# CHISTA: Cultural Heritage Information Storage and reTrieval Application

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**Abstract.** More and more people use software applications and the Internet in their daily routine. Cultural heritage has been a favored domain for using such interactive software systems. Heritage sites, cultural institutions, and travel agencies provide visitors with digital applications, such as information retrievers and guides, aiming to enhance their visit experience. However, such applications support mainly visits at indoor than outdoor environments, are site-dependent as the information is provided for limited and specific cultural heritage items, and they are not customizable to store new information. Our previous work [9] overcome such issues, and in this paper, we extend that work by leveraging the recent technological advances in the telecommunications and the computer science domains. In this paper, we present the design and the preliminary evaluation of CHISTA[3], which is an application for storing and retrieving information related to cultural heritage artifacts, sites, facts, etc. using computer vision techniques. We envision that CHISTA will be used by visitors and travelers to obtain cultural heritage information, which is provided by authorized third parties, using common technologies, such as their smartphones and the Internet.

**Keywords:** Cultural heritage · Computer vision · Mobile application · Tourism · Web-based interactive system.

## 1 Introduction

People use smart mobile devices in their everyday lives for a number of reasons, such as communicating, getting entertained, and connecting with friends. Focusing on the cultural heritage domain, mobile devices have been widely used to enhance visitors' experience in heritage sites, based on either online or on-site

[3] In Iranian and Persian mythology, Chista was the goddess of knowledge who led the mortals to the right way in life by providing them with meaningful information.

interactions. Due to the multidiverse nature of the cultural heritage domain, mobile devices have been used across varying case studies, such as outdoor site exploration throughout different periods of time, based on augmented reality [5], monuments interactive walk-throughs using virtual reality environments [17], interactive storytelling across time and space [7], and 3D visualizations in immersive environments [11].

A common use of mobile devices in the cultural heritage domain is the implementation of guides which provide the visitors with information about a heritage artifact using varying technologies such as location-aware services [1], QR codes scanning, [14], NFC tags matching [3], visual recognition [13], and visual markers [2]. These mobile applications support various functionalities and purposes along with information retrieval, such as educational tasks, gamified context, bookmarking, navigation, visit planning and tracking [6]. However, such mobile applications, which are based on retrieving information from points of cultural interest, support mainly visits at indoor (e.g., museum, art gallery) than outdoor environments (e.g., archaeological sites). This results from the limitations that the outdoor settings introduce, such as the precision of the geo-location of the heritage point of interest, the cost of the Internet connection (especially when traveling aboard), the sensitivity and the non-adaptivity of the mobile apparatus in the changeable outdoor settings (e.g., weather), etc. Various techniques and mechanisms have been used to overcome such issues, such as pattern and object recognition techniques to identify a heritage artifact [10] and techniques to connect indoor and outdoor experiences [12]; however, they were still under evaluation and do not leverage on the recent advances in the computer science and engineering domains (e.g., deep learning, computer vision, and 5G capabilities).

In our previous work [9], we presented a mobile application that overcomes such issues as it retrieves static information using visual markers (e.g., scanning of QR codes). However, it introduces limitations which are as a result of the availability to the end-users (e.g., visitors of an archaeological site, tourists exploring an urban area), the ease of providing new content, the dependence on local authorities and structures of the supported points of interest. Three years later, the use of mobile devices and applications has been exponentially increased and the cost of connecting to the Internet is relatively low even when traveling abroad, since many municipalities and local communities offer free WiFi access or the cost of roaming has been decreased (e.g., according to European Union's "roam like at home" program, travelers do not pay any additional roaming charges when traveling within European Union [4]). Therefore, in this paper, we take advantage of the upward trend of mobility and the recent technological advances in the telecommunications (e.g., 5G networks) and the computer science (e.g., computer vision) domains, and we re-design our mobile application, which will be used by travelers and visitors to retrieve information about a cultural point of interest (e.g., painting, sculpture, building) either in indoor or outdoor settings, aiming to enhance visitors' experience.

[4] https://europa.eu/youreurope/citizens/consumers/internet-telecoms/mobile-roaming-costs

## 2 CHISTA Mobile Application

### 2.1 Design

Several factors characterize a mobile device such as the operating system, its functionalities, the screen size, etc. The design of our mobile application should consider such factors; hence, we adopted a hybrid design approach, as it combines the best features of the native and pure web worlds, it is not costly, it is quick, it can be deployed for the most of the operating systems, and it is a widely used approach [8]. The architecture of the mobile application is depicted in Figure 1.

