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Article

Augmented reality as a support for tourism promotion

Realidad aumentada como apoyo para la difusión del turismo

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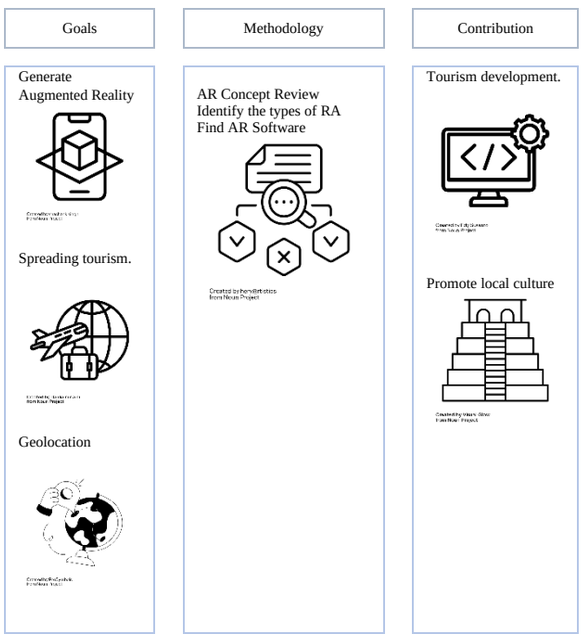
Abstract

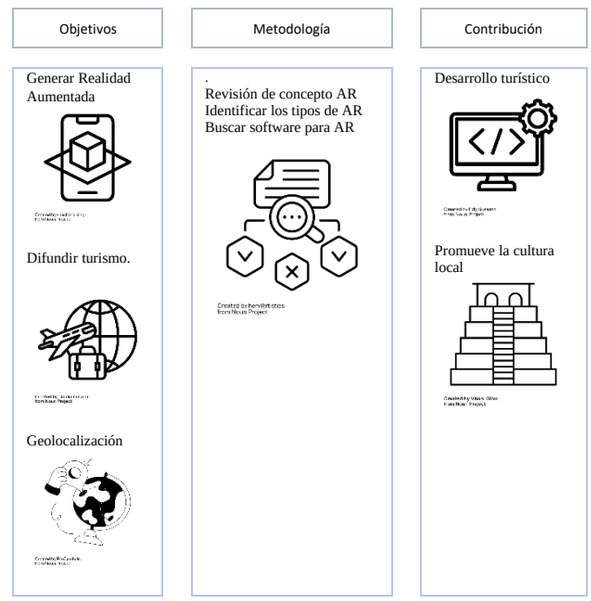
Currently, Augmented Reality (AR) facilitates interaction between virtual environments and the physical world, allowing both to blend seamlessly through technological devices such as webcams, mobile phones (iOS or Android), tablets, among others (Grapsas, 2019). Therefore, the aim is to develop an augmented reality project to promote tourism in a municipality of the state of Puebla. For this purpose, an analysis of the different types of augmented reality available will be carried out, including marker-based augmented reality, geolocation-based augmented reality, object recognition and projected augmented reality, with the aim of providing a better experience for tourists. This article presents the different characteristics of each type of AR, showing application examples, and some of the tools necessary for the development of augmented reality applications.



Augmented reliaty, Geolocation, Tourism

Resumen

Actualmente, la Realidad Aumentada (RA) asigna la interacción entre ambientes virtuales y el mundo físico, posibilitando que ambos se entremezclen a través de un dispositivo tecnológico como webcams, teléfonos móviles (IOS o Android), tabletas, entre otros. (Grapsas. 2019). Por tal motivo, se pretende desarrollar un proyecto de realidad aumentada que permita difundir el turismo en algún municipio del estado de Puebla, para ello se deberá realizar un análisis de los diferentes tipos de realidad aumentada que hay, entre los cuales se encuentra realidad aumentada basada en marcadores, en geolocalización, reconocimiento de objetos y proyectada; esto con el fin de brindar una mejor experiencia al turista. En este artículo se presentan las diferentes características que tienen cada uno de los tipos de AR, mostrando ejemplos de aplicación y algunas de las herramientas necesarias para el desarrollo de aplicaciones de realidad aumentada.



