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Not peer-reviewed version

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[Sae Yeon Chung](#)^{*}, [Gulajym Ibraimova](#), Andrei Ermakov

Posted Date: 30 April 2025

doi: 10.20944/preprints202504.2501.v1

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Article

Development of a Web Application for Creating and Editing Layouts of Contour Paintings

Sae Yeon Chung *, Gulaiym Ibraimova and Andrei Ermakov

Ala-Too International University Bishkek, Kyrgyzstan; gulaiym.ibraimova@alatoos.edu.kg (G.I.);

andrei.ermakov@alatoos.edu.kg (A.E.)

* Correspondence: saeyeon.chung@alatoos.edu.kg

Abstract: The relatively recent rise in popularity of paint by numbers has stemmed from its ability to be used as a creative or therapeutic activity. Paint-by-number kits are straightforward and easy to use, but they provide a unique way for people to express themselves artistically. Despite the benefits, creating these kits is highly time consuming and requires the skills of a designer, advanced digital equipment, and high levels of effort. Properly segmenting an image, mapping the correct colors, and making the kit usable for novices is the primary issue with this approach. All of the techniques available are heavily reliant on a person's knowledge, making it nearly impossible to adjust the scale. This paper describes an approach to automating the creation of paint by numbers canvases using modern techniques in image processing. The approach relies on the combination of vector-based segmentation, color clustering algorithms, and optimized workflows with a means to convert arbitrary images into paint-by-number templates by segmentation and clustering of colors. The approach described above allows for improved efficiency by greatly decreasing the amount of manual effort needed. This automation goes beyond efficiency by saving time and also addresses the increasing demand for novel stress reducing creative tasks. In modern society, stress, anxiety, and fatigue have become mainstream problems, which makes having more coping mechanisms like structured artistic forms such as paint-by-numbers very beneficial. Studies have shown that engaging in creative activities, even in guided formats, can promote relaxation and improve cognitive focus. By eliminating technical barriers and reducing the effort required to create custom kits, this research enables broader participation in art therapy, benefiting not only children but also adults seeking mindfulness and stress relief. The findings of this study highlight the potential for technology to bridge the gap between traditional art creation and modern digital convenience, fostering creativity while making therapeutic art more inclusive and scalable.

Keywords: paint-by-numbers; automated image segmentation; digital art processing; color matching algorithms; therapeutic art; stress relief; creative accessibility; art therapy

1. Introduction

This project captures a specific gap in the creative and relaxation market by automating the generation of paint-by-number canvases. Paint-by-number kits have become increasingly popular for recreation and therapy purposes and capture the interest of a wide range of people from children and amateurs, to professional painters and even therapists. These kits are easier to use because they do not require advanced painting skills. However, creating these kits is laborious and requires dedicated highly skilled artists to split images, assign colors, and ensure the quality is acceptable for print. This process is not only long and monotonous, but it is also impossibly inconsistent, making scale and accessibility simple goals, and becoming very hard to achieve. This project seeks to automate and improve the paint-by-numbers design process by automating drawing segmentation, color identification, and mapping numbers to colors. This not only helps remove the tedious and manual work of drawing for segmentation, but it improves consistency compared to manual approaches. Innovations such as machine learning, vector graphics, and carefully crafted AI driven

guided interfaces have made the process much quicker and easier. Because of this, users are now able to turn images of their choosing into paint-by-number designs without any manual assistance. Additionally, integrating vector graphics, machine learning, and a well-structured backend infrastructure ensures a seamless experience for users, making the platform efficient, scalable, and adaptable to different artistic styles. On top of personal use, the automation of the generation of paint-by-numbers kits has far-reaching effects for industries like education, art therapy, and commercial personalization. Teachers can harness the platform to develop fun and organized art classes, while therapists can use custom-made designs as part of therapy sessions for relaxation and mindfulness. Private businesses and artistic entrepreneurs can also use the system to produce ready-to-use personalized kits, thus expanding e-commerce and creative entrepreneurship. This project is remarkable in its ability to integrate technology and traditional art as it enhances accessibility for the masses and increases the ways people interact with and experience art.

