

APPLICATION OF AUGMENTED REALITY IN AIRPORTS: NATURE-INSPIRED DESIGN

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Abstract: *Technological progress has gradually become an essential part of everyday life. Since the late twentieth century, it has strongly influenced the development of augmented reality and virtual reality, technologies that allow users to interact with digital elements integrated into the real environment. Through these systems, people can explore virtual spaces and engage with interactive content in new and dynamic ways. In recent years, the use of augmented reality in airports has attracted growing interest, particularly in relation to improving passenger experience and facilitating orientation within complex spaces. This paper proposes a conceptual approach for integrating augmented reality through a set of graphic symbols inspired by elements found in nature, especially flora. These visual elements are designed to animate airport spaces and create a more pleasant visual environment, while also reducing the rigid and highly anthropogenic character that often defines airport infrastructure. The proposed concept highlights how nature-inspired visual design, combined with augmented reality technologies, can contribute to a more engaging and intuitive airport environment*

Key words: technology, augmented reality, airport, graphic, symbols, vegetation, natural, areas

1. INTRODUCTION

Over the past decades, technological progress has significantly influenced the way people interact with information and with the surrounding environment. Digital technologies have gradually become part of everyday activities, shaping communication, navigation, and access to services in public spaces. Among the technologies that have attracted considerable interest in recent years are augmented reality (AR) and virtual reality (VR), which enable the integration of digital elements into the real world and allow users to interact with virtual information in a more intuitive way [1].

Augmented reality, in particular, has developed rapidly due to the increasing availability of mobile devices and wearable technologies. By superimposing digital content onto the physical environment, AR systems can provide contextual information and visual cues that enhance the user's perception of space and facilitate orientation in complex environments [2]. These capabilities have encouraged the adoption of AR in various sectors, including education, tourism, healthcare, and transportation.

Airports represent highly complex infrastructures that handle large flows of passengers and involve multiple processes such as check-in, security control, boarding, and baggage handling. For travelers, especially those unfamiliar with a particular airport, navigating these environments can sometimes be confusing or stressful. As a result, airport operators and designers have increasingly explored digital technologies that can support passenger orientation and improve the overall travel experience. Research has shown that augmented reality can provide interactive wayfinding systems and real-time information that help passengers move more efficiently through airport terminals [3]. At the same time, recent studies in environmental design suggest that the presence of natural elements in built environments can positively influence users' perception of space and contribute to reduced stress levels. Integrating nature-inspired visual elements into digital interfaces or architectural environments can create more comfortable and engaging spaces for users [4]. In highly technological environments such as airports, the introduction of nature-inspired design elements may help soften the rigid and strongly anthropogenic character that often defines these infrastructures.

Starting from these considerations, this paper explores the potential use of augmented reality in airport environments through a set of graphic symbols inspired by elements from natural settings, particularly flora. The proposed concept focuses on the creation of a visual language that can animate airport spaces, facilitate spatial orientation, and improve the interaction between passengers and the surrounding environment. By combining augmented reality technologies with nature-inspired design principles, the study aims to contribute to the development of more intuitive and human-centered airport environments.

2. DESCRIPTION OF THE PROBLEM

Airport terminals represent complex environments where a wide range of passenger, commercial and operational activities take place. These buildings are typically organized into several functional areas such as transit corridors, waiting zones, security control areas, and commercial spaces including shops, restaurants and service facilities. All these spaces must operate efficiently while simultaneously providing comfort and accessibility for a large number of passengers with different cultural backgrounds and travel needs.

In contemporary airports, passenger experience has become an important design objective, as terminals are no longer considered only transit spaces but also environments where travelers spend considerable amounts of time before departure or during connections.



Figure 1. Passenger waiting area in a typical airport terminal

As a result, issues related to spatial orientation, visual communication and environmental quality have gained increasing attention in both research and airport design practice [1]. In many cases, however, airport interiors can appear monotonous and highly standardized, which may reduce passenger engagement and contribute to stress, especially during waiting periods (Fig.1).

One of the challenges frequently observed in airport terminals concerns the orientation and information systems used for passenger guidance. Traditional signage panels (Fig. 2) often rely on standardized graphic symbols and static information boards that may not always be intuitive for all users. In addition, the limited use of multilingual information can create difficulties for international travelers, making navigation through complex airport environments more challenging [2].

In this context, digital technologies are increasingly explored as tools for improving passenger interaction with the built environment.



Figure 2. Standard airport orientation signage

Among these technologies, augmented reality (AR) has emerged as a promising solution for enhancing spatial orientation and delivering contextual information in real time. By superimposing digital elements onto the physical environment, AR systems can provide interactive visual cues that help passengers identify directions, services and points of interest within the terminal [3].

