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CONCLUSIONS

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This work has been concerned with the development of the theory of linear and nonlinear feedback shift register sequences, their practical generation, and use in system identification by means of crosscorrelation methods.

The random-noise techniques for impulse response measurements include two principal problems : The generation of a test signal with random futures as much as possible near those of white-noise, and simple calculus of the input-output correlation functions for a system. The cyclic linear shift register m-sequences, although deterministic, exhibit properties in correlation similar to those of white-noise. The generation and processing of the sequences is remarkably simple, and their delayed-versions are likewise readily derived. Because of the periodicity of the sequences, auto and crosscorrelation techniques are both simplified and improved. Also, the power of the m-sequence can be confined to the interested frequency-band by choosing the correct combination of clock-pulse period, and number of shift register stages. Further its amplitude and total power can be controlled precisely by choosing the parameters of the sequence. These properties, once obtained, will not vary with time, temperature or other environmental changes. Thus, for the identification of systems by crosscorrelation techniques, a convenient white-noise approximant is the shift register m-sequence, which is more commonly known by the name pseudorandom sequence by virtue of its noise features.

The results of the comparative study of the existing correlation schemes for linear system dynamic analysis have indicated that the scheme employing pseudorandom binary sequences is reliable and economical, but needed correction for drift-effects. The proposed 'Simultaneous Crosscorrelation Scheme' facilitates quick evaluation of the drift parameters, thereby establishing more confidence in the estimated system dynamics. Where drift parameters cannot be measured, the drift correction principle of Davies and Douce can be effectively applied to this scheme for elimination of polynomial drift effects.

Also, the discussion on the current status of crosscorrelation art using pseudorandom signals in a linear multivariable system identification has revealed that 2-and 3-level shift register m-sequences, either in true or transformed form, provide the desired uncorrelated test inputs. To overcome the short-comings in the test signal imperfections, employed in current schemes, the theory of p-level shift register ideal sequences is presented. The proposed correlation schemes employing these ideal sequences can provide simultaneous measurements of the multi-input system impulse responses within reasonable accuracy.

Further, in the measurement of Volterra kernels of a nonlinear system response by correlation method, the antisymmetric pseudorandom sequences provide reasonable 1st-and 2nd- kernel estimates by virtue of their ability to discriminate against system nonlinearities. However, as their higher-order correlations do not approximate to those of Gaussian white noise, even to measure the 2nd kernel, test signal of period about 100 times the kernel settling time is necessitated. To meet with the purpose, a new correlation pattern of system testing is introduced, wherein a prbs is used to perturb the system and a transformed prbs is correlated with the system response. The new scheme permits effective measurements of the first and second-order kernels with reduced correlation time. Where nonlinearity is much significant, this new scheme in association with the dither injection principle facilitates effective system identification.

Thus, essentially, the statistical characteristic, the deterministic and simple means of generation, and feasibility of adequate control over the parameters of the shift register sequences makes them attractive as test perturbations in system identification by crosscorrelation. Two of the main advantages that can be claimed of this correlation method of system testing are, firstly its ability to produce a reasonable result even in presence of such system disturbances as random noise, and parameter drifts, and secondly its applicability to on-line working.

The effective study of linear shift registers and their sequences depends largely on a polynomial representation of the feedback logic. The composition of this polynomial determines the type of behaviour exhibited by the shift register. In the linear regime, there exists a strong relation between the logic structure and the sequential behaviour of the feedback shift register. This simplifies the synthesis problem of realizing a given cycle structure.

When the feedback logic is allowed to take on forms other than the linear restriction, a non-linear structure results. To set up a flexible theoretical description for the nonlinear case, a simple method is described which enables the feedback logic of a nonlinear feedback shift register to be represented as a nonlinear polynomial using simple logical operations. The polynomial form of nonlinear feedback shift register is capable of furnishing information on the sequential operation of these devices which is not readily apparent from the Boolean logic function. Further, a technique is introduced for the prediction of the cycles of a product feedback shift register from a knowledge of its factors, thereby solving somewhat difficult problem in this nonlinear field. The contralinear feedback shift register is shown to be a special case of the nonlinear product feedback shift registers. Finally, it is seen that the classification of the feedback shift register types has arisen by the definition of the reverse and dual of a cyclic feedback function. The polynomial form of feedback logic is thus seen to be quite a flexible theoretical description for the nonlinear case and it is likely to open up as yet abundant untapped source of codes for a number of new applications.

Indeed, this study was motivated by a desire to achieve a more basic understanding of the shift register sequences and their use in the correlation method of system identification. The mathematical tractability of the linear situation led to the choice of linear feedback shift register sequences for detailed study. The results of the study, as reported, are quite encouraging. A number of mathematical tools and concepts are developed concerning the sequences as well as their applications.

The achievement of analogous goals for (i) nonlinear sequences and (ii) nonlinear system identification is seen to be possible, although not so simple. However, it is seen too, that many of the tools, concepts and results of the linear situation are applicable here.

Although the theory of shift register sequences and their use in system identification is developed here to a considerable extent, there are certainly many unsolved problems worthy of further study.

A major problem in linear system identification is that of finding a more simpler method for complete elimination of drift effects on the system dynamic measurements.

Another concerns with the development of more refined and practicable methods for the generation of uncorrelated sequences with desired statistical features for use in multivariable system dynamic analysis.

It would be of interest to develop techniques for system identification with mixed-moduli test signals.

A broader treatment of nonlinear system identification by means of pseudorandom methods seems to be indicated, too.

A thorough analysis of nonlinear feedback shift registers merits additional effort.