Reviewers Comments

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Reviewer: Ing. Peter Mark Beneš

Diploma Work: Neural Network Methods for Nonlinear Dynamical Systems with Sinusoidal Nonlinearity

Review:

The topic of this students diploma work covers an underlying challenge of HONU architectures in identification of more complex nonlinear process characteristics such as sinusoidal nonlinearities. The scientific contribution and originality of this work is strong as it is a quite novel extension to the conventional HONU architectures which have been quite readily published in the scope of adaptive identification. A strong point of the students work is the connotation to practical mechanical systems as well as a real industrial application of a robotic arm, which is a field receiving quite increased growth in the automation industry.

Given the originality and contribution regarding the extension of complex valued (CV) and exponential complex valued (ECV) HONUs, several remarks are to be noted regarding quality of this diploma work. In the section 2, a closer review of current approaches to complex valued neural networks could have been provided, as well as comment to other polynomial based complex valued neural network methods, including some brief critical study on the drawbacks and advantages in relation to the HONU based architecture. The graphical results shown in certain plots (e.g on page 25) do not label all axes and the font appears to be quite small making it tough for the reader to comprehend. In Figure 9 a subplot could have been included to show a zoomed in detail of the difference in HONU performance with the GD and ADAM learning approaches.

The review of various learning algorithms was covered quite well in this diploma work, however the student may have added a table of sum of square error (SSE) values to Figures 21-22 to emphasis the improved performance behind the CG based HONU. Also in most figures, the parameters used for each HONU could have been stated, along with the respective learning rates and sampling. This would allow further students or researchers to better understand the described architectures and allow for reproducing the results. In section 5.3 the CV-HONU is presented with application to an electrical impedance circuit. A comparison with the ECV-HONU could have been included to see the capabilities and difference of the ECV enhancement. In section 5.6 the Table 1 mentions ECV in the table description, however the caption state CV-HONU which is confusing for the reader. Also again an additional subplot to see closer detail of the performance compared to the conventional form of a static HONU would be better. A great addition to this diploma work was the implementation of a toolbox in python for using the derived architectures and various learning algorithms. A further component I feel the chapter 6 lacks is a snip-it or code extract to example use of the proposed classes and functions, a brief example may have been added as an appendix section in this diploma work.

A key system referenced in this thesis regards the identification of a torsional pendulum of varying amplitudes, although the performance of the students ECV-HONU was not significantly better than the compared conventional HONU, a good foundation was paved in enhancing the nonlinear identification capabilities of HONU via two novel approaches (CV-HONU and ECV-HONU). With this said, given the complexity of the topic and time for research and investigation of an enhancement to HONU architectures for identification of more complex nonlinearities, I feel the student has provided a very good diploma thesis. It is also encouraging that this work should be further investigated given continuation of the PhD study program. I therefore recommend the grade B (Very Good), provided that the student can answer the below listed questions.

Recommend Grade:

B (Very Good)

Reviewers Questions:

1) The literature review in this thesis did not cover a description of other complex-valued based neural network algorithms. Can you briefly describe one or two other similar approaches in the field? What potential advantages can the proposed ECV-HONU have in comparison?

2) A draw back with the ECV was its conversion of a HONU from a linear parameter based architecture to a nonlinear one. Can you suggest some method (maybe even hardware/software based) to improve its computational efficiency? Maybe parameter extraction techniques could be extended (e.g. principal component analysis PCA)?

3) The presented torsional pendulum problem remains to be a challenge for conventional HONU architectures in terms of their nonlinear identification capabilities, particularly at higher input amplitude values where more heuristic approaches like adaptive dynamic programming (ADP) can be rather advantageous. Did you compare the performance of CV-HONUs and ECV-HONUs for higher inputs amplitudes? If the performance is not sufficient, can you suggest the future directions how the problem could be investigated further?

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