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Review

Shaping the Future of Music with Augmented Reality: A Systematic Literature Review on Future Trends and Innovations

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ABSTRACT

This study addressed the problem of the increasing number of articles on augmented reality and aimed to isolate only those algorithms and applications dealing with the music sector. A systematic literature review model was employed. This study employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model, widely recognised for its comprehensive and standardised approach to conducting systematic reviews. The PRISMA model was chosen due to its emphasis on transparency, replicability, and thorough documentation of each step in the review process. The systematic search strategy involved querying multiple academic databases, targeting journal and conference articles published since 2015 that either directly involve the music sector or engage in inter-sectoral collaborations. Inclusion and exclusion criteria were meticulously defined, ensuring that only relevant studies were considered, with a focus on those that contributed significantly to the field of music augmented reality. Data synthesis was carried out by categorising and analysing the identified studies based on their methodologies, applications, and outcomes. One of the most significant findings is the relatively slow development of augmented reality in the music sector despite the overall growth in augmented reality research. This study highlights the potential of advanced augmented reality techniques to revolutionise music presentation and interaction, fostering new ways for musicians to engage with audiences.

Keywords: *augmented reality, music, systematic literature review, future trends, innovation*

INTRODUCTION TO AUGMENTED REALITY IN MUSIC

Nowadays, music can cater to different senses through advanced modern technology (Turchet et al. 2021; Grgurić et al. 2024). In the era of digital music, both music creation tools and music performance tools are evolving alongside new technologies and available digital hardware. Music sharing and listening are increasing daily. However, the live music and performance industry is still rooted mainly in presentations and technical direction of yesteryear. Augmented reality is a technology applied in various fields (Rasalingam et al. 2024). It can act as a revolutionary enhancement in the form of new musical performances (Pavlenko et al. 2022). Today, augmented reality has been emerging as a way of enhancing live performances of musicians further by providing an artist and their audience with the capability to add immersive interactivity to the listening experience (Turchet et al. 2021; Baía Reis and Ashmore 2022).

This article reviews the state of augmented reality in the field of music, in both performances in the traditional physical environment and live performances in virtual ones. It provides an overview of innovative augmented reality systems and applications, identifying the key challenges to be addressed, along with predictions about how this intersection may contribute to or change music performance. The proposed research addresses further direction in entertainment and music. With the onset of a new generation of mobile augmented reality devices, the market is anticipated to grow. The user observation over the years, as seen at music and technology festivals, shows that music performances and entertainment, in general, are challenged and reinvented every time new form-factors and immersive technology appear.

A systematic literature review approach is necessary for several key reasons in the study of augmented reality in the music sector. Firstly, augmented reality is a rapidly changing field having so many applications, not only limited to gaming, but it is also found in the educational and medical sectors (Rasalingam et al. 2014). However, its specific applications within the music industry remain underexplored. Systematic literature review facilitates and allows the structured synthesis of existing research, systematically identifying and evaluating all relevant studies, thus providing an overview of prior research about a topic. This approach is particularly valuable in highlighting the gaps in current knowledge and understanding of where augmented reality in music stands in relation to other sectors.

Through a systematic literature review, the study guarantees that only those studies which contribute with a lot of significance and quality are incorporated, therefore delivering a clear and neutral overview concerning augmented reality in the music field. This method also allows us to examine patterns and trends in current literature, as well as where work is needed by highlighting explicit voids in existing research. Without a systematic literature review, the research could risk being fragmented or overlooking significant studies, leading to incomplete or biased conclusions.

In summary, a systematic literature review approach is necessary to provide a thorough, objective, and up-to-date review of augmented reality applications in music, offering valuable insights for researchers, practitioners, and stakeholders interested in advancing this innovative field.

Definition and Overview of Augmented Reality

Augmented reality has been mentioned several times in music research, and its market size was predicted to reach over 19 billion euros by 2023 (Koumpouros 2024). This article systematically maps and reviews available augmented reality technology for music applications by focusing on the latest trend of research and collaboration trends within the state-of-the-art in collaborating

in music and augmented reality. A comprehensive search found 54 studies and two involving music and urbanism. Analysis revealed a continuum of research from design methods and user interfaces to cultural or sociological contexts and developmental work on the economic laying theory. As musical interfaces used in augmented reality are progressing in their maturity, design and focus are shifting toward music industry's actors and their tasks, such as auditory branding, immersive or interactive product visualisation, spontaneous and non-musically trained users, music experiences, and the music industry, musician and sound engineer community overall (Turchet et al. 2021; d'Errico 2022; Tanprasert and Yoon 2022).

