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VIRTUAL LAYER: PEPPER GHOST ILLUSION AND DIGITAL PROJECTION TO REINFORCE PLACE MEANING

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ABSTRACT
Placemaking transforms space into place by arranging form, activity, and meaning aspects. In a historical urban village context, the physical forms of historical objects are often altered due to space scarcity and growing needs. It could weaken the historical meaning of the place. Digital technologies could represent the lost historical forms or activities as digital placemaking strategies. Combining the Pepper Ghost illusion technique and digital projection produces a virtual layer to represent past events superimposed onto the site's surroundings to strengthen the place's meaning. It provides a practical digital placemaking strategy for urban village communities. This study aims to evaluate the design prototype of the virtual layer strategy by identifying factors that affect design performance and proposing design recommendations. This study was conducted by experiment and prototype testing. Testing with participants involved semi-structured interviews for data collection and content analysis to identify the factors. This study also provides schematic design implementation in Kampung Kungfu Kapasan, Surabaya. The results recommend designing the screen on a human scale, balancing environmental brightness for content clarity and visual comfort, as well as integrating installation design and surrounding elements. The overlapping strategy of past and present conditions forms a virtual layer as a layered enclosure. It affects how users perceive the surrounding environment, thereby shaping their perception of the place's meaning.

KEYWORDS: digital placemaking, historical meaning, media architecture, prototype, sustainable cities and communities

Placemaking merupakan upaya mengubah ruang menjadi tempat dengan menyusun aspek bentuk, aktivitas, dan makna. Dalam konteks kampung bersejarah, bentuk fisik objek bersejarahnya kerap berubah atau hilang akibat keterbatasan ruang dan pertumbuhan kebutuhan penduduk. Hal itu melemahkan makna sejarahnya. Teknologi digital dapat merepresentasikan ulang bentuk bangunan atau aktivitas bersejarah yang telah hilang sebagai strategi digital placemaking. Kombinasi teknik ilusi Pepper Ghost dan proyeksi digital menghasilkan lapisan virtual untuk merepresentasikan masa lalu pada lingkungan fisik masa kini untuk menguatkan makna tempatnya. Strategi ini cukup sederhana dan praktis bagi komunitas kampung. Riset ini bertujuan untuk mengevaluasi prototipe rancangan lapisan virtual tersebut, dengan mengidentifikasi faktor yang mempengaruhi performa dan mengusulkan rekomendasi rancang. Riset dilakukan melalui eksperimen dan pengujian prototipe. Pengujian dilakukan bersama partisipan dengan wawancara semi-terstruktur untuk pengumpulan data dan analisis konten untuk identifikasi faktor. Riset ini juga menghasilkan contoh rancangan skematik di Kampung Kungfu Kapasan, Surabaya. Hasil riset merekomendasikan rancangan layar dalam skala manusia, kontrol pencahayaan lingkungan untuk kejelasan dan kenyamanan visual, serta integrasi instalasi rancangan dengan lingkungan sekitar. Strategi pelapisan masa lalu dan kini membentuk lapisan virtual sebagai selubung bangunan berlapis. Hal itu mempengaruhi cara pengguna di dalam memandang lingkungan di luar, sehingga membentuk persepsi pengguna mengenai makna tempat.

KATA KUNCI: *digital placemaking, makna sejarah, arsitektur media, prototipe, kota dan komunitas berkelanjutan*

INTRODUCTION

The development of digital technology influences the placemaking process. Placemaking turns space into place by integrating human stories into the arrangements of form, activity, and meaning aspects (Ghavampour & Vale, 2019; Hespanhol, 2018). Digital placemaking is a placemaking effort that is mainly mediated by digital technology to enrich those aspects (K. Chen et al., 2022; Foth, 2017; Gonsalves, 2023; Halegoua & Polson, 2021; Maciej, 2024; Razi & Ziminski, 2022; Toland et al., 2020; Witteborn, 2021). One of the digital technologies on an architectural scale is media architecture. Media architecture is an architectural design that incorporates material with dynamic properties to encourage interactive activities with its users (Brynskov et al., 2013; Tomitsch et al., 2015). Nowadays, digital information can be viewed as

a form of architectural material in media architecture (Wiethoff & Hussmann, 2017). Those digital materials could be integrated into architectural design to enhance the place's meaning (Lovendianto et al., 2025). It can digitally represent the physically lost historical forms, as in the Hong Kong Martial Arts Living Archive and The Lost Palace projects (Kenderdine et al., 2021; Morrison et al., 2017).

Those digital strategies could be implemented in a historical urban village context. Studies on digital placemaking in historical urban villages are still limited and often focus on physical aspects and communal activities. Historical forms in urban villages tend to change due to space scarcity and rapid population growth (Shirleyana et al., 2018). Those changes threaten their historical significance, as seen in Surabaya's Old Chinatown on Karet Street (Andrian et al., 2021; Handinoto, 2015). Digital material could be designed within a high-density urban village to reinforce its historical meaning. This study proposes a digital strategy for Kampung Kungfu Kapasan, a historically significant Chinese settlement in Surabaya, acknowledging its evolved form and activities (Handinoto, 2015; Wulandari, 2017; Zakariya, 2023).

