Importance of Mathematical modeling in Cancer disease and Applications of Artificial Intelligence in Cancer detection and treatment

Dr. B. Uma Maheswari

Assistant professor, Department of Sciences and Humanities, Matrusri Engineering College, Hyderabad, India.

gudipatiuma1977@gmail.com

Abstract

Biological systems have been a subject of mathematical analysis and still working is going on what is the best approach to describe mathematical behaviour of such systems. Models of biomedical systems describe the behaviour at various levels from population of species to cell population. Cancer is a complex and multifaceted disease and mathematical modeling can be a powerful tool to help us understand its development, progression and treatment. In this paper we study about modelling of cancer disease and latest technologies like Artificial Intelligence which are used in early detection and treatment of various types of cancer.

Key words: Mathematical modeling, Cancer disease, Artificial Intelligence, Early detection and treatment.

1. Introduction

Most mathematical models put efforts on different paths involved in determination of cell cycle and the role of P53 in metabolism and the dynamics of P53 [1]. Computational oncology has been implemented mostly in biology systems for better understand of cancer biology and mathematical strategies can be used to predict tumour responses and toxicity during treatment and design drug regimens in oncology to decrease toxicity [2]. Modeling the dynamics of Gene regulatory network state is an important approach for understanding cell-fate specification, cell reprogramming, oncogenesis and tissue regeneration [3]. The study of stem cell is an important step for investigating the process of oncogenesis and obtaining an effective stem cell therapy for various cancers. Using bi-compartmental stochastic model for the stem cell to study the spread of mutants with in the body [4]. A discrete event simulation model is used to generate patient appointment schedules that minimise treatment delay and total completion times of treatments in each day including these two constraints covering the drug availability and pharmacists working hours. This simulating model is applied for evaluating operation performance case study and best scheduling rule for waiting time of a patient [5]. Mathematical modeling and analysis can potentially contribute to the discovery of better cancer regimens. Mathematical models on combination cancer therapies developed far for cancer management and the models are discussed based on level of toxicity, drug resistance, Survival benefits and other side effects [6]. Cell's population decay due to radiation was accounted for by coupling the linear-quadratic model and it is used to simulate cancer treatment with the use of numerical variables, numerical and radiation parameters. The results of this model give population changes and final volumes of tumours and cells [7].

The latest progress in Artificial Intelligence is diagnose and treating Colorectal cancer and it is based on a systematic collection of previous literature and the computer aided detection system can significantly improve the polyp and mutating into Colorectal cancer. The AI based high level auxiliary diagnostic systems can improve the readability of medical images and help clinicians make more accurate diagnostic and therapeutic decisions [8]. The applications of AI predict programmed death ligand, tumour mutation burden and tumour microenvironment in cancer patients and the likelihood of immune therapy benefits and side effects. Using AI and ML advance techniques digital biopsy can give benefit to more cancer patients to help in clinical decision making [9]. AI and related technologies can play a vital role in drug development for cancer. They can be used to select the right nanomedicine combinations as well as to maintain optimum drug level in the blood to improve treatment output [10].

2. Modelling of Cancer disease:

The following steps are used to model cancer using mathematical modeling.

1. Define the problem: The first step is to identify the specific aspect of cancer that you want to model, such as tumour growth, metastasis or treatment response. It is important to define the scope and objectives of the model clearly.

2. Gather data: Collect relevant data such as cancer cell biology, genetic and epigenetic factors, and clinical outcomes from published literature, databases and experimental studies.

3. Choose a modelling approach: There are different mathematical modeling approaches that can be used depending on the type and scope of the problem. Some common modelling techniques include ordinary differential equations, partial differential equations and network modelling.

4. Develop the model: Based on the chosen approach, develop a mathematical model that describes the underlying biology and clinical behaviour of cancer. This may involve defining equations or rules that govern the behaviour of cancer cells, their interactions with the microenvironment or their response to treatment.

5. Validate the model: Test the model against available experimental data to assess its accuracy and predictive power. Once the model is validated then it can be used to generate new hypotheses, explore the effects of different interventions or treatment strategies, or predict outcomes under different scenarios. The model can also be refined and updated as new data becomes available.

3. Types of Modeling:

1. Epidemiological modeling: Epidemiological models can be used to study the spread of cancer and identify risk factors that are associated with the disease. Based on mathematical models to study the relationship between environmental exposures and cancer rates in a particular population.

2. Pharmacokinetic modeling: Pharmacokinetic models can be used to predict how drugs will be absorbed, distributed, metabolized and excreted in the body. These models can be used to optimize dosing strategies for cancer treatments and improve treatment outcomes.

These are few examples of how mathematical models can be used to identify cancer. By combining mathematical modeling with experimental data, we can improve our understanding of cancer and develop more effective treatments for the disease. It is important to remember that mathematical models are simplifications of complex biological systems and they always be interpreted in the context of available experimental data.