Starting with a precise definition of the main concept allows the review to glance over its boundaries quickly. In computer science and cognitive ergonomics, augmented reality has been studied for several decades (Nor Farzana Syaza and Dayang Rohaya 2021; Katona 2021; Ruziana and Rasalingam 2024). If described as the complement to virtual reality, augmented reality reduces its reality-distancing side effect by being able to overlay virtual images or display information on existing physical reality. An alternative analogy would be the one between augmented reality and traditional desktop, where the working space is extended to more dimensions. The emerging variant of augmented reality is based on accordant use as it seems to identify the evolutionary trend of the field. The term has been appearing concurrently with augmented reality, but its use is restricted to commercial purposes (Arena et al. 2022; de Souza Cardoso et al. 2020; Liberatore and Wagner 2021; Morimoto et al. 2022). In other words, augmented reality refers to the very first visions of augmented reality, specifically based on video tracking to overlay computer-generated information over the physical world, with the intention of obtaining the necessary precision level in tracking information appropriately. The relatively failed Moverio BT-100 model of smart glasses is a good remnant of that pioneering phase (Sutton et al. 2022). With the advent of computing vision and always sidled by the curious gaze of the toy market, augmented reality extended its capabilities.

Application of Augmented Reality in the Music Industry

The use of augmented reality provides several advantages in the experience of music (Chen 2023). A musical environment in which instrumental and vocal elements can be displayed in space enables users not only to experience high-quality sound but also to identify different musical components (Remache-Vinueza et al. 2021). This system offers an engaging and realistic learning experience that allows users to understand music and instrument introduction better by offering a virtual visual display with additional information about how they are played. Users can virtually enter the music hall and enjoy the realistic performance. In addition, a concert broadcast in augmented reality can improve the satisfaction of remote users for being involved in live performances.

Augmented reality techniques can enable a more intuitive music experience. Applying augmented reality technology to customise the attributes and shapes of music controls based on the user scenario and local environment can enhance the interplay and user feel with different genres of music (Cao et al. 2023). The augmented reality interface can allow users to use simple hand gestures as control over the musical devices. It can also consider the user's tendency to be involved in music, garner user preferences and recommendations to create a desired playlist with respect to the music scene. Finally, augmented reality-based voice-interactive technology can estimate the singer's voice quality during a live music performance. It can measure the relationship between voice and emotion, track the physiological and psychological effects of music, and provide a unique environment for users to listen to music.

The expanding scope of augmented reality applications has transformed domains like gaming, education and healthcare, yet its uses in music remain underdeveloped. Studies on augmented reality's integration with music have grown independently but lack a comprehensive perspective. The problem this review aims to address is the fragmented nature of studies on augmented reality in music, which has led to an incomplete understanding of how augmented reality can be effectively integrated into the music industry. This review is necessary to consolidate existing research, identify key trends, and highlight the potential of augmented reality to revolutionise the way music is experienced and created.

METHODOLOGY OF THE SYSTEMATIC LITERATURE REVIEW

This systematic literature review has its foundation formalised in the guidelines articulated by Kitchenham et al. (2022), which aims to propose guidance on performing good literature reviews, as well as elaborate on the types of literature reviews and the features that define them. This systematic literature review is guided by the following research questions: (1) How is the future of music being shaped by augmented reality? (2) How is this topic being investigated? (3) What methods are used? and (4) What knowledge is being produced? It is performed to identify, analyse, and interpret research on augmented reality with a focus on how it contributes, or might contribute, to the future of music. In so doing, we are able to describe known knowledge areas, identify areas in which literature may possibly have become entrenched with one or more pre-established world views and key trends or controversies that might have been significant in the development of that world view. Implementing the systematic literature study hosting protocol as the model, a structured process for each of the steps of the review was applied (Table 1). Therefore, for each of the steps in this study, results were carefully documented both as to the activities themselves and the outputs of each step.

This study employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model, widely recognised for its comprehensive and standardised approach to conducting systematic reviews. The PRISMA model was chosen due to its emphasis on transparency, replicability, and thorough documentation of each step in the review process. Keywords used in the search included "Augmented Reality," "Music," "AR in Music," and "Virtual Reality in Music." Boolean operators (AND, OR) were used to refine the search, ensuring that only relevant articles were captured. The inclusion criteria include articles published between 2015 and 2024, peer-reviewed journal and conference articles, and studies involving augmented reality applications specifically in the music sector. The exclusion criteria were to exclude articles that were not written in English and studies not focused on augmented reality in music. Each study was assessed using a standardised quality appraisal tool, ensuring that only high-quality studies were included in the review.