Media architecture consists of surface, mediator, and context (Behrens et al., 2018). The surface refers to the physical aspects of digital technology, shaped by the content's value and the carrier's form factors (type, material, resolution, shape, and size). The mediator defines the interaction between users and technologies, characterized by participation level (static, dynamic, controllable) and interaction modalities (body position, gaze, expression, speech, touch). These occur within a context that includes spatial (interaction zones), temporal (scenarios), and social (human behavior) dimensions.

Digital media, by virtual or augmented reality technologies, can represent the historical significance of a place (Foth, 2017; Hartanti & Prabowo, 2024). However, these high-tech options are costly. More economical alternatives, such as digital projection, offer practical accessibility for users with diverse digital skills (Fitria, 2023). It makes them a better fit for sustainable placemaking in urban villages that are primarily self-sustaining within their own community (Lovendianto et al., 2025). It can be combined with the low-cost Pepper Ghost's illusion technique (Barcellos & Junior, 2015; Luo et al., 2017). These techniques mainly focus on visual information for the user's sense. Sensory experiences mediated the human and external world (the built environment of the place) through perception (Steiner, 1981). Visual perception significantly affects how humans perceive architectural objects (Trebacz, 2019). Therefore, these techniques enhance the user's visual perception to shape their understanding of the place's meaning.

The combination of techniques could produce a virtual historical layer on the existing physical environment, allowing users to learn about the historical meaning of a place through the display of past and present conditions within it. Therefore, this study aims to evaluate the design prototype of the virtual layer that combines the Pepper Ghost illusion technique and digital projection. The evaluation mainly focuses on the visual aspect of the design prototype, in terms of the form factors of the design, the quality of illusion content produced as a virtual layer, and the design's performance in shaping the perception of place meaning. The results also provide design recommendations for digital placemaking strategies in historical urban villages.

METHODS

This study was conducted as research through design to evaluate the proposed design concept (Downton, 2013). This study was conducted using a combined strategy in two phases (Groat & Wang, 2013). The first phase employed an experimental method to search for the best technical design, while the second phase utilized a modeling method to test the performance of the design prototype in an actual environment (Niezabitowska, 2018).

Firstly, an experiment was conducted using the Pepper Ghost illusion technique. It utilizes the reflection effect of a projection source on a thin, transparent reflector plane inclined at 45° (Barcellos & Junior, 2015; Luo et al., 2017). The projection source can be a digital screen or digital projection on a reflective surface (Figure 1). This technique enables a virtual impression of 2D digital content to blend seamlessly with a 3D physical environment.

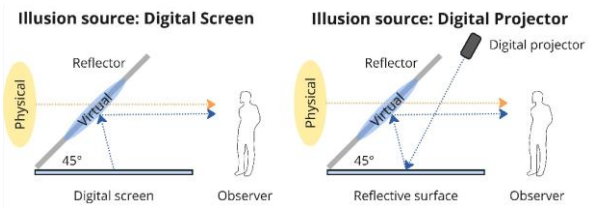

Figure 1. Pepper Ghost Illusion Technique
(Source: adapted from Barcellos & Junior, 2015)

The experimental method manipulated independent variables to observe their influence on the dependent variable through a comparison of the results (Niezabitowska, 2018). Experiments were carried out on a small scale. It examined the influence of reflector shape (pyramid and single-sided plane), the position of the projection source (digital screen and mirror), and environmental conditions (natural, artificial, indoor, and outdoor lighting) as independent variables on the clarity of the resulting projection, which served as the dependent variable (Figure 2). The

tools used are smartphones, 0,5 mm thick PVC transparent sheets as reflectors, mirrors, and illusion content. An analysis was conducted to compare the results and select the best technical design for the virtual layer concept.

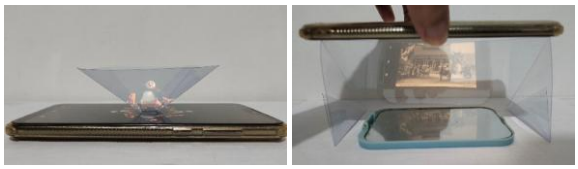

Figure 2. Experiment on Pepper Ghost Illusion Technique (Source: Author's Document, 2025)

Secondly, the physical prototype modelling of the proposed design was done. It was tested in a real environment to evaluate its performance. In the media architecture design process, the prototyping phase focuses on testing hardware technologies (Dalsgaard & Halskov, 2017). The tool used was a full-scale 1:1 model consisting of a 550 ANSI lumen digital projector, a glossy white HPL as a reflective surface, and a 0.5 mm clear PVC sheet inclined at 45° as a reflector. The model was 1.5 m-wide and 1.5 m-high. It considered the human scale, the projector's throw ratio (the projector distance to the width of the projected image), and the model's portability. The digital projector had 1920 x 1080p resolution. It displayed a video of historical buildings and scenes as the illusion content for the virtual layer. The testing activity was conducted in shaded spaces within semi-outdoor environments from 4 p.m. to 6 p.m., in preparation for the results of the first phase of the study. Light intensity in lux was measured by a light meter.