4. Applications of AI in Cancer disease:

Mathematical models can be used to identify cancer through various approaches. These are some latest technologies which are using to identify cancer. Cancer detection using AI has shown great potential to improve early detection and diagnosis of cancer. AI technologies such as machine learning and deep learning can analyse vast amounts of medical data, including medical images, patient records, and genetic information, to identify patterns and markers that are associated with cancer.

One of the most important applications of AI in cancer detection is in medical imaging analysis. AI algorithms can analyse medical images, such as mammograms or CT scans to identify abnormalities or suspicious areas that may indicate the presence of cancer. AI can also be used to analyse genetic data to identify individuals who are at high risk of developing certain types of cancer.

However, it is important that AI is not a replacement for human expertise and judgment in cancer detection. AI algorithms must be developed and validated using large datasets and rigorous testing protocols to ensure their accuracy and reliability. Additionally, AI algorithms must be integrated into existing clinical workflows to ensure that they are used effectively and safely in clinical practice. AI is increasingly being used in various areas of cancer treatment, including diagnosis, treatment selection, and prediction of patient outcomes. Here are some of the latest examples of AI applications in cancer treatment:

1. Precision Medicine: AI is being used to analyse patient data, including genetic information, to identify personalized treatment options. This approach has been shown to improve patient outcomes, particularly in cases where traditional treatments have failed.

2. Radiology: AI is being used to help radiologists detect tumours and other abnormalities on medical images. AI algorithms can quickly analyse large amounts of medical imaging data to identify patterns that might be missed by human radiologists.

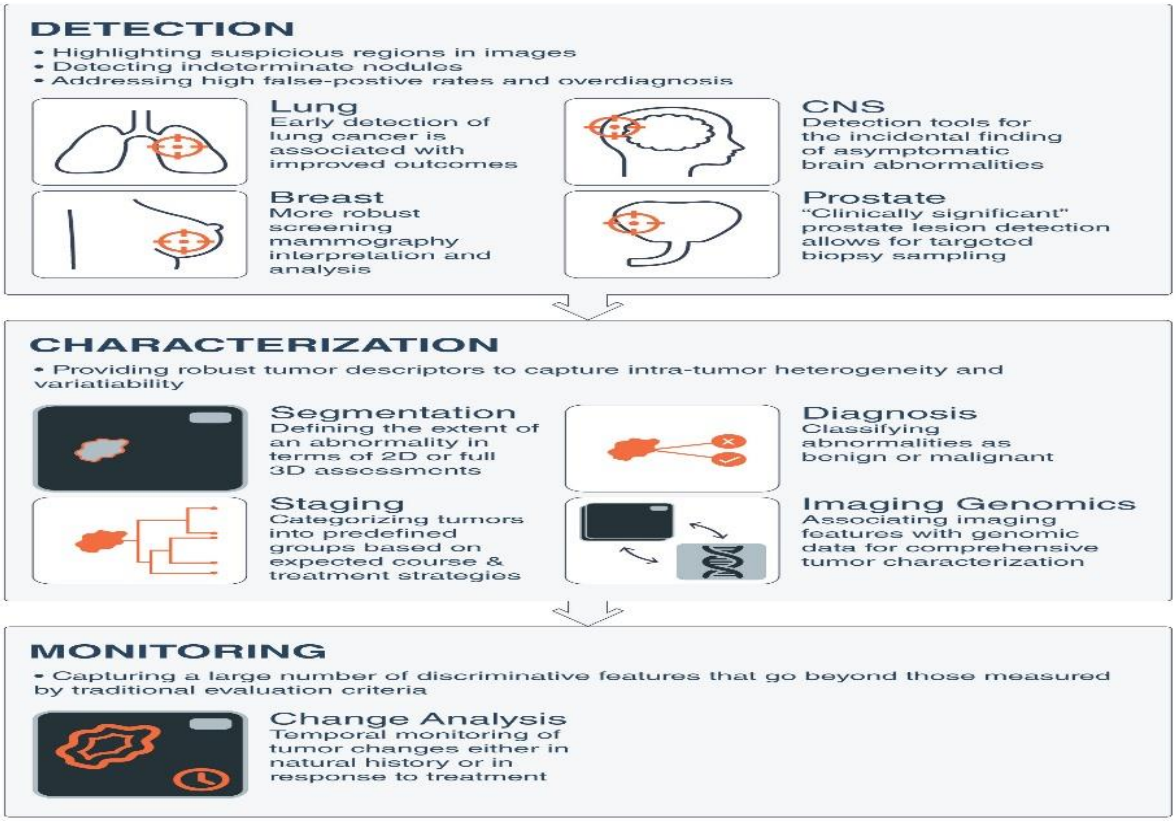
3. Pathology: AI is being used to analyse tissue samples from cancer patients to identify the type and stage of cancer. This can help doctors determine the best course of treatment for each patient.

