THE GRIFFITH PIMEX PROJECT

Yugant Bhargav, David Bromwich, Steven Beames
Griffith University

Keywords: PIMEX, exposure visualisation, telemetry, occupational hygiene, welding

Corresponding author
Dr David Bromwich
School of Environmental Engineering
Griffith University
Nathan Q 4111
D.Bromwich@griffith.edu.au

ABSTRACT

The PIMEX (Picture Mixed Exposure) technique has been used by groups in Sweden, UK and Finland to investigate and communicate the effect of work on toxic exposures in small and medium sized industries. PIMEX uses synchronised video of toxic tasks and exposure data, assisted by software to visualise and analyse the data. An Australian version has been developed at Griffith University with a view to popularising the technique and to make it more affordable. The Griffith PIMEX system permits up to six channels of data to be telemetered from a backpack which monitors instruments such as a MIE MiniRAM or a HNU photoionisation detector, pulses from a Polar heart rate belt and thermistors. Up to eight hours of data can be logged by the backpack. The video data from a webcam is compressed in real time on a laptop computer, allowing many hours of recording to its hard drive. A significant part of the project will be the release of the Visual Basic source code to other researchers to permit further improvements to be made by other groups.

INTRODUCTION

Most occupational hygiene measurements focus on the measurement and evaluation of toxic exposures in the workplace. In the early days of occupational hygiene, Sherwood and Greenhalgh (Sherwood and Greenhalgh 1959) found that when workers were shown their personal inhaled dust, an immediate reduction of 80% of exposure resulted. Whether the reduction was sustained was not noted. Most monitoring does not reveal what part of the process is causing most of the exposure, so shift averages are of limited value in exposure control.

A relatively new technique, the PIMEX (Picture Mix Exposure) method (Rosen and Lundstrom 1987; Rosen 2002) focuses on exposure control and communicating to the workplace how work practices affect exposures. Data from gas, vapour and other sensors is recorded, along with synchronised video of the person wearing the sensor. Similar approaches have been used by ergonomics and physiotherapy (for example, Holzmann 1982; Spector, Eilbert et al. 1982). Analysis of the exposure data permits the hygienist to determine how the performance of a task affects the toxic exposure.

Technological developments have permitted a move from complex and bulky video recorders to laptops. Associated with the technological developments are subtler implementation methods. This is well advanced in Sweden, Finland and UK, where years of trial and error have shown that effective use of the PIMEX technique depends on transferring ownership of the information to the workplace. Rosen (2002) found that a 90% reduction in toxic exposure was possible when empowered workers were able to revise their use of existing exposure controls to reduce that exposure. Just interpreting the exposure information and not fully involving workers and employers limits the impact of the technique. However, this paper will deal only deal with technological developments and not the methods of using it.

METHODS

The project genesis was in 1982 (DB) in an investigation of excessive exposure to toxic metal oxide dust during a drum filling operation. TWA measurements of respirable dust had not identified the main source of the metal oxide exposure. A Rotheroe and Mitchell SimSlin laser aerosol photometer attached to a chart recorder was used so that trends and relative exposures of the dust could be visualised. The chart recording was annotated with a pen during the trials. The chart recorder analysis clearly revealed that the manner of placement of the drum lid was important, as vertical placement of the drum lid displaced an invisible cloud of fine dust. It was found that sliding the lid on minimised the dust exposure.

More work (Bromwich 1995) was done with data (noise exposure) stored on the audio track of a video camcorder, ensuring the data and video were synchronised. The audio was analysed using the PC's sound card and overlaid on the video image as a frequency spectrum using a For-A video overlay box. This approach did permit post-exposure manipulation of the data, but it was still crude. The approach was similar to that of Gressel et al. (1993), but somewhat simpler.

The present project is based on three final year microelectronic engineering student thesis projects. Much of the groundwork was performed trying to develop a system using a sophisticated microprocessor (Motorola HC11) based integrated system (Wythe 2000). A simpler system based on on-screen display technology used in television sets was developed (Naicker 2002). This permitted data from a sensor fed in to a PC to be overlaid on a video stream and recorded on a video recorder, keeping the video and data stream synchronised. The most recent work used the resources of the universities electronics workshops (SB) to fully develop the hardware and the student (Bhargav 2003) to develop the software.

The advent of faster PC's opened the possibility of storing video data straight to a PC. Programs like LabView (National Instruments http://www.ni.com/labview) and custom programs written in C are in use by the groups in Sweden and UK, but they require either considerable expense or programming expertise. Our experience with programming PIC microcontrollers (SB) and Microsoft Visual Basic (DB, YB) has permitted the development of a sophisticated hardware and software system with limited technical resources.

A significant free resource is the ezVidCap Active-X control (Mercer 2000) that not only permits the use of any Video-for-Windows (VFW) compatible camera (including most webcams), but real-time video compression and easy synchronisation of the video and data streams. The real-time video compression permits hours rather than minutes of video to be stored on a laptop hard drive. The VFW technology is now ageing, but more powerful Microsoft Windows DirectShow technology does not yet directly support Visual Basic.

