

A Virtual Museums and 3D Artefacts to Improve Cultural Heritage Education

Bagus Satria *

Software Engineering Technology, Agricultural
Polytechnic of Samarinda, 75131, Indonesia
bagussatria@politansamarinda.ac.id
*Corresponding author

Fajar Ramadhani 

Software Engineering Technology, Agricultural
Polytechnic of Samarinda, 75131, Indonesia
fajar.ramadhani@politansamarinda.ac.id

Syafei Karim 

Software Engineering Technology, Agricultural
Polytechnic of Samarinda, 75131, Indonesia
syfei.karim@gmail.com

Nur Aini

Software Engineering Technology, Agricultural
Polytechnic of Samarinda, 75131, Indonesia
nuraini@politansamarinda.ac.id

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Abstract— In the current era of globalization and modernization, the imperative to safeguard and convey cultural heritage and history to society becomes increasingly significant. Web-based virtual museums have emerged as a pivotal solution, facilitating the preservation and promotion of cultural heritage on a global scale. These virtual platforms offer visitors unprecedented access to artifact collections, transcending the limitations of physical museum visits. The immersive features, such as the ability to view objects from diverse angles and zoom in on intricate details, present a profound and engaging experience. This research is to contribute insights into the development of effective web-based virtual museums featuring 3D artifact representations, thereby making a meaningful contribution to the broader field of cultural heritage preservation. The primary objective of this study is to enrich the exploration and learning experiences of visitors in the realm of cultural heritage through digital platforms. The research employs a structured software development methodology encompassing vital stages like needs analysis, system design, implementation, testing, and maintenance. By focusing on the technological aspects, the study seeks to address challenges related to quality and reliability faced by web-based virtual museums. Furthermore, the findings aim to enhance the overall effectiveness of these museums in offering a comprehensive and captivating journey through cultural artifacts. This research is poised to not only advance the field of virtual museum development but also foster a deeper appreciation and understanding of our rich cultural heritage.

Keywords— Virtual Museum, 3D Artifacts, Cultural Heritage, Website, Visitor Experience

I. INTRODUCTION

In the contemporary era of globalization and modernization, the presentation of cultural heritage and history holds increasing significance. The richness of our

shared human history, manifested in artifacts and historical objects, plays a crucial role in fostering understanding and appreciation across diverse communities (Du & Cui, 2021). However, the accessibility of physical museums, where these treasures are traditionally housed, remains a challenge for many. Factors such as geographical constraints, time limitations, and global events, as witnessed in recent times, have underscored the need for alternative avenues to ensure widespread access to our cultural legacy (Taylor & Gibson, 2017).

Addressing this challenge, the development of web-based virtual museums has emerged as a compelling solution. These virtual spaces, enhanced by 3D artifact representations, bridge the gap between cultural heritage and a global audience, allowing individuals to explore and engage with historical objects remotely. This paradigm shift in museum presentation aligns with the digital age's ethos, where technology becomes an enabler for cultural dissemination (Besoain et al., 2021). As the world becomes increasingly interconnected through the internet, the potential impact of web-based virtual museums on democratizing access to cultural artifacts is substantial (Lee et al., 2015).

A virtual museum, in its essence, is a digital platform that transcends physical boundaries, enabling visitors to navigate collections from around the world via the internet (Ott et al., 2013). This not only addresses the issue of accessibility but also opens doors to objects that may be too delicate or rare to be displayed publicly. Beyond mere observation, virtual museum visitors are provided with contextual information, enriching their understanding of the historical and cultural significance of each artifact (Wei et al., 2019).

Central to the effectiveness of virtual museums is the representation of artifacts in three-dimensional (3D) space. This feature allows visitors to transcend the limitations of traditional two-dimensional displays, offering the ability to view objects from multiple angles and zoom in to scrutinize intricate details (Puspasari et al., 2019). The immersive nature of 3D object visualization is pivotal,

providing users with an experience skin to physically handling artifacts, albeit through the medium of screens. Extensive research suggests that web-based virtual museums employing 3D object displays contribute significantly to the depth of users' exploration of historical objects and narratives (Yang et al., 2023).

