



xR4DRAMA

Extended Reality For Disaster management And Media planning

H2020-952133

D4.1

AR interactive environment and applications

Dissemination level:	Public
Contractual date of delivery:	Month 13, 30 November 2021
Actual date of delivery:	Month 14, 15 December 2021
Work package:	WP4: Interactive AR/VR solutions for media production and hazard management
Task:	T4.1: Visualization of DSS results in AR T4.2: Visual and GIS-assisted uninterrupted navigation for AR T4.3: Scene understanding for AR interaction to assist actors in the field
Type:	Demonstrator
Approval Status:	Final
Version:	0.5
Number of pages:	48
Filename:	d4.1_xr4drama_AR interactive environment and applications_20211215_v0.5.pdf

Abstract

This deliverable documents on the 1st version of the xR4DRAMA ARapp, which is being developed as the interaction interface for the users in the field - 1st responders of PUC1 and location scouts and journalists of PUC2. The ARapp communicates bilaterally with the

platform so the users get the latest information from the platform and at the same time the control room receives updates from the field. Here, the progress and the next steps of the ARapp development are documented. Also, a selection of use cases and a few implementation details are given. The ARapp is being developed under three tasks: the T4.1 that regards, the visualization of platform results in the ARapp; the T4.2 that develops the ARapp navigation in the outdoor world; and the T4.3 that develops scene understanding algorithms at the edge to support the AR navigation and the 1st responders.

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co-funded by the European Union



History

Version	Date	Reason	Revised by
0.1	10/09/2021	Initialisation of the document	Christos Stentoumis
0.2	07/12/2021	Add 2D and AR Visualizations	Christos Stentoumis
0.3	10/12/2021	Add the use cases	Alexandros Nikopoulos
0.4	12/12/2021	Version ready for internal review by NURO	Christos Stentoumis
0.5	15/12/2021	Issue final version	Christos Stentoumis

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Executive Summary

The deliverable D4.1 goes with the demonstration of the 1st version of the xR4DRAMA AR app and briefly presents the implementation approach. The AR app is the interaction interface provided to the users in the field, either they are 1st responders in the *Disaster Management* scenario (PUC1), or they are the location scouts and journalists of the *Media Planning* scenario (PUC2). The ARapp is being developed as a mobile phone application with features that follow the user requirements. The ARapp communicates bilaterally with the platform so the users get the latest information from the platform and at the same time the control room receives updates from the field. In this way, both actors in-situ and away have improved situation awareness. This deliverable supplies demos for using this 1st version, as well as basic implementation details. It also supplies a brief state-of-the-art, including the most common augmented and mixed reality devices. Furthermore, a complete list of the user requirements fulfilled by the ARapp is given. Also, the progress and the next steps of the ARapp development are documented. This 1st version of the ARapp is dedicated to resolving most of the connectivity and integration issues with the backend and the GIS Service, but also concretize and exemplify the user requirements to specific features and processes of the app. As a result, most of the 2D screens needed and the 2D map view of the app have been prepared with fully operating features, such as receiving points of interest (POIs) from the GIS, editing, updating, uploading multimedia at POIs, and getting navigation routes that consider danger zones. Furthermore, the first features related to POIs have been ported to the augmented reality view, as the outdoor navigation issues have been partially resolved. The accuracy of the outdoor navigation and the pose estimation of the user will improve in the next version based on the work that is done on visual SLAM and the scene recognition algorithms.

The ARapp is being developed under three tasks: the T4.1 that regards, the visualization of platform results in the ARapp; the T4.2 that develops the ARapp navigation in the outdoor world; and the T4.3 that develops scene understanding algorithms at the edge to support the AR navigation and the 1st responders.



Abbreviations and Acronyms

API	Application Programming Interface
AR	Augmented Reality
DoA	Description of Action
DB	DataBase
DSS	Decision Support System
GNSS	Global Navigation Satellite System
GIS	Geographic Information System
GPS	Global Positioning System
HCI	Human-Computer Interaction
HMD	Head-Mounted Displays
IO	Innovation Objective
IA	Innovation Activity
KB	Knowledge Base
MR	Mixed reality
OS	Operating System
OSM	OpenStreetMap
POI	Point of Interest
PUC	Pilot Use Case
ROI	Region of Interest
SLAM	Simultaneous Localization And Mapping
TA	Technological Activity
TO	Technological Objective
VR	Virtual Reality
WP	Work Package
XR	Extended Reality



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1 INTRODUCTION

The xR4DRAMA application is a location-aware application that extracts data points from OpenStreetMap and other internet sources of geodata and aggregates them into various Points-Of-Interest (POIs) and Regions-Of-Interest (ROIs). These POIs are organized into thematic Categories and hold relevant information about the geographical landmarks they represent. The application user can interact with these points in the map view, or the AR view and alter them to organize one's tasks and keep the control room updated.

The deliverable starts with an introduction (Section 1) where the position of the ARapp in the xR4DRAMA platform is described. Section 2 provides a brief overview of existing works in outdoor AR applications and the devices that explicitly support AR and MR experiences. Section 3 is devoted in the use cases that describe the current ARapp capabilities. Section 4 describes the progress per task and Section 5 gives the implementation details.

1.1 Tasks & Objectives

This deliverable documents his needs for the following three tasks that constitute the xR4DRAMA ARapp development tasks. The already developed and the forthcoming features are based on the user requirements documented on the D6.2; Section 1.2 details the user requirements covered by the ARapp.

The task **T4.1** ("Visualization of DSS results in AR") regards the development of an ARapp capable of projecting and managing the information available in the xR4DRAMA platform, which helps the situation awareness of the field users, either the 1st responder (PUC1) or the location scouter and the filming crew (PUC2). This application is developed on a dedicated augmented, or mixed reality (AR or MR) device – here, a high-end mobile phone is selected to support the demanding extended reality (xR) frameworks.

The scope of the task **T4.2** ("Visual and GIS-assisted uninterrupted navigation for AR") is to position a field user into the Geographic Information System (GIS) of the platform via the xR device and position the georeferenced info correctly in the world space in AR. This is achieved by exploiting the measurements from the mobile phone sensors (GNSS, IMU, and compass sensors), along with object detection and scene segmentation and SLAM, SfM algorithms, existing in commercial APIs, for pose estimation in an outdoor environment. The localisation algorithm will exploit the information available in the GIS, such as road sections.

The scope of the task **T4.3** ("Scene understanding for AR interaction to assist actors in the field") is to develop the mobile phone algorithms that based on 3D computer vision, object detection and scene segmentation will aid user navigation and identify potential threats and dangers for the 1st responders, such as power cables.

The work described in D4.1 corresponds to the following innovation objective (IO):

IO3 - Develop enhanced interactive AR applications for outdoor media production and disaster management: This objective pertains to delivering an integrated platform for remote outdoor observation and planning, designed to cater to the needs of both media production companies



and disaster relief organisations that require the visualisation of an outdoor area and use this as a canvas for strategic planning.



1.2 User requirements fulfilled

. Table 1, Table 2 and Table 3 document the User Requirement that the ARapp supports. Table 1 refers to the system requirements addressed; Table 2 shows the general information requirements; Table 3 and Table 4 refer to the PUC specific requirements. *The ARapp consumes this served by the GIS Service, the Backend, and the Decision Support System (DSS).*

Req ID	Name	Description
SYS-2	End-user interface	An HCI that allows end-users to communicate with the system easily
SYS-3	Location ingests	Possibility to define a specific location
SYS-4	Location-query	A functionality of the system that allows end-users to initiate a query regarding a specific location in web- and cloud services
SYS-5	Aggregation of query status and results	The capacity of the system to observe the query and aggregate the identified content (e.g. videos, images, text) in an organised manner (categories, clusters, order)
SYS-6	Immersive visual representation	A functionality that visualises the location and additional information to enhance situation awareness (e.g., VR, AR)
SYS-10	Add own data	Control room staff can add images, videos, models, or scans to improve data, or change specific data points that might not have been available, e.g., availability of public parking
SYS-12	Mobile application	An application that allows for operating the system in and from the field
SYS-14	Remote access to Level 1 situation awareness	The system's capacity to grant remote users (e.g. location scout) access to a Level 1 situation awareness representation (partly or in total) via the mobile application. Citizens (PUC 1 only) should receive valuable information such as alerts, risk zone warnings about areas at risk, the position of the safe re, sand-bag distribution, shelters.
SYS-16	System updates	The system processes new input (e.g. from location scout/first responders) and updates previous results and representations
SYS-17	Enhanced (Level 2) situation awareness	The updated data is used to create an enhanced version of the scene graph containing all available relevant content and information

Table 1. System-related requirements addressed by the GIS Service.



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
G-01	Accessibility	Transportation	quality and type of road (highway, street, path), distance to railway station and airport, public transport	User/ OSM / opendata.gov.gr / Vicenza.gov.it	Transportation	Subway station, Bus station, Aerodrome, Road quality, Tram station	Point	
G-02	Geography, Surroundings	Buildings, Monuments	the shape, look and size of buildings, the purpose of buildings	OSM	GeometryView	Buildings	Polygon	
				OSM	Leisure	Monument, Theatres, Attraction, Cinema	Point	
G-03	Geography, Surroundings	Landmarks	indication of high voltage lines, windmills and other landmarks	User/ Visual Analysis	Miscellaneous	Landmark	Point	
G-04	Geography, Surroundings	Roads, Railroads	indication of roads, highways, railroads	OSM	GeometryView	Railway, Roads	Lines	

Table 2. Information-related requirements (General information) addressed by the GIS Services.



