping ratios and even stability properties that vary with forward speed of the vehicle. As such, they are a particularly challenging test case for path planning and lateral control. This extended abstract presents ongoing work to control the roll and steer dynamics of a Fantic Issimo e-bike platform based at the University of Padova. Specifically, we describe two baseline control architectures: a Proportional-Integral-Derivative (PID) controller and a Linear Quadratic Gaussian (LQG) controller. Both approaches utilise a Kalman-Bucy Filter for state estimation from the onboard Inertial Measurement Unit (IMU) and steering sensors. These results serve as a benchmark and platform validation in preparation for the future implementation of Linear Parameter-Varying Model Predictive Control (LPV-MPC) techniques, which will be necessary for robust constrained control of the highly speed-dependent motorcycle dynamics.

Reference Number: p_ 7206

Cooperative Control with Relative Distance Estimation under Limited Field-of-View Constraints

Authors: Songlin Ma, Thien-Minh Nguyen, Dean Connor, Cuebong Wong, Allahyar Montazeri

Abstract

Due to the absence of relative localisation systems, most robust formation control methods are validated only in numerical simulations. Ultra-Wideband (UWB) provides inter-robot distance measurements even under non-line-of-sight (NLOS) conditions. However, there aren't many options available in physics simulation platforms. In this paper, a scalable UWB model with a Gazebo-based simulator is presented with considering four propagation characteristics (line-of-sight, soft NLOS, diffraction and reflection in hard NLOS) and corresponding received signal strength. By using the designed models, the UWB plugin can be easily deployed on different types of robots for multi-robot relative localisation.

Reference Number: p_ 7570

Sum of Squares for Region of Attraction Estimation with Parallel Computing and Multiple Shape Functions

Authors: Abubakar Ibrahim, Namhoon Cho, Venkatraman Renganathan, Bhaskar Biswas, Dmitry Ignatyev

Abstract

Sum of Squares is a useful tool for quantification and validation of the safe operational region of safety-critical systems; however, it requires significant computational resources for real world applications. Our work leverages multiple independently optimized shape functions within a parallelized computational framework that significantly enhances ROA estimation. Drawing upon recent advancements in using shifted shape functions, our approach formulates the ROA estimation as a set of smaller independent subproblems that can be solved in parallel. This parallelization drastically reduces computational time and improves scalability, enabling the analysis of higher dimensional systems. Our approach would not only accelerate the estimation process but also improve the quality of the results for complex irregular ROA geometries, opening new avenues for real-time stability verification and robust control design.

Reference Number: p_ 7587

Low-Speed Steering Assistance of Powered Two-Wheeled (PTW) Vehicles

Authors: Usama Samad Qureshi, Peter Hubbard, James Fleming

Abstract

Motorcycle manoeuvring at low speed is challenging due to the reduced gyroscopic stabilisation effect. It increases the rider's effort required to regulate the roll motion. This

research explores a steering assistance approach that reduces rider effort by adding an assistance steering torque to the rider's steering input. A validated motorcycle model is used in MATLAB/Simulink to perform simulations. The rider is represented by a Proportional-Derivative (PD) Controller that generates steering torque from roll tracking error, while a second PD controller produces an assistance torque based on the same roll dynamics. The combined torque acts on the motorcycle's steer dynamics to track a target roll angle at a low speed in a cornering manoeuvre. The results suggest that the assistance steering system reduces the rider's torque value from 3.5 Nm to 1.5 Nm while improving the roll tracking performance.

Reference Number: p_7648

Energy-Efficient Scheduling of Nitrogen Liquefaction Units

Authors: Abdul Samad, Mark J. Willis, Chris O'Malley,

Richard Adamson

Abstract

Nitrogen liquefaction process is energy-intensive, with electricity consumption being a major part of operational costs. These costs can be minimized by aligning production with periods of lower energy demand and cheaper electricity rates, while still meeting demand. The current study focused on developing a real-time integrated and automated production scheduling optimizer that, based on electricity prices and customer demand, generates an optimized visual weekly schedule for the nitrogen liquefaction units, enabling cost savings and reduced manpower requirements. Customer demand, penalties for plant start-ups, and storage levels constrain the optimizers. The performance of the optimizers was validated against actual operational data spanning four months. This retrospective analysis indicates potential savings of around 12%, which, given the nature of the business, represents a significant financial gain.

Reference Number: p_7894

Learning-Based Strategies for Reducing the Computational Cost of Model Predictive Control

Authors: Gabija Jakelaityte, Constantinos Theodoropoulos

Abstract

This paper investigates learning-based strategies for reducing the computational burden of model predictive control (MPC) applied to distributed-parameter nonlinear systems. Several approaches are considered, including a data-driven neural network (NN) and a physics-informed neural network (PINN), and two controller approximation methods:

optimize-then-train (OTT) and optimize-at-training (OAT). An illustrative example of a tubular reactor with an exothermic reaction is used to assess the efficiency of these approaches. Their performance is evaluated across multiple operating scenarios using tracking error and computational time metrics. The results show that the NNbased surrogate provides the best trade-off between accuracy and computational speed under nominal conditions, while the PINN model exhibits improved robustness in off-nominal scenarios. The OAT and OTT approaches achieve the largest computational speedups, with OAT demonstrating superior robustness among the controller approximations. Overall, the study highlights the potential of learning-based methods as a model reduction MPC methodology, while maintaining good control performance.

