Franck **Djeumou**

Graduate Research Assistant · Autonomous Systems Group · The University of Texas at Austin

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Research Interests

My research lies broadly at the intersection of learning with prior knowledge, reinforcement learning, control theory, formal methods, and optimization. My research particularly aims to build autonomous systems that can learn how to operate in the real world while respecting underlying data, computational, safety, and perception limitations. Specifically, the recurrent theme in my work is that data alone is never the only source of knowledge available for learning. By deriving formal techniques to incorporate prior knowledge into learning, I have shown significant improvement in data efficiency, explainability, and generalization to unseen tasks or environments. Furthermore, I have demonstrated how to use such knowledge for the formal verification of the systems, particularly in the context of safety-critical applications such as aircraft control and robotics.

Education

The University of Texas at Austin — *Austin, USA*

Ph.D. in Electrical and Computer Engineering — *September 2018 - August 2023*

- Ph.D. Advisor: Ufuk Topcu
- Cumulative GPA Over 30 Credits (Ph.D. Major Course Requirements): 3.96

ISAE-SUPAERO (Institut Supérieur de l'Aéronautique et de l'Espace) — *Toulouse, France*

Bachelor of Science and Master of Science in Aerospace Engineering — *September 2014 - June 2018*

- Advised by Prof. Jerome Hugues
- Cumulative GPA: 3.8 | Top 6% of the class
- Thesis on "Safety Guarantees for Drones through Set-Based Formal Verification Methods"

École Polytechnique — *Palaiseau, France*

Master Degree in Computer Science (COMASIC) — *September 2016 - September 2017*

- Advised by Prof. Eric Goubault and Prof. Sylvie Putot
- Cumulative GPA: 3.7 | Graduated with Honours
- Thesis on "Human-Embedded Autonomous Flight Under Formal Task Specifications"
- This master degree was obtained as a collaboration between ISAE-SUPAERO and École Polytechnique

Lycée Fénelon — *Paris, France*

Class Preparatory (Equivalent to Junior Undergraduate Level) in Mathematics, Physics, and Computer Science — *September 2011 - June 2014*

- Graduated with honours

Experience

Autonomous Systems Group — *Austin, USA*

Graduate Research Assistant | Advisor: Ufuk Topcu — *September 2018 - Present*

- Published 10 conference papers (with one currently under review) and 6 journal papers (with 2 papers currently under review)
- Collaborated with researchers from various international academic institutions, national research laboratories and companies, and presented research outcomes at more than 10 invited talks

Toyota Research Institute (TRI) — *Los Altos, USA*

Research Intern — *June 2022 - August 2022*

- Physics-informed neural networks models for model predictive control at the limits of stability of vehicle dynamics
- Autonomous drifting with 3 minutes of driving data

Cosynus Team at Laboratory LIX of École Polytechnique — *Palaiseau, France*

Research Intern | Advisors: Eric Goubault and Sylvie Putot — *March 2018 - August 2018*

- Designed and Built the quadrotor testbed for the research team based on Crazyflie drones
- Implemented a hardware and software in the loop, Gazebo-based swarm simulator for the Crazyflie drones
- The code for the simulator is publicly available at *wuwushrek/sim_cf* and has over 20 stars and 20 forks on GitHub
- Investigated safety of dynamical systems through Taylor-based methods and abstract interpretation
- Investigated on-the-fly, lightweight and real-time verification (reach and safety properties) algorithms to be embedded on Crazyflie drones

Autonomous Systems Group (UT Austin) *Austin, USA*

Research Intern | Advisor: Ufuk Topcu *March 2017 - August 2017*

- Designed and built quadrotors based on the Snapdragon Platform and PX4 as the autopilot. Implemented a fast trajectory generator for quadrotors based on the minimum snap approach via a new problem modeling
- Investigated human interface with virtual reality and autonomous flight of a quadrotor via eye-tracking (*youtube.com/watch?v=AfosHcUJR9M*)
- Investigated the problem of tracking moving targets using POMDPs (Partially Observable Markov Decision Process) and human inputs
- Designed model checking and planning algorithms for UAVs autonomous missions with specifications expressed in temporal logic

Liebherr Aerospace and Transportation *Toulouse, France*

Machine Learning Intern *June 2015 - August 2015*

- Implementation in R of supervised learning algorithms to automatically classify aircraft's equipments from a reliability point of view
- Designed and implemented an application in Java that interacts with Liebherr's database to provide classification results to an expert