Three participants were invited to evaluate the design prototype (Figure 3). Participants were Generation Z, as this young generation had their own perceptions of place meaning and digital technology within the study context (Anggraini, 2021; Azaria, 2022; Effendi & Stenberg, 2022). Data collection was conducted through semi-structured interviews with each participant, using a questionnaire as the primary tool. The questionnaire used open-ended questions in which participant evaluated each aspect and explained their reasoning. Firstly, participants evaluated form factors of the design, in terms of screen size and position. Form factors refer to the physical form of technology used, as seen on the surface in media architecture (Behrens et al., 2018). Secondly, participants evaluated the quality of illusion contents produced as a virtual layer, in terms of its clarity, visual comfort, and integration with surroundings. A sense of clarity and comfort became the parameter to evaluate the presentation-ability of the prototype (Chen et al., 2019). Integration with the surroundings became a key parameter in determining how the prototype could augment space and coexist with the physical characteristics of architecture. These abilities relate to perceiving the architectural quality of media architecture (Wouters et al., 2016). Lastly, participants evaluated the design performance in shaping their perception of place meaning, in terms of the understandability of the techniques and the way of comparing the past-present condition of the place through virtual layers.

Figure 3. Testing of the Design Prototype with Participants (Source: Author's Document, 2025)

The interviews were recorded, transcribed, and then analyzed. Content analysis was done by extracting codes from the keywords mentioned by the participants (Groat & Wang, 2013). By analysing the qualitative data, several factors affecting each aspect could be identified and evaluated. The synthesis of the evaluation produced design recommendations for the virtual layer design concept as a digital placemaking strategy to reinforce place meaning.

RESULTS AND DISCUSSION

Evaluation of Virtual Layer Design by Experiment and Prototype Testing

Small-scale experiments using a smartphone and a clear PVC sheet are conducted to determine the most optimal reflector shape, position of the projection source, and environmental conditions (Figure 4). Experiment results have shown that single-sided reflectors are more space-efficient and less distorted than pyramid reflectors. The single-sided reflector shape is more efficient in terms of the width of the projection source and the width of the resulting illusion, thereby saving more space. Content can be produced on a digital screen or reflected from a digital projection onto a mirror. The projection source could be located above or below the reflector. The content appears optimally in indoor conditions with a dark background and at night outdoors.

Modelling with a physical design prototype and testing in a real environment demonstrates that this system can operate on a 1:1 human scale in semi-outdoor conditions during the afternoon (4 p.m. – 6 p.m.) (Figure 5).

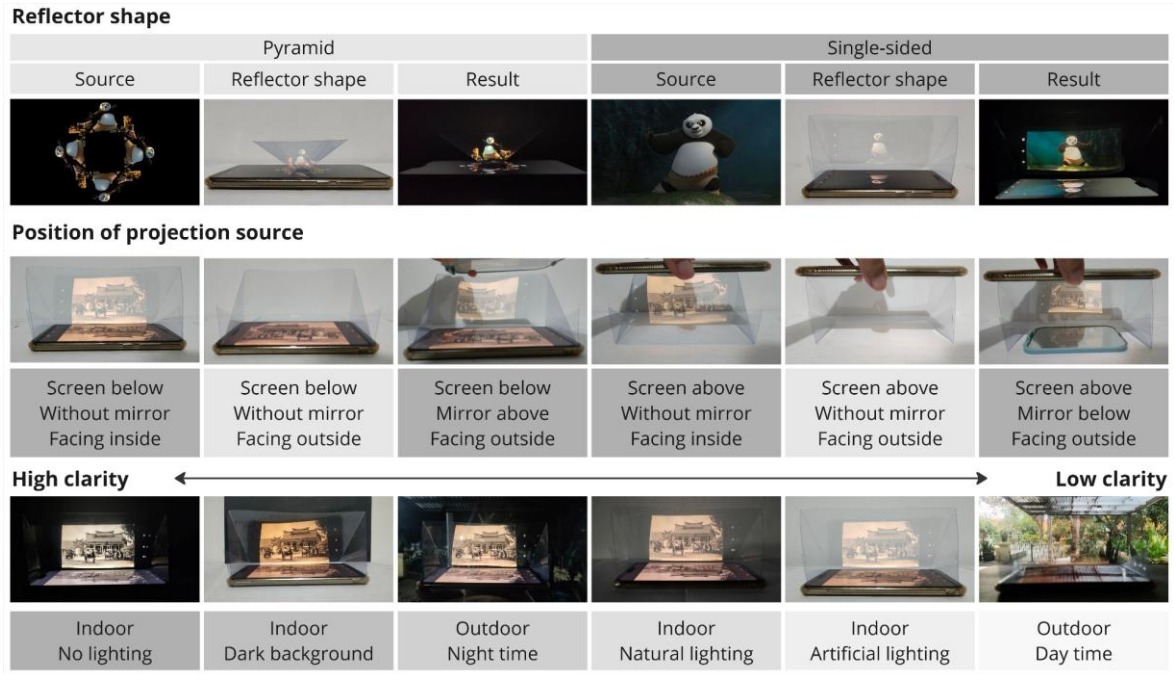

Figure 4. Small-scale Experiment Results
(Source: Author's Document, 2025)

In this design, the digital history layer can present virtual dimensions of the past within the present physical space of the site, thereby strengthening the historical meaning of the place.

