Handheld Computers and Medicine: A Brief Review of Hardware and Software Options

Feisal A. Adatia, M.Sc. (0T3)
Anthony D. LoFaro, B.Sc. (0T3)

Introduction

Handheld computers, or "personal digital assistants" (PDAs), are increasingly being used by our peers in medicine. For example, Wake Forest University School of Medicine recently began to provide second- through fourth-year students, who spend more time in direct patient care, with a handheld device to carry with them on their rounds.[1]

A survey at a national meeting of the American Medical Students Association indicated that 22% of respondent medical students used handheld computers. When the remaining 78% were questioned about their attitudes toward "handhelds", an overwhelming majority believed them to be very useful for both personal and professional data management. Three-quarters of current non-users reported plans to buy a handheld computer within the next year. Although this survey was conducted by MedCompanion Inc., a company that offers clinical handheld computing solutions to physicians, and thus may not be free of bias, the results seem to clearly demonstrate the receptivity of students to emerging technological aids.

Of those using handhelds, the survey found that:

- 63% use condensed versions of medical textbooks;
- 38% use prescription drug references;
- 20% use a patient tracking program;
- 13% use procedure logs.[2]

In fact, Palm, Inc. lists Toronto's own Mount Sinai Hospital as one of the organizations that are employing Palm Operating System (OS) technology.[3] Cedars-Sinai Medical Center in Los Angeles and Harvard Medical School are among a growing list of medical teaching institutions and care centres that are using handheld computers.[4]

Cedars-Sinai Medical Center uses the Palm VII, which has wireless capabilities, to provide clinicians with access to a physician directory, paging, and e-mail, in addition to secure access to confidential patient information, and wireless order-processing for books and articles from the medical library.[5]

Given the vast array of models to choose from, how does one go about assessing and finally choosing a handheld device? There are many models of handhelds, some of which will be briefly discussed in this article. Factors to consider include functionality, price, and expandability. The functionality inherent in handhelds has played a key role in their success. The convenience of carrying out tasks such as scheduling, jotting down quick "to-do" lists and looking up phone numbers have made portable devices popular to a diverse population of users. Given the vast information content of medicine, and the fact that handhelds are able to store medical texts and drug databases, handhelds have become popular among medical students and staff. The on-line accessibility of wireless devices, many of which are expected to emerge soon, have made handhelds popular to organizations and medical centres like that at Cedars-Sinai Medical Centre for the reasons listed above.
Price is always an issue, especially for the student buyer. This is also a market where the technology is developing very rapidly, with better and smaller devices always on the horizon. At the time of this writing, two high-end devices employing new technology, the Visor Edge™ and Palm m500™ series, are new to the market. Currently, the majority of models use 8 MB of RAM (random access memory). This amount of memory provides enough room for a good pharmacopoeia such as *ePocrates qRx* and one large reference book, such as the *Merck Manual*, or two smaller texts such as *Harrison's Companion Edition* and the *5-Minute Clinical Consult*. Some users want it all, and thus expandability, specifically in terms of memory upgrades, is an important consideration.

The focus of this article is on the Palm Operating System (OS), which dominates the handheld market. Other available operating systems include PocketPC/WindowsCE, EPOC and Linux, which collectively make up about 15% of the North American handheld market. PocketPC, the current Microsoft handheld operating system, makes up the bulk of this non-PalmOS market. On the hardware side, *PC Data* reports that in January 2001, Palm, Inc. branded hardware accounted for 60.5% of handheld models sold, while Handspring, who also uses the PalmOS in their Visor devices, holds 26.2% of the market.[6] These two dominant companies have currently added new models to their line-ups, the success of which will be interesting for investors to follow.

Low-to Mid-Range Hardware

Palm's lower-end offerings include the m100™ and m105™. The m100 comes standard with a 16-MHz processor, 2 MB of non-upgradeable memory, and a smaller screen than the other Palm handhelds. The m105 is similar, but comes with 8 MB of on-board memory and a Mobile Internet Kit, which can be used with a modem or cell phone to wirelessly access e-mail or web information from any location. Both also allow the user to change the faceplate of the device to suit his or her own particular style.[7] These devices are poised to replace the Palm III series, which is currently being discounted by Palm. The colour-screened Palm IIIc™ will likely be supplanted by the high-end m505 discussed below.

