

# Augmented Reality Mapping with AR Markers for Enhanced Tourism Experiences

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## Abstract

Implementation of augmented reality (AR) has increased productivity and provides real-time information and data to allow user to be aware of their surroundings. The objective of this research is to develop an augmented reality framework capable of overlaying real-time fruit identification results onto the physical environment in agricultural settings. The method approach to achieve this objective is using AR marker based and designed and developed using MATLAB. The study highlights that, regardless of some image quality limitations, complex feature detection algorithms like SURF and FAST can successfully mitigate the distortion and recovery processes. The results summarize that users of new augmented reality applications can now access helpful translation, mapping, and travel information.

## 1. Introduction

Agrotourism has begun a new era of innovation thanks to AR, especially regarding marker-based applications. Including this technology in agrotourism offers a stimulating prospect of transforming the experience of visitors into agricultural environments. By unique markers such symbols, patterns, or codes like marker-based augmented reality AR enables agrotourism to provide guests with an enhanced, participatory experience. A study has investigated how AR can enhance eco-agritourism by developing an educational AR tool focused on aquaponics [1]. This study highlighted that AR could improve learning outcomes and engagement by combining interactive, immersive experiences with environmental education. This resource showed medium-to-large effects on knowledge retention and motivation to practice sustainable tourism, reinforcing the effectiveness of AR for creating more engaging and informative agritourism experiences. This aligns with the potential of marker-based AR applications to enhance visitor experiences by providing interactive, educational insights into agricultural practices.

Through the lens of AR-enabled devices, visitors can engage with these markers, triggering an array of augmented experiences. From historical narratives linked to sites within the farm to interactive guides providing information on diverse agricultural practices, marker-based AR adds a new layer of depth and engagement. Imagine a tour where visitors, equipped with smartphones or AR glasses, can point their devices at specific areas and witness information about the crops, historical anecdotes about the farm, or even virtual demonstrations of farming techniques. Agrotourism is not an exception to the widespread changes in which the newest technologies are being introduced by Hobson and Williams [2].

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The fusion of marker-based AR with agrotourism not only elevates visitor experiences but also offers agricultural businesses and farms new opportunities for marketing, education, and customer engagement. Despite the potential for smart technologies like artificial intelligence, robots, and the Internet of things to significantly increase productivity and eco-efficiency, Rose and Chilvers in 2018 [3] claim that the social consequences are being neglected. By leveraging AR, farms can highlight their sustainable practices, highlight the story behind their produce, and engage with visitors in novel ways that foster a deeper connection between consumers and the agricultural process. It is being used increasingly successfully in a variety of fields, including in tourism where AR helps to guide with information and locations about the destination as mentioned by Chung [4]. Nowadays, smartphones that come equipped with a camera and a display screen, which is one of the components for perceiving AR. Smartphones, equipped with cameras and display screens, are essential for experiencing AR by capturing real-world scenes and overlaying digital elements onto them. This setup allows users to engage with AR through marker-based or marker-less interactions, making AR accessible and immersive in fields like agrotourism, where visitors can view interactive content overlaid onto agricultural environments. As smartphone technology advances, AR experiences on mobile devices become more seamless and responsive, enhancing user engagement. As technology continues to evolve, marker-based AR in agrotourism holds the promise of continual growth and innovation. Advancements in marker recognition expanded interactive content, and improved user interfaces are set to further enhance the immersive and educational aspects of these tours. The future envisions a more seamless integration of AR within agrotourism, potentially including features such as multilingual guides, adaptive content based on user interests, and collaborative experiences that encourage group participation.

## 2. Study Procedure

AR significantly enhances tourist experiences by overlaying digital content onto real-world settings, allowing visitors to interact with enriched, contextual information about historical sites, landmarks, and attractions. Figure 1 illustrates a workflow where 3D models created in software (like Unity and Blender) are visualized in real-world environments through augmented reality, using a device camera to capture and overlay virtual elements onto live video footage. When tourists use AR-enabled mobile devices, they can view additional multimedia, such as 3D models, audio, and video clips, that bring their surroundings to life. This interactive experience not only increases engagement but also deepens understanding by providing historical, cultural, or educational insights tailored to specific locations. As highlighted by a group of studies, AR applications in tourism have proven effective in improving visitor engagement and learning outcomes, offering a unique blend of physical and digital exploration that traditional tours cannot match [5]. However, the integration of AR in mobile platforms poses challenges, particularly in terms of data processing requirements for natural feature tracking, which demands careful consideration of tracking algorithms to optimize performance and maintain seamless user experience. Another study has determined and monitored the natural area attributes to mitigate the limitation where local scene image features were matched against local reference image features [6]. In this regard, the key determinants of scene and reference image features must be detected and denoted with feature descriptors for matching procedure performance. As core image recognition features, computer vision-based tracking (visual tracking) AR systems and feature descriptors, such speed up robust features (SURF).

