WearCAM Personal Imaging

School of Electronic & Electrical Engineering
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In Association With KODAK

Second Report
MEng Final Year Project
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http://www.isoft.demon.co.uk/wearcam/
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1.0 Introduction
In the last few years there has been increasing public awareness and media coverage of the area of technology called “wearable computing”.

1.1 What is Wearable Computing?
There is now more processing power in a digital watch than was required to land man on the moon 30 years ago, and the power consumption is now so low that a battery the size of a penny will run for many years.

There are already several different types of wearable computer becoming increasingly popular, perhaps without public knowledge that they are wearable computers.

It has already been shown that a digital watch can have features such as: Calculator, Games, GPS, Altimeter, Memo and even TV’s to name just a few. Even more recently has been the development of a mobile phone that is so small, the manufacturers claim it is a ‘wearable phone’. Of course, there are disadvantages to this type of miniaturisation; they can get to be too small. Mobile phone manufacturers are still trying to make phones smaller, while still battling with the fundamental problem that they still need to bridge the gap from the mouth to the ear.

Recently there have been significant developments in video capture and display technologies together with very advanced low power processing devices, allowing new and novel devices to emerge. Most noteworthy and applicable to this project is the area of digital photography, the disadvantage of which is that a computer and printer are still required.

The explosion in sales for digital cameras and other devices based on similar technologies such as scanners and camcorders has made the cost of such systems fall dramatically allowing them to be used for applications that were not viable just a few years ago.

A wearable computer is a device that can be worn either to perform a specific job electronically or for general-purpose use.

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1 The Wearable Phone is from Ericsson
2 Project Aims

The purpose of this project is to investigate wearable camera and display technologies, in order to construct a wearable personal imaging device. The wearable aspect the device gives it great flexibility and could have many other important uses such as military, disabled use or other areas where a normal camera set up would be too awkward. Creating a wearable camera system gives the user a hands-free ability, which might be useful for tourists or people entering dangerous situations where they need both hands free.

The project should include “the design and prototyping of a wearable imaging and display device that can be used to capture, store and share images”.

Taking pictures is very useful, and a system which is based around a wearable computer system should be able to store and sort through the various images with great speed and efficiency. The system should allow for expansion and upgrading of both system hardware components and the software. If the hardware allows, high speed capturing of images could be used to create a moving picture gallery with grouped images or even a small movie.

By the end of this project, there should be a prototype system up and running demonstrating the principles involved. It is unlikely that the system can be made small enough at this stage; therefore, there should be evidence of research into miniaturisation and most importantly power consumption.

Although attention to final cost is a primary consideration during the design part of any product, the emphasis here is on conceptual ideas and technology demonstration.

3 Background Research and Related Documents

There are a growing number of wearable devices around today, infact; there has been media coverage since the project started of wearable computing and its applications. It’s worth pointing out some of the past wearable computing projects that have been attempted by others, since there are some very important lessons to be learned.
The closest project to this one is that from The University of Essex’s VASE laboratory. They set about building their first wearable computer called the Rome Mk I back in 1998.

Figure 1 Rome MK, 1

The Rome Mk 1 was built using PC-104 technology. A PC-104 board is a PC motherboard that is built on a PCB the same dimensions as a floppy disk. Clearly, the advantage of using such a system is optimum compatibility.

In the case of the Rome Mk 1, the big problem is apparent from the pictures is the shear size of the system. In total, four PC-104 boards were used, which stacked up to a great height, they then used a box to hold the system in that had to be even higher. The overall effect has a ‘brick’, which meant that the system was wearable, but only just! To add to the great box, there is also the batteries, and another box that was needed to run the display unit.

Figure 2 Complete Kit
The picture above shows the complete kit. Clearly there are very many components. This type of system would be unsuitable this project as a much smaller system is needed.

3.1 More about PC-104

The PC/104 was brought about by the need for standardisation for embedded PC systems. The standard was introduced by AMPRO computers incorporated who until then had a “Mini-module” form factor board. They then created the non-profit PC/104 Consortium to serve as the custodian for the new standard.

The name PC/104 actually comes from the contactors on the two bus interfaces, 64 pins on P1 and 40 pins on P2.

3.1.1 PC/104 Basic Objectives

The PC-104 specification is an open specification, which means there are several enhancements that have been made to the original specification of the years, such as the plus specification, which will be explained later. However the main objectives of the original system remain the same, these are:

- **Compact** 3.6 x 3.8 inches.
- **Self-Stacking** Expansion cards just stack on to the next level.
- **Pin & socket Bus connector** Reliable in very harsh environments.
- **Four corner mounting** Resistance to shock and vibration
- **Low power consumption** Low heat generation
- **Fully PC Compatible** Reduced development costs and time to market

3.1.2 The PC/104-Plus Specification

The most notable feature of the PC/104 specification is the age. While the amount of time that the system has been around means there is good support with some 200 or so manufactures supporting the specification, there have been many advances since 1992 that have changed the implementation slightly. The most obvious change is the change of bus architecture. Back in 1992, the busses were a mix of 8 and 16 bit ISA types in PC’s, this is the standard supported by the standard 104 interfaces. For a while, there were additions, to this bus such as the VESA local bus (VLB) but the Peripheral Component Interface PCI became the add-on bus of choice. The PCI interface offers a throughput of some 133Mbyte/sec compared to the 5Mbyte/sec of the standard PC bus. This is important to this project because imaging consumes a great deal of bandwidth.
For optimum compatibility and ease of use the PCI implementation had to preserve the original objectives whilst at the same time offering much better performance. This means the new board needs to be the same form factor, and have same electrical specifications.

