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Portable Smart Devices Technologies Base for Augmented Reality

Technologies used as a base for building the "digital sixth sense"

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Abstract — **The purpose of this article is to give the overview of technologies widely used as a base in portable smart devices (smart phones, tablets, smart glasses, head mounted displays, etc.) for the purpose of building the Augmented Reality (AR). Linking technologies like GPS triangulation, camera mapping, motion and visual tracking, markers, global catalogs, social networks, localization, personalization and search engines as an effective approach to enhance human real life experience like a "digital sixth sense".**

Key Words - Augmented reality; Portable devices; Digital sixth sense; Navigation; GPS triangulation; Camera mapping; Visual tracking; Motion detection; Global catalogs; Search engines; Social networks; Localization; Personalization; Fiducial markers; Area markers; Markers; Markerless; Human enhacement

I. INTRODUCTION

Augmented reality (AR) is a variation of Virtual Environments (VE), or virtual reality as it is more commonly used [1]. VE technologies completely immerse a user inside a synthetic environment. While immersed, the user cannot see the real world around him. In contrast, AR allows the user to see the real world, with virtual objects super-imposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it. In an ideal situation, the user has to feel (it would appear to him) as the virtual and real objects coexisted in the same space.

Figure 1 shows an example of what this coexistence looks like. It shows a real time camera feed of a building with its surroundings. Overlapping the picture of the camera display there is an interactive GPS map, as well as personalized highlighted (associated) information of interest. Note that the objects are combined in three dimensions, so that the virtual elements overlap the real world camera feed. When the position of the camera changes, so does the position, and angle of the super-imposed virtual elements.

Figure 1. Augmented reality (AR) application example

Some researchers define AR in a way that requires the use of head-mounted displays (HMDs). To avoid limiting AR to specific technologies, but for the purpose of concept, this paper defines AR as any system that has the following three characteristics [2]:

1. Combines real and virtual;
2. Is interactive in real time; and
3. Is registered in three dimensions.

II. MIXED REALITY ENVIRONMENTS

The term mixed reality environments defines a categorization for various types of virtual reality (VR) type systems [3]. Hence, researchers have defined a continuum of real-to-virtual environments in which VR and AR are parts of the general area of what is now considered mixed reality (Milgram) [4].

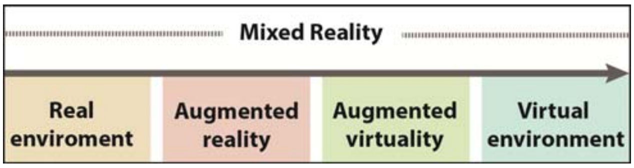

Figure 2. Mixed reality continuum (Milgram) [4]

Figure 2 illustrates this mixed reality continuum. In augmented reality, digital objects are added to the real environment, where as in augmented virtuality, real objects are added to virtual ones.

III. DEVELOPMENT STAGE

Augmented reality (AR) is now at a stage of development across many different disciplines. We understand some applications more completely than others. Yet there is no doubt that, within a few years, AR will come to play as the fundamental part in our lives as the five conventional human senses do today. Technologies that are already widely used in today's smart devices are more than enough to make an impact in our everyday lives.

IV. MAPPING THE WORLD, CALCULATING POSITION AND ORIENTATION (TRACKING)

The basic difference between mobile and non-mobile augmented reality is off course mobility. While the ability to move while still maintaining the validity of the virtual and real world combination, is very convenient, it provides the obvious challenge, of having to continuously determine the exactly position where a smart device is at all times.

The most significant smart devices technical challenge is the measuring of camera's pose (its position and orientation) relative to relevant objects in the environment. In AR, this measurement is commonly called Tracking. If the measurement is established in a global, rather than a local frame of reference, the procedure is sometimes called Localization (Figure 3) [5].

Localization is made up of two components a GPS (Global Positioning System) and an inertial sensor (INS). The GPS serves to provide an exact location of the smart device while the INS allows an estimate to be made about the orientation of the camera.

A. Calculating the position

As a base for calculating the real time position, majority of AR applications and devices use GPS and its use fall into 5 major categories:

1. Location - determining a position;
2. Navigation - getting from one location to another;
3. Tracking - monitoring object or personal movement;
4. Mapping - creating maps of the world; and
5. Timing - bringing precise timing to the world.

The biggest disadvantages of GPS technology are: using it for indoor navigation; and the existence of places without satellite coverage. Difficulties are also posed in outdoor scenarios by the differing atmospheric factors.

B. Visual tracking

Visual tracking uses landmarks and other characteristics of an image to figure out where in known space is a device located. If the object in a given image is distinct enough, visual tracking can be very accurate.