Realidad Aumentada, Geolocalización, Turismo

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Introduction

Since the pandemic confinement caused by the SARS-CoV2 virus, different economic sectors have experienced a large decrease in their population, and the tourism sector was no exception, as access to places was restricted, sometimes only a certain number of visitors were accepted, strict entry times were set or even places were closed and tourists were not allowed access. As the pandemic developed, the tourism sector had to innovate in the way it catered to its visitors, and creative responses and innovative solutions emerged, using technologies that facilitated virtual alternatives that allow the exploration of destinations through virtual tours, online experiences and augmented reality tools. Information provided by (Datos Abiertos. 2024) shows that, in January 2020, Puebla capital had 238,408 tourist arrivals, while in January 2023 there were 193,306, having a decrease of 18.91%, but for the months of September and December of the same years the information shown in table 1 was obtained:

Box 1

Table 1
Comparison of tourists in 2020 and 2023

	Sept. 2020	Sept. 2023	Dec. 2020	Dec. 2023
Tourist arrivals	47,984	244,563	60,930	296,035
Hotel occupancy rate	14.9	58.76	17.21	61.78

Source: Open Data https://datos.pueblacapital.gob.mx/dataset/estad%C3%ADstica-de-turismo-datatur

From this information it is observed that, for the month of September 2023 compared to 2020, there was an increase in tourist arrivals of 409.67% and for the month of December of the same years there was an increase of 385.86%; while hotel occupancy increased by 394.36% in the month of September and 358.97% in the month of December; so a considerable increase in the tourism sector is visualised.

Technology has been taking a very important role in the increase of tourists, initially using live or pre-recorded video media content, podcasts, films or television programmes.

Later, tools such as virtual reality or augmented reality were incorporated, which offers tourists a better user experience, as it provides information in real time about historical places, monuments or art; it also allows for a better guide to tourist attractions that are close to the user, or shows information about restaurants, hotels, opening hours or tourist attractions.

This paper describes different types of augmented reality that will allow the selection of the appropriate tool to disseminate or improve immersive and personalised experiences that adapt to the individual preferences of the traveller. Among the types described in this paper are marker-based augmented reality, geolocation, object recognition and projection.

Some of the necessary software such as Unity, Vuforia, Blender, ARKit, ARCore, VPT8, Heavy M, Mad Mapper, Python and web augmented reality platforms such as Zappar and Onirix will also be described.

The presented article has the following sections: Review of the state of the art in which different studies conducted in the tourism field in Spanish-speaking countries will be analysed; Augmented reality, this section describes what the augmented reality technique consists of; the third section deals with the types of augmented reality, this section helps the reader to identify which type can be applied for various projects and finally, various programs that can be used for augmented reality are described.

State of the art

This section shows a number of works in the area of augmented reality, ranging from application development to user experience guides based on the tourism sector. The works reviewed come from countries such as Spain, Colombia, Ecuador and Cuba; having a panorama of Spanish-speaking countries.

In the work developed by (Bernad Conde. 2020), virtual reality technologies applied to cultural heritage were analysed, particularly the Fuendetodos app, which can only be activated once the visitor is in Fuendetodos, incorporating augmented reality, geolocation and gamification, the use of games as an educational tool.

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The hypothesis put forward for this work was: the use of the Fuendetodos app would allow the user to generate a more complete and dynamic knowledge of the figure and presence of Goya in the town of Fuendetodos, which was positively verified. The use of the application generates learning and allows users to participate in this process.

On the other hand, (Alanis, Gaetan & Martín. 2021) proposed a preliminary set of User Experience guides for mobile Cultural Tourism applications, based on Augmented Reality. The proposal is based on: the review of existing studies on User Experience in software products for Cultural Tourism with Augmented Reality, and also on the analysis of User Experience experts.

