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# Augmented Reality to Enhance Visitors' Experience at Archaeological Sites

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**Abstract.** After archaeological excavations are completed, many of the sites are prepared for visitors by including things such as (1) scientific interpretations of what the uncovered structures might represent, (2) reconstructions of ancient structures and (3) historical items or artifacts found during excavations. In addition to these, technology including augmented reality (AR) can be used to provide additional information on site. We study how currently popular global location-based AR games are supplementing the visitors experience at three archaeological sites in the Levant: *Tel Hazor*, *Tel Megiddo* and *Tel Gezer* by inspecting virtual points of interest (PoIs) in the game *Ingress Prime*. In the three locations, the virtual PoIs are linked to real world locations, however, they cover only a fraction of the visible archaeological structures. A bias was seen in the PoI names and descriptions towards certain archaeological interpretations. We propose location-based AR games should utilize as rigorous information of archaeological sites as possible, in order to provide players the possibility to learn real history in an accurate way.

**Keywords:** Location-based games · Archaeology · AR · Ingress · Levant

## 1 Introduction

Annually millions travel to see archaeological sites of cultural, historical or religious significance. These sites are typically outdoors and are prepared for visitors after archaeological excavations are completed [8]. Pottery and other smaller artifacts found on the excavation site or nearby may also be put on display, as well as models or reconstructions of predicted historical structures. To supplement the artifacts visible on site, signs, guidebooks, audio-guides, games [18, 22] or augmented reality (AR) applications may be created to support the visitors understanding of the place. This additional material typically includes scientific interpretations of who built the structures that are visible on site and when, and for what purpose.

One particularly interesting new solution in this context are the global location-based games (LBGs), also called AR-games or pervasive games, which augment a virtual world on top of the real world. These games can transform physical

PoIs into virtual PoIs and harness the real world as a playground. Many LBGs use virtual PoIs as part of their gameplay, but currently only in three games, *Ingress*, *Pokémon GO* and *Harry Potter: Wizards Unite* they are linked to real world locations [35, 20, 21]. Most archaeological sites that are open for visitors contain these PoIs.

A common challenge in the archaeological sites of *Hazor*, *Megiddo* and *Gezer* is that there exists competing views among scholars with regards to interpretations of the excavated structures dating and original purpose. One of the main questions with regards to the observed three locations has been whether or not the great fortification systems with gates mentioned in *The First Book of Kings 9:15* can really be dated to the reign of Solomon (i.e. to time of united monarchy) or whether they should be dated a little bit later to the Omride dynasty in the kingdom of Israel. At the heart of this debate is the so-called *Low chronology for Iron Age I* as suggested by Israel Finkelstein in his two articles [14, 15] which challenged the united monarchy proposed by William Dever [10] and others. Afterwards the discussion has profiled mainly in the debate between Finkelstein and Mazar (See, e.g., [24, 16, 25, 26, 17]). Methodological assumptions behind Finkelstein’s low chronology have also received criticism [19]. This discussion highlights how scholars have dated stratigraphic layers differently at archaeological sites and consequently interpreted the origin and purpose of discovered structures in varying ways.

Previous studies have shown that games based on virtual PoIs linked to real world objects provide users the opportunity to learn about their environment [29, 21], however it has not yet been demonstrated how well these PoIs match real world objects and how large a quantity of important objects they cover. This study aims to answer the following research questions:

1. How well do currently popular global LBGs cover PoIs at archaeological sites in the Levant?
2. What kind of information is given about the PoIs and which scientific interpretations are supported?

By providing answers to these questions this study aims to supplement the findings of previous studies [29, 21] and consequently increase understanding of the current educational values that global LBGs provide for visitors to archaeological sites, national parks and outdoor museums.

## 2 Research Design

### 2.1 Selecting the Cases

For answering the research questions, three archaeological sites in the Levant were chosen for observation based on the Bible, First Book of Kings chapter 9 verse 15: “*Salomon built Hazor, Megiddo and Gezer*”. All three places, *Tel Hazor*, *Tel Megiddo* and *Tel Gezer* have been excavated by archaeologists and are currently open for visitors [27, 33]. These sites have ruins of ancient structures

which have been discovered in multiple strata such as those dated to Late Bronze Age and Iron Age [34]. *Tel Hazor* and *Tel Megiddo* have been declared World Heritage Sites, meaning their conservation has been recognised internationally to be of great importance.