C. Inertial tracking

Inertial tracking represents the use of sensors to create of a Six Degrees of Freedom picture not of where the object is, but where it has moved relative to its previous location. The starting requirement of this system is an initial position which must be provided by some external method. Once given a starting point Inertial tracking uses motion sensors (generally three accelerometers and three gyroscopes) to calculate amount of movement of a device both transitionally and rotationally.

Combined with knowledge of the starting position, this allows the calculation of the end position. This requires less recalculation than visual tracking since future measurements are based upon former calculations. However, the sensors must be precisely calibrated and frequently recalibrated or they will be inaccurate. Even tiny errors in accuracy can "snowball" because of the fact that each successive calculation is based upon the last one. Because of this fact and the improbability of having no errors in calculation over any extended period of time, this method is inherently less accurate than visual tracking although it is much faster.

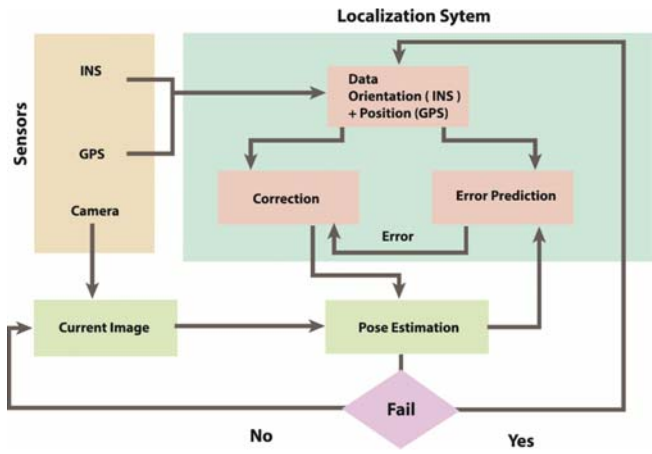

Figure 3. Localization System Diagram [5]

V. MARKER VS MARKERLESS AR

There are two primary types of AR implementations: Marker Based and Markerless.

- Marker Based implementation utilizes some type of image such as a QR/2D code to produce a result when it is sensed by a reader, typically a camera on a smart device; and
- Markerless AR is often more reliant on the capabilities of the device (such as the GPS location, velocity meter, INS sensors, etc). It may also be referred to as Location-based or Position-based AR.

Both Marker Based and Markerless AR require AR specific software or browsers to function. Marker Based AR is currently the most prevalent and easiest to accomplish. While Markerless AR is emerging, it is currently rather limited due to sensor accuracy (i.e. GPS accuracy), service limits (i.e. indoors vs. outdoors), bandwidth requirements (4G is not accessible in all places nor in most of devices), and power pulls on the devices.

VI. MARKERS

A. Fiducial markers

Fiducial markers are printed patterns applied to the object of interest. The most popular type of marker is a black-and-white square framing a 2D barcode pattern [6], but is not limited to it (Figure 4.) [7]. Fiducial markers can also be 3D colorful objects but all of them must have distinct (contrast) boundaries and must not be symmetrical. In other words; they all must have the field of impact to AR and at least one element that marks direction. The more distinctive the marker; the better.

B. Area markers

Area markers are based upon a proximity engaged technologies like Bluetooth, WiFi, NFC and GSM connectivity. The area markers are used to define a field of impact for predefined user experience, or to change the mode of the AR applications. Result is a change of usual AR

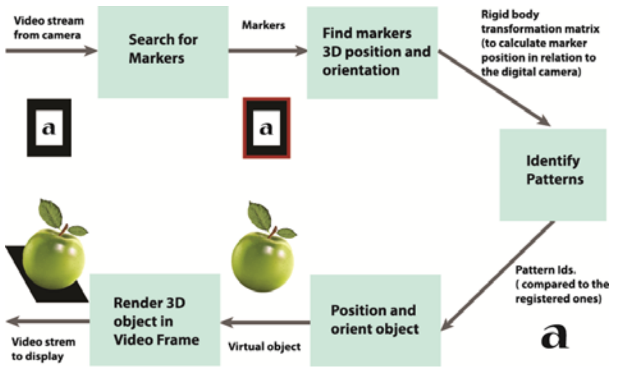

Figure 4. Virtual objects super-imposed upon a simple fiducial marker

responses to marker and markerless AR representations. The use of area markers are not yet used to its full potential and is a theoretical prediction of use of smart phone devices for the purpose of interactivity with the AR applications.

C. Interactive markers

Interactive markers, or user engaged markers are usually voice or hand gesture commands that are recognized by a AR device peripherals to actively interact with AR. It can be used to change the mode of AR application, or to interact with the AR object. In newest smart devices, especially those that have cameras and sensors positioned to catch users facial expression and eye movement, applications can recognize users mood (temper) and adapt its AR with personalized responses.