A typical scenario that is supported by CHISTA is: the end-user (e.g., visitor) uses CHISTA mobile application to take a picture/video of a heritage object; the captured media along with position information are sent to the Computer Vision module (CV-m), which attempts to identify the captured object; once it is identified, the end-user receives the information about the captured object; the information is provided by authorized third parties and stakeholders (e.g., local authorities, museums) that uses CHISTA authoring tool to import the information into the system remote databases.

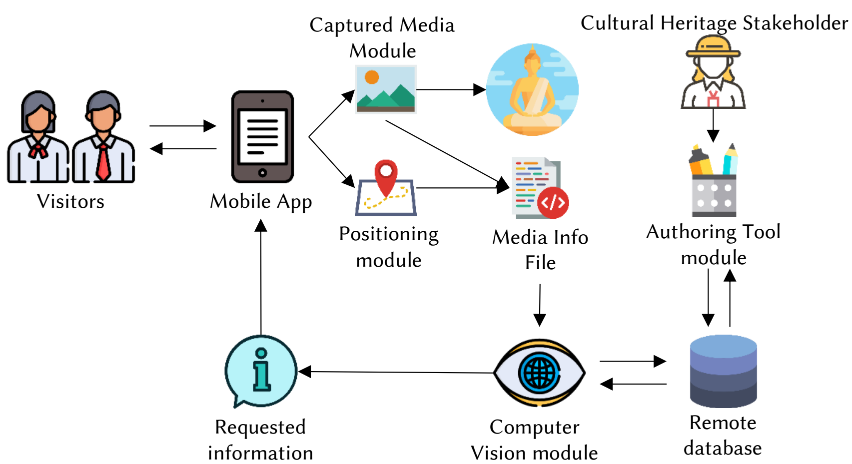


**Fig. 1.** High level architecture of CHISTA

**Authoring Tool module (AT-m)** : The authoring tool is a web service which is offered to authorized stakeholders who want to import new information (e.g., import a new heritage object) or edit stored information (e.g., change information about a heritage object). For each object that is imported in the system databases, a series of photos along with its geo-location must be provided.

**Captured Media Module (CM-m)** : To capture the media (i.e., take a photo or record a video of a cultural heritage object), the built-in camera of the mobile device is used.

**Positioning Module (P-m)** : The Positioning module (P-m) identifies the location of the end-user, exploiting the functionalities of the mobile device and the network input parameters. In particular, it is based on:

- **Global Positioning System (GPS) receiver**: GPS-enabled devices are typically accurate to within a 4.9m radius under open sky [4]. However, the accuracy worsens near buildings, bridges, and trees. Focusing on Europe, European Union turned on *Galileo*[5], which is expected to include 24 live satellites by 2020 (now it includes 18) achieving accuracy within 1 meter.
- **Wi-Fi positioning system**: It uses SSID and MAC address of access points, and by measuring the intensity of the received signal and by "fingerprinting" it detects the location of the mobile device. Wi-Fi location databases (e.g., Combain Positioning Service, Mozilla Location Service) are used to determine the position. The accuracy depends on the number of positions that have been entered into the database, but it typically ranges between 0.6 to 4 meters. In the near future, it can also be used for an indoor positioning system (IPS) to perform ubiquitous indoor localization on a worldwide scale, similar to the GPS outdoors [16].
- **Mobile Network positioning**: It uses the signals from the cell towers of the network to ascertain the position. The accuracy of this method varies and it heavily depends on the concentration of cell base stations.

When combining any of these techniques a high positioning accuracy for both indoor and outdoor settings can be achieved [15]. They can also be used as three pillars, that are activated sequentially (starting from the more sensitive and accurate service) until the position is defined.

**Computer Vision module (CV-m)** The Computer Vision module (CV-m) derives insights from multimedia material (e.g., images, videos). It detects various objects (e.g., popular natural landmarks and man-made structures) within images and through a modeling and classification approach, it identifies the object. The classification is based on a threshold score of the prediction algorithm (e.g., 0.50 out of 1.00). Various APIs can be integrated into the CV-m, such as Cloud Vision API [6] and Microsoft Azure [7]. New sets of labeled images can be inserted in the CV-m and, after a number of training sessions, they can be used to detect an object via multimedia classification.

[5] http://ec.europa.eu/growth/sectors/space/galileo_en
[6] https://cloud.google.com/vision
[7] https://azure.microsoft.com/en-us/services/cognitive-services/computer-vision

### 2.2 Evaluation

The evaluation of our prototype was based on the following scenario: a visitor of an archaeological site sees a building and wants to know about it. She/he takes her/his smart-phone; launches CHISTA mobile application; takes a photo; sends the photo to CHISTA server; the computer vision module identifies (or not) the captured object after using machine learning/classification services and matches it with a database instance; the server sends the requested information to the CHISTA mobile application. The preliminary results about the response time and the accuracy of the computer vision module follow.