Handspring released the Visor, its flagship product, in 1999. Since that time, the Visor's attractive features, such as modular expandability and lower price, have enabled Handspring to capture about 25% of the entire handheld market. This was achieved in spite of the fact that the version of the PalmOS that Handspring includes on their devices cannot be upgraded, unlike units produced by Palm, Sony, IBM, and TRG. The Visor Deluxe™, for instance, ships with OS 3.1 and a 16-MHz processor, whereas the Visor Platinum™, Edge™, and Prism™ all ship with OS 3.5.2 and come with a 33-MHz Motorola Dragonball processor.[8] Whether using devices without an upgradeable OS will be a problem or nor will depend on the software and add-on hardware that an individual wishes to use. Most software today does not require operating software greater than OS 3.1. Whether this will remain the case is far from certain, especially considering that Palm is set to release PalmOS 4.0 in March 2001, and OS 5.0 is scheduled to debut in 2002.

In the past year, however, Handspring has garnered substantial third-party support for their proprietary "Springboard™" expansion slot. This slot permits the use of add-on modules. There are now quite a variety of add-on devices for the Visor, among which are global positioning system (GPS) units, digital cameras, MP3 players, and modems. In addition to these add-ons, Margi Systems has released the Presenter-to-Go™ Springboard module which permits the user to run a PowerPoint™ or web-page presentation from a handheld. This function may even be controlled remotely via the IR (infra-red) port.[9] To follow suit, the new Palm m500 series will also have expansion capabilities via Secure Digital technology, discussed below.

Among the smaller players in the PalmOS market are TRG and Sony. TRG devices use CompactFlash™ (CF) expansion slots,[10] which may be advantageous since CompactFlash has become a standard in solid-state memory and expansion units for other equipment, such as digital cameras. Other plug-ins produced for the CF slots include modems and wireless connectivity devices. A current list of such devices can be found at http://www.trgpro.com/support/cf_compatible.html. Unfortunately, TRG is the only PalmOS licensee to use this technology, and therefore the use of CF cards may be viewed as pseudo-proprietary. The Sony CLIE™, on the other hand, comes with a total of 16 MB of memory: 8 MB on-board RAM with an additional, removable 8 MB via an included Memory Stick™, which fits into the device's Memory Stick expansion slot.[11] Memory Stick is a relatively cheap solution to memory expansion, when compared to Handspring's offerings. Currently, Memory Stick modules up to 64MB can be purchased, compared with 16MB expansions made recently available for Handspring devices. A GPS receiver and a digital camera card may also be used in the Memory Stick expansion slot;[12] however, like Handspring's Springboard expansion slot, Memory Stick is proprietary. Given that each company uses different expansion technology, an individual will not be able to interchange modules between different brands of handhelds, a hindrance should one choose to upgrade to a different manufacturer's device down the road.

One problem that currently plagues the PalmOS is that the main on-board memory is treated differently than that of the Flash ROM, Memory Stick, CF cards, and other memory expansion devices. Should one choose to store editable databases on anything but the main memory, such data may not be accessible unless it is swapped into the main memory when needed – a rather tedious proposition. Fortunately, this issue is beginning to be addressed; for instance, MS Autorun™ permits one to directly launch applications stored on Sony's Memory Stick.[13] Hopefully this problem will be addressed by Palm in future updates to the OS.

Many handheld models are powered by 2 AAA batteries. The colour Palm IIIc and Sony CLIE have internal rechargeable lithium-ion batteries allowing them to be charged in their docking cradle, which is also used to exchange data with a desktop computer. All of the high-end models, such as the new Visor Edge and Palm V/Vx™ and m500/505, also offer rechargeable Li-Ion batteries.

High-End Hardware

The Visor Edge and Palm's m500 series models are soon expected to dominate the high-end PDA market. The Visor Edge is Handspring's first slim, metal-encased handheld. The Edge will run on PalmOS 3.5.2H with a 33-MHz Motorola Dragonball-VZ processor, and comes with 8 MB of on-board memory. The unit possesses a connector that allows for a detachable Springboard slot, or backpack to attach to the Visor Edge. With this add-on, any of the current Springboard expansion modules may be used. The Edge, quite slim when used alone, can become somewhat bulky with the use of expansion modules.[14] However, the coming months should see thinner devices produced for the Edge's new, slimmer expansion slot.[15] The Edge is also equipped with a microphone and a LED indicator which acts as a silent, flashing alarm.

