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Short communication

Smartphones, tablets and mobile applications for radiology

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ABSTRACT

Background: Smartphones are phone devices that may also be used for browsing, navigation and running smaller computer programs called applications. One may consider them as compact personal computers which are primarily to be used for making phone calls. Tablets or "tablet PCs" are fully functioning standalone computers the size of a thin LCD monitor that use the screen itself for control and data input. Both of these devices may be categorized based on the mobile operating system that they use. The aim of this study is to illustrate how smartphones and tablets can be used by diagnostic imaging professionals, radiographers and residents, and to introduce relevant applications that are available for their field.
Materials and methods: A search was performed on iTunes, Android Market, Blackberry App World, and Windows Phone Marketplace for mobile applications pertinent to the field of diagnostic imaging. The following terms were applied for the search strategy: (1) radiology, (2) X-ray, (3) ultrasound, (4) MRI, (5) CT, (6) radiographer, (7) nuclear medicine. Two radiologists and one radiology resident reviewed the results. Our review was limited to english-language software. Additional applications were identified by reviewing the list of similar software provided in the description of each application. We downloaded and installed all applications that appeared relevant to an appropriate mobile phone or tablet device.
Results: We identified and reviewed a total of 102 applications. We ruled out 1 non-English application and 20 other applications that were created for entertainment purposes. Thus our final list includes 81 applications in the following five categories: diagnostic reading, decision support applications, medical books, interactive encyclopedias, and journal reading programs.
Conclusion: Smartphones and tablets offer new opportunities for diagnostic imaging practitioners; these easy-to-use devices equipped with excellent display may be used for diagnostic reading, reference, learning, consultation, and for communication with patients.

1. Introduction

Smartphones are phone devices that may also be used for browsing, navigation and running smaller computer programs called applications. One may consider them as compact personal computers which are primarily to be used for making phone calls. Several vendors offer similar devices, therefore smart phones can be categorized based on the mobile operating system that they run.

Tablets or "tablet PCs" are fully functioning standalone computers the size of a thin LCD monitor, which use the screen itself for control and data input. These devices may also be categorized based on the mobile operating system that they use.

Thus far, there are four main mobile operating systems: iOS [1], Android [2], Blackberry OS [3], and Windows Phone [4].

The iOS, which is a product of Apple, is run by the iPhone (smartphone), iPod Touch (media player and mini computer) and the iPad (tablet) exclusively. This is a closed and controlled system where each and every application must confirm to the rules set by Apple, though this also guarantees that one will find thousands of high-quality and safe applications on iTunes [5].

Android, a brainchild of Google, is a Linux-based, open source operating system that is run by a growing number of mobile phones, netbooks and tablets. The Android Market has been rapidly expanding, but as of now there are only a limited number of medical applications that may be relevant for diagnostic imaging.

Blackberry iOS runs solely on RIM's tablets and mobile phones, while Microsoft's Windows Phone is a unique operating system that is now also available on selected Nokia phones. The Blackberry App World, and Windows Phone Marketplace only offer a few applications of interest, but in the future their selection is expected to expand quickly.

2. Materials and methods

A search was performed on iTunes, Android Market, Blackberry App World, and Windows Phone Marketplace for mobile

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Table 1
Display parameters of a high-end laptop, the iPhone, the iPad and an EIZO medical grade display.

	Apple iPhone5	Alienware M18x	Apple iPad with retina display	EIZO RadiForce™ GS521
Screen size	10.2 cm (4.0 in.)	45.7 cm (18.4 in.)	25 cm (9.7 in.)	54 cm (21.3 in.)
Resolution (width × height; megapixel)	1136 × 640 0.71	1920 × 1080 2.0	2048 × 1536 3.1	2048 × 2560 5.2
Width of 1 pixel (mm)	0.077 mm	0.213 mm	0.09621 mm	0.165 mm
Maximum brightness	500 cd/m^2	265 cd/m^2	300 cd/m^2	700 cd/m^2
Maximum contrast	800:1	736:1	450:1	800:1
Maximum viewing angle	Horizontal: 170°; vertical: 170°	Horizontal: 135°; vertical: 135°	Horizontal: 170°; vertical: 170°	Horizontal: 170°; vertical: 170°

applications pertinent to the field of diagnostic imaging. The following terms were applied for the search strategy: (1) radiology, (2) X-ray, (3) ultrasound, (4) MRI, (5) CT, (6) radiographer, (7) nuclear medicine.