Despite the promising prospects of web-based virtual museums with 3D artifacts, challenges persist in their development and implementation. Issues of image quality, technical glitches, and the substantial costs associated with development and maintenance are recurrent hurdles (Loaiza Carvajal et al., 2020). As technology evolves, it is imperative to address these challenges to ensure the seamless functioning and sustainability of virtual museum platforms.

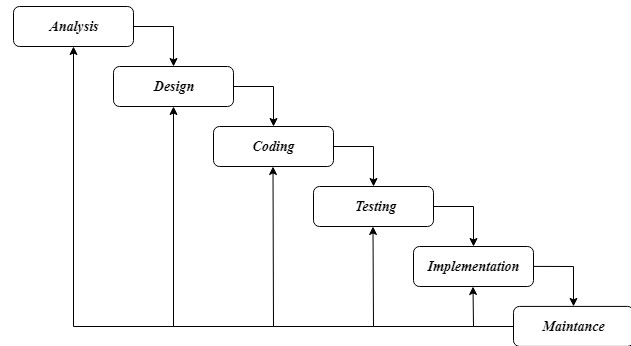
Recent studies on various aspects of virtual museums, emphasizing the potential of 3D technology to enhance the visitor experience. Research by Mercan et al., (2023) delved into the perceptions of visitors regarding their experience with 3D technology in virtual museums. The study conducted surveys among virtual museum visitors, revealing positive attitudes towards the utilization of 3D technology. Visitors reported heightened engagement and improved learning experiences, emphasizing the efficacy of 3D representations in conveying information about artifacts.

Takeuchi et al., (2019) explored the integration of virtual reality (VR) technology in virtual museums. The findings demonstrated that VR technology, while augmenting the learning experience, posed challenges in terms of development and maintenance costs. This resonates with the overarching theme that, while technology enhances the richness of virtual museum experiences, financial considerations remain a critical factor.

While existing studies provide valuable insights into the positive impact of 3D technology on virtual museums, there is a discernible research gap that necessitates further exploration. The current body of knowledge predominantly focuses on user perceptions and the experiential aspects of virtual museums. However, there is a dearth of comprehensive research addressing the specific challenges in the development and maintenance of web-based virtual museums with 3D artifact representations. Understanding the intricacies of these challenges is imperative for refining existing models and fostering the sustainable growth of virtual museum initiatives. This research aims to bridge the gap by systematically investigating the quality and reliability challenges faced in the development of web-based virtual museums. By developing a web-based of a virtual museum, user testing, and surveys, the study aims to provide nuanced insights into overcoming these challenges and enhancing the overall effectiveness of web-based virtual museums with 3D artifact representation. Through this endeavour, the research contributes not only to the scholarly discourse on digital heritage but also to the practical advancement of virtual museum initiatives.

II. RESEARCH METHODS

The method employed in this research will be the waterfall methodology. The waterfall method is a software development model analogized as a waterfall, where each stage is worked on sequentially from top to bottom (Kodmelwar et al., 2022). It involves stages such as analysis, design, coding, testing, implementation, and maintenance (Lawal & Ogbu, 2021). The developmental stages are illustrated in Picture 1.



Picture 1. Waterfall Method

A. Analysis

In this phase, the researcher will conduct a comprehensive analysis of user requirements, the cultural artifacts to be included in the virtual museum, and the technology to be employed. This requirement analysis will involve gathering data and information from relevant sources such as literature, interviews, and observations (Curcio et al., 2018). The findings from this requirement analysis will serve as the foundation for designing the virtual museum and 3D artifacts.

B. Design

In this phase, the researcher will intricately design the web-based virtual museum and 3D artifacts. This design process involves developing the user interface, content structure, as well as configuring navigation and user interactions within the virtual museum. Additionally, the researcher will design the 3D artifacts to be integrated into the virtual museum, encompassing 3D modeling, textures, animations, and interactive functionalities.

C. Coding

The coding phase is where the researcher will execute the implementation of the web-based virtual museum and 3D artifacts based on the design blueprint created in the design phase. During this phase, the researcher will bring to life the user interface, data structure, and database foundation, incorporating features such as navigation, search functionality, and user interactions (Budi et al., 2017).

D. Testing

In this phase, the researcher will conduct testing on the web-based virtual museum and 3D artifacts. Testing is carried out to ensure that the virtual museum and 3D artifacts function in accordance with the predetermined needs and requirements. The researcher performs functional testing to ensure that the features of the virtual museum, such as navigation, search functionality, and user interactions, operate smoothly. Performance testing is also conducted to ensure that the virtual museum and 3D artifacts can run seamlessly under high user loads.

