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ENHANCING USER EXPERIENCE AT MUSEUMS WITH DATA COLLECTION THROUGH AUGMENTED REALITY (AR) APPLICATIONS

ARTIRILMIŞ GERÇEKLİK (AG) UYGULAMALARI İLE VERİ TOPLAYARAK MÜZELERDE KULLANICI DENEYİMİNİ GELİŞTİRME

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ABSTRACT

In our paper, we examined six AR applications used in today's museums. Although all examined examples improve the user experience from different digital perspectives, none of them improves the physical infrastructure of the museums. We recommend data-oriented, cost-effective, and distributed applications using AR technology to enhance the user experience in both the digital and physical world. Suggested improvements are obtained by implementing new AR applications and utilizing the data collection potential of the existing applications. We would like to emphasize the AR applications' potential to act as a medium to measure visitor behaviors and usage statistics. We explain how some insights from this big data can be used to improve the physical structure of the museums. We argue that compared to using museums' resources, a distributed network of user devices lowers initial costs and improves data collection rates while enhancing the experience with AR abilities. This distributed AR approach also offers refreshed experiences compared to static structures with its ability to get updates in time. Some examples of how to use the collected data from existing AR applications and two new AR usage cases for museums are explained in this paper. Our research also showed that this data-oriented approach is not used by any AR application developed for museums today and there is a great potential for user experience improvement in this sector.

Keywords: Museums, Artificial Reality, User Experience, Use Cases, Big Data, Insight, Mobile, Artificial Intelligence

ÖZET

Bu çalışmada günümüz müzelerinde kullanılan altı AG uygulamasını incelenmiştir. İncelenen tüm örnekler farklı dijital perspektiflerden kullanıcı deneyimini iyileştirse de hiçbiri müzelerin fiziksel altyapısını iyileştirmemiştir. Hem dijital hem de fiziksel dünyada kullanıcı deneyimini geliştirmek için AG teknolojisini kullanan veri odaklı, uygun maliyetli ve dağıtılmış uygulamalar önerilmektedir. Yeni AG uygulamalarının uygulanmasıyla ve mevcut uygulamaların veri toplama potansiyelinin kullanılmasıyla önerilen iyileştirmeler elde edilebilmektedir. AG uygulamalarının ziyaretçi davranışlarını ve kullanım istatistiklerini ölçmek için bir araç olarak hareket etme potansiyeli vurgulanmıştır. Bu büyük veriden elde edilen bazı içgörülerin müzelerin fiziksel yapısını iyileştirmek için nasıl kullanılabileceği açıklanmıştır. Müzelerin kaynaklarını kullanmaya kıyasla, dağıtılmış bir kullanıcı cihaz ağının başlangıç maliyetlerini düşürdüğünü ve AG yetenekleriyle deneyimi geliştirirken veri toplama oranlarını iyileştirdiği savunulmaktadır. Bu dağıtık AG yaklaşımı, güncellemeleri zamanında alabilme özelliği ile statik yapılara kıyasla yenilenmiş deneyimler de sunmaktadır. Mevcut AG uygulamalarından toplanan verilerin nasıl kullanılacağına dair bazı örnekler ve müzeler için iki yeni AG kullanım durumu bu yazıda açıklanmıştır. Araştırmamız ayrıca, bu veri odaklı yaklaşımın günümüzde müzeler için geliştirilen hiçbir AG uygulaması tarafından kullanılmadığını ve bu sektörde kullanıcı deneyimi geliştirme için büyük bir potansiyel olduğunu göstermiştir.