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
PUC1-01	Geography, Surroundings	Rivers, Embankments	Indication of rivers, watercourses, riverbanks	User/ OSM	Naturals	River	Polygon	
				User/ OSM / Vicenza.gov.it	Infrastructure	Embankments,	Point	
PUC1-02	Geography, Surroundings	Manholes, electrical and gas pipes	Indication of manholes, electrical and gas pipes	User/ OSM/ Vicenza.gov.it	Infrastructure	Manhole	Point	
PUC1-03	General information	Areas of attention, safe waiting places, shelters	Information on the presence of areas of attention, safe waiting/parking places, shelters, sand-bag distribution areas	User/ OSM	Risk Prevention	Safety areas	Point	
				OSM	Naturals	Park	Point	
PUC1-04	Flood risk management	Flood maps	Raster data of flow velocity and water depth in flood scenarios					This is not currently addressed, but it is a consideration for the final version.
PUC1-05	Flood risk management	Risk maps	Information on flood risk levels in the territory					This is not currently addressed, but it is a consideration for the final version.
PUC1-06	Flood risk management	Flood reports	Information about flood reports localised by					This is not currently addressed, but it is



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
			audio analysis and categorised according to the problem issue					under consideration for the final version.
PUC1-07	Flood risk management	Flooded elements	Information on flooded elements (e.g. cars and people inside the river)	User/ Visual Analysis	Risk Prevention	Elements in water		This subcategory will be renamed as Flooded elements, as well as and the endpoint of SubAPI
PUC1-08	Flood risk management	River embankment's overtopping and/or orderation breaking	Information related river embankments overtopping or breaking	User/ Visual Analysis	Risk Prevention	Overtopping water	Point	
PUC1-09	Flood risk management	Elements at risk	Information on the presence of elements at risk and the degree of emergency	User	Risk Prevention	Risk reports	Polygon	The GIS Service provides a Danger Zones subcategory (Risk reports) to add emergency information
PUC1-13	Human factors	Stress level	Detect by stress analysis the stress level in first responders affected by flooding/involved in rescue operations					This is not currently addressed, but it is scheduled for the final version.



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
PUC1-14	Accessibility	Navigation routes	Possibility to define an appropriate escape route or a suitable way to reach an intervention area					The GIS Service computes a route dynamically, considering the Danger Zones (Risk Reports)
PUC1-16	Flood risk management	Population potentially in danger	Information on the potential presence of people in areas at risk	Visual Analysis	Risk Prevention	Elements in water	Point	“Elements in water” subcategory for visual analysis service could be an approach to serve this requirement.
PUC1-17	Flood risk management	Cultural heritage/natural sites potentially in danger	Information on the potential presence of cultural heritage/natural sites	User	Risk Prevention	Warn this	Point	The GIS service has the POIs regarding cultural heritage sites, so users can manually identify what is at risk.
PUC1-18	Flood risk management	Civil Protection Plan procedures	Information on the localisation, type of action, activation threshold of the Vicenza Risk Management Plan procedures					This is not currently addressed, but it is scheduled for the final version.

Table 3. Information-related requirements PUC1 (Disaster management)



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
PUC2-01	Environmental factors	Noise pollution	identification of possible sources like busy roads or highways, crowds of people, factories, airports, railway stations, railway tracks	User/ Visual Analysis services	Miscellaneous	Noise pollution	point	
PUC2-02	Environmental factors	Light Pollution	identification of possible sources like streetlights, ads	User/ Visual Analysis	Miscellaneous	Light pollution	Point	
PUC2-03	Accessibility	Parking	availability of parking	User/ OSM	Facilities	Parking	Point	
				User/ OSM	Facilities	Wi-Fi	Point	The GIS Service also provided the availability of access to Wi-Fi POIs.
PUC2-04	Legal Issues	The necessity of filming permit on the ground	The necessity of permission for filming on the ground with a crew	Vicenza.gov.it/ Geodata.gov.gr	Prohibited zones	Ground	Polygon	The GIS Service also creates buffer zones at specific subcategories when the project has a generic location.
PUC2-05	Legal Issues	The necessity of filming permit in the air	type of permission for filming with drones, possible restrictions for filming	Vicenza.gov.it/ Geodata.gov.gr	Prohibited zones	Air	Polygon	The GIS Service also creates buffer zones at specific subcategories when



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
PUC2-06	General information	General information on site/buildings	textual information on specific sites/buildings in the area of interest					the project has a generic location. Only if available from OSM
PUC2-08	Facilities	Power	availability and accessibility of power outlets	User/ OSM	Public Service	Charging station, Car rental, Fuel, Police, Pharmacy, Hospital, Bank, ATM	Point	
				User/ OSM	Public Service	Car rental	Point	
				User/ OSM	Public Service	Fuel	Point	
				User/ OSM	Public Service		Point	
PUC2-09	Facilities	Bathrooms	availability and accessibility of bathrooms	User/ OSM	Facilities	Toilets	Point	
PUC2-10	Facilities	Restaurants, Cafés etc.	list of/indication of available places to eat/drink	User/ OSM	Dines	Café, Bar, Pub, Restaurant, Fast food	Point	



Info-ID	Category	Name	Description	Source of information or data	Category	Subcategory	Geometry	Comments
				User/ OSM	Stores	Supermarket, Grocery store, Minimarket	Point	
PUC2-11	Facilities	Props & Gear	Possibility to put props/decoration/etc. in the environment	User	Miscellaneous	Props & Gear	Point	The user can add the location, which can put props.
PUC2-14	Environmental factors	Noise situation on site	the noise situation on-site recorded by the location scout via a Smartex device as mp3-file	User	Miscellaneous	Noise pollution	Point	The user can upload a media file with the recorded noises in a specific POI.

Table 4. Information-related requirements for PUC2 (Media production planning)

1.3 Timeline

Figure 1 presents the timeline of tasks T4.1, T4.2, T4.3 in the xR4DRAMA duration.

Months																							
Year 1 (Nov. 2020 – Oct. 2021)												Year 2 (Nov. 2021 – Oct. 2022)											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				T4.1 Visualization of DSS results in AR																			
				T4.2 Visual and GIS-assisted uninterrupted navigation for AR																			
				T4.3 Scene understanding for AR interaction to assist actors in the field																			

Figure 1. Timeline of the project tasks documented in D4.1.

1.4 Progress

T4.1: Visualization of DSS results in AR

The 1st version of the ARapp, which is included in the 1st prototype of the xR4DRAMA platform, is developed, and the data from the GIS Service are displayed, edited, and streamed back to the platform. The 1st version includes complete screens for the map display and initial work for the AR display. Core functionalities of the application, such as communication with the platform, user, and project management, as well as interaction with the POIs, have been developed. The POIs are presented in map and AR view. The interactions include:

- Creating new POIs as user-specified landmarks.
- Editing or appending information and multimedia files to existing POIs.
- Sharing evaluation information about a given POI through a flexible commenting system.
- Navigating to a POI or a user-specified location through the built-in navigation service.

The tasks to be done include displaying the non-georeferenced data, such as the stress levels, having full functionalities to AR mode, which depends on the T4.2, making interaction improvements, such as the clustering of the POIs at different zoom levels, fulfilling the UR after the pilots.

Many of the screens necessary for the ARapp have been developed and most of the required information for the users is there (Figure 2), as seen in the demos.

