THINK

MIT THINK SCHOLARS PROGRAM

MIT THINK Scholars Program 2024-2025: Complete Guidelines

Overview

The MIT THINK Scholars Program is an educational outreach initiative at the Massachusetts Institute of Technology that promotes student-led innovation in science, technology, engineering, and mathematics. THINK accepts research project proposals from under-resourced high school students across the US and provides mentorship and funding to a select few to make their idea a reality. The program is led by a team of undergraduate students as part of MIT TechX, the largest technology club at the Institute.

THINK is open to all high school students with permanent residence in the United States. Students may apply by submitting a written research proposal outlining a novel science, technology, or engineering idea following the proceeding guidelines.

For the 2025 competition, the THINK team will review applications in two rounds: first an initial proposal review to choose program semifinalists, and then a video interview, after which up to six finalists will be chosen. Finalists will receive an all-expenses paid trip to MIT, as well as continued mentor-ship and funding to implement their proposed projects during the spring of 2025. Finalists will be designated as MIT THINK Scholars upon successful completion of their projects the following May.

Program Vision

Dear students and teachers,

The MIT THINK Scholars Program was founded in 2008 by a group of MIT undergraduates. Our name comes from our vision to promote *T*echnology for *H*umanity through *I*nnovation, *N*etworking, and *K*nowledge.

THINK's mission is to make STEM research and development accessible to creative and motivated high school students who have big ideas to change the world, but who need help implementing them.

Rather than recognizing students' completion of a project after the fact, we support students who wish to implement new ideas from start to finish. Win-ners of the program will receive up to $1,000 of funding and continued mentorship from our team to help make their idea a reality.

Our philosophy is that those who have the creativity and passion to make significant contributions to the world ought to have their voices heard, regardless of experience or resources. We hope to leverage the MIT network to share with students the knowledge and connections they need.

In a results-oriented world, *the process* is often overlooked despite being the most pivotal and challenging aspect of any project. This is where the guidance and support of others can be immensely beneficial to an aspiring scientist or engineer, which is why THINK helps students realize their idea every step of the way.

More than a dozen cohorts of MIT THINK finalists have participated in our program. Year after year, finalists have described the experience as transformational and profoundly rewarding. Several alumni have gone on to attend MIT, both as undergraduates and graduate students, with some even joining the THINK team.

We hope THINK will be an inspirational experience that helps nurture the next generation of young innovators, providing them with the support they need to make their ideas come to life.

– The MIT THINK Team

Program Details

Timeline

Applications Open	1 November 2024
Application Deadline	1 January 2025
Finalist Decisions	Mid-January 2025
Finalist Trip to MIT	Early February 2025
Project Completion Deadline	June 2025

Eligibility Requirements

- Applicants must be full-time high school students (i.e. attending a public, private, or home school) at the time of application
- Applicants must have permanent U.S. residency during the 2024-2025 academic year
  - U.S. citizenship is not required
  - U.S. citizens living outside the country are not eligible
- Applicants may only submit one proposal per academic year
- Proposals may be written by either an individual or a group of two students

Finalists receive:

- All expenses paid trip to MIT that includes:
  - Meetings with MIT professors in the finalists' area of interest
  - Personalized tours of MIT research laboratories
  - Attending MIT classes and experiencing MIT student life
- Ability to reimburse up to $1000 to implement project
- Weekly mentorship meetings with MIT student mentors

Application Process

The process for entering the MIT THINK Competition is as follows:

• Open the Google Form: Using your preferred email address, enter the required personal information and short answer responses

• (Optional) Find a partner: you can work alone or with one partner

• Submit your proposal: upload your written project proposal, making sure to follow the instructions outlined below

Proposal Guidelines

Please read these guidelines carefully and adhere strictly to the format provided. Make sure to clearly address each required component in your PDF submission.

Failure to follow this format may result in disqualification.

Teams should work together to write a single project proposal.

<u>Formatting, Lengths, and Citations:</u>

• Use 12-point Times New Roman or Arial font

• Double spaced (1.5 not allowed) with 1 inch margins

• Page limit: 10 pages. (References will not count against the 10 page limit.)

• Please cite all references and include a list of references at the end of the project proposal.

• All images and diagrams that are not your own should also be cited.

• Include any tables and figures in the body of the text.