Anahtar Kelimeler: Müzeler, Yapay Gerçeklik, Kullanıcı Deneyimi, Kullanım Örnekleri, Büyük Veri, İçgörü, Mobil, Yapay Zeka

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1. INTRODUCTION

Although some artificial reality applications find their way into different sectors as entertainment, healthcare, production, maintenance, and marketing, there is still great unused potential in most of these areas. One of these areas is the user experience at museums. Until today, most of the museums used conventional methods to transfer historic knowledge to the visitors. The most popular examples are printed medium and digital information screens. In guided tours, the user experience is also greatly correlated with the storytelling ability of the pathfinder. The current static structure is presented in the first chapter of this article to understand the new AR applications and their

potentials. In the second chapter, we examined the AR applications that are currently used at some museums and their effects. Although these museums started to enhance their user experience with AR applications, worldwide acceptance of these technologies is very low due to investment costs, effectiveness, and stand against tour guides. In the third chapter, we propose some strategic replacements to the existing systems and propose new cost-effective, flexible, and distributed applications to improve the user experience at the museums. These newly proposed methods will also complement the tour guides instead of trying to eliminate them from the equation. Supporting tour guides is an important decision because we believe even with sufficiently advanced technology, tour guides' personal experiences, story-telling ability and reactivity to the new questions are a very important part of a museum experience. Our proposal is adding data collection abilities into the examined AR applications that use the visitor's phones (Krueger, 1991).

2. AN OVERVIEW OF CURRENT INFRASTRUCTURE

2.1. Smartphone AR Support

In order to use the visitor's smartphones for AR applications and collect data, we need to know what the current smartphone capabilities are. A visitor needs to have an AR-capable device to be able to perceive this improved experience. All the AR-capable phones sold today have Wi-Fi, Bluetooth, GPS, gyroscope, accelerometer, and basic data collection tools needed to gather usage statistics. With this information, we can focus only on AR capabilities since it is the bottleneck for our system to work. Thanks to the investment of smartphone manufacturers like Apple on AR technologies, the number of AR compatible devices increased excessively and currently most of the new devices comes with AR support from both IOS and Android side. Android starting from 4.0.3 version and IOS from 8.0+ version supports AR applications. This implies %99.8 of the devices support AR functionality (Aron, 2021). But for advanced AR applications, ARCore by Google and ARKit by Apple are developed. For Android phones, ARCore is downloaded to only supported devices from Google Play Store and it has more than 1 Billion downloads (ARCore, 2021). This number shows at least %40 of all android users tried advanced AR applications at least once; on the IOS side more than %80 of the devices are capable of running ARKit applications without any download. From these numbers, we can conclude at least %50 of the current smartphone users have used advanced AR applications on their smartphones.

2.2. Museums

Although there are very innovative museums, in the current museum system most of the small and not well-funded museums do not have the resources to add big digital information boards or build simulation rooms to create long-lasting experiences for their visitors. They are forced to trust their printed billboards, and not updated digital info screens. If they are lucky, they can get some tour guides and websites to share the latest news. For these museums, after a few visits, it is hard to impress the visitors with the same pieces. These museums also do not have solid data to improve their user experiences except for some surveys and visitor comments. Most of the time these surveys and comments are subjective and not helpful as numerical data. For museums with lots of resources, measuring the visitor behavior is very hard because you need to cover all areas with sensors to get accurate results which increase costs tremendously. On the other hand, even with good IoT coverage, they are not able to gather as much data compared to collecting data directly from the visitor's smartphones.

Some of the current AR solutions that are aiming to improve visitor experience are examined in the next chapter and we suggest new AR use cases with data collection abilities in the last chapter.

3. AR USE CASES IN MUSEUMS

Six use cases of AR applications with different specialties have been selected for examination in this article.

3.1 Reblink

In Toronto, the Art Gallery of Ontario is using Reblink to give life to their art pieces. With the help of this AR application, art pieces can move, change their posture, come together for your photo or even promote products. Capability is only limited by the illustration artists' imaginations. This application does not need visitors to scan a QR code, it uses the art piece itself as an AR marker. It automatically detects art pieces and shows new 2D or 3D animations on top of the piece (ReBlink, 2021). According to the Gallery's Interpretive Planner Shiralee Hudson Hill, 84% of the visitors felt more engaged with the pieces and 39% checked again the paintings after using the AR application (Museum Next, 2021). An example of Reblink's abilities is given in Figure 1.