An integrated PIC based data acquisition, logging and telemetry system was developed on a single circuit board with the following features:

- Six sensor channels, including a pickup for a Polar heart rate belt and interfaces for thermistors (temperature), a MIE MiniRAM (dust) and HNU 101 Photoionisation detector (solvent vapours). Most other PIMEX systems have 1-2 channels. A LED flashes at each detected heartbeat to show the Polar belt is fitted properly. Two thermistors were used to make a crude ear canal tympanic membrane heat stress sensor and a single thermistor was allocated for skin temperature. A pushbutton was also added to permit recording of "events". For convenience, the system was put in a cheap plastic "Interactor" game backpack that came with a battery drawer (Jaycar, Brisbane http://www.jaycar.com.au).

- An 8-bit A-D converter and data logging for up to 8 hours. The Microchip PIC 16F876 microprocessor was programmed in C by one of us (SB) using the Forest Electronic Developments Wiz C software (FED 2003). User programming of the system and download of the data is achieved by direct serial cable connection to a PC.

- Voltage regulation to permit the batteries to drain to 2V. A 240/12 V power pack was added for use during the development phase.

- Digital FM telemetry at 433 MHz to a matching FM receiver powered by the serial port of the PC. The range of the system was over 20 meters inside the laboratory. An indoor range of 75 meters is claimed (Radiometrix 1998).

- Data and video logging, display and analysis software (Visual Basic 6, Microsoft) on a PC (Intel Pentium 3)

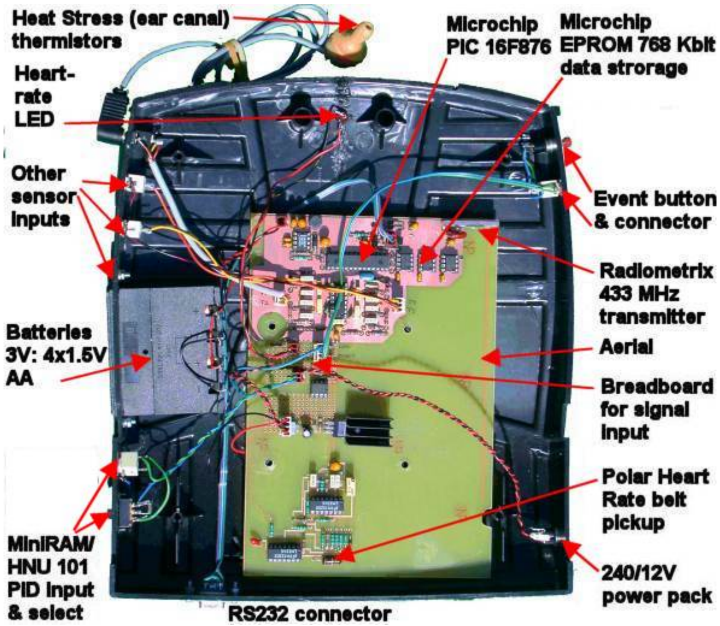

Figure 1 Griffith PIMEX unit

- Remote pan and tilt of the video camera with a mouse, permitting a worker to be followed. This minimises toxic exposures to the hygienist and makes camera placement easier. The Visual Basic software permits automatic return of the camera to a pre-selected view. Servo motors used in radio controlled models with a cheap controller board (Oatley Electronics 2003) The controller board was powered by a modified computer 5-12 V power supply and controlled by the computer via a serial (RS232) port.

Calibration of the sensors was performed using Tedlar Bags (HNU 101 PID), comparison with another sensor (TSI Dustrack for dust, thermometer for thermistors). The calibration curves were calculated with a spreadsheet (Excel 2000, Microsoft) and embedded in the control code.

It was found that 10 frames per second was an adequate frame rate for the video record. The data sets from the sensors were logged at twenty sets per second. As faster PC's become available, the video frame rate will be increased. Much faster data telemetry is available but probably not needed. The frame number and time (to the nearest millisecond) is saved with each data set from the sensors.

Rosen and Andersson at the NIWL, Stockholm use Camtasia (TechSmith, http://www.techsmith.com/) a sophisticated computer screen recording and editing program to assist the preparation of CD reports of trials. This approach has also been adopted with some success.

ISSUES

Real time video compression produced some timing issues in the prototype, as the software still had to process both the video data and the data stream telemetered from the PIMEX unit. Further code optimisation is being performed to permit real time graphing of exposure data. This feature was seen as desirable as insights into exposure patterns can be gained during the recording of sessions. There is also a need for field-testing in the presence of interference of the telemetry signal from electrically noisy operations like electric arc welding, so that the software can correct transmission errors.

