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Mathematics : Probability Theory and Stochastic Processes

Itô, Kiyosi, Kyoto University, Kyoto, Japan

# Poisson Point Processes and Their Application to Markov Processes

- Gives a beautiful elementary treatment of general Poisson point processes in Chapter 1, especially recommended for beginners
- Shows how the notion of Poisson point processes with values in a function space of paths called excursions plays a key role in an extension problem of Markov processes in Chapter 2
- Demonstrates how the general theory in Chapter 2 can answer completely the extension problem for the minimal diffusion on  $[0, \infty)$  with an exit boundary 0

An extension problem (often called a boundary problem) of Markov processes has been studied, particularly in the case of one-dimensional diffusion processes, by W. Feller, K. Itô, and H. P. McKean, among others. In this book, Itô discussed a case of a general Markov process with state space  $S$  and a specified point  $a \in S$  called a boundary. The problem is to obtain all possible recurrent extensions of a given minimal process (i.e., the process on  $S \setminus \{a\}$  which is absorbed on reaching the boundary  $a$ ). The study in this lecture is restricted to a simpler case of the boundary  $a$  being a discontinuous entrance point, leaving a more general case of a continuous entrance point to future works. He established a one-to-one correspondence between a recurrent extension and a pair of a positive measure  $k(db)$  on  $S \setminus \{a\}$  (called the jumping-in measure and a non-negative number  $m < \infty$  (called the stagnancy rate). The necessary and sufficient conditions for a pair  $k, m$  was obtained so that the correspondence is precisely described. For this, Itô used, as a fundamental tool, the notion of Poisson point processes formed of all excursions of the process on  $S \setminus \{a\}$ . This theory of Itô's of Poisson point processes of excursions is indeed a breakthrough. It has been expanded and applied to more general extension problems by many succeeding researchers.

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