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A web scrapping and AI approach for archeologists to analyze the ancient cities

Nusret Demir *1, Cem Sönmez Boyoğlu 2, Deniz Kayikci 3

[1]*Akdeniz University, Faculty of Science, Space Science and Technologies, Antalya, Türkiye*
[2]*Wuhan University, Department of Surveying Engineering, Wuhan, China*
[3] *Universitat Autonomous De Barcelona, Prehistory Department/Quantitative Archaeology Lab, Barcelona, Spain*

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Abstract
Studies on machine learning have started to reach a level where we can save a great amount of time and labor by producing structures that can think as a human and have decisions. Deep learning, one of the methods of machine learning, is an artificial intelligence-training technique that can predict the outputs from the given dataset In this study, the use of web scraping technique was investigated to determine the potential of identifying ancient columns, which are one of the most important architectural elements of cultural heritage, by artificial intelligence. In this study, web scraping approach is presented as a digital data acquisition method for archaeology field to collect imagery datasets from web to analyze the ancient cities. For analysis, a free online, and easy-to-use tool 'Amazon Rekognation' is used for comparing the number of columns found in the scrapped images. For summarizing the research, simply, we have tried to get the answer the question from PC that 'which site has the columns most, Perge, Xanthos or Phaselis?'. With this proposed approach, the archeologists can have a primarily knowledge about the sites they will study with use of operational tools for their further comprehensive research.

1. Introduction

In recent years, as access to huge data in the digital world has increased, AI technologies have started to be used intensively in the production of archaeological information. particularly, machine learning methods are used both in modeling the structures related to cultural heritage and in the interpretation of information.

The goal of archeological science is to study, characterize, and interpret human history using tangible evidence such as human remains. Artificial intelligence, according to recent studies, has the ability to greatly assist archaeologists in this aspect. However, multidisciplinary collaboration is required to conduct research, as explained by Kintigh et al [1], because the archaeological domain encompasses all scientific fields, from biology to computer science, geomatics to chemistry. The general contemporary difficulties of archaeology were examined thoroughly and it was also noted that online studies and digital links should be improved [1]. Because visual observations provide us with essential properties of artifacts/finds such as size, orientation, form, color, texture, spatial location, and shape, archaeology is typically a 'visual' profession. The archaeologist can interpret and describe from these features at the first seeing of the object [2]. They're all value of archaeological observations comes from archaeologists' competence to extract meaning full information from them. This is only possible when all relevant information has been captured and coded. Since archeology is basically a visual discipline, visual digitalization and artificial intelligence-based visual systems are gaining more and more important in this field.

The Semantic Web is a concept that can be used by both people and software. Data acquisition and classification can both be programmed into the software. However, this is a data collection method, not artificial intelligence. This database is interpreted by artificial intelligence, which draws new conclusions. The difference in being able to go outside the framework bounded by ontology and microdata is the most

* **Corresponding Author**

*(nusretdemir@akdeniz.edu.tr) ORCID ID 0000-0002-8756-7127
(cemsonmezboyoglu@gmail.com) ORCID ID 0000-0001-9367-7931
(1592874@uab.cat) ORCID ID 0000-0002-1311-4272

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significant contribution of artificial intelligence, along with "deep learning." As we face a digitalization revolution in the world, the use of digital technologies in the documentation and presentation of cultural heritage has increased, especially with the development of spatial information technologies. In parallel, many cultural heritage institutions (museums, archaeological sites, libraries, etc.) have made their collections available to visitors on the Internet [3]. Today, digital technologies provide an important input not only for the use of visitors but also for reconstruction and restoration processes [4-6]. Moreover, In the erasing of cultural heritage from the earth from both human and natural factors and taking protection measures in this regard. Recently, digitalization studies of cultural heritage have focused not only on transferring data to the computer environment but also on generating information by interpreting these stored data. Digitalization of archaeology and its education is emerging with the development of the tools already [7].

Artificial intelligence is a technic that transfers humanoid features such as learning, analyzing, thinking, and predicting to machines with software and hardware technology [8]. It is divided into narrow, general, and super artificial intelligence [9]. Narrow artificial intelligence focuses on the specified area and produces solutions. General artificial intelligence is a type of artificial intelligence that deals with humanoid features such as image detection, language and speech recognition, and general prediction. Super artificial intelligence is a type of artificial intelligence that is predicted to have all humanoid abilities in the future [10-11].

