A Critical Assessment on Use of Particle Swarm Optimization Techniques in Various Types of Cancer Treatments

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Abstract

Cells are the smallest unit of life and are considered to be as the building blocks of life. Our body is consists of number of cells that grow and divide to form new cells and eventually die. But in the case of cancer, the cell grows uncontrollably and spread to the other parts of the body as well, and forms a growth called tumor. Though it is not possible to cure cancer completely but there are various treatments like chemotherapy, surgery, radiation therapy , target therapy and various others, that can lead cancer in a remission phase, which means that the cancer has shrunk. Optimization is a very effective approach which allows choosing an optimal treatment plan so as to minimize the cancerous cells. In the current paper discussion is made about how nature inspired optimization and particularly particle swarm optimization can be used in the treatment, as these nature inspired optimization techniques can solve complex problems more effectively.

Keyword: Cancer, Optimization, PSO, Hybrid versions of PSO, Feature selection, Cancer classification, Classifier

Introduction

The fundamental building block of any living organism is a cell. In the growth process cell divides and thus produces new cells. This normal cell follows an order in which the cell grows, divides and then eventually dies. But at times mutation of genes takes place and this sequence is disturbed and hence cells grow uncontrollably and forms a lump which is called tumor, which is the initial stage of cancer and then further spreads to other parts of the body. According to the latest article by World Health Organization out of the 56.9 million deaths around the world in 2016 cancer is the listed third in the top 10 causes of death [1].

There are various treatments to treat cancers such as radio therapy, chemo therapy target therapy, surgery and various others. Their main motive is to kill the cancer cells and thus stop cancer from further spreading to other parts of the body. Radiation therapy is widely used and every patient undergoes this therapy at some point of their treatment. These radiations are targeted to the cancerous cells and since their repair mechanism is incompetent to get repaired therefore these cells die. But since these cancerous cells are surrounded by healthy cells as well so our main motive is to direct radiations to only those affected cells. Therefore we apply optimization techniques so as to avoid or minimize radiation exposure to these healthy cells as it is very important because prolonged exposure can also damage these cells as well. Nature inspired optimization techniques are meta-heuristic optimization techniques which can efficiently solve these real world complex problems like cancer

In this paper firstly a brief is given about cancer so that we have a better understanding about what is the problem and how its treatment works, then later about its various treatments and how nature inspired

optimization technique and especially particle swarm optimization (PSO) is used so that only the affected cells are treated and healthy cells are less exposed to it.

CANCER

As we already know that in cancer due to mutation the basic nature of cells to divide in a limited manner changes and thus grows massively in an uncontrolled manner and this excessive growth leads in the formation of tumor. It is the primary where cancer actually starts. Cancer tissues are solid tumors as well as of the blood such as leukemia. These cancerous tissues are malignant which means that they can spread to other parts of the bodies as well. As these tumors grow it breaks off and cells from this tissues travels to the other part of the body via blood and thus forms new tumors. Thus there are various types of cancers that originate in different parts of our body of which few are mentioned such as lung cancer, blood cancer, carcinoma, sarcoma, leukemia, and many others.

There is various treatment process as well to treat the tumor which depends on which stage is it detected. Among which surgery the tumor is removed surgically at the diagnosis phase. Patient whose cancer cannot be treated surgically then they receive sequence of treatment such as radiation therapy of chemotherapy and various other combination treatments. In chemotherapy chemo means 100 different medications to be used which is infused into our vein , given by mouth or topically. Another very common treatment is treating the cancer with radiations. This can be delivered during or after the surgery/chemotherapy. In this therapy the patient receives high dosage of radiations either internally or externally.

The main goal of all the treatment is to either slower the growth of cancer or shrunk the tumor so as to stop it from further growing. These treatments also come with various side effects, and since these affected cells are surrounded by healthy cells so we need to be cautious when giving this treatment, especially radio therapy and chemotherapy. Optimal ways are found out so that only the affected area is targeted. There are various optimization techniques and nature inspired optimization techniques are the ones which solves complex real life problems very efficiently as compared to the classical techniques.

