Proceedings of the 21st International Conference on Automation & Computing, University of Strathclyde, Glasgow, UK, 11-12 September 2015

Innovative Developments in HCI and Future Trends

Mohammad S. Hasan[1] and Hongnian Yu[2]
[1]Faculty of Computing, Engineering and Sciences, Staffordshire University, UK
[2]Faculty of Science and Technology, Bournemouth University, UK
[1]m.s.hasan@staffs.ac.uk, [2]yuh@bournemouth.ac.uk

***Abstract*—The recent developments in technology have made noteworthy positive impacts on the human computer interaction (HCI). It is now possible to interact with computers using voice commands, touchscreen, eye movement etc. This paper compiles some of the innovative HCI progresses in the modern desktop and mobile computing and identifies some future research directions.**

Keywords – HCI, Virtual Reality, Augmented Reality, Haptic Feedback Controller, Smart Glass, Smart Lens.

I. INTRODUCTION

The technological developments in the areas of desktop and mobile (portable) computing in the recent years have changed the Human Computer Interaction (HCI) quite significantly. Current desktop or laptop computers are equipped with speedy and vast processing capabilities e.g. multi-core processors with hyper threading, larger and faster main memory, powerful graphics cards, solid state drive (SSD) based secondary memory as well as built-in input-output devices e.g. web cam, sound card etc. Similarly, mobile devices e.g. smartphones, smart-watch, tablet computers with 8-core processor, 3GB or higher RAM, 32GB or higher SSD storage, multi-touch screen, high resolution cameras, global positioning system (GPS), Near Field Communication (NFC), sensors e.g. proximity, finger print, acceleration, barometer etc. are common nowadays. Many of these advancements have enabled these devices to process information in real time e.g. voice commands, human body pulse rate monitoring etc. Furthermore, the cost of such devices has dropped drastically because of the competitions among the leading manufacturers e.g. Apple, Asus, Dell, HP, Lenovo, Samsung etc. This paper reviews some of the latest developments in hardware and software for desktop and mobile computing HCI. It also attempts to identify future trends, research directions and challenges.

The rest of the paper is organised as follows. Sections II and III discuss some of the recent innovative developments in the desktop or laptop and mobile computing, respectively. And section III.O draws some conclusions.

II. DESKTOP AND LAPTOP COMPUTING

The desktop or laptop computers normally run operating systems such as Linux, Mac OS, Windows etc. The desktop HCI has developed in many areas e.g. affordable augmented and virtual reality, gaming, customer convenience for shopping etc.

A. *Curved and Ultra High Definition (UHD) or 4K Resolution Displays*

Curved monitors, shown in Figure 1, are already available as consumer products and are manufactured by Dell, LG, Samsung etc. These offer better viewing angle, less reflection, better 3D experience etc. However, these displays also have some drawbacks e.g. higher cost, wall hanging problem etc. [1]. The UHD or 4K resolution displays are able to produce 4 times more than the HD i.e. in the order of 4000 pixels horizontally for clearer and crispier viewing experience as shown in Figure 1. Many manufacturers produce displays that are curved and support UHD resolution.

Figure 1: Curved Display and UHD (4K) display [2].

B. *Augmented Reality Headset - Microsoft HoloLens*

Microsoft Hololens is an Optical Head-Mounted Display (OHMD) that offers 3D augmented reality platform [3]. It blends holograms with reality where the user is able to design and customise holograms as shown in Figure 2. It is compatible to Windows 10 which is the next version of the Windows operating system.

Figure 2: The Microsoft Hololens [3].

C. *Virtual Reality Headset*

Headsets such as HTC Vive, Oculus Rift etc. are very popular in the world of virtual reality, gaming etc. HTC vive carries 70 sensors, 360 degree head-tracking with a refresh rate of 90Hz to produce lower delay [4]. Oculus Rift [5], shown in Figure 3, offers low latency 360° head tracking capable of detecting subtle movements to produce natural experience, stereoscopic 3D View etc.

Figure 3: The Oculus Rift Virtual Reality Headset [5].

