Enhancing Carpet Design With Generative Models

Sailesh Shiwakoti **Suraj Niroula** **Surya Narayan Choudhary**
Under the Supervision of
Asst. Prof. Daya Sagar Baral

Pulchowk Engneering Campus
Institute of Engineering
Department of Electronics and Computer Engineering

April 12, 2024

Presentation Outline

Introduction

Literature Review

Study Objectives

Methodology

Model Development

System Implementation

Results

Study Conclusions, Contributions, and Practical Implications

References

Introduction

Motivation of the Study

Nepali Carpet Industry

- Nepal's carpet exports reached an all-time high of Rs. 10.32 Billion in the first 11 months of the fiscal year, indicating a strong rebound for the industry.
- In terms of volume, exports amounted to 444,365 square meters, up 11.25 percent year-on-year.

Need of the Study

- Limited Customization
- Time-Consuming Process
- Difficulty in Iterating Design Concepts

Literature Review

Exisiting System

Alternative Technology गलैचा Galaincha Modern Technology for an Ancient Craft

explorug

$1 ONLY 1DOLLAR DESIGN.COM

ONLYhundred!.com Exclusive Designs Made Affordable

RUGShare Rug customization anywhere

RAMRO DESIGNS

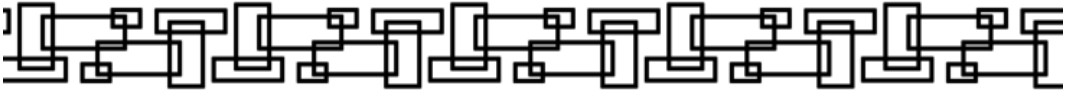
Proposed Solution

Symmetric Group

Symmetry of a pattern is a transformation, or motion, for which the pattern is the same before and after the transformation.

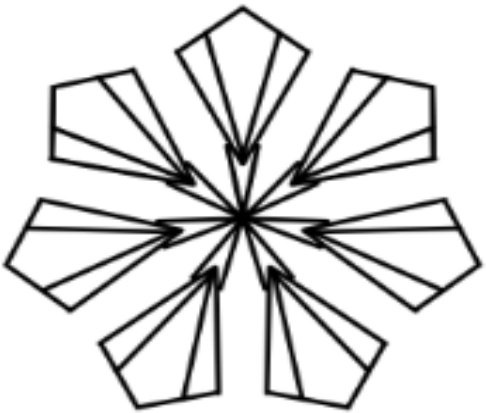
- Wallpaper
- Rostte
- Frieze

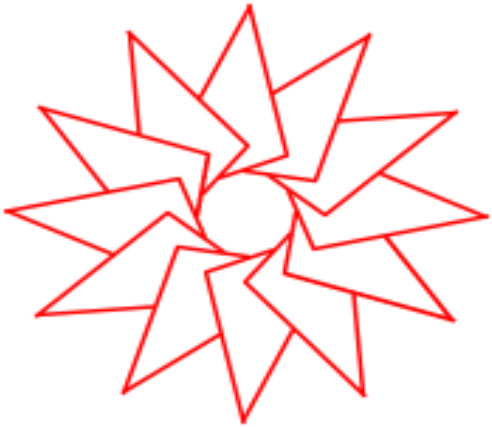
Horizontal Translation Symmetry



Pattern with horizontal translation symmetry

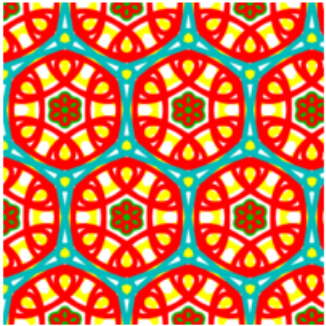
Rosettes

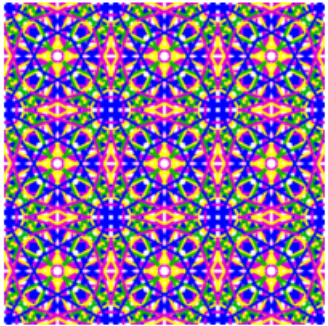




Patterns with symmetry groups D7 and R12.

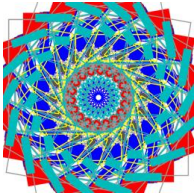
Wallpaper Symmetry Group





Examples of patterns with different wallpaper groups.

