Godot: A real-time data acquisition and control program for the PET microcomputer

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This article discusses a program for the PET microcomputer that is used to record the amount of time a human infant spends attending to one of two stimuli presented via 35-mm slides and a slide projector. The program records the number of attention episodes for either stimulus, the duration of slide presentation, and the number of slides presented. Also controlled are the transfer of data onto cassette tape at the end of the session, the detection of buttonpresses from an external keyboard, and the changing of stimuli. The interfacing used in the system and specialized subroutines are also described.

Durrett (1978) recently reviewed the Commodore PET 2001 and the Radio Shack TRS-80 personal microcomputers as laboratory instruments; two recent articles (Crossman, Williams, & Chambers, 1978; McLean, 1978) described the use of the PET in the control of real-time experiments. The present article discusses the use of the PET to control a simple perceptual task for a human infant in real-time.

The PET, an 8K version, was chosen over the TRS-80 because of its price, real-time clock, extended version of BASIC, and interfacing capabilities.

The documentation supplied with the PET is rather limited, and the majority of the information used to implement the present system was obtained from data sheets supplied with a SYM-1 purchased from the Synertek Systems Corporation. Commodore now offers a more extensive manual than was originally supplied, but it still does not describe the logical configuration of the versatile interface adapter (VIA) integrated circuit chip (Part 6522). This chip will be discussed in the hardware section of this paper.

GENERAL PROGRAM DESCRIPTION

A flow chart of the program is given in Figure 1. The main function performed by the computer is to keep track of the time a subject spends attending to one of two stimuli presented simultaneously on 35-mm slides and a projector. The time spent attending to a particular stimulus is defined as an attention episode; there is room to store a maximum of 30 episodes for each of 11 sets of stimuli. The start of an episode is indicated by the experimenter's pressing one of two "attention" buttons. Time is then accumulated until the same button is pressed again. The duration of each episode is stored following the second "attention" buttonpress.

The PET also controls the changing of stimuli by

Figure 1. Program flow chart.

activating a slide projector, and it displays the duration of slide presentation and the cumulative time in seconds that the subject spends attending to a particular set of stimuli for each successive 30-sec period. The duration of slide presentation is the time elapsed between successive "projector" buttonpresses by the experimenter. When the projector button is pressed, the duration of the slide is stored and the projector is operated via a relay. At the end of the experimental session, the data are transferred onto cassette tape.

A design error of the PET becomes obvious when large amounts of data are transferred to cassette tape: An insufficient amount of leader-trailer is placed between successive blocks of data. A block of data in the PET is 192 characters, the size of the cassette buffer. Because most data transfers require that the buffer be filled more than once, the user must compensate for this error. Documentation mentioning this

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problem was sent with some, but not all, PETs. It is discussed in the new "PET User Manual" (Commodore Business Machines, 1978), in which a solution is offered to keep count of the number of characters written to cassette. Different solutions are discussed in several PET newsletters (Laudereau, 1978; Total Information Service, 1978). The solution given here is simpler than most and is reliable on our machine.

The program in Figure 2 checks that the write to cassette takes less than 2 sec. If verified, the program assumes that the cassette buffer is still being filled and the subroutine is left. If the write takes 2 sec or longer, it is assumed that the buffer has been emptied; more leader-trailer is put on the tape by turning on the cassette motor for six "jiffies." The motor is then turned off, and the user returns to the main program.

INPUT/OUTPUT HARDWARE

Figure 3 is a schematic drawing of the input/output (I/O) hardware. The five pushbuttons are connected to

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10 REM--SAVE THE CURRENT TIME
20 T=T1
30 REM--WRITE THE NUMBER TO CASSETTE
40 PRINT #1,X
50 REM--CHECK FOR ELAPSED TIME
60 GOSUB 200
.
.
200 REM--IF THE WRITE TOOK LESS THAN 2 SECONDS, RETURN
210 IF (T1-T) < 120 THEN 280
220 REM--ASSUME THE BUFFER WAS EMPTIED, TURN ON CASSETTE AND NOTE TIME
230 POKE 59411,53:T=T1
240 REM--WAIT FOR .10 SECONDS
250 IF (T1-T) < 6 GOTO 250
260 REM--TURN OFF CASSETTE
270 POKE 59411,61
280 RETURN

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Figure 2. Subroutine to compensate for cassette buffer.

Figure 3. System input/output hardware.