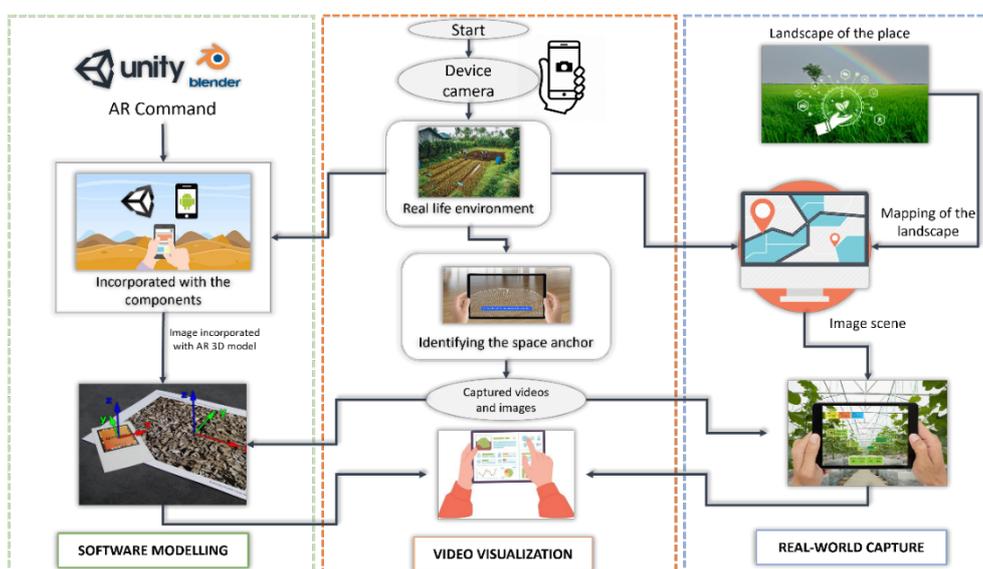


Fig. 1 Study procedure of augmented reality

Due to the advancement of sophisticated smartphone technology. Furthermore, information in an AR application is supplied in a variety of multimedia formats such as 3D models, sound, image-to-video clips, etc. When a user points their device towards an object, they can see additional virtual information superimposed on the real world. This can give benefits for the user by using AR technology delivering interactive information in real-life human interaction and enhancing the tourist experience.

## 2.1 Augmented Reality in Tourism

New emerging technologies have improved the way travelers plan their holidays and trips. The development of technological tools has allowed travelers to virtually experience a tourist destination. Thus, for example, previous studies have demonstrated that pre-visiting a destination through a virtual tour has a positive impact on destination image and accordingly on travellers' intention to visit the place. This study explores the role of a possible virtual tour consumers' visit and purchase intentions. Since the first studies on VR, scholars have highlighted the great potential of virtual tours in determining purchase choices [7].

During the pre-purchase phase, AR, virtual reality and mixed reality can be decisive in influencing customers' purchasing choices as they allow consumers to test and directly experience the product and provide useful information during an entertaining and funny experience [8]. Thus, the interaction with the virtual environment has a positive impact on consumers' willingness to purchase [9].

Following the presentation and extensive use of major smartphone implementations to conveniently allow AR elements, a study has claimed that mobile AR was one of the most rapidly progressing study topics [10]. Location-oriented AR meant a sample distinction of marker-less AR that placed augmentation in a specific location. When users' device data supplemented the location, virtual elements were mapped onto the location and subsequently displayed. Mobile AR hence meant a smart tourism software to locate the best places that suited individual preferences on portable devices.

These days, one of the quickly emerging parts of tourism activities is the AR that plays an instrumental role in ensuring vast experience for visitors by offering enriching and interactive entertainments. A finding in 2024 is digging into AR potential in experiential marketing within tourism domain, where they explain that AR changes what is offered by state-of-the-art marketing from multimedia to full immersion in the tourist activity becoming more attractive with such interaction [11]. This study is a part of the possible areas of use for AR in tourism industry. To date, it has been permitted that tourists can interact with the destinations in contextually rich form. This increases the attractiveness and engagement of the tourists. Furthermore, scholars have scrutinized the transformative power that AR can have in Indian tourism [12]–The result is better satisfaction amongst tourists, higher retention and that enables them to have immersive, interactive experiences where virtual meets the real world in the touristic sites. Furthermore, a case study explains how AR can be applied to e-commerce for tourism products [13]–He argues that the quality of its virtual previews significantly influences the buying decisions of travelers by enabling AR customers to examine virtual versions of the products online through their smartphone, thus contributing to a positive shopping experience in the travel sphere. In a nutshell, the research papers suggest that AR can enhance tourism significantly through a basic giving tourists much more entertaining and individualized experiences.

## 2.2 Personalization with Augmented Reality

The information generated by augmented technology might be context-aware and tailored to user characteristics and needs. Content personalization implied the main advantage of AR information systems, in line with consumer expectations and environmental adaptation [14]. Yet, situational awareness and consumer preference were reflected in the personalization of content in AR systems. As a result, customized goods may be provided with specific options based on traveller preferences for the best possible tourism experiences through AR apps. Also, the option might reduce information overload and content that was of no interest to travellers. In general, personalization refers to the creation of products tailored to specific individuals' demands. According to a study, personalization meant a method that enhanced system usability, interface, information accessibility, or distinction for more relevance on a personal and a group level [15]. Personalization also assisted in predicting consumer needs based on each person's background information. In terms of what to personalize such as content, functionality, user interface, and channel for whom to personalize either individual or group and the personalization catalyst, personalization comprised a three-dimensional construct [16]. Personalization mostly took place while providing user profile knowledge, preference, and context parameters to avoid overbearing information and create an ideal suggestion system. Personalization systems were typically created from an instrumental perspective, using context such as time, location, and the current surroundings. Also, user profile knowledge to draw conclusions or make assumptions and behave accordingly.