3.1.3 Physical Dimensions PC/104-Plus

![Figure 3 Dimensions](image)

![Figure 4 Side View](image)

With reference to the above specifications, the PC/104 solution is very compact indeed for such a powerful module. The main difference with the PC/104-Plus is the...
large connector for the PCI bus, which is shown on the lower diagram on the left hand side.

The main PCB should contain the CPU and a system BIOS. Many models however now contain other items such as 10BaseT Ethernet, Video Outputs, LCD Outputs, Video Input, HDD connectors, FDD connectors and many other items, which is amazing when the fact that the PC/104 board has actually effectively got smaller since the introduction of the PCI connector. There are many suppliers of PC/104 boards, such as AMPRO, but the cost even for low spec boards can be very high, but with a time spent on researching the boards, the prices for these boards vary very wildly, from specification and from manufacturer. There are many older boards that are still being produced and used, and hence are holding their price.
4 WearCAM Technical Details

This section contains a brief description of some of the technical aspects dealt with so far in the WearCAM project. Please note that there is a separate technical journal available on the web site that contains a great deal more information at a detailed level.

4.1 Power Management and Systems

As soon as the decision to use the MSM-P5s board was made, focus was required on the PSU. A great deal of time has been spent on designing and testing of the PSU. One might wonder why so much time be needed on such a simple part such as the power supply. The answer lies in the main board itself. There are very strict guidelines on the power requirements of the board. If the full response of the PSU is not known, and for example, the output goes above 5V under low load, the main board could be destroyed along with any device attached to it. Therefore, it made sense to spend a lot of time while waiting for delivery of the board, to ensure that the PSU is as efficient and well designed as possible.

4.1.0 Linear Voltage Regulation

It is not possible to have a 5 Volt battery, or at least if it was then the battery would not be exactly 5 Volts for very long.

It is therefore standard practice to use a higher voltage source than required say maybe 9 Volts and then regulate the voltage to the main circuit by means of a voltage regulator. The regulation of choice for low power applications is a simple linear voltage regulator shown below.

![Linear Regulation Circuit Diagram](http://www.isoft.demon.co.uk/wearcam/)

**Figure 5 Linear Regulation Circuit**

The 7805 is an off-the-shelf IC that literally just has an input and output and a ground, from this it is able to keep a regulated output until such point as it drops out.
4.1.1 Drop-Out

Figure 6 Battery Voltages - Output Relationship

Shown above is a typical voltage trace for a linear regulator over time. Here there is a load drawing current from the voltage source through the regulator. This makes the battery voltage gradually decay. For this example, let's say the battery voltage is a nominal 9V and the regulation occurs at 5V. This has an impact on efficiency.

4.1.2 Efficiency

In the description for a linear voltage regulator, it was stated that there is a transistor that ‘drops’ the unwanted voltage to produce an output voltage. This drop is a major concern in terms of efficiency.

4.1.3 Efficiency Example:

Suppose our battery was 10 Volts, we need an output of 5 Volts to run our system, and that our system requires 5 Watts. So there is 1 Amp flowing through our load. We also have a 5 Volt drop across our regulator, which also has 1 Amp flowing through it to feed our load. This means that there is a loss in our regulator of 5W! This means that this regulation is only 50% efficient, at best!

Clearly we are using a battery operated system and so we do not want this type of loss, because that would mean we are carrying around batteries that are twice as heavy as needed, or they only last half as long as we need. There are two options, lower the input voltage or use a much more efficient converter.

4.1.4 Voltages

Why is such a large voltage necessary on the input? With reference to the battery voltage versus time graph it is notable that the battery undergoes discharge, and its internal resistance raises causing a drop in its output voltage. This is allowable with
our regulation, and there are advantages. A battery monitor circuit can be built that
monitors this voltage and can produce a low battery warning condition. Also if a
curve comparator is used, battery time remaining can be calculated, which can be
very useful on this type of system, as it gives the user some time to protect unsaved
work in volatile memory.

For the Wearcam long battery life is needed, and the power being lost in a normal
converter could be much more than 50%, this is lost in heat and is very inefficient
and undesirable. Fortunately, there are neat solutions to this problem, at the
expense of complexity and noise.

4.1.5 Higher efficiency – DC-DC Conversion – Longer Battery Life
The solution is to use a DC-DC converter circuit. This type of circuit works on the
principle of chopping the input voltage up on a sort of Pulse Width Modulation basis
and smoothing it out using an output filter. This is more efficient because the
regulation transistor is either on or off, and not in the linear region at any time, so
there is very little loss. 

Efficiencies for this type of voltage conversion can be in the high 90%+ region
depending on the type of regulation required and the load. Another advantage of
switching converters is that they can work in two modes, Buck or Boost
configurations. This allows them to produce outputs that are lower and higher than
the input voltage: - Yes, they can produce a higher voltage at the output than the
input. Conversion efficiency alters with the input voltage. For the Wearcam project,
efficiency greater than 80% can be expected and with access to high quality
components, an efficiency of up to 90%+ can be achieved.