NATURE INSPIRED OPTIMIZATION

Selecting the best out of the given set of alternative(s) is termed as 'Optimization' . This domain is called the search space. And the numerical thoughts for finding the ideal value (the greatest or the least possible value) of a function are called ‘Optimal Techniques’ [2]. Real world optimization issues are frequently exceptionally difficult to settle which requires robust optimization techniques, and many applications have to deal with NP-hard problems. To take care of such sorts of issues, optimization instruments must be utilized; however there is no certification that the ideal arrangement can be acquired. Truth be told, for NP issues, there are no effective calculations by any stretch of the imagination. Therefore, numerous issues must be understood by preliminary and blunders utilizing different optimization strategies. Analysts have affirmed that few frameworks saw in nature can tackle proficiently numerous intricate optimization issues which can't be managed existing deterministic calculations. Along these lines, the pattern to think about and consolidate models of regular methodology in optimization calculations has picked up ubiquity. Specialists have investigated sustenance scavenging practices of regular species and composed calculations that can be utilized to tackle numerical optimization issues in numerous science and engineering domain. Among these new calculations, numerous calculations, for example, particle

swarm optimization, cuckoo, and firefly algorithm, have picked up fame because of their high effectiveness.

PARTICLE SWARM OPTIMIZATION

'Particle Swarm Optimization' (PSO) is a heuristic search algorithm which is inspired by the social behavior of flock of birds[3]. It is a swarm intelligence technique developed by Eberhart and Kennedy [4] in 1995. Particle swarm optimization consists of a population of individuals called swarm, and each individual is called a particle which represents a location or possible candidate solution in a multidimensional search space. Optimum solution is decided by the gathering behavior of these birds in the solution space in which the fly. They pursue some way to achieve their food goal. Local or particle's best solution is the shortest passage travelled by these birds. These particles tend to pursue its local best position(solution) found till now. They additionally monitor global best (gbest) solution, the best (shortest) way found by any particle at the specific occurrence.
Velocity is associated with every particle, via which it moves towards local and global best way, the situation in 'n' dimension space and the current position of particle concerning gbest and lbest. Birds convey messages to one another to locate the most excellent (best) way to achieve its food sources. Therefore they get its local best and global best solutions from the experience they achieve. The algorithm proceeds till global optimum solution is accomplished. PSO algorithm has a few favorable circumstances like basic execution, without derivative, few control parameters, computationally effective, straightforward, powerful. It is a proficient global inquiry algorithm as it is profoundly precise.

CLASSIFICATION OF CANCER TREATMENT USING PARTICLE SWARM OPTIMIZATION

The alteration in the genetic structure of the cell leads to its growth in an uncontrolled manner. Classifying cancer type is the important step in the diagnosis of cancer and determines appropriate treatment and prognosis. Prior characterization of tumor was to a great extent dependent on and without the right distinguishing proof of growth composes, it is infrequently conceivable to give gainful treatments and accomplish expected treatment impacts. Earlier classification of cancer was mainly done on the structure or appearance of the tumor, data extracted from clinical examination and other biochemical procedure. But it was observed that tumors with indistinguishable appearance had other origins and thus responded differently to the same treatment therapy. So an intense classification was required so that the right treatment is applied. And this was achieved efficiently with the help of certain mathematical techniques. And in this paper we will discuss how a nature inspired optimization technique like particle swarm optimization is employed in the classification of cancer.

Rui Xu et.al [5] proposed a combination in which he used Semisupervised Ellipsoid ARTMAP(ssEAM) along with PSO. ssEAM ARTMAP is an incremental neural architecture and it has got its root in Adaptive Resonance [6] Theory and is derived originally from Fuzzy ARTMAP (FAM) [7]. This coalition of ssEAM which was previously referred as Boosted Ellipsoid ARTMAP [8] along with PSO was introduced. ssEAM is used for multiclass cancer discrimination and PSO for informative gene

selection. ssEAM has the ability to acquire the knowledge of associative maps between clusters of an input and an output space. And in some special case it can also be used as a classifier when the set of class of labels is an output space. ssEAM characteristics are that it is stable, fast, and has a finite learning which creates hyperellipsoidal clusters that induce complex nonlinear decision boundaries. Whereas on the other hand PSO is an evolutionary computation technique and has a random velocity which is associated with each potential solution, and also it has the ability to store in its memory the best solution achieved so far. ssEAM/PSO was used to analyze publically available cancer data set: NCI60 data set [9], the acute leukemia data set [10], and the acute lymphoblastic leukemia (ALL) data set [11]. It was found that ssEAM/PSO had better performance in all the three data set and when the result was compared it was found that it was better than other classifiers.

