Aerospace Engineering **Division:**
Level and Major: Master of Science and Ph.D. in Aerospace Engineering

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Course Title: Adaptive Control Systems **Number of Credits: 3**
Prerequisite: **Automatic Control, Modern Control** **Lecturer: Dr. Farhad Fani Saberi**

Course Description:
This course will first review basic concepts of classic control, such as state space transformation, controllability and stability, the minimum and non-minimum phase system, and state feedback controller. Then various methods of adaptive controller design will introduce. A summary of digital control and discretization method will present in 3rd part. System identification based on LS and RLS method will teach. An adaptive controller based on RLS identification method will designed for a SISO system in discrete-time domain. Lyapunov stability theory will present and finally an adaptive controller based on adaptation mechanism method will designed for a SISO system in continuous-time domain.

Course Goals and Objectives:
The Purpose of This Course is: Adaptive Control System Analysis and Design

Course Topics:
1. Basic concepts in Adaptive control- MIT Rule- Design of MRAS using Lyapunov Theory- Adaptive control of Linear systems
2. Introduction Linear and Modern control systems
3. Pole placement Design- Indirect Self Tuning Regulators- Unified Approach Method
4. Direct Self Tuning Regulators- Adaptive Attitude Control of a spacecraft
5. Positive Linear Systems , The KALMAN – YAKUBOVICH Lemma- Nonlinear Control Problems, Stabilization Problems, Tracking Problems- Specifying the Desired Behavior (slotine)
6. Adaptive Control of Nonlinear Systems- Adaptive feedback Linearization
7. Backstepping and Adaptive Backstepping control
8. Small Gain Theorem- Passivity Theorem
9. Adaptive Control Based on Passivity Theorem- Robustness of Adaptive control systems
10. Principals of Regulators and Trackers Introduction to Linear feedback, Effects of Process Variations,
11. Adaptive Schemes, Adaptive Control Problems, Applications
12. Gradient Estimator, Least Squares Estimator, Experimental Conditions, Estimating Parameters in Dynamical systems
13. Concept of Stability- System Analysis Based on Lyapunov' s Direct Method
14. Concept of Stability for Non- Autonomous Systems- Lyapunov Analysis of Non-Autonomous Systems
15. Introduction to Digital Control Systems Linear Parametrization and Regression Model
16. Feedback Linearization Sliding Control

The course aims to:
Students are expected to:
1. Be able to discrete the continuous-time transfer function.
2. Be able to design a linear system identification algorithm based on RLS method.
3. Be able to design and simulate an adaptive control for both continuous and discrete-time system.

4. Be able to evaluate an adaptive controller performance.

Reading Resources:

- Adaptive Control Systems, Techniques and Applications, V. V. Chalam , Marcel Dekker, Inc 1978
- Adaptive Control, K. J. Astrom, Wesley, 1995
- کنترل تطبیقی، تالیف کارل جان آستروم و یورن ویتنمارک، ترجمه دکتر محمد تقی حمیدی بهشتی، انتشارات دانشگاه تربیت مدرس
- کنترل غیرخطی کاربردی، تالیف ژان – ژاک ای. اسلوتین و وایپینگ لی، ترجمه محمدرضا هاشمی گلپایگانی، منوچهر احمدوند، امیر همایون جعفری، انتشارات مرکز نشر دانشگاهی

Evaluation:

Final Exam: 50%
Midterm Exam: 10%
Project & Presentation: 20%
Homework & Assignments: 20%
Participation & Class Activity: additional point