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Creative Visualizer: A Web-Based Tool for Aesthetic Simulation Via Digital Object Wrapping

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Abstract: *Vehicle wrapping has evolved as a widely adopted method for object personalization, particularly in the automotive sector, offering both aesthetic enhancement and surface protection. However, a recurring challenge lies in the limited ability of users to visualize how specific materials and patterns will appear when applied to real objects. Existing catalogs and samples do not provide a reliable simulation of the final result, often leading to uncertainty in the decision-making process. This paper presents the development of Creative Visualizer, a web-based application designed to enable users to preview digital wrapping projects using image manipulation techniques. The system allows users to upload images, define regions of interest, apply wrapping textures, and export visual simulations of the result. Built with a modular architecture based on the MVC pattern and developed using best practices in software engineering, the tool provides a user-friendly and scalable platform for planning customized designs. Initial results demonstrate the system's effectiveness in offering realistic and intuitive previews, supporting both consumers and service professionals. Future work includes the integration of 3D visualization, material libraries, and AI-based recommendation features to enhance user experience and design accuracy.*

Keywords – *wrapping, software, image manipulation, artificial intelligence, customization.*

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I.INTRODUCTION

Automotive wrapping has become a prominent trend in recent decades, providing a highly versatile and easily applicable method for vehicle personalization and protection. Originally developed in the aerospace sector for military applications, vehicle wrapping later migrated to the automotive industry, offering not only aesthetic enhancement but also protection against external factors such as UV radiation, acid rain, and road pollution [1]. Its success in the automotive sector led to further applications on appliances, furniture, and architectural elements, creating a growing demand for materials and adhesives specifically designed for a variety of surfaces.

The global vehicle wrapping market is experiencing substantial growth. According to Transparency Market Research, the number of wrapped vehicles increased from 7.18 million units in 2020 to a projected 26.99 million units by 2031, with a compound annual growth rate (CAGR) of 12.65% between 2021 and 2031 [4]. This surge further highlights the growing demand for efficient planning and visualization tools to assist consumers and professionals in the customization process.

In addition to market growth, recent research has examined the role of visual elements in automotive design and advertising. Ardislamova [5] highlights the power of visual symbols, such as logos and car shapes, to create emotional resonance and brand identity in automotive advertising. Nash [6], through his artistic research, connects the philosophy of car customization with narrative creation, describing it as a rebellious act of shaping both vehicles and text. Jaafarnia and Punekar [7] identify the key visual elements of automotive form, such as line, shape, color, and texture, as primary drivers for establishing emotional communication between cars and users.

Despite the availability of printed samples and catalogs, there remains a significant gap in the market for tools that allow consumers to preview the final appearance of their customized objects before the service is executed. This limitation creates uncertainty and difficulty in selecting the most suitable combination of colors, textures, and materials for a specific object. The lack of visualization capabilities also poses challenges to service providers in terms of planning and material estimation.

Parallel to these developments, advances in inkjet printing technologies have allowed the automotive wrapping industry to incorporate durable UV-curable inks, ensuring high color stability and resistance to environmental factors [2]. Studies have shown that certain film types, such as 3M Scotchcal, exhibit superior color permanence under accelerated aging conditions, making them preferable for high-quality vehicle wraps [2].

In addition to aesthetic and protective benefits, automotive wrapping also offers significant environmental advantages. According to Carlike Wrap, the process of vehicle wrapping uses fewer harmful chemicals and generates less waste compared to traditional painting. Moreover, vinyl films can be removed without damaging the original paint, facilitating recycling and reducing environmental impact [9].

Moreover, vehicle wrapping has evolved beyond personalization and protection; it has become an innovative advertising tool. Recent research analyzing the case of Tokopedia, a leading e-commerce company, demonstrates that vehicle-wrapping advertising significantly improves brand awareness and purchase intention among consumers [3]. The findings highlight that vehicle wrapping, though not a primary advertising medium, serves as a powerful complementary strategy in multi-channel marketing efforts [3].

