Palette-Based Colorization for Vector Icons

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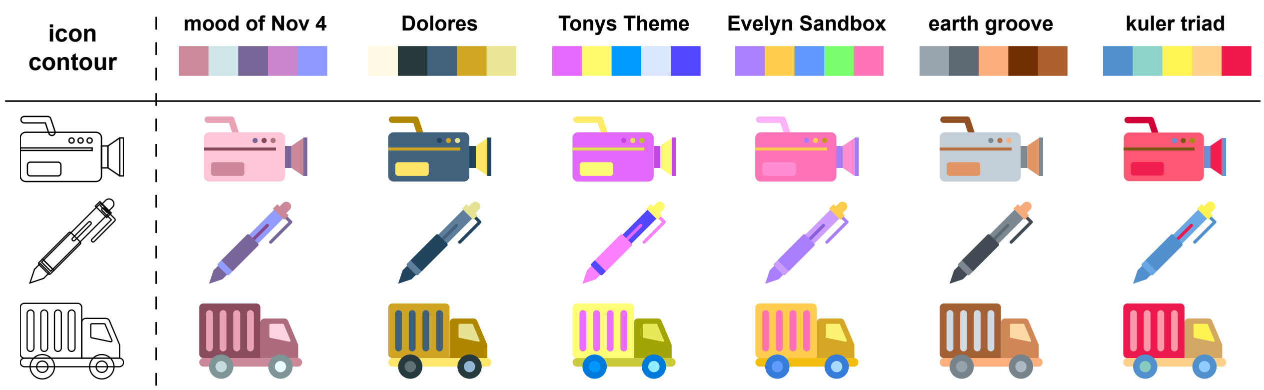

Figure 1: Given an input icon contour in vector format, our method can generate different colorized icons using different color palettes. Designers can further customize the colorization results directly in vector format.

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1 INTRODUCTION

Icons are widely used in designing posters, websites, and banners. Coloring is an essential but time-consuming step in icon design, where designers need to consider various references and constraints, such as text descriptions, color palettes, and overall icon styles. Previously, neural-based methods have been proposed to simplify the process of colorizing bitmap icons [Li et al. 2022]. However, in icon design workflow, vector graphics is the preferred shape representation. Consequently, most of the previous works on colorizing bitmap icons [Li et al. 2022] can not be seamlessly integrated into the standard icon design workflow.

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In this paper, we present a palette-based colorization algorithm for vector icons without rasterization. Given a vector icon and a five-color palette, our algorithm generates various colorized results for designers to choose from. Inspired by the common icon design workflow, we develop our algorithm to consist of two steps: generating a colorization template and performing palette-based color transfer. First, we present a vector icon colorization network that employs a novel MRF-based loss function and a color harmonic loss to generate various colorization templates that composed of harmonious color combinations. Finally, we map the color templates generated by the colorization network to chroma-like palette colors and optimize the relative lightness between curves as final colorization results.

2 METHOD

The input of our colorization pipeline is an icon contour and a five-color palette. Inspired by the standard icon design workflow, we develop our algorithm to consist of two steps: generating colorization templates and performing palette-based color transfer.

2.1 Generating color templates

In this step, our goal is to generate a color template for the input icon that adhere to the principles of color harmony. To avoid generating identical colors for all output curves, we adopt the same technique as Zhang *et al.* [Zhang et al. 2016] used. Specifically, we approach the problem as a classification task and focus solely on predicting

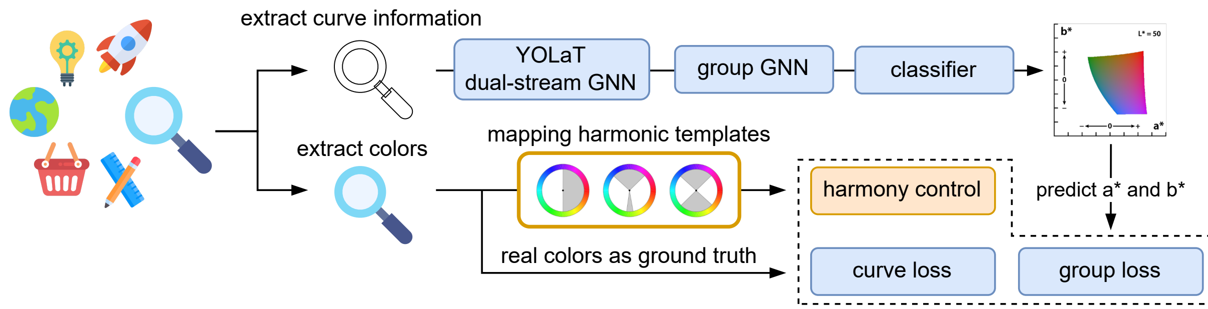

Figure 2: Overview of our colorization template network.

a* and b* color components. These components are divided into 26 classes, with each class representing a ten-bin split. Following, we will describe the details of our network architecture and loss functions to achieve this goal.