4. Drug Discovery: AI is being used to accelerate drug discovery by predicting which molecules are most likely to be effective against specific cancer types. This approach can help researchers develop new drugs more quickly and efficiently.

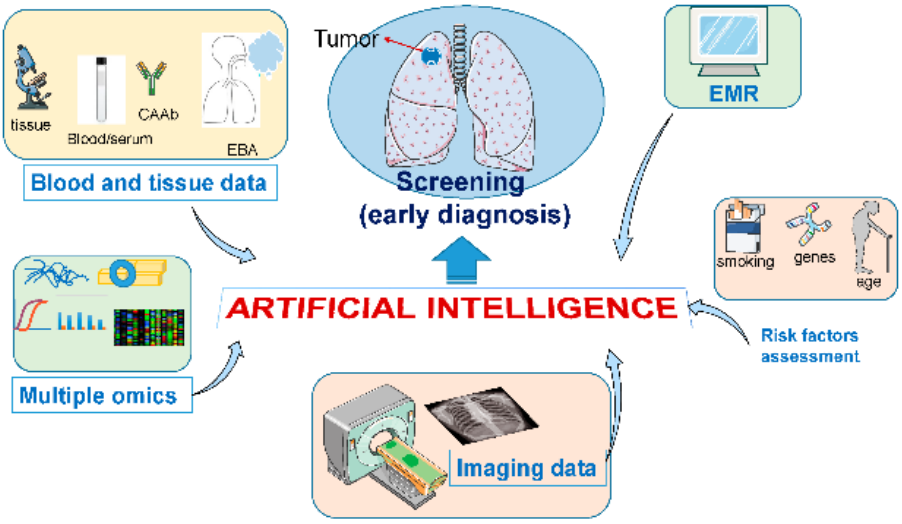
5. Remote Patient Monitoring: AI is being used to monitor cancer patients remotely, using wearable devices and other technologies. This can help doctors detect changes in a patient's condition and adjust treatment plans accordingly.

5. Uses of AI In Cancer detection and treatment

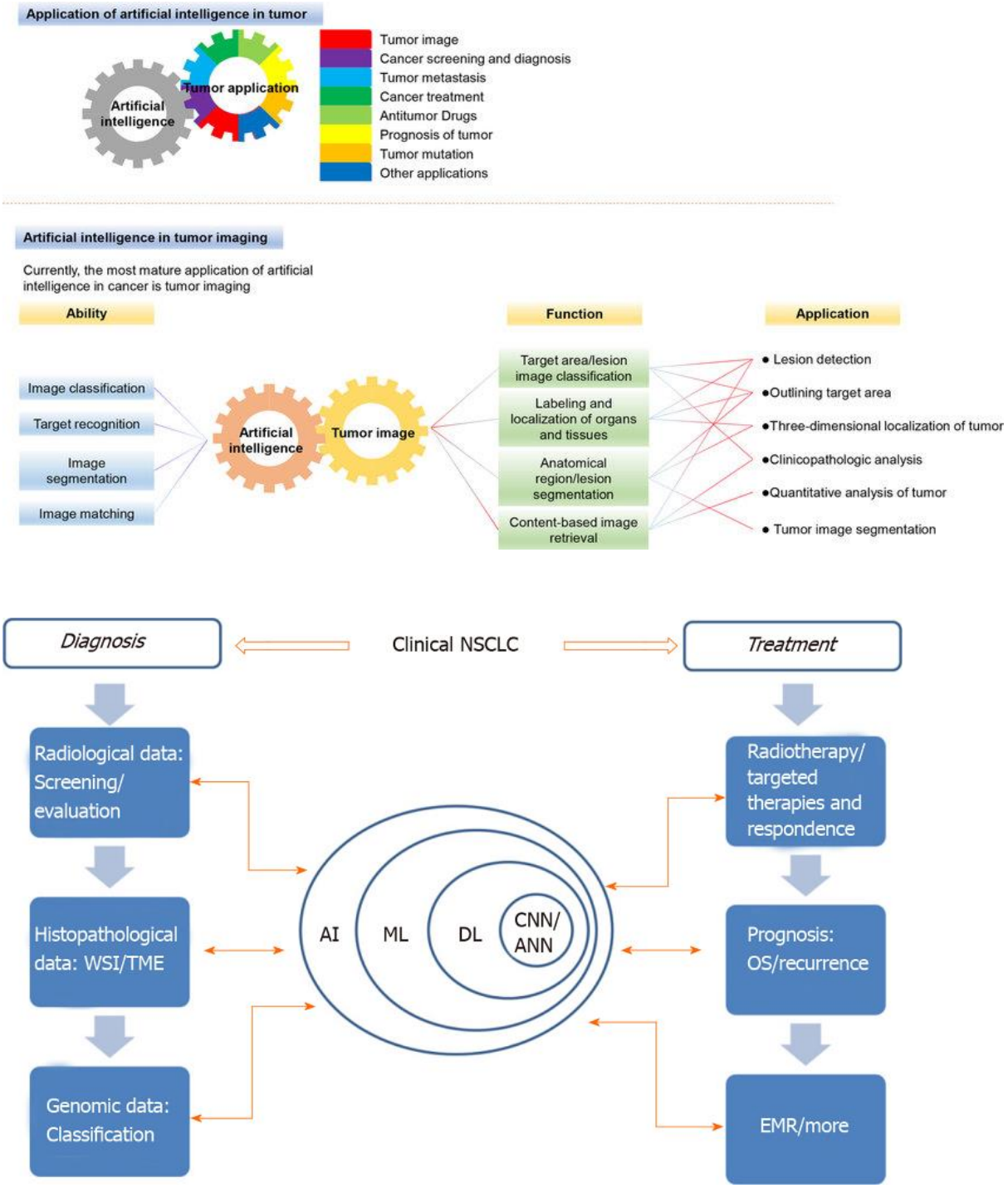
Artificial intelligence tools can be applied in three broad categories of medical image in cancer disease. 1. Detection of abnormalities 2. Characterization of a suspected lesion by its shape and stage of disease 3. The response of treatment over a stipulated time by monitoring 2 - dimensional and 3- dimensional central nervous system.




