

DISPLAY CONTROL OF A CRT-FILM SCANNING SYSTEM*

C. R. Dickens
Stanford Linear Accelerator Center
Stanford University
Stanford, California

1. INTRODUCTION

Characteristic of data reduction systems using on-line film digitizers, in high-energy physics, is the requirement to process large numbers of similarly formatted photographs. Anywhere from 10^4 to 10^6 events or potential events, usually recorded on 35-mm or 75-mm film, must be analyzed with each experiment. The problem is then a large scale reduction of film data to an output of meaningful physics. A system of this type divides roughly into 3 phases, acquisition of raw data from the film using the scanner, preprocessing of the raw data and lastly building the preprocessed elements into physics events. We have worked mostly in the first phase and have developed the display control in this area.

2. BASIC SYSTEM COMPONENTS

The basic components of our data-reduction system are an IBM 360/50, provided by the IBM Scientific Research Center, Palo Alto, with the usual peripherals, an IBM 2250 Model I display unit with keyboard and light pen, an IBM 2701 control unit and the Hummingbird I film scanner. To this add an early and incomplete OS/360 software system plus a set of general purpose scanner control and data reduction subroutines.

3. FUNCTIONAL DESCRIPTION

Roughly speaking we digitize film at one end and conclude with a set of descriptors that uniquely classify the

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event recorded on the film. A pass is made sequentially through the phase mentioned above, event by event. Each phase may be thought of as a succession of transformations on the input set of that phase. The input set to the first phase is the picture itself and to the second are the raw digitizings sitting in the memory of the Model 50.

Actually we further break down each phase into logical sections consisting of related transformations. The transformation may not actually change the character of the data and may only move it from one location to another, e.g., from core to tape.

4. GENERAL CONSIDERATIONS AND MOTIVATION

Efficiency and flexibility of operations are sufficient reasons for centralization of control, but also, in the past the debugging of an on-line scanner system has been an ordeal. This plus the obvious analog between the CRT film scanner and the 2250 display unit led first to monitoring the scanner with the display and secondly to controlling the scanner. At first we merely scanned a picture and then displayed the raw data. With this information we would laboriously reset the scanner controls and recycle. Since all the controls of the Hummingbird became accessible to the program it was a natural step to use the 2250 as a means of setting the controls.

The generality of each transformation depends on having a number of parameters which may be set for each

experiment. Thus both for setting parameters and selecting transformations we need some form of control either external or internal. Ab initio there is no way of determining what all settings should be. After scanning and processing several thousand homogeneous events obviously internal measures may be established and used by the program for complete or nearly complete internal control. Thus we turned to a display control which provides a great deal of interaction initially and can progressively relinquish this as the experiment proceeds.

5. STRUCTURE OF SYSTEM

At the present level of development actual systems design for a particular experiment consists of selecting from a library of general-purpose transformations a composition of transformations which then, with an appropriate specially written control driver, constitutes the data reduction system. Abstractly each system is a circuit-free directed graph with each node representing a transformation of the output from the previous node. Additionally these systems are linearly ordered with one initial node and one terminal.

The graph is divided into disjoint logical sections with the assumption that there is at most one path from a section to any other section. This path leads from the last node to the first node of the next section. For example:

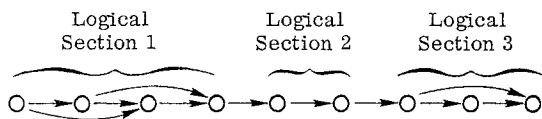


Figure 1

Obviously, in general there may be several ways to group the nodes into logical sections. This choice of grouping is made at design time without the benefit of on-line control and cannot be modified dynamically at a later time. However, during any given run any node within a section may be deleted from execution as long as the graph remains connected. Thus this is a maximum system in the sense that we may delete or execute various transformations dynamically but cannot add ones not included originally. This unfortunately is true for each system at present.

6. DISPLAY CONTROL AND MONITOR

With each transformation, as the data passes through analysis, we have parameters that should be set to optimize the data reduction. Indeed even the execution of a transformation itself may need to be requested or deleted for a particular run. To do this we associate with each logical section a display control section.

This latter section, allowing the external setting of the sequence of transformations lying within the logical section, consists of a pair of display sets, a data-output and a control. In turn, the data-output set usually consists of a single display on the 2250. A convenient representation of the output after the execution of this logical section shows the effects of the parameter settings; for example, a replay of the raw data from the scanner.