The project proposal should be divided into the following sections:

• Title and abstract

• An explaination of your project's motivation and approach

• Project logistics and organization

Follow the format below when writing your proposal to ensure you include all required information and aid the THINK team in the judging process.

1. Project Title

- Name: your name(s), school
- Mentor (optional): name, email address, affiliation (university, school, company, etc.)

2. Abstract

Write an engaging, thorough, and concise abstract of up to 250 words summarizing your project. In paragraph form, please describe the following aspects of your project:

- Motivation: What is the problem you are trying to solve? Why is this an important problem to address?
- Goals: What are the desired outcomes of your project?
- Approach: How do you plan to implement your project proposal?

3. Idea

- Problem:
  - Clearly identify the need or problem you are trying to solve.
  - Explain any background information needed to understand the context and motivation of your project.
  - Cite existing scientific literature to contextualize your project.
  - Include relevant scientific theory.
- Current Work:
  - Identify current state-of-the-art approaches or solutions.
  - Explain why they are insufficient.
- Solution:
  - Describe your proposed solution.
  - Describe how it will address the need or problem.
  - Compare your idea to existing solutions.
  - Explain how your solution improves upon current technology.

4. Plan

- Approach:
  - Walk through the steps to implement your project proposal.
  - Convince us that your project is technically feasible
    - Use diagrams and show calculations as necessary.
- Resources:
  - Specify the resources (i.e. materials, mentorship, and funding) you will need to obtain during the process of implementing your project.
  - How will you acquire these resources?
  - If applicable, are you planning on working with a local mentor in addition to mentorship from the THINK Team?
- Goals:
  - Establish milestones and completion criteria for your project.
  - How will you test and evaluate your project?
  - What are its performance specifications (if applicable)?
  - If you are working with a partner:
    - Discuss how you plan to divide the work and responsibilities.
    - Explain how you will facilitate collaboration.
- Risks:
  - Identify at least three issues you might encounter while implementing your project
  - What specific strategies or solutions could you use to mitigate them?
- Timeline:
  - Identify key deliverables and deadlines.
  - How will you document the implementation process between these milestones?
- Current Progress and Need for Funding:
  - Describe any previous work you have done on this topic. Please be specific and include any upcoming publications if relevant.
  - What, if anything, have you achieved so far, and what remains to be done when implementing your project?
  - How will funding from the MIT THINK Scholars Program allow you to achieve your proposed goals?

- Project Budget:
    - Provide a detailed budget in table form.
    - List each item, amount to be purchased, cost, and links to suppliers if you can find them.
    - If you are unable to find exact costs or have materials with variable costs, estimate to the best of your ability.
    - Please ensure that your total costs do not exceed the program budget of $1000 per project.

5. References

- Cite all consulted sources using the APA format.
- Include both in-text citations and a References section at the end of the project proposal.
- The References section will not count against the 10 page limit.

Important note: make sure to address every bullet point in this outline.

In particular, you ***must*** **address how your project would benefit from funding and mentorship from MIT THINK**. Proposals which do not explain what the applicant(s) will gain from the program will not be selected to advance in the competition.

Judging and Finalist Selection

A panel of MIT undergraduates (the MIT THINK team) will review proposals based on the following criteria:

- Impact:
  - How relevant, important, or interesting is the identified problem?
- Innovation:
  - How novel or creative is the proposed solution?
  - How is it contextualized within existing work?
  - How does it improve upon existing solutions?
- Clarity:
  - Are the goals, methods, and timeline clearly defined?
  - Can the results be clearly and reliably evaluated?
  - Is the discussion of the problem, existing technologies, and proposed solutions accurate and complete?
- Feasibility:
  - Can the stated goals be completed within the cost and resource constraints?
  - Can the project be implemented within the one semester time frame?
- Benefit:
  - How much will the completion of this project benefit from THINK funding and mentorship?

Finalists' Trip

Up to six projects will be selected as MIT THINK finalists; these students will participate in the MIT THINK Scholars Program. Finalists will be invited to MIT for the Finalists' Trip. During the trip, finalists will meet the THINK team, present their project proposals, meet with MIT professors who share their research interests, and tour MIT laboratories. All finalists will be given funding (up to $1,000 of reimbursements) and mentorship to complete their projects. Upon successful project completion and submission of a final report, finalists will be honored as MIT THINK Scholars for the 2025 competition.