Proposed Solution



An interactive web platform which

- Takes a sample carpet design from user through web interface
- Transforms the sample design using Generative Adversarial Networks (GANs) into better and creative design

Study Objectives

Study Objectives

Objective I: Develop a GAN-based model for generating diverse and personalized rug designs based on user-provided input templates.

Objective II: Designing and implementing a user-friendly interface for collecting design preferences from users, including color schemes, patterns, and textures.

Objective III: Integrating the algorithm into the platform to enable real-time generation and customization of rug designs.

Types of Carpet

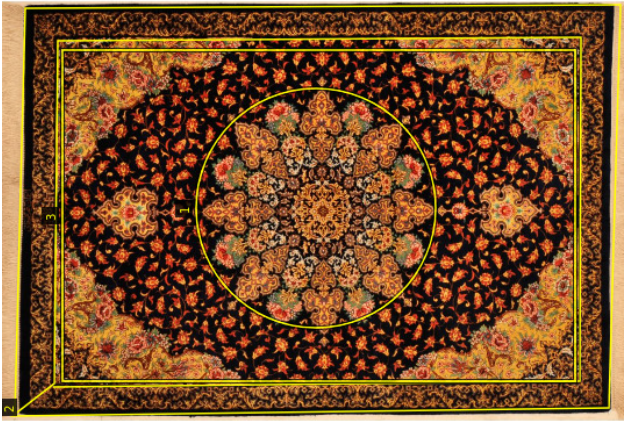
List of types of carpet

- Berber Carpets
- Afghan Carpets
- Turkish Carpets
- Oriental Carpets
- Axminster Carpets
- Persian Carpets

Persian Carpet

- Originated during the **Bronze Age** **in Persia**.
- Handmade carpet from **Iran**, renowned for their intricate designs and patterns, which often feature **floral motifs, geometric shapes, and intricate medallions.**

Persian Carpet Components



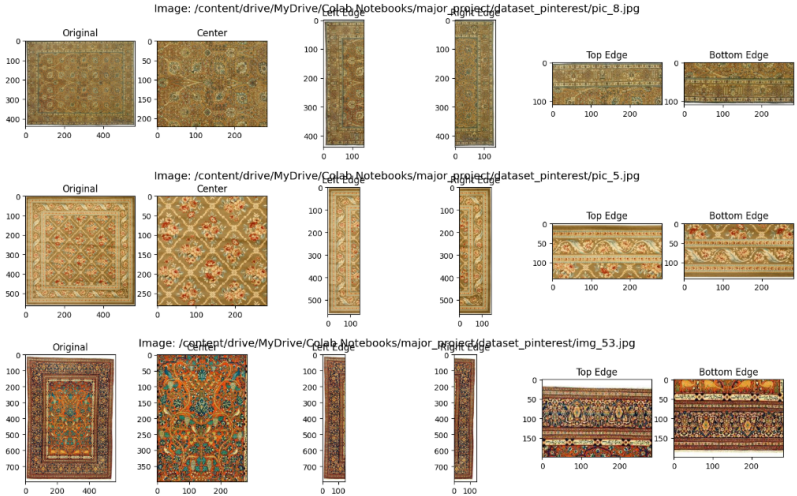
Regions 1, 2, 3 correspond to Rosette, Frieze, and Wallpaper respectively.

Methodology

Data Collection and Preprocessing

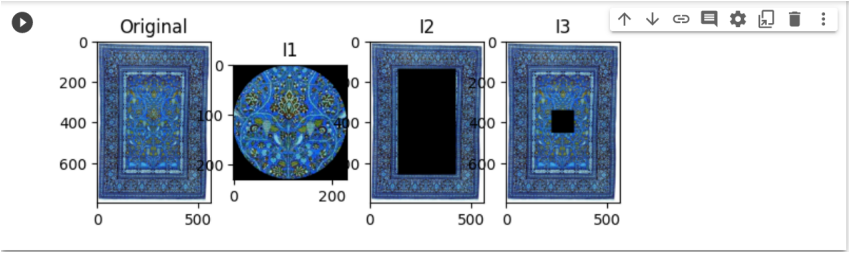
- Pinterest
- George Washington University Museum website
- Dundee University Museum Textiles Collection website