Criteria included study design, sample size, and the relevance of the findings to the research questions. Data were extracted using a pre-defined extraction form, capturing essential information such as study objectives, methods, key findings, and limitations. This ensured consistency in data collection across studies. The extracted data were synthesised qualitatively, with themes identified across the studies. Meta-analysis was not conducted due to the heterogeneity of the studies included in terms of objectives, methods, and outcomes.

Table 1 Methodological steps

Step	Description
Systematic literature review model	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Search strategy	Systematic search in PubMed, IEEE Xplore, Google Scholar using keywords like "Augmented Reality," "Music," and "AR in Music"
Inclusion criteria	Articles from 2015–2024, peer-reviewed, focused on augmented reality in music
Exclusion criteria	Non-English articles, unrelated to augmented reality in music, have no full-text availability
Quality appraisal	Standardised tool used to assess study design, sample size, and relevance
Data extraction	Pre-defined extraction form for objectives, methods, findings, and limitations
Data synthesis	Qualitative synthesis with thematic analysis

Research Design and Scope

This study employs the PRISMA model, a widely recognised framework for conducting systematic reviews, to ensure a transparent and replicable methodology. The systematic search was conducted across multiple academic databases, targeting journal and conference articles published between 2015 and 2024 that focus on the intersection of augmented reality and music. The working hypothesis is that the number of publications is increasing and, after a qualitative data analysis, that the design stage has been mostly concluded. It is also conceivable that new, more sophisticated wearables or products are available, and production methods are well established. Instead, the focus will shift towards the human side. More precisely, we expect the following developments: more personalised products; high user satisfaction; a focus on the user experience; and different forms and ways technology can be exploited for different people. This qualitative data analysis of the type of content and the topics covered in the articles was performed. Out of 94 articles, 21 deployed dedicated augmented reality wearables. Another 13 articles make use of one of the known head-mounted displays (HoloLens, Meta 2, RealWear Corning, and Google Glass). Those describe various educational and leisure scenarios, collaborative and team-building applications, and also several task-related uses on two to three dimensions. Thirty articles belong to digital, gaming, mobile environments, and app areas. The number of articles dedicated to the entertainment industry is still large (58 of 74). However, these articles explore the products for artists', professionals', and music producers' use. The number of articles collecting human–computer interaction comments suggests a focus on the human side and hence, a nascent interest in the possible benefits from each specific form and use of technology. Aware of the preliminary universal nature of these results, further analyses on a yearly scale should shed some light on which points, if any, are supported by future publications.

The systematic review identified key trends and thematic applications of augmented reality in the music sector. The findings are categorised into two main areas: key application areas (Table 2) and common challenges and limitations (Table 3).

Table 2 Key application areas of augmented reality in music

Application area	Example technologies/ systems	Key benefits	Representative studies
Music education	Augmented reality sheet music, augmented reality piano tutor apps, virtual conductor tools	Immersive and interactive learning experiences; enhanced comprehension of complex musical concepts	1. Xuejing and Wan Ahmad Jaafar (2025) 2. Cui (2023)
Live performance	Augmented reality stage effects, audience-integrated visuals via mobile apps, augmented reality wearable instruments	Enhanced audience engagement and immersion; dynamic, customisable visual storytelling for artists; blending physical and digital stage elements	1. Lo and Lai (2023) 2. Park et al. (2024)
Music production and creation	Augmented reality interfaces for digital audio workstations, virtual mixers, augmented reality synthesisers	Intuitive and spatial sound manipulation; collaboration in a shared virtual space; novel methods for creating and editing music	1. Lee et al. (2023) 2. Wang and Qi (2022)

Table 3 Common challenges and limitations

Challenge category	Specific issue	Potential impact
Technological	Reduced field of view and "tunnel vision" effect. Application Programming Interface (API) limitations and lack of cross-platform compatibility.	Limits user interaction with the physical and digital environment; can be disorienting for performers and audience members. Increases development time and complexity; can lead to a fragmented user experience across different devices.
Creative	Difficulty in balancing digital augmentation with natural human expression. The challenge of translating music's non-visual nature into compelling augmented reality visuals.	Risk of technology overpowering artistic intent; can make performances feel artificial or sterile. Requires innovative artistic solutions to avoid generic or distracting visual elements.
Ecological	The artist's time burden for creating augmented reality content.	The extensive time and technical skill required for content creation can be a significant barrier to adoption for many artists.