In (Colpas *et al*., 2024) they conducted a study whose main objective was to evaluate the impact of the implementation of Augmented Reality (AR) technology in the Main Square Alfonso Avila Quintero, with the hypothesis that AR can revitalise tourism and culture in Agustin Codazzi, Cesar. Specific RA experiences were designed for the square, integrating local historical and cultural aspects; likewise, data were collected to identify the characteristics of the developments to be carried out, so that they would have the articulation of the indigenous component of the region. The result was a significant increase in the improvement in the perception and cultural interest of visitors to Agustín Codazzi.

The research carried out by (Sánchez Jorge, Jiménez Valero & Velastegui López, 2022) aims to demonstrate the impact of the use of augmented reality and smart devices to improve key processes in tourism activity, market products and services of the different destinations, add added value and boost communication through interactive resources.

Finally, the work reviewed is that developed by (Núñez Arroba. 2024) which seeks a way to promote cultural tourism in museums, proposing a web application that uses augmented reality. Thus, surveys were carried out to find out visitors' interest in this technology.

In addition, the RAD (Rapid Application Development) methodology was used for the development of the application, which allows close contact with the client and rapid delivery of the product. Express.js and React.js were used as development tools along with the MySQL relational database manager. Also, Model Viewer was used to apply Augmented Reality and the technique of photogrammetry to model the museum's 3D panels.

Augmented reality

Augmented Reality is a computational technique that allows humans to interact between the real world and the digital world through a device such as a tablet or smartphone. Augmented Reality (AR) is a technology that allows virtual elements to be superimposed on our vision of reality (Iberdrola. 2023).

Blender can be used to design three-dimensional objects, as it allows the creation of 3D visualisations, still images, 3D animations and visual effects.

As a cross-platform application, it is possible to use Blender on Linux, macOS and Windows systems. It also has relatively low memory and storage requirements compared to comparable solutions. Its interface uses OpenGL to provide a consistent experience across the entire spectrum of supported hardware and software platforms (Blender, 2024).

Types of augmented reality

1. Marker-based Augmented Reality (RAM)

Marker-based augmented reality is created by using image recognition to identify objects already programmed into your AR device or application. By placing objects in view as landmarks, they can help your AR device determine the position and orientation of the camera. This is usually accomplished by switching your camera to grayscale and detecting a marker to compare that marker to all the others in your information bank. Once your device finds a match, it uses that data to mathematically determine the pose and place the AR image in the correct location (Microsoft, n.d.).

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The markers or patterns are usually printed images, which the user defines what will be displayed when the phone detects it, the larger the marker, the further away from the camera it can be placed; Table 2 shows the size and distance recommended by the Ministry of Education (2024).

Box 2

Table 2

Recommended size and distance for markers

Size	Distance
16 * 16 cm.	1.90 mt.
11 * 11 cm.	1.30 mt.
7.5 * 7.5 cm.	1.00 mt.
3.5 * 3.5 cm.	0.40 mt.
1.3 * 1.3 cm.	0.16 mt.

Source: own elaboration

Figure 1 shows the design of a marker that can be used for object recognition.

Box 3

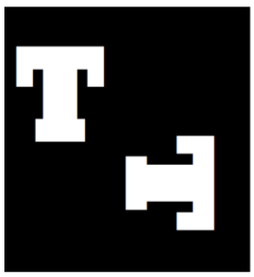

Figure 1

Marker for augmented reality

Source: *own elaboration*

Software that can help create this type of augmented reality includes Unity and Vuforia. 2. Geolocation-based Augmented Reality (GAR). It uses mobile phone GPS data to determine the user's position in the real world and then overlays digital information. Instead of relying solely on markers (seen in the previous point). With this type, the user can be at the geographical coordinate with latitude and longitude: 19.0437048961, -98.1981561970, which belong to the zocalo of the city of Puebla, when the user is at that exact point, he can visualise relevant tourist information, and when he goes to another point like: 19.0439763383, -98.1922419026, which belongs to the Barrio del Artista in Puebla, the phone will show him information about the different Masters, works of art and history of the neighbourhood.

To obtain geographic coordinates, you can use Google Maps, since it provides latitude and longitude of the place. Figure 2 shows the coordinates of Barrio del Artista, Puebla.