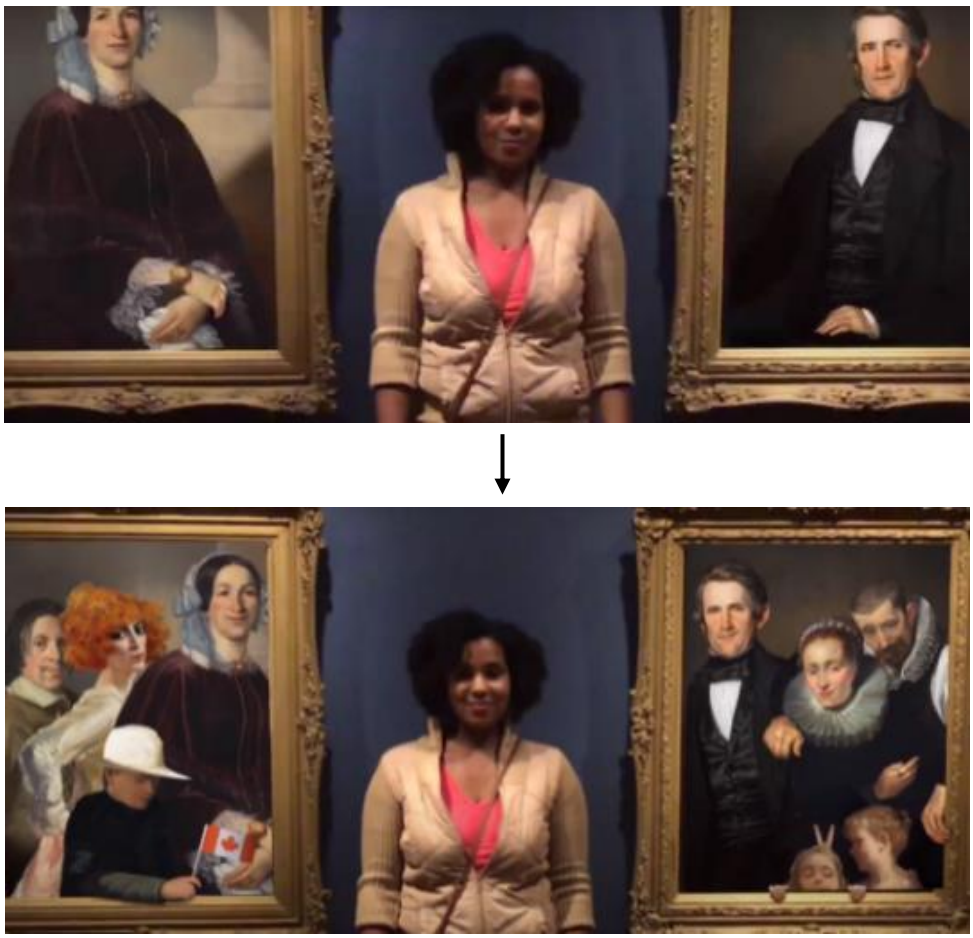

Figure 1. Reblink AR Application

3.2 Skin and Bones

The Smithsonian Institution at Washington D.C developed the Skin & Bones AR application for their natural history museum in order to show how some of the animal skeletons looked like when they were alive. As understood from the name it adds skins on top of the skeletons. The application works by detecting bone structure and using it as an AR marker. Then 3D animal drawings are placed on top of the bones. Visitors are not required to scan any markers except the skeleton itself and this feature improves the usability and adaptation of the application. Visitors appreciate the application for educational purposes. The UI for Skin & Bones app is shown in Figure 2.