The PoI database used in *Ingress* was chosen for analysis as the database is global [35], the virtual PoIs match real world locations [21] and PoIs are visible for all in the Ingress Intel Map [28]. Besides *Ingress*, the same PoIs are largely used also in other games such as *Pokémon GO* and *Harry Potter: Wizards Unite* [21]. Furthermore, games based on this database have been found to increase players place attachment [29] providing preliminary evidence towards LBG's potential for enhancing visitors experience at cultural sites.

## 2.2 Research Process and Analysis

The three archaeological sites were looked up in the *Ingress Intel Map* in October 2019. All found PoIs, their title and location were recorded, and based on these characteristics, they were mapped to corresponding real world objects. If the PoI title was in another language than English such as Arabic or Hebrew, it was translated to English. As a comparison and tool for analysis, information of the sites was obtained from the *Israel Nature and Parks Authority* [27] website as well as major publications on the archaeological findings and their scholarly interpretations.

The virtual PoIs found in *Ingress* were analysed by looking at (1) what kind of a PoI is it? (ruin, sign, model), (2) from which time period or stratum is it from? and (3) which archaeological interpretation does it represent? The virtual PoIs were then roughly compared to the actual visible structures.

## 3 Results

### 3.1 Tel Hazor

Lead by Yigal Yadin, major archaeological excavations took place at Tel Hazor in the 1950's which revealed bronze and iron age structures and evidence of both Canaanite and then later Israelite settlement [2, 3, 37, 39]. The site has been of interest to biblical scholars, archaeologists and historians [3] and has been studied together with several other similar ancient ruins in the region [36, 39]. The largest individual remaining structure in Tel Hazor is an underground water system which was discovered by Yadin's later 1968-1969 expeditions, and has been dated to the Iron-age [38]. Similar water systems have been found in several cities on top of mountains from the same time period [38]. Another major structure is a "*Salomonic city gate*", dating of which has been discussed by scholars to be either from the time of Salomon (10th century BCE) or the Omrid dynasty (9th Century BCE) [36]. Also other structures, mostly interpreted as housing, remain on site [12], including a typical 8th century BC Israelite four-room house [13, 32].



**Fig. 1.** Satellite map view provided by Google Maps and current Niantic PoIs in Tel Hazor

Figure. 1 shows the locations and names of all virtual PoIs (4) of Tel Hazor currently in *Ingress*. Two of the PoIs, *10 Century BC Salomonic Gate* and *The Water System- Tel Hazor* point to ancient historical artifacts. *Yaco 'Bob'The Watchman* shows a modern art piece depicting an ancient Israelite Guard and the final PoI *Tel Hazor-National Park* is a reference to the entire site. It is evident these PoIs only lightly touch the historical depths of this location, as multiple structures such as the Israel four room-house are not included as virtual PoIs and the information of the existing PoIs is limited. For example, with regards to the *10 Century BC Salomonic Gate*, only the interpretation of Yadin and Ben-Tor is shown.

### 3.2 Tel Megiddo

Tel Megiddo is a world heritage site located on a mountain in the middle of the Jezreel plains and has been featured a few times in pop culture due to it being referenced in an eschatological context in The Revelation of John when talking about Armageddon and the apocalypse [7]. Tel Megiddo features a 35 meter deep water system [23] from the Iron Age period, similar to those found in *Hazor* and *Gezer* [38] as well as the ruins of a great temple dated to the early Bronze Age (3000 BCE) [1]. Tel Megiddo has arguably the most detailed data in all of Levant for the period from Late Bronze (3000 BCE) to Iron Ages (750BCE) and has thus unparalleled historical value [34].

