Emre Yılmaz

Researcher
Aerospace Engineer

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Research Interests

- Physics Informed Machine Learning Physics Informed Neural Networks
- Multidisciplinary Design Analysis and Optimization (MDAO)
- Autonomy and Decision-Making
- Flight Dynamics Modeling, Control, Performance, and Trajectory Optimization of Aerospace Vehicles
- Urban/Advanced Air Mobility Multi-Agent Air Traffic Optimization

Coding

Language: Python, FORTRAN, C++, R
ML Library: PyTorch, Tensorflow
Other software: MATLAB, Simulink, OpenMDAO, Dymos, pyOptSparse, IPOPT, PSOPT, Gurobi, XFoil, CasADi, OpenVSP, CATIA, ArduPilot, LaTeX, Docker, Singularity, Mathematica

Academic Career

Publications (Ph.D.)

- Journals: 2 [Accepted], 4 [In preparation]
- Conference Papers: 6
- Invited Talk: 1
- Funding proposals: 1 [Submitted]

Publications (M.S.)

- Conference Papers: 2

(100+ Google Scholar citations)

I. Academic Background

Education

2014-Present	**Ph.D., Aerospace Engineering** , Advisor: Brian J. German Georgia Institute of Technology, Atlanta, GA (3.86/4.00) Minor: Math **(in progress)**, •Thesis: *Hybrid Automaton Based Contingency Planning for Over-Actuated Tandem Tilt-Wing eVTOL Aircraft*
2011- 2014	**M.S., Aerospace Engineering** , Advisor: Ali T. Kutay Middle East Technical University (METU), Turkey (3.79/4.00) • Thesis: *Adaptive Robust Attitude Controller Design for a Quadrotor Platform*
2006-2011	**B.S., Aerospace Engineering** Middle East Technical University (METU), Turkey (3.79/4.00) Rank: 2

Work Experience

2016-Present — Research Assistant School of Aerospace Eng., Georgia Institute of Technology

- **eVTOL Flight Dynamics, Control, and Trajectory Optimization:** Hybrid Automaton Based Path Planning, Control Allocation Optimization, Over-Actuated eVTOL Aircraft Flight Dynamics Modeling and Performance, Distributed Propulsion Concepts, Transition Corridors, Tilting Schedules, Vortex Lattice Method (VLM), Design of Experiments (DoEs), and MDAO Frameworks
- **Physics-Informed Machine Learning:** Application of Deep Learning Techniques (ConvNets and Conditional Generative Adversarial Nets/CGAN) to Airfoil Performance Prediction and Inverse Design
- **Advanced Air Mobility Air Traffic Optimization:** Multi-Agent Path Planning Optimization, Dynamic Obstacle Avoidance, Model Predictive Control, Constraint Aggregation, Deep Reinforcement Learning, and Optimal Control via Pseudospectral Methods
- **Urban Air Mobility Landing Operations:** UAM Landing Approach Surface Design Considering Energy, Power, and Operational Constraints (VRS, h-V Diagram, Acceleration Limits and Obstacles), Influence of Turbulence to Landing Accuracy, Circular Error Probables
- **Reliability of Aerospace Systems:** Fault Tree Analysis, Uncertainty Propagation, Resource Allocation, and Reliability Optimization
- **Modeling Engineering Decision Environment:** Model-Free Learning Methods, Q-Learning, and Gaussian Process (GP) Regression

2014-2015 — Teaching Assistant School of Aerospace Eng., Georgia Institute of Technology

- **Research:** Incorporating Semi-Parametric GP Regression into DDP
- **Teaching:** Control System Design Lab Demos, Dynamics

2011-2014 — Research and Teaching Assistant Department of Aerospace Eng., METU

- **Research:** Investigation of Adaptive, Nonlinear, and Robust Control Techniques, Attitude Controller Design, and Flight and Wind Tunnel (WT) Experiments with a Quadrotor
- **Teaching:** Control Labs, WT Demos, A/C Design, and Performance