2 Please note that the description for a switching regulator is actually more
complicated and beyond the scope of this technical article, however the above
explanation is sufficient for this purpose.
4.1.6 LM2596 Switching Converter

The LM2596 regulator contains circuitry that maintains the output voltage by means of a feedback loop as can be seen from the application note above. It can then vary the modulation duty cycle to maintain a steady output voltage when the load is fluctuating. The regulator works by building a current up in the inductor and then using the current characteristics of an inductor to inject current into the output capacitor. Typically, this circuit uses a switching frequency of about 150kHz, and this switching causes the output voltage to have a ripple and noise at the 150kHz fundamental and at several harmonics either side of the fundamental. As will be shown this can have undesirable effects on the circuits. Usually digital circuitry have their own power supply de-coupling – which means that they filter the supply voltages for their own use and so the noise caused by our converter is usually not a problem in this configuration.

Of course, enhancements can give rise to higher frequencies such as 240kHz. This gives a higher frequency ripple that is easier to remove with smaller output filter capacitors, which leads to a smaller overall more efficient circuit.

Figure 7 LM2596 5Volt version

3 Pictures taken from the data sheet.
4.2 PSU Design Testing and Performance

The PSU has been designed in accordance to the data sheet using an LM2596. The smallest inductor available at this time is a 47uH however; this is not a problem since it helps the unit withstand abuse better. The output stage capacitor is a 250uF electrolytic capacitor, which provides nice low ripple even at full load.

![PSU Prototype (Top View)](image)

Figure 8 PSU Prototype (Top View)

The actual PCB for this PSU is very small occupying some 35mm x 25mm the largest component being the input filter capacitor.

The following has been chosen for this configuration:

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Filter</td>
<td>470uF</td>
<td>25V</td>
</tr>
<tr>
<td>Output Filter</td>
<td>220uF</td>
<td>25V</td>
</tr>
<tr>
<td>Inductor</td>
<td>47uH</td>
<td>3A</td>
</tr>
<tr>
<td>Diode</td>
<td>1N5822</td>
<td>5A</td>
</tr>
<tr>
<td>Switcher</td>
<td>LM2596</td>
<td>3A</td>
</tr>
</tbody>
</table>

4.2.1 PSU Performance

![Switching Waveform](image)

Figure 9 Switching Waveform

The actual performance of the circuit is very impressive offering an output voltage of 5.00 Volts. The circuit was tested with a range of different loads to see what the effect was on the output.
The graph on the left shows the output ripple greatly amplified. The rising slopes are caused by the inductor charging up the filter capacitor and the falling slopes are caused by the filter capacitor discharging through the load while the inductor current is building.

Because of the nature of a switched PSU, there will always be lots of noise in the output. It can be seen that the switching spikes are very large and very fast. Normally these spikes would not be a problem, however it would be a good idea to try to reduce them by adding a few modifications.
4.2.2 Modifications

Figure 10 PSU (underside) with modifications

To help reduce the effect of the stray inductance the ground tracks are all in a single block. If this PSU were to be made on a PCB, it would be advisable to have a ground plane as this helps to keep the interference to other systems down as well.

In addition to the supply input capacitor, a further 100nF ceramic capacitor (brown) has been added to reduce high frequency noise.

On the output, there are two considerations to be made to ensure that no damage occurs to the rest of the system and these are voltage spikes, such as those produced by the switching and input transients.

The output can produce transients above the 5V level if the load changes rapidly or if there is a brief interruption to the supply. Some protection is needed to prevent the output from going too high. The blue component is a ZENER diode. This has a fixed reverse breakdown voltage. In this application a 5V1 (5.1Volt) Zener has been used, and this will help clamp the output to 5.1 Volts should a transient occur thus protecting the system. To help combat the high frequency switching noise on the output, a further 100nF ceramic disc capacitor has been added.

Figure 11 Improved Output
From the graph it is clear that the spikes have been virtually eliminated and the output voltage ripple is normal and to be expected\(^4\). The MSMP5S board is designed to run from a supply of 5V +/- 5\%, which means between 4.75 and 5.25 volts is acceptable. Here the PSU is producing 5.00 Volts with a ripple of about 75mV pk-pk.

### 4.3 PSU Performance

![Power Regulation Graph](image)

**Figure 12 PSU output**

The regulator performed well. It was then taken substantially beyond its designed operating point. Even at 162\% of its designed maximum load, the output voltage is still within 5\% of 5V. The PSU was left to drive this heavy load for 5 minutes with no ill effects.

#### 4.3.1 Supply Rise Time

The manufacturers of the MSMP5S board, Digital-Logic, specify in the user manual for the board, a supply rise time from 0 to 4.75V in 100us. If a normal linear regulator such as an LM7805 were to be used, the rise time would be in the order of a few tens of ms.

\(^4\) The graph shown is a modified version of the original and is not an actual graph; this is because the graph shown is not available. This graph is for illustration purposes only based on actual observations.
After a bit of investigation, it was believed that this rise time quoted by the manufacturers has to be incorrect. The reason for this conclusion is that if all the capacitances of the system including all the supply de-coupling for each of the IC’s is added together, a rise time of 100us would require a few tens of amps to produce.