The tourism industry intensively experimented with a recommendation system, which produced applications and sophisticated tools. The manipulation took place because of the considerable difficulties in independently arranging a trip and the financial importance of travel and tourism in proposing new and useful traveller-oriented

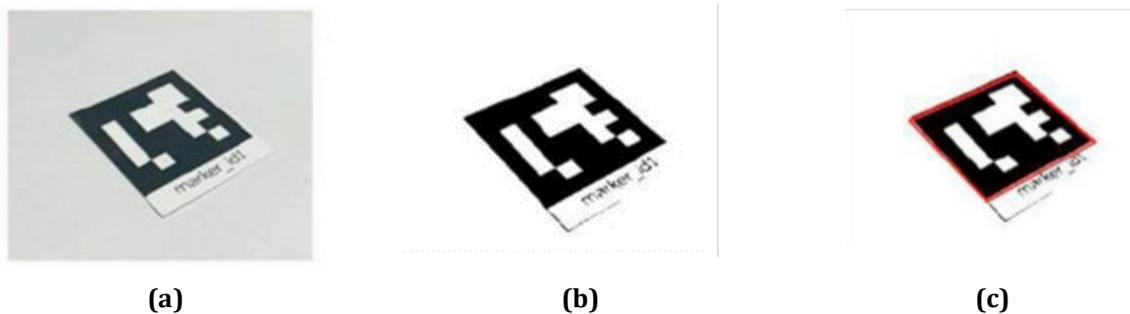
recommendations while visiting foreign places. The popularity of smartphones, tablets, and mobile networks has enhanced support for personalized recommendation systems for travelers [17]. The recommendation systems implemented computer programs that maintained databases of knowledge about the user context, and supplemental web content. For instance, a recommendation system offers forecasts, recommendations, and views based on information by users or other appropriate standards [18]. To provide personalized user suggestions, previous study gather contextual knowledge, and speed up decision-making for destination suggestions, a study has implemented a deep neural network for the recommendation system. The use of neural networks improved the effectiveness of item recommendations [19]. Artificial intelligence (AI) or deep-learning technology deployment could also optimize a personalized content application.

### 2.3 Marker-based Augmented Reality

Employing markers, like symbols, patterns, or codes, as triggers, marker-based augmented reality (AR) applies digital content onto the actual world when seen through an AR-capable device, such as a smartphone or tablet. By serving as reference points, these markers enable augmented reality apps to instantly superimpose digital data, pictures, videos, or three-dimensional models on top of the physical world.

AR devices can recognize the markers with their cameras and specialized software since they usually have distinct visual qualities. When these markers are identified, the AR application adds digital content that is directly linked to them, enhancing the real environment. Marker-based AR operates by scanning a marker, which causes an augmented experience to display on the device.

A software program called an app is typically needed to enable users to scan markers from their device utilizing the camera stream. Study by [20] have used the position of  $(x,y,z)$  and rotation axis for the concept of calculating the space measurement in a room with marker based AR concept. Fig. 2 shows the process of marking process by the authors.



**Fig. 2** Process of marking for marker-based AR (a) Picture from the camera; (b) After adaptive threshold and contour filtering; (c) Pose estimation

On the other hand, a study has devised an AR guide for West Macedonia, utilizing markers and markerless AR technology to develop a location-based AR application [21]. This innovation allows tourists to interact with the digital content triggered through images that are in a particular geographical region which in turn provides them with a better understanding of the area that they have visited through immersive and informative content. The use of AR with markers in agricultural contexts to improve tourist engagement and experience during farm tours is known as marker-based agrotourism. When seen through an AR-enabled device, such as a smartphone or tablet, it uses markers such as symbols, patterns, or codes placed within the agricultural area to trigger digital content.

In the context of agrotourism, these markers might be strategically positioned across the farm or agricultural site. When visitors point their AR-enabled devices at these markers, the technology recognizes these cues and overlays digital content onto the real-world view. This content could include informative details about specific crops, historical information about the farm, interactive guides, 3D models of agricultural processes, or even virtual demonstrations of farming techniques.

The aim of using marker-based AR in agrotourism is to enrich the visitor experience by providing a more interactive and informative tour. It allows for a deeper understanding of agricultural practices, history, and the farm's operations by engaging visitors with interactive and educational digital content overlaid onto the physical setting. This technology bridges the gap between traditional farm visits and a more immersive and educational experience, offering a unique and memorable way for visitors to interact with and learn about agricultural practices.

### 3. Methods

AR has transformed how we experience digital information, bringing it into the real world by overlaying virtual content onto our surroundings. One of AR's most valuable features is its ability to provide context-specific information, making it easier for users to access useful insights tailored to their location. This is especially powerful in areas like industry, tourism, and documentation, where adding annotations through AR enhances understanding and engagement. By using markers such as QR codes and AR-specific images combined with advanced image processing techniques, AR can seamlessly align virtual information with the physical environment. This approach creates an interactive experience where users can access both 2D and 3D information as they move through a space. The sections that follow will delve into how AR markers and QR codes work together, the steps for adjusting image rotation and scale, and the underlying mathematical principles that make these transformations possible.

#### 3.1 AR Marker

Adding annotations to AR is an appealing way to provide people with more location-specific information. Despite being used to manage documentation procedures, knowledge-based information systems do not explicitly or directly take advantage of the geometrical and visual characteristics of 3D data. The reality model can be annotated using a variety of 3D techniques, but they neglect to address the intricate relationships between information and interpretation.

The knowledge that has been contextualized is more interesting and simpler to understand, which increases its overall usefulness. A major advantage of AR technology is its capacity to contextualize and find virtual information. As a result, a large fraction of all AR content consists of annotations. AR annotations may be useful in several ways, as shown by interactive guide systems. Users can edit basic spatially oriented 2D images centered around a dynamic 3D representation to develop, show, and retain significant elements in this 2D or 3D annotation system as illustrated in Fig. 3. In this context, the user can only interact with the interface that is provided on the screen such as AR browser and user can scan and see the annotation or the image in 3D. The elements of this application not only can be used by a single user, but it can also be used by many users depending on the place and the network.

The user interactions are categorized based on the number of participants whether single or multi-user and their engagement level, passive or active. Depending on the interaction type, users engage with one or more user interfaces, such as an AR browser for augmented reality experiences, a 3D user interface for spatial navigation, a tangible user interface for physical interaction with virtual objects, or a natural user interface using intuitive controls like gestures or voice commands. For more complex scenarios, a multimodal user interface combines several of these input methods. The interface then connects users to either offline content stored locally, or online content stored in a cloud-based or web-accessed virtual resources. This methodology ensures a flexible and adaptable system that supports various forms of user engagement with virtual content in both offline and online environments.

