TECHNISCHE UNIVERSITÄT MÜNCHEN
LEHRSTUHL FÜR STEUERUNGS- UND REGELUNGSTECHNIK
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F O R S C H U N G S P R A X I S

Development of a Nonlinear Observer for a Crop Model

Problem description:

With the ever-increasing global population, and the effects of climate change, the question of how cities can be used for local cultivation, urban gardening, and vertical farms is becoming increasingly important. Vertical farms in particular are a promising approach to address these issues but they bring several problems, the most important of which is energy consumption [1]. For this reason, optimal control of crops to minimize energy costs and maximize yield in a closed environment is beneficial.
For this purpose the crop growth is modeled by the SIMPLE model [2]. It is a nonlinear discrete-time state-space model of a plant, where the states are the current biomass, the cumulative temperature and the leaf senescence. All of this states are difficult to measure, therefore a method is sought to simplify the measurement.
From pictures of the crop, the biomass could be estimated with machine learning. However, the cumulative temperature and the senescence of the leaves are still unknown. If the system is observable, the unknown states can be estimated [3]. The goal of this project is to find an observer to estimate the unknown states.

Requirements:

- Knowledge in nonlinear control
- Interested in mathematical methods

Work schedule:

- 1st - 2nd week: Get familiar with the SIMPLE model and simulate the crop growth
- 3rd - 4th week: Analyze the observability of the SIMPLE model (local or global)
- 5th - 6th week: Design a nonlinear observer (e.g. Nonlinear Observer, Extended Kalman Filter)
- 7th week: Simulate the observer and validate the performance
- 8th - 9th week: Write the report and make the end presentation

Bibliography:

[1] S. Asseng, J. R. Guarin, M. Raman, O. Monje, G. Kiss, D. D. Despommier, F. M. Meggers, and P. P. Gauthier, "Wheat yield potential in controlled-environment vertical farms," *Proceedings of the National Academy of Sciences*, vol. 117, no. 32, pp. 19131–19135, 2020.
[2] C. Zhao, B. Liu, L. Xiao, G. Hoogenboom, K. J. Boote, B. T. Kassie, W. Pavan, V. Shelia, K. S. Kim, I. M. Hernandez-Ochoa, *et al.*, "A SIMPLE crop model," *European Journal of Agronomy*, vol. 104, pp. 97–106, 2019.
[3] A. Isidori, *Lectures in feedback design for multivariable systems*. Springer, 2017.

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