Steps were taken to chase up the supplier of the board to confirm our suspicions. It turns out that this rise time is that rise time quoted by Intel for the processor and that that is what they had put in the data sheet. It was pointed out that the processor runs on 1.8V and the board on 5V and that the 1.8V probably needs a rise time of 100us. The reply was: -

--[The specification for the Power Rise Time of 100 micro Seconds (+10 %) is given from Intel.
That's why we are specifying this value in our manual as well. By specifying this value, Intel is going to the safe side. The experience shows, that available power supplies specifying 250 micro Seconds (again on the safe side but in the other direction) are working very well with our MSMP5S boards.

I hope this information will help you a little bit.
Regards]--
>Martin Niggli – Digital Logic

What is the rise time of the switching supply? Note that the converter uses a 150kHz oscillator, that’s a full cycle, every 6us. With this in mind, the converter should have already been through quite a few cycles and be well on its way to 5V by the time 100us has elapsed, it should definitely be more than 1.8V by this time.
The converter was attached to a load that would simulate the wearable computer, and the graph above shows the rise time. It can be seen that the rise time is around 250us, which is most impressive and the overshoot is very small indeed. It's perhaps worth pointing out that a mechanical switch does not have a rise time as clean or as fast as this!

The supplier of the board is satisfied from the graphs and the description, that the power supplies can more than adequately handle the board.
5 WearCAM Progress

After a great deal of searching, the Microspace MSM-P5S was chosen. The MSM-P5S board is made by a company called Digital Logic (http://www.digitallogic.ch) and they have a very wide range of PC/104 boards as well as Slot PC’s and all the peripherals such as frame grabbers, audio cards and network cards etc that are designed for the PC/104 form factor.

The board comes in four types; there are 166Mhz and 266Mhz versions in both 32 and 64 Mb RAM versions.

5.0.1 Memory Capacity

For the purpose of WearCAM, the key is imaging, and imaging requires a large amount of memory, so 64Mb RAM version is the better suited. This also gives advantages in that it produces a faster system with less hard disk drive usage, which means that the power consumption is lower.

5.0.2 Main CPU

The two versions available are the Pentium 166MHz, and the 266MHz. Although it might ordinarily be beneficial to opt for the faster processor, there are other factors to consider.

The 266MHz processor consumes a great deal more power and requires active cooling in the form of a fan, however the 166MHz uses much less power (<5W) and doesn’t require any cooling.

With this in mind, it makes more sense to go for the board with the largest amount of memory with the lower powered 166MHz processor. This will insure that the capacity of the board is sufficient to handle the graphics and the operations that we require, whilst at the same time using as little power as possible.

5.2 The board

When the board finally arrived, there were some cables supplied with it to connect the HDD and all the other components together. Even though at this stage, the PSU

5 See costing for further details.
was certified OK, there was considerable reluctance to power the board up due to some uncertainty on exactly how to apply power to the board.

In the manual, there is a shared power and Infrared connector, but there was a pin called LID. There were no references anywhere in the manual or on the web as to what this pin is used for so support was contacted. In the schematics, there is a reference to JP31, which is a connector next to the power connector. This had no explanation in the manual, only that pin1 is [+ ] and the other is [- ]. It would seem sensible then to assume that this is actually the power connector, and sure enough using a multimeter, the pins were internally connected to those on the power connector. This is where it was decided to apply the 5V for the board. It’s strange that this, perhaps the most important point that should be in the manual, was not mentioned in the manual!

Finally, after connecting an ammeter in series with the power to watch the current consumption, the board, with all its connections made, was powered up.

The board quickly began the boot process, the HDD spinning up and the power lights coming on, and then the system attempted to boot, only to find the contents of the CMOS RAM corrupt. This was because the RAM had no information about peripheral devices, and which is easily fixed by loading in the default values from the set-up menu.

5.3 Setting the board up and testing
The next course of action, with a board that appears to be working is to test the various parts and try to get them working.

At first, the board is set up in its minimum configuration, which is with a HDD, a keyboard, mouse and a monitor. This minimises confusion when it comes to trouble shooting.

The HDD was obtained from a Toshiba laptop and had not been formatted prior to fitting to the board so just out of interest an attempt was made to boot the already installed Windows 95, which was successful. The laptops architecture is completely different from that of the board and so Windows re-detected everything but after which the system was fully functioning.
Finally, the installation of Windows was scrapped in favour of a re-install from scratch, as this removes any parts that might be conflicting and ensures a clean system.

The installation when without any major problems, except it didn’t detect a range of things such as the Network Interface or the Video-Capture device amongst other items. This turns out to be the way that they are used on the board and is quite normal. It took a while to get the Network working, (but for future reference for anyone following this work, you need to set it up in Windows and then use the EEPROM tool to set the actual hardware to the same values that Windows assigned. Then it works OK). The network was set-up with file and printer sharing using the IPX/SPX protocol and TCP/IP. This allows communication with the host PC ‘infinity’ and to its drives, for development purposes.

5.4 Video-Input

Following the manual for the video-in did not help at all. There were many things missed out, or changed by the recent board revision to 3.4. However, a search through the support disks gave some inspiration for the video-in by way of a DOS utility. Perhaps it’s better to get the device working under DOS than Windows, and once working under DOS there should be no problems in windows. After large amounts of time, and frequent conversations with the manufacturers, it now looks as if the board may be at fault. The items learned are.