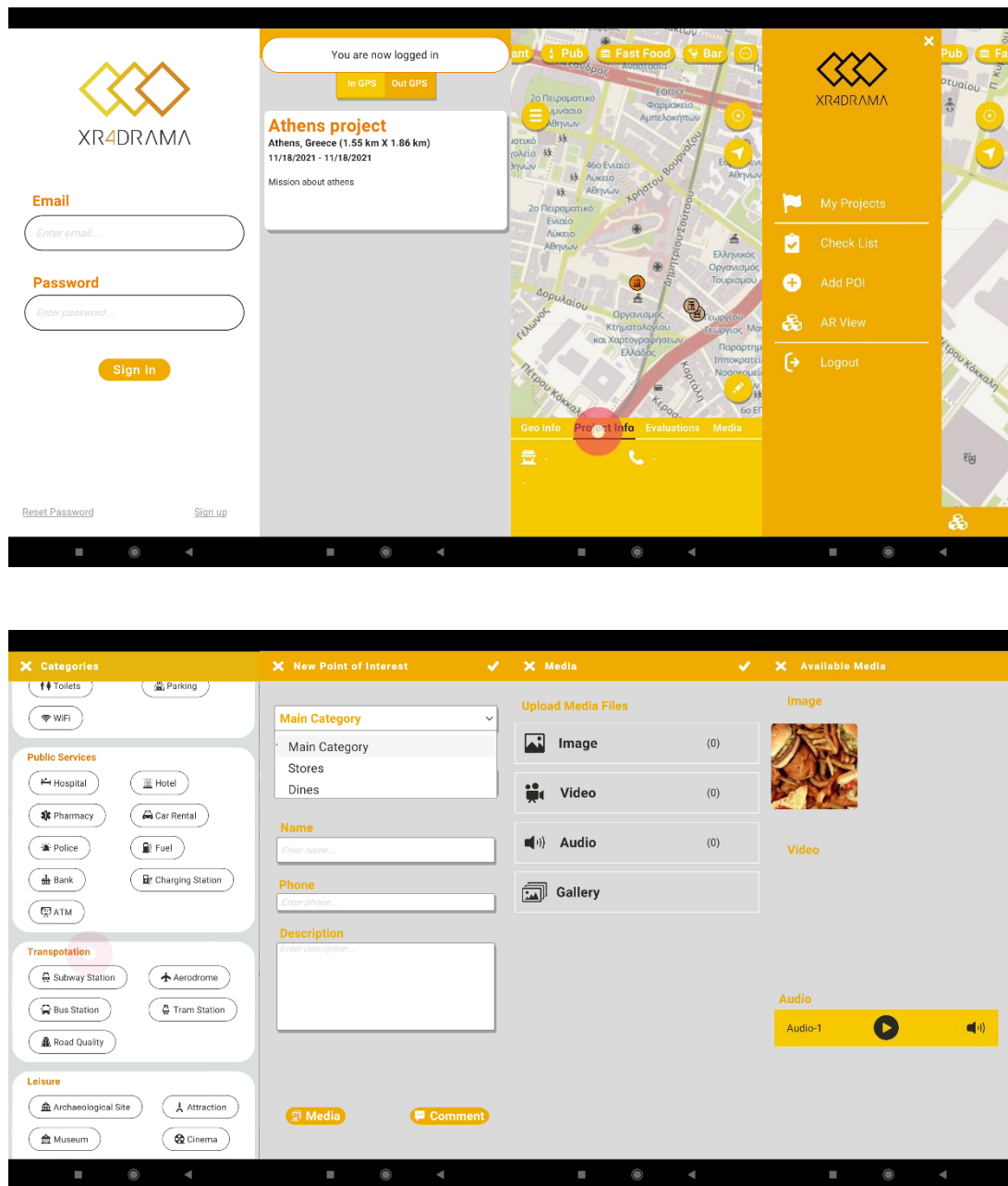


Figure 2. Sample screen views from the 1st version of the ARapp.

T4.2: Visual and GIS-assisted uninterrupted navigation for AR

In the 1st version, the AR app operates in world-scale scenarios based on the sensors and the data retrieved from the GIS service. The AR view is on demand, triggered by the user from the map view of the app (Figure 3). Different algorithms have been evaluated to filter and smoothen the sensor measurements to alleviate noise, signal spikes and improve the stability of the AR view. Figure 4 presents screenshots of the AR view displaying the location of the POIs requested by the user with information on the direction and the distance, as well as other navigation info and a minimap for the users assistance. The following steps will further explore the existing xR frameworks for accurately overlaying the GIS information in the real world

using different pose and depth estimation algorithms and plane and edge detection algorithms.

The work developed in T4.1 and T4.2 is presented in Section 3 via the ARapp use cases.

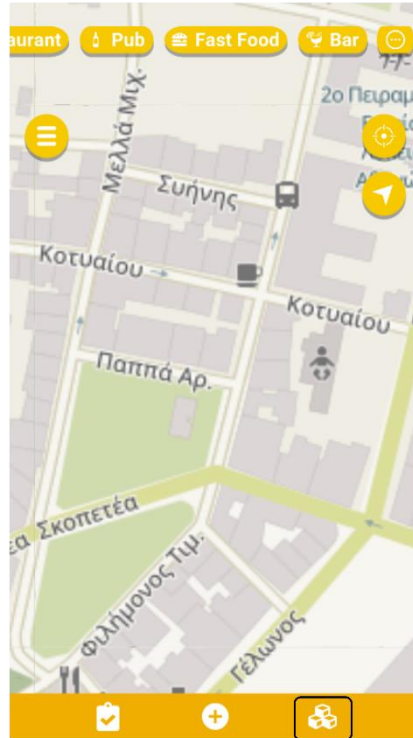


Figure 3. The AR view is triggered by the user via a button in the map view.

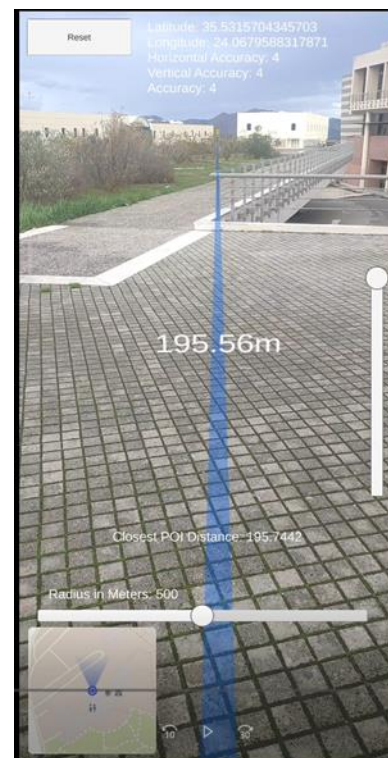
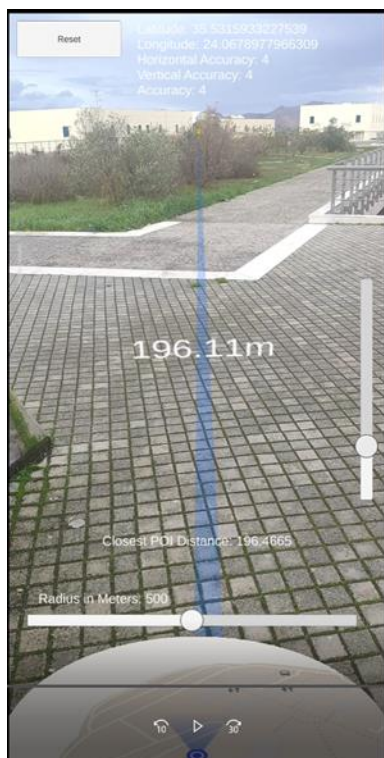
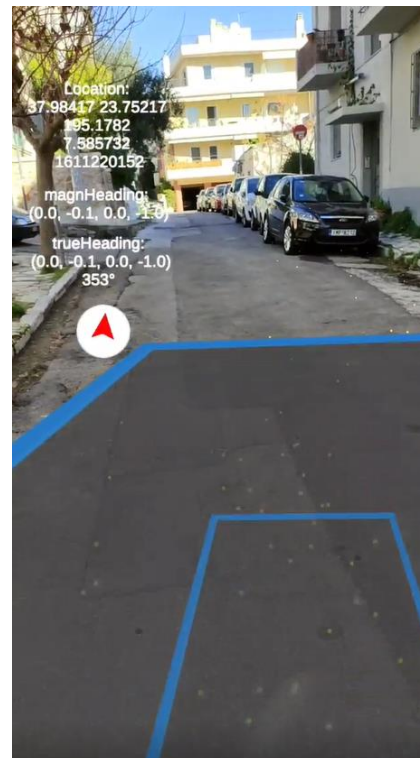
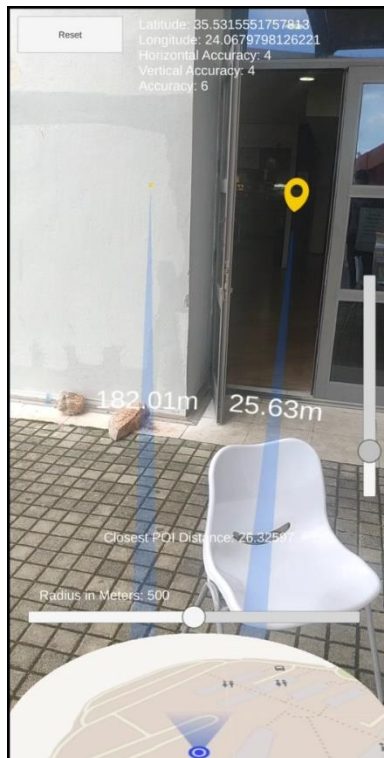




Figure 4. ARapp. View POIs / Navigation/ Minimap. The top right view shows the pavement plane detection to correctly position the POIs.

T4.3: Scene understanding for AR interaction to assist actors in the field

Initial tests and evaluations were made for mobile phone devices and the HoloLens headset. Computer vision algorithms on object detection and scene segmentation were deployed on device to assist the AR and add recognition capabilities to the app. Object detection and scene segmentation machine learning models are tested on the devices and their use is reviewed in the PUCs context. This task was delayed due to the need to clarify the user requirements and exemplify them on each potential device, as well as due to the need to fix the communication with the GIS data and the backend architecture as these are affected and affect the overall technology stack on the AR device. An initial schema for training new object detection and segmentation models and deploying them on devices within the Unity framework has been set up and tested, involving ONNX¹ for interoperability, cross-platform and multiple devices compatibility (Figure 5). These preliminary tests were done using the camera feeds from the devices.