Feature Engineering



Extracting the edges, center and wallpaper components from carpet images

Feature Engineering



Separating components of rug during feature engineering

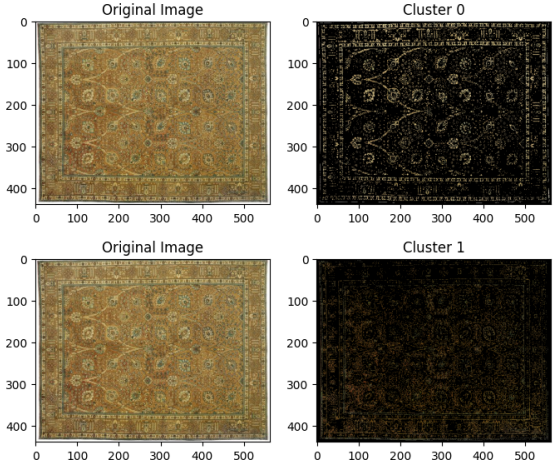
Fourier Transformations

(a) Original image

(b) Segmented image

Segmentation of images using the Fourier Transformation

Dataset Augmentation

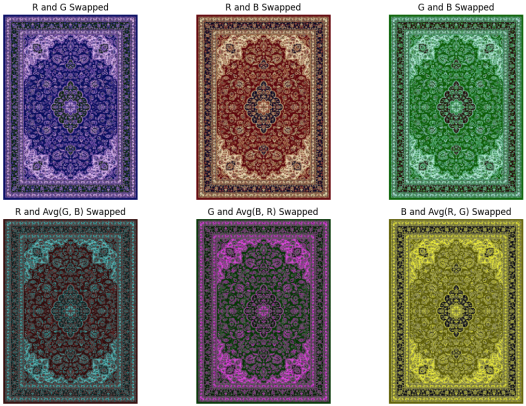


Results from K-Means Clustering with K = 3

Dataset Augmentation

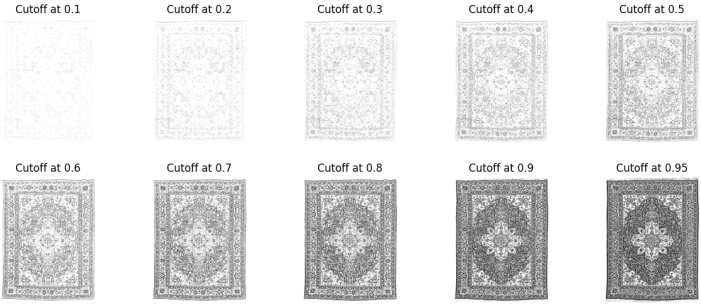
Rotating images clockwise by 90 degrees and varying R, G, and B pixels.

Dataset Augmentation



Result shows swapping strategies for color channels

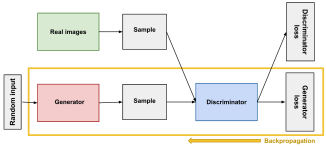
Dataset Augmentation



Result shows sktech effects at various cutoff level

Model Development

Generative Adversarial Network



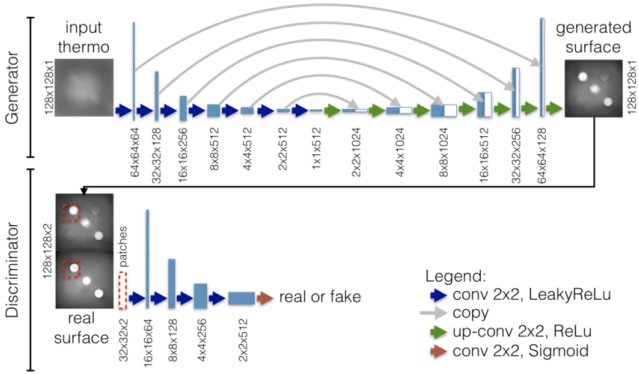
DCGAN: Deep Convolutional Generative Adversarial Network

The **GAN** architecture, comprising a generator network (G) and a discriminator network (D), was chosen due to its remarkable ability to generate realistic and diverse samples. We have used