Reference Number: p_ 7902

Searches for Discrete-Time Altshuller multipliers

Authors: Sayar Das, William Heath, Lanlan Su, Joaquin Carrasco

Abstract

Discrete-time Altshuller multipliers can be used to effectively show the existence of a unique global attractor of a Lurье system with slope-restricted nonlinearities which is excited by a periodic input. The Altshuller multiplier falls under the class of O'Shea-Zames-Falb (OZF) multipliers where the delays are at integer multiples of a particular time period. The period of the Altshuller multiplier is the same as the period of the input. While searches for discrete-time OZF multipliers exist, these searches can be modified to search for discrete-time Altshuller multipliers. This work focuses on a search for a discrete-time Altshuller multiplier. This work also focuses on phase conditions under which there is no discrete-time Altshuller multiplier for a given discrete-time plant and a given time period for the excitation. These conditions can be seen as extensions of the duality conditions for discrete-time OZF multipliers.

Reference Number: p_ 8002

Modelling and Analysis of Aircraft Maintenance Service Chains Using Timed-Arc Colored Petri Nets

Authors: Chao Gu, Nikolaos Athanasopoulos and Seán McLoone

Abstract

We present a modelling and analysis framework for aircraft maintenance scheduling based on timed-arc colored Petri nets (TACPN). We develop a multi-aircraft, multitask maintenance model that incorporates task feasibility constraints, maximum service intervals, and resource constraints, such as manpower and hangar availability. To assess whether a maintenance plan is feasible, we formulate two verification problems: execution admissibility, which addresses whether a given finite maintenance workflow is valid, and feasible-schedule existence, which examines whether there exists an infinite execution in

which no task violations occur. We show that both problems can be addressed using the model checker TAPAAL.

Reference Number: p_8029

Robust Control of Large Scale Nonlinear Systems Using Koopman Operator and NN Controllers

Authors: Gajanand Verma, William Heath, Constantinos Theodoropoulos

Abstract

Model predictive control (MPC) of large-scale nonlinear systems remains challenging owing to nonconvex real time optimization. In addition, the lack of accurate first-principles models further complicates its practical implementation. Data-driven approaches based on deep learning can learn system representations; however, such representations may introduce modeling uncertainty into the system, challenging the closed loop stability. This work develops a unified framework combining machine learning, Koopman operator theory, and integral quadratic constraints (IQCs) to enable data-driven control of large scale nonlinear systems with formal closed-loop guarantees. We employ Neural Networks (NNs) to learn a finite-dimensional Koopman approximation of the nonlinear dynamics and to learn the MPC control law, thereby reducing online computational complexity. To ensure robustness, both Koopman modeling error and NN controller are characterized as norm-bounded uncertainties and incorporated into an IQCbased analysis that establishes stability and performance guarantee. We investigate this approach on a chemical engineering tubular reactor system exhibiting Hopf bifurcation across various parameter combinations.

Reference Number: p_ 8184

Efficient Solutions to the Multi-Stage Robust Security-Constrained Unit Commitment Problem

Authors: Edoardo Scaccia, Eric C. Kerrigan, Elina Spyrou and Anna Sadowska

Abstract

The security-constrained unit commitment problem is common among power system operators. It involves day-ahead scheduling of binary on/off decisions for power generators and optimization of power flows while minimizing costs and satisfying constraints under supply and demand uncertainty. The problem is typically formulated as a mixed-integer min-max-min program known as a two-stage adjustable robust optimization problem. Existing methods compute approximate solutions using an iterative outer-inner scheme, with Benders decomposition at the outer level and approximations of the inner problem. We solve the original two-stage problem without modification using recent extensions of the local reduction method. When the uncertainty set is compact, we obtain a violation-free robust local optimal solution. If the uncertainty set is a hyperrectangle, the global optimum can be found by solving a sequence of mixed-integer and continuous linear programs. We

further extend the approach to multi-stage problems with the same guarantees. The proposed framework applies broadly to two-stage and multi-stage problems in transportation, logistics, facility location, supply chain design, and finance.

Reference Number: p_ 8339

On-Demand Physics-Informed Regression via Constrained Optimisation

Authors: Lorenzo Sabug, Jr, Eric Kerrigan

Abstract

Physics-informed regression seeks to reconstruct or forecast PDE-governed fields from sparse measurements. We recast this task as an on-demand constrained optimisation problem that is solved independently at each query point. The decision variables include the queried state and (optionally) local derivative and curvature quantities. Data consistency is imposed through multivariate Taylor relations, expressed as linear inequality constraints with bounded slack variables. The governing PDE and other a priori assumptions are enforced explicitly as equality constraints on the same variables. This yields transparent, interpretable predictions and derivative estimates without training loops or bespoke architectures. The resulting direct constraints-based regression achieves accuracy comparable to PINNs with substantially reduced setup effort on reaction-diffusion benchmarks.