Figure 5. Prototype Testing in a Real Environment
(Source: Author's Document, 2025)

Testing with participants was conducted in a shaded area in the afternoon, starting at 4:00 p.m. (Table 1). The starting time was chosen to avoid glare from the sky, while still allowing the surroundings to be visible. Participants were interviewed in turns, with each interview lasting 20-30 minutes. They evaluated the form factors of the design, the quality of illusion content produced as a virtual layer, and the design's performance in shaping the perception of place meaning.

Form factors of the design were evaluated in terms of screen size and position. The prototype had a screen size of 1.5 m in width and 1.5 m in height. With that screen, the maximum size of the projected image (the content) was 1.5 m in width and 0.84 m in height, due to the 16:9 ratio of the projector. Participants considered that those sizes were enough for them. The content should be displayed on a full screen. In evaluating the screen position, participants considered both the height of the screen at eye level and the distance between the participants and the screen. The distance was also affected by the clarity of the content. If the content was not explicit enough, participants needed to move closer to the screen.

Table 1. Participant Data

Participant	Testing Time	Light Intensity of Surroundings (lux)
P1	16.00 – 16.20	253
P2	16.20 – 16.50	232
P3	16.50 – 17.10	65

The quality of illusion contents as a virtual layer was evaluated in terms of its clarity, visual comfort, and integration with the surroundings. During the interview, the participants considered several factors that affected their evaluation. Clarity was affected by background brightness, environment brightness, and content color. Regarding the environment, the content looked clearer on the darker background and the darker environment. The existence of external sources of light, such as daylight, reduced the clarity of the content. In that case, P2 mentioned that the edges of the images were difficult to identify. Regarding the content, P3 mentioned that colored images had better clarity than black-and-white images.

The clarity of the content affected the visual comfort of the participant. During prototype testing, the brightness of the background and environment made the content difficult to be seen clearly.

Participants, especially P1 (16:00 – 16:20; 253 lux) and P2 (16:20 – 16:50; 232 lux), mentioned that the content was difficult to see and they needed to exert more effort to see it. Meanwhile, in P3 turns (16:50 – 17:10; 65 lux), the environment became darker, allowing the content to become clearer. P3 also mentioned that colored images were easier to see than black-and-white images. Therefore, visual comfort was also affected by background brightness, environmental brightness, and content color.

In evaluating the integration with surroundings, participants considered the installation elements, illusion content (clarity and transparency), and physical elements of the surroundings. P3 mentioned that the frame of the installation was distracting her from the content. The physical and technical aspects of the installation should be camouflaged so that the illusion of content could blend better with the surroundings. Regarding the content itself, P2 mentioned that he was annoyed with the overlapping of the illusion content and the background, because he could not see the content clearly. The clarity and transparency of the content should be balanced so that it can be displayed better with the surroundings. Regarding the surroundings, P1 and P2 mentioned that they were annoyed with the non-contextual physical elements within the screen frame, such as the plant's pot, benches, and trash can. If those elements were not related to or did not support the narrative of the content, they became obstacles.

Design performance was evaluated in terms of the understandability of the technique, how it provides knowledge about the place's history, and how it helps participants compare the past and present conditions of the place. The understandability of the technique was affected by the quality of the content itself, particularly its clarity and integration with its surroundings (Figure 6 and 7). The integration of the installation, content, and surroundings became the primary consideration. In the prototype, the design of the frame was found to be annoying to the participants. The design should be camouflaged so that it can blend with the surroundings. Its shape, style, material, and placement should also match the concept of the content. In providing knowledge and comparing the past and present conditions of the place, all participants agreed that the considerations focused on clarity, narratives, and the integration of content, making it informative to the participants.

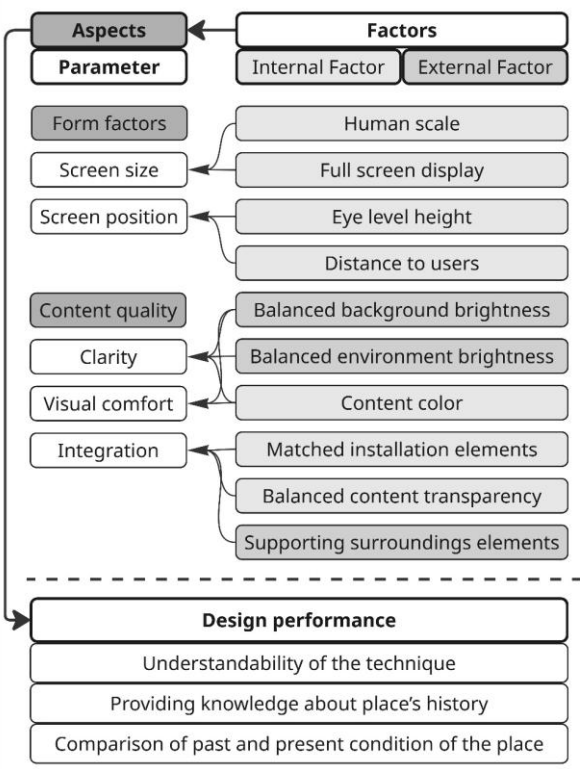

Figure 7. Factors, Parameters, and Aspects Affecting the Design Performance
(Source: Author's Document, 2025)