Supervised learning realizes learning and prediction over the previously processed data. Unsupervised learning is a form of machine learning in which the user self-taught the machine using less data. Reinforcement learning, on the other hand, is a machine learning that occurs without any dataset, and learning with experience. It improves itself by using feedback [11].

Studies on artificial intelligence have been continuing for more than 50 years. The development of studies on artificial neural networks, the increase in the number of layers by adding hidden layers and complexity has formed the concept of "deep learning". Deep learning can be explained as learning of hidden layers between the input layer and the output layer by processing data via hardware [8]. The deep learning method, which is a part of machine learning, was used in this study. Deep learning is a machine learning technique based on training artificial intelligence. It produces output data by making various estimates from the available data inputs.

Along with developing computer technologies, archaeological studies are also kept up with this technology and benefit from ideas such as artificial intelligence. Machine learning, which is one of the subdivisions of artificial intelligence, has provided innovations in many areas and has come to a quick way in adapting artificial intelligence to our daily life. As computers / processors that can learn to think like human beings develop, the time and labor force they provide us increase in parallel.

In this study, a random online photo search was performed on the names of the ancient cities selected for the study and these photographs were analyzed and the results were discussed. Three ancient cities in different regions of Antalya have been chosen as the study area which are south of Türkiye. These cities are Perge, Xanthos and Phaselis. The photographs were collected by scanning the Google database on behalf of each city were analyzed using the deep learning-based visual analysis service provided on the Amazon Rekognition website.

The main objective of this study is automated identification of the most popular items of tested cultural heritage sites with use of web-scrapping and deep learning methodologies. This developed approach will allow the culture heritage research community to identify the availability of the image data, which stored on the internet first. Because the web-scrapping method works accurately in case sufficient data were already stored in. The extracted images were analyzed through cloud based deep learning, which does not require any coding skills. So, any non-programming fluent expert who performs any research on cultural heritage, have benefit from the proposed approach to use in their research problems. The main goal is to show the potential of web-scrapping and cloud based deep learning platform to present the cultural heritage site information in terms of their most popular items.

The goal of this research is to shorten the preliminary preparation time for archaeological research, which requires imagery data from the web and an abstract analysis of the determination of the ancient city formation, where columns are important features. The web scraping method has been proposed for this purpose. As a preliminary stage of archaeological research, the proposed workflow can determine any architectural or other related ancient elements faster than the traditional manually selecting method. For example, the presence of the majority of columns in an ancient city indicates that it was a developed city because it indicates the presence of numerous monumental structures with columns. Furthermore, the extracted data provides information about the texture of the ancient city. As a result, a researcher who studies ancient cities and columns can determine which of the ancient cities in the region he or she is studying was a metropolis from a large number of columns and gain preliminary information about the styles of the ancient columns in this region. Any archaeologist can learn a lot about a site without even visiting it by using a combination of scraping and detection methods. Alternatively, a researcher working on ancient columns can use this data to determine where to begin. This, of course, should not be overlooked: Web scraping also restricts the scope of research to web-based content and makes accessing information from mobile apps difficult.

2. Material and Method

The method has two sections, which are web-scrapping and deep learning. Python programming language was used for the scrapping of cultural heritage images from the Internet. The selenium library was the key tool in development. The deep learning methodology is based on the Amazon Rekognation Cloud Service [12].

Selenium is a framework, which includes various tools and libraries that enable web-browser automation. It can be worked with any web-browser without any human interaction. A piece of the Python code can allow searching information in different file types, including text, images or any other multimedia formats [13].

The other main tool used in this study is Amazon Rekognation. Amazon Rekognition Custom Labels is Amazon's system of tens of millions of images trained in many categories. The content in the photos uploaded to the system is automatically identified by integrated cloud based deep learning. Amazon Rekognition is a visual analysis service that was launched in 2016 and has been used in various fields since its inception. Offering two usage options, Amazon Rekognition offers pre-trained algorithms over data belonging to Amazons, while at the same time it has an algorithm basis that the user can create by training with their own data. The workflow of the proposed method is shown in Figure 1.