Palm is replacing its V-series with the m500 and m505, which have monochrome and colour screens, respectively. The m500 series runs the new PalmOS 4.0, and comes bundled with software allowing the user to edit Excel spreadsheets and Word documents, read eBooks, view video clips and photos, and browse Web content off-line. On-line connectivity is provided via connection to a modem or data-enabled mobile phone. It will use the same

Motorola Dragonball processor as the Visor Edge and Platinum models, but it is anticipated that Palm will move to use to use Intel StrongARM processors in 2002 when version 5.0 of the OS debuts.[16] The m500 series has a vibrating alarm and a silent alarm light which doubles as the power button. Probably the most revolutionary part of the m500 series is its dual expandability via the "Universal Connector," which is the connection port for the docking cradle, and the Expansion Card Slot featuring Secure Digital (SD) technology.[17,18]

Secure Digital (SD) technology is the new expansion feature present in the m500 & m505. The SD Card has two major attributes that make it exciting. The first is its size: the SD Card is roughly the size of a postage stamp and the thickness of a credit card, measuring 32 mm long by 24 mm wide by 2.1 mm thick. Thus, products using this technology can expand their memory or add on devices without needing bulky expansion modules.

The second impressive feature of SD Technology, is the third-party support behind this platform. The SD Association is impressive. Matsushita Electric (Panasonic), SanDisk, Toshiba, Compaq, Hewlett Packard, Mitsubishi Electric, NEC, IBM, Sharp, Canon, Nokia, Phillips, Eastman Kodak, Palm and even Microsoft are among the 204 companies currently listed on their website (www.sdcard.org). The SDA describes itself as an open industry standards organization. Established in January 2000, its mission is to set industry standards for the SD Card and promote its wide acceptance in a variety of applications. It claims that the SD Card standard is being built into a wide range of new digital products such as handheld PCs, cellular phones, audio players, automotive multimedia systems, video and digital still cameras. Initially, Palm has made an SD expansion card with 16MB of memory storage available, with larger expansions expected to come in the future.[19,20] One website displays pictures taken from PalmSource 2000, a Palm developers' conference, showing the Panasonic booth displaying SD memory expansion cards up to 1 gigabyte, or 1000 MBs! This site also shows a modem, scanner, MP3 Player, digital camera, and GPS card set to come out for the SD slot.[20] The SD Card is also compatible with existing MultiMedia Cards (MMC), which are now mostly used in cell phones. Transferring data, images and audio files to desktop and notebook computers will be facilitated via a floppy drive SD adapter, parallel port and Universal Serial Bus (USB) port readers, and a PC Card adapter.[21] With such a broad range of corporations supporting the SD technology, one hopes that many companies will be competing for the SD market, thus keeping prices low and supplying consumers with many devices that can use and thus exchange data via these cards.

General and Medical Software

There are several major sites that allow downloads of general PalmOS based software. Among them are Palmgear.com, Tucows.com, and Memoware.com. Palmgear provides "Top 50 Monthly", "Top 50 Downloads" (of all time), "Essentials", and "Gear's Choice" listings. Both Top 50 listings are based on the number of total downloads, while the ranking of the "Essentials" and "Gear's Choice" listings are based on the opinions of the site administrators.[22] Tucows, via their PDA and PalmOS links, presents software sorted into many different categories. "Medical" is a subcategory under the Calculators, Docs and Productivity category headings.[23] Within each subcategory, programs are rated out of 5 "cows". Memoware lists medical software under their Reference category, which has nearly 300 different listings.[24] However, Memoware does not provide software ratings.

A practical way of quickly finding the software you want is to insert the name of the program in the search field at a site such as Palmgear. Most applications can be found this way, including the many free medical programs, among them a pediatric growth chart program, *STAT Growth Charts 1.4*, and a cardiac risk assessment program named *STAT Cardiac Risk 1.1* by StatCoder.[25] A medical calculator that many find very useful is *Mathias Tschopp's MedCalc*.[26] This program assists in computing over 60 different medically-related formulae – a definite must-have for any health-care professional.