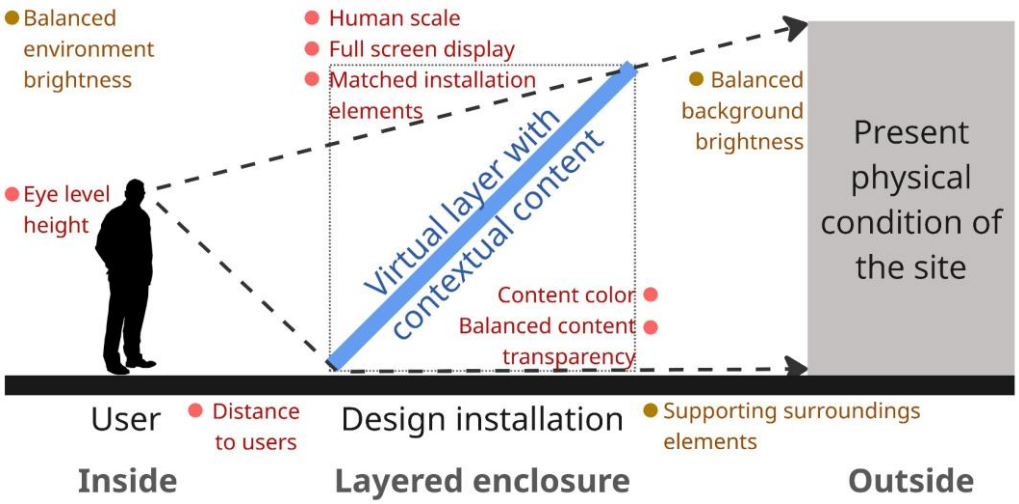

Figure 6. Factors, Parameters, and Aspects Affecting the Design Performance
(Source: Author's Document, 2025)

Therefore, when designing virtual layers, it is essential to consider form factors (screen size and position) and content quality (clarity, visual comfort, and integration). Screen size is determined by human scale and full-screen display, while screen position is determined by eye-level height and distance to the user. Clarity and visual comfort are affected by balanced background and environment brightness, as well as content color. The integration is affected by matched installation elements, balanced content transparency, and supporting elements in the surroundings. The form factors and content quality affect the design performance in making it understandable, providing knowledge and comparison between past and present conditions of the place.

Schematic Design Implementation in Historical Urban Village Context

This study develops that strategy in a schematic design proposal for a community and tourism center in a historical urban village context at Kampung Kungfu, Kapasan Dalam, Surabaya (Figure 8). It is a Chinese community settlement dating back to the Dutch colonial period with historical significance (Handinoto, 2015; Wulandari, 2017; Zakariya, 2023). However, its form and activities have changed.

Legends

1. SITE; former Kungfu training field
2. Original place of Boen Bio temple
3. Today place of Boen Bio temple
4. Local settlements
5. Main road to city center
X. Virtual layers location

Figure 8. Site Location

(Source: Adapted from Google Maps, 2025)

They had Kungfu skills to protect their community and support Indonesia's independence. During the independence war, this urban village also became a hiding shelter for Indonesian fighters, due to the complexity of its alley network. However, nowadays, the Kungfu training activity is stuck in the older generation. Moreover, this urban village reflects the integration between Chinese and local culture. This was reflected in the building form, especially at theoen Bio temple (Olivia, 2021). The first temple initially faced south, toward the Kungfu training field and settlement. However, the temple was then rebuilt facing north towards the main road outside.

Therefore, this virtual layer strategy is proposed within a schematic design of a community and tourism center to reinforce the historical significance of this place, targeting the younger generation, especially Generation Z (born 1995-2010), as the main visitors and users (Figure 9). This design object is situated on the former Kung Fu training field. This study focuses on the design and implementation of a virtual layer, combining the Pepper Ghost illusion technique and digital projection, in this architectural object to reinforce place meaning. The projector can be positioned above or below, depending on the design needs. Moreover, if the installation is not used for permanent activity, it could be designed as modular, non-fixed, and foldable (Figure 10).

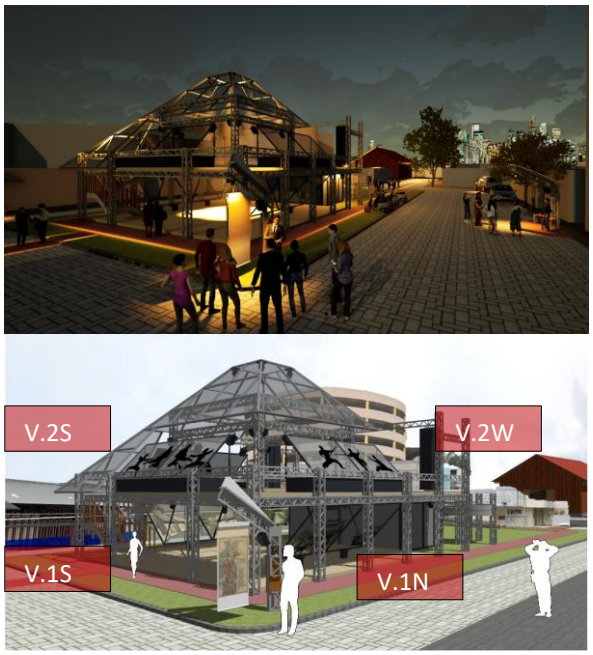

Figure 9. Schematic Design of Community Tourism Center

(Source: Author's Document, 2025)