The greatest technical challenge is to produce an open code system that can be readily adopted by a variety of users, each with their own data gathering system and analysis needs. It is relatively simple to link the telemetered data to a spreadsheet program like Excel (Excel 2000, Microsoft), including automated charting and processing of the data. Excel offers a powerful programming language, Visual Basic for Applications (VBA) especially when coupled with the Windows Application Programming Interface (API). The API permits very fast Window's code to be used directly by the software.

Automated statistical analysis of data has been demonstrated (DB) using Excel, and playback of the video within Excel has been performed. A method of overlaying a moving cursor on the exposure data plots and performing statistical analysis on regions of interest has been developed with Visual Basic and is being applied to work within Excel with VBA. Simple reports can also be generated by automated links to Microsoft Word for immediate discussion in the workplace. Immediacy of data analysis is a key to the effectiveness of the approach and keeping the cost down.

Making the software user-configurable without expensive propriety software (like LabView) is more difficult. A method of video capture and compression that can work within Excel has not yet been found though it is possible to interface instruments directly to Excel. PIMEX software entirely based on Excel is technically feasible, but difficult to implement.

A significant issue in the wider adoption of the technology is the ease of use. For example, most people can operate a videocassette recorder (VCR) at a basic level, but more complex operations (like tuning an extra channel) require a manual. A similar approach has been taken to the PIMEX software design to make basic operations such as recording a session and playing it back very simple and intuitive. More complex features like statistical analysis will be available through menus for "power users".

There are emerging technologies like JavaTV (Sun 2003) that can deal with video, sound and data for interactive television. With such approaches the data stream would be overlaid on the TV screen and contain interactive television program or commerce information. The technology is in its infancy and not yet readily available, but may offer the best approach to PIMEX work in the future.

Parallel sensor developments are also being undertaken. A prototype of a miniature dust photometer (Cully 2003) to fit inside a welding helmet has been developed. The fume sensor will interface with the PIMEX unit, but can also act as a stand-alone monitor as the device has an indicator array inside the helmet next to the visor to give direct feedback of fume exposure to the welder.

The Griffith PIMEX project will continue its technical development phase for some months and begin field trials and development of methodological protocols in workplaces in 2004

CONCLUSIONS

A sophisticated PIMEX system has been developed at a low cost with a number of novel features. There will be ongoing software developments to permit ease of use, and better data analysis and methodological developments for its use it in the workplace.

The ultimate aim of the project is to develop a system for performing PIMEX analysis that is intuitive but powerful, that can quickly analyse the data and produce a written and electronic report on the day of the work.

Performance, affordability and ease of use are the technical impediments to wider adoption of the PIMEX technique. The Griffith PIMEX project seeks to address these issues.

REFERENCES

Bhargav, Y. (2003). 4th Year Microelectronic Engineering Project. School of Microelectronic Engineering. Nathan, Griffith.

Bromwich, D. W. (1995). Teaching Noise Control with Video Overlay. Proc Asian Conference on Occupational Health and Safety, Brisbane.

Cully, A. (2003). 4th Year Microelectronic Engineering Project. School of Microelectronic Engineering. Nathan, Griffith.

FED (2003). WIZ-C, Forest Electronic Developments. URL: http://www.fored.co.uk

Gressel, M. G., W. A. Heitbrink, et al. (1993). "Video Exposure Monitoring - A Means of Studying Sources of Occupational Air Contaminant Exposure, Part 1 - Video Exposure Monitoring techniques." Appl Occup Environ Hyg **8**(4): 334-338.

Holzmann, P. (1982). "ARBAN--A new method for analysis of ergonomic effort." Applied Ergonomics **13**(2): 82-86.

Mercer, R. (2000). EZVidCap Video For Windows Video Capture Control. **2003**. URL: http://www.shrinkwrapvb.com/ezvidcap.htm

Naicker, K. (2002). TEES (Toxic Exposure Evaluating System). School of Microelectronic Engineering. Nathan, Griffith University.

Oatley Electronics (2003). Serial Servo Controller Kit - K172. URL: http://www.oatleyelectronics.com/kits/k172.html

Radiometrix (1998). UHF FM Data Transmitter and Receiver Modules TX2 & RX2. URL: http://radiometrix.co.uk

Rosen, G. (2002). "Seeing is Believing." Ann Occup Hyg **46**(1): 3-4.

Rosen, G. and S. Lundstrom (1987). "Concurrent video filming and measuring for visualization of exposure." Am Ind Hyg Assoc J **48**(8): 688-92.

Sherwood, R. J. and D. M. S. Greenhalgh (1959). "A personal air sampler." Ann Occup Hyg **2**: 127-32.

Spector, B., L. Eilbert, et al. (1982). "Video integrated measurement system." J Manipulative Physiol Ther **5**(2): 55-61.

Sun (2003). Java Technology in Digital TV, Sun Microsystems Inc. URL: http://java.sun.com/products/javatv/

Wythe, B. (2000). 4th Year Microelectronic Engineering Project. Nathan, Griffith University, School of Microelectronic Engineering.