EXCERCISE CHEMICAL ENGINEERING I

Sequential Steering

Supervisor: Fredy Mettler
HCI D 182.5
fredy.mettler@chem.ethz.ch Tel 24527

1. Goal

The student should find out how

- An existing process to brew coffee should be analyzed (coffee machine) and the mass- energy- and information streams are to be identified.
- The desired process (brew coffee) is to be analyzed and characterize all the process steps, especially the steps for the control.
- To translate the analogue measurements data into reasonable input variables to define the control logic
- To identify the information which has to be saved
- To make a process diagram out of the defined control logics
- To program in Lab view the experiment

2. Theory

The formulation of the used theory for the process control is based on the systematic approach of the MENGENLEHRE and relations. For this experiment the most important definitions will be defined in the following.

2.1 How the system is defined

A control system is defined as:

Input variable: $u(t)$, or. $u(k)$
State variable: $x(t)$, or. $x(k)$
Output variable: $y(t)$, or. $y(k)$

2.1.1 Input variable (y)

An example out of our process should show you the performance of the input variable. The water level of the boiler is being updated in each sequence where the input variables are read. This information is primarily an electrical signal. This has to be converted into a digital number. By the means of an analog to digital converter the signal is converted into the desired number. The sequential steering should now work on with his number

2.1.2 Steering variable (u)

The actual steering works by the interference of the automat into the process where the values of the variables u in every time step of the steering is given by the function *g(x (k-1), y(k))*. In our example the binary switches of the controllable machines are: coffee bean mill, heater, valves.

2.1.3 State variable (x) of the steering

The state variable is implemented because of two concepts:

- Keeping the process sequence in order
- To model the not measurable states of the equipment.

Sequence: Many processes have a defined sequence of process steps. To fulfill the right sequence the steering has to know which step has been finished and which step will follow. This is usually kept by the variable x which consists of the step number. If there are several process steps which have to be repeated (E.g. filling a cup of coffee) this iteration variable can be used as a state variable.

The state variable of the steering consists of the plain information of that what happened in the past.

Modeling: To control a process it is essential to know all the equipment states which are used. Some of these states are given by the measurement variable y. Other variables thus are not accessible by the steering (e.g. the amount of the grinded coffee beans). This problem can be solved by implementing a model of the equipement. As an example the amount of grinded coffee beans is known by the equation:

$$m_K = r_M . \Delta t$$

where r_M is the amount of milled coffee which is milled in a certain time by the coffee mill. And so we take other implicit models for the steering such as the coffee. The quantities (Amount of coffee powder, temperature of the coffee, level of coffee in the bowl,...) are not measured but can be approximated by a model. The missing quantities can therefore be added by the model but only if there is the possibility to save the values in between the steps. This can be done by the state variable x.

The variable of state of the steering contains the important information for the modeling of the values which are not measurable.

3. Flow diagram

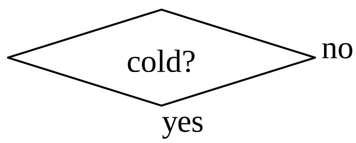
A flow diagram consists of these elements:

- Start,;
- End,

Our diagram should look like this:

- In the square there is a message e.g.:

- In a rhombus, there is the choice of two possibilities. (yes or no) such as:



- Arrows indicate the path.

A process is shown by a flow diagram. An example is shown in the attachment.

4. The setup

The setup is clear and can be easily realized. The final product which is coffee is drinkable.

4.1 Analogous measurements sizes

- Temperature Boiler
- Temperature Heater
- Level in the Boiler
- Weight on the balance

4.2 Digital Input (Switch)

- Home (Start position of the Filter, final sequence)
- Milling (Filter position below the mill)
- Brewing (Filter position under the boiler)
- Tilting (Filter will turned over, final sequence)
- Button "OK" on the main panel (Software)

4.3 Digital Output

- Water valve (fills the boiler)
- Heater for the boiler (min. 1100ml water)
- Heater of heating unit
- Milling (Mill on)
- Brewing (Valve empties the water in the boiler through the filter into the heating unit)
- Dosing (Valve empties the heating unit into a cup)
- Motor left (moves the filter)
- Motor right (moves the filter)

5. Experimental setup

The file PROZESS.VI is the basis for further programming. Each case has to be linked and every line needs it's own signal source. Therefore we conclude that all the outgoing lines from every case are occupied with signals. If all events have occurred a new variable will be sent over the line „varaible neu“ to the new case. It would be of advantage to write a short note to every task which has to be done.
Decisions can be made by compare blocks.
For time dependent functions a timer is provided.
Several variables can be loaded with values, increments and can be read again.

During the experiment the temperature of the heater is to be kept at 40 °C. This shortens the waiting time for the heating.
The milling should take 3 seconds during the test phase.

Even tough the security measurements make the process save all the procedures where certain processes have to be turned on or off are to be programed.

Values for the coffee:
Water: approx. 150 ml/cup milling: 40 seconds

Good luck and cheers!