Augmenting Reality in Sensor Based Training Games

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Abstract. Building an Augmented Reality experience has traditionally been limited by the use of physical markers, and GPS capabilities that are hampered indoors. Physical markers are intrusive in an environment that is dual use between an AR and more traditional experience, making them a less than popular choice for physical locations. GPS solves many of these problems outdoors. Unfortunately, this cannot be capitalized on in an indoor setting where interference from the building cannot guarantee the fidelity of the location data. A recent technology is a low energy Bluetooth transmitter that allows devices to determine their proximity to the transmitter. These devices can be configured and installed discretely in a physical location and power AR experiences and also open up new opportunities to augment, extend, push, and track a user's experience.

Keywords: iBeacon · BLE · Augmented reality · Location based training

1 Introduction

Building an Augmented Reality (AR) experience has traditionally been powered by the use of physical markers and GPS. Unfortunately these technologies have various limitations that keep them from breaking into the main stream. Physical markers are intrusive in an environment that is dual use between an AR and more traditional experience making them a less than popular choice for physical locations. GPS can be useful in many of these outdoor location based games like Google's Ingress [1]. Unfortunately, this cannot be capitalized on in an indoor setting where interference from the building cannot guarantee high enough fidelity of the location data.

A recent technology pioneered by Apple, the iBeacon, has created a solution to this problem [2]. While pioneered by Apple, the iBeacon can interact with any Bluetooth enabled phone including Android devices. Using new technologies such as iBeacon the precise location of an AR device such as a phone or head mount display (HMD) can be determined through triangulation in any room with three or more beacons [6]. This information can be leveraged to generate a similar experience to traditional AR. This could include interacting with real and virtual objects and people.

The iBeacon is a Bluetooth Low Energy (BLE) transmitter that allows devices to determine their proximity to the transmitter, without causing a large battery drain on the user's device. These iBeacons can be configured and installed discretely in a physical location and power AR experiences and also open up new opportunities to interact in

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physical environments not previously possible. They can be used to augment, extend, push, and track a user's experience.

2 Sensor Enabled Augmented Reality Technologies

Using sensors to enable augmented reality experiences is not a new idea. The main type of this is paper based markers viewed by a devices camera. These include custom markers viewed by a camera, Near Field Communication (NFC), and BLE devices like iBeacon.

2.1 Camera Based Paper Markers

Camera Based Paper Markers are the most common type of AR experience. They often use custom markers that can be identified and interacted with. A good example of this is the AR games included with the Nintendo 3DS [3]. Each 3DS comes packed with a pack of cards representing various characters in Nintendo's games. They can be viewed with the cameras in the device and games can be played in the real world, as 3D characters appear on the video being displayed on screen. The paper markers provide context for the games to place the objects. The unfortunate side effect is that the markers are needed for the device to orient itself. In the end, they can easily clutter a physical space.

Also, most markers do not contain any information not already associated with the companion app. One solution to this is the Quick Response (QR) Code. QR Codes provide links or other textual information imbedded in the system. This information, however, cannot be directly changed by the app.

2.2 Near Field Communication

Near Field Communication (NFC) can be used in similar ways to QR Codes for augmented reality applications. While its strength is not in creating 3D overlays of information, they can still be used to augment the user's view of a world. NFC uses a standard for sending data over short distances through radio waves. They require devices to be close to them, and enable two devices to transmit information between them in a peer to peer fashion. They allow the user to both read the data out of them as well as write new data to the NFC chip.

NFC has grown rapidly in popularity as it is the technology powering the Skylanders and Disney Infinity games [4]. In these games when a player puts a toy on a reader the player can now play as that toy. Further they can save their characters stats from the game as they change.

The drawback of NFC is the range is not far. Devices often need to be within a few inches to work. So while AR information can be sent to a device they lose the ability to interact from afar. The main solution to this is combining NFC with camera based markers [5].

2.3 BLE Devices

Bluetooth Low Energy is the standard behind the iBeacon. The iBeacon can be placed in a location and will communicate out to devices. There is no need for line of site, like you have with cameras, and they can reach across long distances (roughly 250 feet). This may initially make them seem to be an obvious solution to augmented reality, but unlike other technologies it is more difficult to get extremely accurate location data without multiple iBeacons present in the space, because there is no directional data in relation to distance from an iBeacon. Knowing your distance from 3, however, allow for triangulation.

Knowing a device's distance from one iBeacon is still useful information. It is easy to tell if a device is in a general location, like standing in front of an exhibit, or in a restaurant. This can be used to augment reality in a multitude of ways.

2.4 A Comparison of Available Technologies

It can easily become confusing to determine which technology is right for a given application. While each technology has its strengths they all have their weaknesses as well. It is not easy enough to just say iBeacon is the right solution all the time, but it does solve many of the problems that current solutions have. The following table should help weigh the options available when making a technology decision about sensors in AR (Table 1).