VII. PERSONALIZATION

A. Socialization

Although social networking has yet to embrace AR, it could benefit from incorporating the technology to let people leave messages, images, and other content on specific objects or places that others could retrieve later [6]. This content might include reviews of businesses and services, messages on virtual billboards in public/semipublic spaces, or links to social media pages. For such applications, “in situ” (in its original place) authoring (editing) content directly in the real world is essential [8]. Most smart devices already have tools for editing images and videos; however, in situ authoring of 3D objects is still a challenge.

B. Social Networks

All modern smart devices have access to user information and know much about the user. Some may argue that the combined, social networks know more about the user, them the user itself. By combining and interconnecting social media information, applications have access to user preferences, personal data, friend and family, gender, skills, level of education, languages, movement habits, communication skills, and most importantly user interests.

C. Searh Engines And Global Catalogues

Data from search engines combined with social profiling is effective when providing personalized search results. From the commercial and marketing perspective this is ideal when targeting potential customers. Both businesses and users are satisfied because the user get information about his interests, and the businesses interactively communicate with their potential customers.

D. Biometrical Data

At this moment, there are few biometrical data most smart devices can collect from the user, but in time, that number will most likely be higher. Face and voice pattern recognition is one of the human characteristics that are easiest to collect, but modern devices go even further and implement fingerprint, signatures, iris and retina recognition (on HMDs) to unlock devices. Gait analysis (study of human motion), as well as typing rhythm are more complex and can be used in combination with other data to absolute certainty identify the user.

VIII. PRIVACY RISKS OF TECHNOLOGIES USED

Since biometric identifiers are unique to individuals, they are more reliable in verifying identity than token and knowledge based methods. Analysis suggests it is likely that biometrical data will be used more as the AR evolves for the purposes of security and unauthorized access to the devices. However, the collection of biometric identifiers raises privacy concerns about the ultimate use of this information and its ability to be manipulated [9].

Arguably, the biggest privacy concerns of late, come not from identity theft individuals, over-paternalistic or authoritarian states, but rather from commercial interests and the advent of huge amounts of data being aggregated by the search engines and social media networks. It is likely that some of the greatest (or most visible) privacy concerns regarding AR will be about further integration of every bit of technology available in the quest for targeted advertising and psychological pressure to purchase.

IX. SAFETY RISKS

Augmented reality, like any mobile media technology presents some real physical safety issues. It is known that mobile phones are currently a distraction while driving a car or crossing the busy streets. Augmented windshield displaying navigational directions, along with unneeded, interactive and unpredictable AR content may poses the biggest safety concern and must be carefully addressed in the future of AR technology developments.

Fiducial markers and QR codes can be used to attack both human interaction and automated systems [10]. As the encoded information is intended to be only machine readable, a human cannot distinguish between a valid and a maliciously manipulated marker [11]. While humans might fall for phishing attacks, automated readers (AR applications) are most likely vulnerable to SQL injections and command injections. Exploring possible consequences and detailed analysis of markers as an attack vector should be further investigated.

X. TECHNOLOGY IMPROVEMENTS

AR technology has seen the advent of smaller form factors, more powerful processors, higher resolution cameras, and distributed computation. The advent of new smart glass technologies have generated renewed interest in the commercial domains. This new eyewear also extends the earlier capabilities of optical/video see through glasses with Bluetooth, WiFi, and 3G connectivity to remote databases.

While there are as yet many significant technical hurdles for industry specific AR systems that must be surmounted to ensure efficient operation, there are still numerous user-centric issues that still need to be addressed to enable the desired safety and efficiency potential of the technology itself.

The issues themselves include ergonomic issues (size, weight of the AR hardware, when dealing with glasses), user interface requirements (font sizes, lighting conditions impacting the legibility of text or the rendering of the digital content, interaction with tablets or glasses) and physiological issues (eye fatigue, user perception due to latency of content rendering, increased user workload).

XI. SOCIAL IMPLICATION OF "ALWAYS LOOKING, ALWAYS CONNECTED" TECHOLOGIES

A. Sousveillance

Interplay between “the few watching the many” (surveillance cameras affixed to large entities such as buildings) and “the many watching the few” (cameras from smart devices or wearable camera of individual people) is laying contextual groundwork for the social implications of AR and inevitable change of everyday life [12].

Widespread surveillance will cause a transition from our one-sided surveillance society back to a situation akin to olden times; when the law officers could see what everyone was doing and everyone could see what the law officers were doing. This neutral form of watching is called “veillance” – from the French word “veiller” which means “to watch”. Veillance is a broad concept that includes both surveillance (oversight) and sousveillance (undersight), as well as dataveillance, uberveillance, etc. It is argued that sousveillance (undersight) is necessary to a healthy, fair and balanced society whenever surveillance (oversight) is already being used; and sousveillance has numerous moral, ethical, socioeconomic, humanistic/humanitarian, and practical justifications that will guarantee its widespread adoption, despite opposing sociopolitical forces.