Given this context, this work proposes the development of an interactive visualization system for object wrapping projects. Through image recognition, manipulation, and artificial intelligence, the system aims to provide users and professionals with realistic previews of wrapping designs prior to execution, improving decision-making and enhancing the overall customer experience.

II.METHODOLOGY

The present investigation is characterized as applied research, as its purpose is to generate knowledge aimed at solving concrete problems with immediate applicability. According to Tumelero [8], applied research consists of a specific method that involves the practical use of scientific knowledge, being particularly effective in addressing everyday challenges, often linked to real and contextual demands.

Regarding the methodological approach, a qualitative perspective is adopted, aiming for an in-depth understanding of the phenomena under investigation, with an emphasis on subjective, descriptive, and interpretative aspects. According to Gerhardt and Silveira [10], qualitative research seeks to understand the "why" behind situations and behaviors, interpreting meanings and symbolic interactions without resorting to statistical measurement or direct empirical verification. The data analyzed in this type of approach are predominantly non-metric, derived from interactive and exploratory contexts.

The study also presents an exploratory nature, aiming to expand the understanding of the phenomenon under analysis, providing a basis for future formulations and the construction of more robust hypotheses.

As for the methodological procedure, a development research approach is adopted, focusing on the design and implementation of a computational solution aimed at solving a practical problem. This strategy allows the proposal to be validated through the creation of a functional artifact and its subsequent analysis regarding its utility and applicability in the target context.

2.1 Physical Architecture

With the completion of the software development, it is planned to register a dedicated domain and host the application on a dedicated server, in order to ensure greater autonomy, availability, scalability, and operational security for the proposed application.

The system architecture was designed using a layered functional model, comprising the user interface (front-end), application logic and control (back-end), as well as network and storage services, as illustrated in Figure 1.