3 Augmented Reality and IBeacons

The recent technological advances made possible through iBeacon are empowering sensor based AR implementations in a far more seamless way than ever before. By wirelessly providing location data to devices without the need for GPS or paper markers, AR experiences can work indoors without polluting the space with markers. The iBeacon technology can interact in AR environments in four primary ways, by augmenting the user experience, extending the use experience, pushing the user to new experiences, or track the user as they interact normally.

3.1 Augment

These experiences can be extremely accurate and depend upon a Head Mount Display (HMD) technology that can track an individual's location within a space and present them with virtual objects or an overlay of a space, the use of beacons allows an individual's position in a space to be accurately determined, allowing the physical space to respond to a user's location. For example, a traditional AR might allow a surgeon to see an overlay on a patient's abdomen that represents where specific organs are within the body using a head mount display. That overlay might be present within the head mount display throughout an experience.

Table 1. Comparison of available AR sensor tech, modified from [7]

Technology	iBeacon	NFC	Markers
Hardware Requirements	Requires a handheld device that supports Bluetooth Low Energy.	Requires a handheld device that supports Near Field Communication (Not iOS)	Requires a device that has a camera installed.
Range	Up to 250 feet away and as close as a few inches.	A few inches away at most. The ability to touch handheld preferred.	Needs a direct line of sight, but could work across varied distances depending upon camera resolution.
App Requirements	Apps must know about specific beacons in advance and know what to do when those beacons are detected	App does not need to know about specific NFC chips though they can. Information can be stored and shared directly from the chip.	Apps may know about specific markers, but some standard format markers can contain information (QR Codes) and could use general purpose apps.
Setup Required by User	The user only needs to install the app and possibly enable Bluetooth through the phones settings. This can be done through the app as well.	The user needs to install the app and enable NFC on their phones. They will also need to physically touch sensors.	The user may have a general purpose app or might need to install a specific app. No other functions need to be modified.
Setup Required by app developer	iBeacons need to be placed in specific locations by the developer. Finding the best location can be difficult.	NFC tags are placed in specific places. Generally easier to place than iBeacons, but may require specific information written to them.	Unique markers must be developed with visual variation.
Benefit	Can determine locations in and around buildings with high accuracy and no physical connection from the user. Can be used for long and short distances.	Can contain information.	Low cost solution Supports most devices

(*Continued*)

Table 1. (*Continued*)

Technology	iBeacon	NFC	Markers
Technology	Can be completely hidden	Can record information for user. Inexpensive Easily Hidden from view	
Issues	Higher cost than other solutions Proximity is directionless Requires Bluetooth on the device	Needs magnetic shielding on metal Short Range No iOS support	Needs line of sight Cannot be hidden Often considered unsightly

Although, when leveraging iBeacon technology, a user might instead be prompted via their device, such as a phone or a tablet to view the same overlay only when they approach the patient's side, the power of Bring Your Own Device (BYOD) AR is present in this. Imagine, for example a factory employee who needs to repair a faulty part in a large machine. Using iBeacon like technology, that user might be prompted to access the repair manual for a specific machine when he/she arrives at the machine itself. This repair manual might include all of the necessary media including 3D models of the parts that need to be fixed, diagnostic information, videos, and step by step instructions.

3.2 Extend

The iBeacons can also be used to extend an experience. Used in informal educational settings, like museums, interactions could result in an additional experiences being provided to the user. For example, if a user was visiting an exhibit about earthquakes at their local science museum, they might have access to games, simulations, videos and various other supplementary information and media related to earthquakes on their phones. This information could be unlocked as they explore different parts of the exhibit and extend the experience for the user. They might decide to spend a few minutes playing these while they are viewing the exhibit, or they might choose to delve deeper into the content when they get home.

Similarly, a student strolling through a park might notice a statue with little information on the small plate installed at its base. Using a technology like iBeacon, that student might have access to relevant websites, information, and other media that surround the statue. This information could be saved, and even tracked via new informal learning management systems. But most importantly, it would be available in an easy to access format on a user's own device.

3.3 Push

The most common use of iBeacons is their ability to push information to a user. By determining proximity of the user to a particular beacon, the system can be used to push notices, information, media or any targeted messages. These messages can be used to provide contextual information about the current location or guide the user to the next one.

A user who visits a store in the mall for the first time, for example, might receive a push notification welcoming them to that store and asking them if they would like to join a loyalty program or receive any coupons or sales that are happening. The same user might be rewarded for multiple visits to the store, and pushed information about items they typically purchase being highlighted.