2010 Summer — Assistant Project Engineering Intern Aerospace Eng. Hangar, METU

- Propulsion System Design & Optimization for a Hand Launched UAV

2009 Summer — Assistant Project Engineering Intern Turkish Aerospace Industries, Ankara

- Performance Calculations for a Jet-Powered UAV

Other Activities

2010-2011 — Undergraduate Projects Dept. of Aerospace Eng., METU

- Hand Launched RC UAV Design for Design, Build & Fly Competition
- RC Cargo UAV Design for Air Cargo Challenge Competition

II. Selected Projects

- **Trajectory and Control Allocation Optimization of Over-actuated eVTOL Aircraft [Fall 2019 - Present]**
  - Control allocation (CA) optimization of over-actuated eVTOL aircraft via linear and non-linear formulations using optimizers such as SNOPT, IPOPT, and Gurobi
  - eVTOL flight dynamics modeling using surrogates (specific focus: tandem tilt-wing DEP VTOL aircraft)
  - Design and execution of computational experiments via unsteady VLM based aerodynamic analysis
  - Hybrid automaton-based path planning architecture constructed using trim points and CA solutions
  - Contingency planning with considerations about transition corridors and tilting schedules

- **Physics Informed Machine Learning for Airfoil Performance Prediction and Inverse Design [Fall 2017-Present]**
  - Training medium-fidelity predictors for airfoil performance prediction via deep convolutional neural networks
  - Deep convolutional neural network and CGAN approaches to airfoil inverse design problems
  - Published three conference papers: [AIAA'20] [AIAA'18] [AIAA'17]

- **Advanced Air Mobility (AAM) Multi-Agent Path Planning Optimization [Spring 2020-Present]**
  - UAM air traffic optimization via model predictive control (MPC), constraint aggregation techniques, and dynamic obstacle avoidance formulations using OpenMDAO, Dymos, SNOPT, IPOPT, PSOPT, and Gurobi
  - ATM path planning in context of AAM using a deep reinforcement learning technique (MuZero Algorithm)
  - Contributed to Extensible Trajectory Optimization Library (ETOL) for Dymos integration
  - Investigation of air traffic metrics, creating optimal highway corridors using multi-commodity flow and MILP
  - Published two conference papers and a journal paper: [AIAA'21a] [AIAA'21b] [AIAA JAT]

- **Urban Air Mobility Landing Operations Research [Fall 2018 - Summer 2019]**
  - Performance analysis of landing approach surfaces in terms of energy, power, and time
  - Constraint analysis using inflow models, VRS, acceleration, obstacle, speed, h-V, and regulation limits
  - Simulations under turbulence using retrofit tilt-wing model and accuracy analysis via circular error probables
  - Published a conference paper: [AIAA'19]

- **Safety Assessment and Reliability Analysis of Aerospace Vehicle Systems via Fault Trees [Fall 2017 - Fall 2020]**
  - Safety and uncertainty analysis of complex systems by propagating statistical moments in fault trees
  - Resource allocation to reduce top event failure probability and optimization via augmented Lagrangian method
  - Sensitivity analysis of nominal and fault tolerant flight operations when subject to failure or uncertainty
  - Published a journal paper: [Elsevier's J-RESS]

- **Attitude Controller Design for a Quadrotor [Fall 2011 - Spring 2014]**
  - Design, simulation, and flight experimentation of attitude controllers using non-linear dynamic inversion, model reference adaptive control (MRAC), and integral backstepping with a quadrotor
  - Published two conference papers: [AIAA'14] [AIAC'13]

- **Wind Tunnel Experiments for Measuring Force and Moments Exerted on a Quadrotor [Fall 2011-Fall 2013]**
  - Wind tunnel experiments to measure force and moments exerted on a quadrotor for different flight scenarios.
  - Participation in the design of measurement system using data acquisition and 6-DOF load cell unit with its substructures and in the integration of the system into the wind tunnel

- **Hand Launched RC-UAV Design for AIAA Design-Build-Fly Competition [Fall 2010 - Spring 2011]**
  - Leader of Anatolian Craft AIAA Design-Build-Fly (DBF) 2010/11 competition team in propulsion systems design and design report submission, *Rank:* **6**/81 and the **best non-US** *team*

