Dynamical systems and Control

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General Information

- 10 Lectures
- 10 exercise sessions
- 4 labs
  - DC motor modelling
  - Angle estimation using Gyros and accelerometers
  - DC motor PID control
  - MinSeg Balancing
- Evaluation: 3p for labs + 3p for exam

General Information

- **Text book**: T. Glad och L. Ljung: "Reglerteknik - Grundläggande teori".
- **Software:** MATLAB, Simulink, Control system toolbox
- **Teaching assistants:**

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What is this course about?

- Models
- Signal processing
- Control

Lecture 1: What is control?

- Introduction
- Examples of control problems
- Models

Introduction to control

and examples of control problems

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Introduction to control

- Making things behave as we want!
- Examples?

Modern cars

Have regulation systems for

ABS: Break

ESC: Anti-skidding

ACC: Speed and distance

Photo credit: https://www.slashgear.com/wp-content/uploads/2017/10/polestar-1-0.jpg

Body

Build-in control systems

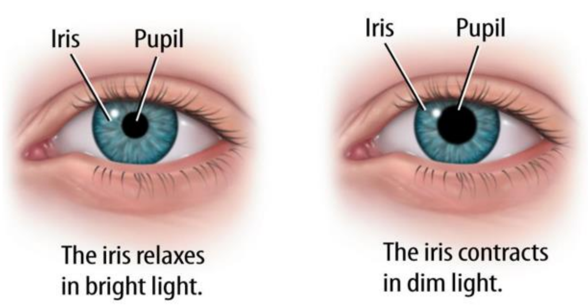

Photo credit: https://www.teachoo.com/10493/3033/What-is-the-function-of-Iris-and-Pupil-/category/Concepts/

Technological control systems

DIABETES SOM REGLERINGSPROBLEM

Students insjuknande i diabetes inspirerade till stort EU-projekt

2002 missade LTH-studenten Fredrik Ståhl en tenta i reglerteknik. Orsaken var att han plötsligt insjuknat i diabetes. Han sökte upp sin lärare Rolf Johansson och förklarade orsaken. Han sa också att han gärna skulle vilja göra ett examensarbete på sitt eget insjuknande och dess behandling!

Nu går de tillsammans vidare inom ramen för ett stort EU-projekt på 7,1 miljoner euro.

Fredrik Ståhl kände de klassiska symtomen, omotiverat stor törst och täta behov att kasta vatten. Läkarna förklarade att Fredrik hade drabbats av diabetes, typ 1. Han förstod att diabetes kunde ses som ett regleringsproblem, precis som alla uppgifter i den tentamen han just förberedde sig för.

Photo credit: https://studylibsv.com/doc/930758/diabetes-som-regleringsproblem

Industrial robots

- Doing repetitive tasks
- Doing task fast and precise

YuMi: ABB’s collaborative robot. Photo credit: https://new.abb.com/products/robotics/collaborative-robots/irb-14000-yumi

Smart phones

- Regulating signal-to-noise ratio
- Need to move more buddy!

Photo credit: https://cdn.dxomark.com/wp-content/uploads/medias/post-90166/MicrosoftTeams-image-7.jpg

Fighter aircrafts

- Designed to be flown automatically
- If the control system fails, they may crash

SAAB JAC 39 Gripen. Photo credit: https://en.wikipedia.org/wiki/Saab_JAS_39_Gripen

Drones

- Are regulated to keep certain height and speed
- Many fun applications

Photo credit: https://www.urbanairmobilitynews.com/commentary/top-level-football-deploy-drones-to-revolutionise-training-methods/

What is a signal?

A quantity which

- is measured
- is of interest
- can affect the system

Photo credit: https://carroar.com/wp-content/uploads/2020/01/tracking-car-location.jpg

Models

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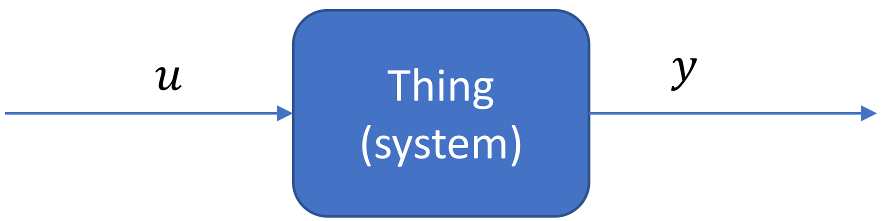
Models

Describing the “thing” or the “system ” quantitively



$$y^{(n)} + a_1 y^{(n-1)} + \cdots + a_n y = b_0 u^{(m)} + \cdots + b_m u$$

Solution?

$$y^{(n)} + a_1 y^{(n-1)} + \cdots + a_n y = b_0 u^{(m)} + \cdots + b_m u$$

Characteristic equation

$$y^{(n)} + a_1 y^{(n-1)} + \cdots + a_n y = b_0 u^{(m)} + \cdots + b_m u$$

Alternative model

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

Question: Which one do you prefer to work with?