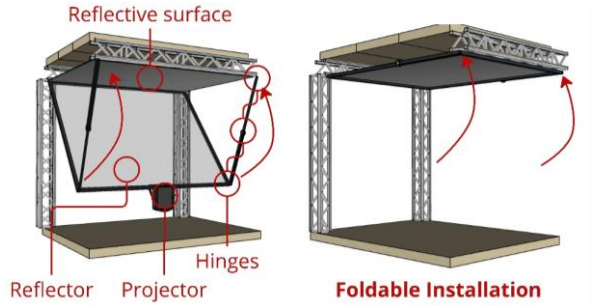

Figure 10. Foldable Design for Virtual Layer Installation

(Source: Author's Document, 2025)

On the former Kungfu field site, on the first-floor level, a design is proposed for a communal space to serve the local Kungfu community and visitors. A virtual layer could be implemented on its surroundings

as virtual façades. On the north side, facing the original location of the former temple, the virtual layer displays old scenes of the former temple superimposed on the present physical condition of that place as the background (Figure 11 – V.1N). On the south side, facing the local settlement, the virtual layer displays old scenes of the settlement from the past, superimposed on the present physical condition of the settlement as the background (Figure 11 V.1S). The projector is located below, projecting content onto a reflective surface beneath the ceiling, thereby creating an illusion that is reflected onto a 45° reflector. This schematic design features a 3 m wide and 3 m high screen module, designed to align with human scale and eye-level height. Users from inside the space could see the illusion with the existing physical surroundings outside as the background. The projector is portable, and the reflector module is foldable, allowing for adjustments to meet the needs of various activities within the space. In this semi-outdoor setting, the virtual layer installations are shaded by the ceiling to balance the environment's brightness. The virtual layers are best activated between 4:00 p.m. and 6:00 p.m. to avoid background glare and excessive daylight, allowing the illusion to be seen clearly. At the same time, the surroundings remain visible as the background.

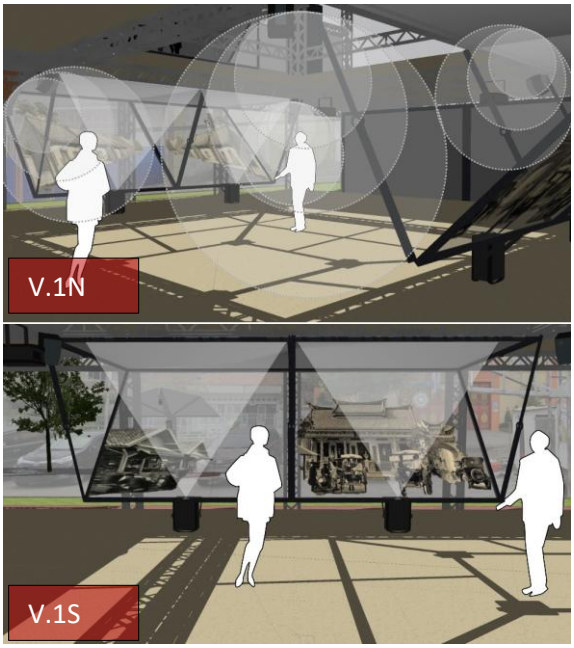

Figure 11. Virtual Layer Installation in Semi-Outdoor Setting
(Source: Author's Document, 2025)

On the former Kungfu field site, on the second-floor level, there is a design for a rooftop space for visitors' sightseeing activities. A virtual layer could be implemented on its surroundings to augment the present urban village's condition with a historical atmosphere. On the south side, facing the local settlement, the virtual layer displays old scenes of Kungfu heroes' actions, superimposed on the local settlement's roof level as the background (Figure 12 – V.2S). Legend says that they could jump on roofs when protecting this village in the past. On the west side facing the city center, the virtual layer displays war scenes in the city, superimposed on the cityscapes as the background (Figure 12 – V.2W). The projector is located above, projecting content onto a reflective surface on the raised plane, thereby reflecting an illusion onto a 45° reflector. This schematic design features a 3 m-wide and 2 m-high screen module, designed to fit the human scale. The reflective surface is raised to a height of 1 m, so the content can be reflected at eye-level height. In this outdoor setting, the virtual layers are best activated from the evening (6.00 p.m.) in a dark environment, so the illusion can be seen clearly. The nighttime setting also matches the historical content displayed. Surrounding artificial light should be balanced to avoid disturbing the illusion.