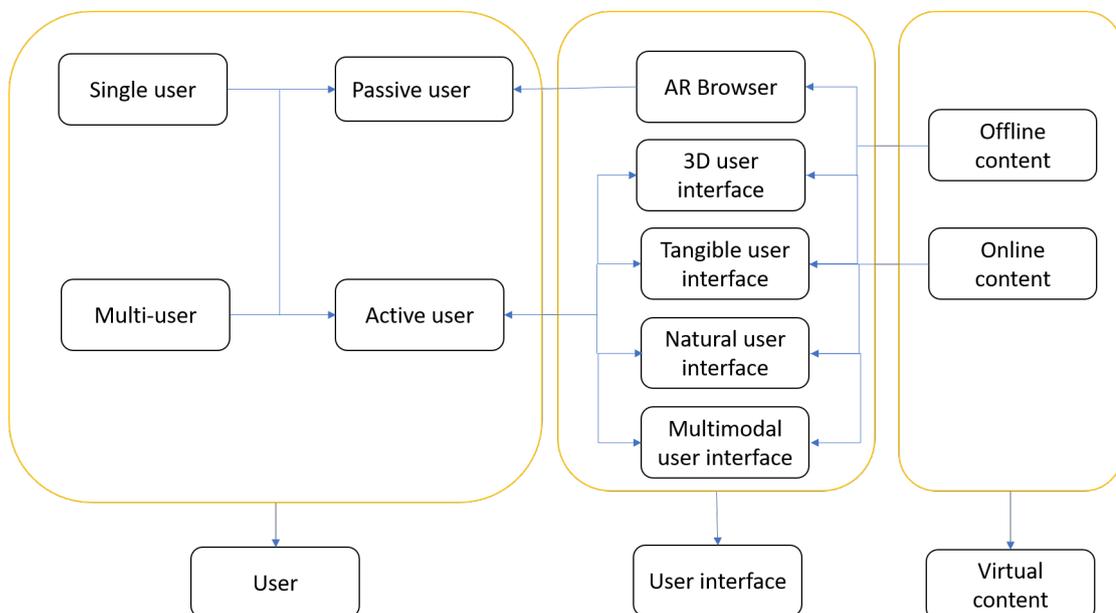


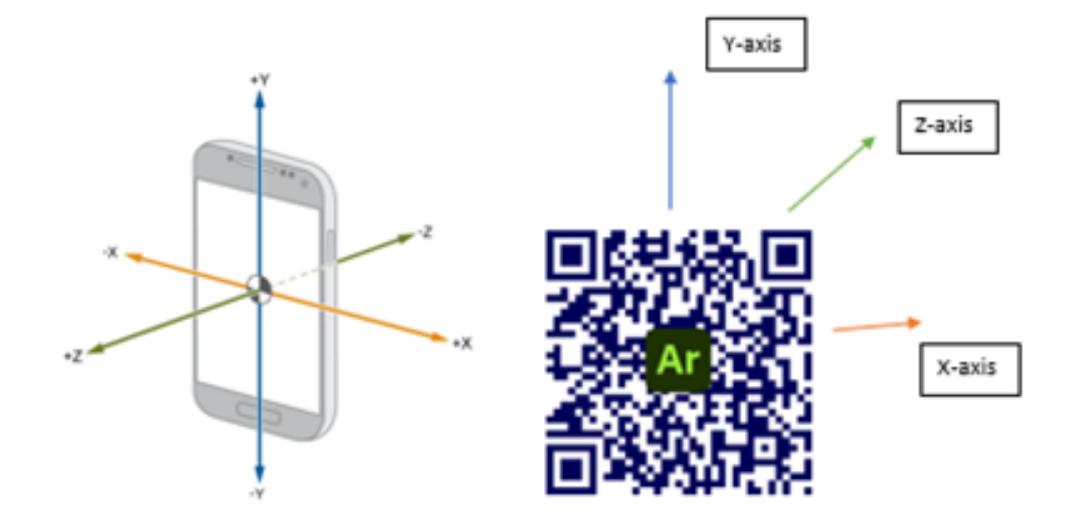
Fig. 3 Elements of AR application

The integration of QR codes and AR markers allows for a more comprehensive and distinctive user experience by combining the features of both technologies. Combining QR codes' quick information access with AR markers' immersive digital overlay capabilities creates a more dynamic and participatory experience.

In the realm of AR, two major classifications which are marker-based and marker-less AR are commonly used across various fields, including industry and tourism. Marker-based AR relies on specific visual markers, which act as triggers for displaying augmented content, making it especially effective in controlled environments where precise information overlay is necessary. Marker-less AR, on the other hand, uses real-world objects and surfaces as anchors for virtual elements, offering greater flexibility and broader applications, such as location-based services in tourism where interactive content can enhance user engagement without needing a physical marker. Research shows that these AR technologies significantly enrich user experiences by allowing dynamic, real-time interactions with the digital elements embedded in real-world settings, thereby broadening the scope of AR applications in sectors like tourism and manufacturing [22].

Instead of using natural markers in this project since they need a lot of processing resources and can cause the device to overheat, we will use artificial markers as seen in Fig. 4. Several elements need to be taken into consideration to successfully integrate artificial markers into the environment. The marker must have a distinctive image with a predetermined visual pattern and dimensions, be simple to recognize by colour or shape and be the right size. We will be using basic QR codes as markers for experimentation purposes. The marker must have a distinctive image with a predetermined visual pattern and dimensions, be simple to recognize by colour or shape and be the right size.