AvantGo is a free program that allows web information to be delivered automatically from the web to a handheld whenever a HotSync (a function which synchronizes files between a desktop computer and a handheld) is performed while the user's computer is on-line. For instance, one could set up *AvantGo* to automatically download the most recent edition of the *Canadian Medical Association Journal* (CMAJ).[27] The CMAJ is not alone in taking advantage of this technology to distribute its materials: *AvantGo* is also being used extensively in the business sector. In fact, many web pages can be loaded to your handheld using this technology. As such, *AvantGo* is quickly becoming a standard in the handheld web-media market.

There are also medicine-specific download sites such as healthypalmpilot.com, handheldmed.com and PDAmd.com. Healthypalmpilot currently provides close to 600 resources available for download.[27] A numerical rating, written comments, and the number of total downloads are given for each software item, although generally few people actually rate the software. Handheldmed lists the large reference texts for sale, such as the *Merck Manual*, *Harrison's Principles of Internal Medicine 14e Companion Handbook* and the *5-Minute Clinical Consult*.[29] Lastly, PDAmd provides a limited number of downloads with no ratings, but does allow readers to post discussion items, and provides a variety of PDA-based articles.[30]

ePocrates Inc. provides a free pharmacopoeia (*qRx 4.0*) and an infectious disease guide (*qID 1.0*). *qRx* provides essential information on commonly-prescribed drugs, including adult and pediatric dosing, contraindications, drug-drug interaction information, mechanisms of drug action, and American drug pricing. The AutoUpdate feature provides updates on information such as new U.S. Food and Drug Administration-approved compounds, changes in drug indications and product recall information. Updated information is added to your handheld when it is synchronized with your desktop computer's Internet connection. More than 200,000 health-care professionals, including nearly 100,000 physicians, have used this program since its launch in November 1999.[231]

Medscape.com, via its Medscape Networks and Med Students links,

has a Medscape mobile section, which provides a few free clinical tools for PDAs.[32] Among these are a pharmacopoeia, a medical calculator and an article reader that allows you to view various specialty-related articles on your PDA.

Featured Free Non-Medical Downloads.

Of course, not all software used by medical students and physicians need to revolve solely around medicine. Some other popular, free downloads include *Noah Lite English Dictionary 0.65*, *BigClock 2.82*, and *DiddleBug 2.15*. *Noah Lite* and *BigClock* are fully described and available for download at Palmgear.com. *DiddleBug* is a program that turns the entire PDA screen into a pad which allows you to quickly jot down notes without having to use *Graffiti*, the alphabet writing system that one must normally use under the PalmOS. It also allows you to tag notes with reminder alarms, such that at a specified time, the PDA will beep and the selected note will appear on the screen. All three programs can be consistently found in the "Top 50 Monthly" section of Palmgear.com.

StreetFinder, a map program by Rand McNally & Co., is a very useful program for those new to an area and longtime residents alike.[33] You can choose to install as many maps for as many cities as you want. Each map occupies about 200 KB of memory, while the application program is slightly smaller. If you need to find a specific address, tag a location of interest for quick reference at a later time, or find a restaurant serving pad thai within a given radius from a specified intersection, then this may be the program for you.

Along with the convenience and utility of downloading programs such as these from an online source or sharing files with others comes the risk of exposure to viruses. Six months after the presence of Phage .936, a virus affecting PC–PalmOS interactions, two companies have come forward with full-coverage virus protection. Symantec has released *Norton AntiVirus 2001* for Palm.[34] Its Professional Edition includes a new technology called script blocking; this permits the detection and eradication of script-based viruses and "worms" even before there is a virus definition for the specific virus.[35] *F-Secure Anti-Virus* for PalmOS protects against any known "malware" on the Palm platform, offering on-device protection with automatic updates.[36]

If you have ever considered moving your Adobe Acrobat PDF documents to the PalmOS, there are currently a few options. You can use the free *PDF2DOC* plugin for Adobe Acrobat. This program converts PDF files to a file type that may be viewed by a variety of Doc readers on the Palm.[37] If you wish to preserve PDF formatting and feel comfortable doing a little optimization of the files, Ansyr's *Primer* may be for you. Their 25 KB application program allows you to view modified PDF files on your PalmOS handheld. The file modification uses Primer's Windows-based tools. This solution, however, costs US$50.[38] Adobe has recently released a beta-version of their PalmOS Acrobat Reader, which is freely available for public testing (http://www.adobe.com/products/acrobat/reader for palm.html). What may be of particular use with these PDF file converters, especially for medical students and staff, are various PDF-format medical atlases and other texts.

