Kiel University
Christian-Albrechts-Universität zu Kiel
Faculty of Engineering

Intelligent Systems

Excersice 10 – Robustness & Autonomous Learning

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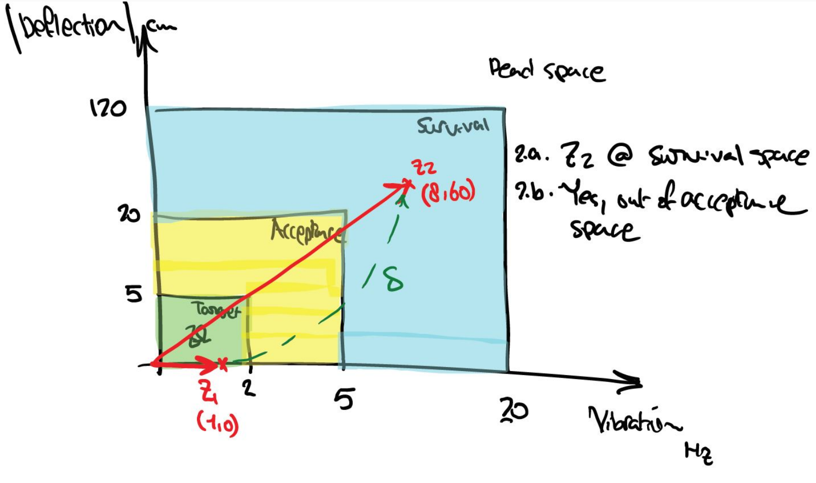
Robustness Quantification I - State Space

1. A

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 ($\pm$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.

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



1. B

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 ($\pm$60 cm, 8 Hz).

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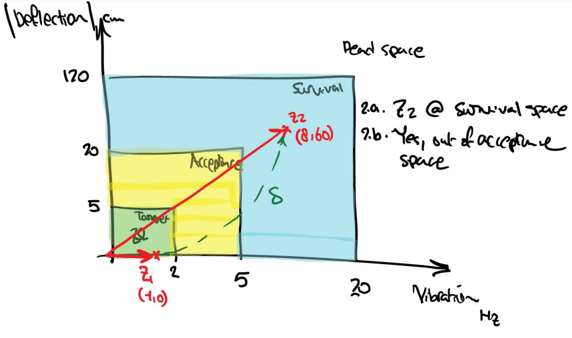
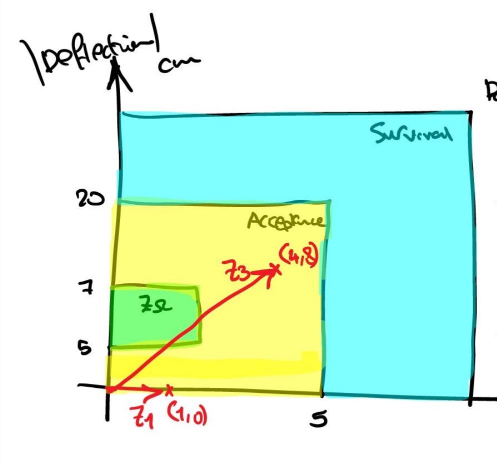


1. Changed conditions

After adding dampers to the tower, the deflection of the tower was to produce required utility electricity for the tower, and due to that the deflection goal changed to $[\pm 5, \pm 7)$; but the other conditions remained the same as the design conditions. **If the (deflection, vibration) after dampers mounting was (± 8 cm, ± 4 Hz). Is your system "flexible"? Is any for control mechanism required?**



1 B System is **Flexible** since after changing the target, the system managed to stay in the acceptance space.

Robustness Quantification II - Calculations

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

Is this system robust? If ”Yes“, classify its robustness (i.e. weak-, ”normal“- or strong- robustness) and explain your result.