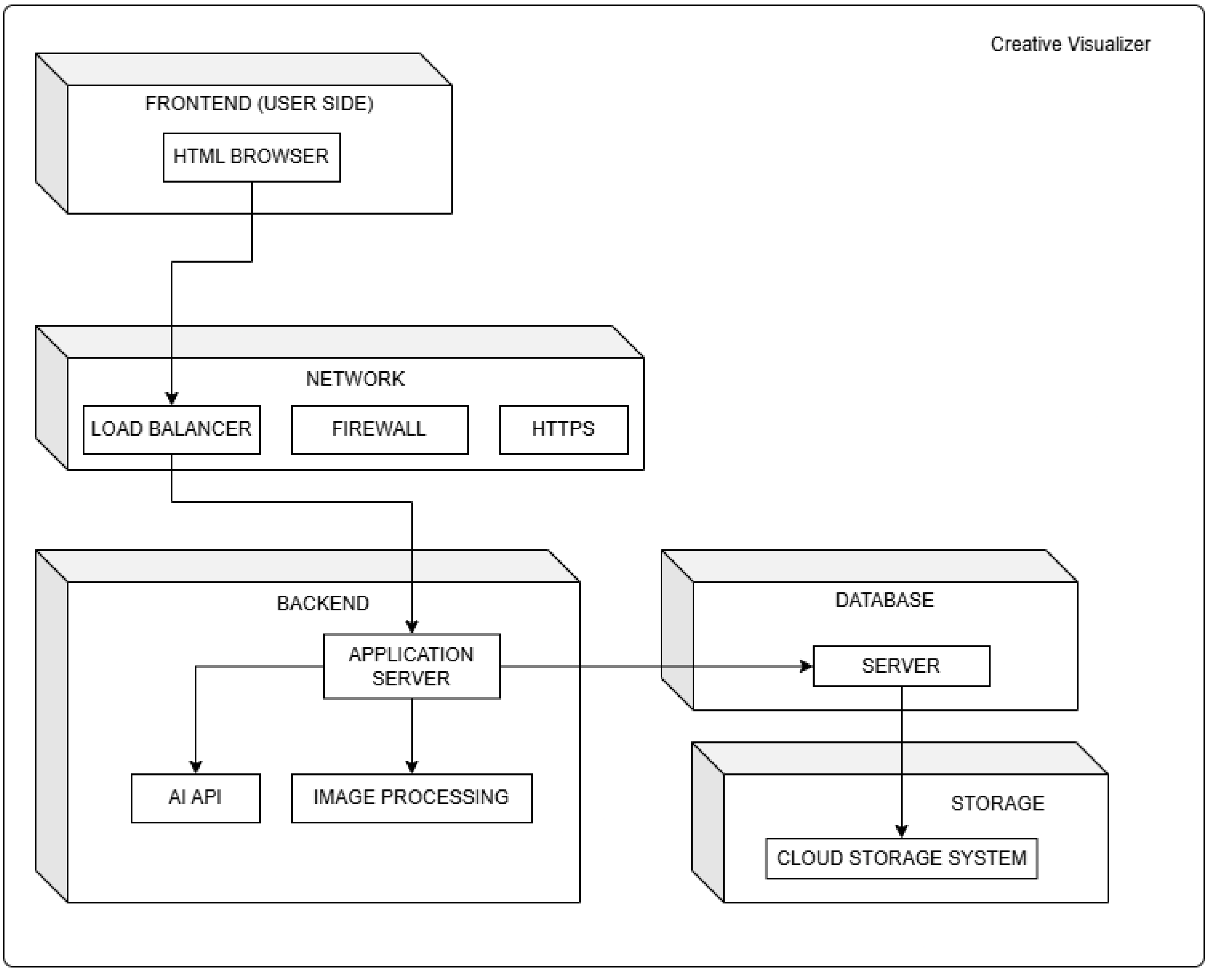


Figure 1. Physical architecture of application

2.2 Logical Architecture

With the aim of promoting efficiency, scalability, and maintainability of the proposed application, this section presents the system's logical architecture. The main components that make up its internal structure, the functional and non-functional requirements, as well as the business rules that guide its behavior, are described. The logical organization of the application was designed to provide an intuitive user experience while also facilitating future enhancements and technological integrations.

