SERVOSISTEMI AEROSPAZIALI 25. Oct. 2010

PROF. G. MENGALI

→ Esame scritto + orale in lingua italiana. (tutto in un giorno)

→ Prove scritte in itinere. (1ª a metà; 2ª dopo la fine del corso)

→ Appunti in dipartimento DIA ed esami vecchi.

LIBRI CONSIGLIATI:

1) FRANKLIN POWELL - "Feedback control of dynamic systems" } Prentice Hall

2) OGATA K. - Modern Control Engineering

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We can divide the course in 2 parts:

1) linear systems and linear analysis.

2) tools that allowed to modify the linear system in order to study the real behaviour.

Importance of control systems

Control systems are very important for technology, in fact they are what make machines function.

Without them, there would be:

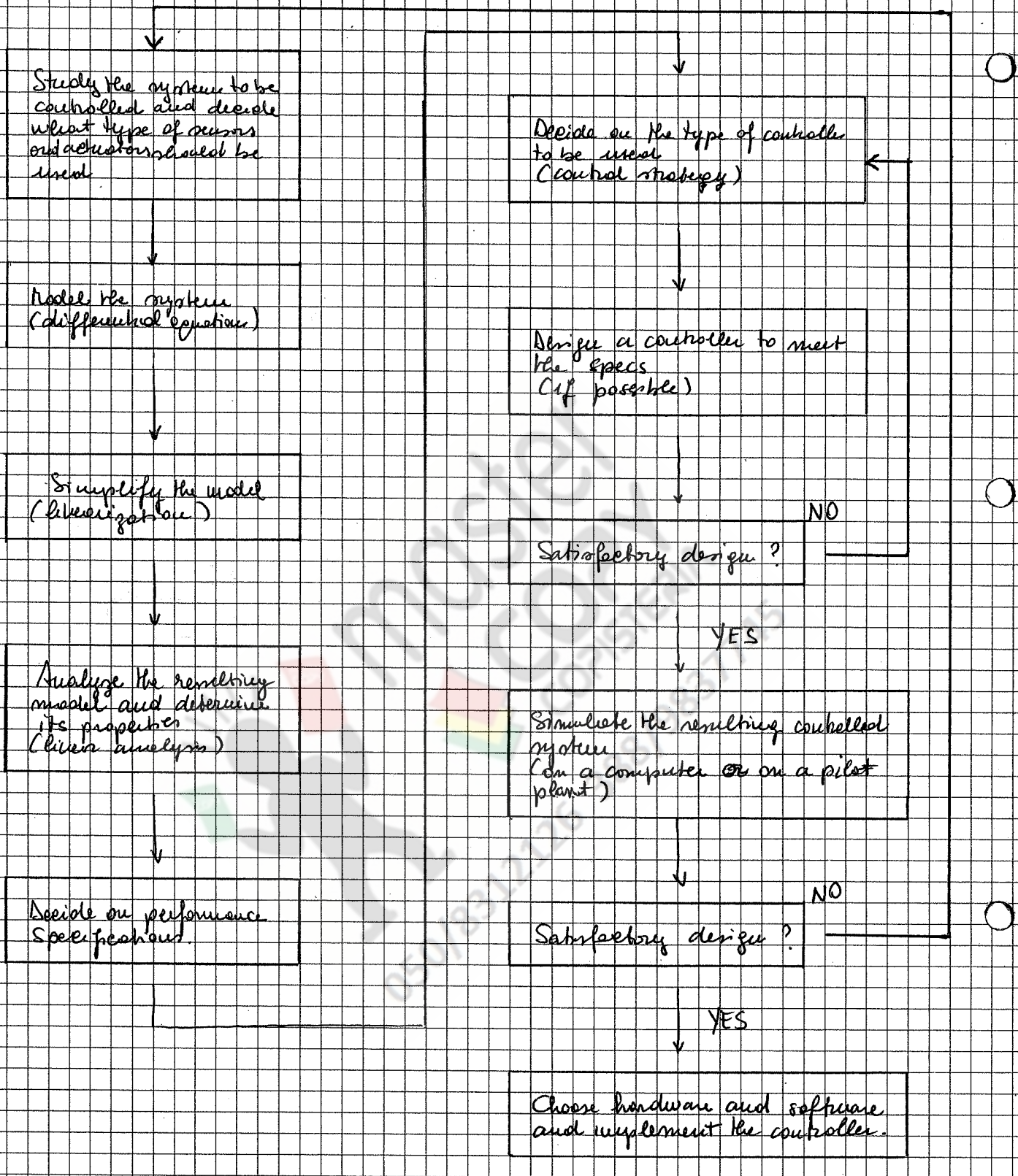
- no manufacturing
- no vehicles
- no computers and so on.

