

TeX in the Operating Theatre: An anaesthesia application

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Abstract

This article describes the author's experience of using TeX for typesetting the *Anaesthesia Record* as part of an automated data-collection system developed for use in the operating theatre.

Introduction

Since the theme of this year's conference is "Integrating TeX with the surrounding world" I would like to describe my integration of TeX with the world of the operating theatre — specifically with the domain of anaesthesia.

One of the many things that occupies anaesthetists during an operation is documentation. This takes the form of a log of various physiological parameters (see Figure 1), drugs used, blood lost, fluids administered, procedures performed etc., otherwise known as the *Anaesthesia Record*. Since this is generally a hand-written record, the documentation side of things can become rather neglected during busy periods, and consequently, anaesthetists are increasingly using computers to automate the collection of such data. This has many advantages including allowing real-time processing of data, generation of various derived parameters, and greatly enhanced information display facilities.

Collecting and processing the data

Since most monitoring equipment used in Critical Care environments has an RS-232 serial interface the process of data-collection, construction of trend graphics, formatting and typesetting can be automated reasonably easily.

My own system is a menu-driven research application which uses compiled QuickBASIC programs to coordinate the access, display and printing of both real-time physiological data and keyboard inputs. The printing module uses L^AT_EX to typeset the text and graphics to create the *Anaesthesia Record* in a format suited to the hospital notes.

The data from the various anaesthesia monitors is accessed via the serial port using a multiplexing device. Individual parameters are then extracted using the relevant software for each of the various monitors — see [1] for interfacing details relating to particular anaesthesia monitors. Unfortunately there is currently no standardisation with regard to data formats for medical monitoring devices, but this may well soon change with the development of the new international Medical Information Bus (MIB) standard.

During anaesthesia the program accesses and displays all the data in real-time as graphic trends, as well as deriving a number of so-called 'value-added' parameters and processing keyboard entries. At the end of the operation the program typesets the text and graphics to form the *Anaesthesia Record*.

The graphics are created using the excellent *freeware* program GNUPLOT¹ which allows batch processing and will output graphics in L^AT_EX picture format.

Armed with the maximum and minimum values for each of the measured parameters, the program writes the GNUPLOT input files, and then calls GNUPLOT, outputting the graphics in L^AT_EX picture format, and placing them into the appropriate directories. The program then writes the L^AT_EX input .tex file, and then calls L^AT_EX to typeset the text and graphics. Finally the .dvi file is printed and put into the hospital notes. In practice all this is performed locally within the operating theatre, such that the *Anaesthesia Record* is printed and placed in the patient notes just as the patient is returned to the recovery area. Figure 1 shows the graphics page of a typical *Anaesthesia Record*.

¹ http://www.cs.dartmouth.edu/gnuplot_info.html

Advantages of ASCII-based systems

The fact that both T_EX and GNUPLOT use inputs which are ASCII-based has the great advantage that their input files can be written on-the-fly by the coordinating computer program. Such flexibility allows the final text and graphics of the document to be tailored to the data. For example, this allows the axes of graphs to be automatically adjusted depending on maximum and minimum values. Similarly, text layout can be made to vary depending on the particular keyboard entries made during the operation.

Small is beautiful

An automated system for data collection, display and printing has clear advantages over the usual hand-written method; it is certainly a more accurate record, and physiological data can be sampled much more frequently. Furthermore, keyboard entry

of drugs and other information can be made simple and fast by careful design of the interface.

Since this is a specific stand-alone application, it is possible to use a much cut-down version of L^AT_EX consisting only of the essential files, fonts and style options required for the application, with the effect that the size of the printing module can be made extremely small. A not insignificant bonus, therefore, of using T_EX as the typesetting engine is that I am able to make use of old 386 PCs having relatively small hard-drives, which have been discarded by my memory-hungry colleagues!

References

1. Nickalls RWD and Ramasubramanian R (1995). *Interfacing the IBM-PC to medical equipment; the art of serial communication*. Cambridge University Press, Cambridge, UK. pp 402. ISBN: 0 521 46280 0.

ANAESTHETIC SHEET

Theatre 1, City Hospital, Nottingham, UK.