D. Virtual Mannequin and Virtual Fitting Room

Many online clothing retailers are now using the "Virtual Mannequin" technology to reduce the volume of returned goods because of wrong size or fitting [6]. The online shoppers enter some of their basic measurements and a virtual mannequin is generated [7] as shown in Figure 4. Another area of development is in-store Virtual Fitting Room. In this case the customer is able to try the clothing virtually in real time and very quickly without even going into a fitting room [8] as shown inFigure 5.

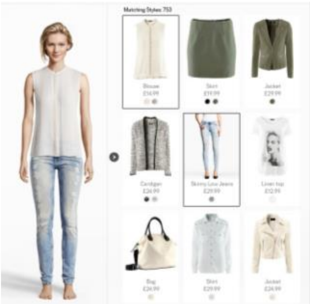

Figure 4: The Virtual Mannequin technology [7].

Figure 5: The Virtual Fitting Room [8].

E. Haptic Feedback Controller

Haptic feedback controllers produce realistic feedback e.g. force, vibration etc. to the user for virtual reality, gaming, tele-robotics, medical applications e.g. computer aided surgery etc. Many current game controllers already support this feature in various forms. For instance, the Steam Controller released by the game developer Valve, shown in Figure 6, offers two trackpads to deliver various physical sensations to the player [9]. Another example is Reactive Grip motion controller [10], shown in Figure 6, that can deliver motion and force feedback to the user using sliding contactor plates.

Figure 6: The Steam controller by Valve [9] and The Reactive Grip motion controller [10].

F. Brain signal Capturing Headset

A brain signal capturing headset is able to detect the changes in voltage when the human brain neurons are working on a thought. The headset normally carries a number of electrodes or sensors that are attached to the human scalp to record the electroencephalographic (EEG) signals and then these signals can be converted into digital form that can be processed by a computer [11]. For example, an epilepsy patient can pick a soft ball using a headset and a robotic arm which is shown in Figure 7. Such systems have been used to drive cars where the driver's captured brain signals are processed by a laptop to drive the vehicle [12]. As an example, the Emotiv EPOC / EPOC+ headset [13] is quite popular in the research community. It offers a convenient brain computer interface with high resolution, 14 EEG channels and 2 references and is shown in Figure 8. The headset has been used to drive a taxi, a wheelchair [14] etc.

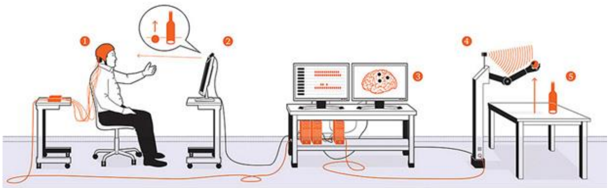

Figure 7: Controlling a robotic arm using a brain signal capturing headset [11].

Figure 8: The Emotiv EPOC / EPOC+ headset [13].

III. Mobile Computing

The mobile devices generally run operating systems such as Android, Bada, iOS, Tizen, Windows etc. The mobile computing HCI has developed in diverse directions and users can interact with modern devices in many ways e.g. touch, voice, heart pulse, body temperature etc.

A. Personal Assistant

Leading mobile device manufactures have introduced "Personal Assistant" e.g. Apple Siri, Google Now, Microsoft Cortana etc. as shown in Figure 9. These software tools use natural language user interface to interact with the user. The personal assistants can perform various tasks e.g. making phone calls, sending messages, scheduling meetings, launching browser, Internet searching, getting updated traffic information, obtaining weather forecast, answering questions etc.

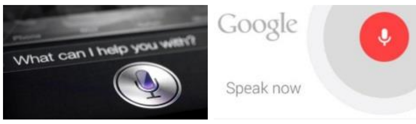

Figure 9: The Apple Siri [15] and the Google Now [16].

B. *Real Time Natural Language Translation Tools*

Many smartphones are able to translate one language into another using translation tool. Recently Google has developed a real time translation tool based on images [17] which is shown in Figure 10 and supports a number of languages.

Figure 10: Real time natural language translation on a smartphone [17].

C. *Ultrasound Fingerprint sensor*

Many mobile devices e.g. smartphones use fingerprint scanner for user authentication. A new type of scanner, shown in Figure 11, has been developed that uses ultrasonic sound waves to scan fingerprints and is able to read finger prints through glass, metal and plastic smartphone covers [18]. It can even scan through sweat, hand lotion, condensation etc.