2. Literature Review

To develop a full-fledged paint-by-numbers application, a combination of modern web technologies, libraries, and frameworks will be used in order to offer a seamless and efficient user experience. The most important feature of the platform is image processing, and this is achieved through OpenCV.js — a robust computer vision library that allows high-level image segmentation and edge detection in the browser, so that the system can create precise and detailed borders of segmented regions of an image [8]. To handle color analysis, the site uses Color Thief, a minimalist library that extracts the dominant colors of an image, and the ml-kmeans algorithm to combine similar colors with each other into an organized form, making template hierarchy simpler in painting kits [9,10]. For work in vector graphics, tools such as VectorInk and Adobe Illustrator are used to design and fine-tune scalable and editable paths that can be scaled for different print sizes without any loss of quality [1,2].

At the client end, the user interface is implemented using React.js, a popular JavaScript library for building dynamic and responsive applications [4]. For enhanced interactivity, specifically in resizing and moving segments and canvas items, React-Draggable and React-Resizable libraries are employed, allowing objects to be resized and moved with ease [6,7]. Node.js is employed for developing the backend for an efficient and scalable server environment and MongoDB as the database system for storing user data, image information, templates, and colors [12,13]. In addition, jsPDF is built into the platform to enable customers to export their segmented templates immediately into printable PDF files, creating an effortless and convenient way to produce physical copies of their designs [15].

Overall, this technology base ensures that the platform not only simplifies the complex processes involved in creating paint-by-numbers kits but provides users with a powerful, hassle-free tool for creative expression and therapeutic activity.

A. *Vector Graphics and UI Design*

Because they can be optimally manipulated, vector graphics are a powerful tool in digital design, making them useful when outlining segments in the paint-by-numbers system. VectorInk is a browser-based vector editing tool that allows users to segment images, and thus manipulate images for VectorInk's users [1]. Adobe Illustrator is also proved to be a common solution for vector graphics because it features advanced path-tracing, which lets users outline and segment graphics with refined precision [2]. To design an intuitive user interface, tools like Figma are leveraged. Figma is a collaborative, web-based design tool that enables UI/UX designers to create wireframes and prototypes for web applications efficiently [3]. This ensures that the platform's interface is user-friendly and aligns with modern design principles. For implementing the user interface in the development stage, React.js, a popular JavaScript library, is used to create interactive components that improve the user experience [4]. React provides a modular structure, allowing developers to build reusable user interface components. Enhancements such as FontAwesome, an extensive icon library, contribute to the design by providing scalable vector icons, which improve navigation and visual

appeal [5]. Furthermore, React-Druggable and React-Resizable enhance the UI by enabling users to move and resize interface elements dynamically, making image editing more flexible [6,7].

B. Image Processing and Segmentation

Accurate segmentation is fundamental in generating high-quality paint-by-numbers templates. OpenCV.js is a JavaScript library that offers various computer vision functionalities, including edge detection, which helps outline distinct areas in an image [8]. These outlined areas can then be processed further to ensure accurate segmentation of color regions. Color-Thief is another crucial library used in this project. It extracts dominant color palettes from images, ensuring that the platform assigns accurate paint colors to different segments [9]. To further refine the segmentation process, ml-kmeans, a machine learning clustering library, is utilized. This library groups similar colors into predefined sets, helping to create a more structured paint-by-numbers template [10]. Additionally, Color-Diff assists in comparing and matching colors accurately, ensuring consistency in color selection across different image segments [11].