JOHN DOE
 dob 24/01/1925
 Hosp No: 123456789
 Nightingale Ward
 Age: 75

DATE: 18 August 2000
 OPERATION: Laparotomy
 ANAESTHETISTS: RWD Nickalls *et al.*
 SURGEONS: AN Other *et al.*

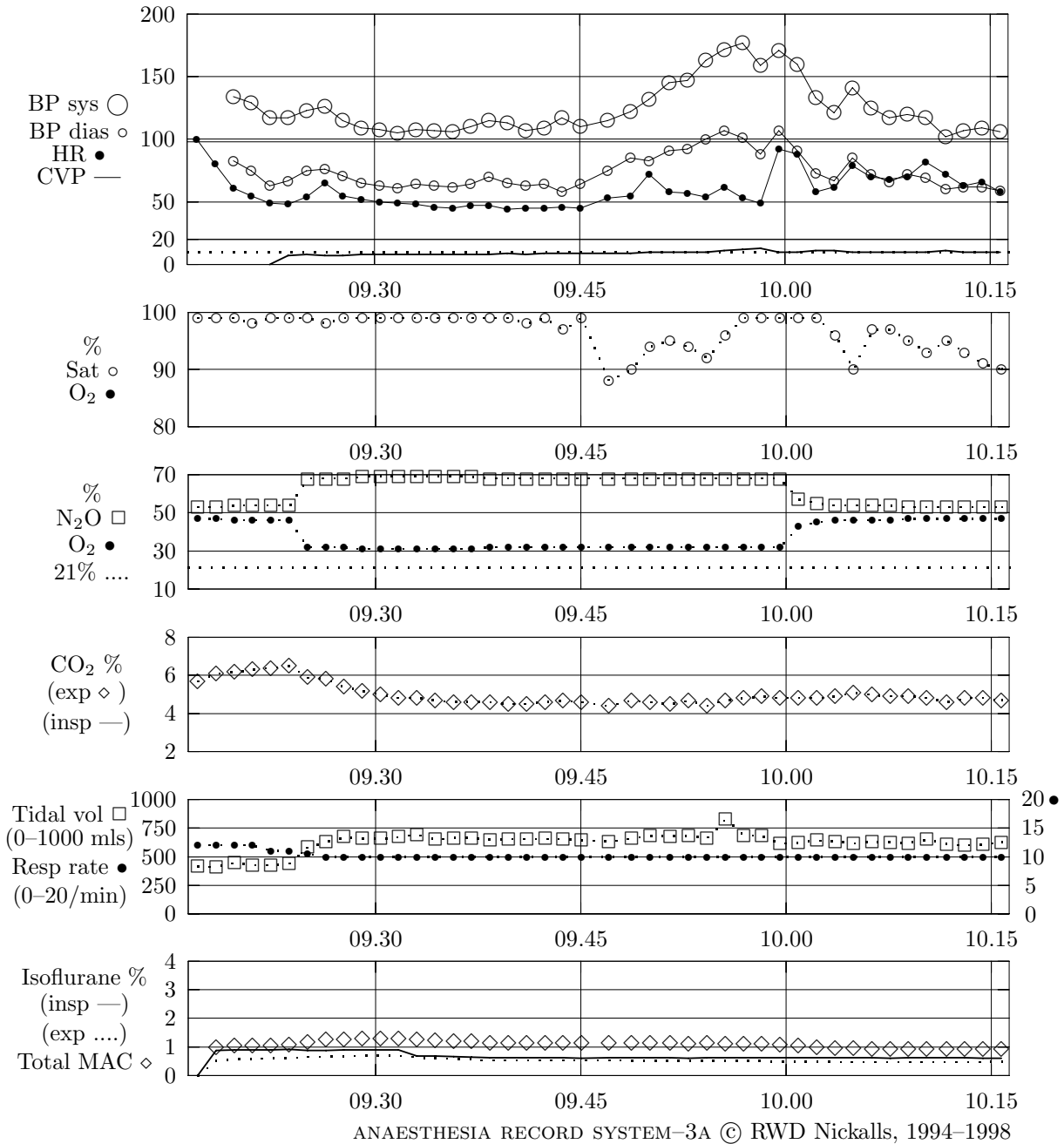


Figure 1: Example of the graphics section of a typical *Anaesthesia Record*. The six graphs are output by GNU PLOT in L^AT_EX picture format. The record shows blood pressure (BP), heart rate (HR), central venous pressure (CVP), oxygen saturation of haemoglobin (Sat), inspired oxygen (O₂), inspired nitrous oxide (N₂O), expired carbon dioxide (CO₂), tidal volume, respiration rate, isoflurane and MAC.