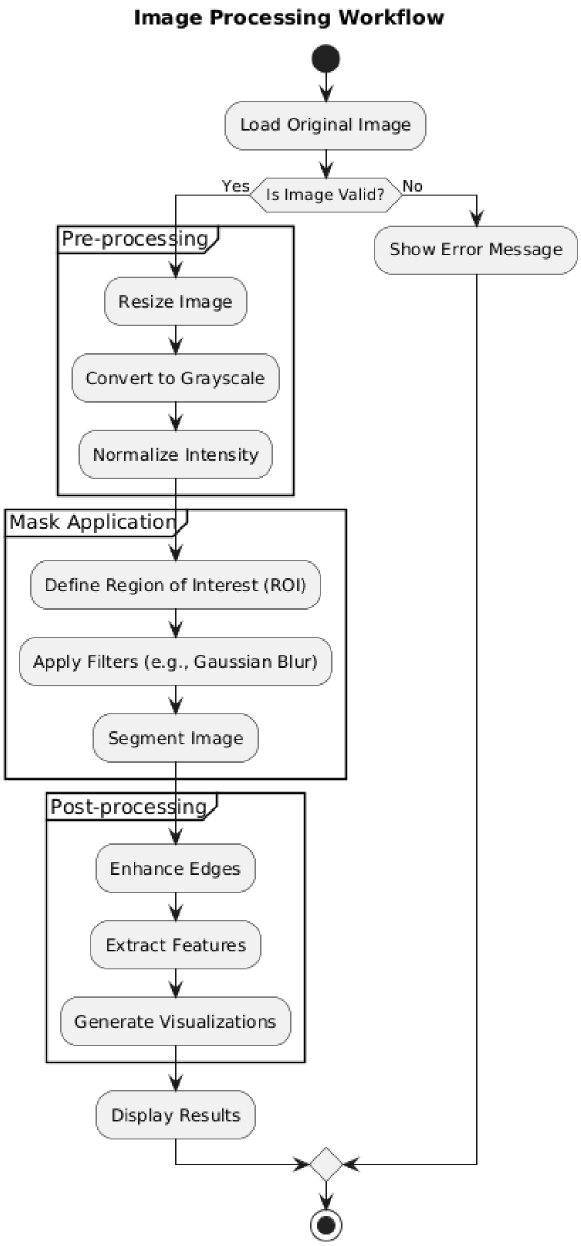


Figure 2. Image processing workflow of application

2.2.1 Software Architecture and Best Practices

During the development of the system, software engineering best practices were adopted to ensure code readability, modularity, and maintainability. The main strategies used include:

- Organization of the directory and file structure to facilitate the location and reuse of components;
- Application of clean code principles, with descriptive names for variables and functions, promoting self-explanatory and understandable code;
- Modular testing of implemented functions to verify expected behavior consistency and ensure proper integration between the application's components.

The adopted software architecture is based on the Model-View-Controller (MVC) design pattern, which is widely used for developing applications with graphical interfaces. This pattern promotes the separation of responsibilities between components, enhancing scalability, maintainability, and code reuse.

- The Model is responsible for managing data and business rules of the application. Any data modifications trigger notifications to the other components.

- The View represents the graphical interface and defines how information is presented to the user.
- The Controller acts as an intermediary between the model and the view, processing user input and updating other components as needed.

2.3 Technologies Used

The work incorporates a combination of front-end and back-end technologies to deliver an interactive web application focused on image processing and visualization. The core of technologies is as follows:

- Python: The primary language of the application, Python is widely used for web development and image processing. Its clear syntax and extensive libraries make it ideal for scientific and academic applications.
- Flask: Flask is a lightweight Python web framework that enables the simple and fast creation of web applications. In this project, Flask is likely used to manage routes, handle HTTP requests, and integrate the back-end with the front-end.
- HTML and CSS: HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) are fundamental for structuring and styling web pages. They are used in the project to create the user interface, defining the layout and visual aesthetics of the application.
- JavaScript: JavaScript is a programming language that allows interactivity to be added to web pages. It is likely used in the project to manipulate interface elements, respond to user events, and dynamically update the displayed content.
- Socket.IO: The integration of Socket.IO, through Flask-SocketIO, enables real-time communication between the client and the server. This technology is essential for providing an interactive experience during area selection, mask visualization, and texture application, ensuring instant responses to user actions.
- Image Processing Libraries: While not explicitly specified in the repository, it is common for Python image processing applications to use libraries such as OpenCV or PIL (Python Imaging Library). These libraries provide functionalities for reading, manipulating, and analyzing images, which are essential for the features proposed in the project.

2.4 Pre-Processing: Mask Generation and Background Removal

The generation of masks and subsequent background removal are key steps in the system, especially for isolating visual elements of interest to enable their use in architectural compositions and interior design projects with greater flexibility.

The system employs a hybrid approach that combines traditional image processing techniques with artificial intelligence-based methods:

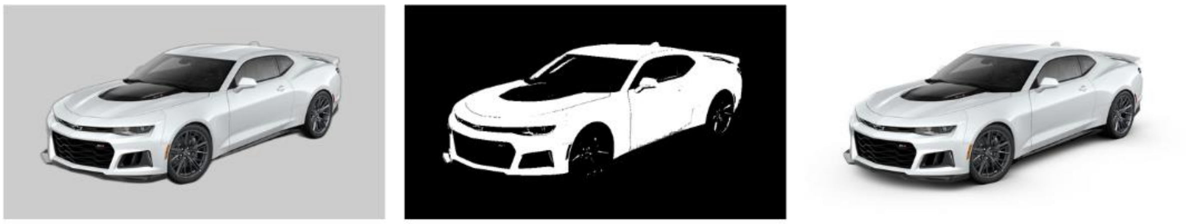
2.4.1 Mask Generation with OpenCV

Initially, the image is processed using the OpenCV library, applying the following operations:

- Conversion of the original image to grayscale;
- Application of Gaussian blur for noise reduction;
- Edge detection using the Canny algorithm;
- Creation of a binary mask that highlights the contours of the main object. This step provides a useful visual reference for validation or manual adjustments by the user.