**Response time** To take a photo, our participants needed about 2 seconds per photo. The total time depends on the number of the taken photographs, the quality of the photographs, whether the user needs to traverse some distance to cover different angles, etc. For the scope of our evaluation study, we stick to the simplest scenario (i.e., one photo). The photo is uploaded to the CHISTA server. The upload time depends on the Internet connection and the filesize. We used a typical smartphone to capture a 1920x1080 photo of about 3.5MB. The upload time is expected less than 7 seconds with a typical line or 3G/4G connection. 5G speeds will shorten the time to less than 1.5 seconds. The computer vision module runs in remote powerful web-servers and completes its prediction processes in less than 5 seconds, considering that the approximate location of the capture object is provided. The download of the matched information depends on the network connection, but it typically needs less than 1 second. Hence, the user receives information about a heritage object in less than 12 seconds. The time is acceptable, but further work is needed to optimize the processes of the computer vision module and to compress more efficiently the captured media.

**Prediction accuracy** For the computer vision module, we trained and evaluated the prediction mechanism following Microsoft Azure Vision services. The more popular a cultural heritage object (e.g., monument) is, the more accurate the prediction is (i.e., more than .950). In case of less popular cultural heritage objects, more labeled images are required, in varying environmental conditions, to train more efficiently the prediction mechanism and achieve results with high accuracy. It is worth mentioning that when the position, within a tolerance range, of the cultural heritage object was considered for the prediction process, we achieved accuracy higher than .950.

## 3 Discussion, Lessons Learned and Impact

We used advanced but common technologies to design a robust software system that can be used a) by authorized cultural heritage stakeholders to store information and b) by visitors/travelers to obtain information about a cultural heritage object. The preliminary results of the small-scale evaluation study indicate that CHISTA delivers the information in a short time with high accuracy.

Conventional technologies can adequately deliver such results. Everyday smart devices can be used to capture an image/video of a heritage object, and, through web services, remote and powerful computer vision modules can identify the captured object and send textual/graphical information about it. However, further work is needed to optimize the process (both in terms of classification accuracy and delivery time) to provide better cultural experiences to the end-users (e.g., visitors, travelers). Moreover, an important parameter of the CHISTA approach is its social impact. We summarize it into the following pillars:

- **Promotion of cultural heritage** The heart of our application is each item or experience that has a heritage story to tell; it can be either a historic relic, an art exhibit, or an archaeological site. The ultimate goal is to transfer the historical knowledge through the provided technological platform.
- **Growth of the touristic flow** The efficient and effective promotion of the application is expected to contribute to the growth of the touristic flow, which in turn will benefit economically and commercially rural areas with rich cultural heritage. In addition, the possibility of providing gamified experiences through our application (e.g., hidden treasure game), could contribute to the increase of the touristic flow in wider areas, stimulate the local economies and increase the public revenue for local and regional authorities.
- **Inclusion to the information society** The use of our application contributes to the inclusion to the information society of the historical relics, art exhibits, archaeological sites etc. and of the local communities where they are located. The digitization of cultural heritage entails not only the creation of a rich database for the art exhibits, the historical relics etc., but also of a dynamic constantly growing and evolving information society of the cultural wealth of a country.
- **Knowledge acquisition and sharing** Through the gamification elements and the configurable content of the platform, knowledge acquisition is achieved at a preferable pace and way for the user. Each one is a member of a worldwide cultural community with multiple benefits both for the user and the community, including the communication with other users and the sharing of the acquired knowledge, the socialization and the virtual empathy.

## 4 Conclusion and Future Work

In this paper we presented our preliminary work on designing and evaluating CHISTA software system, that we envision that will be used a) by visitors and travelers to retrieve information about cultural heritage objects and b) by content providers (e.g., museums, heritage institutions, local authorities) to store information about cultural heritage objects. We anticipate that CHISTA will trigger a) the active participation of the users and arousal of the public for exploring, evaluating and formulating cultural information and b) the movement towards the adoption of a worldwide framework for interconnecting cultural heritage stakeholders (e.g., visitors, curators, institutions). As an impact of the aforementioned anticipated results, we expect CHISTA to contribute to a) the promotion of the cultural heritage of diverse areas, b) the growth of the touristic flow, c) the inclusion to the information society, and d) the knowledge acquisition and sharing. Our immediate future steps consist of a) expanding our dataset, b) testing and evaluating various classifiers and deep learning algorithms to improve the precision and the accuracy of the prediction procedure, c) testing the effectiveness and efficiency of our system in remote areas (e.g. rural areas) and when having increased traffic load.

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