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Regularized error function-based extended Kalman filter for estimating the cancer chemotherapy dosage: impact of improved grey wolf optimization

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Abstract

Objectives: The main aim of this work is to introduce a robust controller for controlling the drug dosage.
Methods: The presented work establishes a novel robust controller that controls the drug dosage and it also carried out parameters estimation. Along with this, a Regularized Error Function-based EKF (REF-EKF) is introduced for estimating the tumor cells that could be adapted for different conditions. It also assists in solving the overfitting problems, which occur during the drug dosage estimation. Moreover, the performance of the adopted controller is compared over other conventional schemes, and the attained outcomes reveal the appropriate impact of drug dosage injection on immune, normal, and tumor cells. It is also ensured that the presented controller does a robust performance on the parameter uncertainties. Moreover, to enhance the performance of the proposed system and for fast convergence, it is aimed to fine-tune the initial state of EKF optimally using a new Improved Gray Wolf Optimization (GWO) termed as Adaptive GWO (AGWO). Finally, analysis is held to validate the betterment of the presented model.
Results: The outcomes, the proposed method has accomplished a minimal value of error with an increase in time, when evaluated over the compared models.
Conclusions: Thus, the improvement of the proposed REF-EKF-AGWO model is proved from the attained results.

Keywords: adaptive GWO; chemotherapy; drug dosage; error function; immune; normal cells.

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Introduction

Cancer is a major reason that leads to a more fatality rate of humans in the world. There are numerous methods to diagnose cancer, like immunotherapy, chemotherapy, radiotherapy, hormone therapy, and surgery [1–3]. Among them, cancer chemotherapy handles the diagnosis of cancer by exploiting drugs, which kills the cancer cells; whereas drugs are controlled through orally or by veins [4, 5]. To sustain a precise drug dosage level in the body, drugs should be distributed based on a regularized schedule. On the other hand, such a process of drug delivery has the undesirable side impact that typical healthy cells might also be destroyed [6–9]. To prevail over this issue, different control approaches were widely exploited. These approaches led to the effectual killing of cancerous cells at the same time, the negative characteristics of drugs on healthier cells are reduced [10, 11].

Till now, there are numerous diverse classes of anticancer drugs developed depending on their action, and they comprise the following: “a) alkylation agents which damage DNA; b) antimetabolites that replace the normal building blocks of RNA and DNA; c) antibiotics that interfere with the enzymes involved in DNA replication; d) topoisomerase inhibitors that inhibit either topoisomerase I or II, which are the enzymes involved in unwinding DNA during replication and transcription; e) mitotic inhibitors that inhibit mitosis and cell division and f) corticosteroids”, which were exploited for the cancer treatment and to reduce the negative consequences from other drugs [12, 13].

Despite the current advancements in anticancer management and the assurance of new targeted therapies, it is expected that “cytotoxic chemotherapy” will be continued in use for the few upcoming decades [14, 15]. It is now identified that the conventional methods of dose estimation for chemotherapy using the BSA model is imprecise [16, 17]. Moreover, these techniques do not consider the marked interpatient difference in handling drugs and therefore the toxicity of drugs is also very much inconsistent and unpredictable [18–20].

– Introduces a robust controller for controlling the drug dosage and also, parameter estimation is performed.