¹ <https://onnx.ai/>

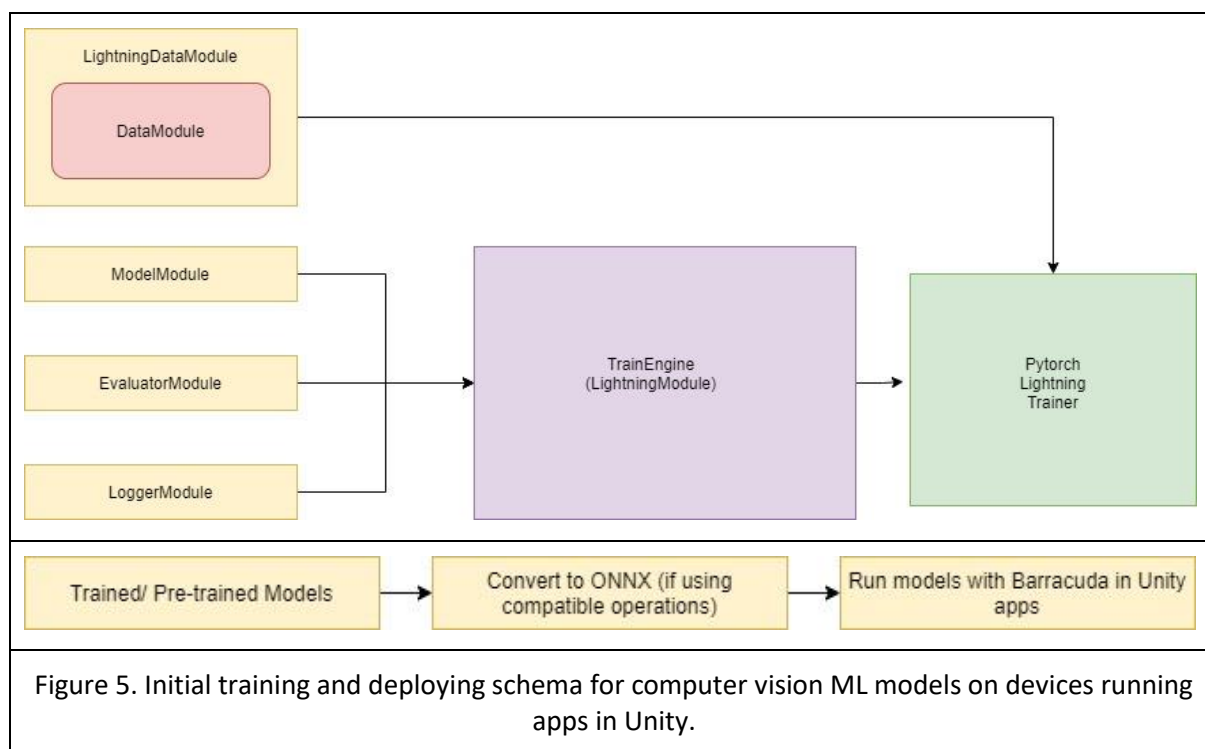


Figure 5. Initial training and deploying schema for computer vision ML models on devices running apps in Unity.

2 REVIEW

Augmented Reality (AR) refers to the concept of viewing virtual objects in the real world. It can enable and facilitate many facets of work, such as previewing prototypes before production, guiding a person towards a location, or visualizing hard to see objects. For the xR4DRAMA, an *outdoors augmented reality* system is being developed for mobile phones, although AR can be supported by both *handheld devices* and *head-mounted displays* (HMDs). Among others, the primary user requirements are i) the positioning of virtual 3D/2D objects into the real world based on their respective geo-locations, ii) the visualisation of various kinds of infrastructures (such as pipes, valves, manholes), and iii) the guidance of actors wherever is needed in the real world.

Achieving these requirements outdoors while providing seamless AR capabilities emerges significant as technical h/w issues, registration issues, and tracking challenges arise. Primarily, these difficulties relate to the accurate registration of 3D content in an exact real-world position, without the use of black and white markers, which are typically placed on surfaces on *marker-based AR*. Moreover, the visualisation of 3D content outdoors, considering extreme sunlight, visitors obscuring views, inaccuracy of geo-location based on global positioning system (GPS), as well as unstable computer vision-based registration approaches, adds even more complexity and technical challenges to the entire process.

Throughout the years, implementations with various techniques and approaches have been proposed in the research field of *outdoors AR*. An online visualiser was created, displaying underground infrastructure based on images and videos [1]. The infrastructure is superimposed on top of the input media, after which it looks as if x-ray vision is used to view it. A drawback of this method is that the user cannot view the infrastructure in real-time, reducing its practical usability. Another project for outdoor AR has been done relating to real-time visualisation of this type of data using an AR device [2]. The AR device is a tablet PC with various sensors attached. It can be mounted on a tripod or worn using a strap. While functional, the AR device is large and clunky compared to the flexibility provided by the HoloLens headset. In [3], AR is also used to visualize underground infrastructure; a laptop was used to power a handheld device that consists of a screen to visualise the information, a GPS receiver to locate the user, a camera to record the image that the virtual content is superimposed on, and various controls for navigating the software. The goal of the project was to develop a system to aid workers in the maintenance, planning and surveying of underground infrastructure. In a more commercial application, Meemim has created a tool called vGIS that turns GIS, CAD, and other types of data into mixed reality visuals [4]. The tool is available as an augmented reality application for iOS and Android devices. The tool is also a true mixed reality application developed for the Microsoft HoloLens [5]. These solutions provide only software for bridging GIS with a visualisation engine while relying on third-party surveying equipment for localisation. An exception to this is Trimble SiteVision, an all-in-one solution for outdoor GIS data visualisation [6]. Recently, ar4.io proposed and designed a self-contained sensor box to solve the outdoor localisation problem. This platform follows the work of Stranner et al. [7] on integrating all required components on a single board with a small form factor. Its main components include a differential GPS-RTK sensor, a highly

accurate smart IMU with integrated sensor fusion, and a performance pressure sensor with altimetry. The board is powered over a USB with an integrated charging circuit [8]. Another system that uses a Hybrid RTK GNSS and SLAM tried to solve the localisation problem. Still, the system is used out of three subcomponents, and the user is required to wear a backpack computer, while a GNSS stable base station is needed in a close range of the user [9]. MORMethodsrn method imports machine learning algorithms to detect objects of the real world more naturally and extract information about the camera's view. This may be useful for labelling real world building/objects, but it comes with computation complexity, and it does not solve the localisation problem on its own [10]. A better solution is seemed to be a method like Arth et al. [11], which built systems that combine detection of visual features in the surrounding environment with GPS data. In this direction, Google is integrating a large-scale feature-tracking system with its popular Maps application [12].

2.1 MR / AR headsets

Augmented reality applications are typically deployed to mobile phones, tablets, and head-mounted devices and screens. The latter are supposed to offer fewer distractions than hand-held devices. Still, they pose several other limitations, such as the need for a highly priced device or the need to wear an uncomfortable device. Although a mobile phone has been selected as an ARapp deployment device in the xR4DRAMA project, the essential AR/ MR devices are listed here for reasons of completeness. Most of the headsets are based on Qualcomm or ARM processors, which give different potentials to the developers via dedicated APIs to run algorithms at the edge on top of the manufacturers' applications.

The Magic Leap Headset² supports a comprehensive list of features for the user and is, along with HoloLens, the most formidable mixed reality (MR) headset (Figure 6). From these features, the most promising for outdoor usage is the world reconstruction which supports meshing of the real-world scenes, plane extraction, and ray casting, among others. Another essential feature is user interaction; the Magic Leap headset supports head pose and eye-tracking. Game engines like Unity³, Unreal Engine⁴, or exploiting the Lumin OS runtime⁵ and the Magic Leap C APIs⁶. Lumin OS includes a set of features you can use to develop, enhance, and manage Magic Leap apps.

Varjo XR-3⁷ is an impressive MR headset (Figure 6 – bottom right), made in Europe, which provides photorealistic MR with 12 MP video pass-through and high-resolution displays – the device does not have a holographic screen. The world reconstruction capabilities are provided by an integrated LiDAR, which supports occlusion handling and pose estimation, among other

² <https://developer.magicleap.com/en-us/home>

³ <https://unity.com/>

⁴ <https://www.unrealengine.com/en-US/>

⁵ <https://developer.magicleap.com/en-us/learn/guides/lumin-os-overview>

⁶ <https://developer.magicleap.com/en-us/learn/guides/lumin-sdk-overview>

⁷ <https://varjo.com/products/xr-3/>

features necessary for placing virtual objects on the real-world view. Also, this device supports inside-out hand-tracking without external trackers and beacons, which are common in VR devices, and eye-tracking for the user interaction experience.

HoloLens 2⁸ by Microsoft is another well-known MR headset that corresponds to a full ecosystem of applications running within the Windows OS. Like the Magic Leap headset, it is based on a holographic presentation of virtual objects, and it uses a vast variety of computer vision algorithms and sensors to bring seamless immersive experiences, as well as user interactions. Thus, it supports hand and eye tracking, world reconstruction (spatial mapping), pose estimation etc. HoloLens applications can also be developed on top of the Unity engine exploiting the Mixed Reality Tool Kit⁹ (MRTK).



Figure 6. MR devices. *Top*: Magic Leap; *bottom left*: HoloLens 2; *bottom right*: Varjo XR-3.

RealWear headset¹⁰ on the other side, follows a more conventional technological approach to facilitate the user tasks in industrial environments and, although described as an AR device, it is more of a head mounted tablet that you can control with voice commands. The screen does not superimpose information on the real world, but it shows information on a mini screen close to the user's eye. RealWear provides Unity plugins to access some of the device sensor,

⁸ <https://www.microsoft.com/en-us/hololens/hardware>

⁹ <https://docs.microsoft.com/en-us/windows/mixed-reality/mrtk-unity/?view=mrtkunity-2021-05>

¹⁰ <https://realwear.com/>

whereas the application development can happen on Unity, but also in other typical environments, such as Xamarin¹¹ and React Native¹².

The Blade Upgraded Smart Glasses¹³ by VUZIX are self-contained AR smart glasses that exploit see-through waveguide optics to merge digital instructions onto the real-world to support user's tasks. Through dedicated mobile app the user can connect to the phone and receive step-by-step directions in the AR glasses. Typically, the device has head motion trackers, and the rest of the interaction is via the connected mobile phone, thus any new featured are developed via the Android SDK. Other AR glasses include Solos smart glasses¹⁴ for providing basic functionalities while cycling and the forthcoming AR glasses by Apple.