- Deep Convolutional GAN
- Pi2pix GAN
- Neural Style Transfer

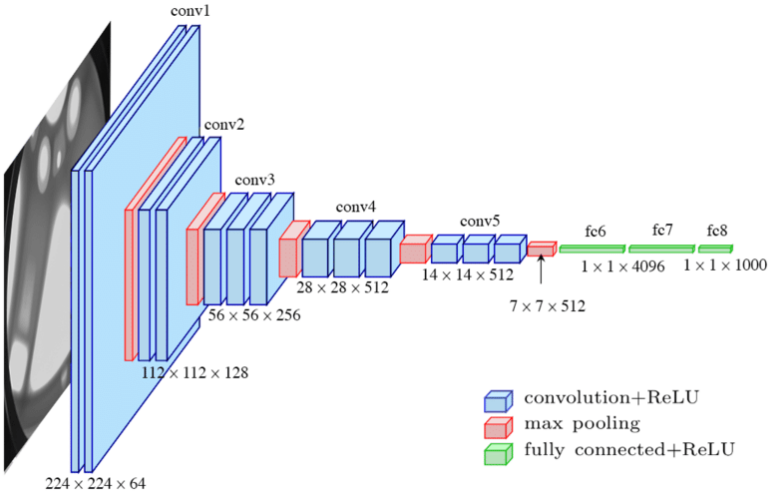
in our project to study their outputs.

U-Net as Generator in Pix2Pix model



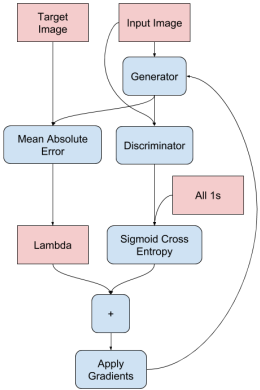
U-Net architecture

Pre-trained model VGG in Neural Style Transfer

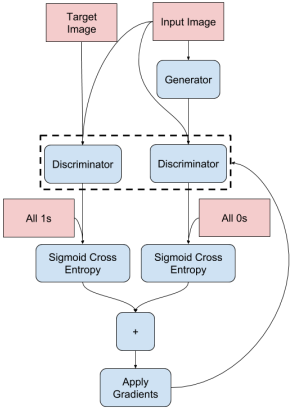


VGG-16 architecture

GAN training procedure



(a) Training procedure for the generator



(b) Training procedure for the discriminator

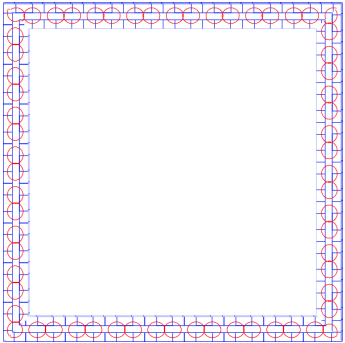
System Implementation

Tools and Technologies Used

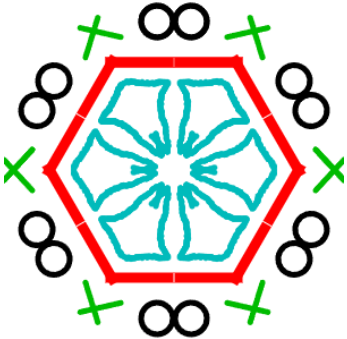
- Backend
  - Django
- Frontend
  - React
  - Tailwind CSS
- Deep Learning
  - Tensorflow