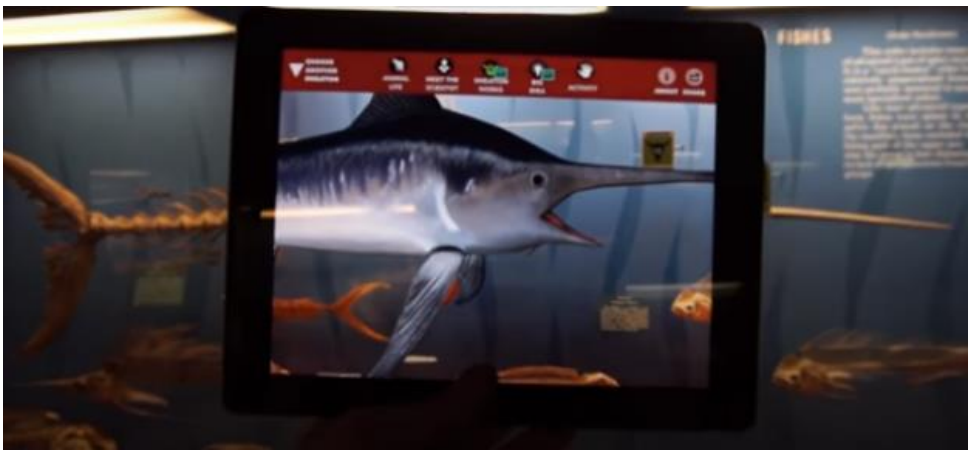

Figure 2. Skin & Bones AR Application

3.3 Speaking Celt

This AR application developed by The Museum of Celtic Heritage uses separate AR markers that are located next to the art pieces to summon a digital museum guard. When you show the appropriate QR code, a digital museum guard explains some facts about the piece in front (Morozova, 2018). You can see the museum guard explaining the piece in Figure 3.

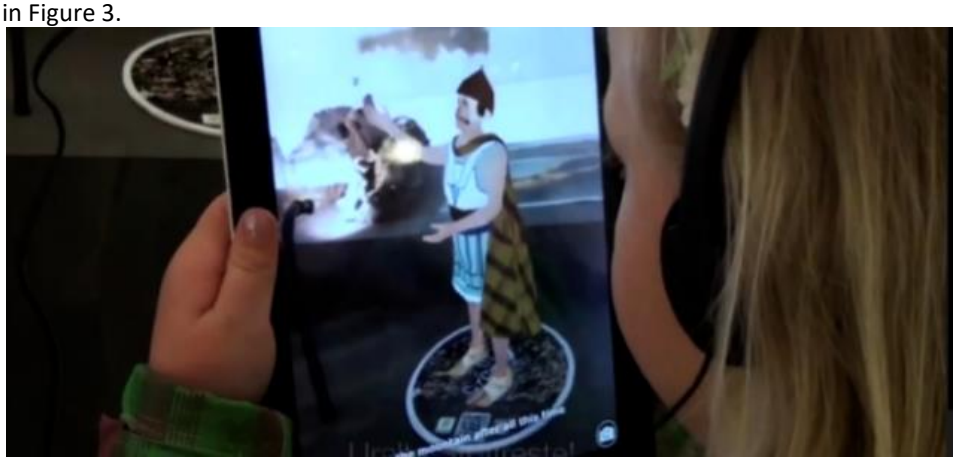

Figure 3. Speaking Celt AR Application

3.4 Gladiator School Site

With the help of the Carnuntum Gladiator School Site AR application, you can observe a historic place that is not even excavated yet. The true-to-scale digital 3D model of the Gladiator School site is used to improve the user experience at the guided tours (Franz-Lidz, 2016). This is a perfect example of how AR technology can complement tour guides. This application utilizes GPS signals and smartphone sensors to detect your position to let you freely examine the site. You can see the application UI from Figure 4.

