Thesis or project on neural network-based predictive control

- Error-bounds and stability analysis for neural-network-based controllers -

Job description

Neural networks (NN) are very popular in many fields due to their ability to approximate a large class of functions with arbitrary accuracy. Most often NN are used for classification, e.g. recognition of specific objects on images or for function approximation. The latter application is also interesting for control tasks, since NN can be used to approximate the controller $\boldsymbol{u}(\boldsymbol{x})$. The problem is that in most cases it is not clear how to choose the topology of the NN , i.e., number of layers, neurons per layer and activation (see Fig. 1) to get a low approximation error. However, recent research has shown that NN with ReLU or maxout activation can represent controllers with a piecewise affine (PWA) input-output relation exactly [1]. One popular control scheme of this type is classical model predictive control (MPC). In fact, it is well-known from explicit MPC that the resulting control law is PWA (see Fig. 2). Thus, it is possible to compute NN that exactly emulate MPC. The aim of this project is to implement a recently presented algorithm [2] to compute the worst-case-error between an NN approximation of the control law and the actual MPC. Subsequently, it should be verified taht the algorithm applied to an NN, which exactly represents the control law, results in a worst-case-error of zero.

Your profile

Ideally but not necessary you already have some knowledge of

- model predictive control
- neural networks
- basic knowledge of linear algebra
- Matlab

Interested?

If this project has aroused your interest or you have further questions about the topic, please do not hesitate to contact us via dieter.teichrib@tu.dortmund.de.

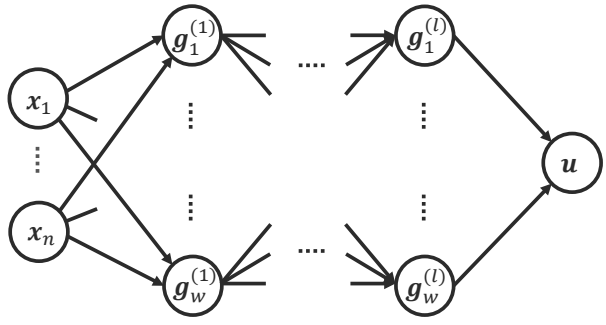

Figure 1: Structure of a standard NN with activation $\boldsymbol{g}$ and w neurons in each of the l layers.

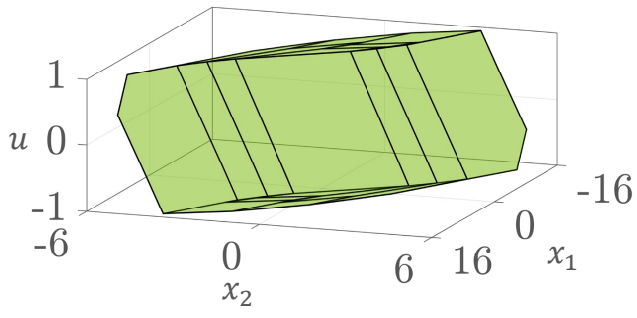

Figure 2: 2-D piecewise affine control law of an explicit MPC.

References

[1] R. Arora, A. Basu, P. Mianjy, and A. Mukherjee, "Understanding deep neural networks with rectified linear units," arXiv:1611.01491v6 [cs.LG], 2018.

[2] F. Fabiani and P. J. Goulart, "Reliably-stabilizing piecewise-affine neural network controllers," arXiv:2111.07183v3 [eess.SY], 2022.