Topic ID: 246-IT-EN-03

Soft-computing Methods for Solving Complex Differential Equations

Supervisor: doc. Ing. Libor Pekař, Ph.D.

Consultant: ---

Department: Department of Automation and Control Engineering

Programme: Information Technologies

Abstract:

There exist many complex differential equations that have attracted considerable attention from researchers due to their historical significance and immense applications across many fields of human activity, e.g., in heating-cooling loops, population dynamics, communication systems, economic methods, propagation, and transport systems.

Some of them have been solved, despite the fact that their analytic solutions are onerous. However, some others are still solved by known methods. For both categories, it is reasonable to propose a numerical solution that is sufficiently accurate and sufficient for practical reasons. One possibility is to define a fitness function based on the errors in the differential equation and the initial conditions, which are then further minimized using advanced soft-computing methods (possibly adopting artificial-intelligence techniques).

The work should focus on equations that model the delay effect or the non-simultaneous action of multiple physical quantities (especially delay-differential equations of retarded and neutral types and delay partial differential equations), which are based on physical laws describing the given process or are introduced artificially to capture the complex dynamics of the system faithfully.

Literature:

[1] LIU, Gang; FENG, Weiming; YANG, Kun and ZHAO, Junfeng. Hybrid QPSO and SQP algorithm with homotopy method for optimal control of rapid cooperative rendezvous. Journal of Aerospace Engineering. 2019, vol. 32, no. 4. ISSN 0893-1321. DOI: 10.1061/(asce)as.1943-5525.0001021.

[2] OMABA, McSylvester Ejighikeme. New analytical method of solution to a nonlinear singular fractional Lane–Emden type equation. AIMS Mathematics. 2022, vol. 7, no. 10, pp. 19539-19552. ISSN 2473-6988. DOI: 10.3934/math.20221072.

[3] RAJA, Muhammad Asif Zahoor; MEHMOOD, Jabran; SABIR, Zulqurnain; NASAB, A. Kazemi and MANZAR, Muhammad Anwaar. Numerical solution of doubly singular nonlinear systems using neural networks-based integrated intelligent computing. Neural Computing and Applications. 2017, vol. 31, no. 3, pp. 793-812. ISSN 0941-0643. DOI: 10.1007/s00521-017-3110-9.

[4] SABIR, Zulqurnain; AMIN, Fazli; POHL, Daniel and JUAN L. G. GUIRAO. Intelligence computing approach for solving second order system of Emden–Fowler model. Journal of Intelligent & Fuzzy Systems. 2020, vol. 38, no. 6, pp. 7391-7406. ISSN 1064-1246. DOI: 10.3233/jifs-179813.

[5] SABIR, Zulqurnain; SAID, Salem Ben; AL-MDALLAL, Qasem and ALI, Mohamed R. A neuro swarm procedure to solve the novel second order perturbed delay Lane-Emden model arising in astrophysics. Scientific Reports. 2022, vol. 12, no. 1, art. no. 22607. ISSN 2045-2322. DOI: 10.1038/s41598-022-26566-4.

[6] UMAR, Muhammad; SABIR, Zulqurnain and MUHAMMAD ASIF ZAHOOR RAJA. Intelligent computing for numerical treatment of nonlinear prey–predator models. Applied Soft Computing. 2019, vol. 80, pp. 506-524. ISSN 1568-4946. DOI: 10.1016/j.asoc.2019.04.022.

[7] BACHLER, Simon. On Modeling and Control Design for Large Cooling Loops. Dissertation. Hall in Tirol: UMIT TIROL, 2022.

[8] WURM, Jens; BACHLER, Simon and WOITTENNEK, Frank. On delay partial differential and delay differential thermal models for variable pipe flow. International Journal of Heat and Mass Transfer. 2020, vol. 152, art. no. 119403. ISSN 0017-9310. DOI: 10.1016/j.ijheatmasstransfer.2020.119403.

[9] BACHLER, Simon; WURM, Jens and WOITTENNEK, Frank. Open-loop temperature control for a distributed parameter model of a pipe. IFAC-PapersOnLine. 2020, vol. 53, no. 2, pp. 7765-7770. ISSN 2405-8963. DOI: 10.1016/j.ifacol.2020.12.1540.

[10] TAHERI, Tayebeh; ALIREZA AFZAL AGHAEI and PARAND, Kourosh. Bridging machine learning and weighted residual methods for delay differential equations of fractional order. Applied Soft Computing. 2023, vol. 149, art. no. 110936. ISSN 1568-4946. DOI: 10.1016/j.asoc.2023.110936.

[11] UMAR, Muhammad; AMIN, Fazli; AL-MDALLAL, Qasem and ALI, Mohamed R. A stochastic computing procedure to solve the dynamics of prevention in HIV system. Biomedical Signal Processing and Control. 2022, vol. 78, art. no. 103888. ISSN 1746-8094. DOI: 10.1016/j.bspc.2022.103888.

[12] SABIR, Zulqurnain; RAJA, Muhammad Asif Zahoor; ALI, Mohamed R. and SADAT, R. An advance computational intelligent approach to solve the third kind of nonlinear pantograph Lane–Emden differential system. Evolving Systems. 2022, vol. 14, no. 3, pp. 393-412. ISSN 1868-6478. DOI: 10.1007/s12530-022-09469-7.