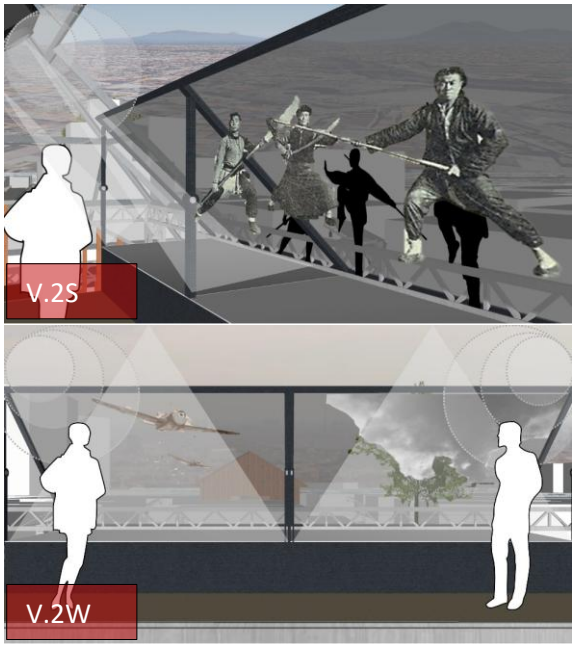

Figure 12. Virtual Layer Installation in an Outdoor Setting
(Source: Author's Document, 2025)

Besides the contextual content displayed, those schematic design implementations consider several factors to optimize the design performance. The screen size and position (3 m in width and 2-3 m in height) reflect the human scale and eye-level height, as well as the distance from users, taking into account space availability. Lighting controls for the environment and background (including shading, artificial light settings, and activation times) are crucial in ensuring content quality, particularly in terms of clarity and visual comfort. Clarity and visual comfort ensure the presentability of virtual reality (Chen et al., 2019). Black frames are chosen so they will be

camouflaged in darker environments. Full-screen display, content colors, and transparency are adjusted to augment the space and coexist with the surroundings. Those things ensure the architectural quality of media architecture (Wouters et al., 2016).

Virtual Layer as a Layered Enclosure to Reinforce Place Meaning

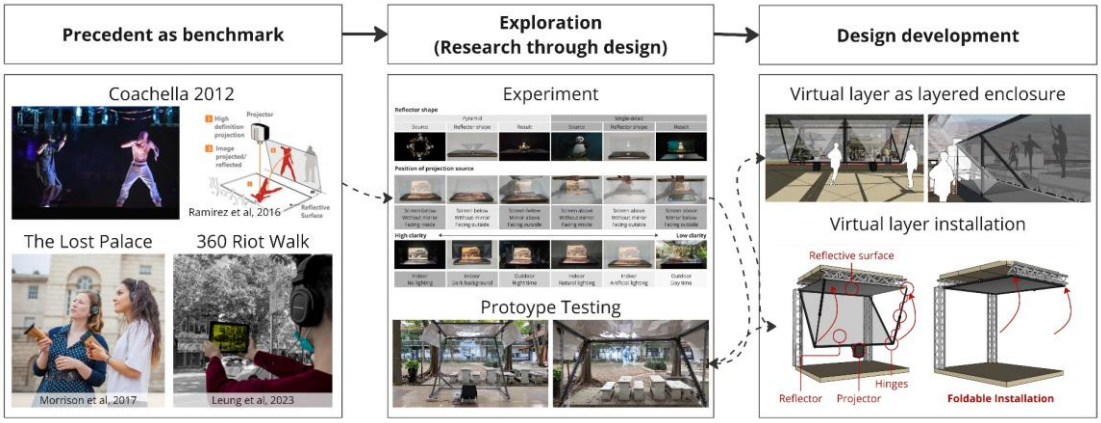

Figure 13. Design Innovation toward Previous Studies
(Source: Author's Document, 2025)

Rather than physically recreating historical artifacts, technology can create them digitally, as in the The Lost Palace project, which recreates the burnt Whitehall Palace in London by utilizing virtual reality technology (Morrison et al., 2017). Digital media can tell the historical meaning of places (Foth, 2017; Hartanti & Prabowo, 2024). However, technology like virtual reality is quite expensive. Alternative techniques, such as digital projection, are more affordable, practical, and familiar to users (Fitria, 2023). As part of spatial augmented reality, projection installations enrich physical objects by projecting digital content on their surfaces, both in 2D and 3D (Dalsgaard & Kim, 2011; Katkeviča & Strode, 2022).

This study focuses on the design of a virtual layer that combines the Pepper Ghost illusion technique with digital projection. The physical model prototype system has been tested in a real environment. Digital media can virtually display the past historical dimension by overlaying it onto the present physical space on the site, thereby strengthening the historical meaning of the place. Digital projection techniques are more affordable, practical, and familiar to users than the use of expensive virtual reality technology. It is suitable for historical urban village contexts, where placemaking projects are mainly self-supported by the village community itself. This digital projection can be combined with the cost-effective and straightforward Pepper Ghost illusion technique (Barcellos & Junior, 2015; Luo et al., 2017). This technique was employed on the 2012 Coachella stage to create the illusion of a late singer from the past appearing to duet with a current singer (Barcellos & Junior, 2015; Ramirez et al., 2016) (Figure 13). In this study, this technique could bring a layer of digital history to the existing physical environment without disturbing it.

This study extends the findings of Dalsgaard & Halskov (2011), which classify digital projection onto a full-scale 1:1 physical object as an augmented reality. This overlapping strategy in this study is similar to Leung's 360 Riot Walk projects (2023). It was a walking tour of Vancouver's Chinatown enriched with augmented reality (AR). The AR was accessed from the user's smartphone. It superimposed the digital past onto the present physical surroundings along the walk (Leung, 2023). However, Leung's strategy was only visible on the user's smartphone scale. This study extends it on an architectural scale, in which the digital information itself could form the space and transform it into a place (Figure 13).