- Saainit for some reason swaps 1 and 3 (inputs are reversed)
- The device does not work at all after powering up except very occasionally usually after long periods.
- When it doesn't work in DOS, it doesn't work in windows.
- When it works in DOS it works in Windows.
- Software reset i.e. ctrl-alt-delete allows reset without making it fail
- Hardware reset i.e. power off or reset switch make it fail
- Overlay surface and capture resolution depends on screen mode and depth
- Current consumption appears very slightly higher when it works properly
- Video input very good when it works, good spatial definition.

The reply to which is to send the board back for investigation. This would mean being without the board for an extended period. A decision is yet to be made.
6 The Future of WearCAM

The WearCAM project has to be constantly looking at future developments, because even since the project started there have been a great deal of enhancements and break thoroughs made that could have an effect on how the final design would look. Therefore, it’s important to keep the search going for new and interesting ideas or developments that might be useful.

For now, the project is in a good position to go in any direction. This is because the Wearable PC approach gives the ability to take on any hardware that might be developed in the future. However, now that a PC is up and running there are obvious milestones completed, and many yet to come.

Clearly, although the system is small and is potentially wearable, a neat enclosure needs to be constructed that allows for expansion and modification in the near future.

There have been offers made for producing an injection-moulded enclosure, and this has the advantages that a nice ergonomic design can be realised to get away from the ‘brick’ idea. Unfortunately even though the device does not require cooling, if the heat sink is enclosed there could be a problem since temperatures of 60 Degrees Centigrade have been measured. Therefore, a thermal analysis needs to be carried out before this kind of development can be done.
6.1 Project Time Plan

**Approximate Time Plan For the Remainder of Project WearCAM**

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<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
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<td>Exams</td>
<td>Resolve Remaining Hardware Issues</td>
<td>Investigate Injection Moulding Case</td>
<td>Design Review</td>
<td>Search for new Technologies to Improve Design</td>
<td>Project Decision Based on Review What needs to be Done Or Changed</td>
<td>Bench Inspection Preparation</td>
<td>Bench Inspection</td>
<td>Final Report Processing</td>
<td></td>
</tr>
</tbody>
</table>

**KEY**

- **Priority**
  - High
  - Medium
  - Low

**Figure 14 Project Time plan**

The time plan can only be approximate, due to the uncertainty of getting the video-input working. There are several fall back positions that can be taken should the need arise.

The important item on this time plan is the design review in the middle. On large projects, it's often the case that design reviews need to be made frequently. It's very easy to lose sight of the original aims of the project. This project is of course aimed at wearable imaging.

The design review offers the chance to sit back and look at what has been learned and what still needs to be done, and still leaves time for changes to be made.
6.2 Other issues – Displays

The original aim of the project is to produce a wearable imaging device. Therefore, the display is an important issue. For the early stages of development, the board was using a standard computer monitor for a display. This is not a very wearable solution, but there are other solutions.

Initially it was the intention to make use of the LCD interface on the board. This interface allows interfacing to just about any flat panel display required. There are of course penalties for using this approach. If a new panel is needed that has not been used on the board by anyone else before, a BIOS needs to be written specifically for it and this is far too complex to be done by the Original Equipment Manufacturer. The panel would need to be sent to the manufacturers who would produce a BIOS for a small fee. This approach should not be ruled out however because there are suitable panels ready for use such as the citizen 4.7” panel (see costing section 7.3.2).

Alternatively, in the School of Electronic & Electrical Engineering, other devices have been bought for other purposes.

A Head up Display unit has been tried and tested in the board and it works great. The unit is a Black and White 640x480 pixel display that is worn in front of the eye. This has been demonstrated to a number of people including KODAK, who have said they quite like the display, as it’s much sharper than they thought it would be. Also new to the Department is a set of glasses from the Micro-Optical Corporation. These are normal glasses with a small projector on the side. They are very light and look very un-obtrusive. Unfortunately, since they are only a prototype there are many problems with them, the image is very small and distorted, and the colours tend to bleed and change badly. However, it’s well worth keeping a good look out for these new technologies.

The clear advantage of the PC approach is that any display can be used, allowing a great deal of flexibility.
7 Costing Information

WearCAM Initial Proposal and Costing Report

The approach to the design of the wearable imaging project, with the constraints in mind has been to use a wearable computer.

This type of approach fulfils many requirements for the HandLeR group requiring a small, unobtrusive platform on which to base the HandLeR system. This interest together with work that has been carried out before by others is assurance that this work is both useful and very relevant. There are commercially available wearable computing systems on the market but the specification of such devices are low and the cost is very high in the many thousands of pounds. My aim is to produce a device that is very small and robust that will have maximum compatibility and performance at a much-reduced cost, to enable a wearable system to be produced that is small enough to be useful and usable for Children and Adults alike.

7.1 Main Processor Solution

Figure 15 MSM-P5s Board (Computer)

The item which makes this possible and the key to such a high performance low cost system lies in embedded technology, and in particular Embedded PC’s. The main international standard for an embedded system is the PC-104 specification, which provides a small (90mmx99mm) PC, which has very low power consumption, and despite its compact size is only mechanically different from normal PC’s.