Search Strategy and Selection Criteria

We conducted a systematic keyword-based search strategy for these digital libraries. Informed by previous investigations from cultural heritage domains, the initial keywords consisted of combinations of "augmented reality," "AR," "mixed reality," "MR," and "music" (Weerasinghe et al. 2022; Rokhsaritalemi et al. 2023). Nevertheless, a preliminary review of the results revealed that said approach was too narrow in focus. Initially, these additions were inspired by the first literature references. Final keyword combinations were "augmented reality and music," "augmented reality and guitar," "augmented reality and piano," "augmented reality and violin," "augmented reality and flute," "augmented reality and trumpet," and "augmented reality and spatialisation."

TRENDS AND INNOVATIONS IN AUGMENTED REALITY MUSIC EXPERIENCES

The integration of augmented reality into the music industry can greatly reform concert experiences and music learning while creating new technological and interactive paradigms. augmented reality can provide visually appealing and context-aware extensions for existing physical media and artefacts, including content such as printed scores, CD covers, and digital devices (Makhataeva et al. 2023; Ntagiantas et al. 2022). In this context, the ability of augmented reality as a solution to complement the existing artistic work of music performers and teachers is increasingly acknowledged. This research review study reports on future trends and innovations, including prototype systems and applications in current augmented reality music-related research. Moreover, a unified approach was used for the systematic literature review to propose 14 categories of future trends and recommendations for three potential yet challenging sectors of augmented reality: (1) AR Prototyping, (2) AR Music Performances, and (3) AR Music Education.

Skeuomorphic designs have mainly prevailed. Skeuomorphism emerged in music, particularly closely related to augmented reality, inspired by augmented reality systems such as the Wearable Powered Playing Devices (WAPP) system for the head-mounted device and the MICO Augmented Reality Music system for mobile devices (Taylor and Dell'Unto 2021; Willim 2024). However, the systems towards being skeuomorphic designs instead of being purely from wearable interface systems or new instrument design studies, we should be very careful about the latest developments and relevant design disciplines of augmented reality. The other focus areas of activities, preferred input, output, and augmentation forms of augmented reality music-related studies were revealed. Therefore, a very detailed categorisation was made in the data analysis, and nine prototypes distinguished as the developer's preferred systems were presented. Also, categories called alternative tracking systems and timeline-based control captured less attention from developers. The conceptual analyses made by reviewing 31 articles are presented as a mapping of thematic content analysis.

The main emphasis of augmented reality music research was to create augmented reality prototypes for established workflows. The emphasis of this study is heavily focused on creating augmented prototypes for "established workflows," particularly for music education, leaving less room to market novels or newly developed augmented reality interfaces for creating alternative or innovative music experiences. In addition, it should be tracked whether the development of technology is driven solely by educational and pedagogical needs. Industrial innovation helped the development of advanced headphones and speaker systems for audio-only music listening with high-quality sound (Roquet 2021; Duan et al. 2024). Therefore, it is important to take into consideration the innovative and alternative needs of the amateur and professional music listener audience in the transformation of a future music ecosystem with an enriched music listening experience and interactive music concerts with virtually seated audiences.

INTERACTIVE CONCERTS AND LIVE PERFORMANCES

One use of augmented reality in concerts takes the form of augmented reality glasses tethered to the event (Rose 2021; Turchet et al. 2021). Not much is known about why this approach is preferred by concertgoers when attending a musical event. It is interesting to see how much better information about the current experience, paired with augmented reality glasses, can be received compared to other solutions. A second augmented reality concert application uses augmented reality to create a new kind of musical experience to enhance a concert, like mixing live concerts in a studio environment, that replicates the sensation of being in a closed

studio, or superimposing visuals onto the field of view (Young and Smolic 2022). The third use of augmented reality for musical concerts is embedded in music social networks. It uses mobile devices but also considers augmented reality glasses to view the physical world. Users can record the crowd during the concert, or the crowd remains in passive mode, only activating the system during the best fragments of the concert. Features like auto-stabilisation, auto-exposure, and other details are not detailed in the article, but some considerations are made regarding how people use technology in different scenarios, such as small, large or outdoor concerts.