Project Implementation and Mentorship (for Finalists)

The THINK team will provide support through funding, weekly mentorship via virtual meetings, and networking opportunities with sponsors, MIT students, faculty, and alumni. In return, you must document your process with weekly progress reports. Documentation should show the successful completion of milestones and goals, and any challenges encountered along the way. Your project experience will be shared with our sponsors and the MIT community. By the end of the spring semester, you will be expected to submit a detailed final report documenting your project from start to finish.

FAQs

When is the application due?
11:59pm EST on 1 January 2025

Can my proposal be longer than 10 pages?
Unfortunately, no. Additional pages can only contain references.

I am in a team of two. How do we submit an application for two people?
Submit separate Google forms, fill in the application information individually, and submit the same proposal at the end.

I am an international student. Can I still apply?
Unfortunately, we currently only accept applications from high school students with permanent residence in the U.S.

Who judges these applications?
The THINK team: a group of MIT undergraduates with whose interests and experience reach all corners of the world of STEM.

How will I know if I won?
Semifinalists will receive an email invitation for an interview in mid-January. The final results will be posted on our website later that month.

Where can I send my other questions?
Please send us an email with your questions at *think@mit.edu*.

EXAMPLE PROJECT PROPOSAL - NOTE: The personal interest section has been removed and is now a short answer question.

From Pixel to Paragraph: A Deep Artwork Paragraph Generator

Audrey Cui, Monta Vista High School

ABSTRACT

Art influences society by shaping our perspective and sense of self. Since not all pieces of art are extensively captioned, I wonder: would it be possible for computers to understand and then describe artwork? Automated artwork analysis will make art more accessible to the visually impaired and facilitate semantic searches for artwork conveying specific themes, enabling a wider audience to enjoy art and experience what artists communicate through their artwork. The goal of my project is to develop an artificial neural network system that interprets input artwork and generates a paragraph describing objects and low level features present in the artwork, as well as ideas and emotions the artwork conveys. I will develop a visual-semantic embedding space that learns the relationship between artwork image features and art analysis paragraph sentences. The embedding module retrieves the most relevant sentences to the input artwork features. These sentences are fed into a generative adversarial network with a novel sentiment filter to generate the final art analysis paragraph, whose relevance to the input artwork is evaluated with a SPICE score. By expanding upon a human's interpretation of artwork with new and sometimes surprising insight, my project makes progress towards developing a creative AI.

MOTIVATION AND APPROACH

Not all art pieces are extensively captioned — therefore, my project of generating art analysis paragraphs based on input artwork will make art more accessible to the visually impaired and also facilitate semantic searches for artwork conveying specific themes. Training machines to understand artwork will also advance progress towards innovating creative AI.