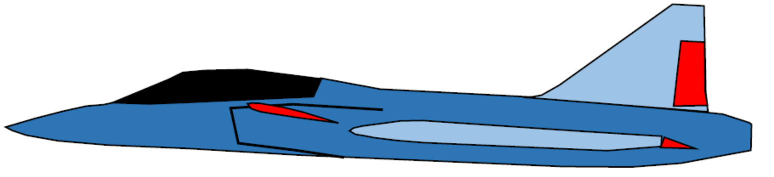
SAAB JAS 39 Gripen- General info

Pay load: 5 300kg

Maximum take off weight: 14 000 kg

Wing area: 30 m^2

Thrust: 1×296 kN



SAAB JAS 39 Gripen

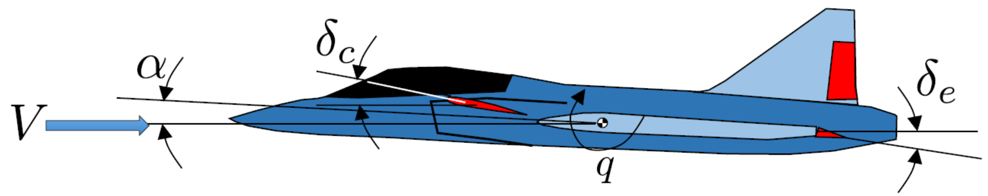
V: Velocity

α: Angle of attack

q: Pitch rotation rate

δ_e: Elevator angle

δ_c: Canard angle

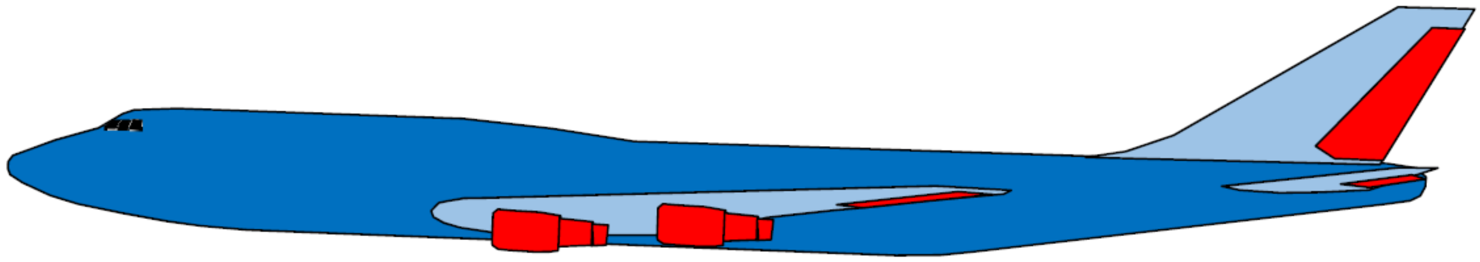


SAAB JAS 39 Gripen- Model

$$\begin{bmatrix}\dot{\alpha}\\ \dot{q}\end{bmatrix} = \begin{bmatrix}-0.6790 & 0.9920\\ 1.3990 & -0.5370\end{bmatrix}\begin{bmatrix}\alpha\\ q\end{bmatrix} + \begin{bmatrix}-0.2200 & -0.0120\\ -10.3300 & 4.3240\end{bmatrix}\begin{bmatrix}\delta_e\\ \delta_c\end{bmatrix} + \begin{bmatrix}v_\alpha\\ v_q\end{bmatrix}$$

$$\begin{bmatrix}\alpha_m\\ q_m\end{bmatrix} = \begin{bmatrix}1.0000 & 0.0000\\ 0.0000 & 1.0000\end{bmatrix}\begin{bmatrix}\alpha\\ q\end{bmatrix} + \begin{bmatrix}0.0000 & 0.0000\\ 0.0000 & 0.0000\end{bmatrix}\begin{bmatrix}\delta_e\\ \delta_c\end{bmatrix}$$

Boeing 747-General info



Pay load: 55 300 kg

Maximum take off weight: 447 700 kg

Wing area: 554 m^2

Thrust: $4 \times 296\ kN$

Boeing 747-Model

$$\begin{bmatrix}\dot{\alpha}\\ \dot{q}\end{bmatrix} = \begin{bmatrix}-0.3958 & 1.000\\ -1.5549 & -0.5367\end{bmatrix}\begin{bmatrix}\alpha\\ q\end{bmatrix} + \begin{bmatrix}-18.5198\\ -1.2053\end{bmatrix}\delta_e$$

$$y = \begin{bmatrix}0 & 1\end{bmatrix}\begin{bmatrix}\alpha\\ q\end{bmatrix} + 0\delta_e$$

What do we cover next?

- Laplace transformation
- Stability
- Characteristics of first and second-order systems

Ask us!

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