Reference Number: p_ 8505

ML-Based disturbance modelling for enhancing adaptability of Lyapunov-based control system for 6-DOF autonomous submersible vehicles

Authors: Ali Abbasi

Abstract

This paper presents a learning-enhanced disturbance modeling framework for ocean-operated systems based on the adaptive architecture of the referenced \mathcal{L}_1 -inspired predictor design. In the original formulation, matched uncertainties are approximated using a semi-linear structure dependent on the infinity norm of the state. While effective for bounded uncertainties, this representation can be restrictive for realistic marine environments characterized by wave-induced colored disturbances and nonlinear current drag forces.

To address this limitation, we replace the semi-linear uncertainty approximation with an online radial basis function neural network (RBFNN) embedded directly within the state predictor and adaptive compensation channel, preserving the original control structure. The disturbance model incorporates a second-order wave shaping filter driven by stochastic excitation and quadratic relative-velocity drag to emulate ocean currents. Simulation results demonstrate that the proposed RBFNN-based disturbance estimator significantly improves disturbance reconstruction accuracy and reduces predictor error

compared to the semi-linear baseline, without altering controller architecture. The approach provides a minimal yet effective learning-based enhancement for marine adaptive control systems under realistic environmental disturbances.

Reference Number: p_ 8625

Stationarity-Augmented Integrated Residual Transcription for SQP-Based Optimal Control

Authors: Kailai Shi, Eric C. Kerrigan, Simos A. Evangelou

Abstract

Integrated residual methods (IRMs) are direct methods for transcribing optimal control problems that address the limitations of direct collocation in terms of accuracy and feasibility. IRMs are promising for model predictive control due to their efficiency; however, existing formulations limit their potential by producing nonlinear programs (NLPs) that are either difficult for a sequential quadratic program (SQP) to solve or difficult to warmstart. We propose stationarity-augmented integrated residual (SAIR) transcription, based on the direct alternating integrated residual method with additional residual stationarity conditions. SAIR enforces the system dynamics as constraints, avoiding penalty updates and mesh refinement loops. Examples show improved conditioning compared to existing IRMs: Jacobians are closer to full rank and provide additional gradient information, enabling more reliable SQP solves.

Reference Number: p_ 8838

Reinforcement Learning-Based Intelligent Control of Lower Limb Exoskeletons for Personalized Gait Rehabilitation

Authors: Yiyang He, Ziwei Wang, and Tao Xue

Abstract

Lower limb exoskeletons hold great promise for gait rehabilitation, yet conventional PID and impedance controllers suffer from response lag, inability to adapt to individual gait abnormalities, and unnatural assistance. Recent breakthroughs show that reinforcement learning (RL) policies trained in simulation can achieve up to 24.3% metabolic cost reduction on real hardware. This work proposes a dual-layer RL framework: the first layer builds patient specific pathological gait models using the MyoSuite musculoskeletal simulation (80 muscles) with a metabolic energy reward; the second layer trains an anticipatory assistive policy minimizing muscular effort with near-zero-lag torque delivery. A curriculum-based progressive reward guides pathological gait toward healthy patterns, while instrumented insole sensors provide real-time gait phase detection. The framework aims to advance exoskeletons from passive tools toward intelligent rehabilitation agents.

Reference Number: p_ 8873

Data-Based Control for Large Ensembles of Similar Biological Systems

Authors: Peilin Zhang, Antonis Papachristodoulou, Idris Kempf

Abstract

Cybergenetic gene expression control enables applications in engineering biology, drug development, and biomanufacturing. Microfluidic devices enable control of millions of cells in parallel, but throughput requirements and biological system heterogeneity limit algorithm choice in practice. In this study, we develop a similarity-aware control framework to increase computational efficiency of cybergenetic control applications, and implement data-based control to accommodate biological system heterogeneity. We cluster cells according to similarity and develop a hierarchical leader-follower architecture, significantly reducing computational requirements. The results are validated in simulations of ensembles of biological systems, but are generally applicable to ensembles of similar systems.

Reference Number: p_ 9105

Active pantograph contact force regulation for high-speed trains using hybrid feedforward and sliding mode control

Authors: Saikat Duᳵa

Abstract

The stability of the contact force between the pantograph and catenary is a critical factor in ensuring reliable current collection for high-speed trains. This study proposes a novel active control architecture designed to regulate contact force dynamics. The proposed strategy uses an estimation technique to reconstruct interaction forces, enabling high performance control without the limitations of traditional physical sensors. To address the inherent nonlinearities and time-varying stiffness of the catenary system, a hybrid control law is analysed, combining a Feedforward (FF) compensator with a Sliding Mode Control (SMC) algorithm. The FF component provides pre-emptive rejection of measurable periodic disturbances arising from span traversals, while the SMC ensures robust stability against model uncertainties and stochastic excitations from base vibrations. The performance of the controller is evaluated through simulations, and the validation framework is aligned with the EN 50318 European standard. Results demonstrate that the integrated FF-SMC approach significantly reduces contact force variation and prevents contact loss at high speed.