As noted earlier, there are several sites from which you can download hundreds of freeware or shareware titles. Unfortunately, the authors of such software do not employ standard readers or viewers. Hence, it may be necessary to carry several readers on your handheld, such as *iSilo* for text and web documents,[39] *EZ Reader* for several of the medical textbooks, *HanDBase* for various database files,[40] and *TealDoc*, *TealInfo* and the whole *Teal* software suite which permits viewing of a wide variety of file formats.[41]

Word-Processing and Spreadsheet Capabilities.

Word processing capabilities are available from several third-party software companies. A standard function is the ability to exchange documents with Microsoft (MS) Word, allowing document transferability between handheld and desktop computers. Currently *MegaDoc 1.7*, *Quick Office 5.0* and *Documents To Go Professional 3.004* are the most popular with consumers. All except *MegaDoc* also allow you to also synch spreadsheets with MS Excel; *TinySheet 3.2* allows you to synch with MS Excel only. All are available at Palmgear.com and other major sites. Currently, Palm and Handspring offer fold-out keyboards which make word-processing and spreadsheet capabilities on handhelds more comfortable.

The Future of Handhelds

Why should health-care professionals consider the use of handheld computers? There are several reasons, but those specifically concerning health-care include information management and decision support. If, for example, your patient is currently on several medications, you can use *ePocrates* software to check for known drug-drug interactions or for contraindications to treatment. For students, applications such as the *5-Minute Clinical Consult* provide necessary basic information and treatment guides, while stimulating lateral thinking by providing broad differential diagnoses.

Medical record and patient tracking systems will undoubtedly become more useful as wireless connectivity becomes standard. Health care professionals will be able to access up-to-the-minute information on any of their patients. Other uses will include accessing on-line reference materials, guides, evidence-based medicine tools, and billing systems. The key feature to all of these applications is that they may be accessed at the point-of-care. The fact that Palm, Inc. has announced plans to invest in ePhysician, a company that designs products to help doctors improve patient care and practice efficiencies through handheld services and information delivery, signifies that the role of handhelds in health-care is viewed as a critical market.[42] The future of handhelds may provide medicine-specific expansion devices, standard on-line connectivity and even "eWallet" functionality.

Palm gave some suggestions of future uses that Secure Digital hardware expansions may have in industry-specific fields. In health care, mobile heart monitors, blood pressure monitors and on-the-spot insulin/glucose meters are some of the industry-specific modules that may be developed in the future.[43]

Currently, with the Palm Mobile Internet Kit you can use your Palm handheld in combination with a data-enabled cell phone to

establish a wireless connection with your Internet Service Provider and download information from the Web onto your Palm handheld screen.[44] This unit works with all Palm-brand models.[45]

It is likely that future models of handhelds, like the current Palm VII, will be wireless-enabled on their own, allowing for such capabilities as instant messaging, e-mailing and web browsing. In fact, Sprint PCS and Palm, Inc. have announced an agreement to market and sell wireless solutions for handhelds (and smartphones) using the PalmOS platform. This will provide Internet content via the Sprint PCS Wireless Web on Palm handhelds or PalmOS smartphones.[46] Currently, Palm.Net which provides wireless capabilities used by the Palm VII is not available in Canada; it is unclear whether Palm, Inc.'s many new alliances will allow for service in this country.