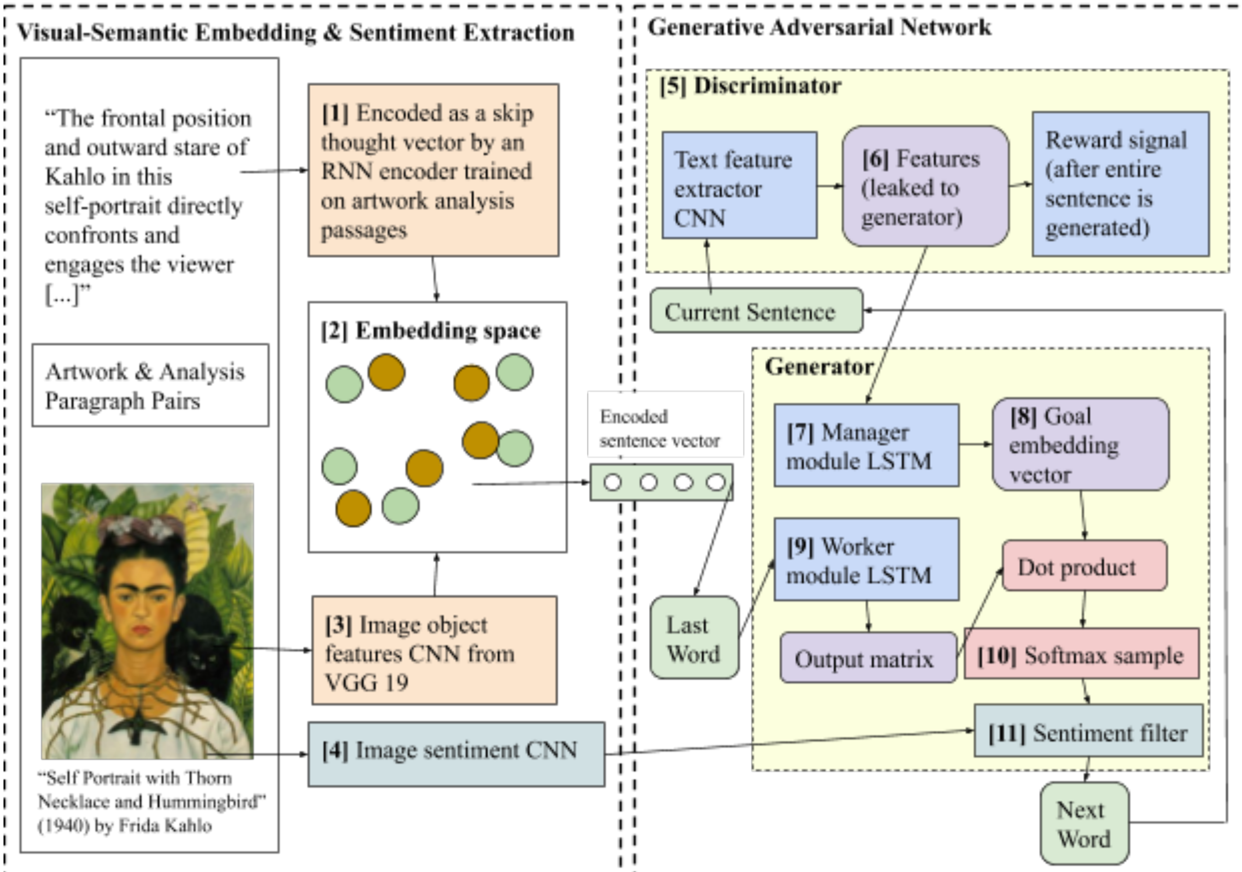
The objective of my project, generating paragraphs based on images, is similar to that of (Kiros, 2015). Kiros generated romantic stories from images by training an RNN decoder on a corpus of romance novels to decode the closest Microsoft COCO captions retrieved by an embedding module (Lin et al., 2015; Kiros et al., 2014a). In an embedding module, the input is encoded into a vector representation that can then be mapped to the most similar vector representation of the output modality, which is subsequently decoded into the final output. This approach is effective for image captioning in general, but is less effective for describing artwork and generating long sentences. Themes in artwork are abstract and usually implicitly conveyed through its stylistic features such as texture and color palette in addition to the objects present. Furthermore, such objects often have exaggerated proportions or are abstractly rendered, so a captioning model trained on real life photographs (i.e Microsoft COCO) most likely would not be able to describe artwork accurately. In addition, using an RNN decoder to generate paragraphs is subject to exposure bias — each word is generated based on only previously generated words, so one error may render the rest of the sentence nonsensical (Yu et al., 2017).

Generative adversarial networks (GAN) have shown great promise in text generation. A GAN consists of a generator, which generates data that is evaluated by a discriminator. The discriminator learns to differentiate between the generated data and the ground truth. During adversarial training, the discriminator improves at telling apart generated data from real data, forcing the generator to gradually generate more realistic data (Goodfellow et al., 2014; Yu et al., 2017). Since it is an iterative process rather than one-and-done as with a single decoder, a GAN should generate more comprehensible paragraphs than a decoder. LeakGAN introduced a hierarchical structure to the generator by splitting it into a manager and a worker module (Guo et al., 2017). The discriminator creates a features map that is "leaked" to the manager, which forms a goal embedding vector including syntactic and semantic information to guide the worker in generating the final paragraphs. This modification enables the generator to better learn the syntactic and semantic structure of sentences, making long text generation more effective.

I will develop a visual-semantic embedding (VSE) module trained on a corpus of artwork images and their corresponding analysis paragraphs, a sentiment extractor CNN, and a GAN to generate the final paragraph analyzing input artwork. The paragraph will contain sentences similar to "the coarse brushstrokes convey the strained relationship between man and nature." Like LeakGAN, my GAN consists of a discriminator that leaks information to the generator, which includes a manager and worker, so that it can effectively generate relatively long text. To narrow the semantic gap between the generated paragraphs and input artwork, my GAN will generate paragraphs based on sentiments conveyed by the artwork via a novel sentiment filter that I propose. My solution is feasible because I have already implemented a "prototype" of the VSE and the code for LeakGAN, which I will build upon, is open source.