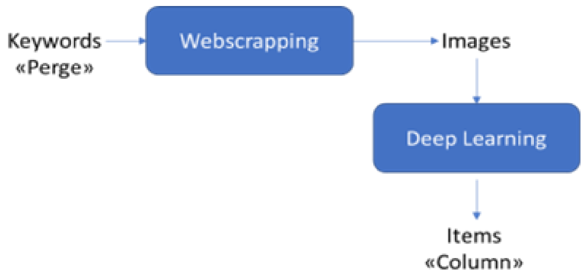

Figure 1. Method overview

As shown in Figure 1, only keywords are given into Web scrapping process, and then the images are extracted from the web. The extracted images from web, later are given as inputs into the cloud based deep learning system, to identify the most items in the investigated cultural heritage site. In this example, given "Perge" keyword has a result "column" which is the correct result since the most explored items are columns in Perge.

2.1. The concept of semantic web and web scraping

Worldwide Web is now the main so-called library of the modern world without a doubt. The scholarly publications are placed digitally, and people store and post information empirically, besides the reliable information. The web is also the main source of fake information since it is a wide and open area where everyone can post anything they want. The amount of information on the Web now allows conducting big data analysis, which is the baseline of Artificial Intelligence research and applications.

The Semantic Web is an extension of the current Web, not a replacement for it. The semantic web concept enables software and people to collaborate due to the loaded well-defined information. The World Wide Web's main feature is its universality. It covers a wide range of topics such as culture, language, and media. However, it is designed primarily for human consumption. It isn't designed for machines. The data generated for the machines is not the same. Databases and sensor outputs, for example [14]. The Semantic Web [15] aims to reduce this disparity. Searching and extracting information from the Web is time-consuming, thus needed to be automated. Web scrapping which is a semantic web approach with a programming language, mainly Python allows researchers to do the queries on search engines in an automated way, any type of file including images can be downloaded. Internet (web) scraping technologies come into prominence in terms of access to data. In this way, the relevant data on the relevant subject collected by different methods (for scientific purposes or by the society) can be obtained automatically from the written or visual internet environment. Web scraping is the process of extracting data from open source and / or public social media accounts from the web in accordance with legal and ethical rules using software tools [16]. The most used libraries for web-scraping are Urllib, selenium, beautiful Soup, and Pyquery. These libraries are widely used to retrieve information over HTTP and HTML. These tools automate the process of reviewing a website and retrieving relevant data. Also allows the pages to be downloaded and indexed. This is critical for indexing websites. For web-scraping, Python is highly preferred for its ease of use and popularity, and its use is increasing day by day.

In this study, we have used the Python programming language with Selenium web-scrapping package based on the codes provided by [17]. The package use web-browser driver and applies the queries as done in search engine manually. One line of code contains the desired keywords to be used in the query. One other line of code includes the file type to be downloaded.

2.2. Amazon rekognition

Identification of the objects in the images is a difficult, subjective, and time-consuming process in case done manually. Deep learning methodologies bring a big advantage to analyze the content in images with automated way, but the preparation phase includes labeling tens of thousands of images to run the deep learning model precisely. This process needs a considerable amount of time, running the model is another high-cost stage in terms of time.

Amazon Rekognation is an online cloud based deep learning service, which allows automated identification in the images. It includes tens of millions of images trained in many categories. The photos uploaded to the system are automatically detected by checking the database behind the scenes. Amazon Rekognition is a visual analysis service that was launched in 2016 and has been used in various fields since its inception. Offering two usage options, Amazon Rekognition offers pre-trained algorithms over data belonging to Amazons, while at the same time it has an algorithm basis that the user can create by training with their own data.

Amazon Rekognation does not require artificial intelligence expertise, which is useful for cultural heritage research since there are many stakeholders, contributors from non-technical fields. The system includes AI features and can automatically preprocess data, train a model, and provide model performance metrics. Amazon Rekognition Image also provides a percentage score of how confident Amazon Rekognition relies on the accuracy of each detected tag. We have selected the item with the maximum value to determine the most popular object in the image extracted from Web scrapping process.

2.3. Test sites

In this study, the ancient cities of Xanthos, Perge and Phaselis of Ancient Lycia-Pamphylia are selected as the test site. We have tried exploring the extracted information from AI-based methodology by comparing with human knowledge.

Xanthos is famous with its theater, Perge with its columns, and Phaselis with its harbor and aqueducts. Our aim is asking AI-based system that the most frequent item appeared on the stored image on the Web. We have set the maximum number of images to get scrapped as one hundred per site.

