PhD Project

Neural network-based model predictive control

In practice, sometimes modeling is complex and or for other reasons should be avoided. As a consequence the internal structure or mathematical relationship between inputs and outputs of a nonlinear system is hard to be achieved. Under this condition, neural networks have been applied very successfully in the identification and control of nonlinear dynamic systems. The universal approximation and prediction capabilities of the multilayer perceptron have made them useful for representing nonlinear models or controllers. In theory, any systems can be approximated by a multilayer neural network, which is generally sufficient with one hidden layer and one output layer.

The purpose of this thesis is to control multi-input-multi-output (MIMO) nonlinear systems using a neural network-based model predictive control, which is based on neural networks ability of prediction. With the predictive capability, the controlled input for the next step will be chosen by an optimization algorithm and sent to system plant.

In cooperation with other coworkers and experiments a class of suitable approaches should be developed, discussed, applied and generalized. Using simulated and experimental examples a new kind of adaptive MPC approaches will be developed.

Within this PhD topic, the student should be able to realize new approaches in this field, to extend them, to develop new ones, to extend the Chairs competence in model predictive control, neural network identification, deep learning, and control of MIMO nonlinear systems using neural network-based model predictive control. Experiments using the existing MIMO nonlinear test rigs and related simulated systems have to show both the functionality and the robustness of the new approaches.

The next intended research development steps concentrate on

- Identification and control of MIMO nonlinear systems using neural network approaches
- Neural network-based model predictive control

Beside the development of method(s) we validate our approaches using our own test equipment. For this research several DSP-equipped test rigs are available: inverse elastic pendulum, elastic crane, fully sensored 3TS, fully sensored Hardware-in-the-Loop hydraulic cylinder for force and position control.

Therefore we need students from the automation and control field and/or mathematics with clear engineering-oriented background with
i) strong theoretical background in automation and control,
ii) strong programming skills, and
iii) shown expertise in control and control applications.
If two of the three requirements are fulfilled, feel free to apply.

From the new candidate, we expect that s/he is willing to become very fast an important and valuable member of our Chair.

Therefore we expect

i) a shown and strong expertise in related scientific fields to be integrated,

ii) your ability and commitment to develop and validate NEW methods and approaches, and

iii) your willingness and commitment to write scientific contributions on a world class level.

Depending on the candidate's background this can be related to approaches defined by the following keyword set (Nonlinear control, robust control, model predictive control, neural network identification, …).

In case of interest please provide beside the usual application material (CV, grades, ...) material stating that you have strong English language skills (TOEFL IBT better than 95, IETLS better than 6.5) and a detailed and described interest ONLY in the described research fields. Your German language skills can be (if necessary) improved by language courses in parallel (for example at the Goethe Institute, Düsseldorf) (on your cost). For further information about the requirements see also the website of the Chair SRS: www.uni-due.de/srs/prospective.

About you:

Bachelor and Master degree in Electrical or Mechanical Engineering or Information science or Mathematics or Automation/Control (with strong interests in programming) (with clear related specification) necessary, deep interest in the field, excellent grades in related courses. Related and/or diverse qualifications can possibly also be very attractive.

About us:

Chair SRS (Head: Prof. Söffker) at U DuE, Germany:

With a mix of coworkers and PhD students the Chair has a strong and long tradition in supervising academic trainees. The internal organization scheme will allow an improved organization of the academic work of the PhD students in guided groups. Academic qualification includes not only the PhD topic related work but also advising coworking students (Bachelor/Master level) based on individual qualification and skills etc.

The PhD students working in the group are financed by the university or by public funding, financed by industry projects, by their home countries or by DAAD scholarships.

Be aware about the time schedule of your DAAD-application:

An application now or in September/October year 1 leads to the beginning of german language courses in May/June year 2 and start PhD research at the Chair SRS in October year 2.

In case of other application (government programs, national/university training programs):
You should be supported for more than 3,5 years. In case of support for less than 3,5 years, you should convince us based on existing international publications from the last five years.

The successful candidate is primarily directly related to:

Prof. Söffker (Scientific supervisor: Prof. Söffker)

Next steps:

1. Be aware of your national DAAD application deadline (which varies between February and November each year).

2. Contact Prof. Söffker directly by E-Mail (soeffker@uni-due.de, subject: DAAD-Appl. VBMPC) and send copy of CV, certificates, recommendation letters as well as a first proposal (2-3 pages) about your understanding of the intended topic, your intended working schedule, the state of the art in this field as well as the deduced definition of your project. A 'copy and paste'-strategy will disqualify you immediately.

3. 3. Be aware about the time schedule of your application: DAAD example application in September/October year 1 leads to begin language courses in May/June year 2 and start PhD research in October year 2.

4. 4. Joint improvement of the proposal: If the quality of the project proposal is finally fitting to the groups standard (=perfect) Prof. Söffker will invite you by writing the required acceptance letter.

5. 5. The final decision is with the DAAD committees.

Chair of
Dynamics and Control UNIVERSITÄT DUISBURG ESSEN www.srs.uni-due.de