The combination of AR markers and QR codes offers a comprehensive user experience by providing immediate access to information via QR codes and then transitioning into an augmented, interactive view through AR markers. This integration enhances user engagement and interaction, particularly in contexts where both quick access to information and immersive experiences are desired.

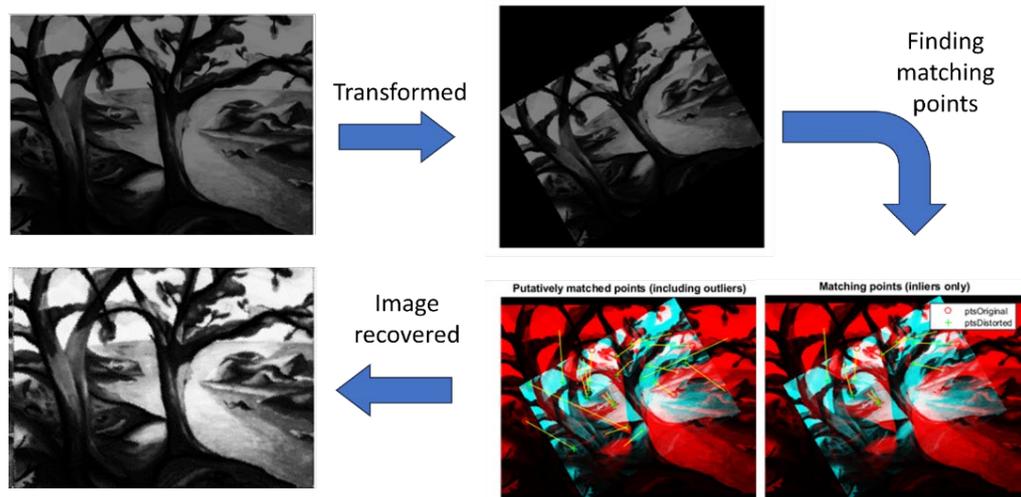


**Fig. 4** AR Marker using QR code

### 3.2 Image Rotation and Scale

In MATLAB, marker-based AR was implemented, as illustrated in Fig. 5, to resize and rotate the image from its original state. The image was rotated clockwise by 30 degrees and scaled down to 70%, resulting in what is referred to as the "distorted" image. In Fig. 5, the objective is to assess the geometric properties of the image transformation between pairs of images. When one image is distorted concerning another through rotation and scaling, the functions `[detectSURFFeatures]` and `[estimateGeometricTransform]` are employed to determine the rotation angle and scale factor. Subsequently, the distorted image is transformed to recover the original image. Fig. 8 depicts the outcome of the image transformation, with the result presented in terms of theta instead of using the scale of the recovered images.

To estimate the transformation, the first step involves finding a transformation corresponding to matching point pairs using the statistically robust M-estimator Sample Consensus (MSAC) algorithm, a variant of the RANSAC algorithm. During the calculation of the transformation matrix, this algorithm eliminates outliers, enhancing the reliability of the results. It is important to highlight that the outcomes of the transformation computation may exhibit variability due to the utilization of random sampling in the MSAC algorithm.



**Fig. 5** The image displays matching point pairs used in the computation of the transformation.

Geometric transformation is used to recover the scale and angle. Since we compute the transformation from the distorted to the original image, we need to compute its inverse to recover the distortion consists of the following steps:

$$\text{Let } sc = s \cdot \cos \theta \quad (1)$$

$$\text{Let } ss = s \cdot \sin \theta \quad (2)$$

$$\text{Then, } A_{inv} = \begin{matrix} sc & ss & tx \\ -ss & sc & ty \\ 0 & 0 & 1 \end{matrix} \quad (3)$$

Fig. 5 and equations together illustrate a process for correcting image distortions by recovering scale, rotation, and translation using geometric transformations. Equations (1) and (2) define components of the transformation matrix, where  $sc = s \cdot \cos \theta$  and  $ss = s \cdot \sin \theta$  represent the scaled cosine and sine of the rotation angle, respectively. These values are used in the inverse transformation matrix Equation (3), which undoes the distortion by rotating, scaling, and translating the transformed image back to its original state. In the figure, this process is visualized, the transformed image (top left) is matched to the original by finding matching point pairs (top right and bottom-right panels), which are then used to compute the inverse transformation. Applying this inverse matrix realigns and restores the recovered image (bottom left), accurately correcting the distortion based on the computed transformation values.

## 4. Results and Discussions

As AR continues to evolve, effective model design is crucial to creating immersive, interactive experiences that are adaptable to users' unique needs and environments. Modern AR models emphasize user engagement, personalization, and adaptability to provide a seamless integration of digital content within real-world contexts. These design approaches seek to enrich the AR experience by fostering meaningful interactions and ensuring that the technology remains accessible and intuitive for users. The following subsections delve into the foundational elements that shape effective AR model design, highlighting the strategies and methodologies that enable responsive and user-centered AR experiences.