Figure 11: The ultrasound fingerprint sensor revealed by Qualcomm [18].

D. *Curved and Flexible Displays*

Mobile device manufacturers have launched devices with curved displays e.g. Samsung Galaxy S6 Edge [19] which can display notifications, text messages, weather information etc. on the curved edge for the convenience of the user as shown in Figure 12. Other areas of developments are flexible and transparent displays as shown in Figure 12 and Figure 13 that have been developed by Samsung, LG etc. Many of the flexible displays use polymide film as the backplane. Polyimides are strong, flexible plastics that can achieve high degree of curvature by allowing a much thinner backplane than the conventional plastic [20]. Transparent displays with transmittance of 30% have already been achieved which is shown in Figure 12. These displays could be useful in advertising, security etc. applications.

Figure 12: Curved display for smartphone [19] and transparent display [20].

Figure 13: Flexible display [20].

E. *Smart Glass e.g. Google Glass*

Smart glass e.g. Google Glass is a smart phone like hands free device that is able to take voice commands as shown in Figure 14. It is a heads-up display (HUD) equipped with a camera, microphone and GPS etc. and can perform various tasks e.g. taking and viewing pictures, online searching, reading emails, satellite navigation, taking and making calls etc. [21]. However, Google has stopped commercial production of the Glass in 2015.

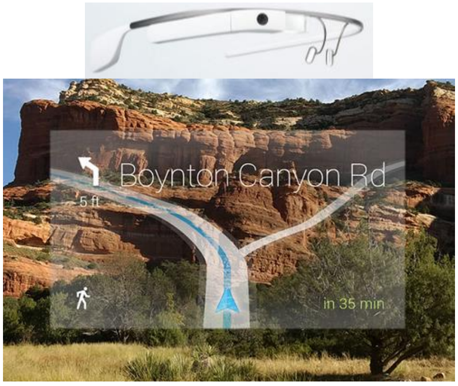

Figure 14: Smart glass e.g. Google glass and its application [21].

F. *Google Cardboard*

Google Cardboard [22] allows users to build a very low cost headset to experience virtual reality using smartphones as shown in Figure 15. As the name suggests, the Google Cardboard comes with cardboard, lenses, straps etc. The smartphone needs to run special application to create the stereoscopic view for both eyes. Various smartphones e.g. Apple iPhone, Google/LG Nexus, HTC Sensation, Huawei Ascend, LG G2, Optimus, Samsung Galaxy, Sony Xperia etc. are compatible to Google Cardboard.

Figure 15: The Google Cardboard [22].

G. *Smart Contact Lens*

Google has developed a smart contact lens prototype that can measure glucose levels in tears for diabetes patients. The lens is equipped with a tiny wireless chip, a miniaturised glucose sensor and a tiny LED that lights to indicate high glucose level [23], [24] and is shown in Figure 16.

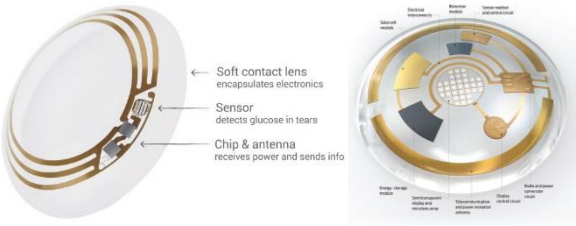

Figure 16: The Google's smart contact lens [23] and the Bionic Contact Lens for augmented reality [25].

H. Bionic Contact Lens

The bionic contact lens has an antenna to collect incoming radio frequency energy from a separate portable transmitter as shown in Figure 16. Solar energy can also be harvested to provide a boost to the lens. The total collected energy is used to power the internal circuits e.g. display to produce the augmented reality environment, communication with an external computer etc. [25]. The user can read emails, view images e.g. using the contact lens [26].

I. Smart Watch

Mobile devices are not limited to only phones, tablet etc. now. Various manufactures e.g. Apple, LG, Motorola, Samsung, Sony etc. have released smart watches as shown in Figure 17. These devices normally communicate with a smartphone using wireless technology e.g. Bluetooth to make or receive phone calls, display messages, notifications etc. Smartwatches can also play music, take photos, display stored photos, perform flight check-in, monitor human body fitness, run simple applications etc. without a smartphone [27], [28].

