UNIVERSITÄT ZU LÜBECK
INSTITUT FÜR TECHNISCHE INFORMATIK

Exercise Sheet 4

Process control by using parallel state charts

Lecture *Real-Time Systems*, Summer semester 2021

Dr. Javad Ghofrani

A discussion forum for the exercise can be found at: `moodle.uni-luebeck.de`.

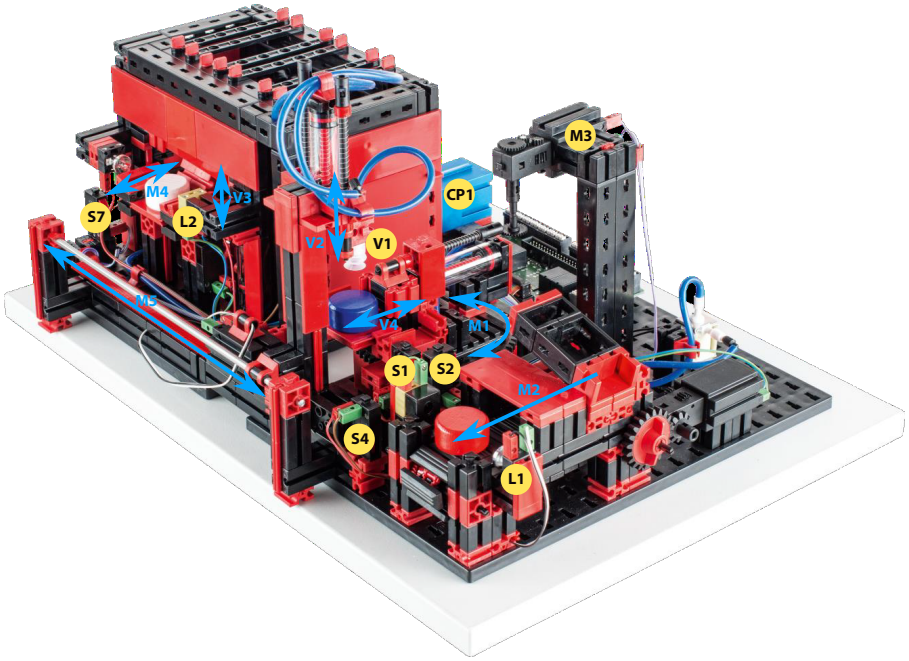

Figure 0.1: Multi processing station. Not all signals are shown. Check the simulation for missing signals.

In this exercise, we will use state charts in Matlab Simulink/Stateflow[1] to control the multi processing station 0.1, already known from exercise sheet 2.
The first step is to model the technical process as a simulation. Next, the control is modelled. The control is then simulated in combination with the model of the system. The corresponding software (MATLAB with Simulink and Stateflow) is installed on the VMs and can also be obtained free of charge from ITSC[2]. You will also need the SIMATIC target for Simulink and the SIMATIC ODK. They can be downloaded from Moodle. A short and a detailed introduction to Matlab Stateflow can be found in Moodle.

Use the Simulink template from Moodle to solve this exercise sheet.

[1] `https://www.mathworks.com/products/stateflow`
[2] `https://www.itsc.uni-luebeck.de/matlab`

The following signal tags are used to control the multi processing station:

	Tag	Type	True	False
Reference switches	S1 - S7	NO	triggered	untriggered
Light barriers	L1, L2	NC	uniterrupted	interrupted
Motors	M1 - M5	-	turning	stoped
Pneumatic valves	V1 - V4	-	opened	closed
Heater	LED1	-	on	off
Air compressor	CP1	-	on	off

The oven is the first substation. It has a tray, in which a workpiece can be placed. A light barrier detects a workpiece. The tray can be moved by a motor to the inside of the oven. To do this the oven door has to be opened with pneumatic pistons and an air compressor. Inside the oven is a LED, which emulates a heating element. Two reference switches tell weather the workpiece tray is fully retracted and therefore inside the oven or extended and thus in its homing position.

The gripper can trasport workpieces between the oven and the turntable. It has a pneumatic piston to lower the gripper onto the workpiece underneath it and a suction cup activated by a valve, to pick it up. The gripper is moved horizontally by a motor and also has two limit switches on both ends.

The turntable has a pneumatic piston attached to it for unloading and a saw at its 12 o'clock position. The turntable moves a workpiece unloaded onto it to the saw or the conveyor belt by turning. It has three position switches, one at which the turn table faces towards the gripper, one at the saw and one at the conveyor station. The saw can be activated to manipulate a workpiece underneath. When facing to the conveyor belt, a workpiece can be unloaded with the pneumatic piston.

The conveyor belt is located at the end of the multi processing station. It can move a workpiece towards the next part of the factory. It is equipped with a light barrier at its end, to know when a workpiece is leaving this station.

Exercise 1

Implement the simulation and control for the multi processing station. First download the template *RTS-Template-ex4.zip* from Moodle.

(a) Getting started with Simulink/Stateflow

Use the lecture notes and the Stateflow tutorial (*Chapter 5*) given in Moodle to familiarize yourself with creating statecharts with MATLAB. For specific questions, consult the linked Stateflow Users Guide and use our forum. See also the *Notes on the exercise sheet* in Moodle.

(b) Simulation of the technical process

The template contains three state charts, Simulation, Control and Visualisation. The simulation chart gets the motor and valve signals as inputs and returns the status of the sensors as outputs. The control chart gets the switch and light barrier signals as inputs implements the control of all stations.

The Visualisation is updated every 0.1 seconds and uses the output variables of the simulation as its input. Make sure that signals are set long enough for to be visualization to recognize them. You are not supposed to make any changes to the visualization

Implement a simulation of the system within this block. Model the system with parallel state charts for the oven, the gripper, the turntable and the conveyor. Choose appropriate timings in places where they are not predefined.

Use the variables p1, p2, p3, p4 and p5 to control motions inside the system. Each of these variables is expected to be in range of zero to one, whereby a 0 means the start of a motion and a 1 the end. p1 controls the movement of the ovens tray. p2 controls the movement of the gripper. p3 controls the rotation of the turntable and p4 the motion of the turntables piston. p5 is used for the motion on the conveyor belt and is given as an example in the template.

There are two input signals for the simulation that are used for putting tokens in and taking tokens out of the multi processing station (PutToken and TakeToken). These variables can be changed by clicking the switches in the main window of Simulink while the simulation is running. Setting one of the signals should put or take one token, to take or put another token the switches should be toggled a second time.

(c) Control

Open the Stateflow block *Control* in the given Simulink model. Implement the behaviour of the multi processing station in individual charts for each station.
The behaviour of the stations is the same as on exercise sheet 2. Use the light barriers as inputs for the control to know when a token is put into or taken out of the MPS. For example the light barrier L2 is interrupted while a token is put onto the ovens tray. As soon as the process of putting in a token is completed the light barrier is uninterrupted again.

Use variables as an synchronisation interface between stations. The stations must be able to work pipelined.

(d) Testing control and simulation

Test your control together with your simulation. Your controller should be able to fill all stations if the token is not removed from the conveyor at the end. After it is removed, all stations should continue their work.