In line with Wiethoff and Husmann (2017), digital information is integrated as material in architecture. Moreover, it supports the placemaking process by integrating contextual content to reinforce the place's meaning. The digital information in this study is the virtual layer created by digital projection and illusion techniques. The dynamic properties of the material allow it to respond to user control, enabling the content to evolve over time. Users can choose from various options, and the narratives can be adjusted based on the project's aim. The contextual content in this study is a video of historical scenes of the place. The contextual content could shape users' knowledge about the place's meaning (Haeusler, 2017).

In the digital placemaking process, digital media produce digital information to be received by the user's senses. It affects their activity and perception of place meaning (Lovendianto et al., 2025). In this study, digital media virtually represent the historical past in the present physical space on the site to reinforce the historical meaning of the urban village. This strategy proposes a concept of a layered enclosure, which occurs by overlapping narratives and user's sensorics ranges (Figure 14). The overlapping of past and

present narratives at the same point on site is represented by overlapping the virtual layer of past content onto the physical surroundings of the present situation. The sensorics range is created by the digital information from the digital media. It indicates the boundaries of a space, as well as defines the activity and meaning inside, thereby transforming that space into a place.

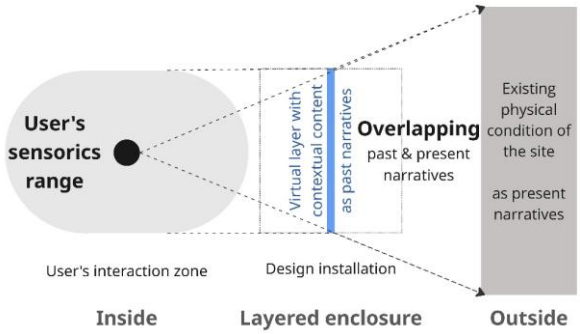

Figure 14. Principles of Layered Enclosure
(Source: Author's Document, 2025)

Digital information can define a space and act as an intangible enclosure. According to a media architecture study, an interactive zone was created where participants could interact with the installation (Kao et al., 2021). It aligns with the spatial context in the media architecture framework (Behrens et al., 2018). The digital information received by the user's senses can form a spatial boundary and determine the activities within. In this study, the spatial boundary is defined by the range of how far participants can interact with digital information (to see, watch, and understand the virtual layer). The user's sensorics range becomes an intangible boundary that defines the space. Therefore, the digital information (the virtual layer) could act as an intangible enclosure.

This enclosure separates the inside space (the user's interaction zone) from the outside space (the physical surroundings of the site). This enclosure influences how users inside perceive the outside. From the interaction zone inside, users could see the virtual layer of historical scenes overlapped onto the existing physical surroundings of the site. The superimposition of past situations onto present situations enriches users' knowledge about that location. Moreover, the contextual content (historical scenes) adds meaning to that space, thereby transforming it into a place.

Design Recommendations for Virtual Layer to Reinforce Place Meaning

The concept of a virtual layer can digitally represent the historical form of an urban village whose original form has been physically lost, changed, or inaccessible. This layered enclosure concept is also applicable to reinforce historical meaning in an urban village where its historical form still exists today. This concept could superimpose the virtual past on the physical present situation to strengthen its historical meaning.

Technical considerations for designing the virtual layer to reinforce place meaning are as follows.

1. The content should be displayed on a human scale, full screen, and at eye level. The distance between the virtual layer and users should consider the user's sensory range.
2. The lighting environment of the surroundings, especially the background side, should be controlled to ensure the clarity of the content.
3. The installation's physical technical elements should be camouflaged so that the illusion content blends better with the surroundings.
4. The installation design (shape, style, material, placement) should align with the content's concept. The surrounding elements should be arranged to support the content's narrative.

CONCLUSION

A virtual layer strategy, combining the Pepper Ghost illusion technique and digital projection, provides a low-cost, practical, and familiar approach for digital placemaking in a historical urban village context. It could represent the historical past virtually in the present physical space on the site to reinforce the meaning of an urban village. The digital information displayed could define a space and act as an intangible enclosure of the user's sensory range inside. The overlapping strategy of past and present conditions forms a virtual layer as a layered enclosure. It affects how users perceive the surrounding environment, thereby shaping their perception of the place's meaning. Technically, the implementation of this strategy should consider several parameters and factors, such as screen size and position (human scale, eye-level height, full-screen display, distance), clarity and visual comfort (environment and background brightness, content color), as well as integration with surroundings (matched installation design, balanced content transparency, supporting surroundings elements) to optimize the design performance.

This study extends the classic Pepper Ghost illusion techniques on an architectural scale. This study of the virtual layer provides a low-cost and simple strategy to represent the historical meaning of place, comparing it to conventional augmented reality (AR) and virtual reality (VR) strategies that use costly high technology. The use of digital projectors is more practical and familiar for self-supported digital placemaking projects by communities in urban village contexts. This strategy is suitable for historical urban villages whose historical form or activity has been physically lost, so it can be represented digitally. However, the quality of the content produced by this strategy may be less realistic and immersive than that

produced by conventional AR or VR devices. This study mainly focuses on its visual aspects. Further research may either explore other aspects and factors or improve this strategy to achieve optimum quality. The portability and maintenance of the installation should also be taken into consideration.

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