Accuracy of using a tablet device for the use of digital radiology manipulation and measurements

Dr Yasith Edirisinghe MBBS, Mr Marcus Crossette BaAppSc

Southern Health, Clayton, Australia
Corresponding Author: yasith_e@yahoo.co.nz

Background: Integration of information technology and the birth of e-health has been a phenomenon in the last few decades and currently it is thoroughly embraced. It has been a tampered concept in the past to use portable devices to access digital radiology. However necessary resolution and processing capabilities have not been available to meet the demands. With the integration of high-resolution tablet devices and easy access touch software, we are now at a point where this concept can finally become a reality. As part of this feasibility analysis we have conducted a small experiment to assess tablet devices and its ability to manipulate and gain measurements of complex high-resolution computed tomography (CT) images.

Methods: A human skeleton foot was put through an advanced 320 slice dynamic CT scanner. The obtained DICOM data was manipulated and distance measurements were taken using Osirix software between 2 very distinguishable points. The same 2 points were identified on the skeleton and the distances were measured precisely using calipers.

Results: When measuring distances using defined anatomical landmarks on a real skeleton and the CT scan on the iPad, the measurements correlated to within 1mm, with a mean percentage error of 1.3%. The tablet device image processing capability was very user friendly and ergonomic. However the software processing capability of the tablet was limited to simple distance measurements. The processing speed was inferior to a laptop and 3D reconstructions were not possible with the current software.

Conclusion: Tablet devices have reached the complexity needed to be an excellent portable digital radiology access point. However at the moment this remains as a concept envisioned but not applied. This concept currently is limited by the processing capability and the software design of these devices. This is undoubtedly going to change with the further advancement of tablet technology and its software.

Introduction

Apple Corporation® has just released the latest iPad featuring a high resolution “Retina Display” and it is a familiar feeling of yet another advancement to a device that has become a part of every day life. Tablet devices seem to be discovering their own niche in our society in the last 2 years. It is a familiar occurrence to the current generation of medical practitioners to have a tablet and smart phone devices using 3G/4G/Wi-Fi communication streams to efficiently and effectively communicate and acquire new information.¹ The appeal of tablet devices has emerged through their portability and versatility compared to lap top computers.

The need for physicians and surgeons to understand the importance of information technology and the evolution of e-Health into the 21st century has been
well documented and the benefits have been well recognized. With its natural evolution into the 21st century the influence it had on Diagnostic Imaging was even stronger. The standardization of digital images acquired by the different medical imaging equipment has further facilitated the diffusion, transmission and communication in radiology within hospitals as well as on web. Since then all hospitals have seen the benefit of ‘filmless’ radiology and gradually have migrated to adopting this concept.  

Tablet devices have been an extension of the concept of smart phones, which have mainly come about with the introduction of the iPad in April 2010. Even though initially seen as an ‘expensive toy’ more and more clinicians have taken to discovering ways for smartphones and tablet devices to be useful and have assimilated them into their practice. A growing number of ‘Apps’ are being used, including journals and textbooks, and surgical device instructions. Inevitably, the evolution of this technology is poised to be introduced into accessing radiology with the same portability and versatility. With such potential we can conceptualize radiological image manipulation and measurements by the clinician on the move, actively sharing image data with patients at bedside, effectively teaching students in radiology and advanced on the field research. Currently mobile Picture Archiving and Communication System (PACS) software are starting to emerge for smartphone and tablet devices, which are marketed heavily and is pushed by the tablet device enthusiasts. Advanced image manipulation software companies are also starting to focus on tablet and smart phone platforms.

It is true that a lot of current medical practitioners have mobile tablet devices. However when assessing feasibility and necessity of such a devices to aid our work, it is important to approach the situation with objectivity. The need for evidenced based practice with mobile technology is starting to be recognized as a necessity. As a first step in determining whether a tablet device has an integral role to play in the field of digital radiology processing, we conducted a small study to analyse and process 3D computed tomography (CT) rendered data using a tablet device. We attempted to manipulate the images and take accurate measurements using currently available tablet software. We hypothesise that novel iPad based software is an accurate interface for the measurement of anatomical data.