Box 4

Figure 2

Obtaining latitude and longitude of Barrio del Artista, Puebla

Source: Google maps

Among the tools that allow working with RAG is Unity, ARKit or ARCore, however, it is important to mention that a geolocation API must be used that allows developers to integrate maps and location data into applications. The Google Maps Platform includes the Geolocation API. However, there are web platforms that help to generate RAG, among them are Zappar and Onirix. Within Onirix you can generate different tourist sites, show important information or some animation of the place, when you have the places ready, you can see them on a map which will show the route from the origin to the destination. Figure 3 shows an example of a tourist map with 9 places in the municipality of Santa Rita Tlahuapan, Puebla. It shows information of a specific place, the location marked with red colour and the route to follow from the current location to the destination.

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Box 5

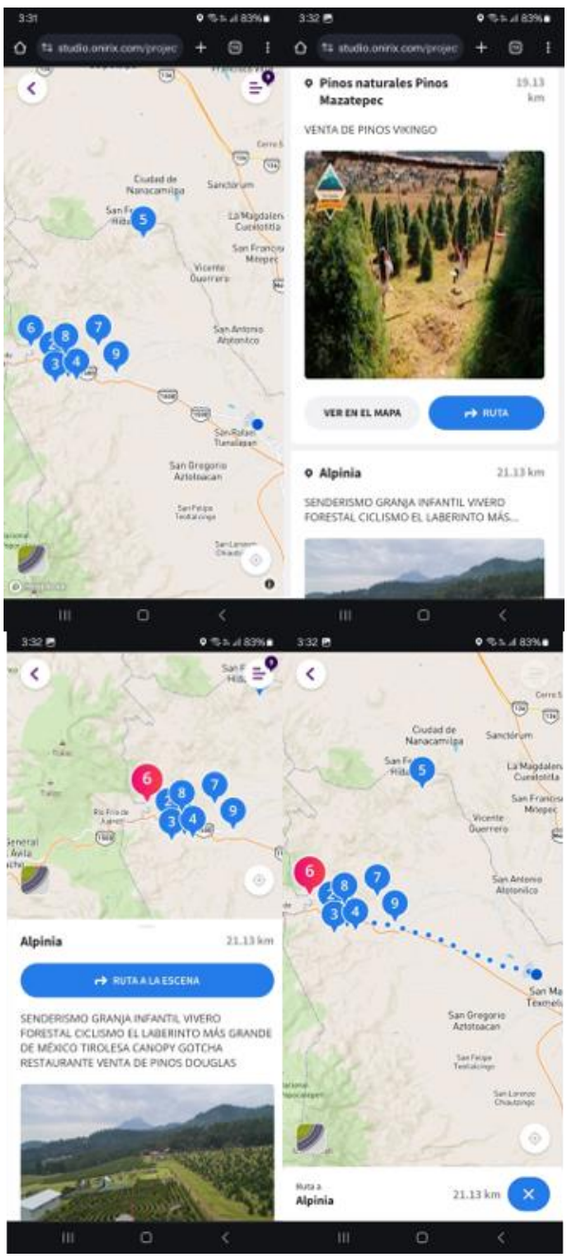

Figure 3
Information on Onirix
Source: own elaboration

3. Augmented Reality based on Object Recognition (RARO)

An augmented reality with artificial intelligence is able to recognise objects in the real environment in such a way that it will superimpose additional content by linking it to the object (Tolsan. 2020). For example, if a tourist is in the parish of San Martín Texmelucan, Puebla, and points his phone at the monolith there, it can show him the legend of the monolith. Figure 4 shows the monolith of the parish.

Box 6

Figure 4
Monolith of San Martin Texmelucan
Source: https://www.tiktok.com/@sanmartintexmelucan/video/7052441310011198725

Software tools such as Unity, ARKit, ARCore, Vuforia, ARCore Object Detection API or ARKit Image Recognition can be used to realise RARO depending on the platform for which it is to be developed.

4. Projection-based Augmented Reality (PAR)

Finally, within the types of augmented reality is based on Projection, clarifying that there are other types of augmented reality and not only the 4 that cover this work, RAP is a technique that allows the deployment and manipulation of virtual objects in a real world such as flat surfaces or with relief, this will allow the tourist (user) to have a perception of being manipulated in a natural way a virtual object, without the need to have a smartphone.