GLOBAL TECH COUNCIL
Artificial Intelligence (AI)
Can Help In Lung Cancer
Screening
www.globaltechcouncil.org


tissue
CAAb
Blood/serum
EBA
Blood and tissue data
Tumor
Screening
(early diagnosis)
EMR
smoking
genes
age
ARTIFICIAL INTELLIGENCE
Risk factors
assessment
Multiple omics
Imaging data


Artificial Intelligence in Cancer Imaging:
Bridging the Gap between Pathologist and Algorithm



6. Conclusion

The mathematical modelling can help provide insights into the complex dynamics of cancer, guide experimental design, and gives clinical decision making. Overall Artificial Intelligence is proving to be a valuable tool to fight against cancer, helping doctors and researchers to

diagnose, treat, and prevent cancer more effectively than ever before. but it is important to continue research and development to ensure that AI technologies are safe, accurate, and effective in improving patient outcomes.

7. Future Scope

In future, integration of AI technology in cancer care can improve the accuracy and speed of diagnosis, fast clinical decision making and it leads to better health outcomes. The most recent insights in Nanotechnology, Artificial Intelligence and Internet of things could help in cell therapy treatments with low cost and AI will help to resource constraints in terms of infrastructure and human resources.

References:

1. E.Kim, J.Y.Kim.J.Y.Lee., Mathematical modeling of P53 pathways., International journal of Molecular Science (2019), Vol.20, Issue 20.
2. Dominique Barbolosi, Joseph Ciccolini, Bruno Lacarelle., Nature Reviews Clinical Oncology (2015), Vol.13, PP. 242-254.
3. Joanna E. Handzlik, Yen Lee Loh & Manu., Dynamic Modeling of Transcriptional Gene Regulatory Networks., Journal of Modeling Transcriptional Regulation (2021), Vol.2328, Pp.67-97.
4. L. Shariyari, A.Mahdipour-Shirayeh., Modeling Dynamics of mutants in heterogeneous stem cell niche., Physical Biology (2017), Vol.14.
5. M. Heshmat & A. Eltawil., Solving Operational problems in outpatient Chemotherapy clinics using mathematical simulation., Annals of Operation Research (2021), PP.289-306.
6. Joseph Malinzi, Kevin Bosire Basita, Sara Padidar., Prospect for application of mathematical models in combination cancer treatment., Journal of Informatics in Medicine Unlocked (2021), Vol.23
7. Musiliu Folarin Farayola, Sharidan Shafie, Fuaada Mohd Siam., Mathematical modelling of radiotherapy cancer treatment using Caputo fractional derivative., Computer Methods and Programs in Biomedicine (2020), Vol.188.

8. Zugang Yin, Chenhuj Yao, Limin Zhang and Shaohua Qi., Application of Artificial Intelligence in diagnosis and treatment of colorectal cancer: A novel Prospect., Journal of Frontiers in Medicine (Lausanne) 2023, Mar 8.

9. Gao Q., Yang L., Lu M. et al., The artificial intelligence and machine learning in lung cancer immunotherapy., Journal of Hematology and Oncology (2023), Vol.16.

10. Barnabas Wilson & Geetha KM., Artificial intelligence and related technologies enabled nanomedicine for advanced cancer treatment., Journal of Nanomedicine (2020), Vol.15, No.5.