Results

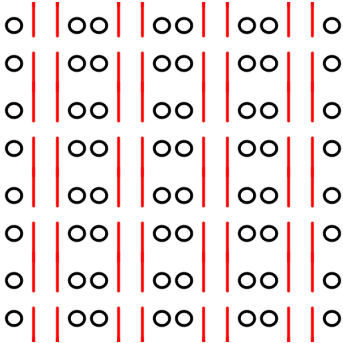
React JS Result



(a) Frieze



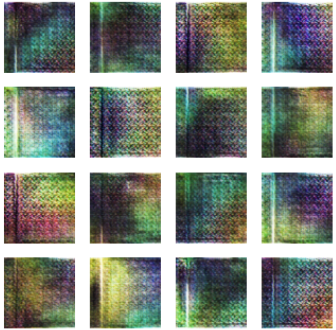
(b) Rosette



(c) Wallpaper

User Generated Carpet Components

DCGAN Model Result

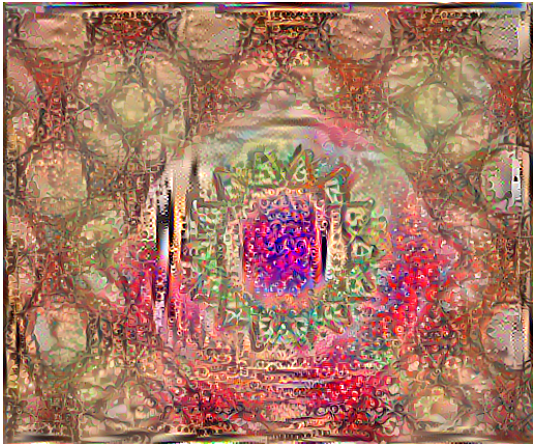


DCGAN output at 500 epoch

Pix2Pix Model Result

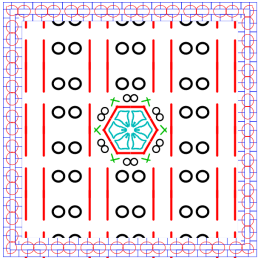
Output from Pix2Pix model

Neural Style Transfer Result



Output obtained by using the style transfer

Overall Result



(a) Combined Carpet as User Input

(b) System Generated Carpet 1

(c) System Generated Carpet 2

(d) System Generated Carpet 3

System Generated Carpets: The first image is the combined carpet provided by the user, and the following three images are the system-generated carpets based on the input.

Study Conclusions, Contributions, and Practical Implications

Conclusions

- Utilized DCGAN for learning from unlabeled datasets, ensuring robust model performance.
- Employed Pix2Pix for colorization of sketches into finalized carpet designs.
- Integrated neural style transfer for enriching carpet textures and promoting creative flexibility.
- Leveraged React.js and `<canvas>` for frontend development, facilitating user-friendly design interactions.

Contributions

- Facilitated streamlined carpet design through automated dataset tailoring and model training.
- Introduced innovative applications such as Pix2Pix and neural style transfer for enhancing carpet aesthetics.
- Integrated user-friendly technologies like React.js and `<canvas>` for intuitive frontend carpet design interfaces.
- Enabled personalized carpet design recommendations based on room photos using mobile camera inputs.
- Enhanced carpet design creativity and efficiency through AI-driven tools like GANs for rapid prototyping.

Implications

- Simplified carpet design process by allowing users to submit rough designs transformed via symmetry patterns.
- Expanded design possibilities with AI-driven tools like neural style transfer, enhancing creative flexibility.
- Facilitated segmentation of carpet designs, enabling users to select specific motifs such as rosette or frieze.
- Enabled mobile integration for capturing room photos and generating carpets tailored to room aesthetics.
- Enhanced user experience by suggesting diverse motifs and patterns based on labeled datasets, promoting personalized carpet design solutions.

References I

[1] Unspecified, "Generalization of convolutional network to domain adaptation network for classification of disaster images on twitter," https://www.researchgate.net/figure/VGG-19-Architecture-39-VGG-19-has-16-convolution-layers-grouped-into-5-blocks-After_fig5_359771670, accessed: 12 April 2024.

[2] "Galaincha," https://galaincha.com.np/, 2023, accessed: 2023-01-01.

[3] "Explorug," https://explorug.com/, 2023, accessed: 2023-01-01.

[4] "Ramro design," https://ramrodesigns.com/, 2023, accessed: 2023-01-01.

[5] "Only1dollardesign," https://only1dollardesign.com/, 2023, accessed: 2023-01-01.

[6] "Onlyhundred," https://onlyhundred.com/, 2023, accessed: 2023-01-01.

[7] T. Karras, S. Laine, and T. Aila, "A style-based generator architecture for generative adversarial networks," 2019.

[8] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," 2015.

[9] L. A. Gatys, A. S. Ecker, and M. Bethge, "A neural algorithm of artistic style," 2015.

[10] D. Eck, "Symmetry information," https://math.hws.edu/eck/js/symmetry/symmetry-info.html, 2023, accessed on: 11 05 2023.

[11] "George Washington University Museum," https://museum.gwu.edu/, accessed: 2023-04-10.

[12] "Dundee University Museum Textiles Collection," app.dundee.ac.uk/museu/collections/textiles/index.html, accessed: 2023-05-03.