2.2 AR / MR Frameworks

Different frameworks for developing xR applications exist, most of which have a strong correlation to the selected device for deploying an application and some of which are closed-sourced. Here, the VR frameworks are out of the scope, so the research is targeted to the AR / MR frameworks. Apple has developed the ARKit¹⁵ for iOS that targets its own set of devices and ecosystem. This can support a variety of spatial computing functionalities, such as world reconstruction via the integrated LiDAR scanner, realistic occlusion estimation, blending, spatial anchors, and scene recognition, such as floor and walls recognition. It also supports typical functions, such as face tracking and other user interaction. Simultaneously, Google has developed ARCore¹⁶ which mainly targets the Android devices and supplies similar functionalities for spatial computing and AR experiences. Microsoft is developing Mixed Reality Tool Kit (MRTK) to mainly serve the HoloLens device that offers impressive spatial computing capabilities. On the other hand, Vuforia¹⁷ is a commercial framework that targets enterprise AR applications and provides enhanced capabilities for “traditional” marker-based AR, such as identifying image/ area targets and objects, but also planes and edges tracking. Vuforia is integrated to Unity, and it also offers Vuforia Fusion, which exploits the device specific frameworks, i.e. iOS ARKit, Android ARCore, and Windows MR. The differences among the AR / MR devices and the supporting frameworks are raising difficulties to the cross-platform application development. Hence, Unity is providing AR Foundation, a unified multi-platform framework, which aggregates the AR capabilities of the major AR frameworks to develop applications always in the same environment, and currently supports ARKit, ARCore, Magic Leap and Windows XR plugin. Other frameworks are EasyAR¹⁸ with support for city-

¹¹ <https://dotnet.microsoft.com/en-us/apps/xamarin>

¹² <https://reactnative.dev/>

¹³ <https://www.vuzix.com/products/blade-smart-glasses-upgraded>

¹⁴ <https://solos-wearables.com/>

¹⁵ <https://developer.apple.com/augmented-reality/arkit/>

¹⁶ <https://developers.google.com/ar>

¹⁷ <https://www.ptc.com/en/products/vuforia>

¹⁸ <https://www.easyar.com/>



scale 3D mapping, WebXR¹⁹, and SolAR²⁰ which is an open-source framework to solve computer vision related problems for AR.

¹⁹ <https://immersiveweb.dev/>

²⁰ <https://solarframework.github.io/>

3 AR APPLICATION USE CASES

The following section will present the various use case scenarios that are supported via the ARapp in the current development cycle. The scope of this presentation is to explain all the intended usage of the AR application in a structured way and clarify any misunderstandings that might occur during evaluating the ARapp. All available use cases are displayed in the diagram in Figure 7 and are being analysed further below. Each use case is presented in a relevant video.

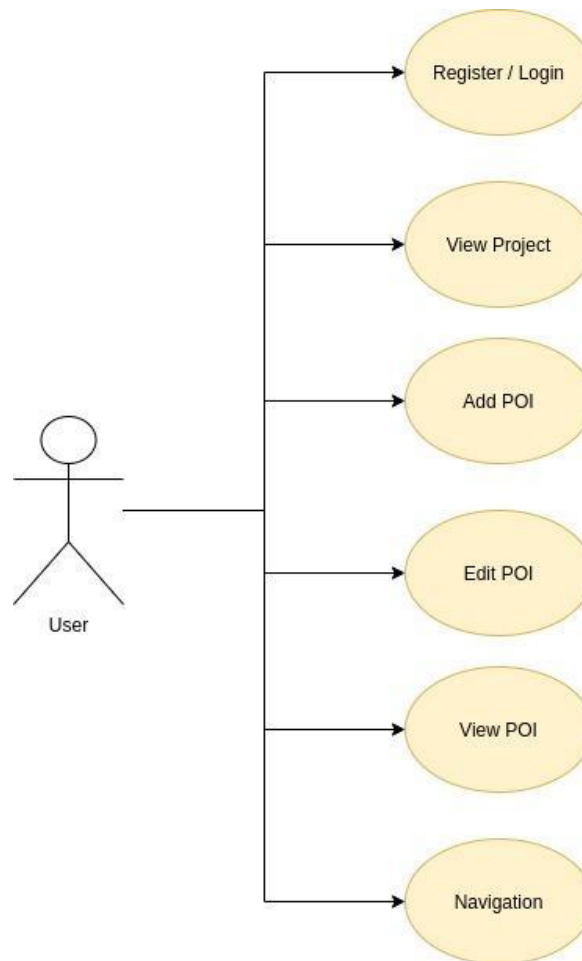


Figure 7. ARapp use cases.

3.1 Register / Login

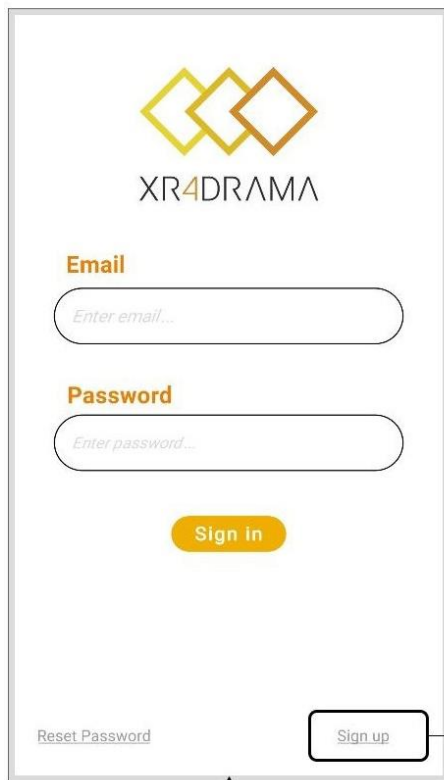
- The user opens the AR application.
- The user inserts his registered credentials and presses **Sign in** to log in the application.
- The user can register a new account by pressing **Sign up** and filling the required form and she, or he will be redirected back to the login view after registering a new account.

A video demo is provided [here](#). (The password is xr4dramaAR)

Register / Login

Login

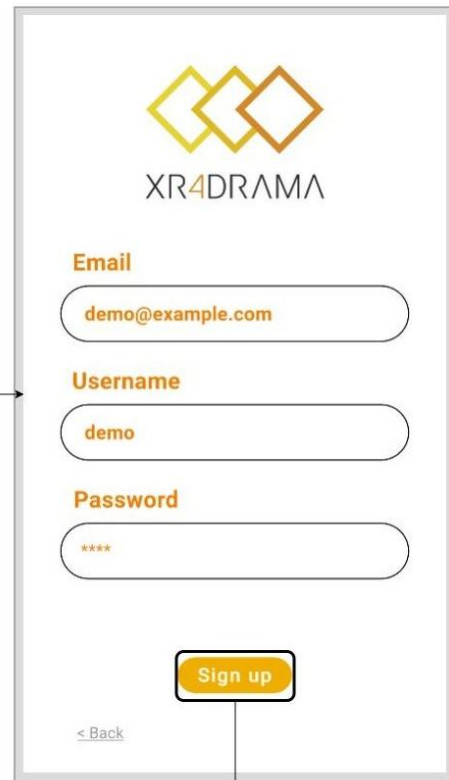
Login requires registered email and password credentials. The user can click Sign up (bottom right corner) to register a new account.



The login screen features the XR4DRAMA logo at the top. Below it are two input fields: 'Email' with a placeholder 'Enter email...' and 'Password' with a placeholder 'Enter password...'. A yellow 'Sign in' button is positioned below the password field. At the bottom left, there is a 'Reset Password' link, and at the bottom right, there is a 'Sign up' button.

Create Account

To register a new account, the user needs to insert an email, username and password.



The 'Create Account' screen features the XR4DRAMA logo at the top. Below it are three input fields: 'Email' with the value 'demo@example.com', 'Username' with the value 'demo', and 'Password' with the value '****'. A yellow 'Sign up' button is positioned below the password field. At the bottom left, there is a '< Back' link.

Registration
Success

Figure 8. ARapp; Register / Login.

In the following use cases, the user is signed in to the application.

3.2 View Project

- After signing in, the user can view all the projects into which he is registered. The projects are classified as **In GPS** or **Out GPS** depending on the user's GPS location. More project features are available inside **IN GPS** projects.
- The user can click on a specific project to view it. Detailed information about the selected project is displayed here.
- By clicking the map icon on the bottom menu, the user gains access to the project's map view.

- Inside the project's map view, the user can click on the **Side Menu**, **Redirect Position** or **Navigation** buttons. The user can also select a POI category to view on the map (inside the project's scope) using the scroll view on the top of the screen.