Reference Number: p_ 9548

Incremental Nonlinear Dynamic Inversion for Longitudinal Flight Control of a PVTOL Aircraft

Authors: Iarlaith Caffrey, Toufik Souaneᳵ, James F. Whidborne

Abstract

This work presents an Incremental Nonlinear Dynamic Inversion (INDI) based controller for the Aston Martin Volante Vision concept, using a Planar Vertical Take-Off and Landing (PVTOL) model to represent hover behaviour. Nonlinear Dynamic Inversion (NDI) and INDI controllers are designed and assessed in simulation. The results show that INDI maintains stable and accurate tracking under modelling uncertainty and actuator saturation, whereas NDI exhibits degraded performance.

Reference Number: p_ 9795

Modelling and Control of Slot-Die Coating in Battery Electrode Manufacturing: Challenges and Perspectives

Authors: Hyuntae Kim, Idris Kempf

Abstract

Despite the economic impact of coating thickness nonuniformity on yield, scrap, and downtime, most lithiumion battery (LIB) electrode manufacturing lines remain operated through manual intervention and fixed recipes, highlighting the need for automated real-time feedback control [1]. To enable real-time control on manufacturing lines, three technical challenges must be addressed. First, while high-fidelity CFD captures the complex coating physics, it is analytically and computationally intractable for feedback design and implementation, necessitating reduced-order models (ROMs) that preserve crossdirectional (CD) thickness dynamics for control [2]. Second, scanning metrology and finite sensor aperture can alias machine-direction (MD) variation and unresolved high-frequency CD content into apparent low-order CD profiles, making point-sensing abstractions misleading without additional assumptions [3]. Third, practical slotdie actuation is often realised through low-dimensional operator-adjustable settings (knobs), turning profile setting into an inverse input-design problem. This extended abstract frames these challenges and argues for a “controlready loop” viewpoint: CFD-to-ROM identification for CD control, aperture-aware sensing models with worstcase recoverability limits (companion manuscript in preparation), and knob-parameterised optimisation to ensure implementable slot-die settings.

Reference Number: p_ 9919

Analysis of Dynamic Output-Feedback Control for Cyber-Physical Systems Under DoS Attacks

Authors: José F. V. D. Moreira, Wesley Peres and Marcio J. Lacerda

Abstract

A dynamic output-feedback control technique is proposed for Cyber-Physical Systems (CPS) subject to Denialof- Service (DoS) attacks. First, robust synthesis conditions are derived to

design the dynamic output-feedback controller. Subsequently, stability analysis conditions are conducted to guarantee robustness against DoS attacks, specifically determining the maximum number of consecutive attacks that the system can withstand while remaining stable. The effectiveness is demonstrated through numerical examples, confirming the stability achieved by the dynamic controller against prolonged DoS disruptions.

Reference Number: p_ 0035

Modeling and Control of Cooperative Transport Systems with Active End-effectors on Uneven Terrain

Authors: Shanqi Guo, Yuanjian Zhang, Jingjing Jiang

Abstract

To enhance the stability of payloads in cooperative transport systems operating on uneven terrain, this paper investigates the control of mobile robots equipped with active lift end-effectors. A kinematic model of the proposed mobile robots is formulated as a linear parameter-varying (LPV) system. Based on the model, a robust H_∞ controller has been developed. The controller design employs linear matrix inequalities (LMIs) to compute state feedback gains that ensure system stability. Simulation results demonstrate that the proposed control strategy achieves two key improvements for heavy payloads on uneven ground: reduced vibrations and improved movement stability.

Reference Number: p_ 0041

Disturbance-Compensated Data-Driven Predictive Control for Permanent Magnet Synchronous Generators

Authors: Ruo Chen Zhao, Ross Drummond, Paul Trodden

Abstract

This work presents a data-driven predictive control (DPC) scheme for permanent magnet synchronous generators (PMSGs) to achieve fast load sharing under disturbances. The controller builds Hankel matrices from measured input-output trajectories to predict future behaviour without an explicit model. To reduce sensitivity to high-frequency switching disturbances, we propose a disturbance-compensation law that decreases current fluctuations by 75.1% and improves tracking of the reference d-q currents compared with conventional DPC.

Reference Number: p_ 0071

Exact Continuous Reformulations of Logic Constraints in Nonlinear Optimal Control

Authors:

Abstract

Many nonlinear optimization and optimal control problems require enforcing logical structure alongside continuous dynamics, e.g., conditional constraints, hybrid mode logic, or temporal specifications. Standard encodings introduce binary variables and yield mixed-integer nonlinear programs that can be computationally burdensome and solver-restrictive, especially for nonconvex dynamics. We present an exact, binary-variable-free reformulation for a broad class of propositional logic constraints composed of inequality and equality predicates with Boolean operators. The method rewrites formulas into conjunctive normal form (CNF), converts CNF clauses into equivalent max-min inequalities, and applies an exact smoothing transformation that preserves the feasible set while inheriting the predicates' differentiability. The resulting formulation can be handled by standard continuous nonlinear programming solvers and supports compact encodings of common temporal operators (e.g., until and release) with linear growth in the horizon length. Numerical benchmarks on quadrotor trajectory optimization with conditional obstacle avoidance and on a hybrid two-tank system with temporal logic constraints demonstrate improved feasibility and solution quality relative to representative differentiable binary-elimination baselines.