Address	Register and function
59457	Input-Output Port Contains the state of the bits on the parallel edge connector.
59459	Data Direction Register The contents of this register determine whether the corresponding bit in the I/O port is to be considered an input or an output line.
59467	Auxiliary Control Register (ACR) Bit 0 when set, controls latching on a CA1 transition.
59468	Peripheral Control Register (PCR) Bit 0 controls whether positive or negative logic will be used to interpret a CA1 transition.
59469	Interrupt Flag Register (IFR) Bit 1 is set on a transition of CA1 if the corresponding bit is set in the IER.
59470	Interrupt Enable Register (IER) When bit 1 is set, a CA1 transition will set the corresponding bit in the IFR.

Figure 4. PET control register addresses and functions.

the I/O port of the PET and to the debouncing circuit for CA1 through a simple diode matrix. Two SN 74121 one-shot integrated circuit chips are used to debounce the line to the CA1 pin. Negative logic is on the input side of the circuit; that is, a low input is true and a high input is false. Lines PA6 and PA7 are set as output lines and serve to operate two relays via transistor switches. A relay, rather than a solid state device, activates the slide projector that changes the set of stimuli, so that the same hardware configuration can be used in a number of experimental situations. For the same reason, the duration of relay operation is controlled by the program. One relay is used in this study; a second relay is included for future research.

The system configuration relies on the use of the latching capabilities of the 6522 VIA. After the appropriate instructions are given, the VIA latches the state of the bits of the I/O port when line CA1 changes state. The user has the option of specifying whether negative or positive logic is used to interpret the CA1 transition, that is, for a high to low or low to high state change of CA1 to result in latching. The information is held in the I/O port until a command is given to clear a set bit in the interrupt flag register (IFR). Figure 4 shows a list of the addresses in base 10 of the various registers used to set the VIA for latching. The function performed by each register is also given.

For the VIA to latch data, Bit 0 of the auxiliary control register (ACR) and Bit 1 of the interrupt enable register (IER) must both be set. This is accomplished by "POKEing" a 1 into the ACR and a 2 into the IER. After these bits are set, a CA1 transition causes Bit 1 of the IFR to be set and the state of the pins at the parallel connector to be latched into the I/O port address. The data remain latched until Bit 1 of the IFR is cleared by POKEing a 2 into that register.

If a positive logic interpretation of the CA1 transition is desired, Bit 0 of the peripheral control register (PCR) must be set. Again, this is accomplished by POKEing a 1 into this register. Bit 0 of the PCR is cleared when the PET is powered up. Consequently, negative logic is the default interpretation of the CA1 transition.

Advantages to using the latching capabilities of the

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Comments provide instructions.
CL = character to clear screen.
HM = character to bring cursor to top left corner.

90 CLR
100 DIM A(11,32), B(11,32), C(10)
    Set bits PA 6 & 7 as output for end of film box
110 POKE 59459, 192
120 POKE 59457, 0
130 GET C$: IF C$ = "" THEN 135
140 Clear interrupt flag register
150 POKE 59469, 2
    Set interrupt enable register to note CAI pulse
160 POKE 59470, 2
    Set auxiliary control register for CAI latch
170 POKE 59467, 1
    Wait for button press
180 WAIT 59469, 2
    Clear register
190 POKE 59469, 2
    Deliver slide and continue initialization
200 GOSUB 590
210 I=1
220 J=3
230 K=0
240 FOR L=1 TO 30
250 C(L)=0
260 NEXT L
270 T3=0
280 D1=1
    Clear clock
290 T1$="000000"
    Read interrupt flag register
300 X=PEEK(59469) AND 2
    Save current time in tenths of seconds
310 T1=INT(T1/6)
    If no pulse on CAI, display the time information
320 IF X=0 THEN 2000
    If pulse on CAI, read I/O port and convert to positive logic
330 X=7-PEEK(59457) AND 7
    Clear interrupt flag register
340 POKE 59469, 2
    Determine which button caused the flag to be set.
    If attention button, determine which button
    and whether this is start or end of episode.
350 IF X=4 THEN 400
360 IF X=1 THEN 400
    If reset button, store data onto cassette
370 IF X=5 THEN 700
    If projector button, change slide and save duration
    of slide presentation.
380 IF X=2 THEN 520
    If any other button, display time
390 GOTO 2000
    If end of episode, skip over
400 IF K=1 THEN 440
    If start of attention episode, set K
    and save current time
410 K=1
420 T=T1
    Then display time information
430 GOTO 2000
    If end of episode, clear K and save
    attention episode duration for
    respective button
440 K=0
450 T3=0
    If button #2, skip over
460 IF X=1 THEN 500
    Save duration for button #1
470 A(1,J)=INT((T1-T)/10)
480 J=J+1
490 GOTO 2000
    Save duration for button #2
500 B(1,J)=INT((T1-T)/10)
510 GOTO 480
    If end of slide presentation, save
    total duration
520 A(1,2)=INT(T1/10)
    Then change slide
530 GOSUB 590
    Copy the information for button #2
540 B(1,2)=A(1,2)
    Save the number of attention episodes for
    this slide
550 A(1,1)=3
560 B(1,1)=A(1,1)
570 I=J+1
    Initialize episode counter and clock then
    wait for the start of another attention
    episode
580 GOTO 210
    Subroutine to change slides
    Clear screen
590 PRINT"CL"
    Operate relay #1
600 POKE 59457, 64: V=T1
    Wait for .05 seconds
610 IF (T1-V)<.3 GOTO 610
    Restore relay
620 POKE 59457, 0
630 RETURN