Figure 17: The iWatch by Apple [27] and Galaxy Gear by Samsung [28].

J. Fitness Tracking devices

A number of fitness tracking devices e.g. Fitbit Charge HR, Fitbit Surge, Basis Peak, Jawbone UP Move, Swarovski Shine etc. are available nowadays [29]. These devices can monitor and display information about the user's heart rate, calorie burning e.g. running, walking, gym activities etc. Some fitness tracking devices e.g. Swarovski Shine, shown in Figure 18, combines the fashion and technology together as these can track running, cycling, swimming etc. activities and can be powered by solar energy.

Figure 18: The Fitbit Charge HR and the Swarovski Shine [29].

K. Smart Jewellery

HCI has also entered the world of fashion and jewellery in the form of Smart devices [30]. For example, the "CSR and Cellini Bluetooth Pendant", shown in Figure 19, is capable of connecting to a smartphone and is able to change its LED colour or brightness depending on the mood or clothing of the user. Furthermore, it can also generate notification of incoming calls, emails or text messages to the user by changing LED colour or flashing or vibrating. Another example is the "June Bracelet or Brooch", also shown in Figure 19, which looks like a diamond in a metal e.g. platinum, gold etc. or on leather strap or it can be worn as a brooch. The device feeds data to a smartphone and shows summary of the user's exposure to the sun. It produces UV index, weather forecast etc. for sunscreen, sunglasses etc. to protect the user's skin from sun damages or premature wrinkles.

Figure 19: The CSR and Cellini Bluetooth Pendant and the Netatmo June Bracelet or Brooch [30].

L. Smart Shoe, Bluetooth Insoles, Smart Sock

Smart shoe, shown in Figure 20, generates power using two devices – a "shock harvester" and a "swing harvester" which produce power when the heel hits the ground and when the foot is swinging, respectively [31]. The generated power is three to four milliWatt (mW) and can be used to power sensors and an antenna. One of the applications of the shoe is indoor navigation and rescue operation. Similarly Bluetooth insoles, shown in Figure 20, are equipped with a number of sensors, accelerometers etc. and can monitor activity levels, walking health issues, therapy progress [32], communicate with smartphones to give directions using vibrations [33] etc. Another area of development is Smart sock which is shown in Figure 21. The smart sock from Sensoria has embedded sensors and is able to produce feedback on the running techniques via smartphone application for a sportsperson [34].

Figure 20: The smart shoe capable of generating power [31] and the Bluetooth insole [32].

Figure 21: The smart sock from Sensoria Fitness [34].

M. Habit Changing Wristband

Technology can help us to get rid of bad habit as well. For example, the Pavlok, shown in Figure 22, can be programmed e.g. visiting time-wasting websites, launching a maximum number of tabs in the browser etc. and it will generate an electric shock for the user to remind of bad habit [35].

Figure 22: The Pavlok wristband [35].

N. Baby monitors

A number of smart devices are available to monitor baby activities as shown in Figure 23. For example, the Sensible Baby SmartOne monitor [36] and the Owlet Vitals Monitor [37] etc. allow parents to monitor baby's position, movement, body temperature, heart rate, oxygen level etc. on a smartphone or tablet in real time.

Figure 23: The Sensible Baby SmartOne monitor [36] and the Owlet Vitals Monitor [37].

O. Thought controlled bionic leg

It is now possible to read the nerve signals of a human body and to control an artificial leg or arm. For example, a patient who lost the lower part of his leg has been fitted with a bionic leg that is controlled by his thoughts [38] which is shown in Figure 24.

Figure 24: First thought-controlled prosthetic leg [38].

IV. CONCLUSION

Latest HCI innovations have made many technologies e.g. virtual reality, personal digital assistant, biometric authentication e.g. finger print scanner etc. available to us and have made our lives convenient and secure. Nowadays, we can monitor our health, manage our daily schedules, navigate from one place to another etc. using different forms of hardware and software HCIs. In the desktop computing HCI, many areas e.g. real time translation of one natural language into another, object recognition from images, low cost virtual studio etc. can be identified as the future researches. On the other hand, for mobile computing, e.g. eye movement tracking, hand gesture recognition, obtaining heart rate by putting a finger on the touchscreen for some time, starting a vehicle remotely, feedback on driving behaviour etc. can be identified as future researches.