2.3.1. Perge

Perge was one of the most important cities of Pamphylia. It is located 20 km east of today's Antalya and 11 km inland from the seaside(Martini, 2013). This city, where the first settlement is dated to the Chalcolithic period, was excavated by Arif Müfit Mansel and Jale İnan in the past and its name was first mentioned as "Parha" in the B.C. 13th century Hittite records (Rutherford, 2020).Mycenaean-style cult objects from the Late Bronze Age (1600-1200 BC) as well as late Mycenaean ceramics show contacts beyond the cultural sphere of Anatolia. Simultaneously, BC. Ceramic materials dated to 700 also prove the Rhodes influence. At the beginning of the 1st century B.C., the city was enlarged, and the walls were strengthened with a city gate with two towers and a circular courtyard. During the Roman period, large structures such as baths and theaters in the city show the high level of welfare. It also had an imposing street in the city center with a water channel in the middle. In the following periods, other buildings such as stadiums and streets were built outside the city. And the construction of a two-storey nymphaeum longer than 60 meters in front of the city gate was built. The construction of three basilicas inside the city and in the acropolis since A.D. the fourth century indicates that the city developed in the early Byzantine period, while there are few remains of the middle Byzantine period. That shows the city's collapse in the middle Byzantine period [18], Perge has been on the UNESCO World Heritage Tentative List since 2009.

2.3.2. Phaselis

The second test site is Phaselis. The name of Phaselis come from, colonists of Rhodes who built the city in the seventh century B.C. and it were also mentioned by the ancient geographer Strabon at the beginning of the first century A.D. However, he could not be certain whether the city was a Lycian city or Pamphylia city. The city had an important position in the Lycia-Pamfilya border region. Alexander the Great conquered the city in 333 B. C. According to the ancient coins, the city was under the control of the Ptolemaios until 190 B.C. Moreover, it was part of Lycian Unions which was one of the first federation systems of the world around 167 B.C. Phaselis has gained its name as an important port city in the trade in the Mediterranean since the beginning of the colonial years of Rhodes. Egypt, Syria and Greece have been in the trade network. It was also used as a military base by the Cilician pirates [19].

During the Roman period, Phaselis developed and new buildings were added to the city. During Roman Emperor Hadrian's visit to Phaselis in 129 or 131 A.D. there was a colonnaded street, agora, several temples, theaters, baths and aqueducts in the city. In the city, where two churches belonging to the Byzantine period were identified, the defense wall made of spolia blocks shows that the city has weakened over time [19].

2.3.3. Xhantos

The ancient city of Xanthos is located in southwest of Antalya, today's Kınık district, close to the Mediterranean shores. The city is surrounded by 2 km long walls. Archaeological excavations started in 1950 are still ongoing today. City BC It is dated to the 6th century. It came under Persian control in 546 BC, and despite this, it preserved many of its local characteristics. The most famous of these are the "column tomb". These pillar tombs are probably designed for dynasties and are pillar structures with a burial chamber, which can be decorated with carved reliefs and can weigh more than 150 tons. One of these columns carries the longest Lycian inscription, a language that has not yet been solved. Another famous tomb is the monumental tomb named as the Nereid monument and has reliefs on it [20]. This Monument is in British Museum now. Alexander the Great's conquest of Xanthos in the 4th century B.C., the city was politically completely under Greek influence. İn the next centuries it presided over the Lycian federation. The city has theaters, market areas, baths, aqueducts and basilicas belonging to the Hellenistic, Roman and Byzantine periods. It is thought that the city was completely abandoned in the 12th century [20]. Also, Xanthos has been on the UNESCO World Heritage Permanent List since 1988.

Figure 2. The location of Perge, Phaselis and Xanthos in Ancient Map [17 - 18]

3. Results

As shown in Table 1, the name of the site and the term 'ancient site' were queried inside the apostrophe to make the examination more stable and fixed in the stable terms. After given queries for three ancient sites, 94, 101, and 100 images for Perge, Phaselis and Xanthos have been found respectively. Some extracted images are shown in Figure 3.

Table 1. Keywords used for web-scrapping

Ancient City Name	Keyword
Perge	"Perge"+"Ancient site"
Xanthos	"Xanthos"+ "Ancient site"
Phaselis	"Phaselis"+ "Ancient site"

For web-scrapping the following keywords were quarried through selenium tool (Table 1).

For identification of the contents in the per downloaded image, they were processed in the Amazon Rekognation to derive the items in the web-scrapped images. The following figure shows one example from the result given by the service (Figure 1).

Figure 3. Some downloaded images via web-scrapping for three sites (extracted by web-scrapping).

