NOVIA
UNIVERSITY OF APPLIED SCIENCES

Pre-task: Automation Technology

Master of Engineering, Automation Technology
Novia University of Applied Sciences, Vasa

Advance assignment: This pre-task is a part of the entrance examination for Master of Engineering in Automation Technology at Novia University of Applied Sciences in Vasa. The advance assignment should be submitted no later than 26 January 2022 at 15:00 Finnish time. The submission can also be used in the mandatory entrance examination interview.
Chose and complete **exactly two** of the three tasks below.

1. The sigmoid function is widely used in machine learning. One definition of the sigmoid function is

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

a) Give some concrete examples of different areas in artificial intelligence and machine learning that make use of the sigmoid function. Maximum length of answer is 500 words.

b) Usually, the sigmoid function includes a set of parameters, for example,

$$\sigma(x) = \frac{1}{1 + e^{-\omega x - b}}$$

Estimate the parameters ω and b from the plot in Fig 1. below. Include necessary calculation steps and explain your solution approach.

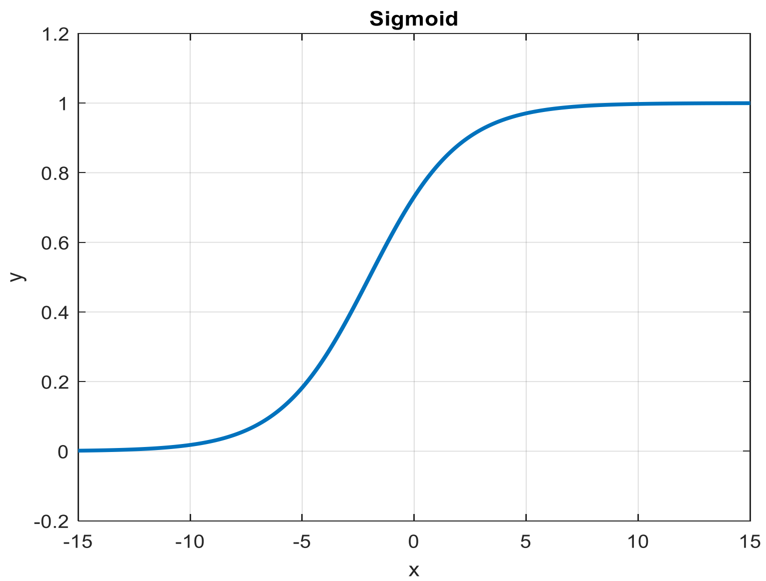

Figure 1. A sigmoid function.

2. You work as a quality engineer at a company that manufactures high quality hand-held tools, for example battery driven screwdrivers and drilling machines. The quality testing procedure is to be automated. One aspect of tool quality is the sound of the tool. It is known at the company that several defects can be identified by anomalies in the sound of the tool. Discuss how you could use machine learning techniques (unsupervised and/or supervised learning) to identify product defects based on sound. Maximum length of answer is 1000 words.

3. Fig. 2 illustrates the change in measured flow (y, red line) after a step change in the control signal to the pump (u, blue line). Such a step response can be used to extract information that can be used to determine the proportional gain P and integration time T_I in a PI-controller given by

(1) $$u(t) = P\left(e(t) + \frac{1}{T_I}\int e(t)dt\right)$$

where $e = u - y$ is the control error. One possibility to extract the information is to assume that the step response can be characterized by three parameters:

- the process gain K defined by the total change in y divided by the total change in u,
- the lag time (also known as the delay time) L defined by the time after the change in u before a change in y can be observed and
- the time constant T which can be defined as the time after the lag time until the change in y reaches 63 % of the total change in y.

For the illustrated step experiment, these parameters have been determined to $K = 1.7$, $L = 0.5$ seconds and $T = 1.5$ seconds.

a) Are these values reasonable given the step experiment illustrated in Fig. 2? Explain.

b) Use these values, or values that better reflect the actual experiment illustrated in Fig. 2, to choose the proportional gain P and the integration time T_I that will be used in a PI-controller given in the form Eq. (1) for controlling the process. Motivate your choice.

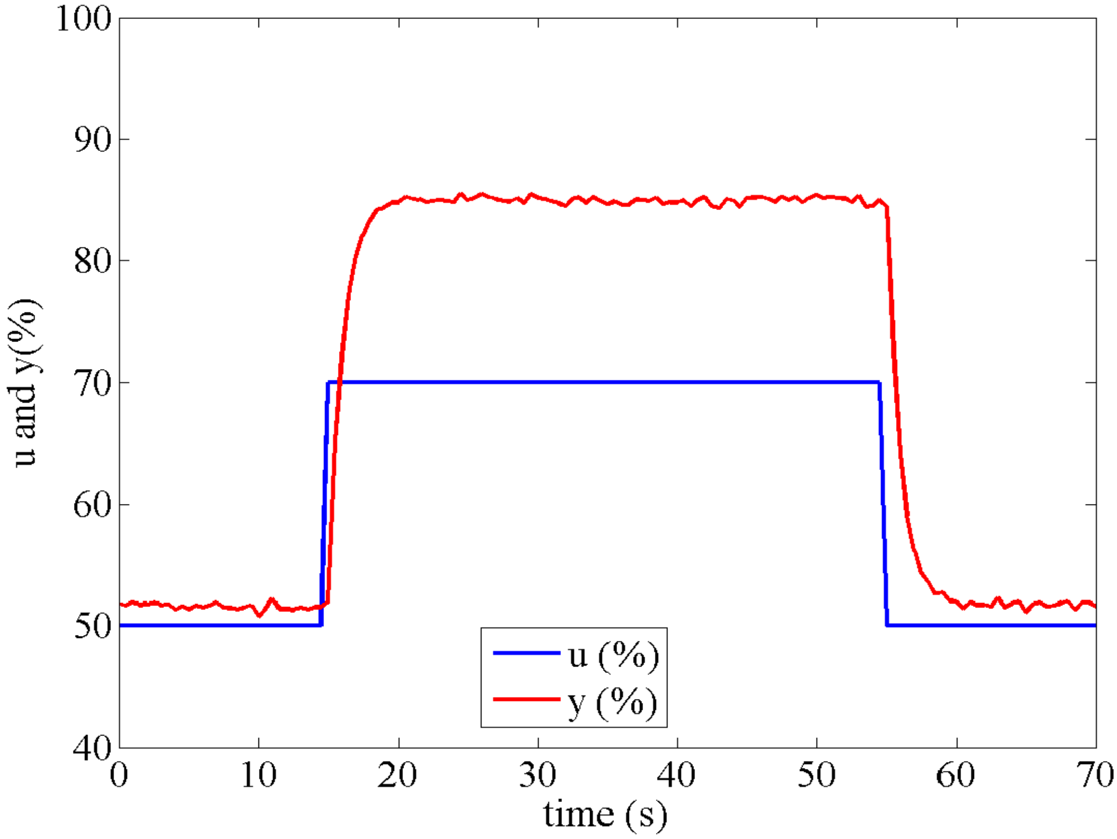

Figure 2: Flow y (red, in %) and control signal u (blue, in %) for a fluid flow system controlled by a pump.