REFERENCES

[1] "Curved Monitors – Pros and Cons | Ebuyer Blog," *Ebuyer*, 05-Jan-2015. [Online]. Available: http://www.ebuyer.com/blog/2015/01/curved-monitors-pros-and-cons/. [Accessed: 01-Apr-2015].

[2] "Infographic: High End Display PPI Showdown | Infogram," 21-Oct-2013. [Online]. Available: https://infogr.am/High-End-Display-PPI-Showdown. [Accessed: 12-Apr-2015].

[3] "Microsoft HoloLens," *Microsoft HoloLens*. [Online]. Available: http://www.microsoft.com/microsoft-hololens/en-us. [Accessed: 01-Apr-2015].

[4] "The best VR headsets," *Wareable*, 06-Mar-2015. [Online]. Available: http://www.wareable.com/headgear/the-best-ar-and-vr-headsets. [Accessed: 01-Apr-2015].

[5] "Rift," *Oculus VR*. [Online]. Available: https://www.oculus.com/rift/. [Accessed: 01-Apr-2015].

[6] R. Preston, "'Virtual mannequins' promise better fit for online shoppers," *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/technology-25812130. [Accessed: 12-Apr-2015].

[7] "Virtual Fitting Rooms - are they a gimmick or an essential tool for fashion ecommerce?| App Commerce Platform," *Poq Studio | App Commerce Platform*. [Online]. Available: http://poqstudio.com/2013/02/virtual-fitting-rooms-are-they-a-gimmick-or-an-essential-tool-for-fashion-ecommerce/. [Accessed: 12-Apr-2015].

[8] "Virtual Fitting Room Courtesy of the Kinect," *Daily Bits*. [Online]. Available: http://www.dailybits.com/virtual-fitting-room-courtesy-of-kinect/. [Accessed: 12-Apr-2015].

[9] "Valve reveals haptic game controller for release in 2014," *BBC News*, 27-Sep-2013. [Online]. Available: http://www.bbc.co.uk/news/technology-24304272. [Accessed: 01-Apr-2015].

[10] "Products | Tactical Haptics," *Tactical Haptics*. [Online]. Available: http://tacticalhaptics.com/products/. [Accessed: 01-Apr-2015].

[11] "How to Catch Brain Waves in a Net," *IEEE Spectrum*, 21-Aug-2014. [Online]. Available: http://spectrum.ieee.org/biomedical/bionics/how-to-catch-brain-waves-in-a-net. [Accessed: 01-Apr-2015].

[12] "Look, no hands (or feet): Scientists develop car that can be driven just by THINKING," *Mail Online*. [Online]. Available: http://www.dailymail.co.uk/sciencetech/article-1359512/Computer-scientists-Germany-invented-car-steered-power-thought.html. [Accessed: 01-Apr-2015].

[13] "Emotiv EPOC / EPOC+," *Emotiv*. [Online]. Available: http://emotiv.com/epoc.php. [Accessed: 02-Apr-2015].

[14] "Emotiv Claims Its Brainwave Scanner Allows People to Control Wheelchairs with Their Minds," *Wearable Tech World*, 03-Feb-2014. [Online]. Available: http://www.wearabletechworld.com/topics/from-the-experts/articles/369076-emotiv-claims-its-brainwave-scanner-allows-people-control.htm. [Accessed: 01-Apr-2015].

[15] "Siri, Your wish is its command," *Apple*. [Online]. Available: https://www.apple.com/uk/ios/siri/. [Accessed: 02-Apr-2015].

[16] "Google Now. The right information at just the right time.," *Google*. [Online]. Available:

https://www.google.co.uk/landing/now/. [Accessed: 02-Apr-2015].

[17] "Pardon? Testing Google's speedy translation tool," *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/technology-30824033. [Accessed: 07-Apr-2015].

[18] L. Kelion, "Fingerprint sensor revealed by Qualcomm at MWC," *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/technology-31692988. [Accessed: 07-Apr-2015].

[19] "Galaxy S6 & Galaxy S6 edge - Pre-order online." [Online]. Available: http://www.samsung.com/uk/galaxys6/. [Accessed: 02-Apr-2015].