B. “Know it all” sindrome

The idea behind AR is coexistence of digital and real life experience in the same space, while bringing related information to the user in the most friendly and natural way.

The sources of information, knowledge and interactive content that is constantly available from the connection to the Internet databases, is too much for the users to critically process in the highly dynamic environment. Having information, knowing its validity (having the ability and time for critical thinking over it), and knowing how to use it in a right way, may poses a challenge in the society heavily using AR. Information overload [13] is something that is not exclusively related only to AR, but will be more obvious as the communication and exchange of information sources become just "one look away".

XII. CONCLUSION

Portable smart based augmented reality is a rapidly growing field which shows a lot of promise for supporting both fun and useful real life applications. Major challenge at the moment is to provide its users with as much functionality as possible without overloading the still relatively small video computational power, as well as filtering the information supplied by the inexhaustible Internet based databases. Long usability, physical fatigue, easy control, security, privacy and practical issues are still to be overcome, but AR systems, with their sophisticated input/output capabilities, have the potential to significantly benefit many.

Endless combinations of fiducial, area and interactive markers combined with real time data, while providing its natural interactivity with reality, have the potential to make augmented reality producing dynamic and immersive user experience that can be described like a "digital sixth sense".

REFERENCES

[1] Azuma R., Bailot Y., Behringer R., Feiner S., Julier S., and Mac Intyre B., “Recent Advances in Augmented Reality”, IEEE Computer Graphics and Applications 2001. 21(6) 34-47.

[2] R.T. Azuma, “A Survey of Augmented Reality,” Presence: Teleoperators and Virtual Environments, vol. 6, no. 4, 1997, pp.355-385.

[3] Doswell Jayfus, “Codifying Pedagogy in 3D Virtual Instructors”, Archives & Museum Informatics: Museums and the Web 2005, April 2005

[4] P. Milgram and F. Kishino, “Taxonomy of Mixed Reality Visual Displays”, IEICE Transactions on Information and Systems, 1994, pp.1321-1329.

[5] Zendjebil I.M., Ababsa F., Didier J.-Y., and Mallem M., “Hybrid Localization System for Mobile Outdoor Augmented Reality Applications”, Image Processing Theory, Tools and Applications, 2008. IPTA 2008. First Workshops on, pp.1-6

[6] Michael Gervautz, and Dieter Schmalstieg, “Anywhere Interfaces Using Handheld Augmented Reality”, IEEE Computer Society, June 2012, pp.26-31

[7] Alcimar Barbosa Soares, Edgard Afonso Lamounier Júnior, Adriano de Oliveira Andrade and Alexandre Cardoso (2012), “Virtual and Augmented Reality: A New Approach to Aid Users of Myoelectric Prostheses”, Computational Intelligence in Electromyography Analysis - A Perspective on Current Applications and Future Challenges, Dr. Ganesh R. Naik (Ed.), ISBN: 978-953-51-0805-4, InTech, DOI: 10.5772/50600, October 2012, chapter 17

[8] Guven S., Oda O., Podlaseck M., Stavropoulos H., Kolluri S., Pingali G., "Social mobile Augmented Reality for retail", Pervasive Computing and Communications, 2009. PerCom 2009. IEEE International Conference on , pp.1-3; 9-13, March 2009

[9] Suman Jana, Arvind Narayanan, Vitaly Shmatikov, and Scanner Darkly, “Protecting User Privacy From Perceptual Applications”, Security and Privacy (SP), 2013 IEEE Symposium, May 2013, pp.349-363

[10] A. Sankara Narayanan, “QR Codes and Security Solutions”, International Journal of Computer Science and Telecommunications, vol. 3, issue 7, July 2012

[11] Peter Kieseberg, Manuel Leithner, Martin Mulazzani, Lindsay Munroe, Sebastian Schrittwieser, Mayank Sinha, Edgar Weippl, QR code security, Proceeding MoMM '10 Proceedings of the 8th International Conference on Advances in Mobile Computing and Multimedia Pages, 430-435, ISBN: 978-1-4503-0440-5

[12] Steve Mann, “Veillance and Reciprocal Transparency: Surveillance versus Sousveillance, AR Glass, Lifeglogging, and Wearable Computing”, Technology and Society (ISTAS), Social Implications of Wearable Computing and Augmediated Reality in Everyday Life, 2013 IEEE International Symposium, June 2013

[13] Allen G. Schick, Lawrence A. Gordon, Susan Haka, Information overload: A temporal approach, Accounting, Organizations and Society, Volume 15, Issue 3, 1990, pp.199–220