Reference Number: p_ 0158

A Receding Horizon Polynomial Planner for Trajectory Optimisation

Authors: Mohammad Abdallah, Peter Hubbard and James Fleming

Abstract

An online trajectory planning and optimisation technique for motorcycle applications using polynomial splines and Receding Horizon Control (RHC) is discussed. The planner is designed using a reduced order model of the motorcycle tracking control system to ensure dynamic faithfulness. Preliminary results are tested using an obstacle avoidance scenario, to test safety guarantees. The solver optimises the solution in an average of 0.61 ms on a standard laptop computer, making it computationally tractable to run the planner in real time. This is due to the convexity of the optimisation problem and the simplicity, yet dynamic faithfulness, of the reduced order model constraints used. Testing is ongoing for the planner on a simulated motorcycle model. Additionally, the online planner must remain recursively feasible, as such, terminal costing, invariant sets and constraint techniques will be investigated.

Reference Number: p_ 0249

Multi-Experiment Battery Parameter Estimation

Authors: Paing Hmu Ko, Yuanbo Nie, Ross Drummond

Abstract

Battery parameter identification for optimisation and control is often performed using a single experiment and monomial open-circuit voltage (OCV) fits, which can yield biased

parameters and poor control performance. This paper proposes a multi-experiment joint estimation framework for a control oriented Thevenin equivalent circuit model in which a shared parameter set is identified across multiple current profiles. A demonstration of joint estimation across four discharge profiles (0.6 A, 3 A, 10 A, and 20 A) is shown to produce consistent voltage reproduction and a close match in capacitance estimates (3.11 Ah vs. 3.12 Ah).

Reference Number: p_ 0861

Distributed Unknown Input Observer for Highway Traffic State Estimation

Authors: Ruixuan Zhao, Guitao Yang, Boli Chen

Abstract

Global traffic state information is crucial for network-level control, yet centralized estimation becomes increasingly unsuitable in large-scale corridors due to latency, scalability constraints, and vulnerability to single-point failures. This paper proposes a distributed unknown input observer framework in which each monitoring node reconstructs the entire highway state using only local measurements and neighbor communication. Macroscopic traffic dynamics are modeled as a discrete-time LPV system derived from conservation laws. Unmeasured ramp flows and speed estimation errors from incomplete connected-vehicle penetration are reformulated as structured unknown inputs. Exploiting the spatially structured coupling of traffic dynamics, we extend geometric unknown input observer theory to a distributed sensing setting, replacing restrictive local decoupling conditions with a network-level reconstructability requirement. The resulting architecture enables full-state reconstruction without global input access, improving scalability and resilience.

Reference Number: p_ 1163

Intention-Aware Safe Motion Planning in Uncertain Traffic

Authors: Qidong Zhou, Jian Zhou, Pian Yu, and Yulong Gao

Abstract

Safe motion planning for autonomous vehicles is often hindered by the unpredictable control and behavioral intentions of surrounding vehicles. This paper proposes an efficient, intention-aware motion-planning strategy that learns and integrates these uncertainties into online predictions via analytical forward reachability analysis. By capturing both low-level control inputs and high-level behavioral intentions, the framework improves the feasibility and safety of ego-vehicle decision-making. The method's effectiveness is validated through distributed multi-vehicle planning tasks and real-world traffic dataset case studies.

Reference Number: p_ 1226

Symbolic Cut-Based Feedback as Supervisory Constraint Control for LLM-Driven Planning

Authors: Javal Vyas, Mehmet Mercangoz

Abstract

Large language models (LLMs) are increasingly investigated as decision aids for supervisory control and fault handling, where rapid generation of recovery actions may be required under uncertainty. However, LLM-generated plans often contain infeasible or unsafe actions, limiting their reliability in closed-loop operation. This work treats iterative LLM planning as a stochastic decision process embedded within a supervisory layer and introduces symbolic cut-based feedback as a fault-aware refinement mechanism. After each failed attempt, an invalid transition is recorded as a symbolic “cut,” discouraging repetition of that action in subsequent iterations while preserving flexibility elsewhere. On constrained graph reachability tasks, this approach reduces repeated violations, increases the depth of feasible plan prefixes, and typically reaches valid solutions more efficiently than naive reprompting or verbal feedback. The results indicate that structured feedback can improve the usefulness of LLMs within supervisory fault-handling loops.

Reference Number: p_ 1291

Bayesian Optimization of a Multi-Product Reactor Using Physics-Informed Surrogates

Authors: Liqiu Dong, Marta Zagórowska, and Mehmet Mercangöz

Abstract

We tackle Bayesian Optimization (BO) of a multiproduct reactor by formulating the economic objective in a composite way from multiple data-driven models that link the decision variables to individual process outputs. Instead of learning profit and constraints as black-box surrogates, we learn mappings from inputs to flow rates, compositions, and temperature, and compute profit analytically, with external variables such as product prices and utility costs appearing explicitly. This approach (i) makes the objective parametric in prices, so handling economic changes do not require retraining, (ii) and makes it possible to plug the surrogate predictions into a known steady-state energy balance to form a physics residual, which we use in the acquisition function to avoid regions, where the datadriven models cannot fulfill the energy balance with a large residual. We demonstrate the approach on a non-isothermal multi-product reactor. The proposed physics-residual-guided BO reaches the optimal operating point without constraint violations and within the trial budget.