PROJECT LOGISTICS AND ORGANIZATION

I will develop an artificial neural network consisting of a VSE module, sentiment extractor, and GAN to generate a paragraph analyzing an input piece of artwork. To generate a paragraph from end to end, the artwork image object features are first computed as the output feature map from the penultimate layer of VGG19, a pretrained image recognition CNN (Simonyan and Zisserman, 2015). Image sentiment features are computed by another CNN that I will train. The VSE module retrieves the top 5 nearest pre-encoded sentence vectors to the encoded image object features. The mean of the nearest sentence vectors is fed into a GAN, which also conditions on the artwork sentiment to generate the final paragraph.



Below, [#] refers to the numbered step in the diagram.

To build my datasets for training models, 3,180 images of artwork and their corresponding analysis paragraphs are scraped from theartstory.com using the library BeautifulSoup (Zurakhinsky, 2018; Richardson, 2018). A text encoder model **[1]** is first trained on a corpus of the scraped paragraphs and learns the features of the paragraphs in order to encode text as its skip thought vector representation (Kiros et al., 2014b). Since skip thought vectors are biased for length, vocabulary, and syntax, the final generated paragraphs should sound like the art analysis paragraphs the encoder was trained on.

The embedding space **[2]** is a common vector space in which the encoded image object features from VGG19 and skip thought vectors can be projected upon for learning textual representations of input images. The image object features **[3]** are encoded with a pretrained image encoder from (Kiros et al., 2014a). The art analysis paragraphs are first summarized as its 3 most important sentences with Text Teaser to reduce computational load and then encoded by my trained encoder model **[1]** (Balbin, 2014). The dataset is split into 70% train, 15% validation, and 15% test for developing the embedding module.

Parallel to this, I will train an image sentiment CNN **[4]** on OASIS, a dataset of 900 images annotated with valence and arousal (VA) ratings (which is a number between 1-9), in order to predict the VA of input artwork (Kurdi et al., 2017; Hu and Flaxman, 2018). VA is a model widely used in psychology that can express any emotion in the two parameters of valence (pleasantness) and arousal. Since low level features such as color palette and composition influence sentiment, image features are represented by the output of an intermediate layer of VGG19, which captures such low level features (Gatys et al., 2015).

The GAN for paragraph generation will be based on a LeakGAN framework, which is state of the art for long text generation (Guo et al., 2017). Like LeakGAN, the discriminator **[5]** in my GAN leaks a feature map **[6]** to a manager module **[7]** that creates goal vector **[8]**. The goal vector, which includes sentence structure and semantics, guides the words generated by a worker module **[9]** via a dot product of the worker's output and the goal vector. I propose that following the softmax **[10]**, which creates a probability distribution for possible next words, a novel sentiment filter **[11]** selects for words close in sentiment to the artwork. To do this, my corpus of words from art analysis paragraphs is embedded with a dataset of 13,915 English lemmas annotated for VA (Warriner et al., 2013). The sentiment filter modifies the probability distribution by multiplying each word's probability with their cosine distance from the lemma closest to the input artwork's VA. The distribution is normalized so that each probability is between 0 and 1 and the distribution sums to 1. This modification of LeakGAN enables the generated paragraphs to take into consideration sentiment, which is a key aspect of art analysis.

Since my project is purely computational, a laptop and desktop are the only physical resources I need, both of which I already have. I would love to be mentored by the THINK team, receive advice from MIT professors, and possibly be granted access to larger text/image datasets by MIT.

I have already implemented a "prototype" version from end to end — an encoder encodes image object features, which the embedding space uses to retrieve encoded sentences. A decoder conditions on those sentences to generate the final paragraph, which were nonsensical ("Cubisme Rotterdam Rotterdam college colonial-inspired [...]"). Going forward, here are my milestones:

1. **Implement LeakGAN w/o the sentiment filter to generate comprehensible paragraphs.** While a decoder is subject to exposure bias, I believe paragraphs generated by a GAN would be more comprehensible because the output is refined iteratively. To evaluate how close semantically the generated paragraphs are to ground truth paragraphs, I will calculate a Semantic Propositional Image Caption Evaluation (SPICE) score (Anderson et al., 2016). For reference, the SPICE of fairly recent photograph captioning models are 0.05-0.06, while randomly generated words are 0.008. I hope to achieve a SPICE of >0.03, since artwork is more subject to interpretation than photographs.
2. **Train an image sentiment CNN.** To evaluate this CNN, I will calculate the mean square error (MSE) between the ground truth and the predicted values for valence and for arousal (Hu and Flaxman, 2018). MSE should be less than 2 for both valence and arousal.
3. **Implement sentiment filter and generate paragraphs conveying sentiment.** Generated paragraphs will be evaluated with SPICE. Since I do not want to sacrifice relevancy for

sentiment, the SPICE of a sentimental paragraph should not be more than 10% less than the SPICE for a non-sentimental paragraph generated from the same image.

The following addresses possible issues and solutions:

1. If my GAN does not generate comprehensible paragraphs, I will train it on a larger dataset including art history ebooks in addition to my art analysis corpus, decrease the learn rate, and increase the number of epochs during adversarial training.
2. I am not entirely sure whether my sentiment filter enables the generated paragraphs to convey artwork sentiment while retaining meaning. If it does not meet my performance specifications, I will develop a method to incorporate sentiment in either the leaked features or the reward signal given to the generator from the discriminator.
3. If none of the approaches for incorporating sentiment in the GAN mentioned above successfully generates paragraphs conveying artwork sentiment, I will develop an embedding module that learns the relationship between the analysis paragraphs and both image object AND sentiment features. While the retrieved sentences should convey information about artwork sentiment, my training corpus is relatively small so I believe that incorporating sentiment in the GAN would more likely be successful.

Timeline:

1. 2/24/18: Implement LeakGAN without the proposed sentiment filler. The generated paragraphs and their SPICE scores will be documented.
2. 3/10/18: Train an image sentiment CNN. MSE and results for sample inputs will be documented.
3. 3/24/18: Embed art analysis corpus with English lemmas. The top 10 words closest in VA to and the VA of sample words from the art analysis corpus will be documented.

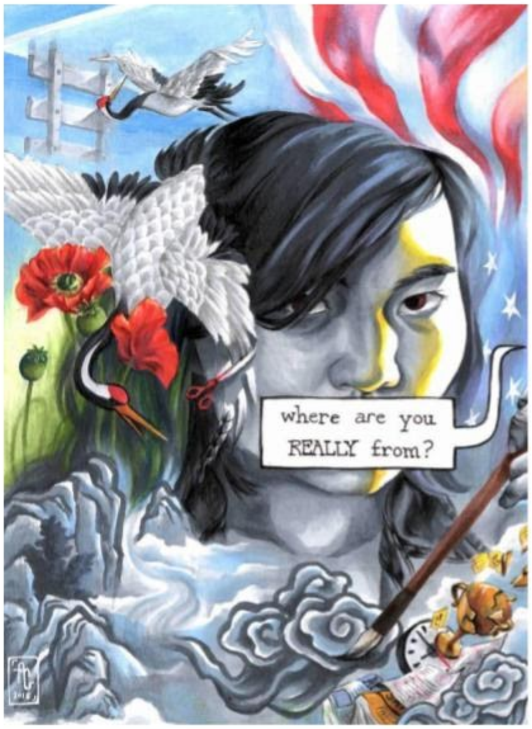
4. 4/14/18: Implement my proposed method for the sentiment filter to adjust the probability distribution for the next generated word. Samples of probability distributions before and after the sentiment filter will be documented.

4. 4/21/18: Generate paragraphs, which will be documented, via the GAN with the sentiment filter.

5. 5/26/18: Buffer time for incorporating sentiment in generated paragraphs if my proposed approaches are ineffective. Otherwise, I will adjust the embedding module and the GAN to improve the accuracy, comprehensibility, and SPICE of generated paragraphs. My final code will be uploaded to Github.

Current Progress:

As stated above, I have already implemented the VSE that relates encoded artwork features to sentences in analysis paragraphs. Below is a sample of the nearest sentences retrieved by the embedding space when inputted my own artwork.