2.4.2 Background Removal with Rembg

After the segmentation step, the system performs background removal using Rembg, a library based on neural networks specifically trained for this task. This tool is capable of automatically and accurately separating the object of interest from the background, generating a final image with a transparent background, ideal for insertion into virtual environments. The Figure 3 illustrates this process in three visual steps.



a. b. c.

Figure 3. Demonstration of the mask generation process: a) Original image with background; b) mask generated with OpenCV; and c): final image without background, obtained using Rembg.

This combined approach provides a robust and practical solution, enabling users to quickly obtain ready-to-use images for realistic visualizations in their creative projects.

III.RESULTS

This section presents the main results obtained from the development of the proposed system, highlighting the implemented features, the graphical interface, and the user interaction flow. It describes the visual aspects of the application and how the system enables the simulation of sticker application on images, providing an intuitive and accessible preview of wrapping projects.

Figure 4 illustrates the application's home screen, where the user is invited to upload the image that will be used in the wrapping preview process. This interface was designed with a focus on usability, prioritizing simplicity and clarity of instructions for uploading the image, in order to facilitate the start of interaction even for users with limited experience in digital tools.

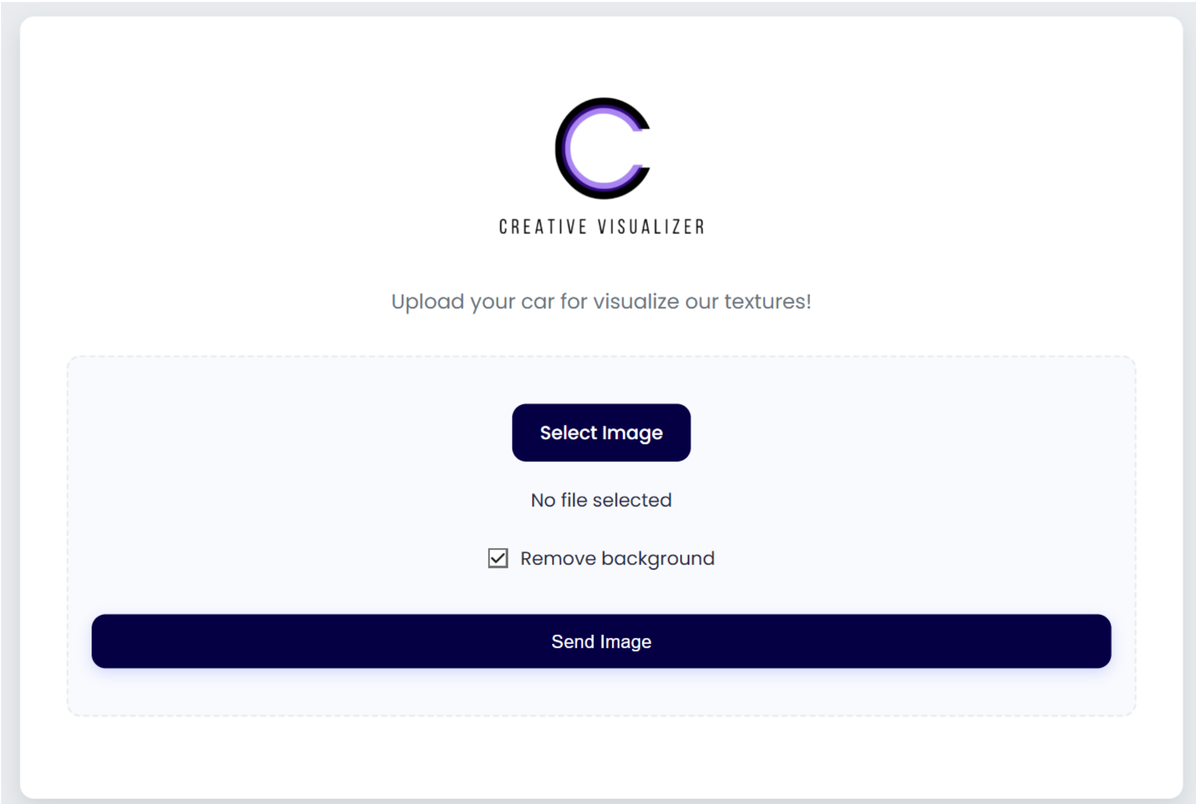


Figure 4. Initial screen for uploading the reference image

Figure 5 presents the main interface of the application, where the image uploaded by the user is displayed — in this example, a vehicle. This step represents the working environment of the tool, allowing the user to preview the reference image before applying the stickers. The interface has been designed to provide a wide and clear view of the original image, serving as a base for selecting the region of interest where the visualization technique for wrapping elements will be applied.

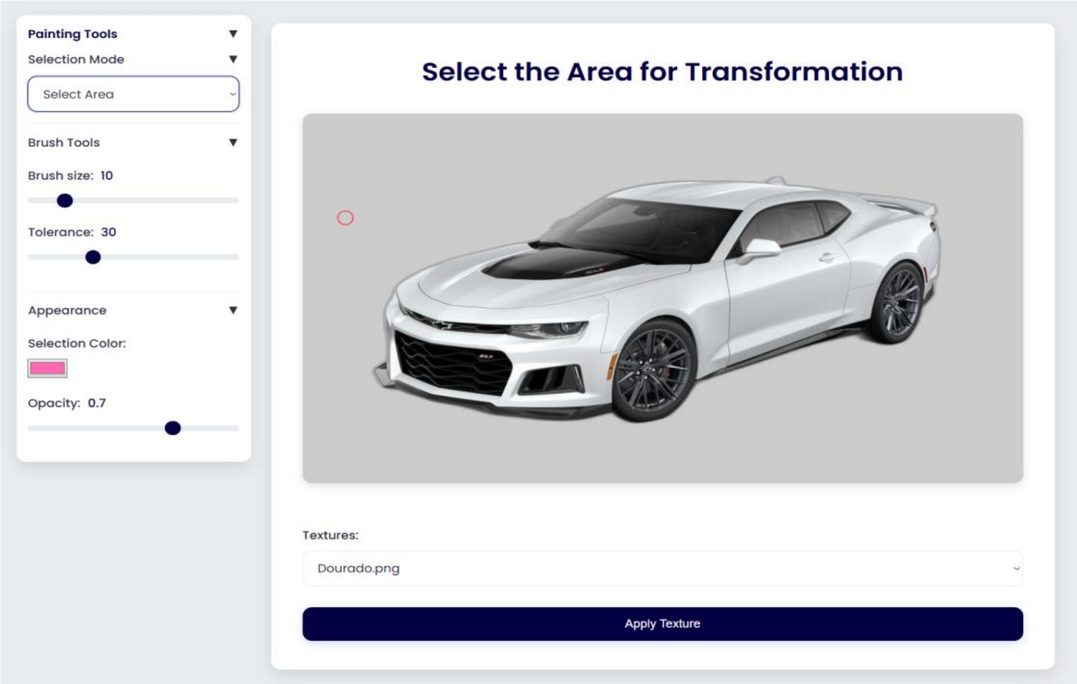


Figure 5. Application screen: an example of a vehicle for applying the visualization technique

Figure 6 shows the step of selecting the Region of Interest (ROI) on the uploaded image. This feature allows the user to precisely define the specific area where the sticker will be applied. The ROI selection is crucial to ensure the accuracy of the preview, enabling the wrapping simulation to be restricted to the desired zone, which enhances precision and control over the final project outcome.