RAP projects digital images onto physical objects in a real physical space. It may or may not be interactive and is used to create a projection of objects that are viewed in depth (Moreno, 2023).

This type of augmented reality requires special software and hardware to be able to generate the projections, within software that can be used is VPT8, Heavy M, Mad Mapper and Python, in the case of Python, the modules OpenCV - cv2 - (image and video processing) and Pynout (controls and monitors input devices) must be used.

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The hardware required is short or medium distance projectors, if not available, an extended screen can be used, a Full HD 1080p, 30 FPS, 120°FOV webcam and preferably a portable tri-foot is also required.

Among the applications that could be developed for tourists in a rural environment, would be the projection of animals and that tourists could manipulate them, be it moving them, rotating them or making them bigger or smaller.

Figure 5 shows an animal of a set size, with RAP and gesture detection, it is possible to modify the size or rotate it by hand.

Box 7

Figure 5
Object in a set size
Source: own elaboration

Figure 6 shows the same object manipulated by hand to make it larger and rotated.

Box 8

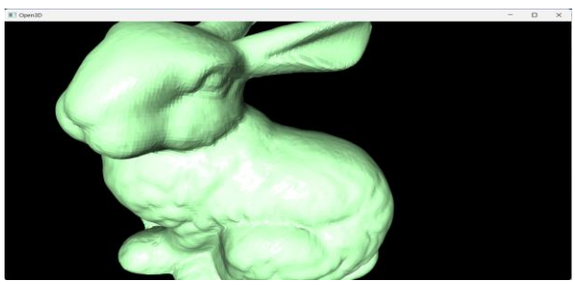

Figure 6
Manipulated object with hands
Source: own elaboration

Python and objects designed with .obj or .ply extensions are used to develop this type of augmented reality. Table 3 below shows a portion of the Python source code for object manipulation.

Box 9

Table 3
Portion of the Python source code for manipulating an object with RAP

```
with   mp_hands.Hands(min_detection_confidence=0.8,
min_tracking_confidence=0.5) as hands:

while cap.isOpened():

ret, frame = cap.read()

image = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
#image = cv2.resize(image, (320,180)) #para 16:9
#imagqe = cv2.resize(image, (640,480))

frameWidth = image.shape[1]
frameHeight = image.shape[0]

image = cv2.flip(image, 1)

image.flags.writeable = False

results = hands.process(image)

image.flags.writeable = True
image = cv2.cvtColor(image, cv2.COLOR_RGB2BGR)
pos = (0,0)
cv2.rectangle(image,        pos,        (frameWidth,
frameHeight),(0, 0, 0), -1)

totalHands = 0
```

Source: own elaboration

Software for augmented reality

As seen in the four types of augmented reality, software is required for its development, some of which are described below:

Unity

Masterd (2024) defines Unity as: is what is known as a development engine or game engine. It has a set of programming routines that enable the design, creation and operation of an interactive environment'.

Typical functionalities of a game engine include the following:

- Graphics engine to render 2D and 3D graphics.
- Physics engine to simulate the laws of physics.
- Animations.
- Sound.
- Artificial Intelligence.
- Programming or scripting.

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Vuforia

Is a cross-platform Augmented Reality (AR) and Mixed Reality (MR) application development platform with robust tracking and performance on a variety of hardware (including mobile devices and head-mounted mixed reality displays (HMDs) such as Microsoft HoloLens). Vuforia's integration of Unity allows you to create vision apps and games for Android and iOS using a drag-and-drop authoring workflow. Vuforia supports many third-party devices (such as AR/MR glasses) and virtual reality devices with rear-facing cameras (such as Gear VR) (Unity Documentation. 2018).

ARKit

It is an infrastructure that allows developers to produce augmented reality experiences in their app or game. Developers can add 2D or 3D elements using the front or rear-facing cameras of an iOS or iPadOS device (Apple Inc. 2024).