Network architecture. Our network architecture employs the dual-stream GNN proposed in Jiang *et al.* [Jiang et al. 2021] to extract curve features (Figure 2). While their research aims to recognize meaning elements in black-and-white vector graphics, our method focus on colorizing icons, where individual curves may not carry substantial meaning. As a result, relying solely on the unary curve feature is inadequate to distinguish curves within an icon. To tackle this limitation, we randomly select pairs of curves and extract their pairwise relationships using GNN layers. Our model predicts the color of each curve in CIELAB color space.

Loss function. Our overall loss function comprises of three loss functions:

$$\mathcal{L} = w_{\text{unary}} L_{\text{unary}} + w_{\text{pairwise}} L_{\text{pairwise}} + w_{\text{harmony}} L_{\text{harmony}}, \quad (1)$$

where we set w_{unary} and w_{pairwise} to 1.0, and w_{harmony} to 0.05.

Unary term We use the cross-entropy loss to evaluate each curve's predicted color.

Pairwise term The goal of this term is to preserve the color similarity between each edge pair in the input icon. Specifically, the color similarity between curve i and curve j in the input icon is defined as:

$$s_{i,j} = \exp\left(-\alpha \times D_{i,j}\right), \text{ for } i, j = 1, \ldots, M, \quad (2)$$

where M as the number of classes, D_{ij} is the Euclidean distance between the classes of curve i and curve j. The color similarity between the predicted colors of curve i and curve j is defined as:

$$\hat{s}_{ij} = \left(\frac{\hat{\mathbf{y}}_{\mathbf{i}} \cdot \hat{\mathbf{y}}_{\mathbf{j}}}{\|\hat{\mathbf{y}}_{\mathbf{i}}\| \|\hat{\mathbf{y}}_{\mathbf{j}}\|} + 1\right) / 2, \quad (3)$$

Overall, we measure the distance between all pairs of curves of both a* and b* as our loss function:

$$L_{\text{pairwise}} = \frac{1}{N} \sum_{k=1}^{E} [(s_k^a - \hat{s_k}^a)^2 + (s_k^b - \hat{s_k}^b)^2], \quad (4)$$

where E is the number of edge pairs.

Harmony term The goal of this term is to maintain the visual harmony of the output color combinations. We encourage the output colors to fall in the harmonic template regions defined by [Tokumaru et al. 2002]. To achieve this, we calculate the hue distance between a predicted hue of an curve ($H(\hat{x})$) and its best-matched template (T_m) at a given angle α_0:

$$L_{\text{harmony}} = \sum_{\hat{x} \in \hat{X}} \|H(\hat{x}) - E\| \cdot S(\hat{x}), \quad (5)$$

where E denotes the nearest valid region boundary of T_m and $\hat{X}$ denotes all curves of the input icon. We also consider the saturation of each predicted curve color ($S(\hat{x})$) because it affects perceived distance [Cohen-Or et al. 2006].

2.2 Palette-based color transfer

After predicting the initial color template of the input icon, we update $\mathbf{I}$ to fit the desired palette by solving following optimization problem:

$$\arg\min_{\mathcal{I}} \left(\sum_{i=1}^{n} \|\mathbf{C}_i - \mathbf{I}_i\|_2 + \sum_{i=1}^{n} \sum_{j=1}^{n} \left(\frac{\lambda}{(\mathbf{I}_i^L - \mathbf{I}_j^L + 1) \times (\|\mathbf{I}_i - \mathbf{I}_j\|_2 + 1)} \right) \right) \quad (6)$$

where $\mathbf{I}$ and $\mathbf{C}$ represent initial template and palette colors in CIELAB color space, n is the number of curves, and we set $\lambda = 1000$. The goal of the first term is to minimize the distance between template colors and the corresponding palette colors. The second term aims to differentiate the curve colors by increasing their lightness values differences.

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REFERENCES

Daniel Cohen-Or, Olga Sorkine, Ran Gal, Tommer Leyvand, and Ying-Qing Xu. 2006. Color harmonization. In *ACM SIGGRAPH 2006 Papers*. 624–630.
Xinyang Jiang, Lu Liu, Caihua Shan, Yifei Shen, Xuanyi Dong, and Dongsheng Li. 2021. Recognizing vector graphics without rasterization. *NeurIPS* 34 (2021), 24569–24580.
Yuan-kui Li, Yun-Hsuan Lien, and Yu-Shuen Wang. 2022. Style-Structure Disentangled Features and Normalizing Flows for Diverse Icon Colorization. In *CVPR 2022*.
Masataka Tokumaru, Noriaki Muranaka, and Shigeru Imanishi. 2002. Color design support system considering color harmony. In *FUZZ-IEEE'02*, Vol. 1. IEEE, 378–383.
Richard Zhang, Phillip Isola, and Alexei A Efros. 2016. Colorful image colorization. In *ECCV 2016*. Springer, 649–666.