Emre Yılmaz

Researcher
Aerospace Engineer

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Research Interests

- Control, Flight Dynamics, Trajectory Optimization, and Performance of eVTOL Aircraft
- Physics Informed Machine Learning
- Urban/Advanced Air Mobility (UAM/AAM) Air Traffic Optimization
- Autonomy in Flight
- Multidisciplinary Design Analysis and Optimization (MDAO)

Academic Career

Publications: 10+

Citations: 75+

H-Index: 4

Funding proposals: 1 [Submitted]

Coding: Python, FORTRAN, C++

ML Library: PyTorch, Tensorflow

Other software: MATLAB, Simulink, XFoil, OpenMDAO, Dymos, pyOptSparse, IPOPT, PSOPT, Gurobi, Mathematica, CasADi, CATIA, OpenVSP, ArduPilot

LaTeX

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:
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 Control and Path Planning:** Hybrid Automaton-Based Path Planning, Control Allocation Optimization, Over-Actuated eVTOL Aircraft Flight Dynamic and Performance Modeling, Distributed Propulsion Concepts, Transition/Tilting Considerations, and Multi-Disciplinary Analysis and Optimization 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/UAM 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 Surface Design with Considerations about Energy, Power, and Constraints including Vortex Ring States, Dead Man's Diagram, Acceleration and Obstacle Limits, 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

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

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

- **Research:** Adaptive, Non-linear, and Robust Control Techniques, Attitude Controller Design, Experimentation on a Quadrotor, and Wind Tunnel (WT) Experiments with a Quadrotor Platform
- **Teaching:** Control Lab, WT Demos, A/C Design, 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 and Services

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

- Hand Launched RC UAV Design for DBF Competition
- RC Cargo UAV Design for ACC Competition

II. Selected Projects

- **Path Planning and Control Allocation Optimization of Over-actuated eVTOL Aircraft [Fall 2019 - Present]**
  - Control allocation (CA) optimization of over-actuated eVTOL aircraft via linear (cascaded generalized inverses, etc.) and non-linear methods (NLP, SQP, and primal dual interior point solvers)
  - eVTOL flight dynamic and performance modeling (specific case: tandem tilt-wing eVTOL aircraft)
  - 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 Convolutinal Neural Network and CGAN Approaches to Airfoil Inverse Design Problems
  - Published three AIAA conference papers: [AIAA'20], [AIAA'18], [AIAA'17].
- **Advanced Air Mobility Multi-Agent Path Planning Optimization [Spring 2020-Present]**
  - UAM air traffic optimization using model predictive control and constraint aggregation. Solved dynamic obstacle avoidance problems. Used libraries: OpenMDAO, Dymos, SNOPT, IPOPT, SLSQP, Gurobi etc.
  - ATM Path Planning in context of AAM using a Deep RL technique (MuZero Algorithm)
  - Investigation of Air Traffic Metrics, Creating Optimal Highway Corridors Using Multi-Commodity Flow and MILP
  - Contributed to Extensible Trajectory Optimization Library (ETOL) for Dymos integration
  - Published two AIAA conference papers: [AIAA'21a], [AIAA'21b]. Submitted a journal paper to [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, and speed limits, h-V diagram, and FAA regulations. 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 via Fault Trees of Aerospace Vehicle Systems [Fall 2017 - Fall 2020]**
  - Safety analysis of aerospace vehicle subsystems by propagating statistical moments in fault trees.
  - Resource allocation to reduce top event failure probability via propagating uncertainty in fault trees and optimization via Augmented Lagrangian technique
  - Sensitivity analysis of nominal and fault tolerant flight operations when subject to failure or uncertainty
  - Submitted a journal paper to [Elsevier RESS].
- **Attitude Controller Design for a Quadrotor [Fall 2011 - Spring 2014]**
  - Investigation of adaptive, non-linear and robust control techniques
  - Design and simulation of attitude controllers using non-linear dynamic inversion, model reference adaptive control, robustness modifications, and integral backstepping. Experimentation with a quadrotor platform.
  - 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 Competition [Fall 2010 - Summer 2011]**
  - Co-Leader and presenter of Anatolian Craft EUROAVIA Air Cargo Challenge 2011 competition 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 a Hand Launched UAV [Summer 2010]**

- Propulsion system optimization for a hand-launched UAV and Performance Calculations using battery, propeller, and brushless motor models

- **Modeling Engineering Decision Environment [Spring 2016 - Summer 2016]**
  - Application of algorithms based on reinforcement learning and Gaussian Process for learning engineering decisions during experiments and design processes.
- **Incorporating Semi-Parametric Regression into Differential Dynamic Programming [Spring'15 - Fall'15]**
  - Preliminary research on the incorporation of the semi-parametric regression methods, mainly Gaussian Processes with basis vectors, into differential dynamic programming 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. Course Background and Teaching

Teaching

- **Teaching Assistant (Georgia Tech) [Fall 2014 - Fall 2015]**
  - 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) and Dynamics [AE 2220] (Fall'15).
- **Teaching Assistant (METU) [Fall 2011 - Spring 2014]**
  - Held discussion to assist students, provided feedback on course material, graded homework assignments, 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** (Numeric Methods for Dynamic Systems, Stochastic Process), and **machine learning** (Statistical ML, ML Control for Dynamical Systems).

IV. 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, 2022 (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]

Journals

4. **E. Yılmaz** and B. J. German,, "Control allocation optimization methodologies for over-actuated tandem tilt-wing eVTOL aircraft flight dynamic models considering aerodynamic interactions", (in preparation).
3. **E. Yılmaz**, M. Kotwicz Herniczek, O. Sanni, and B. J. German, "Model predictive control approach to UAM air traffic optimization via constraint aggregation", (in preparation).

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", (submitted to Journal of Reliability Engineering and System Safety) .
1. M. Kotwicz Herniczek, **E. Yılmaz**, O. Sanni, and B. J. German. "Drawing the highways in the sky for urban air mobility operations," 2022 (submitted to Journal of Air Transportation, current status: "to appear").

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 Proceedings of AIAA AVIATION Forum, 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 Proceedings 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 Proceedings of 2018 Multidisciplinary Analysis and Optimization Conference, AIAA AVIATION Forum, 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 Proceedings of 18th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, AIAA 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 Proceedings 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 .

V. 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.

VI. Reviewing, Volunteering, Leadership, and Funding Proposal Experience

Reviewing

1. AIAA Journal

Volunteering and Leadership

4. **Conference Session Co-Chair**, AIAA Aviation Forum, 2020.
3. **President**, Turkish Student Organization at Georgia Institute of Technology, 2018-2021, Atlanta, GA.
2. **Organization Team**, UAM Expo, Georgia Institute of Technology, 2019, Atlanta, GA.
1. **Culture Chair**, Turkish Student Organization at Georgia Institute of Technology, 2017-2018, Atlanta, GA.

Funding Proposal Experience

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