Figure 4. Gladiator School Site AR Application

3.5 Overly

Overly is used by Latvian National Museum to show detailed information about pieces to the visitors. This application helps the visitors that want to learn every detail about a painting. It does not stop by giving general information about the paintings, it also lets users select specific parts of the pieces to examine appropriate explanations. Different from Reblink and Skin & Bones, Overly application is a platform that lets you create your own AR applications also. Although this platform approach may stop museums from implementing innovative AR applications, it greatly reduces the cost for museums that have strict budget constraints. You can observe the results of this application from Figure 5.

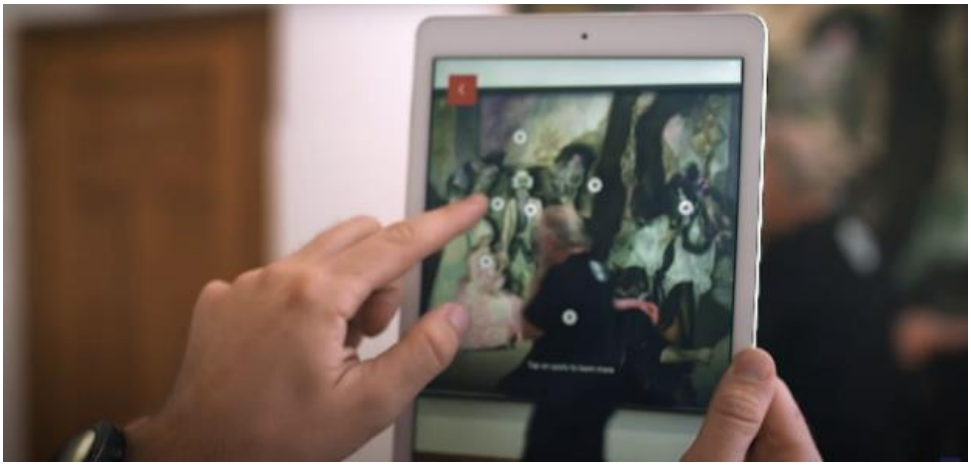

Figure 5. Information points on the art pieces supported by the Overly application (Overly app, 2021).

All the use cases shown in the examples up to this point uses AR marker technology which is also a cost-effective approach that lets museums digitally showcase any art piece at their showrooms. This technology can also allow schools in low-income rural areas that don't have a chance to visit the museums. The teacher can print some AR markers in the form of QR codes and with a tablet or smartphone, everyone can live a museum experience. You can see how easily a museum can be created with some QR codes and a tablet in Figure 6.

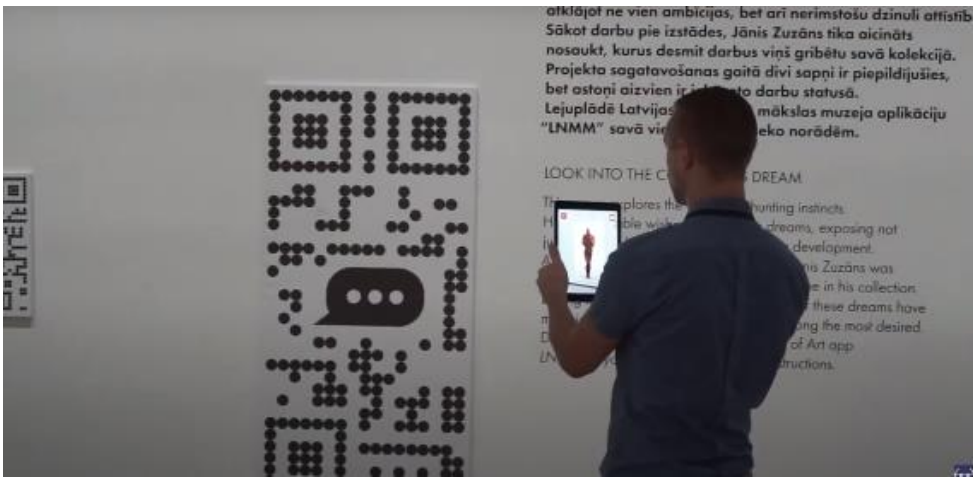

Figure 6. Museum without any real art pieces

3.6 GuideBOT

GuideBOT is a virtual assistant that shows you the way in closed environments like museums. It can navigate 300 meters on multiple floors without any problem (Guide bot, 2021). They use a 3D scan of the museum for navigation since GPS is not very accurate in closed areas. The company also has solutions with GPS for outdoor applications like cities or open-air museums. You can examine how GuideBot shows the way from Figure 7.