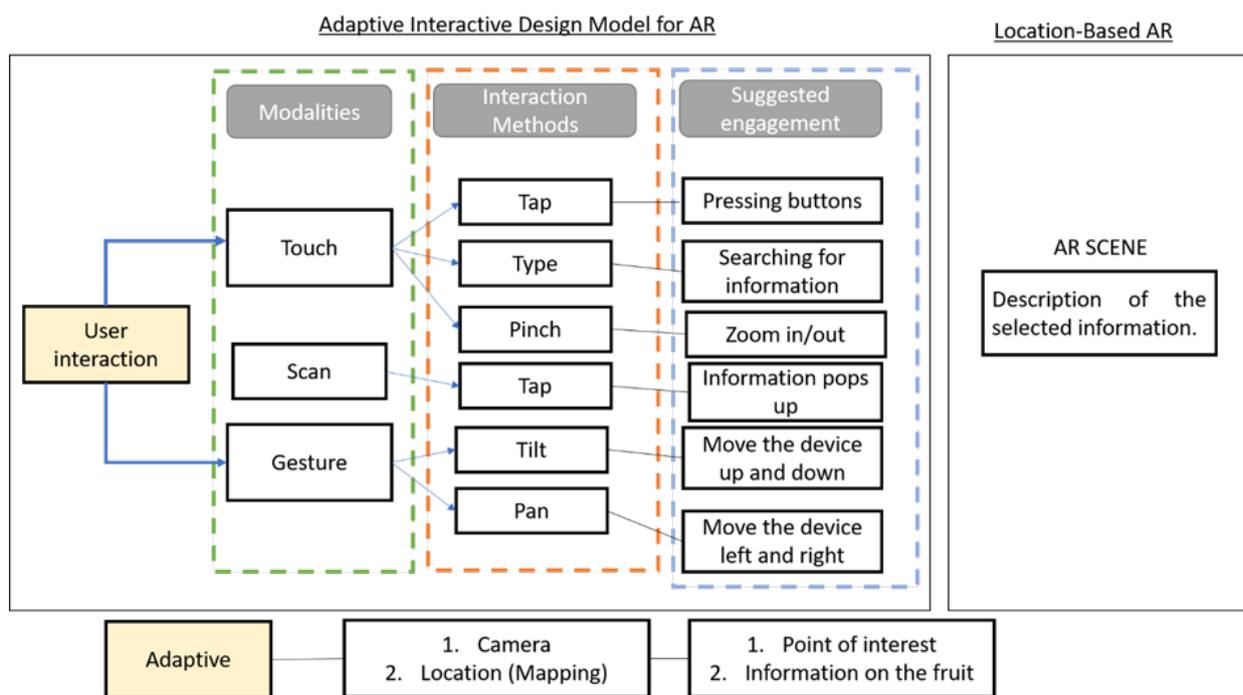
### 4.1 Model Design

The main key component of the design model is the user-centered approach where there is a user profiling to understand the user preferences, behavior and needs to create tailored AR experiences. In this component, users can incorporate with the feedback loop mechanisms that provide feedback and allowing for iterative

improvements based on user responses such as user can touch then can pinch or tap for interaction between user and the AR which includes the component of the multimodal engagement as illustrate in Fig. 6.

AR as shown in Fig. 7 is a model that caters to the dynamic and evolving nature of AR experiences, focusing on creating user-centered, adaptable, and engaging interactions within AR environments. This model is designed to accommodate the various elements that influence the design and implementation of AR experiences, aiming to deliver personalized, intuitive, and responsive interactions for users.

The next component is the adaptive content delivery where it utilizes real-time information, such as location or environmental data, to adapt content delivery within the AR environment also offering content that suits individual preferences and behaviors, ensuring a more relevant and engaging experience. The design of the AR must be agile, embracing iterative design processes to continuously refine and adapt the AR experience based on user feedback and technological advancements. This implementation gives customized experiences where the model allows for personalized AR experiences, adapting content and interactions based on individual user profiles and real-time contextual data. The iterative improvement, which is the constant feedback loops and iterative design processes enable continuous enhancements, resulting in a more refined and user-friendly AR experience.



**Fig. 6** Adaptive interactive design model for AR

The Adaptive Interactive Design Model for AR is a strategic approach to design and develop AR experiences that prioritize user engagement, adaptability, and personalization. By catering to the ever-changing needs and preferences of users within various AR environments, this model aims to deliver more compelling and user-centric AR interactions.

The fruit identification model is being transformed by the integration of AR and computational intelligence, as agriculture adopts new technologies. To provide an immersive interface for real-time fruit identification in agricultural settings, this research investigates the synergies between AR technologies and computational intelligence algorithms, which are built for robust fruit recognition. The goal of the project is to improve fruit identification methods' accuracy and efficiency while addressing issues that both researchers and farmers encounter. This research contributes to the convergence of computational intelligence and AR by developing and implementing a novel AR framework, opening the door for technologically advanced and sustainable agricultural practices. The results of this study have the potential to improve fruit identification procedures, promote well-informed decision-making, and eventually increase agricultural ecosystem productivity.