    Program segment to get name and store data
    onto cassette
    Entering an asterisk will cause one character
    back to be eliminated
    Entering a period will cause the data to be
    transferred to cassette
700 PRINT"CL"
710 PRINT"ENTER TODAY'S DATE AND SUBJECT I.D."
720 AS=""
    Wait for a letter to be entered
730 IF AS<>" " THEN 730
    If no error, skip
740 IF AS<>"*" THEN 770
    If error, delete last character
750 GOSUB 1050
    And get another character
760 GOTO 730
    Add current letter to string
770 AS=AS+AS
    Print string
780 PRINT"PM"
790 PRINT AS
    If not end of characters, continue
800 IF AS<>"." THEN 730
    If end of characters, delete period
810 GOSUB 1050
820 AS=AS+""
    Compute number of slides presented
830 J=J+1
    Open file to write data into
840 OPEN 1, 1, 1
    Save current time
850 T1$=T1$
    Write out subject's name and I.D.
860 PRINT #1, AS
    Check for buffer being emptied
870 GOSUB 1080
    Write out number of slides presented
880 PRINT #1, J
    Write out data for button #1
890 FOR I=1 TO 0
900 FOR K=1 TO 12
    Save current time
910 T1$=T1$
    Write out data
920 PRINT #1, A(I,K)
    Check for buffer being emptied
930 GOSUB 1080
    Repeat process for button #2 data
940 T1$=T1$
950 PRINT #1, B(I,K)
960 GOSUB 1080
970 NEXT K
980 NEXT I
990 T1$=T1$
    Close out file
1000 CLOSE 1
1010 GOSUB 1080
    Indicate that data transfer is complete
1020 PRINT"CL"
1030 PRINT"THE DATA TRANSFER IS COMPLETE"
1040 END
    Subroutine to erase last character entered
1050 I=LEN(AS)
1060 AS=LEFT$(AS,I-1)
1070 RETURN
    Subroutine to compensate for the small
    cassette buffer of the PET
    If this write to cassette took less than
    2 seconds, skip
1080 IF (T1-T)< 120 THEN 1120
    If the buffer was emptied, turn on the cassette
1090 POKE 59411, 53:T=T1
    Leave it on for .1 seconds
1100 IF (T1-T)< 6 THEN 1100
    Turn the cassette off
1110 POKE 59411, 61
1120 RETURN

