at EOF for operator to change tapes) or to utilize additional tapes if available. This would be of value in many emergency situations or where a standard program is written to be run on different machine configurations.

b. Most buffered machines may have more than one buffer, capable of simultaneous reading or writing but not capable of handling more than one or two tapes at a time. Given that we wish the computer to optimize tape assignment, we will wish it to arrange the placement of files in such a manner as to take best advantage of the characteristics of the buffers (of which there may be one or several present).

As stated this is a fairly simple problem in optimization; a good solution would be of great value to the industry. It seems that the programmer would have to supply some information about the synchronous or asynchronous behavior of files. The ideal solution would require a minimum of information from the programmer and would operate quickly to determine the optimum assignment for each run.

REQUEST FOR METHODS OR PROGRAMS

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DISCUSSION OF GENERAL DATA REDUCTION ROUTINE

The following type of problem is encountered so frequently in almost all fields of research that it is considered worthy of special attention in order that automatic computer procedures be developed for the rapid solution of said problem.

Problem Statement

Given some dynamic system—physical, logistical, economic, biological or otherwise—with much historical data available concerning the inputs and outputs of the system, it is desired to find a system of differential equations which adequately describe the relationship between a particular output variable and each input variable.

It is assumed that the system can be represented in block diagram form as shown in Figure I (at least for the linear cases) where the input variables appear on the left (e.g. F_1 (t), F_2 (t), etc.), the transfer functions in differential operator form appear in the middle (e.g. G_1 (s), G_2 (s) etc.) and the output variable, x (t), appears on the right. The end objective of the problem is to determine the transfer functions (G_1 (s), G_2 (s), etc.) relating the input variables to the output variable. All variables would generally be expected to be functions of time.

Observations of input and output variables recorded simultaneously are indicated by having identical numbers for the second digits of the subscripts of the input variables and by the subscript of the output variable. Thus, the set of variables used for the third observation of a system would appear: F_{13} (t) for one input variable; F_{23} (t) for some other input variable; F_{33} (t) for a still different input variable etc. and x_3 (t) for the output variable. (See Page 3, Case I)

The following distinct cases of this problem are mentioned in order that each can be considered separately.

CASE I

The system is assumed to be capable of description by a system of ordinary linear differential equations with constant coefficients. All input variables, initial conditions, and the output variable are zero for $T < 0$. The number of observations equals the number of input variables.

CASE II

Same as Case I except that the number of observations is greater than the number of input variables.

CASE III

Same as Case I except that the number of observations is less than the number of input variables.

CASE IV

One way to attack this problem would be to proceed just as in Case I. If the time constants appearing in the transfer functions thus determined were short compared with the length of time of the particular observations used, then it might be concluded that these transfer functions were fairly reliable since the effect of the input variables for $t < 0$ could not be very considerable in the absence of large time constants in the transfer functions. Much more theoretical background information is needed before attacking this program.

CASE V

A combination of the approaches of Cases II and IV appears feasible here.

CASE VI

Again some statistical approach might be useful.

CASES VII through XII

Perhaps some converging trial and error procedure could be devised incorporating appropriate applications of statistical multiple correlation and Laplace transform routines. No general, proven, straightforward method is known to the author for any of the Cases, III through XII, as described above.

Uses

In general, all of the cases described above would be applicable to the same problem areas. However, some types of systems could be expected to be more non-linear than others. Certainly no actual systems would be perfectly linear.

Certain general uses immediately come to mind for applying a general purpose data reduction system.

In the study of economic and logistics systems, the basic underlying relationships might be quickly found. Such systems could then be studied more thoroughly by simulation using suitable digital or analog computers.

General equations underlying chemical reactions might be uncovered so that tailor-made chemical compounds might be designed mathematically with tremendous savings in time and expense.

A very promising application of the above problem solution would be to find differential equations peculiar to a certain locality with which the weather could be more accurately predicted, utilizing input data from surrounding reporting stations.

And finally (and inevitably), someone would certainly try to utilize this approach for "playing the stock market."

Approaches to Case Solutions

CASE I

For this case, the following equations can be written:

$$L\,F_{11}\,(t)\,G_1\,(s) + L\,F_{21}\,(t)\,G_2\,(s) + \ldots L\,F_{N1}\,(t)\,G_N\,(s) = L\,x_1\,(t)$$
$$L\,F_{12}\,(t)\,G_1\,(s) + L\,F_{22}\,(t)\,G_2\,(s) + \ldots L\,F_{N2}\,(t)\,G_N\,(s) = L\,x_2\,(t)$$
$$\vdots$$
$$L\,F_{1N}\,(t)\,G_1\,(s) + L\,F_{2N}\,(t)\,G_2\,(s) + \ldots L\,F_{NN}\,(t)\,G_N\,(s) = L\,x_N\,(t)$$

The solution of this case for any particular transfer function can be theoretically found by suitable application of matrix algebra. For example:

$$G_2(s) = \frac{\begin{vmatrix} L\,F_{11}(t) & L\,x_1(t) & \dots & L\,F_{N1}(t) \\ L\,F_{12}(t) & L\,x_2(t) & & L\,F_{N2}(t) \\ \vdots & \vdots & & \vdots \\ L\,F_{1N}(t) & L\,x_N(t) & & L\,F_{NN}(t) \end{vmatrix}}{\begin{vmatrix} L\,F_{11}(t) & L\,F_{21}(t) & \dots & L\,F_{N1}(t) \\ L\,F_{12}(t) & L\,F_{22}(t) & \dots & L\,F_{N2}(t) \\ \vdots & & & \\ L\,F_{1N}(t) & L\,F_{2N}(t) & \dots & L\,F_{NN}(t) \end{vmatrix}}$$

The symbol, L, is used above to indicate the Laplace transformation of a function. Theoretically this case can be programmed for automatic solution by a large scale digital computer.

CASE II

This case can be solved exactly as Case I. In addition, the solution can be repeated using different observations in order that transfer functions already found can be verified. If many slightly different values were found for the same transfer function, they might be "averaged" in order to find the most representative one. No rigorous mathematical justification for such a procedure is known to the author, however.

CASE III

Perhaps some statistical method may be devised for finding the most probable transfer functions for this case.

CASE IV

Same as Case I except that the initial conditions are not known and the values of the variables are not known for $t < 0$.

CASE V

Same as Case II except that initial conditions are unknown.

CASE VI

Same as Case III except that initial conditions are unknown.

CASES VII–XII

These are respectively the same as Cases I through VI, except that one or more of the transfer functions is non-linear or one or more of the transfer functions is representative of an ordinary linear differential equation with variable coefficients, where such coefficients are functions of one or more of the input variables, of which there are N. x (t) is the output variable.