Two radiologists and one radiology resident reviewed the results. Our review was limited to english-language software. Additional applications were identified by reviewing the list of similar software provided in the description of each application. We downloaded and installed all applications that appeared relevant to an appropriate mobile phone or tablet device.

3. Results

We identified and reviewed a total of 102 applications. We ruled out 1 non-English application and 20 other applications that were created for entertainment purposes. Thus our final list includes 81 applications in the following five categories: diagnostic reading, decision support applications, medical books, interactive encyclopedias, and journal reading programs.

4. Diagnostic reading applications

The aforementioned devices cannot compete with the screen size and resolution of modern medical displays, but their viewing angles, brightness and contrast levels can match up to diagnostic monitors, therefore they may play an important role in diagnostic imaging [6]. In Table 1. we list the important display parameters of a gaming laptop, a popular smartphone, a tablet, and a medical grade EIZO display [7–10].

Though they are considered unfit for primary diagnostic reading, these smartphones and tablets can be an optimal and cost-effective extension of workstations [11]. Given the necessary security protocols and an adequate device, the referring doctor can access the results of diagnostic scans anywhere from the hospital grounds. Thus the clinician can get a more thorough picture of the patient's condition, and he can give a more informed answer to the patient regarding his or her treatment plan. Results of different rendering techniques such as MIP, VRT, and SSD are demanding on hardware, yet easier to understand for non-radiologists. If a dedicated central server performs the calculations that are necessary for these rendered images, then a portable, less powerful device can display these images via the hospital wireless network. This server can theoretically serve several portable devices at the same time.

This may also be relevant in the operating theather where a tablet has already proven itself useful. During surgery the surgeon need not turn away from the area under operation in order to view the relevant images, because the tablet can be taken into the operating room while respecting the rules of sterility [12].

At the ER, valuable time can be saved by having the relevant lab results, medical history and diagnostic images of the patient in an easy-to-access, compact device.

There are several applications for viewing DICOM files on mobile devices. Though the jury is still out on whether portable devices such as smartphones and tablets should be allowed, to be used for primary reading, the FDA [13], and Health Canada [14] have already cleared iOS applications for diagnostic reading.

A distinction should be made between tomographic and digital X-ray images since the latter may have a much higher resolution and also a wider tonal range. Mobile software developers have also addressed this issue. The majority of applications in the diagnosic reading category are described as "not for diagnostic use" or as "only for non-significant risk studies." These are rather for displaying DICOM datasets either for consultation with another colleague – during tumor board for example – or while discussing therapy plans with a patient. Some vendors specify that display is only supported up to 1024 × 1024 pixel images, and that larger files will automatically be downscaled. Others such as Mobile MIM (Fig. 1.) have FDA clearance for viewing, registration, fusion, and/or display for diagnosis of medical images for the following modalities: SPECT, PET, CT, MRI, X-ray and ultrasound. This application supports files up to 25 megabyte in size, but mammography is, as with all the other diagnostic reading mobile software, specifically excluded.

The results of two research teams proved that reading done on a workstation versus a mobile device can be performed with similar results [15,16]. In a third study, researchers compared the effectiveness of diagnostic reading on a Dell PDA and an iPod Touch against that of a Viewsonic secondary medical display [17]. The results of this study are promising; there was no significant difference between the performance of the radiologists using mobile devices versus that of radiologists using the Viewsonic display, however the sample size was only 84.

Further studies proved that the iPad2 is suitable for reading virtual colonoscopy studies [18], for evaluating pneumothorax [19], tuberculosis [20] and acute stroke on CT [21] and assessing solitary pulmonary nodules [22]. Furthermore, in a recent study, the iPad also deemed to be a valuable tool in evaluating MR spinal injury cases [23].

Diagnostic reading applications available for smart phones and tablets support raw data, and they also allow for basic manipulation of the images such as zooming, windowing, rotation, distance measurement, and changing the contrast and brightness. Their main disadvantage is that it can be difficult to perform measurements on the small screen using fingers, and to display the image data of the present and previous scans side-by-side. Viewing such a small screen can also be strainful for the eyes, therefore the FDA stated that these applications cannot substitute dedicated workstations, and that mobile devices are to be used for diagnostic reading only when no workstations are available at hand [24] (Table 2).