**Methods**

Using a Toshiba Aquillion One™ 320 slice CT scanner, we scanned a true skeleton foot and ankle model. Raw Digital Imaging and Communications in Medicine (DICOM) scan data and the 3D reconstructed DICOM data was sent through to an iPad 2 running Osirix app (Figure 1). The Osirix app is available on the Apple App store, costing $AUD31.99 and is a 24.7MB download. Osirix is a well calibrated software that has had wide utility in digital radiology processing in the past. We picked Osirix as it was apparent through database searching that it was the most user friendly/advanced radiology software available for this platform even at this time. Using the foot and ankle models, the same bony landmarks were identified on the physical model, and the pre-prepared, 3D reconstructed data on the iPad. These distances were then measured using calipers, and using the Osirix app on the iPad (Fig 2-4).

Subsequently, measurements from a real CT scan of a wrist, and head, were then performed using prominent anatomic landmarks. The gold standard was considered to be measurements taken using the calibrated Aquillion one CT scanner and its inbuilt Vitrea software. Measurements were then taken on the iPadand compared to the gold standard.

After scanning the foot, raw DICOM data as well as 3D rendered data was sent through to the tablet using a Digital Video Disc (DVD) and linking through iTunes. Even though PACS network linking capabilities existed with Osirix software, the Southern Health PACS server did not accommodate such access at the time.

With the current software capabilities of iPad version of Osirix, simple viewing, distance measurements and area measurements were only possible. 3D reconstructions were not possible with the app version unlike its laptop/pc counterparts. Since 3D reconstructions were not possible we could only use Osirix to apply distance markers on 2 dimensional planes. Thus to get accurate 3D distances the correct orthogonal plane rotation of the scan was needed and distance markers added with easy finger drags (Figure 5).

Technical aspects and difficulties of this process were carefully recorded.

**Results**

**Quantitative Analysis**

There was very clear identification of bony landmarks by Osirix software (Figure 1). Applying the distance markers was a simple finger dragging process with surprising accuracy and ease. The results correlated to within 1 millimeter (mm) of the measured results from the iPad and the actual caliper results from the
skeleton (Table 1). The average percentage for error for these measurements was 1.3%.

When comparing the 3d marker measurements to the iPad measurements (done using 2D reconstructions in the appropriate plane), we found that there was a mean discrepancy of 2.6%. The CT head measurements were accurate to within 0.1mm (Table 2).
Measurements in millimeters.

Table 1: Measurements taken using iPad and caliper measure of markers on foot and ankle model. All measurements in millimeters.

<table>
<thead>
<tr>
<th>Marker</th>
<th>iPad measure (mm)</th>
<th>Caliper measurement (mm)</th>
<th>Percentage error of iPad measurement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>44</td>
<td>44.8</td>
<td>1.8</td>
</tr>
<tr>
<td>2</td>
<td>59</td>
<td>59.3</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>23.5</td>
<td>23.1</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table 2: Measurements taken to perform dynamic volume rendering of a wrist and head. All measurements in millimeters.

<table>
<thead>
<tr>
<th>Measure</th>
<th>iPad measure (mm)</th>
<th>3D marker measure from scanner</th>
<th>Percentage error of iPad measurement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd metacarpal</td>
<td>48</td>
<td>45.2</td>
<td>5.8</td>
</tr>
<tr>
<td>3rd Metacarpal</td>
<td>41.3</td>
<td>41.2</td>
<td>0.2</td>
</tr>
<tr>
<td>4th metacarpal</td>
<td>48.1</td>
<td>46</td>
<td>4.4</td>
</tr>
<tr>
<td>5th metacarpal</td>
<td>47.1</td>
<td>46.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Radial styloid to trapzium</td>
<td>24.8</td>
<td>23.3</td>
<td>6.1</td>
</tr>
<tr>
<td>CT head</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sagittal diameter</td>
<td>155.3</td>
<td>155.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Coronal Diameter</td>
<td>131.3</td>
<td>131.3</td>
<td>0.0</td>
</tr>
<tr>
<td>2D CT distal radius</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulna styloid to Radial Styloid</td>
<td>43.4</td>
<td>42.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Diameter of the capitate</td>
<td>22.5</td>
<td>23.1</td>
<td>2.7</td>
</tr>
</tbody>
</table>