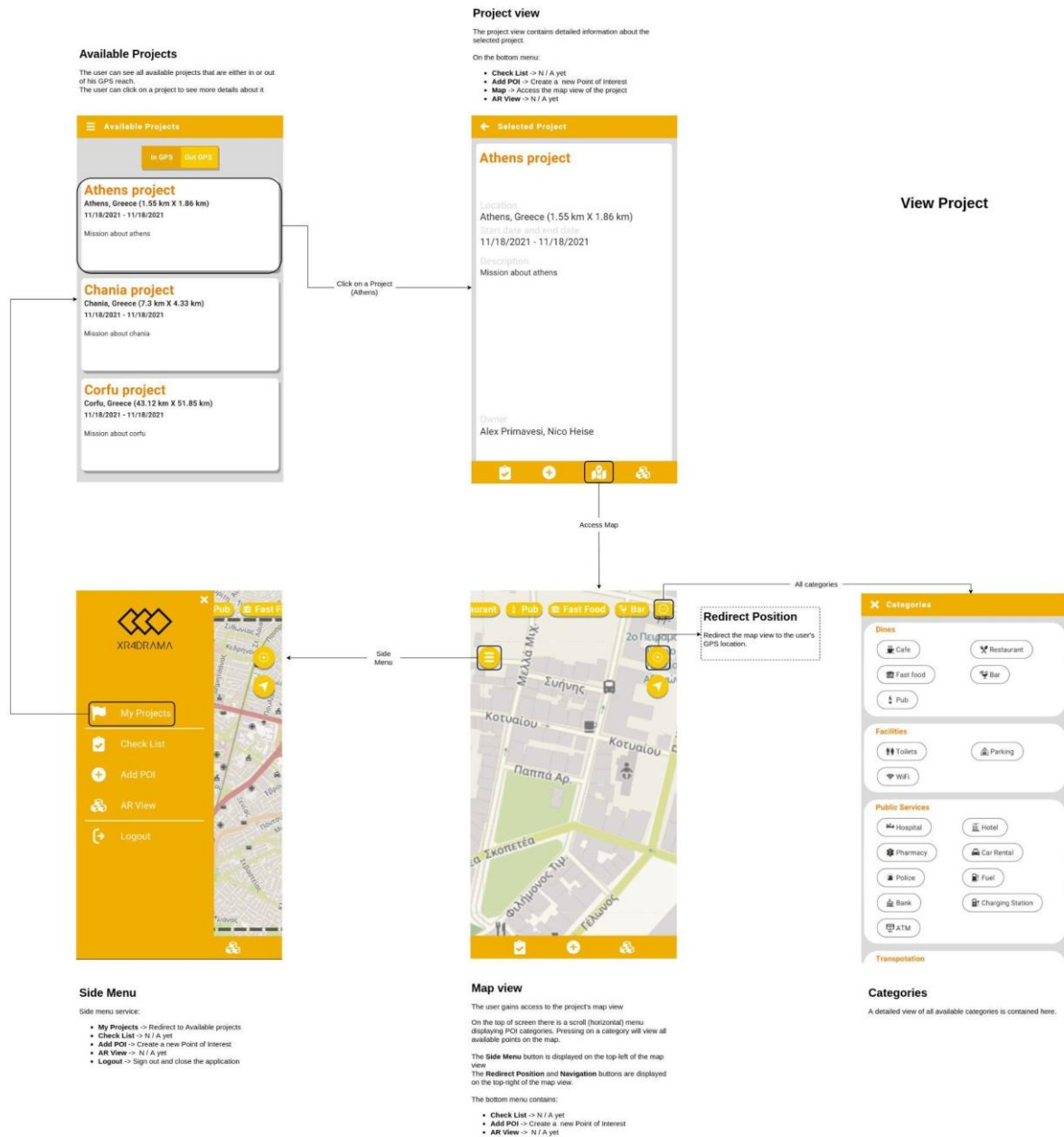


Figure 9. ARapp; View Project.



3.3 Add POI

- Inside **Project view**, **Map view** or **Side view** the user can press the **Add POI** button to add a new POI. The application transitions to the **Map View**.
- By sliding the map, the user can decide the POI location. When the location is decided, the user must press the upper-right button to validate it.
- The user must now fill the POI submit form. **Main category**, **Subcategory** and **Name** are mandatory and need to be filled. The user can also append media files by pressing **Media** and/or add a comment by pressing **Comment**.
- By pressing the upper-right button, the form is submitted, and the new POI is created.

A video demo can be seen here [link](#).

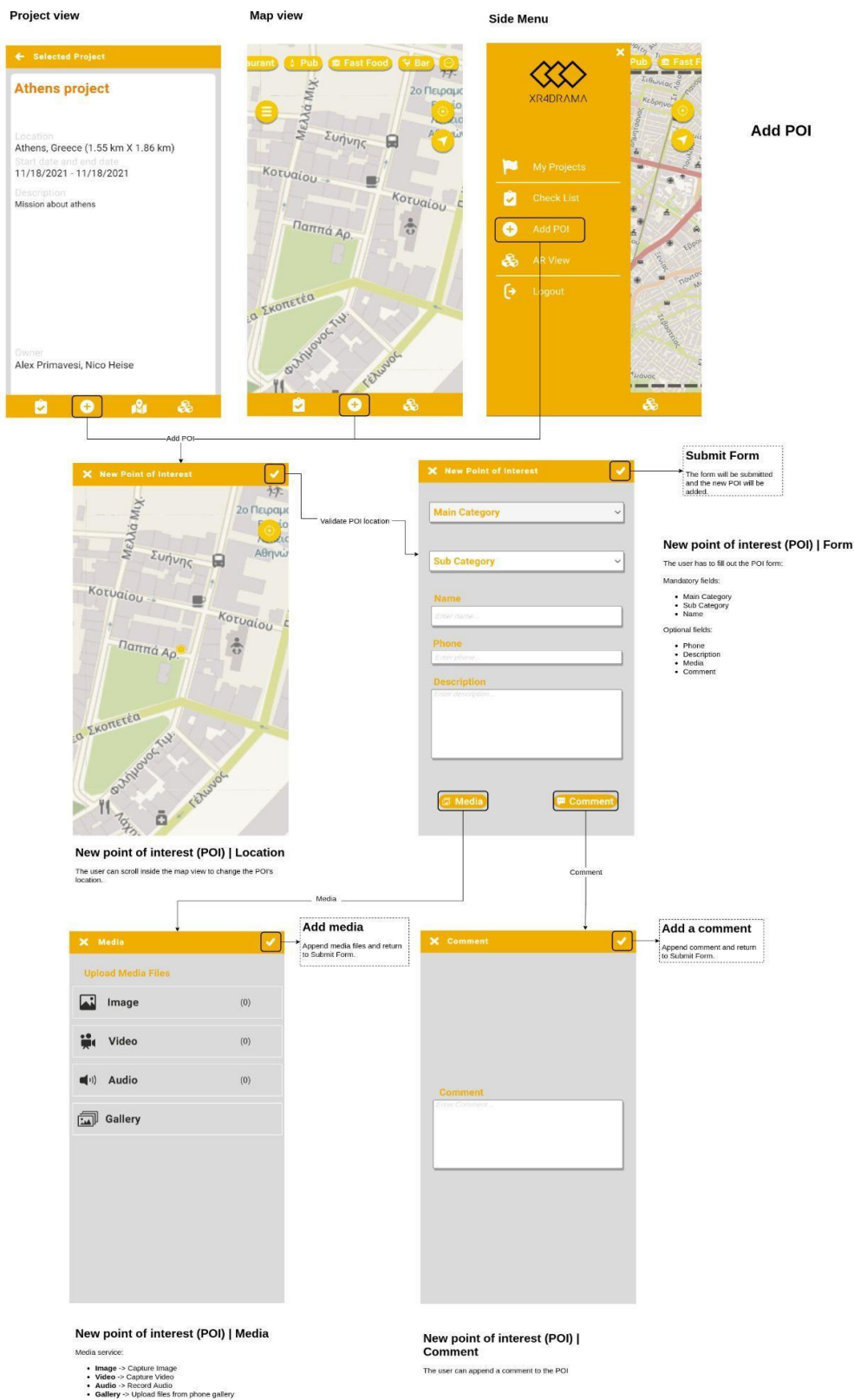


Figure 10. ARapp; Add POI.



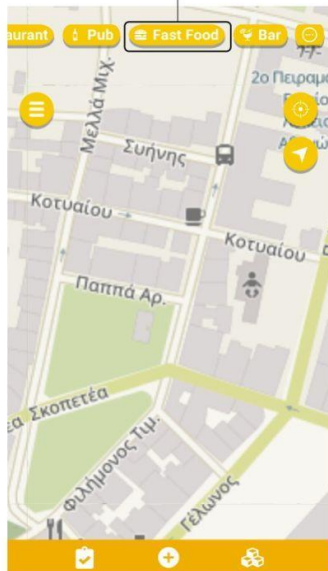
3.4 Edit POI

- Inside the **Map view**, the user can display the POIs of a specified category by selecting it on the topside scroll menu.
- By selecting one POI the user can view its properties on the bottom side of the screen.
- The user can click the **Edit** button on the bottom right corner to edit the information about the POI.
- Inside the **Update Form**, the user can update the **Name**, **Phone**, **Description** and even append new **Media** files and a **Comment**. The user cannot change the **Main category** and the **Subcategory** of the POI.

A video demo can be found [here](#).

Edit POI | Add extra information

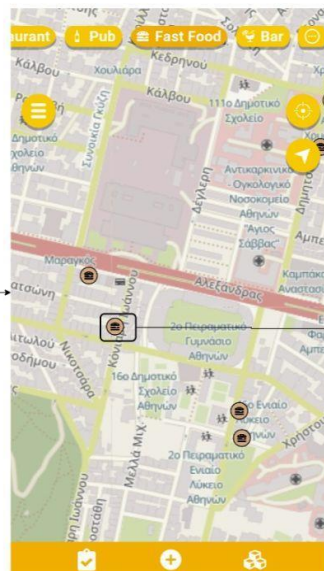
Map view



Display POIs
(Main Category: Dines
Sub Category: Fast Food)

Display POIs

The requested POIs are visible on the Map view.



POI clicked

Properties

The user can see the properties of the selected POI at the bottom side of the screen.

Properties:

- **Geo Info** -> Information provided by GeoPortals
- **Project Info** -> Information provided by users
- **Evaluation** -> Comments provided by users
- **Media** -> Media files provided by users

New point of interest (POI) | Edit

The user can edit POI information and append new media files.
The user can not edit main category and sub category.

X
Edit Point of Interest

Dines

Fast Food

Name
Fast Food (Name)

Phone
0123456789

Description
Fast Food (Description)

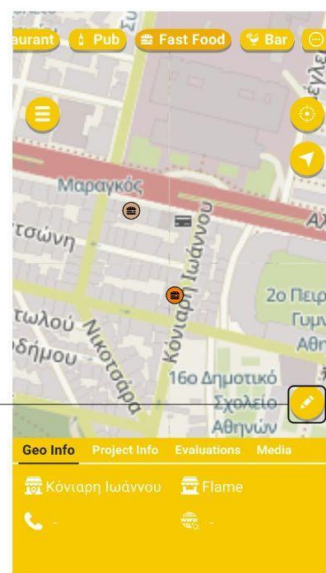
Media

Comment

Update Form

The new POI form is submitted.