Figure 7. GuideBot Navigation AR Application

4. AR APPLICATION IMPROVEMENTS

In this chapter, we propose methods to further improve the user experience with the help of data collection and 2 new AR use cases that can be implemented for different museum types.

4.1 Data Collection and Insights

All the artificial reality solutions explained in the previous chapter propose good improvements to the user experience via utilizing the visual power of AR at museums. But they are unsuccessful in utilizing the data that could be collected while using the applications. These AR applications have access to the camera feed, Bluetooth, Wi-Fi, gyroscope, accelerometer, GPS data and they can measure the usage statistics as viewing times, screen touches, reading times. Since the visitors will use the AR application throughout their museum trip to enhance their experience, data will be always collected without affecting them. This big data can be processed to improve the user experience in the physical world also. Some examples are as follows:

Big museums can find out which routes are preferred by the visitors or which ones are not used, so they can publish notifications that warn the visitors to not miss anything.

Museums can detect which pieces are more appealing to the visitors and create merchandise to sell at their store so they can increase their income.

Museums can send a targeted notification about the appropriate merchants if a visitor examines one piece more than the usual amount.

- Museums can detect if a very popular piece loses its appeal, and they can act in time to apply new creative ways to get the attraction to the pieces back. Reblink is a nice example of regaining attention and refreshing the experience.
- If some routes in the big museums get more attention than others there might be crowds on these routes that will negatively affect the experience. Museums can use this information to keep areas from being too crowded by updating the distribution of pieces.

Examples can be extended but to sum up, more AR features added to the applications more people will want to use it. When more people use it, more data will be collected. More data collected means more data-oriented improvements can be detected and applied to the museums. Better museums will get more visitors and more income so they can spend more on AR solutions. As you can see this is a positive feedback loop when you start with some data-oriented AR applications it starts a snowball effect. You can observe the positive feedback loop explained in Figure 8.