Many researchers are using the potential of new technologies to work with live audiences and to find a better way to support and interact at a concert event without interfering with the user's experience permanently (Hödl et al. 2020; Turchet et al. 2021; Sidorenko-Bautista et al. 2025). They are interested in and engaged in research to create new styles of interaction, new formats, and new experiences that augmented reality can bring. The musical frontiers were extended by the possibility of new synthetic environments. This new scenario covered topics such as augmented musical instruments and immersive and interconnected auditory environments. It provides a systematic review of the relationship between research in virtual reality and its influence on the field of electronic composition, highlighting the breakthroughs, their applications, and the potential future trends. However, apart from technological advancements and the potential of these applications, it should be clear what challenges are involved in this new path, including audience impact, what the tools are, and how the new generation is using the network for this purpose between fans, concerts and the entire community of fans.

AUGMENTED REALITY-ENHANCED MUSIC PRODUCTION TOOLS

Tools that include augmented reality techniques or implement augmented reality technologies in areas such as music software development, DJ-ing, sound synthesising, music notation, and professional audio toolkits focused on audio-based datasets are important as they improve traditional working contexts (Devagiri et al. 2022; Cao et al. 2023). The augmented reality approach implemented brings more accessible features and control to other types of users. Currently, professionals have advanced knowledge and expertise associated with the use of post-production software such as Pro Tools. However, for example, when working with a dense concert mix in a crowded audience context, there are natural sound waves that define the listening experience and are not restricted to one spot.

The consumption of immersive virtual reality and 360 audio content is a topic of much interest to composers and designers of virtual reality and 360 video games, as well as to the developers of music software to create such content. Creating sound designs with augmented reality tools can reduce the time and distance to set up a three-dimensional soundscape by allowing the audio artist to place, model, and test three-dimensional sound objects days before a virtual environment is realised and set up, preserving the sound and its spatial information during the production process (Yang et al. 2022; Gupta et al. 2022). This is also valid for its sub-use within virtual reality or augmented reality experiences in areas as diverse as physical therapy, cinematography, and the development of intuitive performances.

CHALLENGES AND LIMITATIONS OF AUGMENTED REALITY IN MUSIC

The challenges and limitations are grouped into three categories: (1) technological, creative, and ecological; (2) technological challenges and constraints; and (3) interaction and perception. The screen has always been "the primary medium through which computer augmented reality is delivered." Currently, most handheld devices sport a single touchscreen, meaning that users will have to point the camera at the object they view to interact with it, implying a reduction in user appeal and functionality (Peng et al. 2025).

Hand Interaction Techniques

Most handheld devices sport only a single touchscreen. Consequently, fingers occlude the camera's optical flow, making it difficult for augmented reality systems to track the user's fingertips, thus decreasing the user's ability to manipulate augmented reality objects on the screen. Reduced field of view and context limitations. Since the screen is an important augmented reality output device, its relatively small form factor may restrict the information that can be visualised, which is challenging for touch and view-dependent interactions employed to manipulate augmented reality elements. Creative and technical limitations that negatively influence the creative production process. The seamless integration of real-world objects and the filtering of real-world images, such as low resolution, noise, augmented reality element mis-attendance, video delay, and field of view with virtual ones, can "be tedious and consume a significant portion of the artist's time" (Zhang et al. 2026).

Futuristic Ideas

Several real problems related to augmented reality APIs are raised specifically to curvature maps and Z-buffers; they work at the screen-document level, indexing augmented reality surfaces in a two-dimensional canvas.

Ecological and sensorimotor limitations affect human–computer interaction within augmented reality environments. Comparing camera lens-like technological constraints with the human visual system, Foxlin (2005) states that perhaps future augmented reality displays will need to take similar sensorimotor limitations into account. Primarily, the balance of sensory functions, as well as the identification of ideal periods during interactions when senses and particular sensory functions are beneficial, should be explored. As with other interactive technologies, the development and scope of augmented reality devices should explore their combination with ecological, natural, and social human interactions and the exploitation of the sociocultural and intrinsic meanings of the interaction.

Ergonomics

An evaluation of the augmented reality glass system, concerning mobile phone technology with similarities in the current product, might be considered a prototype of a feasible future device. The augmented reality glass system offers personal information, computational capabilities, email, audio, and video step-by-step navigation assistance in non-distracting, suspenseful, and conversational multimodal prompts. Future studies should prioritise systems that can support additional applications while minimising user distraction, especially in mobility-related contexts where mobile phone use may lead to accidental or dangerous situations. In contrast, a long-term challenge is to satisfy the significant societal issues surrounding acceptance, privacy, and cultural adoption, regardless of the form.