NEAREST SENTENCES

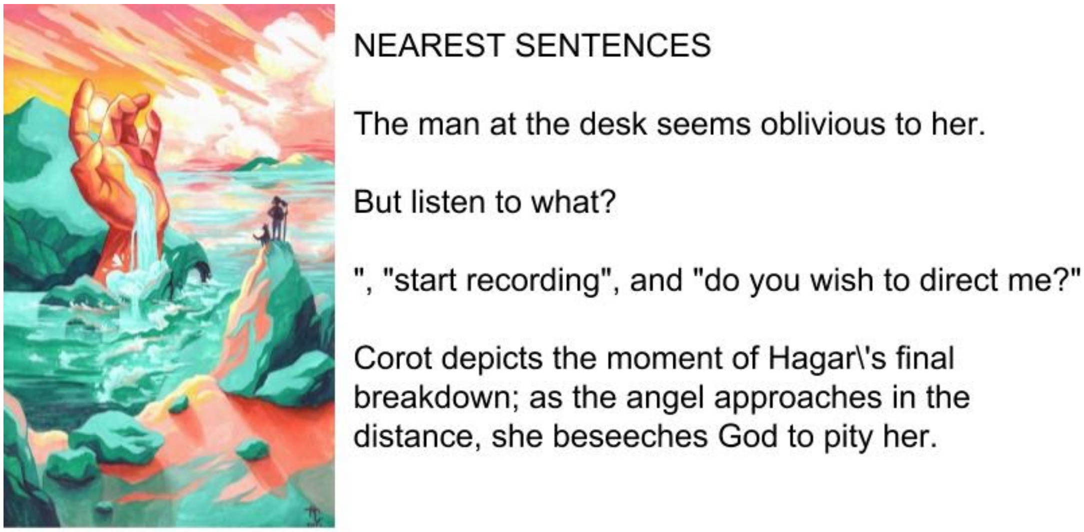
As Michele Wallace, the artist\'s daughter and art critic, has noted, the work answers the question "what are we (as black women) supposed to do with our lives and how are we supposed to do it?"

Artist Joan Jonas explained, "I see how experimental she was with form and color and shape and the canvas itself, and it\'s very funny...the forms are dynamic."

After the audience settles down and relaxes, the changes start - whole sequences with sound effects only, interrupted stuttering speech."

That aside, the important art critic, Philippe Burty, referred to Bracquemond as "one of the most intelligent pupils in Ingres\'s studio."

For example, my piece "Hyphenated American" above expresses my relationship with my Chinese American identity. Although the highest ranking sentence ("As Michele [...] do it?'") questions society's expectations for black women, it appropriately captures the theme of identity present in my artwork, showing that the VSE is fairly successful. The retrieved sentences may not describe the input artwork perfectly, but some of them capture the overall meaning of the artwork to some extent.



My piece “The Explorer and Her Cat” above is about exploration igniting imagination. Interestingly, the sentence “Corot depits [...] pity her” comes from a painting with a composition similar to mine and suggests a new meaning for my artwork — the explorer figure looks towards the hand as a divine figure for mercy. This sentence does not describe the intended themes in my artwork, but instead provides new insight that is reasonable in the context of my artwork.

Funding will go to purchasing a GPU for training models on larger data corpuses faster.

Item	Amount	Cost	Link
GeForce RTX 2080 graphics card	1	$799	https://www.nvidia.com/en-us/geforce/graphics-cards/rtx-2080/

PERSONAL INTEREST

I once saw computer science, which abides by the unbending laws of logic, and art, which transcends the boundary dividing reality and imagination, as two separate universes. This dichotomous view of my two interests was shattered when I learned about neural image style transfers that could transform my photos into paintings. The idea that rigid math could generate art and possibly even understand art blew my mind. In the future, I want to research artificial intelligence and neurobiology in order to apply the intricacies of our cerebral processing system towards optimizing computer vision and NLP and to ultimately innovate a truly creative AI.

To design my approach for generating art analysis paragraphs, I read through numerous papers to gain a good understanding of methods in computer vision and natural language processing. I have already implemented the VSE, a key part of my project. During the process, I became more familiar with how machine learning models are implemented and with using libraries such as nltk and keras (Bird et al., 2009; Chollet, 2018). Currently, I understand conceptually how a GAN works, but I will need to learn its implementation details for modifying LeakGAN in order to generate paragraphs conveying sentiment.

References

Anderson, P., Fernando, B., Johnson, M., Gould, S. (2016). SPICE: Semantic Propositional Image Caption Evaluation. *Computer Vision – ECCV 2016 Lecture Notes in Computer Science,* DOI: 10.1007/978-3-319-46454-1_24

Balbin, J. (2014). TextTeaser. *Github repository,* https://github.com/MojoJolo/textteaser.