Results	%
Ruins	97.7
Architecture	93.8
Building	93.8
Column	82.6
Pillar	82.6
Temple	70.6
Worship	67.6
Shrine	67.6
Rock	63.7
Parthenon	55.1

Figure 4. The items found in the Google-scrapped image from Perge site

As shown in Figure 4, the service has identified the image that contains ruin, building and architectural structures. The column term reached to ca 83% probability. Therefore, ruins which are buildings that have columns and pillars, probably a temple with 70% probability, and some rocks also appeared on the images the right bottom corner. Some other results contain a single result for instance Figure 5 and the system can only be found the item 'ruins' without detailing the contents. The popularity of the sites has a negative effect in scrapping results since the downloaded images of Phaselis include some samples from hotels, restaurants, pensions, restaurants and any other tourism facilities, while it is rare for the Perge and Xanthos. Therefore, we can mention that the intensity of connected touristic activity effect to find the proper images. As we have this drawback in scrapping, the identification process in the Amazon Rekognation is also affected accordingly. Another problem observed in the study is that the elements that are expected to be detected easily in the photographs are not found in the results (Figure 6). For example, although a column is clearly observed in the photo shown in Figure 4, the results given by Amazon Rekognition do not contain the words "Pillar" or "Column".

A total of 295 photographs from 3 cities were examined one by one by subjecting them to the visual analysis service of Amazon Rekognition. We simply tried answering the question "Which ancient city has more columns?". An image that contains the item recognized 'column' or 'pillar' as taken. The following table shows the total number of images that contain columns.

Table 2. Total number of images, which have column item found by Amazon Rekognation

Ancient City Name	Photos have columns	Total Number of İmages
Perge	28	94
Phaselis	2	101
Xanthos	16	100

Results	%
Ruins	98.6

Figure 5. One example from single result-derived image (from Google Scrapping)

Results	%
Ruins	99.1
Flagstone	77.1
Building	61.1
Architecture	61.1

Figure 6. One example from multi result-derived image from Perge (from Google Scrapping)

4. Discussion

As shown in Table 2, the site that has the columns most are Perge, and the least is Phaselis, this is also confirmed information by local archeologists. In the literature, no existing studies analyze the items and compare with the other sites. In this research conducted on three ancient cities, the results show the potential of automated methods in the area of information extraction for archeology. Although some errors have been raised, it has been observed that useful results can be achieved with automated search/browsing on the Internet with ready-to-use recognition tools. But two general problems must be outlined as;

- The unique objects, buildings are not being detected, only the general attributes are listed. That means, the recognition is possible to categorize the outcomes, but not specifically identified.
- The correct location of the found images might be wrong, e.g., the webpage with the searched image has a wrong information.

Although listed problems, some alternative solutions can be mentioned. The use of Amazon Rekognation also has an alternative tool that lets to enter the training dataset. With this function, the tools' capabilities can be improved by adding extra labels. Although additional training data would increase the quality of the results, this will require higher time to derive the results. We have not used this option, and the results we get received are meaningful by comparing the existing information of the sites, such as the ordering of the total number of columns match well with the ground truth since Perge had the maximum number of columns while Phasalis has the least.

5. Conclusion

Machine learning, which will bring a new dimension and speed to archaeological research, is of great importance in archeology science, such as categorization, classification, questioning, etc. It will contribute in many areas and will continue to develop. It has been observed in the study how useful deep learning can be and it is easily expected that much more efficient results can be achieved thanks to the algorithms and databases put in by the user. A system that can improve itself over time and reach a certain level that will give results with higher accuracy where the user can enter specific parameters to access archaeological inquiries in the desired area can be created. In this study, we have analyzed the capability of web-scraping tools to identify objects in several ancient sites in terms of their popularity. The study shows that the web-scraping tools have the big capability to search the data which are related to the ancient site in an automated way, and then AI systems can extract useful information out of the found content from the Internet. However, these procedures are not well developed yet to replace human activities but can accelerate related studies done by scientists to filter and categorize the data stored on the internet. The web scraping approach will make an important contribution to the acquisition of preliminary information for archaeological research, as it accelerates the preliminary preparation process. On the other hand, since the visual data to be obtained by the web scraping method is limited to the web only, it can be used early in the preparation of an archaeological survey.

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Author contributions

Nusret Demir: Methodology, implemented the codes, wrote the draft version **Cem Sonmez Boyoglu**: Conduct experiments and produced the results. **Deniz Kayikci** Collected the historical information, evaluated the results, wrote the draft version

Conflicts of interest

The authors declare no conflicts of interest.

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