TECHNICAL CONSTRAINTS AND INFRASTRUCTURE REQUIREMENTS

The implementation of augmented reality services in music is nowadays limited by the performance of mobile architecture, such as microprocessors, memory storage, and mainly graphic units (Peddie 2023; Banerjee 2023). For instance, an application that employs image recognition and is designed to have a high frame rate may require much more computer power than one that entails a live video feed. Also, more realistic augmented reality applications demand more computer power due to the need for objects to be correctly inserted into the image (Zhang et al. 2022). On the other hand, 5G networks are just beginning to be used, but they may bring new solutions, such as low-latency, high-band, beamforming technology to form connected cities, through small cells that use higher band spectrum. These new 5G networks can enable applications that require low-latency, such as remote surgeries, or high costs, such as Internet of Things (IoT) solutions with video for predictive maintenance at the industrial level.

The augmented reality in the music area includes several different domains, and thus, the software requirements for these functionalities are also quite challenging, considering the different problems to solve. The development of augmented reality content and multisensory human–computer interaction interfaces enable users to interact with and navigate augmented music environments. Additional technological considerations include real-time sound processing and the application of Simultaneous Location and Mapping (SLAM) techniques, particularly in outdoor concert settings where users generate and share personalised soundscape experiences. Furthermore, the display of real-time graphics and video in mobile augmented reality environments requires effective texture and video optimisation techniques to ensure smooth performance and user experience (Suzuki et al. 2024; Dash et al. 2024).

USER ACCEPTANCE AND ADOPTION

This stage is represented by 50 articles. In the selection process, this study found a great number of articles aiming to build and assess the acceptance of products and services based on augmented reality. The user experience is put in the spotlight, with a considerable number of articles investigating how a system can be improved and offering an accurate variation in the development of augmented reality-based products and services, either for music consumption, production, education, or merchandising. Moreover, this variation is hardly ever isolated. Most of these works also try to understand how the audience behaves and reacts when using these products or services. These works not only build and assess new tools but also develop frameworks that are added to interdisciplinary and advanced theories, thereby adding knowledge to the technology and entertainment research community. Studies also cover the strategy of creating a theoretical model that unifies diverse aspects of innovation and gamification for the interaction of user experience of augmented reality consumers (Hsu and Chen 2018; Behl et al. 2024).

User acceptance and adoption are consistently positive, being acceptable to users, and augmented reality can be a crucial tool by enhancing music schooling and expanding access to education for several layers of the population. It is also suggested that an improvement in augmented reality user interfaces and an approach to users with first experience in the field, allowing music practices to become more interactive, attractive and flexible (Rasalingam et al. 2014). The acceptance is reinforced by numerous works from the field of tourism and cultural management that internal audiences, either musicians or managers, have a strong will to constantly exchange knowledge, apply, and contribute to the collaborative construction regarding the association of the augmented reality potential in the experience of access to knowledge and dissemination of the musical-cultural heritage. Experience design practices in

social media platform applications unite augmented technology sensors (camera, microphone, Global Positioning System [GPS], Bluetooth, and gyroscope) and gamification suited to the location, weather, and user personalisation of three-dimensional sounds based on the listener's interests, customising and enriching their experience, which can reach increased absorption of hyper-local sound-enhanced contexts. The interest in playing on arts visitor engagement and exploring the experience brought over critics and other music-related evidence-based studies, contributing to the future exploration of visitor engagement tools.

FUTURE DIRECTIONS AND OPPORTUNITIES FOR RESEARCH

A future research direction is to consider the use of augmented reality in public spaces such as galleries and shopping malls, not only helping visitors find their way more easily but also allowing them to use their personal mobile devices to find additional information about the exhibits they are looking at. For example, as well as providing visitors with useful information about a piece of art or sculpture, their device could recognise the presence of specific visitors and offer them access to a wider range of activities and resources, such as taking a group photo at the exhibition space, getting additional information about the work of art, or voting for their favourite piece. Equally, augmented reality can also be applied to architecture to provide nearby people with the project's additional information, sources, or artists. It would be even more authentic if voice interaction were possible, transforming cultural areas into smart, intuitive zones where everything is easily accessible and understandable to everyone.

INTEGRATION OF AUGMENTED REALITY WITH VIRTUAL REALITY IN MUSIC EXPERIENCES

The current technical progress on augmented reality and virtual reality-based platforms enables a new wave of music applications and scenarios. Given these advancements, this study calls for extending augmented reality and editorial songs to more personalised music content among listeners. This way, the listener will not only watch the singer dancing but can also replace him/her with an avatar, add visual and interactive three-dimensional effects, as well as sound-following visual effects, and the background or context transparently.