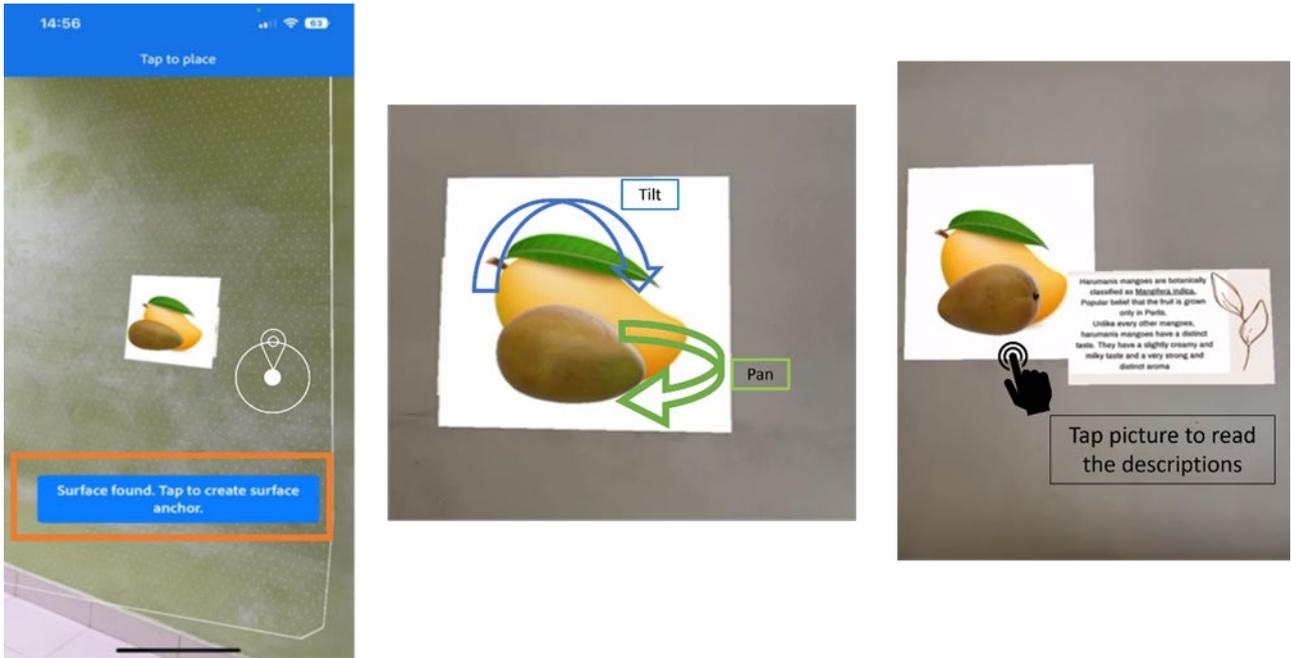


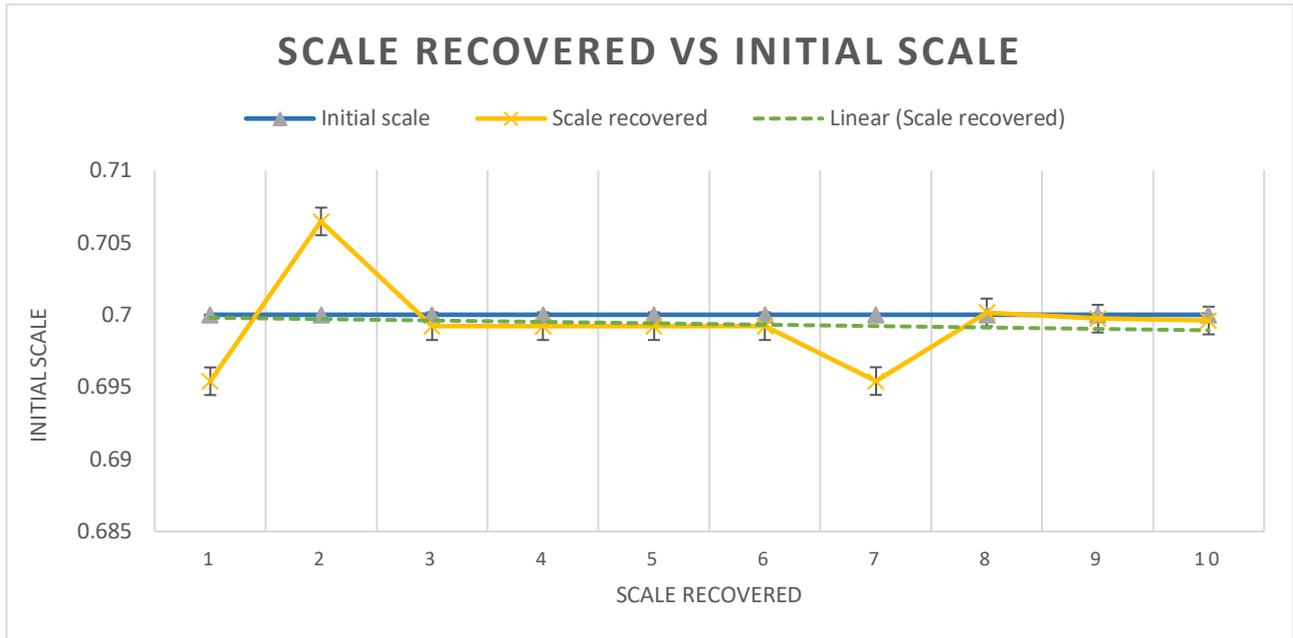
Fig. 7 Surface anchor of AR using Adobe Aero application

Table 1 Error squared value for scale recovered

Test	Initial scale	Scale recovered (E-06)	Error (E-06)	Error Squared value (E-06)
1	0.7	695400	4600	21.2
2	0.7	706500	-6460	41.7
3	0.7	699200	790	0.624
4	0.7	699200	790	0.624
5	0.7	699200	790	0.624
6	0.7	699200	790	0.624
7	0.7	695400	4590	21.1
8	0.7	700200	-160	0.0256
9	0.7	699700	270	0.0729
10	0.7	699600	400	0.16

Table 2 Summary of the values

Sum of the squared value (E-06)	Number of observations	Mean Squared Error (E-06)
86.7	10	8.67



**Fig. 8** Graph of scale recovered vs initial scale

Table 1 and Table 2, along with Fig. 8, collectively highlight the accuracy and consistency of the scale recovery process. In Table 1, each test starts with an initial scale of 0.7, and the recovered values mostly align with this target, although minor deviations are observed, particularly in tests 2 and 7. These deviations lead to higher squared error values, but overall, the squared errors remain low, as reflected in the summarized Mean Squared Error (MSE) of 8.67E-06 in Table 2. Fig. 8 visually reinforces this by showing that, aside from a few outliers, the recovered scale closely follows the initial scale of 0.7, with the linear trend line further confirming this stability. Together, these results demonstrate that the scale recovery process is reliable, with only minor variations that do not significantly affect its accuracy.

