3.5 A microprocessor based system for traffic data collection.
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INTRODUCTION

For some time, the Operational Research Group at Royal Holloway College has been studying driver behaviour at non-urban T-junctions. During this research, we have been involved in a number of data collection exercises using video-tape recordings of traffic behaviour at the junction. We are particularly interested in deriving gap acceptance parameters from the data to use as input to a simulation model\textsuperscript{1,2}.

To obtain gap acceptance functions and to study their dependence on other traffic parameters, we need detailed records of the events which occur at the junction, and the times at which they occur. Events of interest are the arrival time of turning and non-turning vehicles at the junction, the commencement of a turn and the completion of a crossing manoeuvre. We also record the type of vehicle, the speed of main road vehicles and, on occasions, various other descriptions on the vehicle and its occupants.

In our previous work\textsuperscript{3,4,5}, video tapes of the T-junctions were made and a digital clock image incorporated later. The tapes were analysed by running them in slow motion, stopping them at an event of interest and noting the event and clock time. The final output from this process was a list of events and the times at which they occurred to the nearest tenth of a second. This information was transferred to punched cards and analysed by computer.

Video techniques have the advantage of providing a complete record of events. However, the extraction of detail from the video tapes and the subsequent transfer to punched cards is extremely time consuming and may be very tiring for the analyst. The time required for this phase of the analysis is of the order of twenty times the observation period.

This paper describes the design and construction of an alternative
system to collect traffic data and transfer it to a central computer for processing. The use of this new system in recent observations of traffic behaviour at T-junctions is discussed and compared with the video techniques described above.

REQUIREMENTS FOR THE DATA COLLECTION SYSTEM

We wished to develop a system of traffic data collection which would be capable of recording detailed data on driver behaviour over periods of several hours to cover for example morning and evening peak periods. For this purpose, the system must incorporate some of the properties associated with our previous video techniques. It must be portable, having its own power supplies, and be physically small enough to be transported in a car. It must provide an accurate time base so that traffic parameters of reasonable accuracy can be obtained from the data. It must be able to record the times of vehicles passing points on the road and further information on the vehicle and its occupants. To do this we required inputs of two kinds: data input manually by observers and data from automatic sensors (e.g. pressure tubes, induction loops). In trying to eliminate the serious disadvantage of our video systems - the lengthy analysis phase - we needed to store the data internally and allow later direct transfer of this data to a mainframe computer. Punched paper tape was ruled out as being bulky, noisy, dependent on mechanical parts and easily damaged. Two possibilities remained: random access memory (RAM) or magnetic tape storage. As our intention was to put the raw (unprocessed) data onto a mainframe computer for later analysis, and the quantity of data collected at any one time was expected to be relatively large, permanent storage on RAM would be prohibitively expensive.
CHOICE OF EQUIPMENT

To design and build our own hard-wired system was not possible because we had neither the resources nor the necessary experience. We decided that a microprocessor based system would be more appropriate for our needs, and such a system could relatively easily be altered should our requirements change.

We considered some commercial systems and decided to base our data collection equipment on the Golden River MK4 system which could be used for a variety of traffic applications (for example, see Dalgleish and Tuthill\textsuperscript{5}). This is a modular system based on a microprocessor. It has facilities for using RAM and Programmable Read Only Memory (PROM), a real time clock, a number of input and output (I/O) facilities and its own power supply. The relevant specifications for the modules used in our system are summarised in Appendix I.

Our choice of I/O port (the MK4/12 I/O Port B) works on an 8 bit byte switch closure input, and an 8 bit byte output. With suitable programming, the system can easily handle eight distinct on/off inputs for each such I/O port in the system.

Some applications of the Golden River MK4 systems have used a digital cartridge recorder. Such devices are costly and a cheaper alternative was sought. Computer Workshop market the SWTPC (Southwest Technical Products Corporation) "AC-30" cassette interface. This is a mains operated unit designed as an interface between a 300 BAUD UART (teletype) port and one or two audio cassette recorders. If a cassette recorder with a remote stop-start facility is used, the AC-30 is capable of stopping and starting the cassette motor according to signals from the connected computer (or microprocessor). Therefore the MK4 could be used to send a signal to start the tape recorder motor, output data to the cassette and then stop the motor on a second signal. Data could be transferred in a continuous mode from...
cassette tape via the AC-30, to a UART port on a mainframe computer, provided the mainframe computer could handle the input rate of the data stream. This proved possible on the CDC 6600 we used, and is further discussed below.

A drawback of the AC-30 is that it is a mains-operated unit. However, its specifications showed that only low voltages and fairly low power were needed to run the device. Golden River agreed to modify the AC-30 from the kit provided to operate with a rechargeable battery supply.

