Exercise Sheet 11
Intelligent Systems
January 27, 2020

Robustness & Autonomous Learning

Exercise 1 - Robustness Quantification I - State Space

A new wind tower was constructed in Kiel of height 30m. Two factors where considered as crucial for continuous monitoring to check the stability of the tower:

- Deflection (assume one axis is observed for simplicity)
- Wind blades vibration

At design time, the goal is to have deflection of $[0, \pm 5)$ cm and vibration of $[0, 2]$ Hz. No control mechanism is required in deflection range of ± 20 cm an vibration of 5 Hz, but the structure would fail if the deflection exceeds ± 120 cm or the vibration exceeds 20 Hz.

A. Plot the sate spaces (target-, acceptance-, survival-, and dead- state space) of the wind tower taking in to consideration both crucial attributes.

B. At first day of mounting the tower the (deflection, vibration) was (0 cm, 1 Hz), but on a windy day it was (± 60 cm, 8 Hz).
   - In which state space is the tower right now? Please plot in your state space.
   - Is any control mechanism required? If "Yes" explain please why.

Exercise 2 - Robustness Quantification II - Calculations

In the lecture you learned that: the main goal of "organic" control structures in technical systems is to achieve robustness. In this context, we have quantified robustness by maintaining a utility function (in terms of a given objective function that defines good and bad system behavior).

Figure 1 illustrates the reaction of the same system with three different control mechanisms (called A, B, and C) is exposed to the same situation. The utility function is defined in the interval $[0, 10]$. Take the following guidelines (we only consider integer values):

- Target space is reached at the utility achievement of mor than or equal 9.4.
- Acceptance space is defined in the range between 8.5 and 9.3 (inclusive).
- Dead space is defined as 2.0 (and below). Leaving the dead space requires manual intervention.

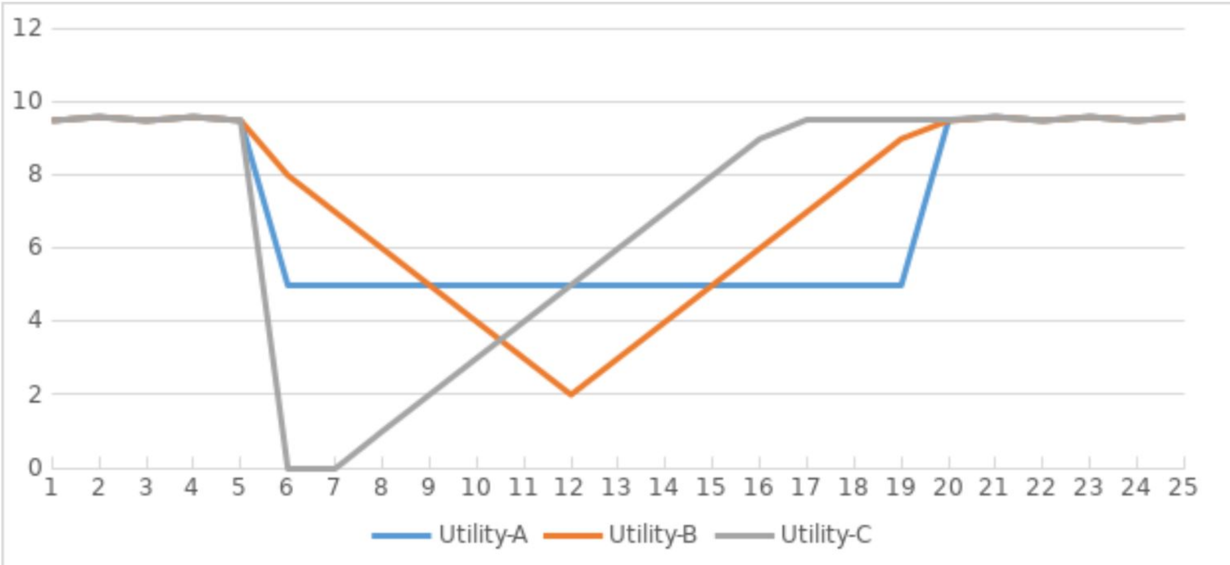

Figure 1: Example system with three different control mechanisms A, B, and C. Shown the result of system performance over time and through the three control mechanisms achieved utitlity.

A. Is this system robust? If "Yes", classify its robustness (i.e. weak-, "normal"- or strong- robustness) and explain your result.
B. Determine the degree of robustness for all three control mechanisms.
C. Determine the following values
   - ΔU for all three control mechanisms
   - t_δ
   - $u_{disturbed}$
   - $u_{passive}$ for all three control mechanisms
   - t_{drop} for all three control mechanisms
   - $t_{recovery}$ for all three control mechanisms

Exercise 3 - XCS - Population

As part of the lecture, you are currently dealing with the question of how organic computing systems can improve their behavior at runtime. In this context, you find a brief overview of the research field of the extended Classifier System (XCS) in the lecture slides of chapter *Learning*.

A. What is the population [P] of an XCS?
B. Does [P] at the end of an ordinary learning process consist solely of classifiers with high fitness and high prediction? Justify your answer reasonably.