In Figure. 2 all found virtual PoIs (8) in *Tel Megiddo* are depicted. Seven of them are named in English and the final one is in Hebrew, which represents a city gate. Three of the PoIs are signs: *Tel Megiddo*, *Tel Megiddo World Heritage Site* and *Tel Megiddo National Park*. Then there are three sculptures: *Battle Ready Chariot Sculpture*, *Chariot Sculpture* and *Salomon's Stabled Horse*. Unlike in *Hazor*, the PoIs in *Megiddo* do not offer direct references to ancient structures except for the city gate. For example, the "*Salmonic Gate*" or the water system are not PoIs and neither is the ruin of the Bronze Age (3000 BCE) Canaanite



**Fig. 2.** Satellite map view provided by Google Maps and current Niantic PoIs in Tel Megiddo.

temple [1]. Thus, we conclude that virtual PoIs in *Megiddo* provide hardly any connection to the historical depths of the location.

### 3.3 Tel Gezer

Ancient Gezer was an important strategic area due to its geographical location guarding Via Maris, Valley of Aijalon and the trunk road leading to Jerusalem [11]. Excavations began at the site in 1902 lead by Robert Alexander Stewart Macalister and lasted seven years [9]. More excavations have since taken place such as Alan Rowe's six-week campaign in 1934 and The Hebrew Union College Excavations in 1964-1966 [9]. Structures from multiple strata dating to Late Bronze Age and Iron Age have been discovered from the location [11, 30, 39] including a Salomonic four-entryway city gate, a similar which is also found in Tel Hazor and Tel Megiddo [11]. However, the Gezer gate is a bit different in it being based on a square plan instead of a rectangular one [36]. A Canaanite water tunnel has also been found in the ruins along with Masseba stone structure and many other smaller structures.

In Figure. 3 we see the *Ingress* PoIs that are currently located at Tel Gezer. These PoIs are in Hebrew and are roughly translated, going clockwise as (1) Sheikh Aljazarli's Tomb, (2) Area of Worship: Masseba Site, (3) Salomon Gate, (4) Canaanite Gate, (5) Water System, (6) Map of the vicinity of Tel Gezer and (7) Gezer Calendar. Compared to the other two observed locations, *Tel Gezer* has the largest quantity of virtual PoIs representing ancient structures. Yet, for example, the debate regarding the chronology of visible structures is not visible. Similarly to virtual PoIs in *Tel Hazor*, Finkelstein's Iron Age low chronology [14, 15] is dismissed.



**Fig. 3.** Satellite map view provided by Google Maps and current Niantic PoIs in Tel Gezer

## 4 Discussion

### 4.1 Key Findings

We summarize our findings with three points:

- Ingress PoIs represent only a fraction of the visible archaeological structures in all three observed sites.
- Scholars have proposed varying interpretations regarding observed structures and their chronological origins. This debate is not visible in the observed PoIs.
- PoIs represent structures from different strata, but are all displayed on the same level. Thus, the visitor does not get support from the game in understanding the chronology of their observations.

Regardless, games based on the Ingress PoIs can bring relevance to these sites by helping players find the site, guiding players through the site (though currently sub-optimally due to the limited number and accuracy of existing virtual PoIs), offering players short snippets of information regarding the real world locations virtual PoIs represent, and providing players a fun game and motivation to travel to these sites.

### 4.2 How AR can Support Archaeological Sites in the Future?

To utilize AR more optimally in archaeological locations, more cooperation between technology developers and scholars is needed. Currently archaeologists are not harnessing AR to its fullest potential and the observed game Ingress is not using the scholarly information of archaeologists adequately. Based on the results of this study, we propose three areas of improvement.

**Increasing the Quality and Quantity of Virtual PoIs** As *Ingress* PoI submission and review are crowdsourced, there is variance in the quality of PoIs depending on the area [20, 21]. Virtual PoIs in location-based AR games should cover the key real life PoIs on the site to support learning of real history. *Ingress* currently allows PoIs to have a short description and photos in addition to their name and location, which can be used to contain relevant information. We propose that with world heritage sites, such as *Tel Megiddo*, location-based AR game developers should cooperate with local authorities and scholars to create virtual PoIs that better serve the location.