- Utility A: Goes to the survival space, then back to target space $\rightarrow$ Weak robust
- Utility B: Goes to the survival space, then back to target space $\rightarrow$ Weak robust
- Utility C: Goes to the dead space $\rightarrow$ Not robust

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.
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- ΔU **for all three control mechanisms**
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- $u_{disturbed}$
- $u_{passive}$ **for all three control mechanisms**
- t_{drop} **for all three control mechanisms**
- $t_{recovery}$ **for all three control mechanisms**

Determine the following values:

- ΔU

Utility A	Utility B	Utility C
$8.5 - 5 = 3.5$	$8.5 - 2 = 6.5$	$8.5 - 0 = 8.5$

- t_δ

Utility A	Utility B	Utility C
5.5	5.5	5.5

- $u_{distrubed}$
  It's the lowest U value of all the CM's, since all represent the same system with the same environment and exposed to same disturbance = 0

2. C Robustness Values (2)

Determine the following values:

- $u_{passive} = u_{min} - u_{disturbed}$

Utility A	Utility B	Utility C
$5 - 0 = 5$	$2 - 0 = 2$	$0 - 0 = 0$

- $t_{drop} = t_{min} - t_{\delta}$

Utility A	Utility B	Utility C
$6.3 - 5.5 = 0.8$	$12 - 5.5 = 6.5$	$6 - 5.5 = 0.5$

- $t_{recovery}$
  Time required for the CM to get the system back from the first t_{min} to the acceptance space

Utility A	Utility B	Utility C
$20 - 6.3 = 13.7$	$18 - 12 = 6$	$15 - 6 = 9$

A. Is this system robust? If ”Yes“, classify its robustness (i.e. weak-, ”normal“- or strong- robustness) and explain your result.

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- ΔU for all three control mechanisms
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Determine the degree of robustness for all three control mechanisms.

Approximate the utility degradation:

$DU \approx \Delta U \cdot \frac{t_{rec}}{2}$

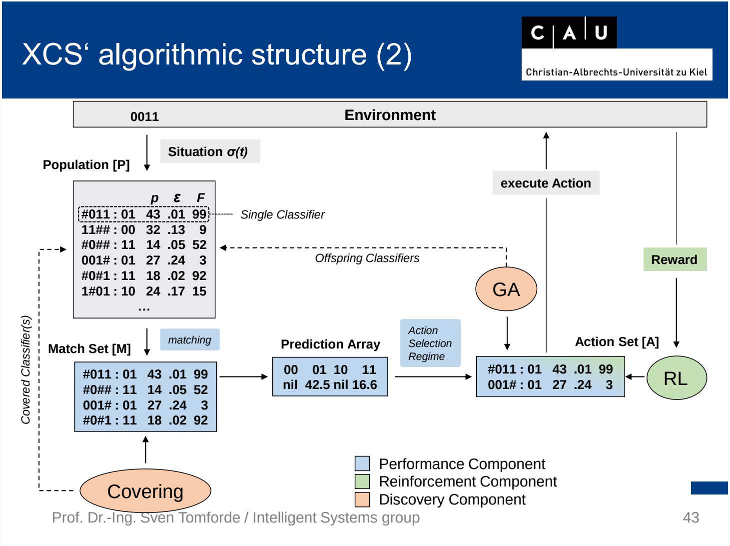
Measure	Utility A	Utility B	Utility C
Utility degradation $Du = \Delta \cdot \frac{t_{rec}}{2}$	24.5	19.5	38.25
Recovery speed $s_{active} = \frac{\Delta u}{t_{rec}}$	0.25	1.08334	0.9445

XCS - Population

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.

What is the population [P] of an XCS?

→ The set of all classifiers



3. B

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.

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

- No. On the one hand, not all ”bad“ classifiers are completely displaced.
- On the other hand, it is impossible to achieve good values in individual niches. Here, the prediction tends to be low (since no better value is to be achieved) and the fitness high (because the forecast of the prediction is precise).

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

- In other words: XCS bases its fitness and thus the selection operator of the GA on the accuracy of the reward-forecast (predictions). For this reason, high-fitness classifiers often get the chance to be re-produced. A classifier that has high fitness but forecasts a low prediction for a proposed action is still accurate! Thus, typically classifiers with low forecastreward (prediction) will also be included in the population but with a high level of fitness. XCS tries to learn a complete action map $X \times A \rightarrow P$.