E. Implementation

The implementation phase is where the web-based virtual museum and 3D artifacts, which have been tested and deemed ready for use, will be fully deployed. The researcher uploads the museum 3D artifacts website to a server or platform prepared for user access. The researcher ensures that the museum 3D artifacts website are accessible and can be used optimally by users.

F. Maintenance

The maintenance phase is where the researcher will perform maintenance and improvements on the web-based virtual museum and 3D artifacts after implementation. The researcher monitors the performance of the virtual museum and 3D artifacts to identify potential issues or necessary enhancements. Routine maintenance tasks, such as data backups and system updates, are carried out by the researcher. Additionally, the researcher evaluates the performance of the web-based virtual museum and 3D artifacts and takes corrective actions if needed.

III. RESULT AND DISCUSSION

A. Analysing Museum Collection

In the analysis phase, the primary focus is on converting objects into 3D representations to construct informational media about museum collections. Firstly, identify the museum collections that will be represented in the form of 3D objects, emphasizing the most culturally and historically relevant items. Subsequently, classify and categorize objects based on specific themes to facilitate visual grouping and visitor navigation. Determine the appropriate level of detail for each object, considering the required complexity level. The information structure to be presented alongside 3D objects also needs to be defined, including historical information, cultural aspects, and broader context. Choose the platform and technology to be used, considering loading speed, interactivity, and device support.

Through user needs analysis, consider what is most engaging for them, be it visual details, contextual information, or 3D object interactivity. Integration with external resources such as museum databases needs to be considered to ensure information accuracy.

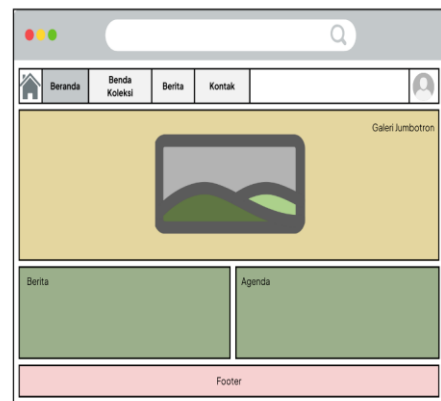
B. Designing User Interface

The interface design process involves creating the user interface of a system, product, or application (Shamat et al., 2017). The goal of interface design is to create a user experience that is efficient, effective, and satisfying when interacting with the system. Interface design encompasses the visual, structural, and functional aspects of the interface (Guney, 2019).

To represent a rough visual representation of how the web pages will look, the creation of mock-ups is conducted. Mock-up creation is an initial step before creating a more detailed and final web design. The mock-up design includes several pages, namely:

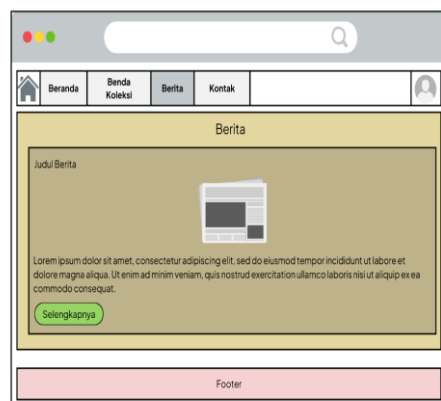
1. Homepage
2. News Page
3. Collection Items Page
4. Contact Page

The homepage mock-up consists of menus such as home, collection items, news, and contact. It also includes a jumbotron gallery displaying the latest gallery or news inputs, along with news and agenda columns showing the latest news and agenda data. The design of the homepage can be seen in Picture 2.



Picture 2. Homepage Design Mock-up

The news page mock-up showcases the latest news input by the admin, with a "read more" button to view the full news content. The news page design can be viewed in Picture 3.