Skills

Languages	French (native), English (fluent), Japanese (beginner)
Programming	Python, C++, C, Java, R, Matlab, HTML5/CSS3 | *My GitHub stats* estimate more than 100k lines of code
Tools & Technologies	ROS, JAX, TensorFlow, Unity, Gazebo, PX4 Autopilot, Crazyflie, MuJoCo, RTOS, CVXPY, Gurobi, Mosek, Arduino

Publications

* indicates equal contribution

Peer-Reviewed Conference Articles [10]

Autonomous Drifting with 3 Minutes of Data via Learned Tire Models
Franck Djeumou, Jonathan Goh, Ufuk Topcu, Avinash Balachandran
Submitted *at IEEE International Conference on Robotics and Automation(ICRA)*
URL: `Processing` 2023

Taylor-Lagrange Neural Ordinary Differential Equations: Toward Fast Training and Evaluation of Neural ODEs
Franck Djeumou*, Cyrus Neary*, Eric Goubault, Sylvie Putot, Ufuk Topcu
International Joint Conferences on Artificial Intelligence (IJCAI)
URL: `https://www.ijcai.org/proceedings/2022/0405.pdf` 2022

Neural Networks with Physics-Informed Architectures and Constraints for Dynamical Systems Modeling
Franck Djeumou*, Cyrus Neary*, Eric Goubault, Sylvie Putot, Ufuk Topcu
Learning for Dynamics and Control Conference (L4DC)
URL: `https://proceedings.mlr.press/v168/djeumou22a/djeumou22a.pdf` 2022

Learning to Reach, Swim, Walk and Fly in One Trial: Data-Driven Control with Scarce Data and Side Information
Franck Djeumou, Ufuk Topcu
Learning for Dynamics and Control Conference (L4DC)
URL: `https://proceedings.mlr.press/v168/djeumou22b/djeumou22b.pdf` 2022

Task-Guided Inverse Reinforcement Learning Under Partial Information
Franck Djeumou, Murat Cubuktepe, Craig Lennon, Ufuk Topcu
International Conference on Automated Planning and Scheduling (ICAPS)
URL: `https://ojs.aaai.org/index.php/ICAPS/article/view/19785` 2022

Blending Controllers via Multi-Objective Bandits
Parham Gohari*, **Franck Djeumou***, Abraham P Vinod, Ufuk Topcu
American Control Conference (ACC)
URL: `https://ieeexplore.ieee.org/document/9867486` 2022

Learning-Based, Safety-Constrained Control from Scarce Data via Reciprocal Barriers
Christos K Verginis, **Franck Djeumou**, Ufuk Topcu
IEEE Conference on Decision and Control (CDC)
URL: `https://cverginis.github.io/publications/conferences/CDC21_safety.pdf` 2021

On-the-fly, Data-driven Reachability Analysis and Control of Unknown Systems: An F-16 Aircraft Case Study (**Best Demo/Poster Award**)
Franck Djeumou, Aditya Zutshi, Ufuk Topcu
International Conference on Hybrid Systems: Computation and Control (HSCC)
URL: `https://dl.acm.org/doi/abs/10.1145/3447928.3457355` 2021

On-The-Fly Control of Unknown Smooth Systems from Limited Data
Franck Djeumou, Abraham P. Vinod, Éric Goubault, Sylvie Putot, Ufuk Topcu
American Control Conference (ACC)
URL: `https://ieeexplore.ieee.org/document/9483367` 2021

Probabilistic Swarm Guidance Subject to Graph Temporal Logic Specifications
Franck Djeumou, Zhe Xu, Ufuk Topcu
Robotics: Science and Systems (RSS)
URL: `http://www.roboticsproceedings.org/rss16/p058.pdf` 2020

Journal Articles [6]

Task-Guided IRL on POMDPs at Scale with Information Asymmetry
Franck Djeumou, Christian Ellis, Murat Cubuktepe, Craig Lennon, Ufuk Topcu
Conditionally Accepted *at the special issue VSI:Risk-Aware Autonomy for consideration at the journal of Artificial Intelligence*
URL: `Processing` 2022

Probabilistic Control of Heterogeneous Swarms Subject to Graph Temporal Logic Specifications: A Decentralized and Scalable Approach
Franck Djeumou, Zhe Xu, Murat Cubuktepe, Ufuk Topcu
IEEE Transactions on Automatic Control (IEEE TAC)
URL: `https://ieeexplore.ieee.org/document/9779942` 2021