Control systems are based on FEEDBACK: the signal to be controlled is compared to a reference signal and the difference is used to compute a corrective control action.

We will pay attention mainly on CLASSICAL CONTROL THEORY: analysis of single-input, single-output feedback controls.

→

ISSUES in CONTROL SYSTEM DESIGN



26. OKT. 2010

WHAT IS FEEDBACK?

Feedback usually is used to refer to a situation in which two or more dynamical systems are connected together. Each system influences the other one: their dynamics are strongly coupled. An example of feedback system is due to biology: for example the regulation of glucose in the body.

WHAT IS CONTROL?

It has different meanings.

Here is: THE USE OF ALGORITHMS AND FEEDBACK IN ENG. SYSTEMS

- electronic amplifiers
- controllers in chemical and materials processings
- fly-by-wire systems.

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PRINCIPAL COMPONENTS OF FEEDBACK CONTROL:

Different are the tasks of a modern controller

1. it senses (SENSES) the operation of a system
2. it compares that against the desired behavior into a reference signal
3. it computes corrective actions in order to obtain the right behavior - that is based on a model of the system's response to external inputs.
4. it actuates the system to effect the desired changes.

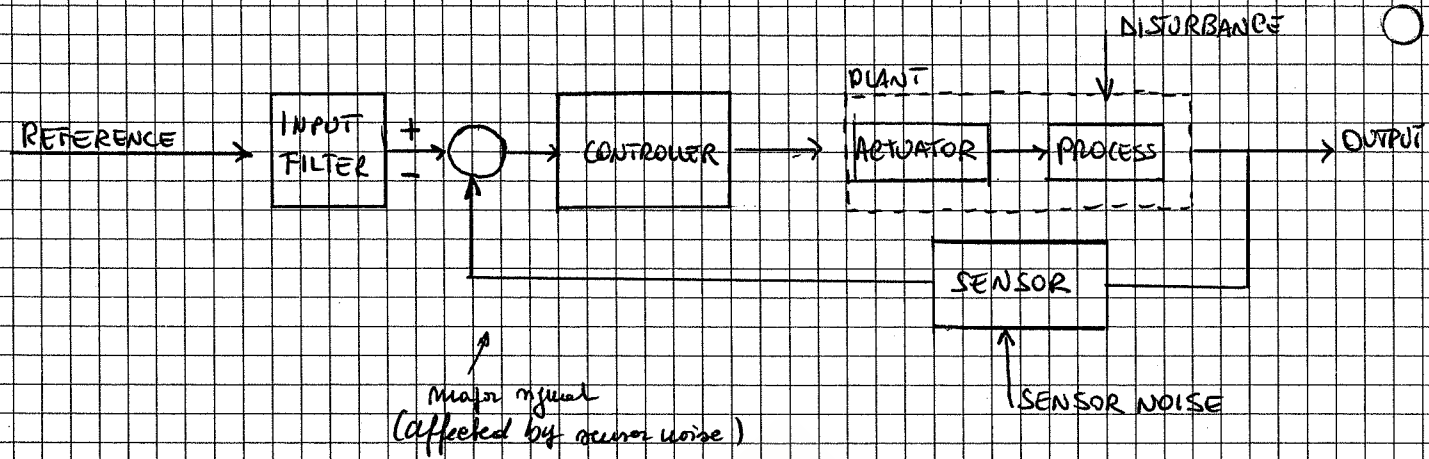
Feedback control has to ensure

- STABILITY of the closed loop systems dynamic. (bounded (BOUNDED) disturbances give bounded errors).
- DESIRED BEHAVIOUR (good capability of the system to reject any external errors, fast responsiveness to changes in operating point, etc...)