Edit Point



Append Media

Append a comment

Figure 11. ARapp. Edit POI and add extra information.



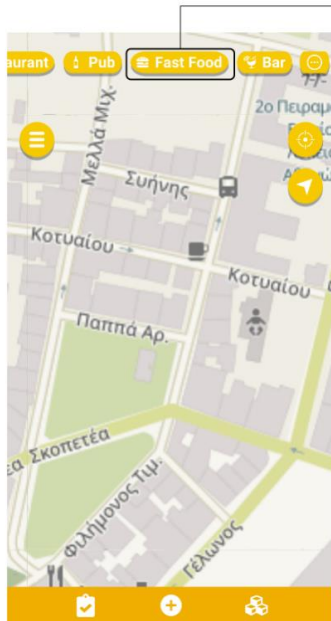
3.5 View POI

- Inside the **Map view**, the user can display the POIs of a specified category by selecting it on the topside scroll menu.
- By selecting one POI the user can view its properties on the bottom side of the screen.
- **Geo Info** is the first tab in the properties menu. It displays information provided by the various GeoPortals
- **Project info**, the second tab in the properties menu, displays information provided by the users of the application (during **Add POI** or **Edit POI** use cases)
- **Evaluations** contain the comments provided by the users
- **Media** contains all available media uploaded by the users.

A video link can be found [here](#).

View POI

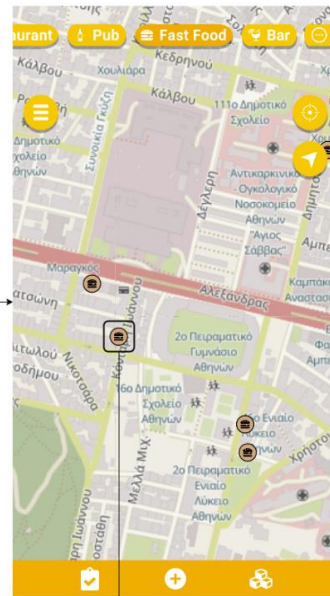
Map view



Display POIs

The POIs of the selected category are displayed

- POI that does not contain user information
- POI that contains user information
- The currently selected POI

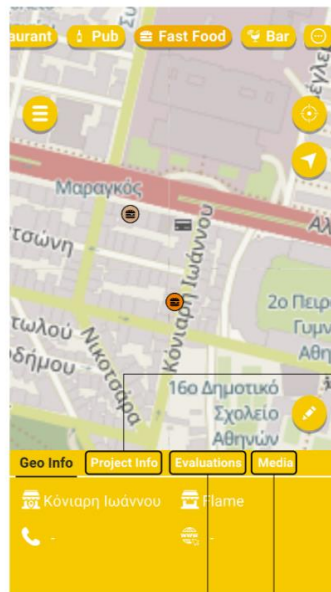


Properties

The user can see the properties of the selected POI at the bottom side of the screen.

Properties:

- **Geo Info** -> Information provided by GeoPortals
- **Project Info** -> Information provided by users
- **Evaluation** -> Comments provided by users
- **Media** -> Media files provided by users



Click on a POI

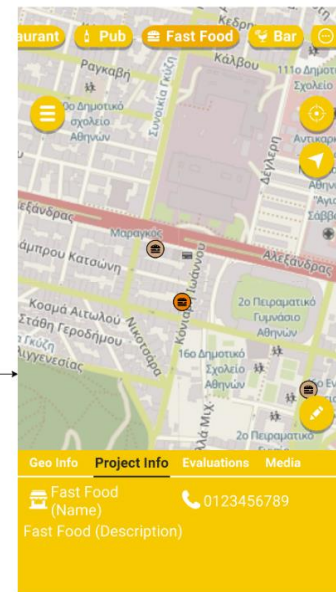


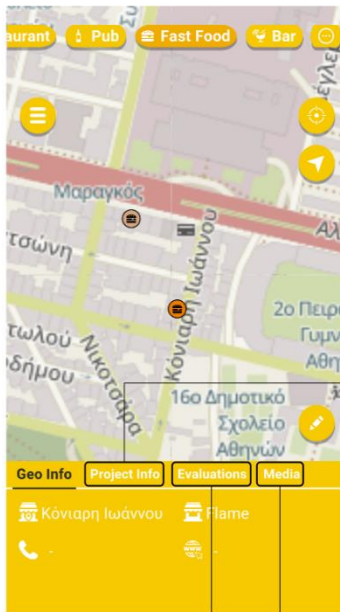
Figure 12. ARapp; View POI.

Properties

The user can see the properties of the selected POI at the bottom side of the screen.

Properties:

- **Geo Info** -> Information provided by GeoPortals
- **Project Info** -> Information provided by users
- **Evaluation** -> Comments provided by users
- **Media** -> Media files provided by users



Click on a POI

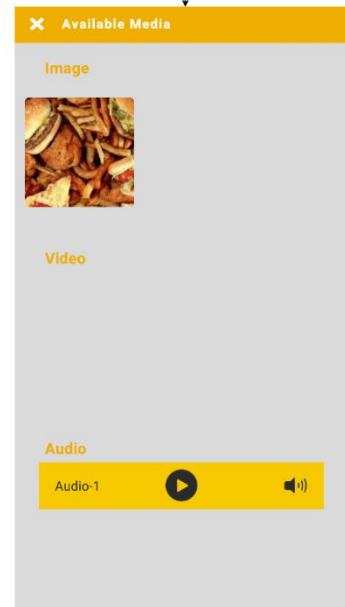
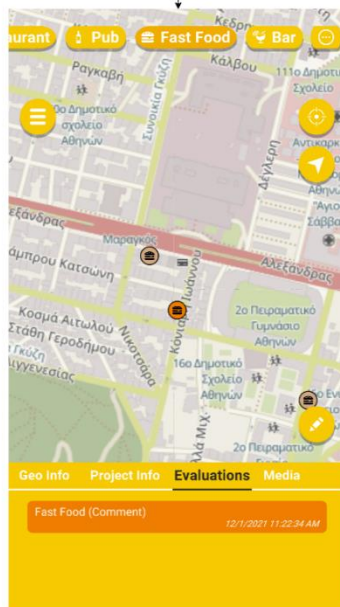
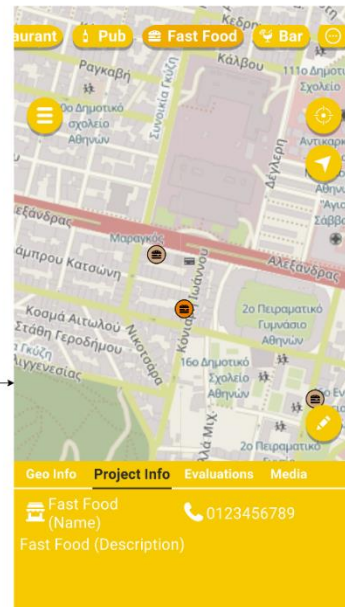


Figure 13. ARapp; View POI.



3.6 Navigation

- Inside the **Map view**, the user can initiate the navigation functionality by pressing the **Navigation** button (top-right side).
- The user can scroll through the map and select a destination point for the navigation procedure. The source point is chosen automatically to be the user's GPS location.
- After confirming the destination point, the shortest road path is calculated and is displayed on top of the **Map view**. Other useful information like distance in Km and ETA are also displayed.

A video demo is available in [this](#) link.

Navigation

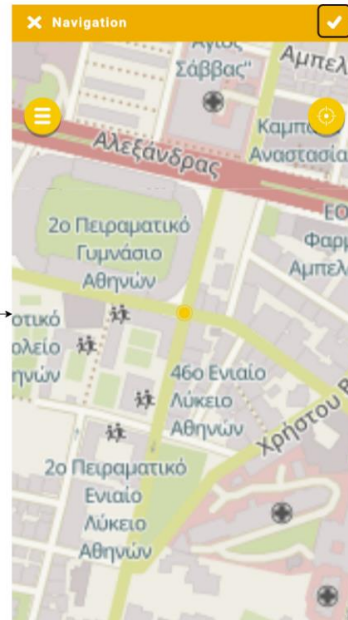
Navigation

The user can scroll inside the map view to change the destination point.

Map view



Navigation



Navigation

The shortest road path is calculated and displayed on top of the Map view. Other useful information like distance in Km and ETA are also displayed.

Start Navigation



Figure 14. ARapp; Navigation.

4 IMPLEMENTATION

4.1 Hardware

For the xR4DRAMA ARapp, deployment on a mobile phone was selected after a thorough discussion with the users, as the mobile phones seamlessly offer GNSS and other sensors, as well as integrated connectivity to the internet. They are also easy to provide to any users and are low priced, at least compared to a h/w solution such as the HoloLens headset. Furthermore, it was proven after relevant testing and prototype development that the outdoor usage of holographic devices is uncomfortable under bright sunlight conditions. On the other hand, headsets provide a more immersive experience and have the potential of rendering the hands of the user free of holding the device. Table 5 presents the minimum requirements of a mobile phone device.

Requirements	
Operating System	Android 8.0 (Ver. 26) and newer
CPU power	1,8 GHz or higher
CPU model	Snapdragon 636 or higher
RAM	3 GB or higher
Disk storage	64 GB or more
Battery storage	4000 mAh
Ability to connect to internet with or without WIFI connection	YES, 4G connection at least
ARCore ²¹	YES
Depth API ²¹	YES

Table 5. Minimum mobile phone system requirements for the 1st version of the ARapp.