- **RC-UAV Design for Air Cargo Challenge (ACC) Competition [Fall 2010 - Summer 2011]**
  - Co-Leader and presenter of Anatolian Craft 2011 ACC team and leader in aerodynamics, flight stability, and design report submission, *Rank:* **2**/27 *in the sum of report and presentation scores and* **9**/27 *overall*

- **Propulsion System Optimization for an Electric Powered Hand Launched UAV [Summer 2010]**
  - Propulsion system optimization for an electric powered hand-launched UAV and performance calculations using battery, propeller, and brushless motor models

- **Modeling Engineering Decision Environment [Spring 2016 - Summer 2016]**
  – Application of RL and GP based algorithms for decision making during experiments and design processes
- **Incorporating Semi-Parametric Regression into Differential Dynamic Programming [Spring 2015 - Fall2015]**
  – Preliminary research on the incorporation of semi-parametric GP regression into DDP and adaptive control
- **Internship at Turkish Aerospace [Summer 2009]**
  – Performance calculations for a turbo jet-powered UAV
  – Manufacturing and assembly practice on the sub-assembly parts of various Boeing jet airliner models

III. Thesis and Publications

Thesis

E. Yılmaz, Hybrid automaton based contingency planning for over-actuated tandem tilt-wing eVTOL aircraft, Ph.D. Thesis, Georgia Institute of Technology, Atlanta, GA, 2023 (expected), *Committee:* Brian J. German [Advisor], Eric Feron, J.V.R. Prasad, Graeme J. Kennedy, and Justin S. Gray.

E. Yılmaz, Adaptive robust attitude controller design for a quadrotor platform, Master's Thesis, METU, Ankara, 2014. [Thesis]

Journal Articles

Journal Articles (in preparation)

4. **E. Yılmaz** and B. J. German, "Hybrid automaton based trajectory and contingency planning for tandem tilt-wing eVTOL aircraft", (in preparation).
3. **E. Yılmaz** and B. J. German, "Control allocation optimization for over-actuated tandem tilt-wing distributed propulsion eVTOL aircraft considering aerodynamic interactions", (in preparation).
2. **E. Yılmaz** and B. J. German, "Flight dynamic modeling of a tandem tilt-wing eVTOL aircraft using unsteady vortex lattice method based surrogates", (in preparation).
1. **E. Yılmaz**, M. Kotwicz Herniczek, O. Sanni, and B. J. German, "Model predictive control approach to UAM/AAM multi agent air traffic optimization via constraint aggregation", (in preparation).

Journal Articles

2. **E. Yılmaz**, B. J. German, and A. R. Pritchett, "Optimizing resource allocations to improve system reliability via the propagation of statistical moments through fault trees", Reliability Engineering & System Safety, Volume 230, February 2023, 108873, doi: 10.1016/j.ress.2022.108873, [Link]
1. M. Kotwicz Herniczek, **E. Yılmaz**, O. Sanni, and B. J. German. "Drawing the highways in the sky for urban air mobility operations," 2022 Journal of Air Transportation, doi: 10.2514/1.D0278, [Link].