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BLOCK DIAGRAM OF A FEEDBACK CONTROL

Let us now look at a typical block diagram:



In this scheme there are 3 important signal: - the signal we want (reference)
- Disturbance (unwanted)
- Sensor noise (unwanted)

Disturbance → a signal that acts to the reference signal in terms of forces acting on aircraft, wind and so on.

CONTROL PROBLEM:

We can speak about different control problems:

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Considering: y = output
u = input
r = reference input
e = error

Two classical problems: THE REGULATOR PROBLEM
THE SERVO PROBLEM (or tracking problem)

- REGULATOR PROBLEM (manipolare l'input per neutralizzare l'effetto del disturbo): the control system is used to manipulate u (input) to NEUTRALIZE/counteract the effect of the disturbance d.
→ the control system has the task to minimize the disturbances.

- SERVO PROBLEM (manipolare l'input per mantenere l'output il più possibile all'input di riferimento (r)): the control system is designed in order to manipulate the input u to keep y close to a reference input r.
→ the output is "forced" to follow in the best way the reference signal.

IMPORTANT: in both cases:

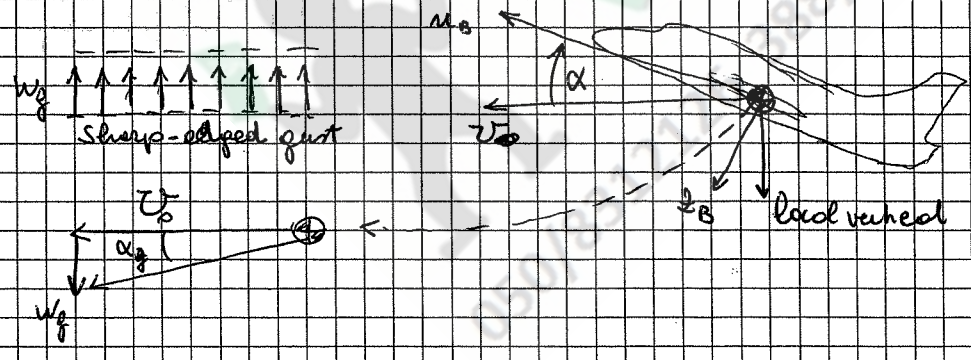
⚠ the control error must be small: $e \triangleq r - y$ (reference input, output)

↳ the algorithm to adjust the input is the controller K

PROBLEMS in DESIGN:

- design of control system → good job / low cost.
- the choice of the best configuration
- not only the theory should lead to good system designs, but also indicate when performance objectives CANNOT BE MET.
- the SYNTHESIS PROBLEM must be able to take into account many problems:
  - → uncertain plants (we don't have the perfect knowledge of our system)
  - → unmodeled dynamics produces uncertainty, usually at high frequencies
  - → sensor noise
  - → input signal level constraints (limit (in magnitude)) (very important)

SIMPLIFIED LONGITUDINAL DYNAMICS OF AN AIRCRAFT. Considering a simplified aircraft model for which only ROTATIONS are allowed, and the near-state equilibrium and a sharp-edged gust, we will have:



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According to this simplified model, when the aircraft encounters the sharp-edged gust, the angle of attack is varied:

$$\alpha_g \cong \frac{w_g}{v}, \qquad \alpha_g \ll 1$$

the equations that represent the equilibrium is: (QUASI STATIC EQUILIBRIUM)

$$M_\alpha (\alpha - \alpha_g) + M_\delta \delta = 0 \Rightarrow \left[\alpha = -\frac{M_\delta}{M_\alpha}\delta + \alpha_g \right]$$

where: α = angle of attack
δ = rotation of elevator
v_0 = aircraft velocity (w.r. to air)

M_α, M_δ moments di Cerniere