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Final Research Report

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APPLIED TO CONTROL, REPLACEMENT, AND SIGNAL ANALYSIS

supported by

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ERHAN ÇINLAR

Northwestern University

1. SUMMARY

The following is the list of papers completed during June 1979 to May 1980 under this contract.

1. E. ÇINLAR. Chung processes. In Encyclopedia of Statistics, ed. by N.L. JOHNSON and S.M. KOTZ. Wiley, New York. (To appear)
2. __________. On a general entrance-exit problem.
3. __________. Creep of concrete under stochastically varying humidity conditions.
4. __________, J. JACOD, P. PROTTER, and M.J. SHARPE. Semimartingales and Markov processes. A. Wahrscheinlichkeitstheorie verw. Gebiete. (To appear)
5. __________ and H. KASPI. On Lévy systems for Chung processes.
6. H. KASPI. On the symmetric Wiener-Hopf factorization for Markov additive processes. Z. Wahrscheinlichkeitstheorie verw. Gebiete. (To appear)
7. B. MAISONNEUVE. Subordinators regenerated. Teoriya veroyatnostei ee Primenen. (To appear)

In addition, there are a number of papers at different stages of completion. Such work in progress includes "Representations for Markov processes", "Image of a Markov additive process", and "Characterization of regenerative systems as images of Markov additive process".

2. DESCRIPTION OF WORK REPORTED

On regenerative systems and Markov additive processes, the completed work is reported in [6] and [7]. MAISONNEUVE [7] shows how to use the theory of regenerative systems in order to study increasing Lévy processes. Lévy processes are well-known objects in probability, and their probabilistic laws as well as their stochastic structures have been known for some time. Hence, when working on strictly regenerative systems, it used to be advantageous to first characterize the regeneration set as the image of an increasing Lévy process, and then use the known results on the latter to study the former. MAISONNEUVE [7] reverses this completely: he shows that the theory of regeneration has reached a level of maturity that enables it not only to stand on its own but also to help its parent fields.

KASPI [6] concentrates on Markov additive processes (X_t, Y_t), where X is a Markov process with finitely many states and where Y takes values in $\mathbb{R}$. The objective is to express the infinitesimal generator of (X,Y) as the product of two infinitesimal generators one of which corresponds to "the increases" of Y and the other to "the decreases". In addition to their analytical usefulness, such decompositions were meant to provide insight into the stochastic structure of (X,Y): and this paper fulfills both the aims admirably. There is a decomposition that is analytically explicit; and the factors in the decomposition are related to the increasing and decreasing ladder processes.

The general entrance-exit problem of [2] is a continuation of our work on the problem with Markov additive processes. The basic problem is as follows. A particle is moving within some region E. Its motion is observable intermittently. We are interested in the joint distribution of (R_t^-, R_t^+, X_t) where R_t^- is the amount of time elapsed since the particle was seen the last time, R_t^+ is the time until the particle gets to be seen next, and X_t is the position of the particle at t. We had solved this problem in the case where the particle's motion was Markovian as a function of the clock time, where the clock is so constructed that is moves only when the particle is observable. In the present paper [2], the only assumption on the basic motion is that it is continuous. Of course, the computational results one obtains are not as sharp as in the Markovian case, but simulation studies might yield just as sharp results.

Two papers on Chung processes, [1] and [5], do not contain much that is new, but are of methodological interest. In [1], we give the general outlines of the theory of Markov processes with countably many states. We show that, instead of starting with assumptions on the probability transition function or generators, the theory should start with assuming that the sample paths are right continuous and have left-hand-limits. Then, everything becomes straightforward: the transition function turns out to be standard and "infinitely" differentiable, Kolmogowu differential equations hold, and have unique solutions, etc.

The Lévy systems provide the basic machinery for studying the jump structures of processes, and are used in entrance-exit decompositions. For Chung processes, such results have been obtained by direct "brute force" techniques without using Lévy systems, mainly because it was thought to be difficult to obtain Lévy systems for processes possessing discontinuities of the second kind. In [5] we show how to obtain Lévy systems by using random time changes and the theory of Markov additive processes.

Our work on creep of concrete in [3] builds a model for the deformation law of concrete under varying humidity conditions. Humidity process is left totally arbitrary, except for an assumption that it is continuous and differentiable. Creep of concrete is sensitive both to the level of humidity (higher the humidity, higher the rate of creep) and to changes in humidity (any change in humidity, upward or downward, increases the rate of creep). We model creep as a process with locally gamma structure given the underlying humidity process. If the humidity is taken to be a deterministic constant, the model reduces to our earlier basic model of creep.

The contents of [4] were reported in the last year's report.