    Program segment to display total slide duration
    and accumulated time spent attending to one of the
    two stimuli. The accumulated time is displayed in
    bins that are 30 seconds wide.
    Compute the minutes and seconds that the slide has
    been displayed.
2000 XS=RIGHT$(T1$,2)
2010 YS=MID$(T1$,1,2)
2020 X1=VAL(YS)
2030 X2=VAL(XS)
    Display minutes and seconds
2040 PRINT"HM TIME",X1,X2
    Compute amount of time since last display
2050 L=1
2060 T2=INT(T1/10)
    Set up the 30 second bin
2070 D=INT(T2/30)+1
    If the subject is not attending, skip
2080 IF K=0 THEN 2190
    If the subject is attending, compute accumulated
    attention time for this bin
2090 T4=INT(T1/10)
2100 T2=INT(T2-T4)
2110 T4=T2
2120 T2=T2-T3
2130 T3=T4
    If the bin hasn't changed since the last display, skip
2140 IF D1=D THEN 2170
    Store this time in last bin used
2150 C(D-1)=C(D-1)+T2
    Then skip
2160 GOTO 2180
2170 C(D)=C(D)+T2
    Save this bin number
2180 D1=D
    If less than 20 bins have been used, skip
2190 IF D<20 THEN 2210
    Otherwise, reset pointer
2200 L=20
    Display accumulated time in each bin used
2210 PRINT"PM"
2220 FOR N=1 TO D
2230 PRINT N, C(N)
2240 NEXT N
    Then check to see if a button has been pressed
2250 GOTO 400

```

Figure 5. Godot program listing.

VIA are that only one line, CA1, needs to be debounced and that no additional external logic is required to hold the data till they are processed; and, because Bit 1 of the IFR remains set until it is cleared, a program can alternate between processing data and checking for an event in the world outside of the CPU. Naturally, the more processing that takes place between checking for a set bit in the IFR, the longer the program recognizes that CA1 was active. This is not a critical factor in our application.

PROGRAM

Figure 5 is a listing of the program. One variable, K, is used as a flip-flop to determine whether an attention buttonpress represents the subject's beginning or ceasing to attend to a stimulus. If the subject has started to attend, the flip-flop is set, and the program continues to display the time information. If the subject has stopped attending, the duration of the attention episode is stored, the flip-flop is cleared, and the program continues to display time information. Because only one of two possible variables for each attention episode is used, the experimenter can easily determine from the data whether or not the subject is switching his attention from one stimulus to another. After the final set of stimuli is displayed, the experimenter presses the reset button, which causes the program to store data onto cassette tape. The recording scheme used by the PET is quite slow. In fact, so much time is spent waiting for all of the data to be transferred that this program is named "Godot."

BINARY CODING OF DATA

The limit of 30 attention episodes for each of 11 sets of stimuli can be expanded by using the PEEK and POKE commands to store and retrieve data in binary coded format. This is possible because the data, as in most psychological experiments, are integers. The version of BASIC supplied with the PET requires 7 bytes of memory to store a number in floating-point format. Using 2 bytes in a binary scheme, however, allows the numbers from 0 to 65,535 to be coded. This range of numbers is probably sufficient for most psychological experiments. To convert an integer to binary form, a scheme such as that given in Figure 6 can be used.

```

250 REM--INITIALIZE THE POINTER
260 A=5000
.
.
300 REM--DETERMINE HIGH ORDER BYTE QUANTITY
310 H=INT(X/256)
320 REM--DETERMINE LOW ORDER BYTE QUANTITY
330 L=X-256*A
340 REM--STORE THE LOW ORDER BYTE
350 POKE A,L
360 REM--INCREMENT THE POINTER
370 A=A+1
380 REM--STORE HIGH ORDER BYTE
390 POKE A,H
400 REM--INCREMENT THE POINTER
410 A=A+1
420 RETURN
```

Figure 6. Floating-point to binary subroutine.

```

500 FOR K=5000 TO 7000 STEP 2
510 REM--GET THE LOW ORDER BYTE
520 L=PEEK(K)
530 REM--GET THE HIGH ORDER BYTE
540 H=PEEK(K+1)
550 REM--RESTORE TO FLOATING POINT FORMAT
560 X=H*256+L
570 REM--SAVE THE CURRENT TIME
580 T=TI
590 REM--WRITE THE NUMBER TO TAPE
600 PRINT #1,X
610 REM--CHECK TO SEE THAT THE BUFFER HASN'T BEEN EMPTIED
620 GOSUB 200
630 REM--CONTINUE
640 NEXT K
```

Figure 7. Binary to floating-point subroutine.

Because 1 byte in the PET can only code for the numbers from 0 to 255, the original number (X) is first divided by 256 to determine the high-order byte (HOB) quantity. Then, the HOB times 256 is subtracted from the original number. This is the low-order byte (LOB) quantity. For example, the number 526 is coded as HOB=2 and LOB=14. The LOB and HOB quantities can then be POKed into two successive locations using the variable A as a pointer. After all of the data are stored, they can be converted back to floating-point notation before they are written onto tape. Figure 7 is an example of the scheme. This program segment assumes that 1,000 numbers are stored starting at location 5,000.

In the program, L is first set equal to the LOB and H is set equal to the HOB. X is then set equal to the original number and is written out to the cassette recorder. Subroutine 200 is the subroutine listed in Figure 2. PET stores the program to be executed starting at the lower part of memory and the variables used by the program starting at the higher part of memory moving toward the lower. If the use of variables is kept to a minimum, room sufficient to store 1,000 data points is then a possibility, even with a fair-sized program in core. A similar scheme can be used to read data back into core for further analysis. The numbers can then be popped (or more accurately PEEKed) out of memory one at a time and converted to floating-point notation before they are manipulated statistically.

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