4.2 Software

Figure 15 shows the technology stack for the ARapp. The Unity XR plugin is compatible with UnityEngine 2019.3 or newer. This plugin allows UnityEngine to develop applications for all XR devices (Android, iOS, Oculus). The XR brings together AR, VR, and MR. The ARapp is an AR application based on the ARCore plugin. This plugin support AR applications for Android devices. The ARapp is compatible with Android devices via the Unity XR plugin that connects with the ARCore plugin.

²¹ List of compatible android devices [here](#)

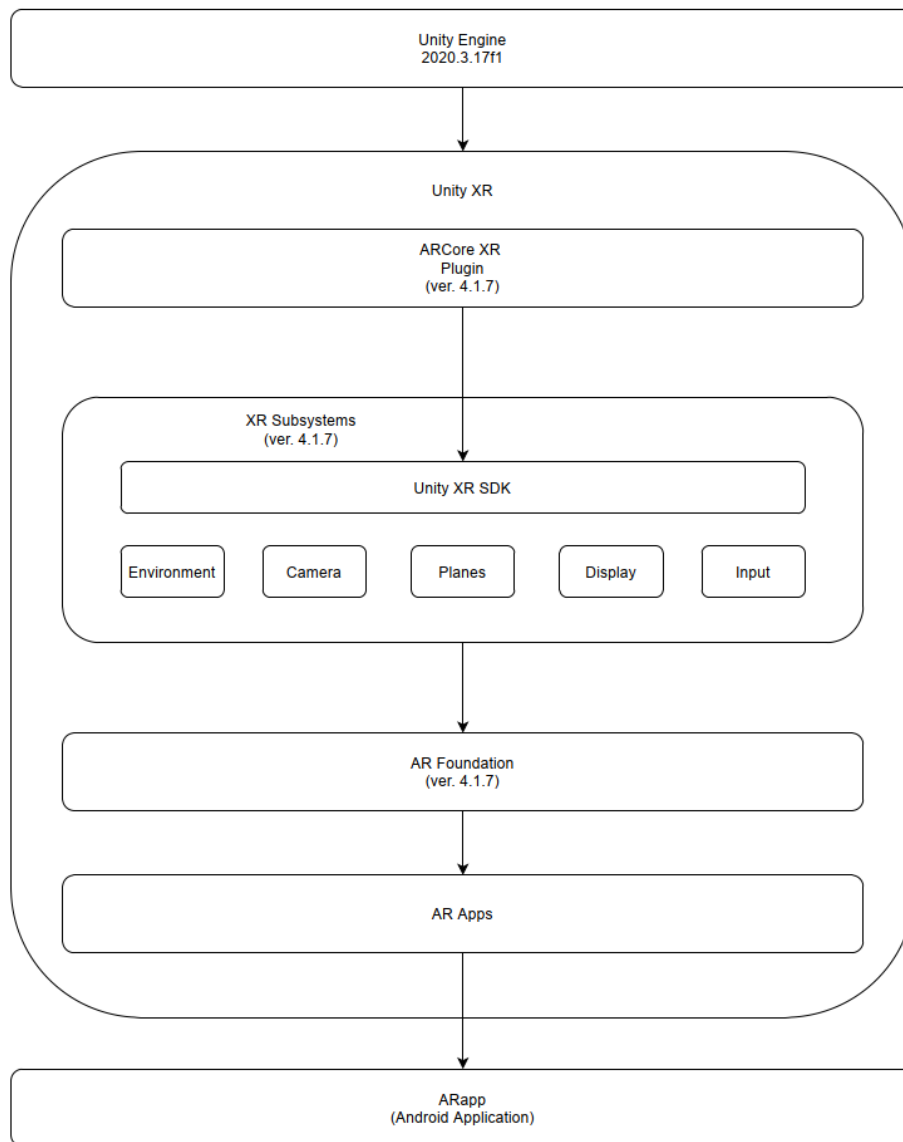


Figure 15. ARapp technology stack.

4.3 Communication with the GIS Service

Figure 16 walks you through the communication between the **ARapp** and the **GIS Service** when the client wants to create a new POI or edit/append the information and media files to existing POIs. For the GIS Service, the Geo Info represent the POIs from the geoportals, and the client can only append information on those. Thus, when the user chooses to append information on the *Geo Info* POI, the ARapp creates a new POI assigned to the specific *Geo Info* POI.

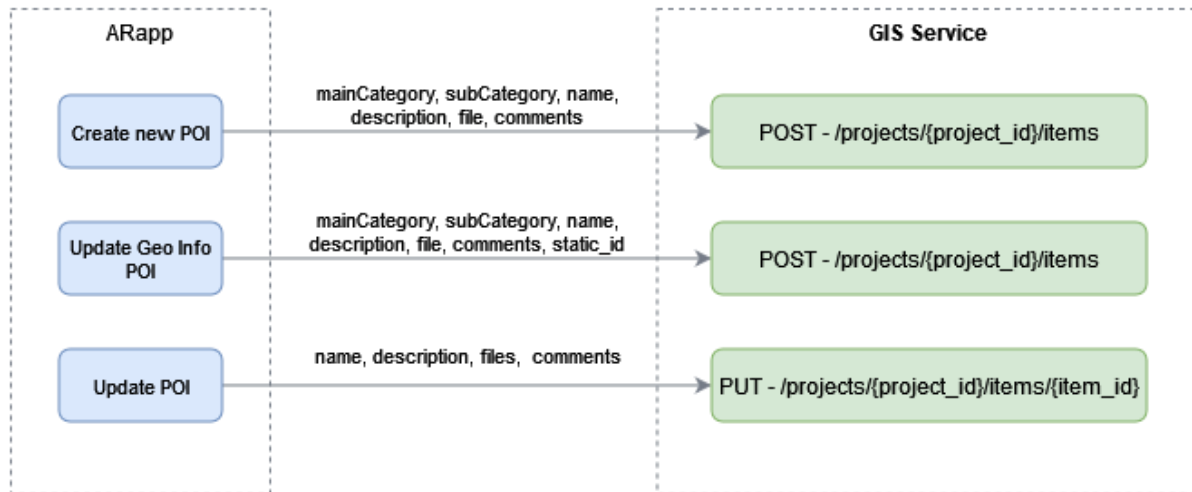


Figure 16. Create or edit/append POIs

Figure 17 shows the communication between ARapp and the GIS Service to visualise geospatial data. Specifically, ARapp takes all the available information for a specific subcategory from the [/projects/{project_id}/layers](#) URL and displays it on the map. In addition, when the client selects a POI, then ARapp gets all the available fields (e.g. description, comments, media files as thumbnails) from the [/projects/{project_id}/items/items/{items_id}](#) URL to show it. Finally, when the client chooses a media file, ARapp downloads the specific one from the [/projects/{project_id}/items/items/{items_id}/files/{file_id}](#) URL.

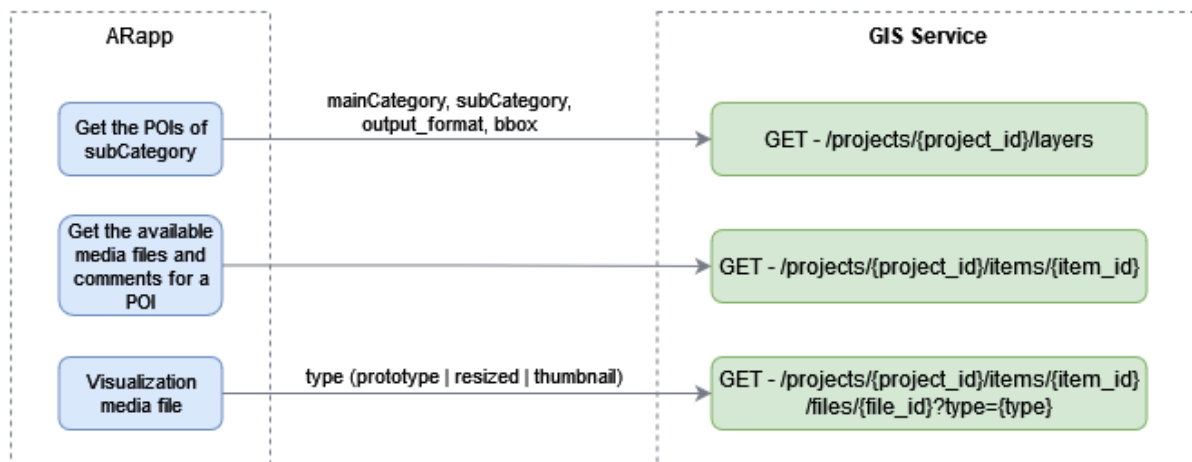


Figure 17. Get the available POIs

5 CONCLUSION

The development of the ARapp is on the right trails, following the project schedule. Initial difficulties on selecting the device and the technology stack are taken care of after a thorough understanding and exemplification of the user requirements and after solving some communication issues with the GIS Service regarding the representation of the available data. The ARapp will be fully functional till the end of the Media Planning demos and DW visiting Corfu Island, Greece for evaluation. Scene understanding algorithms are also being developed after a first delay that had to do with the device selection, which required thorough testing and evaluation via prototypes of the mobile phone as an AR device and the HoloLens headset to better perceive their appropriateness in the project. Using AR as an immersive user interaction for outdoor scenarios poses important difficulties, but we are at a good point at the end of the first year to claim that a very interesting AR application will result via the xR4DRAMA project.

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A.1. xR4DRAMA ARapp flowchart