ARCore

Google ARCore is a software development kit (SDK) for the Android operating system (OS). Through ARCore, developers can also create applications that allow a phone to understand real-world environments and even interact with different types of information. ARCore's functionality boils down to three key pillars that help integrate virtual and real-world content (Pocayo. 2023).

VPT8

It can be used to project mappings in complex shapes, adapt a projection to a particular space/surface, combine recorded and live images, for multi-screen HD playback, for interactive installations using arduino sensors or camera tracking ++. VPT is very flexible in terms of control, with presets and a built-in cue list, as well as control over almost all parameters via OSC, midi, serial communication, integrated LFO and ArtNet. It also supports siphon (mac) and spout (windows) for sharing video streams between applications (HC Gilje. n.d.).

Heavy M

is a video mapping software with a wide range of tools to cope with any situation: integrated visual library, musical reactivity, edge-bl, offers intuitive drawing tools to create fast and adaptive projection maps (HeavyM. 2024).

Mad Mapper

A mapping software that makes videomapping possible: it simplifies the adjustment of projections on various surfaces, whether three-dimensional or two-dimensional.

Zappar

Vegas (2017) describes Zappar as follows: it has an interesting idea to create augmented reality projects in a simple way: through a visual environment you can drag and drop the elements you want to project and finally launch the app under an intuitive and straightforward system. Zapwork has several benefits:

- Three types of creations (widgets, designer, studio).
- Transparent costs.
- Support.
- Image tracking.
- Create apps.
- Has analytics.
- Also uses virtual reality.

Onirix

Onirix is a platform that allows you to create different types of augmented reality experiences in a fast and easy way. Onirix consists of three different components: Onirix Studio, a web application to manage all your projects and content, Onirix Web AR Player which is the way to display your experiences from the browser (Web AR), and Onirix SDK, a software development kit for you to create your own augmented reality experiences for web AR (Onirix. n.d.).

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Results

From the state of the art, which included the review of 5 developed projects related to augmented reality and its application to cultural tourism, it can be said that the tourism sector in Mexico needs to employ technologies that allow tourists to improve their experience, in such a way that allows them to interact with the environment they are in or to obtain historical or cultural details about a specific region or place.

The review of the concept of augmented reality allows a breakthrough in the way in which users interact with the environment, by combining digital elements and the real world, in this case, in the area of tourism; so that subsequently a classification can be given to the types of AR that exist.

By describing the different types of AR that exist, it allows those who wish to implement this type of technology to clearly understand the technological diversity that exists to implement it in tourism according to their needs, as they will be able to compare the benefits and limitations that each type of AR has.

Finally, it is very important to mention the different software available on the market, both free and paid, to facilitate the selection of appropriate tools and optimise the efficient development of augmented reality projects, adjusting to the specific needs and available budgets depending on the type of project and AR selected.

Conclusions

In the tourism sector, each of the types of augmented reality can be directly applied to provide the tourist with a better experience in person or even from a web application that works in the mobile browser. The four types of reality analysed have their advantages in the tourism sector, whether rural, nature, cultural, gastronomic, among others. The three-dimensional objects that you want to present to the user must be well realised so that the user has a great experience of the site of interest.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Sánchez-Juárez, Ivan Rafael: Contributed in the search for software tools to create augmented reality and in realising different projects for AR types.

Paredes-Xochihua, Maria Petra: Contributed in the search and identification of the types of AR that exist, allowing to make the classification described, as well as searching for reality projects to feed the state of the art.

Availability of data and materials

The data obtained are available in each of the references used and if you require further information on the results, please contact the author of this article.

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Abbreviations

API	Application Programming Interfaces
AR	Augmented Reality
FOV	Field Of View
GPS	Global Positioning System
HD	High Definition

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HMD	Head-Mounted Display
LFO	Low Frequency Oscillator
MR	Mixed Reality
OSC	Open Sound Control
RAG	Augmented Reality based on Geolocation
RAM	Marker-based Augmented Reality
RARO	Augmented Reality based on Object Recognition
VPT	Video Projection Tool
VR	Virtual Reality
RAP	Projection-based Augmented Reality
SDK	Software Development Kit
SO	Operating System

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