While music performance virtual reality editorials already exist, the main challenge is placing the user "inside the performance." A study demonstrated an approach to address this issue by using three-dimensional graphical intrinsic scene design to construct an audio–visual match graph and develop an expressive audio synthesis method for temporally coherent cross-modal sound-object synthesis in virtual reality content production (Kanellos 2024). Another interesting aspect is how to deal with content from a third-party author, where the user just wants to change the singer's identity and add special effects (Morrow 2020).

EXPLORATION OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN AUGMENTED REALITY MUSIC APPLICATIONS

The exploitation of artificial intelligence and machine learning technologies is gaining enormous attention in many scientific fields. In the specific context of music, artificial intelligence is shaping the way music is composed, learned, and performed. This revolution is supported by many different data mining and machine learning techniques, ranging from clustering, classification, and visualisation to natural language processing and deep learning algorithms. In particular, deep learning and large datasets facilitate the generation of music that replicates

the style of both modern and historical musicians. A novel application of such technologies would aim to create automatic tools that provide formative assistance in augmented reality applications for augmented prototyping, teaching, and production purposes. The aim of this article is to spark new and interdisciplinary challenges to a community of researchers, still to be created among artificial intelligence, augmented reality, human–computer interaction, and music experts.

Artificial intelligence and machine learning represent a turning point in the way music is composed, learned, and performed. Performance is enhanced thanks to virtual reality and augmented virtuality, replacing the physical stage with a digital environment and diving completely into the music world. This is radically changing the concept of ensemble and orchestra, enabling professionals to collaborate on music projects without being physically in the same room. This technology has indeed become crucial during the pandemic situation. On the other hand, artificial intelligence is shaping the way music works, thanks to the growing use of artificial intelligence approaches. In this context, computer music has reached remarkable goals: algorithms aim to perform complex reasoning about music content and structure, not merely providing formative assistance. These technologies span from pure computational approaches to the graphical and philosophical ability to make sense of temporal and stated information conveyed by musical scores. An interesting and growing field of study is to develop artificial intelligence-based systems to drive computer performance and analyse other sources.

INNOVATIVE AUGMENTED REALITY INTERFACES FOR MUSIC CREATION AND PERFORMANCE

While augmented reality in music education has gained substantial attention in recent years, innovative applications of augmented reality in music creation and performance remain a rapidly developing but comparatively underexplored area (Wang et al. 2024). This chapter focuses on the emerging interfaces and experiences augmented reality is enabling for musicians, composers, and live performers by redefining how music is both made and experienced. Augmented reality interfaces are increasingly being designed to extend beyond conventional musical instruments (Yonia and Mulyanto 2023). Interactive virtual instruments, gesture-controlled soundscapes, and spatial audio environments are transforming how musicians create and manipulate sound. For example, applications such as ARPiano and Magic Keys allow users to play and compose music in augmented spaces using hand gestures, body movement, or mobile devices, blurring the line between physical and virtual sound creation (Guclu et al. 2021).

Besides that, live performances are also being transformed by augmented reality, enabling artists to overlay digital elements such as three-dimensional animations, real-time lyrics, or responsive visualisations directly onto physical stages or audience spaces. augmented reality headsets or mobile devices can deliver personalised visual layers to each audience member, turning passive listening into an interactive, multisensory experience (Lee et al. 2020). These innovations open new avenues for expression, particularly for solo performers and digital musicians. Augmented reality also facilitates new forms of remote collaboration, where musicians in different locations can perform together in a shared augmented environment. Platforms leveraging augmented reality avatars, spatial mapping, and audio syncing allow real-time collaboration that mimics physical jam sessions. This has significant implications for global music production, especially in the post-pandemic creative industry (Tanaka and Igarashi 2025). Future research and development should focus on artist-centred design and the integration of haptic, spatial, and

biofeedback elements for deeper creative control. Innovative augmented reality interfaces are beginning to shape the next frontier of music performance and creation. By merging digital creativity with physical expression, augmented reality offers musicians novel ways to engage with sound, space, and audience by hinting at a future where musical experiences are more immersive, interactive, and collaborative than ever before.