Palm's CEO, Carl Yankowski, performed what he called the world's first commercial credit card purchase using a handheld computer. Using the infrared port on his Palm, Yankowski beamed his personal credit card information to a cashier at a mock Sharper Image store set up on stage at a consumer electronics show. His company plans to turn its handheld computers into "eWallets" that could replace the multitude of cards and paper that most people carry in their wallets, such as their drivers license, library card, health insurance card, credit and debit cards as well as photographs of loved ones.[47]

Undoubtedly, the future of handhelds is bright. The forecast by IDC, a global market intelligence company, predicts worldwide sales for "smart" devices will leap from 12.9 million units in 2000 to over 63.4 million by 2004. Personal companions, a category IDC defines as a step up from personal digital assistants (PDAs), make up the bulk of the smart handheld device market with 73 percent of worldwide shipments in 2000. (Smart handhelds are devices that can be expanded by software downloads or the addition of hardware).[48] With companies like Sega announcing that they will be making video games for PalmOS devices, the demographics of handheld users is also likely to broaden.[49]

Medicine and technology are necessarily intertwined; advances in one can spur progress in the other. As technology progresses, or as medicine demands such progress, the two evolve together. The current popularity of handhelds in the medical field is probably a factor of the high information load of the discipline. Future medicine-specific add-ons such as heart monitors may further expand their functionality in practice.

Currently, we are in the midst of a technological revolution. MP3 technology has gained great popularity, "smart devices" such as smart-phones and handhelds continue to permeate the marketplace, and we may soon see smart-appliances and even smart-automobiles. Perhaps Steve Jobs, Apple's CEO, says it best: we are entering the "digital lifestyle era."[50]

References

1. http://www.palm.com/enterprise/studies/study9.html
2. http://www.pdamd.com/columns/column-40.xml
3. http://www.palm.com/enterprise/studies/customers.html
4. http://www.palm.com/enterprise/studies/cedars.pdf
5. http://www.palmos.com/platform/success/2000/health-care1.html
6. http://www.idg.net/go.cgi?id=431938
7. http://www.palm.com/products
8. http://www.handspring.com
9. http://www.handspring.com/products/sbmodules/presentertogodetails.jhtml
10. http://www.trgpro.com
11. http://www.sonystyle.com/flashmovies/clie_redirect.html
12. http://www.purepalm.com/pp/content/articles/dir/0000000017/index.htm
13. http://www.ita.sel.sony.com/support/clie/softupdates/index.html
14. http://www.handspring.com/products/visoredge/expandit.jhtml
15. http://www.handspring.com/company/pr44.jhtml
16. http://www.zdnet.com/enterprise/stories/main/0,10228,2679114,00.html
17. http://www.palm.com/products/palmm500/
18. http://www.palm.com/products/palmm500/m500ds.pdf
19. http://www.palm.com/products/accessories/expansioncards/
20. http://www.purepalm.com/pp/content/articles/dir/0000000016/pan_samples.htm
21. http://www.palm.com/europe/prdesk/docs/sd_card_specs.pdf
22. http://www.palmgear.com
23. http://www.tucows.com
24. http://www.memoware.com
25. http://www.statcoder.com
26. http://medcalc.med-ia.net
27. http://www.cma.ca/cmaj/etoc/etoc-pda.htm
28. http://www.healthypalmpilot.com
29. http://www.handheldmed.com
30. http://www.pdamd.com
31. http://www.epocrates.com
32. http://www.medscape.com
33. http://www.randmcnally.com
34. http://www.symantec.com
35. http://www.zdnet.co.uk/news/2001/9/ns-21495.html
36. http://www.computeruser.com/news/01/03/09/news19.html
37. http://www.tinystocks.com/pdf2doc.html
38. http://ansyr.com/products/primerpalm.asp
39. http://www.iSilo.com
40. http://www.ddhsoftware.com
41. ttp://www.tealpoint.com
42. http://www.palm.com/about/pr/2001/012301-pqa.html
43. http://www.palm.com/pr/062700c-pqa.html
44. ttp://www.palm.com/solutions/jump/mypalm_info2.html
45. http://www.palm.com/software/mik/
46. http://www.palm.com/about/pr/2000/010401-pqa.html
47. http://www.cnn.com/2001/TECH/computing/01/08/palm.purchase.idg/index.html
48. http://www.newsbytes.com/news/01/162425.html
49. http://www.palmgear.com/news/shownews.cfm?sid=66951120010220154340&resID=12226
50. http://www.apple.com/hotnews/articles/2001/01/mwsf/

* all websites listed above were accessed between 03/15/2001 and 04/18/2001.