PC-104 board (90mmx99mm)

7.2 Input Solution
Figure 16 Various Cameras

The input to the system is a small camera, with either a digital interface or composite video capabilities.

There is a large range to chose from, and they are low cost typically from £50 - £100 Small low-cost CCD cameras

7.3 Development Costs

The following items have been chosen for compatibility.

7.3.1 Microspace PC/104 plus MSM-P5S embedded PC module:

This device consists of a 1.8V P5 Core running at 166 or 266 MHz and all the RAM needed and graphics capabilities. The cost varies depending on specification. This module will be useful for many things in the department besides this project.

MSMP5-166-64 with Video Input is £793.00 in 1 off

Contact; Mike Hiller,
Miles Industrial Electronics Ltd Phone: 01604 497544, Fax: 01604 646670

7.3.2 Display Panel

The panel chosen here is compatible with the MSM-P5S and they have tried and tested BIOS, which will ensure that the system will work.

“4.7” DSTN citizen K6481L~FF is £240.50 + delivery

Contact; Trident Displays Limited, Tel: 01737 780790

7.3.3 Camera

Any colour CCD bare camera, prices ranging from £50 to £100 available from Maplin Electronics Ltd or any preferred supplier. This has to be decided later because of uncertainties with the video-input.
The extras required such as a 2.5” drive and connectors should be available in the department and/or come under the normal MEng project budget.

### 7.4 Total Cost to Date

<table>
<thead>
<tr>
<th>Item Purchased or Built to Date</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU - Parts</td>
<td>£ 10.00</td>
</tr>
<tr>
<td>Anti-Static Work Mat</td>
<td>£ 14.00</td>
</tr>
<tr>
<td>MSM-P5s embedded 166-MMX, 64Mb, Video-in</td>
<td>£ 793.00</td>
</tr>
<tr>
<td>Cable Kit, MSM3486VDX-CK</td>
<td>£ 67.00</td>
</tr>
<tr>
<td>MSLAN-CK Ethernet Cable</td>
<td>£ 9.00</td>
</tr>
<tr>
<td>Miscellaneous Hardware</td>
<td>£ 1.00</td>
</tr>
<tr>
<td><strong>Total Approx</strong></td>
<td><strong>£ 894.00</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items on Loan</th>
<th>From</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toshiba 810MB 2.5” HDD</td>
<td>Myself</td>
</tr>
<tr>
<td>Toshiba Micro Floppy Drive</td>
<td>Myself</td>
</tr>
<tr>
<td>12V 7Ah Yuasa Sealed Lead Acid Battery</td>
<td>Myself</td>
</tr>
<tr>
<td>12V 1A AC Adapter</td>
<td>Myself</td>
</tr>
<tr>
<td>Power Supply management Equipment</td>
<td>Myself</td>
</tr>
<tr>
<td>One Microsoft Serial Mouse</td>
<td>Dept of EEE</td>
</tr>
<tr>
<td>One Philips Monitor</td>
<td>Dept of EEE</td>
</tr>
<tr>
<td>Antistatic Leads and Strap</td>
<td>Dept of EEE</td>
</tr>
<tr>
<td>One Head up Display and Lead Mono 640x480</td>
<td>Dept of EEE</td>
</tr>
<tr>
<td>Micro Keyboard</td>
<td>Dept of EEE</td>
</tr>
<tr>
<td>Micro trackball</td>
<td>Dept of EEE</td>
</tr>
</tbody>
</table>
# 8 Glossary

The computer industry is littered with jargon; this is because many of them are too much of a mouthful to say every time and often people don’t actually know or need to know what a particular acronym stands for. It is not the intention of the author to produce a complete computer industry jargon list, but it is favourable to include definitions of any jargon that may be included in or is related to this document.

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACPI</td>
<td>Advanced Configuration &amp; Power Interface, a standard that supersedes and combines both APM and Plug &amp; Play. This standard is not fully supported by any hardware or software at this time. There is some support with Win98 and almost complete support with Win2K</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface; an interface through which applications may communicate with the system at a lower level. Win32 API represents an interface through which windows may be created, files manipulated etc.</td>
</tr>
<tr>
<td>APM 1.0</td>
<td>Advanced Power Management; a standard PC’s use to manage power consumption.</td>
</tr>
<tr>
<td>APM 2.0</td>
<td>As APM 1.0 but with enhancements such as under-clocking and battery status enquiry.</td>
</tr>
<tr>
<td>BIOS</td>
<td>Basic Input Output System; The first block of code that is executed by the system to tell it how to talk to basic devices such as the HDD and Keyboard Display etc. BIOS’s nowadays can handle more complex operations such as power management and PNP options.</td>
</tr>
<tr>
<td>BUS</td>
<td>A collection of wires in parallel along which data travels.</td>
</tr>
<tr>
<td>CCD</td>
<td>Charge Coupled Device; An array of light sensitive cells used to create pictures. CCD’s are the standard for home video cameras, scanners and CCTV’s etc.</td>
</tr>
</tbody>
</table>
CMOS  Complementary Metal-Oxide Semiconductor; a form of RAM that requires very little current because there is never a conducting path from ground to supply.

COM  COMmunications I/O port. Usually RS-232 standard of 9 or 25 pin connector. A standard for serial communication of any speed and format up to 115,200 bps.

