

# Mahathi Bhargavapuri

PHD CANDIDATE IN APPLIED CONTROL THEORY

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## Summary

Currently working part-time as a Co-founder & Systems and Control Engineer in a start-up called EndureAir Systems whose main aim is to provide long range and high endurance VTOL solutions for disaster relief operations. I specialize in applied control theory with special emphasis on unmanned aerial vehicles. My doctoral studies focuses on robust and adaptive nonlinear control as well as vision-based autonomous flight. Hope to take my knowledge of drones to the next level while working in a team of highly skilled interdisciplinary professionals.

## Education

### IIT Kanpur (Indian Institute of Technology Kanpur)

M.TECH + PHD IN APPLIED CONTROL THEORY

Kanpur, India

Jul. 2014 - Jan. 2020 (expected)

### SJCE (Sri Jayachamarajendra College of Engineering)

B.E. IN INSTRUMENTATION TECHNOLOGY

Mysuru, India

Aug. 2010 - Jul. 2014

## Research

### Vision-Based Autonomous Tracking and Landing of a Fully-Actuated Rotorcraft

Control Engineering  
Practice, Elsevier

Aug. 2019

BHARGAVAPURI, M., SHASTRY, A.K., SINHA, H., SAHOO, S.R., AND KOTHARI, M.

- This paper presents vision-based tracking and landing of a fully-actuated tilt-augmented quadrotor on a moving target.
- A fully-actuated vehicle allows higher freedom in terms of control design since the position and attitude states are decoupled.
- An adaptive control law is designed to track a moving target with only relative position information from a camera.
- Low-cost hardware is used, and experiments are carried out to validate the proposed methodology for targets moving at realistic speeds.

### Robust Nonlinear Control of a Variable-Pitch Quadrotor with the Flip Maneuver

Control Engineering  
Practice, Elsevier

Jun. 2019

BHARGAVAPURI, M., SAHOO, S.R., KOTHARI, M., AND ABHISHEK

- Robust nonlinear backstepping control laws are designed for a variable-pitch quadrotor for its full flight envelope.
- A systematic method to obtain controller gains is proposed to ensure overall closed-loop stability in the presence of dynamic control allocation.
- Detailed analysis of the flip maneuver in the presence of input saturation is presented for the first time.
- The proposed methodology is validated through matlab simulations as well as experiments on an off-the-shelf variable-pitch quadrotor frame.

### Global Attitude Stabilization using Pseudo-Targets

arxiv (ongoing)

Nov. 2018

BHARGAVAPURI, M., SAHOO, S.R., AND KOTHARI, M.

- The topological obstructions on the attitude space of a rigid body make global asymptotic stabilization impossible using continuous state-feedback. This work presents novel algorithms to overcome such topological limitations and achieve arbitrary attitude maneuvers with only continuous, memory-less state-feedback.
- Nonlinear control laws designed using both rotation matrices and quaternions give rise to one almost globally asymptotically stabilizable equilibrium along with a nowhere dense set of unstable equilibria. These unstable equilibria are uniquely identified in the attitude error space.
- Pseudo-targets are then designed to make the controller believe that the attitude error is within the region of attraction of the stable equilibrium.
- Further, the pseudo-target ensures that maximum control action is provided to push the closed-loop system toward the stable equilibrium.

### Robust Attitude Control for a Variable-Pitch Quadrotor with Parameter Uncertainty

ACC, USA

Jun. 2018

BHARGAVAPURI, M., SAHOO, S.R., KOTHARI, M., AND ABHISHEK

- A robust PD controller is designed to handle uncertainty and changing rotational inertia values.
- Classical loop shaping methods are utilized to obtain the controller gains given a rough estimate of the vehicle's inertia.
- Numerical simulations and experiments are carried out to validate the proposed technique.
- This work has been extended to all types of multirotors in my masters thesis.

## A Low-Cost Tilt-Augmented Quadrotor Helicopter: Modeling and Control

ICUAS, USA

BHARGAVAPURI, M., PATRIKAR, J., SAHOO, S.R., AND KOTHARI, M.

Jun. 2018

- This paper proposes a low-cost solution to the problem of underactuation in UAVs which restricts the full potential of such vehicles.
- A tilt-augmented quadrotor helicopter which is a fully-actuated system as the number of control inputs are equal to the system degrees of freedom is designed and flight tested. Control for each degree of freedom is carried out separately.
- Mathematical modeling of the tilt-augmented quadrotor and control laws to enable attitude stabilization and position tracking is presented.
- Matlab simulations as well as experimental results are presented to validate the proposed vehicle model and control design.

## Quaternion Based Adaptive Control for Package Delivery using Variable-Pitch Quadrotors

ICC, India

SHASTRY, A.K., BHARGAVAPURI, M., SAHOO, S.R., AND KOTHARI, M.

Jan. 2018

- This work discusses the importance of adaptive control laws in the scenario of automated delivery systems using multirotor UAVs.
- We present a nonlinear adaptive control design of a variable-pitch quadrotor. Sudden changes in mass and uncertainty in the rotational inertia of the quadrotor emphasizes the necessity for an adaptive control technique.
- Matlab environment is utilized to show a drone-delivery simulation along with trajectory tracking and inverted flight.

## Work Experience

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### EndureAir Systems

Kanpur, India

CO-FOUNDER & CONTROL ENGINEER

Jan. 2019 - Present

- Co-developer of NAAVIK autopilot with autonomous navigation and package delivery for helicopters with an all-up-weight of 12.5 kg.
- Design, development, and testing of novel VTOL unmanned vehicles for simple and efficient flight.

### Intelligent Guidance & Controls Laboratory

Kanpur, India

SENIOR RESEARCH ASSOCIATE

Jun. 2018 - Present

- Worked extensively on linear and nonlinear attitude control of rigid bodies. Developed and tested robust and adaptive control laws on various unmanned systems. Also worked on motion planning and cooperative control of multiple UAVs.
- Currently involved in mentoring new members of the laboratory and giving shape to new ideas and research.

### Indian Institute of Science, Bangalore

Bengaluru, India

RESEARCH INTERN

Jun. 2013 - Aug. 2013

- Designed and implemented instrumentation amplifiers for improving the signal-to-noise ratio of an atomic force microscope
- Obtained an in-depth knowledge of engineering mathematics by being around some of the smartest people in the country.

## Awards & Extracurricular Activity

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SENIOR SYSTEMS & CONTROL ENGINEER

- Won the bronze medal in the Warehouse Inventory Management with Drones held during the 2017 Inter IIT Technical Meet.
- Our team utilized the novel tilt-augmented quadrotor to eliminate the use of gimbals for indoor vision-based localization of the drone.
- This project presented a unique opportunity to mentor and guide extremely talented undergraduate students in the team.

CARNATIC CLASSICAL MUSICIAN

- An All India Radio (AIR) 'B High' grade artist in Carnatic Classical Instrumental Music (Violin).
- Second place in the All India Radio Music competition (Carnatic Instrumental, Violin), 2011.
- Actively involved in learning from well-known vocal and violin maestros and teaching music to the campus community.

BASKETBALL TEAM IIT KANPUR, FORMER MEMBER

- Won the bronze medal while representing the institute (basketball) in the 2017 Inter IIT Sports meet organised by IIT Madras
- Actively participate in all kinds of team sports and keep myself engaged physically.
- Help mentoring younger players for the institute basketball team (who won the silver medal in the 2018 Inter IIT Sports Meet).