Policy Approximation for Optimal Treatment Planning

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Abstract

Markov decision process (MDP) models are powerful tools which enable the derivation of optimal treatment policies, but may incur long computational times and decision rules which are challenging to interpret by physicians. To reduce complexity and enhance interpretability, we study how Poisson regression may be used to approximate optimal hypertension treatment policies derived by a MDP for maximizing a patient’s expected discounted quality-adjusted life years (QALY).

Background

Cardiovascular (CV) Disease

Figure 2.2 Coronary heart disease (CHD) accounted for 53% of the deaths related to cardiovascular diseases.¹

Sequential Decision Making

Hypertension Treatment

Treatment Selection

Blood pressure reading

Health Outcome

Blood pressure reading

Hypertension Treatment

Figure 2.1 Hypertension treatment can be translated as a sequential decision making problem. Treatment selection will vary according to the health status of the patient.

Methodology

Markov Decision Process

Figure 3.1 The optimal number of medications per patient at each decision period was obtained using a MDP.

Generalized Linear Mixed Effects Model

\[ y = X\beta + Z\gamma + \epsilon \]

Equation 3.1

The policies derived from the MDP were approximated using a Poisson regression model, parameterized on 20,000 patients² through linear mixed-effects modeling. This allows for the interpretation of the effect of each regression coefficient.

Figure 4.1 Policies were tested on a cohort of 60,000 patients. The Poisson policies were able to accurately approximate the policies determined by the MDP model.

Results

Number of Medications Prescribed by MDP and Poisson Treatment Policies

Table 4.1 The MDP policies were also accurately matched by the Poisson policies in terms of the expected health outcomes.

Additional Analyses Performed

• Evaluation of treatment policies using a distinct risk calculator: Differences between the optimal policy and the Poisson policies remained 2.5%.
• Assessment of treatment policies under ±25% risk calculator calibration error. The approximations were not highly affected by the calibration error.

Summary and Conclusions

• By building upon large longitudinal datasets to derive policy approximations, our algorithms provide fast, interpretable, reliable and software-free decision support.
• While first developed for hypertension treatment planning, our methodology could be applied to derive treatment plans for patients with other chronic conditions.

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References