With regards to the difficulties of this process it was clear that compared to an average desktop computer/laptop, the processing speed of the iPad 2 still seemed inferior. Rapid browsing between image series still appears to be limited by lagging image data compared to its PC counterpart versions. When handling 3D volume rendered image browsing iPad version required about 1 second to load each slide.

Also the software available for iPad 2 for radiology image processing still appears to be of a simple design at the moment. Apart from distance/angle measurements, no other image processing was possible (Figure 1).

Discussion

The idea of a portable device to access digital radiology is not a novel concept. It was tampered in the early part of 2004 with the use of PDA (personal digital assistant) in Beth Israel Deaconess Medical Centre, Boston United States. In this institute digital radiology reporting and transmission was done using small PDAs and they predicted their techniques will be common practice in two to three years. They saw the potential in a versatile and a portable radiology device and envisioned it as an excellent radiology teaching tool. However it was clear that even though this was a great concept, the demands of digital radiology exceeded the technological capability at that time. Even though they justified many uses for their practice, it could be argued that similar functions would still been possible from a portable laptop device.

The human eye is limited by our retinal rods and cones have a maximal resolution capability of 2 lines per minute arc (able to distinguish 2 lines spaced at 1/60 of a degree). The recently released iPad “3” boasts specifications of 2048 x 1538 square pixel resolution on a 24.2cm x 18.5mm with the 24 bit colour display which is on par with the best desktop digital radiology processing computers. Therefore by mathematics we can approximate that if an iPad “3” is held at 50cm from our eyes our maximal perceived resolution at that angle would be 1236 lines. (Fig 6) Therefore one can argue that with the new iPad “3” specifications of 1538 pixels on a short axis, we have exceeded the maximal resolution of the eye providing its held at arms length (50cm).
Perceived angle = tan⁻¹((18.5/2) / 50) = 10.48
Maximal perceived resolution = 10.48 x 10.48 x (2 x 60) = 1236

Figure 6. Perceived angle of resolution of new generation iPad.

Through this simple demonstration study, we have managed to show that an iPad can be used to handle CT image data. It was clear that the current software available yielded very accurate measurable results. Currently the main limitation lies within the processor capability and software features. These at the moment limit functions that medical practitioners would expect from a portable radiology device. It was clear that complex reconstructions and 3D rendering processes is still not possible using an iPad alone. This limits getting accurate 3D measurements and manipulations, which is becoming more and more of a necessity for medical specialties such as orthopaedic and neurosurgery. However it was just as possible to quickly and accurately measure pre rendered 3D data with desired clinical accuracy using an iPad. From the aspects of ergonomics, user friendliness and portability the iPad appeared to be far superior compared to a laptop computer.

In conclusion it was clear that in comparing information processing capability the iPad 2 as a tablet device was inferior to laptop and desktop computers. Its radiology handling at the moment is of a simple design focused on simple viewing. However the key to a tablets contribution lies in its portability and versatility. Conceptually it is a great portable reference tool for simple radiology access at any situation such as ward rounds, teaching and outpatient setting. It can be argued that there would be an increase in productivity using these devices. Quantifying this is currently conceptually difficult. At the moment processing and software capabilities appear to be the limiting factor for advocating wide spread use of tablets for digital radiology. Even with current software its potential as an excellent radiology reference device is evident. With the natural assimilation of tablet technology to the practice of doctors further rapid enhancement of radiology software and processing capability is needed. With the capabilities and specifications of the new released iPad with a high resolution display, these limitations may already have been addressed. If current trends continue tablet devices will become a very strong platform to handle digital radiology and its undoubted increase in productivity will reveal itself.

References
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