Reference Number: p_ 1321

Data-Driven Control of a 2DoF Drone

Authors: Jeongheon Lee, Kaiwen Chen, Sophie Franziska Armanini, and Thulasi Mylvaganam

Abstract

We present a direct data-driven infinite horizon linear quadratic regulator (LQR) for a two degree-of-freedom quadrotor system. Given that a direct data-driven approach to solve LQR problems can be poor in the presence of process and measurement noise, we employ a variant that features a soft constraint to achieve stability, despite noise corrupting the data. In addition, an interpolation-based strategy is proposed to cope with sampling time mismatch and irregular data loss. Using high-fidelity simulations of the quadrotor in Gazebo, we demonstrate the datadriven LQR with the aforementioned soft constraint and interpolation-based strategy are effective when applied to the nonlinear simulation environment.

Reference Number: p_ 1359

Real-Flight Validation of a Two-Stage RLS for Quadcopter Mass and Actuator Fault Estimation

Authors: Mohamed Ahsan Mafaz, Nadjim Horri, Qian Lu and Matthew England

Abstract

Parameter and fault estimation methods for quadcopter UAVs are commonly validated in simulation, with performance under real flight conditions and autopilot implementation constraints less explored. This paper presents a practical validation of a two-stage recursive least-squares estimator for identifying UAV mass and actuator loss of effectiveness using real-flight data. Building on prior simulation-based work, the estimator is evaluated through real flights with controlled payload variations that induce known parameter changes. The results demonstrate consistent convergence to the true vehicle mass across multiple payload configurations and reliable identification of nominal actuator effectiveness. The study highlights practical aspects influencing estimator performance, including filtering requirements and interactions with onboard state-estimation pipelines. We demonstrate the feasibility of extracting reliable parameter and health information from standard autopilot data, providing a reproducible step toward integrating online estimation into future adaptive and fault-tolerant UAV control systems.

Reference Number: p_ 1523

Virtual Model Control Enables Efficient Object Search and Path Planning in Dynamic Environments

Authors: Alessio Canzolino, Alessandro De Blasi, Omar Faris and Fulvio Forni

Abstract

Autonomous search for objects and planning paths towards them in unstructured and complex environments are crucial tasks for robots. Conventional path planning methods struggle in the presence of dynamic obstacles, whereas existing active object search methods are tailored for mobile robots, leading to poor performance in confined spaces and under occlusions. In this work, we propose a new approach based on Virtual Model Control for active object search and efficient path planning in unstructured, dynamic environments. The key step is in the pairing of both tasks to specific virtual mechanisms (including springs and dampers), which enable continuous reaction/adaptation to the environment. Preliminary tests demonstrate promising results in confined, occluded spaces and dynamic scenarios.

Reference Number: p_ 1702

Unscented Cooperative Control (UCC) for Resilient Multi-agent operation under uncertainty

Authors: Sabyasachi Mondal¹ and Venkatraman Renganathan

Abstract

In this paper, a new approach for a cooperative control framework for nonlinear agents is proposed which pioneers the integration of unscented transform in cooperative control to provide a resilient MASs operation under stochastic uncertainty. This framework can handle a) uncertainties in communication (switching, delay, noise, intermittency, bandwidth limitation, etc.), b) provide efficient and low-computation uncertainty propagation, and c) use minimum channel bandwidth to ensure safe and reliable MAS operation. It can be useful in executing MASs behaviour like consensus and formation control under uncertainty while avoiding collision and obstacles.

Reference Number: p_ 1998

Probabilistic Assume-Guarantee Contracts for Unmanned Airspace Networks

Authors: Venkatraman Renganathan, and Sabyasachi Mondal

Abstract

(UAVs) into the low-altitude urban airspace is transforming air-traffic operations into a highly distributed, multi-player involved cyber-physical system operating under pervasive uncertainty. The design of emerging UAV airspace (henceforth referred as U-Space) management architectures involving autonomous fleet operators, delegated airspace service providers, and dynamically evolving interaction networks needs a paradigm shift in thinking from the design of traditional commercial air-traffic control with human-piloted aircraft. Certifying the global safety and verifying the efficiency in such challenging environments requires scalable and modular frameworks where rigorous system-level guarantees stem by composing local decisions made under uncertainty. The aim of this

research is to establish a probabilistic assume-guarantee contract (PAGC) framework for distributed control and formal verification of UAV airspace networks and thereby laying a modular and certifiable foundation for safe and scalable coordination in future autonomous UAV ecosystems

Reference Number: p_ 2109

Attention-Based Soft Supervisory for Controlling Multiple Systems

Authors: Klinsmann Agyei, Pouria Sarhadi

Abstract

Generalist agents are emerging controllers capable of handling multiple dynamical systems and represent a promising path toward universal control. However, their deployment in control engineering is limited, and they typically require knowledge of which system is currently under control. Manual system labelling is impractical for fully autonomous operation. We present a learning-based approach that recognises dynamical systems in real time by observing closed-loop state and control action trajectories. We train a neural classifier on trajectories generated by five diverse systems spanning linear (stable differential drive, non-minimum phase, Boeing 747 model), nonlinear (Nomoto ship model), and unstable dynamics. The architecture combines state and action encoders with LSTM-based temporal processing and an attention mechanism, trained on expert trajectories produced by an LQI controller tracking step references. Simulation results under previously unseen conditions demonstrate classification accuracy across all five systems. These results could enable label-free generalist control, allowing the controller to autonomously identify the system under control and eliminating the need for external labelling, thereby supporting fully autonomous operation across heterogeneous platforms. The approach can also be employed as a soft supervisory algorithm in classical switching controllers.