Safety-Constrained Learning and Control using Scarce Data and Reciprocal Barriers
Christos K Verginis, **Franck Djeumou**, Ufuk Topcu
Under Review *at IEEE Transactions on Automatic Control (IEEE TAC)*
URL: `https://arxiv.org/abs/2105.06526` 2021

On-The-Fly Control of Unknown Systems: From Side Information to Performance Guarantees through Reachability
Franck Djeumou, Abraham P Vinod, Eric Goubault, Sylvie Putot, Ufuk Topcu
IEEE Transactions on Automatic Control (IEEE TAC)
URL: `https://ieeexplore.ieee.org/document/9930630` 2022

Policy Synthesis for Switched Linear Systems with Markov Decision Process Switching
Bo Wu, Murat Cubuktepe, **Franck Djeumou**, Zhe Xu, Ufuk Topcu
IEEE Transactions on Automatic Control (IEEE TAC)
URL: `https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9691772` 2021

Online Synthesis for Runtime Enforcement of Safety in Multi-Agent Systems
Dhananjay Raju, Sudarshanan Bharadwaj, **Franck Djeumou**, Ufuk Topcu
IEEE Transactions on Control of Network Systems (IEEE TCNS)
URL: `https://ieeexplore.ieee.org/document/9362272` 2021

Honors & Awards

2022	**Rising Star,** Selected to participate at the 2022 Rising Stars in Aerospace (RSIA) Symposium hosted by the University of Colorado Boulder and sponsored by CU-Boulder, MIT AeroAstro, Stanford, and Penn State.	*Boulder, USA*
2022	**Rising Star,** Selected to participate at the Cyber-Physical Systems (CPS) Rising Stars Workshop 2022 hosted by the University of Virginia Link Lab	*Virginia, USA*
2022	**Scholarship,** Category 'Award Winners, Invited Speakers and Sponsors' at the 32nd International Conference on Automated Planning and Scheduling (ICAPS)	*Virtual, Singapore*
2021	**Winner,** Best Demo/Poster Award at Proceedings of the 24th International Conference on Hybrid Systems: Computation and Control (HSCC 2021)	*Nashville, USA*
2017	**Scholarship,** Foundation of Ecole Polytechnique	*Palaiseau, France*
2017	**Scholarship,** ISAE-SUPAERO Foundation	*Toulouse, France*
2016	**Scholarship,** ISAE-SUPAERO Foundation	*Toulouse, France*
2015	**Scholarship,** ISAE-SUPAERO Foundation	*Toulouse, France*
2014	**Scholarship,** ISAE-SUPAERO Foundation	*Toulouse, France*

Professional Services

Workshops Organized

Workshop on Safe and Reliable Robot Autonomy under Uncertainty *Philadelphia, USA*
International Conference on Robotics and Automation (ICRA) *May 2022*
Co-organizer

Reviewer

I was a reviewer at the following journals and conferences.

- IEEE Open Journal of Control Systems (OJ-CSYS) (2022)
- International Conference on Robotics and Automation (2022)
- American Control Conference (2020, 2021)
- IEEE Conference on Decision and Control (2021)
- IFAC symposium system identification (2021)

Selected Talks

2022	**Neural Networks with Physics-Informed Architectures and Constraints for Dynamical Systems Modeling**, SIAM Conference on Uncertainty Quantification (UQ22)	*Atlanta, USA*
2021	**Incorporating Physics-Based Knowledge into Neural Network Dynamics Models**, Galois Inc: Final Briefing for the Assured Autonomy Project	*Austin, USA*
2021	**How to learn to reach, walk, swim and fly in one trial? Well, first, admit that you are not dumb**, Lockheed Martin	*Austin, USA*
2021	**How to learn to reach, walk, swim and fly in one trial? Well, first, admit that you are not dumb**, Texas Robotics Symposium	*Austin, USA*
2021	**Data-Driven, On-The-Fly Reachability and Control of Unknown Systems**, Mini-Symposium on "Leaning for Dynamical Systems and Control" at the SIAM Conference on Applications of Dynamical Systems	*Portland, USA*
2020	**Learning On-the-Fly with a Case Study in Hypersonic Flight**, Sandia National Laboratories: Autonomy for Hypersonics Virtual Field Day	*Austin, USA*