

Probability Theory II

Basics of Stochastic Processes; Markov Processes and Martingales

Seiji HIRABA

October 8, 2020

Contents

1	Definitions of Stochastic Processes $(X_n, P), (X_t, P)$	1
2	Discrete-time Markov Chains	1
2.1	Basic examples	1
2.2	Time-homogeneous Markov chain	1
2.3	d -dimensional random walks	6
2.4	Galton-Watson process (GW process)	8
3	Martingales	11
3.1	Uniform integrability	11
3.2	Radon-Nikodym theorem and conditional expectations	12
3.3	Definition and properties of martingales, Doob's decomposition	14
3.4	Stopping times and optional sampling theorem	15
3.5	Sub-martingale inequalities and convergence theorems	16
4	Continuous-time Markov Chains	20
4.1	Exponential times	20
4.2	Poisson processes	21
4.3	Continuous-time random walks	25
4.4	Continuous-time Galton-Watson processes	25
4.5	Continuous-time Markov chains & transition probabilities	26

In this text, we describe Markov properties and martingale properties on discrete/continuous-time stochastic processes

We give examples of Markov processes, random walks, Galton-Watson processes and Poisson processes, and we investigate their properties.