**Table 3** Error squared value for theta recovered

Test	Initial Theta	Theta recovered	Error (E-01)	Error Squared value (E-01)
1	30	30.60	0.60	3.530
2	30	30.07	0.70	0.048
3	30	30.12	1.20	0.144
4	30	30.12	1.20	0.144
5	30	30.12	1.20	0.144
6	30	30.12	1.20	0.144
7	30	30.06	0.60	0.033
8	30	30.10	1.01	0.102
9	30	30.13	1.31	0.171
10	30	30.08	0.78	0.061

**Table 4** Summary of theta recovered

Sum of the squared value (E-01)	Number of observations	Mean Squared Error (E-01)
4.52	10	0.452

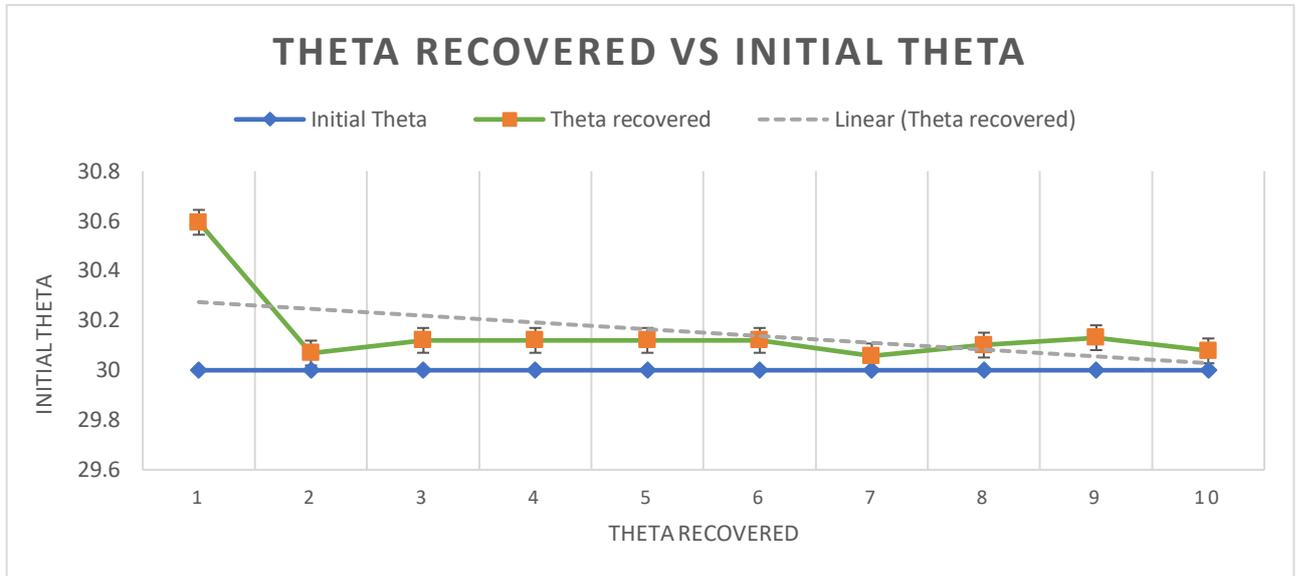
**Fig. 9** Graph of theta recovered vs initial theta

Table 3 Table 4 and Fig. 9 summarize the accuracy of recovered theta values compared to the initial theta value (set to 30) across ten tests. The first table shows the initial and recovered theta values, the error which are the difference between initial and recovered values and the squared error for each test. Most recovered theta values are close to the initial theta, with small errors. The second table provides a summary, showing a total squared error of  $4.52E-02$  across ten observations. The figure visually represents the initial theta, recovered theta values, and a linear trend line for the recovered values, showing that the recovered values consistently approximate the initial theta, with minor deviations.

The application of AR markers in tourism has resulted in noticeable outcomes. The study shows that sophisticated feature detection algorithms like SURF and FAST can effectively mitigate the distortion and recovery processes, even though they introduce certain limitations in image quality. Even with their size reduction, the recovered images show the possibility of increased accuracy through the identification of added feature points. The imperfections surrounding the edges highlight how crucial accuracy is to the transformation process. Given the circumstances, the use of AR markers in tourism offers a window into the revolutionary potential of AR, offering better travel experiences and opening the door for more developments in the intersection of technology and exploration.

## 5. Conclusion

In conclusion, this study underscores the significant impact of augmented reality (AR) development on transforming tourism experiences. Through the integration of AR, visitors can now engage with destinations in a highly interactive, immersive manner that goes beyond traditional, passive observation. By layering digital information, AR redefines the way tourists experience and understand their surroundings. This technological advancement not only adds educational depth but also enhances entertainment, making each visit more personalized and memorable. Furthermore, AR applications facilitate the creation of dynamic, story-driven narratives and gamified interactions, providing visitors with a sense of participation and exploration that traditional tourism settings may lack. As AR technology continues to evolve, it has the potential to revolutionize the tourism sector, fostering a more engaging, informative, and customized approach to exploration that caters to diverse visitor interests and needs.

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## Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

*Nadiah Muhammad Kharibi, Siti Fauziah Toha, Nur Liyana Azmi, Ahmad Syahrin Idris, Mohammad Osman Tokhi contributed to this work as follows: Nadiah Muhammad Kharibi: **Manuscript preparation, writing, drafting and submission, framework of AR and data collection, Image identification, data analysis and optimization, Image verification and data analysis, Data analysis and evaluations**; Siti Fauziah Toha: **Manuscript writing, Manuscript preparation, Manuscript drafting, checking, and submission, Dataset creation and annotation**; Nur Liyana Azmi: **Manuscript writing, Manuscript preparation, Manuscript drafting, checking, and submission, Dataset creation and annotation**; Ahmad Syahrin Idris: **Image identification, data analysis and optimization, Image verification and data analysis, Data analysis and evaluations**; Mohammad Osman Tokhi: **Image identification, data analysis and optimization, Image verification and data analysis, Data analysis and evaluations**. All authors reviewed and approved the final manuscript.*

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