INITIAL SYSTEM

The initial system consisted of an MK4 microprocessor-based system including four 8-bit push button input units and a UART I/O port; the modified AC-30 cassette interface; and a National Panasonic portable cassette recorder with a remote stop/start facility. It proved possible to use commercial audio cassette tapes with this configuration. A brief description of the individual modules is given in Appendix 1, and a block diagram of this initial system is shown in Fig. 1.

INPUTS

Data is input to the system via four of the MK4/12 I/O Ports B. Each of these ports has two connectors in parallel. The connectors may be used to receive input from several types of source. We use two, handsets and automatic sensors. Each handset has eight push-buttons as inputs to the MK4; each button has a corresponding LED indicator powered from the MK4. Any type of automatic sensor, such as pneumatic tubes or induction loops may be used provided its output can be converted to a switch closure signal. We have been using coaxial cable and a suitable interface to detect the passage of vehicles and input the information to the I/O port.

OUTPUTS

Data is output from the system through the UART I/O port. For our
purpose, this output is transferred via the AC-30 to the cassette recorder. The cassette motor is controlled by two output bits of a specified I/O port - the control port.

SOFTWARE

The MK4 system uses the COSMAC microprocessor as its central processing unit (CPU). We have written and documented a program to collect, format and output the data (Golden River kindly allowed us the use of their development systems to write and test the programs). The development systems included an editor, assembler and various debugging aids.

The program was written in assembly language and is described in detail elsewhere. The program begins by initialising counters, registers and constants and clearing memory, which takes about one millisecond. When this process is complete a signal is sent to a designated control handset via the appropriate I/O port as a message to the user that the system is ready to accept data. Subsequently, every 10 ms. the program checks the status of the input lines on those I/O ports to which handsets may be connected. The state of the input lines is shown on the LED indicators of the corresponding handset except for the two bits on the control handset which are reserved for cassette motor control. If, since the previous search, any input bit has changed from 0 to 1 (e.g. a button has just been pressed), the time, the handset number and the button number are recorded in ASCII code. This information, together with a parity symbol, is stored in RAM and forms one record.

Twenty such records form one block of data which is then output to tape. The output line on one bit (bit 7) of the control port is momentarily set high (= 1). This port is also connected to the cassette interface and the signal is used to start the cassette motor. A software delay of 1.25 seconds then occurs to allow the tape to reach its full speed. The program then outputs a START BLOCK message followed by the twenty records, and an END BLOCK message. The output line on bit 6 of the control port is then set high; this signal stops the cassette motor. It takes about eight seconds to output one block of twenty records.
While the output procedure is taking place the program continues to check the inputs and record events in a buffer area in RAM. In the present system the buffer can hold five blocks (100 records) of data. Before beginning to record a new block, the program checks that there is sufficient space in the buffer to record the data. If this is not the case, a signal is output to the control handset to indicate that an overflow has occurred. The program must then be restarted and any data not already transferred to the cassette recorder is lost.

In order for an overflow to occur, the access rate must average more than 150 events per minute. For present purposes the access rate is low enough not to overflow the system. However, the system may be extended to cope with a higher access rate.

DATA ANALYSIS

The raw data is played back from tape via the AC-30 through a UART port at 300 BAUD to files on a CDC 6600 computer. The accuracy of the transfer is checked using the parity symbol on each record and the data is reformatted for use with our existing analysis programs.

DISCUSSION

The data collection system described here satisfies all of our initial requirements. Although the equipment is portable, it is larger than was first envisaged - this is mainly due to the size of the AC-30 and the batteries used as its power supply. A second version is being designed which should eliminate the need for the AC-30.

Most automatic traffic detectors in present use are based on induction loops or pneumatic tubes. Induction loops are generally used for permanent installations, and are relatively expensive. Pneumatic tubes provide a cheaper alternative, and may be used with the ATRN system. We have
used coaxial cable (with a suitable interface) in preference to pneumatic tubes because we found them much easier and quicker to install. Trials have shown this method of detecting vehicles to be successful, provided that the vehicles are travelling quickly enough (of the order of 10 mph and above) to "hit" the cables with sufficient force to produce a signal.

An observer presses a button on a handset to indicate that a specific event has occurred. The present system records the time the button was pressed to an accuracy of one hundredth of a second. The accuracy of the data recorded is limited by the accuracy of the observers.

The existing system is very versatile. It accepts data from switch closure inputs, formats it and outputs it to cassette tape. Thus it could be used for many real-time data collection purposes - not necessarily confined to traffic studies - provided analysis programs were available or could be written on a mainframe computer. Indeed a mainframe computer is not necessary. The data could be fed back into the MK4 system and a program written so that the microprocessor could analyse the data. The main limitations are on the data acquisition rate and the data transfer rate.

Although, at present, we use the system merely to collect data, the system could be adapted for many computing tasks. By connecting a teletype, VDU or similar device to the UART port of the MK4 system, one has a self-contained computer system. The cassette interface can accommodate two cassette recorders, allowing program and data storage, and the possibility of developing editing programs.