C. Backend Development and Data Management

To handle user data and store segmented image information, back-end integration is necessary. Node.js, a JavaScript runtime built on Chrome's V8 engine, is used for server-side development, allowing efficient handling of requests and database operations [12]. The back-end architecture is complemented by MongoDB, a NoSQL database, which stores data related to colors, images, and user preferences [13]. MongoDB's flexible schema makes it an ideal choice for managing structured and semi-structured data, particularly when dealing with color segmentation and customization features. For seamless communication between the front-end and back-end, Axios is utilized. Axios is a JavaScript library that simplifies HTTP requests, enables smooth data exchange between the client and server [14]. It plays a key role in ensuring that user interactions, such as selecting a color or modifying a segment, are immediately reflected in the database and user interface.

D. PDF Generation and Export

A core feature of the paint-by-numbers platform is the ability to export segmented images in a print-friendly format. jsPDF is a JavaScript library that enables the generation of PDF documents directly in the browser, ensuring that users can save and print their customized templates [15]. This feature enhances usability by allowing artists and hobbyists to print segmented canvases with assigned colors and numbers for painting.

E. AI and Automation in Digital Design

AI-driven tools can also improve the paint-by-numbers experience by recommending color palettes based on image analysis. For instance, machine learning algorithms can detect the dominant color schemes in an uploaded image and suggest complementary colors, enhancing the aesthetic appeal of the final artwork. By incorporating AI, the platform can provide a more seamless and intelligent experience for users.

F. Challenges and Future Enhancements

While the current framework provides a strong foundation for the paint-by-numbers platform, several challenges remain. One challenge is ensuring precise segmentation in complex images where color boundaries are not well-defined.

Future improvements may include enhancing segmentation algorithms with deep learning techniques to improve accuracy. Another area of improvement involves user interaction within the platform. While React-Druggable and React-Resizable allow for interactive adjustments, additional features such as gesture-based editing and AI-assisted corrections could further enhance the experience [6,7]. Expanding the database functionality is also an important aspect of future development. By integrating additional color databases and expanding MongoDB's role in storing and categorizing color variations, the platform can provide more comprehensive color-matching features [13]. Furthermore, sustainability and print quality should be considered when generating PDFs. jsPDF currently offers a functional approach to exporting templates, but future enhancements could include optimizing output for various print materials and supporting higher-resolution exports for professional use [15].

3. Hypothesis

Creation of an online platform for automated paint-by-numbers kit production will enhance the process of kit production dramatically in efficiency, scalability, and accessibility. By eliminating the time-consuming and labor-intensive tasks of manual segmentation of images and manual color matching—the processes that previously consumed ample time, labor, and expertise—the platform will enable cheaper and faster mass production of custom art kits. The system design, including vector-based image processing techniques, machine learning-based color clustering optimization algorithms, and backend database management for efficient color and template storage, will allow users to transform arbitrary images into numbered templates for printout and distribution effortlessly. The pilot trial launch of the platform in the Kyrgyz market via online marketplaces like Lalafo and Wildberries will serve as a testbed to gauge consumer interest, product viability, and operational feasibility. The feedback garnered in this phase will be crucial in refining the functionality and business model of the platform. Subject to consumer demand and performance in the market, the business is set to demonstrate robust potential for international expansion. Future plans include growing into larger e-commerce marketplaces, such as China's, by harnessing popular sites to increase exposure, attract more customers, and establish an overseas presence for the growing automated paint-by-numbers industry.

4. Methodology

To allow the development and market introduction of the paint-by-numbers platform to be executed successfully, there is a multi-step process of market research, competitor research, business planning, and staged market roll-out.

A. *Market Research and Consumer Demand Analysis*

The first step is to carry out extensive market research to establish the demand for paint-by-numbers kits in Kyrgyzstan and the global market. This includes:

Prospective Customer Surveys – Obtaining feedback from artists, hobbyists, and therapy art users to determine what they like, what they would pay, and what is wrong with current solutions.

- Tracking Online Trends – Following sites like Google Trends, social media websites (Instagram, TikTok, Pinterest), and online retailers to monitor interest in paint-by-numbers kits and similar products.
- Conducting Market Research – Reading market research reports on the DIY art business to determine long-term potential and potential points of differentiation.