Health applications could push messages guiding users to take the stairs when they are near the elevator. Integration with other technologies might allow users to receive suggestions of what to order at a restaurant based on the number of calories they had previously logged that day and their weight related goals. This same technology can be used to push a user further through the physical world by suggesting the go somewhere else, similarly to the hotter/colder game children play.

3.4 Track

One of the biggest advantages of iBeacon over traditional AR technologies is the ability to track the users as they interact with the iBeacons. The experience is based on users connecting to the iBeacons and sharing that data with a server. So, while the iBeacon powers the experience the infrastructure is also designed around tracking how they are used. This tracking does not need to be explicitly shared with the user. It is possible to track that a user is taking the stairs vs the elevator, or turns right compared to left when entering a space. This information can be used to optimize the use of a space.

In retail it would be possible to determine a customer's shopping habits, and use that data to direct coupons to the customer. In a school it could be used to determine if a student showed up to class, or if a Hall Pass ever made it to the bathroom or Principles office. Of course, this information can be logged and used to customize pushing and extending, it can exist on its own.

4 Limitations

One significant limitation of technologies like iBeacon is their reliance on a user provided device. While some organizations and educational institution might provide devices to learners, such as tablets or computers; these technologies have been designed to capture your attention outside of formal learning during regular life experiences, necessitating in some cases that the user leverage their personal device. While the concept of using a personal device is certainly not uncommon (termed BYOD for bring your own device), significant portions of the world at large do not

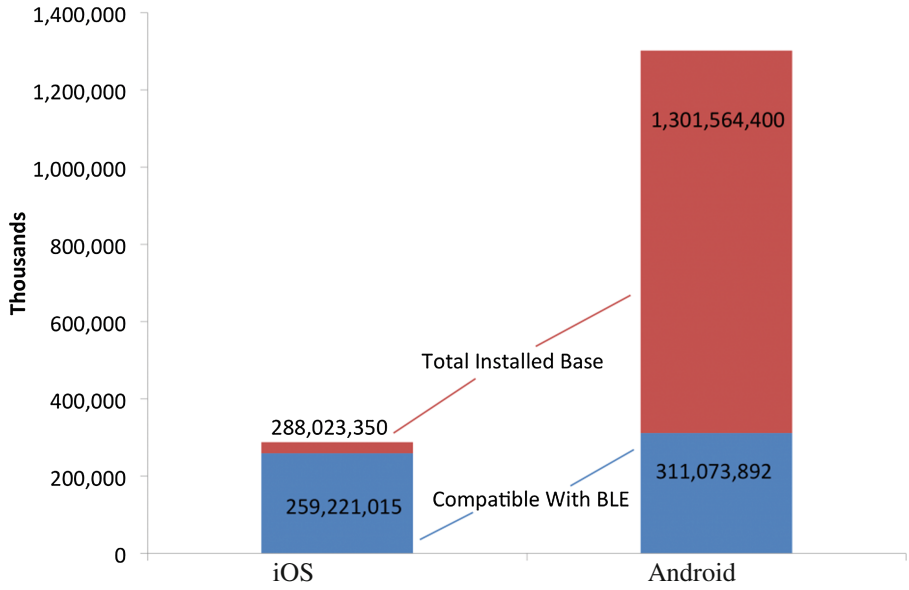

Fig. 1. Global active smartphones compatible with BLE (Source: BI Intelligence) [8]

have the technology that would be necessary to take full advantage of the features that technologies like iBeacon would require (Fig. 1).

Additionally, many individuals might be hesitant to use their personal devices as certainly tracking occurs, and individual privacy might be perceived as being at risk. While getting a message that a product was left in a virtual shopping cart online is interesting, getting a message that says you might have left a tangible object in an actual shopping cart might border on creepy. Honoring user's privacy is becoming more and more of an issue. The role of COPA is also at question here. AR implementations that leverage technologies such as iBeacon that work most efficiently when consumed on personal devices would have to innovatively create value propositions for individual users that would entice them to use the technology and not to opt out of receiving information and notifications.

This could present additional problems for those who pay for data usage or by text message. While Bluetooth is free, it is generally used to prompt internet traffic through the device. If this traffic is not wanted or valuable and has the user incur cost, these apps will soon find themselves uninstalled. Providing value for sharing data is also an important issue.

5 Conclusions

The use of iBeacon technology is increasing at a dramatic rate. The major industry driving this forward is retail, but as it becomes ubiquitous there, the technology is going to become an important driver in other experiences as well. The technology is

going to augment our environments in ways that have not been thought of yet. It will be providing more information and context to the data available as users explore informal learning spaces, art installations, and more. The iBeacon creates new opportunities for AR games and applications to be developed for both indoor and outdoor locations. By not relying on physical markers they provide a more discreet solution than traditional AR. With backing from major manufacturers of hardware, the iBeacon will change the way we interact and learn within augmented environments in the future.

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