CPU  Central Processing Unit; The CPU is the general-purpose component that does most of the computation in a PC. Other devices such as graphics and soundcards now have their own CPU’s, rather ironically they can be faster than the main CPU!

CRT  Cathode Ray Tube; Description of a standard monitor as opposed to a flat panel screen.

DMA  Direct Memory Access, a peripheral has the ability to dump its output directly into or out of memory without the main CPU. This gives a great increase of speed.

DOS  Disk Operating System; the operation system that is loaded from a disk.

DRAM  Dynamic RAM; See RAM, used for the system memory.

EEPROM  Electrically Erasable Programmable Read Only Memory. ROM that actually can be updated if required such as a BIOS.

EL  Electro Luminescent; Production of light by electrical stimulation of chemicals. The idea was stolen from nature.

EMC  ElectroMagnetic Compatibility; Systems are so fast today that problems can be caused due to both their susceptibility and their EMI emissions.
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMI</td>
<td>ElectroMagnetic Interference; Caused by high frequency switching along wires.</td>
</tr>
<tr>
<td>ETHERNET</td>
<td>A network type. Describes a system used for communication with other machines in the locality.</td>
</tr>
<tr>
<td>FLASH</td>
<td>A variant on EEPROM, it is the same only its performance is better and programming is faster.</td>
</tr>
<tr>
<td>FPU</td>
<td>Floating Point Unit. This additional part allows floating point operations to be speeded up by using Floating Point dedicated hardware. FPU’s are built-in to processors since the 486DX.</td>
</tr>
<tr>
<td>HDD</td>
<td>Hard Disc Drive; large non-volatile storage device.</td>
</tr>
<tr>
<td>I²C</td>
<td>A communications protocol and system for inter-device communication.</td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated Drive Electronics; A standard by which the HDD looks after most of its own operations.</td>
</tr>
<tr>
<td>IRQ</td>
<td>Interrupt ReQuest line; There are 16 IRQ’s in a PC, they are for hardware devices to interrupt the CPU so that it can respond to them.</td>
</tr>
<tr>
<td>ISA</td>
<td>Industry Standard Attachment; Interface to the standard AT bus.</td>
</tr>
<tr>
<td>JPEG</td>
<td>Joint Picture Experts Group, a form of compression of bitmaps. The compression describes the contents of the image rather than each individual pixel. This provides very significant savings in storage at the expense of much higher demands on processing for compression and de-compression. Since the format relies on encoding descriptions rather than specifics, a picture with high detail such as sharp edges is liable to noticeable artefacts.</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network.</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display.</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>LEP</td>
<td>Light Emitting Polymer; Technology to produce screens</td>
</tr>
<tr>
<td>LPT</td>
<td>Parallel Port; for printers or other such devices require low to medium speed communication to the host PC.</td>
</tr>
<tr>
<td>MJPEG</td>
<td>Motion JPEG (jay-peg) is a standard that reduces video bit rates by encoding each frame as a JPEG. This offers significant savings in storage space, and is often performed in real time on today's machines. This helps to reduce the effect on video performance by waiting for storage devices.</td>
</tr>
<tr>
<td>MMX</td>
<td>Matrix Math eXtensions; Quickly changed to Multi Media Extensions by Intel for marketing reasons, these extra 57 instructions to the x86 architecture allow for much faster processing of matrix based operations hence giving a big boost for Multi-Media image manipulation.</td>
</tr>
<tr>
<td>MPEG</td>
<td>Motion PEG, is a method of reduction as with MJPEG but with the added benefit that it only encodes the differences from one frame to the next. This offers a much reduced bit rate but requires a powerful system to implement in real-time since it requires the storage of many frames and motion prediction to be of any use. MPEG has a fixed bit rate that has difficulty in noisy or fast moving scenes since the whole picture is moving.</td>
</tr>
<tr>
<td>MPEG II</td>
<td>An advanced version of MPEG that has a higher bit rate and can be used at many different sizes. An MPEG II supports interlaced video and has many layers that can be used to encode lots of soundtracks or subtitle information. Due to its higher bit rate the picture quality is very good, and this has been used for many video applications such as CATV, Digital TV and Satellite and DVD.</td>
</tr>
<tr>
<td>NIC</td>
<td>Network Interface Card; The card that connect the computer to a network.</td>
</tr>
<tr>
<td>NOS</td>
<td>Network Operating System.</td>
</tr>
</tbody>
</table>
### NVRAM
Non-Volatile RAM.

### OS
Operating System; software on a system that handles the gap between the software and the hardware/system BIOS, usually produces and environment in which to run applications.

### OVERLAY
An overlay surface is a portion of Video RAM other than that being used to for the main display. Video cards that support overlay can show this portion of video memory in a window on the primary surface. This gives the advantage of allowing other devices to fill this RAM such as a video digitiser or an MPEG decoder card. Video cards that support overlay can usually perform colour space conversion on the overlay surface, which leads to stretching of the window without any impact on performance at all.

### PC/104
Personal Computer, single board with a bus connector of 104 pins.

### PC/104plus
As with the PC/104 but with the addition of a PCI bus connector.

### PCI
Peripheral Component Interface; A high-speed bus that is separate from the AT bus.

### Pentium
586 Processor, ‘Pent’ meaning 5.

### Pentium Pro
686 Processor designed for accelerating 32 bit operations.

### Pentium II
686 Hybrid, offering higher performance for 16 and 32 bit instructions. Available in many flavours, including Celeron which has no cache, the Celeron 128 that has 128k cache, Celeron 370 which is a different shape for mobile and low cost systems.

