Artificial Intelligence In Medicine 119 (2021) 102152

Contents lists available at ScienceDirect

Artificial Intelligence In Medicine

journal homepage: www.elsevier.com/locate/artmed

Optimization assisted Kalman filter for cancer chemotherapy dosage estimation

Utkarsha L. Mohite *, Hirenkumar G. Patel

Sardar Vallabhbhai National Institute of Technology, Surat, India

ARTICLE INFO

Keywords:
Chemotherapy
Drug usage
Kernal
Kalman filter
Regularized Error Function
MF-PSU.

ABSTRACT

Cancer is regarded to be the earth's most deadly disease, with one of the highest mortality rates among people. "Surgery, radiotherapy, chemotherapy, hormone therapy, and immunotherapy" were all options for treat cancer. Chemotherapy is a medication that is most often deployed for treating cancer, as cancer cells develop and proliferate faster than other cells in the body. Even though chemotherapy is an effective method to treatment various kinds of cancers, the treatment includes risk as it causes side effects due to improper drug usage. The application of a controller-based strategy for determining the optimal rate of drug injection during treatment has risen dramatically in recent years. Thereby, this work develops a robust controller for controlling the dosage of drugs that is carried out under parameter estimation. In addition, a Modified Regularized Error Function-based Extended Kalman filter (MREF-EKF) is introduced for estimating the tumor cells and it can be exploited for diverse conditions. Moreover, the overfitting issue that occurs during drug dosage estimation is also solved using this approach. Further, to improve the performance of the developed approach, the initial state of EKF is fine-tuned via Mean fitness-based Particle Swarm Update (MF-PSU), which is the enhanced version of Particle Swarm Optimization (PSO). At last, the supremacy of the presented approach is proved with respect to convergence analysis and error analysis. For instance, our method outperforms existing GWO + $e_k + m$, AGWO + $e_k + m$, and PSO + $e_k + m$ approaches in convergence analysis at noise level 0.41 by 0.009%, 0.002%, and 4.9% respectively. In error analysis, the error values for tumor cells have reached a minimum error value of zero for all noise levels (0.41, 0.43, and 0.55). The findings of this study can help for a better understanding of our presented robust controller's effectiveness in controlling the dosage of drugs.

1. Introduction

Chronic diseases such as cancer [59], asthma [34], cystic fibrosis [36], respiratory difficulties [58], and are ruined and ended prematurely the lives of far too many individuals around the world. The rate of cell death and cell division should be balanced in a healthier body. A genetic factor could disturb this course of action, which is termed as cancer. The rising risk of cancers has encouraged speedy advancements in diagnosis technologies that include surgery, immunotherapy, chemotherapy, radiotherapy, and their amalgamations. One of the most effective techniques to treat cancer is by injecting chemotherapy drugs [9–11].

Chemotherapy is a diagnosis method that slows or stops the growth of cancer by destroying cancer cells. Usually, chemotherapy is given to the patient in cycles, that is; the drugs were infused into the body at predestined intervals after diagnosing cancer [12,13]. These drugs should be scheduled properly for ensuring an effective diagnosis at the right time [14,15]. Accordingly, certain scheduling standards were followed for selecting the time /dose/therapy, which is generally based on the type of tumor, body weight of the patient, level of white blood cells, and some other factors. However, various limitations were encountered by clinical and scientific communities in determining the drug dosage, which motivates the use of arithmetical solutions for determining the optimal drug dosage control for chemotherapy [16–18].

The general diagram of chemotherapy drug dosage estimation is shown in Fig. 1. Basically, estimation/ prediction is performed in pre-processing, feature extraction, feature selection, and prediction stages. Lately, the methods have been developed due to the effect the technology enhancement. Some of the existing methods in the field have been discussed as below: Early, some models like log-kill [46], E_{max} [47], and Norton-Simon hypothesis [48] are relatively simple and use a first-order ordinary differential equation to describe the development rate of cancer cells and their eradication by chemotherapy. These models, on the other hand, evolved through time and began to

* Corresponding author.
E-mail addresses: utkarshamohite@gmail.com (U.L. Mohite), hpatel.svnit@gmail.com (H.G. Patel).

https://doi.org/10.1016/j.artmed.2021.102152
Received 23 January 2021; Received in revised form 22 July 2021; Accepted 16 August 2021
Available online 20 August 2021