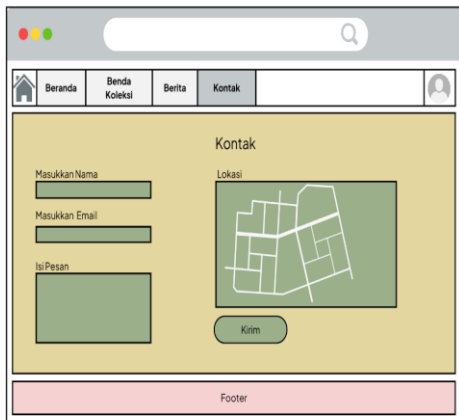
Picture 3. News Page Design Mock-up

The collection items page mock-up displays the collection of artifacts inputted by the admin. The design of the collection items page can be seen in Picture 4.



Picture 4. Collection Items Page Design Mock-up

The contact page mock-up includes a form for users to contact or send messages to the administrators. The contact page design can be viewed in Picture 5.



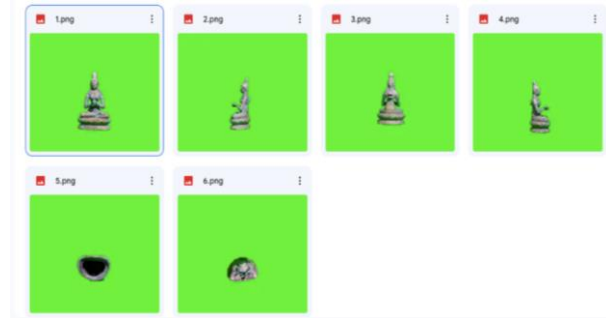
Picture 5. Contact Page Design Mock-up

C. 3D Object Modeling

The 3D modeling stage involves a series of steps or processes to create three-dimensional (3D) objects from initial concepts or designs (Bikmullina & Garaeva, 2020). This stage is a crucial part of 3D model or animation development. The initial step in 3D modeling is planning the object or environment to be created, involving creating a conceptual representation, sketch, or clear description of the model. This includes planning shapes, textures, colours, and details to be incorporated.

After completing the initial step of capturing basic object images, the next action in this process involves adding textures and materials to the object. In this context, "texture" refers to patterns applied to the object's surface to provide a richer and more realistic visual detail. The application of textures is realized through software called Blender, which has the capability to generate essential visual effects in this context.

To gain a deeper understanding of how textures on 3D objects are created and applied using Blender, further information can be found in the illustrative image shown in Picture 6 and Picture 7.



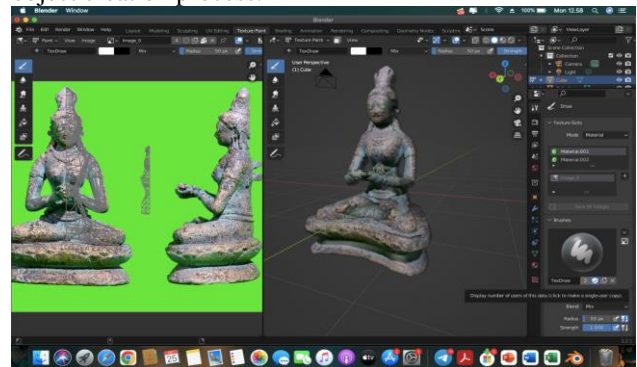
Picture 6. Capturing Images for 3D Object



Picture 7. Creating 3D Object Using Blender Application

The final stage in the 3D object modeling process is the refinement of details (Le et al., 2023). In this stage, a series of steps are taken to enhance the object's level of detail by adding relevant additional elements, such as cuts, scratches, or decorative elements, according to the desired design. This action plays a vital role in creating an appearance that is closer to realism, which, in turn, can enhance the visual quality and appeal of the object being created.

It is important to note that enhancing detail not only affects the visual aspect but can also contribute to the object's complexity and functional capabilities. Therefore, the detail refinement stage is a key step in the overall 3D object creation process.