[20] S. Anthony, "LG's flexible and transparent OLED displays are the beginning of the e-paper revolution," *ExtremeTech*. [Online]. Available: http://www.extremetech.com/computing/186241-lgs-flexible-and-transparent-oled-displays-are-the-beginning-of-the-e-paper-revolution. [Accessed: 03-Apr-2015].

[21] "Google Glass UK release date, price and specs: Google Glass will go offsale on 19 January; how to buy Google Glass," *PC Advisor*. [Online]. Available: http://www.pcadvisor.co.uk/features/gadget/3436249/google-glass-release-date-uk-price-specs/. [Accessed: 03-Apr-2015].

[22] "Google Cardboard, Experience virtual reality in a simple, fun, and inexpensive way," *Google*. [Online]. Available: https://www.google.com/get/cardboard/index.html. [Accessed: 03-Apr-2015].

[23] "Inside Google X's Smart Contact Lens," *Re/code*. [Online]. Available: http://recode.net/2014/01/16/inside-google-xs-smart-contact-lens/. [Accessed: 03-Apr-2015].

[24] "Google unveils 'smart contact lens' to measure glucose levels," *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/technology-25771907. [Accessed: 03-Apr-2015].

[25] "Augmented Reality in a Contact Lens," *IEEE Spectrum*. [Online]. Available: http://spectrum.ieee.org/biomedical/bionics/augmented-reality-in-a-contact-lens/eyesb1. [Accessed: 03-Apr-2015].

[26] M. R. H. reporter, "Bionic contact lens 'to project emails before eyes,'" *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/health-15817316. [Accessed: 03-Apr-2015].

[27] "Apple (United Kingdom) - Apple Watch," *Apple*. [Online]. Available: https://www.apple.com/uk/watch/. [Accessed: 02-Apr-2015].

[28] "Samsung Galaxy Gear Watch (Jet Black) - 1.63" Super AMOLED, 1.9MP, 4GB," *Samsung UK*. [Online]. Available: http://fb.uk.samsung.com/consumer/mobile-devices/wearables/gear/SM-V7000ZKABTU. [Accessed: 02-Apr-2015].

[29] "Best fitness trackers 2015: Jawbone, Misfit, Fitbit, Garmin and more," *Wareable*. [Online]. Available: http://www.wareable.com/fitness-trackers/the-best-fitness-tracker. [Accessed: 03-Apr-2015].

[30] S. Hill, "Smart jewelry is proving wearable tech doesn't have to be hideous," *Digital Trends*. [Online]. Available: http://www.digitaltrends.com/mobile/smart-jewelry-roundup/. [Accessed: 03-Apr-2015].

[31] P. Rincon, "Smart shoe devices generate power from walking," *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/science-environment-30816255. [Accessed: 05-Apr-2015].

[32] "Watch your step -- with a Bluetooth-connected insole," *CNET*. [Online]. Available: http://www.cnet.com/uk/news/watch-your-step-with-a-bluetooth-connected-insole/. [Accessed: 06-Apr-2015].

[33] L. Kelion, "CES 2015: Preview of the new tech on show in Las Vegas," *BBC News*. [Online]. Available: http://www.bbc.co.uk/news/technology-30643396. [Accessed: 06-Apr-2015].

[34] "Sensoria Fitness Smart Sock Preview," *CNET*. [Online]. Available: http://www.cnet.com/uk/products/sensoria-fitness-smart-sock/. [Accessed: 06-Apr-2015].

[35] "Pavlok Uses Mild Electric Shock To Help You Break Any Habit," *Pavlok*. [Online]. Available: http://pavlok.com/. [Accessed: 06-Apr-2015].

[36] "No more tiptoeing around," *Sensible Baby*. [Online]. Available: http://mysensiblebaby.com/. [Accessed: 06-Apr-2015].

[37] "Owlet Vitals Monitor," *Thing Alive*. [Online]. Available: http://thingalive.com/owlet-vitals-monitor. [Accessed: 06-Apr-2015].

[38] "NEJM: First thought-controlled prosthetic leg," *MedCity News*. [Online]. Available: http://medcitynews.com/2013/09/nejm-first-thought-controlled-prosthetic-leg/. [Accessed: 02-Apr-2015].