### Pentium III
still a 686 since the only difference is extra instructions that allow the use of the FPU and MMX at the same time, thus increasing speed, since the P II uses the same registers for both which is slow, because they need to be purged.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNP</td>
<td>Plug aNd Play; a system by which the BIOS detects devices and automatically assigns memory I/O and IRQ’s automatically so they can be detected and installed automatically under PNP OS’s.</td>
</tr>
<tr>
<td>PSU</td>
<td>Power Supply Unit; A module that performs power conversion to produce power suitable for the Main Board.</td>
</tr>
<tr>
<td>RAM</td>
<td>Random Access Memory; the system’s working memory, this memory is volatile, which means that it is lost when the power is disconnected.</td>
</tr>
<tr>
<td>RFI</td>
<td>Radio Frequency Interference. See EMI and EMC.</td>
</tr>
<tr>
<td>ROM</td>
<td>Read Only Memory; Memory that cannot be changed and that can only be read.</td>
</tr>
<tr>
<td>RTC</td>
<td>Real Time Clock; An area of memory that is constantly updated with the current system time, even when the power is off.</td>
</tr>
<tr>
<td>SFI</td>
<td>Special Function Interface; an interface for fiddling many custom aspects of the motherboard.</td>
</tr>
<tr>
<td>STN</td>
<td>Super Twist Nematic; A passive matrix flat panel LCD screen.</td>
</tr>
<tr>
<td>TFT</td>
<td>Thin Film Transistor; An active flat panel LCD screen.</td>
</tr>
<tr>
<td>UDMA</td>
<td>Ultra DMA, where an IDE device can move data at twice the rate of conventional devices. (See DMA)</td>
</tr>
<tr>
<td>VGA</td>
<td>Video Graphics Array; Separately driven Red Green Blue colours on a display such as a monitor. As opposed to composite Video where all colours and chrominance is encoded on a single wire, hence limiting the bandwidth and hence the maximum resolution.</td>
</tr>
<tr>
<td>VRAM</td>
<td>Video RAM, Fast access ultra wide RAM for high performance 2D video applications.</td>
</tr>
</tbody>
</table>
WIN32 32 bit operating system based on the WIN32 API such as Win95, Win98, WinNT3.51, WinNT4 or Win2K.

X86 The X86 architecture has been the standard PC processor architecture for some time. There have been many generations of this processor, but processors from 386 upwards have really allowed PC’s to become very powerful due to the way it handles memory. Further generations usually add instructions, pipelining and processing extensions, such as MMX, FPU etc. Giving roughly double the performance with each enhancement as well as increasing in speed.
9 References and Further Reading

1,3 Ampro Computers Incorporated,
http://www.ampro.com/forum/wpapers/i104p.htm

2 PC/104 Specification Version 2.3 June 1996 – The PC/104
Consortium

4 http://wearables.essex.ac.uk/spec/wear-construction.html

Related Documents

Revised November 26, 1995; Submitted for publication. Affective Computing R.
W. Picard MIT Media Laboratory; Perceptual Computing; 20 Ames St.,
Cambridge, MA 02139


2. Startle Cam: A Cybernetic Wearable Camera Jennifer Healey and Rosalind
Picard Rm. E15-389, The Media Laboratory Massachusetts Institute of
Technology 20 Ames St., Cambridge, MA 02139

http://wearables.essex.ac.uk/spec/wear-construction.html

3. Position Paper for the VRAIS'98 Workshop on Interfaces for Wearable
Computers, Some Issues in the Design of User Interfaces for Collaborative
Wearable Computers, Gerd Kortuem, Wearable Computing Research Group,
University of Oregon.

4. Software Technologies for Wearable Computers, Gerd Kortuem, Wearable
Computer Research Group 1 Department of Computer and Information Science
University of Oregon kortuem@cs.uoregon.edu, June 19, 1996

5. Context-Aware Computing (or, why context needs wearables and wearables
need context) Bradley Rhodes


http://www.isoft.demon.co.uk/wearcam/
9.1 Further Reading

Here are some sites that contain lots of information; particularly it seems towards affective computing:


[Fig 4] TekGear  [http://www.tekgear.ca/]

Wearable Computing Magazine – Contains lots of information on wearable technologies, such as the shirt pocket Web Server.  [http://www.wearablecomputing.com/]

Research Papers Dealing with various aspects of wearables. Such as Interfaces, Software and Hardware. In addition, the effects of wearables have been dealt with.  [http://www.cs.uoregon.edu/research/wearables/Papers/]

Wearable Webring. –This contains many major sites that are all related by wearable technology.  [http://wearables.gatech.edu/webring.htm]

Affective Wearables  

Wearable Computing Introduction Page  

http://www.isoft.demon.co.uk/wearcam/  Page 37 of 40  15/03/00
9.2 Contact and Further Information

For further information contact:

Author: James Cross
Email  jcross@iee.org
Tel  +44 121 446 4927 or +44 797 688 5123
Web  http://www.isoft.demon.co.uk
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11 Appendices

Various Email messages regarding the project. In reverse order.