The system will use magnetic tapes and other dismountable media so that successful operation can only come through close cooperation between the computer operator and the system. Unfortunately, in times of stress, humans are likely to take short cuts even when these involve substantial risk. It is therefore important to design a recovery procedure that offers resistance to unreliable operating procedures, but it should also encourage human verification of action automatically taken; a printed record of events is indispensable.

Many of the problems that must be faced when designing the dump and recovery system are posed by the possibility of hardware failure during the dump and recovery operations themselves. Each of these programs must be written in a way that allows the system to recoil from one error situation so that it can recover itself for another try. For example, the incremental dumper will need to be able to identify those files that are new or have changed and need dumping. One might therefore think that a simple flag is all that is needed to control this operation. However, if the latest dump tape is damaged the system will need to be able to backtrack and, in doing so, find all those files that will need to be dumped again. For this purpose, the Cambridge system records the tape name and block position in the file directory when a file is dumped.

The file reload program has its own similar problems. For example, a file directory may have to be reloaded from the most recent incremental dump tape. If, by some unfortunate chance, the tape cannot be read the system must ask to use a duplicate copy and then if both fail it must backtrack to an earlier tape. The backtrack itself means that the controls for the incremental file dumper may have to be re-set and this will have some effect on other jobs already scheduled to run. It is just this type of situation which is so difficult to foresee when planning a filing system, yet considerations such as these form an essential part of any bid to provide a smooth operating system and a high level of file integrity.

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Book Review

Conditional Markov Processes and their application to the Theory of Optimal Control, by R. L. Stratonovich, 1968; 350 pages. (*Elsevier Pub. Co. Ltd.*, £8 5s. 0d.)

The adoption of the state space description of systems has led to substantial advances in optimal control and filtering theory in recent years. Using this description the state $x(t, w)$ of the system and the (noisy) observation $y(t, w)$ of the state are Markov Processes. The basic problem in optimal filtering becomes the derivation of equations describing the evolution of the probability distribution of $x(t)$ conditional in the available observations $y(\tau)$, $\tau \epsilon [t_0, t]$, or the evolution of some risk function determined by the posterior distribution. The optimal control problem becomes the determination of a realisable control (function of t and the available observations) to minimise an expected risk. To deal rigorously with these continuous-time conditional Markov processes requires the development of mathematical tools of the same kind as those available for Markov processes, and this is one of the main intentions of the present volume. By contrast the theory for discrete-time systems is reasonably complete. Repeated application of Bayes' rule yields the conditional distribution of the state; the control problem is, admittedly, more difficult, but the dynamic programming technique can be applied, at least in those cases where it is possible to find a finite dimensional sufficient statistic (called sufficient coordinates by Stratonovich in a significant early contribution) for the posterior distribution.

The first problem to be faced (Chapter 1) is the relation between physical systems and stochastic differential equations. Related to this is the definition of stochastic integrals (Chapter 2) where Stratonovich defines an integral by means of central differences rather than by forward differences (as used in the Ito integral). Stratonovich's integral has the advantage of permitting formal manipulation by the ordinary rules of calculus, and leads, at least in the scalar case, to a simpler relation between the physical system and the stochastic differential equation. However, it has been shown by Clark that this apparent simplification disappears in general for the vector case. In addition the Ito integral possesses other advantages, such as the martingale property.

The central part of the book, consisting of the development of some basic concepts in Chapters 3 and 4, and the development of Stratonovich's main results for conditional Markov processes in Chapters 5–7, is written in an extremely abstract fashion. Most engineers, who are familiar with the underlying physical problems, will, like the reviewer, find the material difficult, if not impossible, to digest.

The remaining Chapters (8–11) consider various problems in filtering, detection and control theory. The examples are interesting and stimulating.

Stratonovich's earlier work was much more accessible to engineers. This volume, however, will be appreciated only by a few specialists. Nevertheless the problems considered are mathematically interesting and practically important, and this book should reward the perseverance of any reader with the necessary mathematical background. Stratonovich has been a major influence in the development of the subject.

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