Reference Number: p_ 2547

Aerodynamically Informed Optimal Control Allocation for Quadrotor

Authors: Bilal Mubdir and Emmanuel Prempain

Abstract

Conventional quadrotor control allocation relies on algebraic mappings that assume constant rotor thrust and torque coefficients independent of aerodynamic conditions. These simplifications neglect the influence of induced velocity, inflow distribution, and the quadrotor's translational and angular velocities on rotor performance, leading to decreased control accuracy during aggressive maneuvers. This paper presents an aerodynamically informed optimal control allocation framework that integrates thrust and torque models based on momentum and blade-element theories. The approach directly incorporates aerodynamic effects into the allocation process by solving a nonlinear system of equations for rotor speeds that satisfy the commanded forces while respecting motor constraints.

Simulation results demonstrate improved stability, reduced oscillation, and less overshoot in rotor responses compared with conventional direct allocation.

Reference Number: p_ 2596

Applications of Safe Shared Control with Control Barrier Functions

Authors: James Josep Perry

Abstract

Shared control has emerged as a promising alternative to humans as monitors, while retaining the safety benefits of automation. Here we consider an architecture in which control authority allocation is facilitated via the solution of a Quadratic Programme, with Control Barrier and Control Lyapunov constraints. The benefits and drawbacks of such a system are discussed.

Reference Number: p_ 2606

LHM-Humanoid: Learning a Unified Policy for Long-Horizon Humanoid Whole-Body Loco-Manipulation in Diverse Messy Environments

Authors: Haozhuo Zhang, Jingkai Sun, Michele Caprio, Jian Tang, Shanghang Zhang, Qiang Zhang, Wei Pan

Abstract

We present LHM-Humanoid, a benchmark and learning framework for long-horizon whole-body humanoid loco-manipulation in diverse, cluttered scenes. The agent must repeatedly: walk to a target, pick it up with whole-body postures under balance constraints, carry it while avoiding obstacles, and place it at a goal—all within a single continuous episode without any environment reset. The task demands cross-scene generalization and unified one-policy control: layouts, obstacles, object properties, and start/goal poses vary substantially, requiring a single policy that directly outputs actions without pre-trained skill libraries. Our dataset covers four room types (bedroom, living room, kitchen, warehouse) with 350 scenes, 79 objects, and 25 movable targets. Without scene-specific ground-truth motions, we train goal-conditioned teacher policies via RL and distill them into a unified student policy using DAgger, further distilling it into a visionlanguage- action (VLA) model driven by egocentric RGB and natural language. Experiments in Isaac Gym show LHMHumanoid substantially outperforms RL baselines and prior loco-manipulation methods on both seen and unseen scenes, demonstrating strong long-horizon robustness and cross-scene generalization.

Reference Number: p_ 2787

Learning Interpretable and Robust Virtual Model Controllers with Genetic Algorithms

Authors: Yi Zhang, Fulvio Forni

Abstract

Learning-based controllers for dexterous and contact-rich manipulation are often sample-inefficient, hard to interpret, and brittle under sim-to-real transfer because policies are typically represented by unstructured function approximators. Virtual Model Control (VMC) provides an interpretable alternative framework for dexterous manipulation. We propose a structured VMC policy optimized via a Genetic Algorithm (GA), which evolves both the morphology and parameters of the virtual mechanism at the core of virtual model control. The GA representation defines the placement (relative to robot, object, and task frames) and the physical properties of each component. We will evaluate GA-VMC on two dexterous manipulation tasks with a dual-arm setup: bi-manual grasping and object reorientation. We hypothesize that, compared to a deep RL baseline trained in the same simulator and reward setting, GA-VMC will provide competitive or improved sample efficiency and success rate, and smaller sim-to-real performance drops.

Reference Number: p_ 2872

Adaptive-Robust Control and Closed-Loop Fault Compensation of a Quadcopter with Faulty Actuators

Authors: Seyed-Yaser Nabavi-Chashmi and Karim Ahmadi Dastgerdi

Abstract

Actuator faults represent a major challenge to the safe and reliable operation of quadrotor unmanned aerial vehicles, especially in safety-critical and fully autonomous missions. In this paper, we propose a digital-twin-assisted fault-tolerant control framework that integrates online actuator fault identification with robust adaptive control. A digital twin of the healthy system is employed to separate fault estimation from the closed-loop dynamics, thereby preventing estimation bias. The estimated faults are then compensated through control reallocation, while robustness against modelling uncertainties and external disturbances is achieved using adaptive control techniques. Simulation results confirm that the proposed approach accurately identifies actuator faults and maintains stable trajectory tracking even under severe actuator degradation.