Refereed Conference Proceedings

8. **E. Yılmaz**, O. Sanni, M. Kotwicz Herniczek, and B. J. German, "Deep reinforcement learning approach to air traffic optimization using the MuZero algorithm," In Proc.of AIAA AVIATION, 2021, doi: 10.2514/6.2021-2377, [Link].
7. M. Kotwicz Herniczek, **E. Yılmaz**, O. Sanni, and B. J. German, "Drawing the highways in the sky for urban air mobility operations," In Proceedings of AIAA AVIATION Forum, 2021, doi: 10.2514/6.2021-2376, [Link].
6. **E. Yılmaz** and B. J. German, "Conditional generative adversarial network framework for airfoil inverse designs," In Proceedings of AIAA AVIATION Forum, 2020, doi: 10.2514/6.2020-3185, [Link].
5. **E. Yılmaz**, M. Warren, and B. J. German, "Energy and landing accuracy considerations for urban air mobility vertiport approach surfaces," In Proc. of AIAA AVIATION Forum, 2019, doi: 10.2514/6.2019-3122, [Link].
4. **E. Yılmaz** and B. J. German, "A deep learning approach to an airfoil inverse design problem," In Proc.of 2018 Multidisciplinary Analysis and Optimization Conference, AIAA AVIATION, 2018., doi: 10.2514/6.2018-3420, [Link].
3. **E. Yılmaz** and B. J. German, "A convolutional neural network approach to training predictors for airfoil performance," In Proc.of 18th AIAA/ISSMO MDAO Conf., AVIATION Forum, 2017, doi: 10.2514/6.2017-3660, [Link].
2. **E. Yılmaz** and A. T. Kutay, "Adaptive robust attitude controller design for a quadrotor platform," In Proc. of AIAA Atmospheric Flight Mechanics Conference, AIAA AVIATION Forum, 2014, doi: 10.2514/6.2014-2671, [Link].

1. **E. Yılmaz** and A. T. Kutay, "The simulation of attitude controller design for a quadrotor model via several methods from literature," In Proceedings of 7th Ankara International Aerospace Conference, AIAC'13, 2013 .

Invited Talks

1. **E. Yilmaz** and B. J. German, "Emerging deep learning approaches for the problems of airfoil performance prediction and airfoil inverse design," INFORMS Annual Meeting, 2021.

IV. Course Background and Teaching

Teaching

- **Teaching Assistant (Georgia Tech) [Fall 2014 - Fall 2015, Fall 2022]**
  - Held discussion to assist students, conducted experiments related to control engineering topics and aerospace systems, and graded the lab reports.
  - **Courses:** Control System Design Lab [AE 4525] (Fall'14 and Spring'15), Dynamics [AE 2220] (Fall'15), and Rotorcraft Design [AE 4343] (Fall'22).
- **Teaching Assistant (METU) [Fall 2011 - Spring 2014]**
  - Held discussion to assist students, provided feedback on course material, graded homework assignments, and conducted control engineering demos and wind tunnel tests. Held MATLAB sessions.
  - **Lead Coordinator**, *Control and Simulation Laboratory*: Participated as the leading coordinator in the establishment of the lab equipped with mechanisms for control engineering experiments, organized the lab hardware and software, conducted experiments, and prepared the lecture materials.
  - **Courses:** Introduction to Aircraft Performance [AE 172] (Fall'12,Fall'13), Aeronautical Engineering Design [AE 451] (Spring'11,Spring'12), and Control Engineering Design [AE 384]
  - **Supporting Lab Assistant:** Flight Dynamics [AE 372] and Aerospace Engineering Laboratory [AE 410].

Course Background

- Attended a wide variety of courses about **control** (Planning and Decision for Autonomy, Automatic Flight Control Systems, Linear Systems, Nonlinear Stochastic Optimal Control, Robust Control), **estimation** (Kalman Filtering, System Identification), **optimization and design** (R/C Design, A/C Design, Optimization for the Design of Engineered Systems), **dynamics** (Advanced and Structural Dynamics), **mathematics** (Numerical Methods for Dynamic Systems, Stochastic Process), and **machine learning** (Statistical ML, ML Control for Dynamical Systems).

V. Awards

1. TÜBİTAK (The Scientific and Technological Research Council of Turkey) 2210 M.Sc./M.A. Scholarship

VI. Funding Proposal Experience

1. **ARPA-E**: DIFFERENTIATE (Design Intelligence Fostering Formidable Energy Reduction and Enabling Novel Totally Impactful Advanced Technology Enhancements) Program (submitted).

VII. Professional Service

Reviewing

2. AIAA Journal
1. Transportation Research Part C

Volunteering and Leadership

3. **Conference Session Co-Chair**, AIAA Aviation Forum, 2020.
2. **President**, Turkish Student Organization at Georgia Institute of Technology, 2018-2021, Atlanta, GA.
1. **Organization Team**, UAM Expo, Georgia Institute of Technology, 2019, Atlanta, GA.