Shutao Li et al[12] have proposed a method in which Genetic Algorithm (GA) and a hybrid version of Particle Swarm Optimization (PSO) is combined for gene selection, and as a classifier Support Vector Machine (SVM) is used. They key plan of 'hybrid PSO/GA' algorithm is to merge GA operators into the PSO algorithm. In this hybrid version initial population is generated then the fitness value of each individual is calculated. After the initialization PSO operator is performed in which the position and velocity of each individual is updated. Now the Termination condition is checked and if this condition is satisfied then the final solution is given else GA operator is applied on those individual, and again fitness value of each individual is calculated. Now again if the termination condition is satisfied a final solution is given else again PSO operator is applied and thus the chain continues till the termination condition is not satisfied. This procedure behind the gene selection by the hybrid PSO and GA is that firstly using the tenfold method (ten subdivisions of identical sizes are made randomly from the n samples) all the samples are divided into training and testing samples. For the procedure of gene selection n out of the ten subsets are used and from the gene chosen classifier is trained. Performance is tested by the remaining subsets. At every fold of the data this work should be done. "Wilcoxon rank sum test" is executed in the training samples due to which large number unnecessary and noisy genes are filtered. Each gene is evaluated and ranked and top N genes with the top score are chosen and a new subset is formed. In this paper as a part of crude gene subset, 40 genes with top scores are selected. In the testing sample corresponding genes are also chosen concurrently. Now from the training samples selection of final gene is performed using the hybrid PSO/GA. After selecting the final most informative gene the classifier is trained using SVM which is based on the subset of gene acquired from the proposed method. Then finally the classifier is used to estimate the testing samples. The proposed method is analyzed on three data set that were publically available which were (a) Leukemia Dataset (b) Colon Dataset (c) Breast Cancer Dataset, and it was observed that 97.7% of tenfold accuracy is obtained with top three genes on Leukemia Dataset, for Colon Dataset an accuracy of 91.9% is obtained with thw selection of top nine genes, and 100% of tenfold classification accuracy is obtained with top eleven genes in the case of Breast Cancer Data. Experimental outcome with Leukemia and Colon Dataset suggested that the proposed strategy reduce the dimensionality of the dataset. It was also observed that the PSO integrated with GA enhanced the gene selection process as compared to the classification accuracy that was obtained by PSO and GA alone. Experimental outcome with Leukemia and Colon Dataset suggested that the proposed strategy reduce the dimensionality of the dataset.

Mohd Saberi Mohamad et al [13] proposed an Improved Binary Particle Swarm Optimization (IBPSO) for the selection of gene. IBPSO selects small subsets of informative genes that are most relevant for the classification of cancer. To check the efficacy of the proposed method IBPSO was applied on ten gene

expression data set which includes binary and multi classes of data set. And from the experimental result it was found out that IBPSO is better than other PSO and BPSO based methods with regard to the number of genes selected and classification accuracy. It was supreme because it overcame with the limitations of BPSO and PSO based methods. It did so by introducing a scalar quantity called particles' speed and an updating rule x_i^d (t + 1), due to which the probability values can be increased or decreased, which led to the selection of small number of genes and form a gene subset. Run time of IBPSO is also low as compared to BPSO because small numbers of genes are selected which is again another reason for it to be better than the latter one.

Kun-Huang Chen et al [14], proposed a new method using PSO along with decision tree as a classifier. This method spotted the tissue-specific gene and the housekeeping genes with altered expression pattern which gives high distinction ability on the classification of cancer. This method has non linear search capability of PSO and linearly separable advantage of decision tree (DT).Experiments were conducted on eleven gene expression dataset of cancer to test the performance of our method and five-fold cross-validation method was used to justify performance of our proposed method. It was found out that it had a higher accuracy as compared to other methods. The performance of our proposed method was also compared with other benchmark classification method which came out to be a better one and it was seen that our method was also compatible to SVM for certain specific datasets.

Maolong Xi et al [15] proposed a hybrid method in which BQPSO was used for cancer feature gene selection and SVM as a classifier for the classification of good gene subset. To make the classification better leave-one-out cross validation method is used which validates the genes selected. BQPSO with SVM, BPSO with SVM, and Genetic algorithm with SVM were tested for feature gene selection and cancer classification on five microarray data sets, namely, Leukemia, Prostate, Colon, Lung, and Lymphoma. The experimental results show that BQPSO/SVM has significant advantages in accuracy, robustness, and the number of feature genes selected compared with the other two algorithms.

CONCLUSION

Along with many other advantages PSO algorithm has the ability to explore the solution space faster and thus makes it better option to solve the various problems related to cancer from diagnosis to treatment. Here various improved versions of PSO are discussed and how the results have come out to be better than the previous methodologies that have been applied.[16] [17] And only focusing on affected area and exposing the treatment to its surrounding healthy cell area as least as possible.

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