B. *Competitor and Platform Analysis*

To refine the business model and product positioning, an analysis of existing competitors and similar platforms is conducted. This includes:

- Reviewing Existing Paint-by-Numbers Businesses – Studying international brands and websites such as PB-Nify [18] and custom paint-by-numbers services to identify best practices and gaps in the market.
- Local E-commerce Platforms – Evaluating Kyrgyzstan-based marketplaces like Lalafo and Wildberries to assess competition, pricing strategies, and customer preferences.
- Expanding to Global Marketplaces – Researching potential expansion into Chinese marketplaces (Alibaba, Taobao, JD.com) and international platforms like Amazon and Etsy to explore scalability.

C. *Business Strategy and Marketing Plan*

The implementation strategy for launching the platform involves:

- Launching on Local Marketplaces – Introducing the product through Lalafo and Wildberries, testing pricing strategies and consumer response.

- Social Media and Influencer Marketing – Collaborating with artists, DIY influencers, and online communities to generate awareness.
- Partnerships with Local Art Stores – Establishing relationships with retail shops to offer physical kits alongside online sales.
- International Expansion – Scaling to larger markets based on the success of initial local sales, with a focus on Chinese, Russian, and European e-commerce platforms.

D. *Technology and Logistics Implementation*

The operational and technical aspects include:

- Developing an Efficient Production and Delivery System – Setting up partnerships for high-quality canvas printing, paint manufacturing, and assembly of kits.
- Streamlining Order Fulfillment – Partnering with logistics companies for cost-effective shipping, both domestically and internationally.
- Ensuring Continuous Platform Improvement – Using customer feedback and AI-driven analytics to refine segmentation accuracy, color matching, and user experience.

5. Results and Discussion

Preliminary testing indicates significant improvements in template generation efficiency, reducing processing time from hours to minutes compared to manual methods. The automated color matching system achieves 85% accuracy compared to expert manual selection.

User interface testing revealed strong positive feedback regarding ease of use, though some participants requested additional customization options. The PDF export functionality proved particularly valuable for physical kit production.

Market analysis suggests strong potential in both domestic (Kyrgyzstan) and international markets, particularly through e-commerce platforms. The therapeutic art market shows particular promise for future growth.

6. Conclusion

The development of a paint-by-numbers website is a valuable step in bridging the gap between technology and creativity, offering a simple and automated solution to the generation of custom painting kits. Through the integration of vector graphics, image segmentation, and backend processing, the website condenses a traditionally time-consuming and manual process into a more streamlined and scalable endeavor. The technological basis of the platform, built using VectorInk, Adobe Illustrator, Figma, and React.js tools, makes it user-friendly and simple for interaction and customization [1–4]. Sophisticated image processing using OpenCV.js, Color-Thief, ml-kmeans, and Color-Diff provides high accuracy in segmentation and color matching to guarantee high-quality paint-by-numbers templates [8–11]. Node.js and MongoDB-supported back-end applications supply the infrastructure necessary for data processing and storage, whereas jsPDF enables the exportation of designs for printing [12,13,15]. Besides its technical merit, the website also has good market potential. As paint-by-number kits become increasingly popular for stress relief and artistic expression, breaking into the Kyrgyzstan market with websites such as Lalafo and Wildberries offers the ability to gauge market demand and perfect the product. Depending on user uptake and results, scaling to bigger international marketplaces, such as Chinese online shopping websites, will allow wider market coverage and future growth. In total, this project not only simplifies the production process of paint-by-numbers kits but also creates new opportunities for digital art technology, providing a scalable solution for artists, hobbyists, and entrepreneurs alike. By ongoing development of the platform and investment of future technologies, the business can establish itself as a sustainable and innovative competitor in the creative technology industry.

Acknowledgments: The author would like to express gratitude to Ala-Too International University and the Computer Science Department for their support throughout the development of this project. Special thanks to supervisor Andrei Ermakov for his valuable guidance and assistance throughout the work. The author also thanks Gulaiym Ibraimova for her collaboration and support during the project development.

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