The control set is one or more displays together which set up and initiate the execution of the transformations within the associated logical section. Each display, called a control page, is divided into three functional areas, denoted A_i , $i=1,2,3$. The parameter area (A_1) presents to the operator the mnemonic and present value of each parameter. The values may be changed by pointing the light pen to a small dash in front of the mnemonic and typing in the new value desired, either fixed point or floating. These parameters are the usual numerical ones associated with subroutines and do not affect the overall program flow. The second area (A_2) is a set of yes-no switches which request the execution or non-execution of transformations in this logical section. Again the mnemonic appears preceded by a small dash and is followed by the word 'yes' or blanks. By pointing the light pen at the dash, the state flips and the blanks go to a 'yes' or vice versa. Included is a yes-no switch determining whether the data-output set of displays is wanted at the end of execution of the logical section. A special parameter is included which determines the number of iterations through this logical section before the control appears again. In both areas mentioned above the values of the parameters usually remain the same until changed at the scope. However, at the beginning of the run an initialization program sets nominal values before the first display.

Entries in the next area (A_3) determine the next step after all modifications on this control page have been

completed. The operator may want to give up and exit, go on to execution, switch control to the master section described below, go on to the next page in this control section, or go to a special input display which is just an extension of A_3 . The selection is made as in A_2 and the 'end' key is depressed. Note that this area is not directly related to the logical section but only to display control. Execution of the selected transformations in the logical section does not begin until all interaction has been completed.

Some control is given to the operator at the time of the data-output display; if it has been requested, he may ask for a return to the control set of this section by depressing the 'cancel' key or just push the 'end' key to continue on. In this fashion he may cycle through logical section execution several times changing parameters at each pass until he is satisfied with the output display. He also may ask for a display of output data from previous logical sections.

It should be pointed out that modification of the output display is not permitted. Interaction with the data itself is defined to be another transformation and fits into one of the logical sections as any other transformation does.

Overall control over the control sections themselves is carried out in an analogous way by the master control section, with the exception that there is no data-output display and no program parameter area. Area A_1 of the master control page contains the options to exit, to initialize and begin, to continue and begin, and to return to the control section which called the master control. The second area (A_2) is a series of yes-no switches which control whether we use the control section with its associated logical section or not. These switches control only the display interaction and do not in any way affect the execution of the logical section. At this level we may join control sections together. For example, suppose we have two adjacent sections each with one page in its control set, then after joining we would have one control section with two pages in its control set and having as a data-output set the displays of the two control sections. In this manner and in conjunction with the ability to turn off the data-output display for each section, the operator can exert less and less external control until he has one control section

covering the entire system with a single display at the end of each event processed. Even this control section may be deleted by using the master control. Similarly we may separate sections already joined. This joining and breaking is implemented by using the light pen first to select the 'join' or 'break' operation then point at the two sections to be joined or at the single section to be isolated.

The following is an example of the master control page.

MASTER CONTROL

CONTROL

- EXIT
- BEGIN AND INITIALIZE YES
- RESTART
- RETURN

DISPLAY FLOW

NAME	DISPLAY
- SECTION 1	YES
- SECTION 2	
- SECTION 3	YES
- SECTION 4	YES
- SECTION 5	
⋮	
- JOIN	
- BREAK	

Figure 2

Note the square brackets. These show that control sections 1 - 3 have been joined together and also that sections 4 and 5 have been, while the control pages for sections 2 and 5 will not appear on the 2250 display unit.

One additional feature has been added which is the interrupt. By hitting any key during program execution the control section associated with the logical section executing appears on the face of the scope, unless it was turned off at the master control level. In that case, we get the master control and an indication of which logical section was in execution.

Below we have a typical control section page.

'SECTION NAME'		PAGE 1
CONTROL		PARAMETERS
- EXIT		- PARM1=00001
- EXECUTE	YES	- PARM2=00320
- MASTER CONTROL		- PARM3=01•42
- NEXT PAGE		- PARM4=24•01
- OTHER PARAMETERS		• • • • •
FLOW		
- TRANS1	YES	
- TRANS2		
- TRANS3	YES	
- TRANS4	YES	

Figure 3

In the control area (A_1) only one option can be specified at a time and in case there are no more pages, the 'EXECUTE' option will be the standard one unless the operator overrides.

7. CONCLUSION

This approach not only speeded the debugging of the Hummingbird, but has enabled us to switch from one type of film to another and set up runs very easily. This set-up used to consist of running the scanner with a variety of parameter settings and subsequently looking at a series of plots of the data. This mode had two serious drawbacks: one, the sets of parameters had to be fairly extensive to cover all contingencies, and, two, we waited a day or two for voluminous printer plots. Now we merely sit at the console of the 2250 display unit, try one set of parameters and see the results seconds later.

One of the immediate problems we have now is remembering which set of parameter values went with which resultant data-output display. Presently we take a Polaroid picture manually of the data-display and request a printout of the parameter values. We hope to use a CRT film plotter to record both in the near future.

Another area that needs attention is the construction of these systems themselves: one, we wish to use more complex structures, and, two, we want to configure data handling systems using a display unit. Thus we could tailor a system as we proceeded with an experiment.