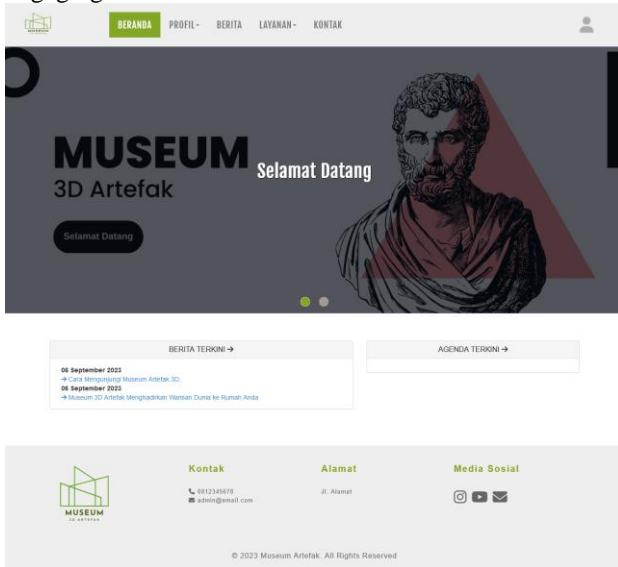


Picture 8. Refining 3D Object Details

D. Design and Development Results

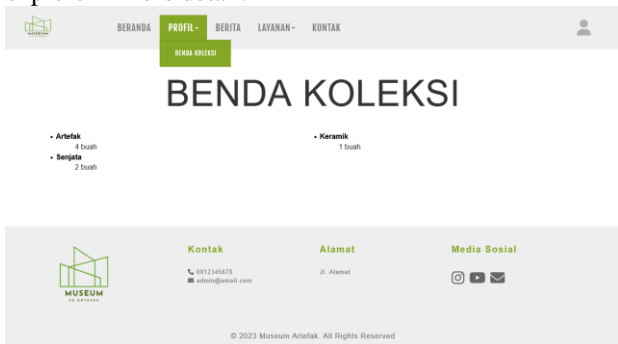
The concrete results of the design and development process have been successfully achieved, following the analysis and previous design for the website and 3D objects. This development stage was carried out with precision according to the previously established design.

The website has been developed using the PHP Laravel framework, known for its ability to facilitate more efficient and reliable web development processes (Laaziri et al., 2019). The main view of the Museum 3D Artifact website can be seen in Picture 9, showcasing five main menu options: Home, Profile, News, Services, and Contact. Each of these menus has been carefully designed and implemented to ensure optimal user experience and to EThe overall appearance and functionality of this website primarily aim to present information and connect visitors with the Museum 3D Artifact in an informative and engaging manner.



Picture 9. Museum 3D Artifact Website Home Page

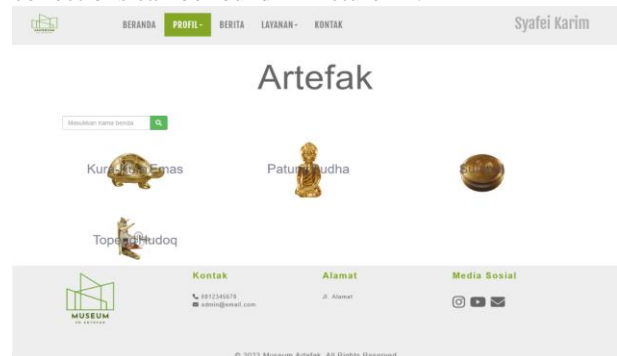
Within the "Profile" menu, there is a submenu called "Collection Items" designed to display a complete list of artifacts available on this website. The appearance of the "Artifact Items" menu can be found in Picture 10. For a more in-depth understanding of a specific artifact collection, users can select the collection they wish to explore in more detail.



Picture 10. Collection Items Submenu on Museum 3D Artifact Website

Picture 11 displays examples of artifacts that have been inputted into the collection. To gain a more comprehensive insight into the three-dimensional aspects of a specific artifact, users can click on one of the artifacts, which will redirect them to a specific detailed page for that artifact. On this detailed page, users will find the prepared three-

dimensional model along with a description covering relevant information about the artifact. Further information about the details of one of the artifact collections can be found in Picture 12.



Picture 11. Artifact Collection Page on Museum 3D Artifact Website



Picture 12. Detailed Description of Artifact Collection on Museum 3D Artifact Website

In summary, the design and development process have successfully integrated the mock-ups of the website interface and the 3D object models into a functional and engaging user experience. The website's intuitive navigation, coupled with detailed artifact representations, provides an informative and visually appealing platform for users to explore and appreciate the Museum.

E. Testing and Implementation

The testing phase of the Museum 3D Artifact website aims to ensure that each unit or small component, such as functions, methods, and classes, operates correctly in isolation. It tests the interaction between components or systems and ensures that the entire website functions according to the plan. The testing phase are carried out using black box testing, a method focused on evaluating the functionality of the 3D Artifact website without internal knowledge of the program's implementation.