Reference Number: p_ 3311

Gaze-Controlled Dual-Arm Teleoperation Based on Visual Separation Scheme: Towards Operational Space-Sensitive Elderly Assistive Manipulation

Authors: Yicheng Shi, Ziwei Wang

Abstract

Global population ageing is increasing the demand for teleoperated assistive robots in domestic environments. Elderly-care scenarios often involve operational space sensitivity (OSS), where confined layouts, cluttered objects, and residual human mobility tighten

coordination and safety constraints. In such settings, operators must alternate between issuing manipulation commands and monitoring dynamic surroundings, leading to visual functional conflict. To address this, we propose a Visual Separation Scheme (VSS) that structures visual allocation for command execution and situational awareness. Based on VSS, a gaze-controlled dual-arm shared autonomy framework is developed: the primary arm follows proportional gaze-to-velocity mapping, while the assisting arm executes cooperative behaviour through a state-conditioned policy. The framework is evaluated in OSS-constrained assistive tasks using completion time, placement error, trajectory smoothness, and collision count.

Reference Number: p_ 3320

The Role for Nonlinear Observer and Filtering Methods for Aircraft Icing Detection

Authors: Toufik Souanef and James F. Whidborne

Abstract

Aircraft icing represents a continuing hazard for the safe operation of aircraft. In particular, new regulations introduced in 2010 by the FAA and EASA in 2011 include more stringent requirements, particularly for aircraft operation supercooled droplet icing. This presents a challenge for aircraft manufacturers. This abstract presents some of the past and ongoing research at Cranfield University on nonlinear observer and nonlinear filtering approaches for aircraft and UAV icing detection. Finally, suggestions for future work are given that can exploit some of the unique facilities at Cranfield.

Reference Number: p_ 3647

System Identification with k-contracting Lurie Systems

Authors: Carl R. Richardson and Matthew C. Turner

Abstract

This paper proposes a class of stability constrained Lurie systems for modelling dynamical systems with convergent dynamics. k-contraction analysis is used to define a generalised stability measure which guarantees global convergence to a point, line or plane in the state-space. An unconstrained parametrisation of this condition is derived, allowing the parameters of the Lurie system to be trained using standard optimisation algorithms, whilst limiting the search space to solutions satisfying the k-contraction constraint.

Reference Number: p_ 3806

Terrain-Aware Hybrid Path Planning for Autonomous Robot Navigation

Authors: Adeel Bashir, Ajreen Qammar, Muzammil Ali, Dr. Ali Albeladi

Abstract

This paper presents a terrain-aware hybrid path planning framework for autonomous mobile robot navigation in known environments. Four configurations are investigated: Rapidly-Exploring Random Tree (RRT), RRTMarch, RRT integrated with the Dynamic Window Approach (RRT+DWA), and RRT-March integrated with DWA. The global planners generate collision-free paths in two simulation environments, namely a custom Blenderbased landscape and a rocky desert terrain, while DWA provides reactive local obstacle avoidance. In the hybrid schemes, DWA is guided using intermediate goals extracted from the global path. The framework is also evaluated in the presence of moving obstacles to assess robustness under dynamic conditions. Results show that the RRTMarch+DWA configuration provides smoother trajectories, improved success rate, and better obstacle avoidance than the other tested configurations. The study demonstrates that combining terrain-aware global planning with reactive local control offers a reliable solution for autonomous robot navigation in complex and partially dynamic environments.

Reference Number: p_ 3818

A Reinforcement Learning Approach to Approximate Dual Control for Active Sensing

Authors: David Mansfield, Allahyar Montazeri

Abstract

This work considers the problem of active sensing for environmental monitoring, where an autonomous agent must simultaneously estimate an unknown spatial process and plan sensing actions under uncertainty. This setting naturally gives rise to a dual control problem, in which control actions must trade off immediate task performance with information acquisition to reduce model uncertainty. We propose a control-oriented framework that integrates Gaussian Process (GP) regression for spatial estimation with a hierarchical policy-gradient reinforcement learning architecture to approximate dual control behaviour. A model-based information-seeking control action is embedded directly into the action space, selecting sensing motions that maximise expected information gain with respect to the current GP belief. The remaining actions correspond to primitive motion controls.

Reference Number: p_ 3839

MIMO L1 Adaptive Control for Fault-Tolerant Longitudinal Control of a Hypersonic Aircraft

Authors: Meera Alkaabi, Toufik Souanef, James F. Whidborne

Abstract

This paper presents a multi-input multi-output (MIMO) L1 adaptive control architecture for the longitudinal dynamics of a hypersonic aircraft. The proposed controller augments a baseline linear quadratic integral (LQI) controller and provides fast adaptation to compensate for modelling uncertainty, external disturbances, and variations in actuator

effectiveness. Simulation results show that the proposed approach improves robustness and fault tolerance compared to a conventional LQI controller, while maintaining smooth control inputs and acceptable tracking performance.