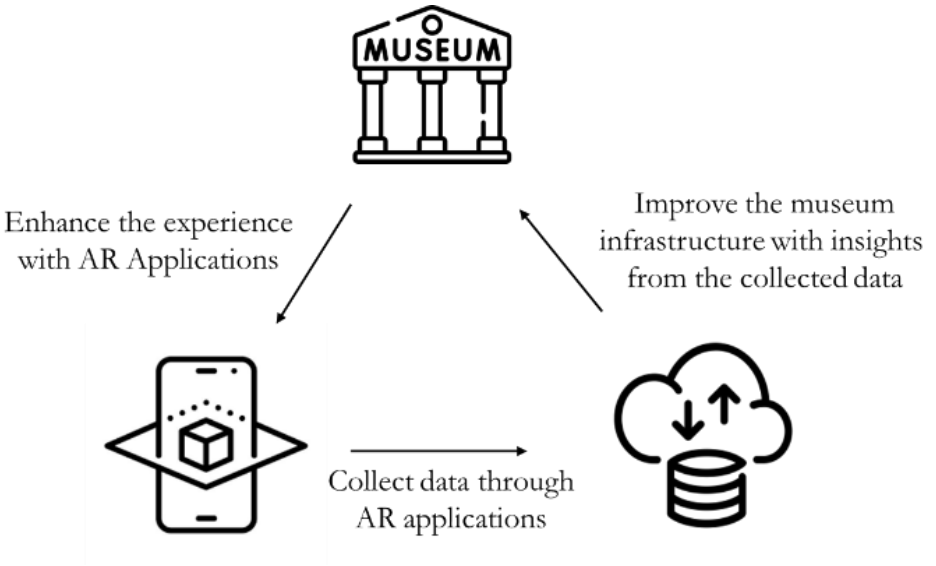

Figure 8. Experience improvent with data through AR application

4.2 AR Scavenger bunt at Museums

A scavenger hunt is a competition type that you need to solve some puzzles with the help of your environment to win a prize. In a museum, your solutions would require examining and learning the art pieces. Via adding AR into these scavenger hunts the potential is infinite. These events can be done in cooperation with schools to educate students. With AR applications you will not need to print, paint anything on the walls of the museum, no need for big banners or huge cardboard models to get the attraction. Since you do not alter the real world, the next day museum will be functional without any hassle and this lets you organize as many hunts as you want. Central Park Natural History Museum organizes sleepovers that let visitors sleep at the museum at night (Amnh, 2021). These sleepover events would be the perfect opportunity to apply these AR scavenger hunts.

4.3 Restoration of the Atmosphere

Today renovation of a historic place is a very complex process that requires multiple disciplines to work together. Most of the time these renovation projects are either very costly or done poorly. To overcome these problems, we propose to keep the original

piece as much as possible and show the missing parts on top of the existing structures via AR applications. Current AR technology can detect your place, recognize images of the monuments and add visual artifacts on top of the real image with AR technology. Current applications are focused on either adding informational content or completely covering the existing part with another version of the piece. In our research, we did not encounter any application that completes the missing parts. In closed areas, it is easier to apply this method since lighting conditions are fixed and movement capabilities are limited. But for open-air museums like Efes ancient city in Turkey, developers of the AR application should consider the lighting differences due to weather and it needs more resources to completely 3D scan big structures like monuments. On the other hand, open-air museums allow utilizing GPS as an extra input to the system. GPS signal can be an asset for both data gathering and image recognition purposes in AR apps.

Completing missing pieces of buildings and monuments is not the best we can do to recreate an area with AR, we should also try to imitate the historic atmosphere as much as possible. We can re-build the whole area with digital living beings with the help of AR. For example, developers can add theater actors, spectators with appropriate clothes, antique food sellers to places like antique theaters at Efes ancient city. If visitors can see and hear the real atmosphere at those historical places instead of reading from a paper the effect will be much more permanent. When you show what people were eating in that era or how they dressed, you can also sell those products in your gift shop. People will be very curious to taste the antique tastes or buy some unique fashion products.

5. RESULTS and DISCUSSIONS

In this paper, we examined 6 different AR applications used at museums to enhance the visitor experience. 4 of these real-world cases used AR markers to enhance the experience. Skin & Bones and Overly applications try to improve the experience by presenting the information in a visually pleasing way. Reblink regains attraction back to the original pieces by showing them from a different creative perspective. Speaking Celt narrates some fun facts about the pieces. Gladiator school lets people examine a real historic place which is not possible to see physically yet. GuideBot makes it easier to walk around the museums with the help of AR. Research showed that although all these applications improve the experience on the digital plane, none of them utilizes the power of the big data that can be collected while using the applications. We suggested that museums can obtain useful insights from the data collected through AR applications. Some of these insights can be used to increase the sales of merchandise or to update the physical infrastructure of the museum to improve user experience. This data-oriented strategy can be implemented in all applications examined in this article. We also explained how AR scavenger hunts can be used to get attention and, our Restoration of Atmosphere project aims to not just reduce the restoration costs, also helps to enhance the user experience by showing how were those historic places used by our ancestors. When we examine the selected AR applications and our proposals, we can conclude that museums have a great potential to implement new AR applications and obtain insights from these applications. These applications can also help the tour guides to transfer their stories in a better way. The museums that use these AR applications and utilize the data collection potential of these applications can give visitors a better experience, lower costs, increase their income and regain lost attention with continuous minor updates to the art pieces and the museum infrastructure.

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