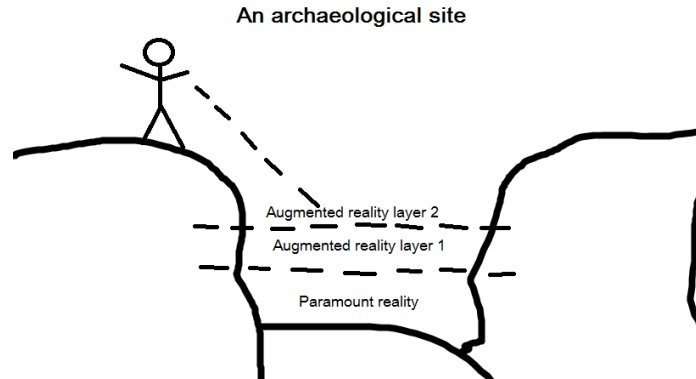
**Informing Visitors of Differing Scholarly Interpretations** As scholars sometimes disagree on interpretations of archaeological evidence, it is important to accurately present evidence of all cases for visitors. Table 1 shows the interpretations of *Hazor* findings from strata X and IX according to two different schools: Yadin and Ben-Tor and Finkelstein. When reconstructing structures from these layers, only one reconstruction can be presented at the correct location using traditional means. AR solves this issue as the reconstructions are digital and can be switched at will. For example, a broken ancient wall, which depending on the theory was either an arc or just a wall, can be displayed as both to the user using AR.

**Table 1.** Comparison of Chronological and Historical Explanations of Ruins and Artifacts Discovered in Strata X and IX in Tel Hazor

Yadin and Ben-Tor		
Stratum	Dating	Historical Setting
X	10th Century BCE	Salomon
IX	Late 10th, Early 9th	Israelite
Finkelstein		
Stratum	Dating	Historical Setting
X	Early 9th Century BCE	Israel: Omrides
IX	First half of 9th Century BCE	Israel: Omrides

**Differentiating Strata and Visualizing Lost Information** Several excavations such as those that have taken place in Tel Hazor [4, 3, 8, 6, 5] have revealed structures from multiple time periods across many strata. Furthermore, when archaeologists wish to dig deeper to reveal older structures, they are sometimes forced to remove strata on top. As a result of this process, many excavation sites are left with structures from different strata to display. AR gives the possibility of visiting the same physical place multiple times, each time with a different era lens through which the site can be looked at [31]. An example of this is visualized in Fig. 4 where an observer can see layers of destroyed history through the AR lens.





**Fig. 4.** Visualizing how destroyed layers, for example, late and early iron age, can be reconstructed and displayed in AR

### 4.3 Negative Effects of Using AR at Archaeological Sites

Gamification of archaeological sites through AR can also have negative consequences. First, having PoIs at world cultural heritage sites might attract unwanted attention. Players with no regard for the site could in worst cases cause damage to the place if they focus too heavily on the game and dismiss real life guidance on how to behave. Second, as these sites can be the target of pilgrims and serious contemplation, roaming LBG players could disturb the atmosphere. On the flip side, this atmosphere might also teach the players to appreciate cultural heritage more. Finally, over-gamifying places might steal visitors attention too much away from the actual real life sights.

### 4.4 Limitations

This study is limited by its scope in both the observed AR-solutions and observed locations. We only looked at one AR solution, the location-based game *Ingress*, and only three major archaeological sites, all from the same geographical area. This study could also be expanded to other AR solutions besides games, and to archaeological sites in other parts of the world. Furthermore, empirical evidence on people playing *Ingress* while visiting these locations could increase the understanding of how well the existing technologies serve these sites.

## 5 Conclusions

The positive side of *Ingress* and other similar apps is, that as they are global, users are not required to download a new museum app for each site they visit, but can instead use the same app everywhere. Despite the observed PoIs of *Ingress* being linked to real world locations, they present only a fraction of the historically rich structures at *Tel Hazor*, *Tel Megiddo* and *Tel Gezer*. The possibilities

of LBGs and AR for supplementing the visitors experience at archaeological sites are greater than what the existing solutions offer. Collaboration between AR content designers and archaeological scholars should be increased to enable visitors to accurately learn real history via the technologies.

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