

SKRIPSI
MODEL PROSES KEPUTUSAN *MARKOV* PARSIAL TERHADAP
KANKER PROSTAT
PARTIALLY MARKOV DECISION PROCESS MODEL FOR PROSTATE
CANCER

Diajukan untuk memenuhi salah satu syarat memperoleh derajat
Sarjana Matematika (S.Mat.)



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ABSTRAK

MODEL PROSES KEPUTUSAN MARKOV PARSIAL TERHADAP KANKER PROSTAT

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Kanker prostat merupakan salah satu penyebab kematian terbesar pada pria di dunia, dan pengawasan aktif menjadi strategi yang direkomendasikan untuk pasien berisiko rendah hingga menengah, namun penentuan waktu biopsi yang tepat masih menjadi dilema antara risiko prosedur dan keterlambatan deteksi progresi. Penelitian ini menganalisis model *Partially Observable Markov Decision Process* (POMDP) untuk menentukan kebijakan biopsi optimal secara matematis. Model diformulasikan dengan dua keadaan klinis, *low-risk* dan *high-risk*, dengan ketidakpastian kondisi pasien direpresentasikan melalui *belief state* yang diperbarui menggunakan aturan *Bayes*. Melalui pembuktian induksi matematika, fungsi nilai optimal terbukti bersifat *piecewise linear and convex* sehingga kebijakan optimal berbentuk *threshold policy*. Solusi numerik diperoleh menggunakan algoritma *Point-Based Value Iteration* berdasarkan data empat kohort klinis internasional. Analisis sensitivitas menunjukkan bahwa bobot penalti keterlambatan deteksi merupakan parameter paling dominan terhadap nilai ambang optimal.

Kata kunci: Pengawasan aktif, *Partially Observable Markov Decision Process*, *belief state*, *threshold policy*, *Point-Based Value Iteration*, Analisis sensitivitas.

ABSTRACT

PARTIALLY MARKOV DECISION PROCESS MODEL FOR PROSTATE CANCER

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Prostate cancer is one of the leading causes of death among men worldwide, and active surveillance has become the recommended management strategy for patients at low to intermediate risk however, determining the appropriate timing for biopsy remains a dilemma between procedural risk and delayed detection of progression. This study analyzes a Partially Observable Markov Decision Process (POMDP) model to determine the optimal biopsy policy mathematically. The model is formulated with two clinical states, low-risk and high-risk, in which the uncertainty of the patient's clinical condition is represented through a belief state that is updated each period using Bayes' rule. Through mathematical induction, the optimal value function is proven to be piecewise linear and convex, so that the optimal policy takes the form of a threshold policy. Numerical solutions are obtained using the Point-Based Value Iteration algorithm based on data from four international clinical cohorts. Sensitivity analysis shows that the penalty weight for delayed detection is the most dominant parameter affecting the optimal threshold value.

Keywords: Active surveillance, Partially Observable Markov Decision Process, belief state, threshold policy, Point-Based Value Iteration, Sensitivity analysis.