[13] "City Rugs," https://www.cityrugs.com/, accessed: 2023-05-08.

References II

[14] J. V. McMullan, *Islamic Carpets*. Near Eastern Art Research Center, 1965.

[15] I. J. Goodfellow, J. Pouget-Abadie, M. Mirza, B. Xu, D. Warde-Farley, S. Ozair, A. Courville, and Y. Bengio, "Generative adversarial networks," 2014.

[16] A. Radford, L. Metz, and S. Chintala, "Unsupervised representation learning with deep convolutional generative adversarial networks," in *International Conference on Learning Representations (ICLR)*, 2015.

[17] J. Johnson, A. Alahi, and L. Fei-Fei, "Perceptual losses for real-time style transfer and super-resolution," in *European Conference on Computer Vision (ECCV)*, 2016.

[18] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "Imagenet classification with deep convolutional neural networks," in *Advances in Neural Information Processing Systems*, F. Pereira, C. Burges, L. Bottou, and K. Weinberger, Eds., vol. 25. Curran Associates, Inc., 2012. [Online]. Available: https://proceedings.neurips.cc/paper_files/paper/2012/file/c399862d3b9d6b76c8436e924a68c45b-Paper.pdf

[19] H. Lee, R. Grosse, R. Ranganath, and A. Ng, "Unsupervised learning of hierarchical representations with convolutional deep belief networks," *Commun. ACM*, vol. 54, pp. 95–103, 10 2011.

[20] A. Saxena, M. Sun, and A. Y. Ng, "Make3d: Learning 3-d scene structure from a single still image," *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, vol. 30, no. 12, pp. 1949–1956, 2008.

[21] F. Yu, Y. Zhang, S. Song, A. Seff, and J. Xiao, "Lsun: Construction of a large-scale image dataset using deep learning with humans in the loop," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2015.

[22] "Planner 5d," https://planner5d.com/.

[23] J. Doe, "Color theory in rug design," *Journal of Rug Design*, vol. 10, no. 2, pp. 45–62, 2023.

References III

[24] J. Smith, *Patterns in Rug Design: From Traditional Motifs to Contemporary Interpretations*. Design Publications, 2023.

[25] ——, *Spatial Considerations in Rug Design: Creating Harmonious Room Environments*. Design Publications, 2023.

[26] D. A. Norman, *The Design of Everyday Things*. Basic Books, 2002.

[27] D. Flanagan, *JavaScript: The Definitive Guide*. O'Reilly Media, 2006.

[28] M. D. Network. (2023) Drag and drop api. [Online]. Available: https://developer.mozilla.org/en-US/docs/Web/API/HTML_Drag_and_Drop_API

[29] J. D. Foley, A. van Dam, S. K. Feiner, and J. F. Hughes, *Computer Graphics: Principles and Practice*. Addison-Wesley Professional, 1995.

[30] D. Shreiner, G. Sellers, J. M. Kessenich, and B. Licea-Kane, *OpenGL Programming Guide*. Addison-Wesley Professional, 2013.

[31] R. Szeliski, *Computer Vision: Algorithms and Applications*. Springer, 2010.

[32] R. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*. Cambridge University Press, 2004.

[33] S. M. Seitz, B. Curless, J. Diebel, D. Scharstein, and R. Szeliski, "A comparison and evaluation of multi-view stereo reconstruction algorithms," *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2006.

[34] M. Kazhdan, M. Bolitho, and H. Hoppe, "Screened poisson surface reconstruction," in *Proceedings of the ACM SIGGRAPH 2006 Papers*, 2006.

[35] H. Hoppe, T. DeRose, T. Duchamp, J. McDonald, and W. Stuetzle, "Surface reconstruction from unorganized points," *ACM SIGGRAPH Computer Graphics*, vol. 26, no. 2, 1992.

References IV

[36] T. Karras, T. Aila, S. Laine, and J. Lehtinen, "Progressive growing of gans for improved quality, stability, and variation," 2018.

[37] O. Ronneberger, P. Fischer, and T. Brox, "U-net: Convolutional networks for biomedical image segmentation," 2015.

[38] P. Isola, J.-Y. Zhu, T. Zhou, and A. A. Efros, "Image-to-image translation with conditional adversarial networks," 2018.

“If you have knowledge, let others light their candles in it.”

Margaret Fuller

Thank You!