Table 1, presenting the result of login page testing. The result indicated that each scenario ran as expected, demonstrating the effectiveness of the login functionality.

Table 1. Login Page Black Box Testing

No	Test Scenario	Expected Result	Test Result	Conclusion
1	All fields on the login page are left blank, then click log in	The system will reject entry and display "please fill out this field" in the username column	As Expected	Valid
2	Fill the username with other fields left blank, then click log in	The system will reject entry and display "please fill out this field" in the password column	As Expected	Valid
3	Fill the username and password with incorrect data, then click log in	The system will reject entry and display "Login Failed. Make sure your email and password are correct"	As Expected	Valid
4	Fill the correct username and password, then click log in	The system accepts the login	As Expected	Valid

Table 2 represent the registration page testing, reveal that all scenarios that executed according to expectations. And table 3 also affirmed that each scenarios perform as anticipated. Table 3 presenting the collection object page testing.

Table 2. Registration Page Black Box Testing

No	Test Scenario	Expected Result	Test Result	Conclusion
1	Username, email, and password are left blank, then click register	The system will reject and display "please fill out this field" in the username column	As Expected	Valid
2	Username is filled but email and password are left blank, then click register	The system will reject and display "please fill out this field" in the email column	As Expected	Valid
3	Username and email are filled but password is left blank, then click register	The system will reject and display "please fill out this field" in the password column	As Expected	Valid
4	Username, email, and password are filled but the password is less than 8 characters, then click register	The system will reject and display "password minimum 8 characters" in the password column	As Expected	Valid
5	Username, email, and password are filled with an 8-character password, then click register	The system will accept and display successful registration, then proceed to the home page	As Expected	Valid

Table 3. Collection Object Black Box Testing

No	Test Scenario	Expected Result	Test Result	Conclusion
1	Click on the collection object navigation	Displays the collection object page	As Expected	Valid
2	Already logged in, on the Collection Object page click on one of the categories, namely artifacts	Displays the artifact collection category page and shows the collection of artifact objects	As Expected	Valid
3	Not logged in yet, on the Collection Object page click on one of the categories, namely artifacts	Displays the category page and shows "You must log in" to view the collection objects	As Expected	Valid
4	Already logged in, on the Collection Object page, in the artifact category, click on one object, namely "Golden Turtle"	The system will display the Golden Turtle detail page	As Expected	Valid
5	On the Golden Turtle detail page, hover over the turtle image	The system will display a zoomed-out view of the object pointed to by the cursor	As Expected	Valid
6	On the Golden Turtle detail page, click the arrow next to the right side of the 3D image of the Golden Turtle	The 3D image of the Golden Turtle will rotate to the right	As Expected	Valid
7	On the Golden Turtle detail page, click the arrow next to the left side of the 3D image of the Golden Turtle	The 3D image of the Golden Turtle will rotate to the left	As Expected	Valid
1	Click on the collection object navigation	Displays the collection object page	As Expected	Valid

After testing phases, which each feature was examined to ensure it operates as expected, the next phase is to publish the museum 3D artifact website. This process involves placing or hosting the website on a server accessible to the public. The website becomes accessible to anyone with internet access. It allows users to begin exploring the 3D artifact collections, and enjoying other developed features. The publishing process also includes server and domain configuration, ensuring data security, and confirming the website's online availability.

IV. CONCLUSION

The Museum 3D Artefak website development successfully addresses the challenges of presenting cultural heritage and artifacts digitally. Meticulous planning results in an engaging platform for exploring the museum's collection. User interface design plays a crucial role in shaping the user experience, ensuring intuitive navigation through web pages and user-friendly mock-ups. 3D object modeling adds depth and realism to displayed

artifacts, enhancing their visual appeal. Texture integration using Blender achieves authentic representations. The implementation provides an immersive experience, contributing significantly to cultural heritage preservation. Users can explore artifacts in intricate detail, transcending physical museum limitations. The interactive platform fosters engagement and broadens cultural education access.

The Museum 3D Artifact Website show the integration of technology, design, and cultural preservation, paving the way for the digital future of museums. It stands as a testament to digital platforms' potential in preserving and promoting cultural heritage, inspiring future digital museum endeavours.

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