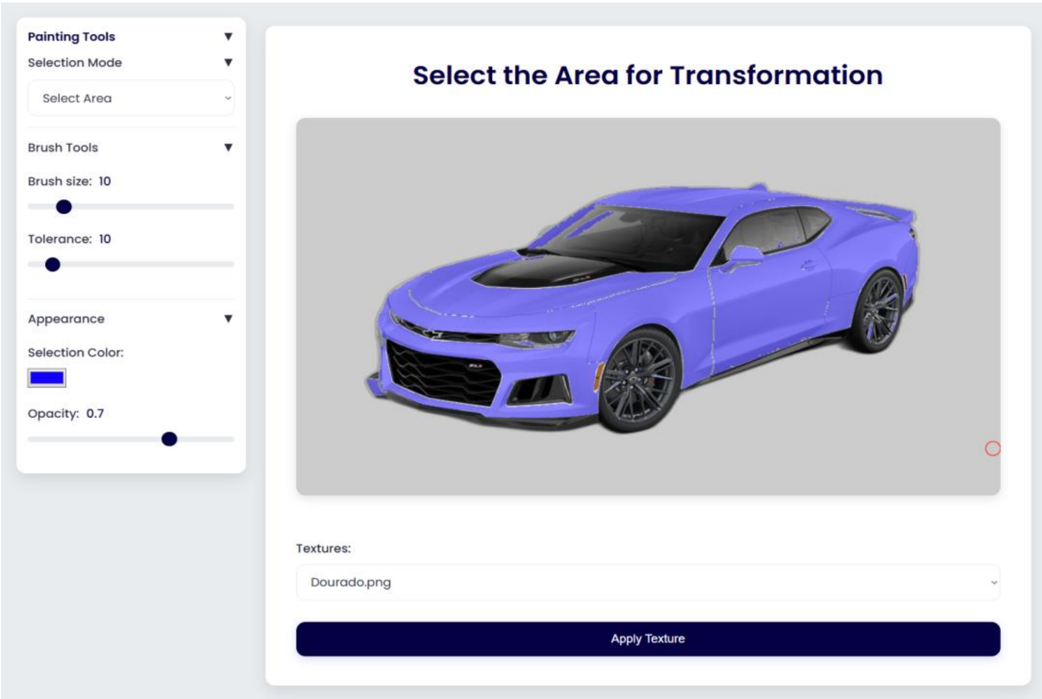


Figure 6. Region of Interest (ROI) selection for texture application

Figure 7 demonstrates the result of applying the wrapping texture onto the previously selected image. This step corresponds to the final project preview, where the user can observe how the chosen material visually behaves when applied to the real object. The texture rendering respects the defined area and the original proportions of the image, providing a realistic simulation that supports decision-making before the physical execution of the wrapping.