Bird, S., Loper, E., Klein, E. (2009). Natural Language Processing with Python. *O'Reilly Media Inc.*

Chollet, F. (2018). Keras applications. *Github repository*, https://github.com/keras-team/keras-applications.

Gatys, L. A., Ecker, A. S., Bethge, M. (2015). A Neural Algorithm of Artistic Style. *Journal of Vision, 16(2).* DOI: 10.1167/16.12.326

Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., Benglo, Yoshua. (2014). Generative Adversarial Nets. *Advances in Neural Information Processing Systems 27 (NIPS 2014).*

Guo, J., Lu, S., Can, H., Zhang, W., Yu, Y., Wang, J. (2017). Long Text Generation via Adversarial Training with Leaked Information, *arXiv preprint* arXiv:1709.08624

Hu, A., Flaxman, S. (2018). Multimodal Sentiment Analysis To Explore the Structure of Emotions. *arXiv preprint* arXiv:1805.10205.

Kahlo, F. (1940). Self Portrait with Thorn Necklace and Hummingbird [oil on canvas]. Harry Ransom Center, University of Texas Austin, Austin. *The Art Story.*

Kim, H., Kim, Y., Kim, S., Lee, I. (2017). Building Emotional Machines: Recognizing Image Emotions through Deep Neural Networks. *arXiv preprint* arXiv:1705.07543v2

Kiros, J. R. (2015). Neural-storyteller. *Github repository,* https://github.com/ryankiros/neural-storyteller.

Kiros, J. R., Salakhutdinov, R., Zemel, R. S. (2014a). Unifying Visual-Semantic Embeddings with Multimodal Neural Language Models. *arXiv preprint* arXiv:1411.2539.

Kiros, J. R., Zhu, Y., Salakhutdinov, R., Zemel, R. S., Torralba, A., Urtasun, R., Fidler, S. (2014b). Skip Thought Vectors. *arXiv preprint* arXiv:1506.06726.

Kurdi, B., Lozano, S., Banaji, M. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods*, *49(2),* 457-470. DOI: 10.3758/s13428-016-0715-3

Lin, T., Maire, M., Belongie, S., Bourdev, L., Girshick, R., Hays, J., Perona, P., Ramanan, D., Zitnick, C. L., Dollar, P. (2015). Microsoft COCO: Common Objects in Context. *arXiv preprint* arXiv: 1405.0312v3

Liu, B., Fu, J., Kato, M., Yoshikawa, M. (2018). Beyond Narrative Description: Generating Poetry from Images by Multi-Adversarial Training. *arXiv preprint* arXiv: 1804.0847

Maleab, Mahar. (2017). Recall and Precision at K for Recommender Systems. *Medium*. https://medium.com/@m_n_malaeb/recall-and-precision-at-k-for-recommender-systems-618483226c54.

Richardson, Leonard. (2018). Beautiful Soup. https://www.crummy.com/software/BeautifulSoup.

Sartori, A., Culibrk, D., Yan, Y., Sebe, N. (2015). Who's Afraid of Itten: Using the Art Theory of Color Combination to Analyze Emotions in Abstract Paintings. *Association for Computer Machinery*. DOI: 10.1145/2733373.2806250

Simonyan, K., Zisserman, A. (2015). Very Deep Convolutional Networks for Large-Scale Image Recognition. *arXiv preprint* arXiv: 1409.1556

Vasa, H. (2015). Google Images Download. *Github repository.* https://github.com/hardikvasa/google-images-download.

Warriner, A., Kuperman, V., Brysbaert, M. (2013). Norms of Valence, Arousal, and Dominance for 13,915 English Lemmas. *Behavior Research Methods, 45(4),* 1191-1207. DOI: 10.3758/s13428-012-0314-x

Yu, L., Zhang, W., Wang, J., Yu, Y. (2017). Seqgan: Sequence Generative Adversarial Nets with Policy Gradient. *arXiv preprint* arXiv:1609.05473

Zhao, S., Gao, Y., Jiang, X., Yao, H., Chua, T., Sun, X. (2014). Exploring Principles-of-Art Features For Image Emotion Recognition. *ACM Multimedia*. DOI: 10.1145/2647868.2654930

Zurakhinsky, M. (2018). "The Art Story: Modern Art Insight." Theartstory.com