Optimal Biopsy Decision Making in Breast Cancer using Reinforcement Learning

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Problem Definition

Breast Cancer remains significant global health challenge, with increasing incidence rates. It is estimated that 2.3 million new cases of breast cancer were diagnosed in 2022 and it caused 670,00 total deaths globally[4]. Annual Mammography is the standard practice followed by most of the advanced countries to detect Breast Cancer in early stages. In the United States approximately 39 million mammograms are performed annually as of year 2021[2]. Post mammogram more than 1 million women undergo breast biopsies annually. These biopsies are crucial for diagnosing breast abnormalities and determining whether a lump or mass is benign or cancerous. Approximately 20% of breast biopsies performed in the U.S. each year turn out to be cancerous, while the remaining 80% are false positives (benign)[3]. This cause unnecessary treatments, patient anxiety, and expenditures. This project focuses on exploring Reinforcement Learning(RL) techniques to optimize breast cancer biopsy decision-making. This approach aims to optimize decision-making, reduce unnecessary procedures, and mitigate the economic impact of false positives, ultimately improving patient outcomes.

Research Objectives

Through this research project, I aim to accomplish the following objectives:-

- Implement different RL techniques - Q-Learning and Deep Q-learning to optimize Biopsy Decision Making process
- Access the impact of these methods in reducing false-positives(unnecessary procedures) while maintaining true-positives(actual cancer cases)
- Compare effectiveness of these methods in minimizing false positives biopsies compared to existing methods (traditional and MDP(Markov Decision Process)-based methods)
- Formulate reward functions to guide RL agents in making decisions, considering factors such as disutility of biopsy to achieve better better performance

Dataset

State-Transition probabilities for breast cancer risks available on GitHub Repository[1] will be used to build RL framework.

References

[1] *Breast Cancer transition Probabilities*. URL: `https://github.com/atlas3107/Breast_Cancer_transition_probabilities`.

[2] Radiology Business. *Breast imaging*. URL: `https://radiologybusiness.com/topics/medical-imaging/womens-imaging/breast-imaging/3d-mammography-approaching-50-percent-breast`.

[3] MedicineNet. *Breast Biopsies*. URL: `https://www.medicinenet.com/percentage_of_breast_needle_biopsies_are_cancer/article.htm`.

[4] WHO. *Breast Cancer*. URL: `https://www.who.int/news-room/fact-sheets/detail/breast-cancer`.