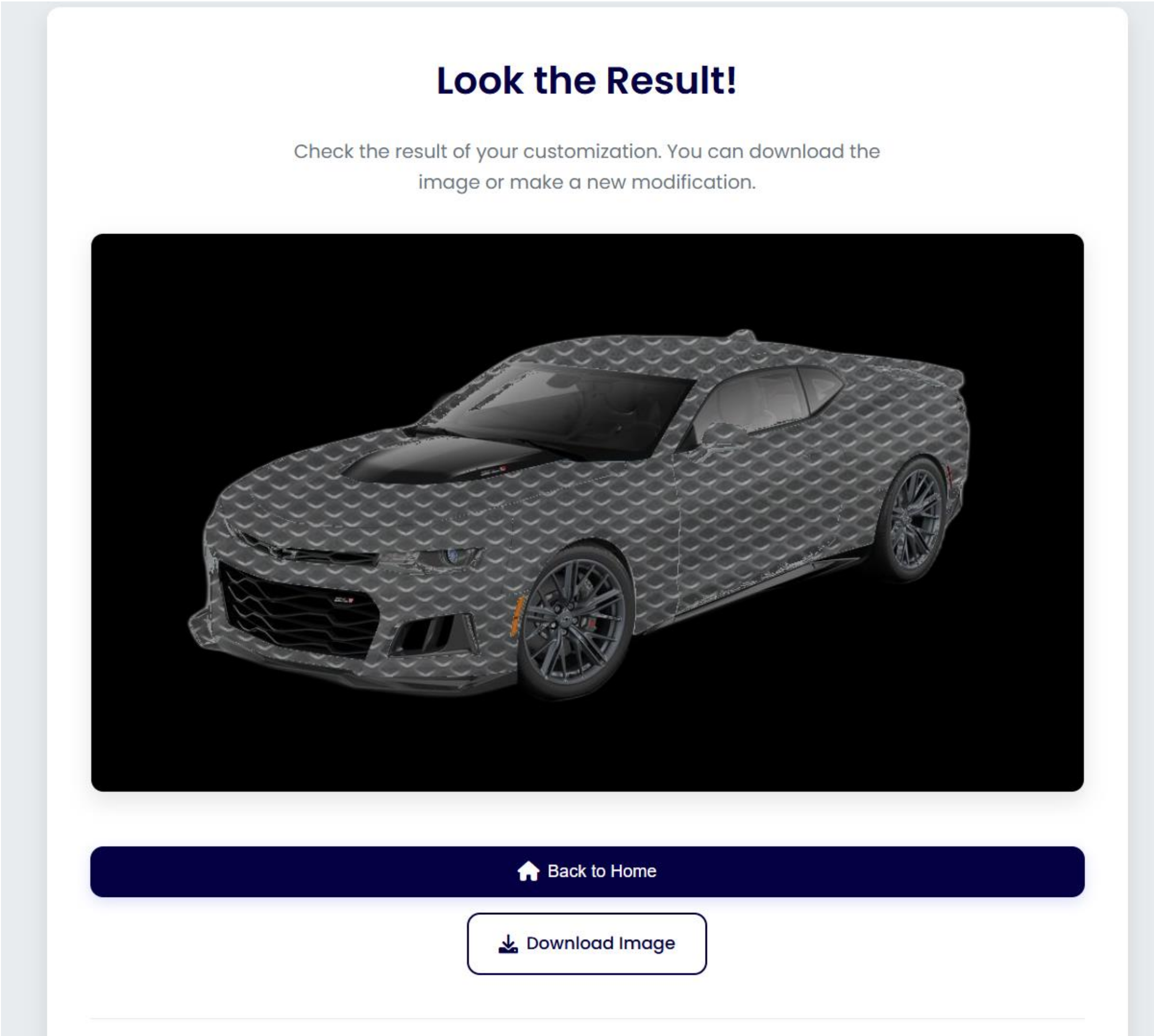


Figure 7. Texture application on the selected area

IV.CONCLUSION

This work presented the development of a web application designed for the preview of wrapping projects, focusing on the realistic simulation of sticker application onto user-provided images. The proposed solution aims to address a recurring gap in the visual customization process by enabling users and professionals to achieve greater predictability and aesthetic control before the physical execution of the service.

The adopted architecture, based on the MVC model and supported by best development practices, enabled the construction of a modular, intuitive, and scalable system. The implemented functionalities — including image upload, region of interest selection, texture application, and preview generation — have demonstrated adherence to the functional requirements and successfully met the proposed objectives.

For future work, it is suggested to expand the system with 3D rendering capabilities, integration with commercial material libraries, and the implementation of intelligent suggestion algorithms based on user preferences. Such enhancements could increase the tool's potential as a technical and creative support resource in contexts such as design, advertising, and automotive customization.

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