The use of augmented reality in airport environments offers several potential advantages. First, AR applications can support intuitive navigation by displaying virtual guidance elements (Fig. 3), such as directional arrows or location markers, directly within the passenger's field of view. Second, these systems can improve accessibility by enabling automatic translation of information and providing personalized guidance for users. In addition, augmented reality allows the introduction of dynamic visual content that can animate otherwise monotonous spaces and contribute to a more engaging and interactive passenger experience [4].

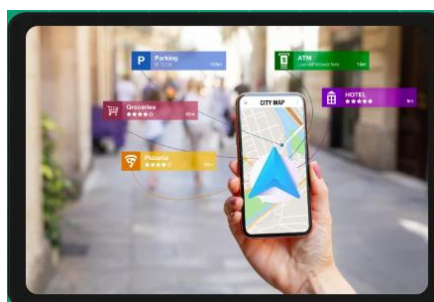


Figure 3. Augmented reality interface used for airport navigation [5]

Another important advantage of AR-based systems is their accessibility. Most augmented reality applications can be accessed through smartphones or tablets, which are

already widely used by travelers. As long as internet connectivity is available, passengers can interact with digital layers of information without the need for complex or specialized equipment. Considering these aspects, the integration of augmented reality into airport terminals represents a promising direction for improving both passenger orientation and the overall quality of the airport environment. Through the combination of digital information systems and innovative visual design concepts, AR technologies have the potential to transform airport spaces into more interactive, accessible and user-centered environments.

3. DESIGN PRINCIPLES

This study proposes the development of a system of digital graphic panels inspired by elements from natural environments in order to improve passenger orientation within airport terminals. The concept combines augmented reality technologies with nature-inspired graphic design to create a more intuitive and engaging orientation system for airport users.



Figure 4. Conceptual sketch of nature-inspired augmented reality wayfinding panels for airport terminals.

The main visual elements used in the design of the digital panels are inspired by the shapes of tree leaves. These forms function as graphic symbols associated with the different services and facilities available in the airport, such as restaurants, entertainment areas, cultural spaces or relaxation zones. The use of distinctive symbols may help passengers recognize and remember orientation panels more easily, thus facilitating navigation in complex airport

environments [6].

Another reason for using these “leaf panels” is their potential educational value. By representing different types of leaves through graphic symbols, passengers may become familiar with various plant forms and species. In this way, the orientation system can also contribute to informal learning experiences, especially for younger passengers who interact with the digital content. The textual information associated with each panel is designed as an independent digital layer that can adapt automatically depending on the language settings of the user’s mobile device. This feature allows the system to display information in multiple languages, which can significantly improve accessibility for international travelers and overcome some of the limitations of traditional static signage systems [7]. The integration of vegetal elements within the visual design is also supported by studies in environmental psychology. Research has shown that the presence of natural elements in built environments can contribute to reduced stress levels and increased psychological comfort for users. Exposure to vegetation or nature-inspired environments may induce feelings of tranquillity, relaxation and well-being, particularly in highly technological or crowded spaces such as airports [8].

Augmented reality technologies also allow the creation of dynamic visual scenes based on plant compositions. These scenes may include animated representations of plants or small animals that visually enrich airport interiors and transform waiting areas into more engaging spaces. For children, such interactive environments may have an additional educational role, as users can access informational menus that provide details about the plants or animals present in the augmented scene. This approach is particularly useful in airport terminals where architectural or operational constraints limit the possibility of introducing real vegetation. Through augmented reality, digital natural environments can be created without requiring physical modifications to the airport infrastructure. As a result, AR systems may contribute both to improved passenger orientation and to the creation of a more pleasant and human-centered airport atmosphere [9]. In the following section, a series of conceptual sketches are presented in order to illustrate the development process of the vegetal-inspired orientation panels and the design principles that guided their creation.

4. APPLICATION FIELD

The purpose of this study is to explore new possibilities for improving the quality of the passenger experience within airport environments. The research proposes the development of an original orientation concept that could be applied in various airport terminals, particularly in those where spatial or architectural constraints limit the possibility of integrating natural elements such as plants or large physical information panels.

Based on the preliminary sketches and the analysis carried out during the research process, a thematic set of information panels was developed. These panels are designed to support passenger orientation through the use of an augmented reality application created specifically for this purpose. By accessing the application on their mobile devices, passengers can interact with the visual elements and obtain guidance within the airport space in a more intuitive way.

In order to improve accessibility for international travelers, the information associated with the panels is presented in both Romanian and English. This bilingual approach facilitates understanding and makes the system usable for a wider category of passengers.