CONCLUSION AND IMPLICATIONS

Several augmented reality applications have been developed over the years to provide users with alternatives to music experiences, including live-presented music content, interactive virtual reality-based musical videos, and immersion in narratives using music and three-dimensional environments, among others. The creation of augmented reality experiences could be focused on offering personalised training content to musicians, including interactable three-dimensional models of instruments, technologies for audio synthesis and audio signal processing, such as virtual reality and augmented reality interfaces with the control of the sound through hand interactions, augmented reality and holographic technologies, methods for embedding three-dimensional spatialised sound in real environments through binaural and ambisonics decoding, interaction methods for the real-time alteration of the acoustics of the scenario for the generation of effects and immersive sound environments. There are also no proposals of augmented reality-based systems aiming at emotional documentation, intelligent audio accompaniment, and musicological studies within the scope of the music industry.

It can also be seen that there are some types of computational augmented reality technology developed for the musical domain, such as virtual agents, outdoor installations, music applications, automotive directional sound systems, and tools for creative processes of professionals in the area. Different augmented reality tools can support the collaborative creative process of musicians. These tools can create multimedia-rich annotations of sound files, have mechanisms for localisation of the sounds within the environment of a musician, and have intelligent assistant agents that prepare and visualise their datasets or act upon the signal data. Currently, most of the proposed ideas focus on providing information about songs on two dimensions of the genres, that is, (1) the lyrical, such as the mood of the song, and (2) the lyric translations and the musical, such as explanations of musical concepts and descriptions of the recording context.

Summary of Key Findings

To sum up the key findings of this study, augmented reality and music have been a research interest in the emerging field of Multimedia and Augmented Media. Blending the real and virtual environment in the sense of adding virtual sound elements to the real world expands traditional media for future entertainment-based musical experiences. Currently, augmented reality technology is still in its beginning stages and only focuses on a few aspects and related research fields, such as music notation-based music teaching and learning; conferences and demonstrations, which form an increasingly related literature. Autonomous audio and intelligent music editing pose continuing future research challenges. From the innovative angle, current visual display hardware and software for the visual (graphic) tracking, sound spatialisation and physical simulation have not been developed as a principal backing of the augmented reality tools. Based on an intensive literature review and analysis, this systematic literature review

synthesises the core concepts of augmented reality music and its real-world applications, augmented reality-based audio–visual display and tracking technologies, and potential music and sound applications integrated with other emerging technologies:

1. The augmented reality-exclusive inventive tools, augmented reality-based audio production and real-time visualisation tools, in combination with artificial intelligence, enable further successful commercial development in the audio professional field.

2. The emphasis remains on initial efforts in the field of augmented reality for music education for beginners, as well as on conferences and demonstrations. This includes prototypes for sensing, developing systems, and presenting conference articles and demonstrations, along with experimental evaluations and qualitative results.

In addition, the review outlines a process for exploring augmented reality applications for music and sound, including the features of augmented reality solutions and potential evaluations to aid in future message transmission. Therefore, it provides clarity and guidance for future research.

Practical Implications for Business and Education

This study has some practical implications for both academic researchers and industrial professionals. It identifies many opportunities for the music industry to benefit from augmented reality. Lack of a clear roadmap hinders the proper implementation of augmented reality applications, and while there is still a paucity of related work or examinations, it is crucial for both sides to make constructive contributions. Several inspirations are proposed for business development and application purposes, which may demonstrate the feasibility and potential of augmented reality in the respective domains. The augmented reality music creation tools and the concept of augmented reality-aided music learning are obviously not new. Many developments and practical strengths from different augmented reality aspects have emerged in different academic communities and areas of industry professions. The opportunities and strengths identified in each area are presented as follows.

Business Development

Innovations such as the development and utilisation of augmented reality music creation tools were mentioned in several of the works reviewed. Industrial communities can investigate the possibilities and the technical combinations associated with this tool and develop need-aware music creation software or services. Furthermore, the concept could be transcended and expanded into the development and exploration of more diversified augmented reality music creation tools and associated augmented reality turnkey solutions, as inspired by the increased potential. The stronger capabilities provided can set off chain reactions, in coherence with more vital, urban augmented reality experiences for augmented reality music festivals and augmented reality concert sessions. Potential opportunities in augmented reality-fuelled future industries can be dissected and illustrated, such as the experiential tourism business model. Research about spatial music-based augmented reality design and the deployment of these tools can be conducted according to experimentation models in different user experience scenarios or for other user types. With continuous collection or integration, augmented reality understanding and meaning making in this field have yet to be continuously advanced, and known detail gaps and the issues must be resolved through user interface and user experience essence mining and interactions with nominal technologies.

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