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作品名稱 **IlluminaMed: Developing Novel Artificial Intelligence Techniques for the Use In a Biomedical Image Analysis Toolkit and Personalized Medicine Engine**

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Abstract

Despite the multitude of biomedical scans conducted, there is still relatively low accuracy and standardization of diagnoses from these images. In both the fields of computer science and medicine there is very strong interest in developing personalized treatment policies for patients who have variable responses to treatments.

The aim of my research was automatic segmentation of brain MRI scans to better analyze patients with tumors, multiple sclerosis, ALS, or Alzheimer's. In particular, I aim to use this information, along with novel artificial intelligence algorithms, to find an optimal personalized treatment policy which is a non-deterministic function of the patient specific covariate data that maximizes the expected survival time or clinical outcome.

The result of the research was IlluminaMed, a biomedical image analysis toolkit that relies on the development of new artificial neural networks and training algorithms and novel research in fuzzy logic. The networks can detect patterns more complex than humans can identify and create patterns over long periods of time. IlluminaMed was trained by a dataset of professionally and manually segmented MRI scans from several prestigious hospitals and universities.

I then developed an algorithmic framework to solve multistage decision problem with a varying number of stages that are subject to censoring in which the "rewards" are expected survival times. In specific, I developed a novel Q-learning algorithm that dynamically adjusts for these parameters. Furthermore, I found finite upper bounds on the generalized error of the treatment paths constructed by this algorithm. I have also shown that when the optimal Q-function is an element of the approximation space, the

anticipated survival times for the treatment regime constructed by the algorithm will converge to the optimal treatment path. I demonstrated the performance of the proposed algorithmic framework via simulation studies and through the analysis of chronic depression data and a hypothetical clinical trial.

IlluminaMed can automatically segment the scans with 98% accuracy, find tumors with 96% accuracy and approximate their volume within a 2% margin of error. It can also find lesions in MS and ALS, distinguishing them from tumors with 94% accuracy. IlluminaMed can, in addition, determine the tendency of a patient to develop Alzheimer's several months before patients develop symptoms correlating the brain structure and its fluctuations. Lastly, the censored Q-learning algorithm I developed is more effective than the state of the art clinical decision support systems and is able to operate in environments when many covariate parameters may be unobtainable or censored.

IlluminaMed is the only fully automatic biomedical image analysis toolkit and personalized medicine engine. The personalized medicine engine runs at a level that is comparable to the best physicians. It is less computationally complex than similar software and is unique in the fact that it can find new patterns in the brain with possible future diagnoses.

IlluminaMed's implications are not only great in terms of the biomedical field, but also in the field of artificial intelligence with new findings in neural networks and the relationships of fuzzy extensional subsets.

評語

個人化疾病預測，結合創新的模糊，集合來處理重要的特徵值，以提高預測的準確率，作品亦自行開發部份的 SVM Library 以融入修正的模型，理論論述完整，資料的收集也相當完備，堪稱是科展中少有的佳作，程度在博士班、研究生之上。