When using the existing system it is a simple matter to check visually that the cassette recorder is stopping and starting. LED indicators on the AC-20 show when it is receiving data. There is, however, no check that the data is reaching the cassette recorder, or that such data is meaningful.
An external earphone can be connected to the cassette recorder to check that some sort of signal is reaching the recorder. To check that the data is meaningful it would be necessary to connect some form of digital display between the interface and the recorder or to the output socket on the recorder. This is not thought to be worthwhile for our present purposes as data can be quickly checked on return from the field, and the site can always be revisited. However, if the system is used for other tasks, such a check may be required.

The data collection system, as described in this paper, has been used at several T-junctions. As with almost all new systems, there have been some problems. These have arisen primarily from two sources: bad connections between the cassette interface and the cassette recorder; the power supplies on the cassette interface and cassette recorder have sometimes become too low to operate effectively. The latter problem is caused by human error in leaving power switches on or in not keeping the equipment fully charged. The second version of this equipment (now being designed) will eliminate both these shortcomings, as the cassette interface and cassette recorder are being replaced by a cassette unit within the MK4 system, thus eliminating the need for connecting wires and separate power supplies.

Despite the "teething troubles", we now have a considerable amount of data on the files of a mainframe computer. This new system of collecting traffic data requires, as was expected, much less time between observations and results, than the previous video methods.

CONCLUSIONS

(1) The system has been used to collect traffic data from several T-junctions.
Analysis of this data is comparatively easy, and much quicker than using video techniques.

(2) The accuracy of the data is limited by the accuracy of observers in a real-time situation.

(3) The equipment, although fairly bulky, is portable; a second version is being designed which will be physically smaller than the initial system.

(4) The system can be used for other data collection purposes or, with modifications, it can be used to perform many computing tasks.

(5) At present, data collected on site cannot be checked there. Checking the data on site is thought to be feasible but not necessary for our present purposes.
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APPENDIX I

EQUIPMENT

(a) Golden River Equipment

(i) 1 MK4/1 Card Frame.
This houses and connects all the various modules in an MK4 system up to 17" in total width.

(ii) 1 MK4/2 Case.
This accommodates one MK4/1 Card Frame to provide a finished housing for an MK4 system in a protected environment. An environmental case is also available but the lighter (in weight), cheaper MK4/2 is sufficient for our purposes as we do not intend collecting data in the rain nor do we leave our equipment unattended.

(iii) 1 MK4/4 Power Supply.
This consists of rechargeable Nickel Cadmium Cells. Provision is made for operation and charging from 240 V AC or a 12 V DC supply, such as a car battery.

(iv) 1 MK4/4 Microprocessor.
The microprocessor provides all the logic to perform the instructions stored in program memory.

(v) 1 MK4/6 Random Access (1024) Bytes.
This is used as a temporary data storage space and provides a "working area" for the program.

(vi) 1 MK4/7 Programmable Read Only Memory.
This is used as read only memory for areas of program or data which must not be altered in the course of program execution.
(vii) 4 MK4/12 I/O Port B.

These units each take 8 switch-closure inputs. Outputs are used for LED indicators on the MK4/19 handsets and, in our configuration, two bits of one MK4/12 output are used for the cassette motor control. Each MK4/12 has two parallel I/O sockets.

(viii) 1 MK4/13 RS232C Interface.

This is the UART port which allows for devices such as modems, teletypes, VDU's to exchange data with the processor and memory.

(ix) 1 MK4/18 Real Time Clock.

This provides a time base for maintaining an accurate software based clock by generating an interrupt cycle every 1, 10, 100 or 1000 ms.

(x) 4 MK4/19 Handheld digital I/O units.

Each of these consists of 8 push buttons as inputs to the MK4; 8 LED indicators as outputs from the MK4; 4 toggle switches to control the state of 4 external flag lines (not used); and one toggle to switch off the LED indicators to conserve power.

(b) SWTFC AC-30 Cassette Interface

This is a mains powered unit which has been modified to run off rechargeable batteries. Its purpose is to connect a computer (or microprocessor) to one or two audio cassette recorders for the purpose of program or data transfer. Signals from the computer can be used to stop and start the cassette recorder motors. Software delays must be included in the controlling program to allow the motors to attain full speed before data transfer.
This is a National Panasonic cassette recorder, Model RQ-212DAS; it has a remote jack socket which can be connected to a remote control to stop and start the cassette motor.
REFERENCES


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Fig. 1 Data Collection System

![Diagram of Data Collection System]

- **SE~SORS**
- **HANDSET**
- **CONTROL I/O PORT**
- **I/O PORT**
- **PROM**
- **CLOCK**
- **MICROPROCESSOR**
- **UART I/O PORT**
- **AC-30 INTERFACE**
- **CASSETTE RECORDER**

**Data Flow**

**Control Signals**