Another distinctive aspect of the proposed concept is the use of various leaf-inspired

graphic designs. Different types of leaves were used in the creation of the panels, providing visual diversity and helping passengers identify and remember the symbols more easily. At the same time, these vegetal elements reinforce the nature-inspired character of the concept and contribute to a more pleasant visual atmosphere within the airport environment.

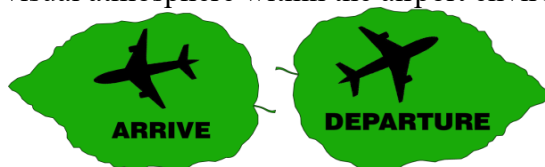


Figure 5. Common beech leaf used as a visual reference for the nature-inspired signage concept



Figure 6. Graphic representation of airport services using leaf-inspired design elements.



Figure 7. Graphic symbols for airport navigation integrated into leaf-shaped design panels.

The figures illustrate several examples of the proposed nature-inspired orientation concept developed for airport environments. By using elements derived from natural forms, such as branches and leaves, the visual system aims to create a more intuitive and recognizable method of communication for passengers. These graphic elements are designed to represent different airport functions and directions, while maintaining a coherent visual identity based on natural structures. Figures 8 present a selection of conceptual sketches that demonstrate how these elements can be integrated into orientation panels intended for use within airport terminals.



Figure 8. Visual representation of connecting flights using nature-inspired graphic elements.



Figure 9. Directional guidance represented through Japanese maple leaf symbols.

To illustrate the direction of movement (Figure 9), the design incorporates the shape of Japanese maple leaves. Their form resembles natural traces, which fits well within the concept proposed in this study. The leaves are displayed in two colours, red and green, in order to make the directional elements easier to distinguish.

An additional information panel (Figure 10) is proposed for placement at the airport entrance to notify passengers about the augmented reality application.



Figure 10. Airport entrance information panel presenting the augmented reality application.

After completing the database of basic orientation panel models, the next step was to develop the spatial context in which these elements could be integrated. For this purpose, a 3D model of an airport available online was used as a starting point [10]. The model was adapted and further improved conceptually using SketchUp and Lumion. In order to create a more realistic environment, several contemporary furniture elements were also introduced, such as seating areas and planters.

Once the digital information panels and the two proposed visual scenes were completed, they were integrated into the 3D environment (Figure 11). This step allowed us to obtain an overall view of how the proposed orientation system would function within the airport space and how the different elements interact within the designed environment.



Figure 11. Orientation scene base.



Figure 12. View through the augmented reality application.

The nature-inspired design integrates harmoniously within the otherwise monotonous and rigid spatial configuration of the airport waiting area. The proposed scene, enriched with vegetal elements and small animals, contributes to the creation of a more pleasant and engaging environment for passengers, while also offering potential educational and recreational value during waiting periods.

The vegetal composition has been carefully structured to evoke characteristics of natural landscapes, with the aim of mitigating the perception of architectural rigidity and emphasizing the relationship between humans and natural environments.

The two visual scenarios presented were developed to illustrate the proposed concept and to demonstrate the potential of augmented reality technologies as tools for enhancing spatial orientation and improving the overall passenger experience within airport environments.

5. CONCLUSION

This study explored the potential of integrating augmented reality technologies with nature-inspired visual design in order to improve orientation systems within airport

environments. The proposed concept demonstrates how natural forms, particularly leaf structures and vegetal compositions, can be used as graphic elements to create a more intuitive and visually distinctive guidance system for passengers.

The development of a set of conceptual orientation panels and their integration into a simulated airport environment highlighted the possibility of enhancing spatial communication through augmented reality applications. By overlaying digital information onto the physical environment, passengers can interact with visual guidance elements in a more dynamic and accessible manner, which may facilitate navigation in complex airport terminals.

Another important aspect of the proposed concept is the incorporation of natural elements into the design of airport spaces. Vegetal forms and landscape-inspired scenes may contribute to reducing the perception of rigidity typically associated with airport interiors, while also creating a more pleasant and engaging atmosphere for travelers. In addition, the introduction of interactive natural elements through augmented reality may offer educational and recreational value, particularly for younger passengers.

The visual simulations developed during this research illustrate the potential applicability of the concept in airport waiting areas and circulation spaces. Although the project remains at a conceptual stage, the results suggest that augmented reality combined with nature-inspired design could represent a promising direction for improving passenger orientation and overall airport experience.

Future research could focus on the practical implementation of such systems, including user testing, technological integration, and the evaluation of passenger interaction with augmented reality-based navigation tools.

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