Computergestuurde Regeltechniek
exercise session 1

Analyzing a MIMO system

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In this exercise, you will analyze a linear Multi–Input Multi–Output (MIMO) system in state space form. To load the system into MATLAB, type (at the MATLAB prompt):

```
load fileN
```

where `fileN` is the name of the .mat-file you can find on the Toledo website. The system is described as :

$$\begin{aligned} x_{k+1} &= Ax_k + Bu_k, \\ y_k &= Cx_k + Du_k. \end{aligned}$$

Questions

1. System properties (course notes page 76 – 92) :
   a. What are the poles of the system?
   b. Is the system stable?
   c. What are the transmission zeros?

d. Take a transmission zero (if there exists one), preferably a real negative one, and determine the input and the initial state that will make the system output identically zero. You may want to verify that this initial state and input transmission zero indeed drives the output to zero.

e. Calculate the transfer function from input 1 to output 1.
What are the poles and zeros of this SISO subsystem? Do they correspond to the results you obtained from 1a and 1c?

2. Controllability-observability (course notes page 60 – 75) :

a. Is the system controllable? Check this in two different ways (controllability matrix rank test, PBH test).

b. Is the system observable ? Check this also in two ways.

c. Which modes are controllable[1]? Which modes are observable ? Is the system stabilisable? Is it detectable?

d. Remove all uncontrollable and unobservable modes and obtain a so–called minimal realization. Interpret the results.
Hint : Use MATLAB command **minreal**.

3. From transfer function to state space realization

a. Consider the system with transfer function $\frac{s+a}{s^2+7s+12}$. Convert the given transfer function into a state space realization. Do this by constructing 1) the control canonical form and 2) the observer canonical form.

b. Are there any values of a for which the previous systems become uncontrollable? Unobservable?

c. Can you conclude anything about observability/controllability based on the transfer function directly?

d. What happens with controllability/observability if you transform the system with a random nonsingular linear transformation? (see notes on page 63)

e. How do the previous results relate to the properties of transformation invariance of observability and controllability?

[1]If we ask for modes, just give the eigenvalues associated with these modes.