emoji generation based on textual input using generative adversarial networks

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DEDICATION

Firstly, I would like to dedicate the master’s thesis project to my parents who have inspired, supported and always encouraged me during the journey. TODO

ACKNOWLEDGEMENTS

I would like to thank and express my gratitude to all those who have contributed to development of this master’s thesis. TODO

ABSTRACT

With the increase in popularity with its wide variety of uses, emojis have become so necessary and important that sending or responding to a message and commenting or reacting to a post on social media without emoji seems to be impossible. Emoji represents emotions, culture, age, gender, actions, gesture, expressions, sports, foods, places and objects.

Despite the importance the number of emojis are countable and finite in quantity. In this research we will be creating a generative model to generate new unique emojis using short text for more complex and distinction emojis

We will be using the state-of-the-art generative models which consist of mainly two-part generator and discriminator. The generator and discriminator will work one after the other. First the generator will be trained to generate new emojis and after couple of rounds the discriminator will be trained to detect is the emoji is fake or real. This is followed by generator and discriminator rounds. This process continues until the discriminator is not able to detect is the emoji is fake.

This will help the community to generate wide variety of emojis based on the requirement rather than choosing from a finite set of emojis.

This research will help to generate high quality and diverse emojis. It will also help the tech community with the comparison of the different GAN models with different evaluation metrics.

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LIST OF ABBREVIATIONS

GAN Generative Adversarial Network

VQGAN Vector Quantized Generative Adversarial Network

DCGAN Deep Convolution Generative Adversarial Network

CLIP Contrastive Language-Image Pre-Training

AI Artificial Intelligence

ML Machine Learning

RGB Red Green Blue

RGBA Red Green Blue Alpha

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Emoji is a visual representation of human interaction based on Human emotions, living beings, objects and symbols. These are in widespread use across the internet such as in textual messaging application, social media platforms which are known as informal modes of communication. Below is an image about the most frequently used emojis during informal modes of communication.

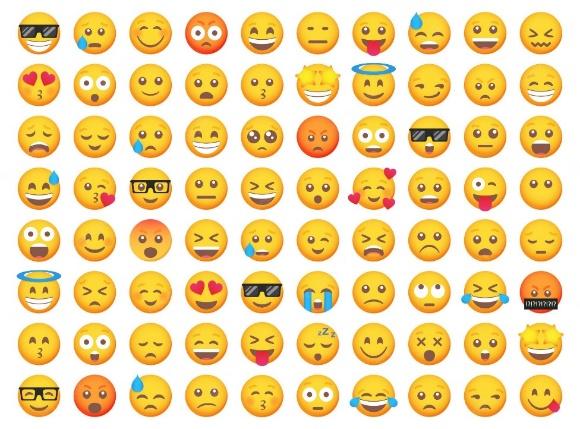


Figure 1 Sample emojis used frequently in informal communication.

According to (Kennison et al., 2024) emojis represent faces with human expressions, objects, animals, and actions.

Emojis are often used to in replacement of words, thus acting as a part of communication and language (Provine et al., 2007). As per the research (Urumutta Hewage et al., 2021) the emojis are static images which are often preserved as human like emotion and expressions. Further, as per (Erle et al., 2022) the communication has greater emotional intensity when we communicated to people using emojis rather than without emojis.

Other application of emojis other than informal communication includes

* Rating/Feedback Form : The feedback forms using emoji instead of stars or numbers. The research has found that the chances of the user giving feedback is higher when emojis are used.
* Providing a Reaction : These days most online applications or websites provide emojis to react to a post, blog, article or tweet.
  + Thumbs up and down emojis are used to like and dislike.
  + Facial emojis are used to express feeling like surprise, wow or shocked.

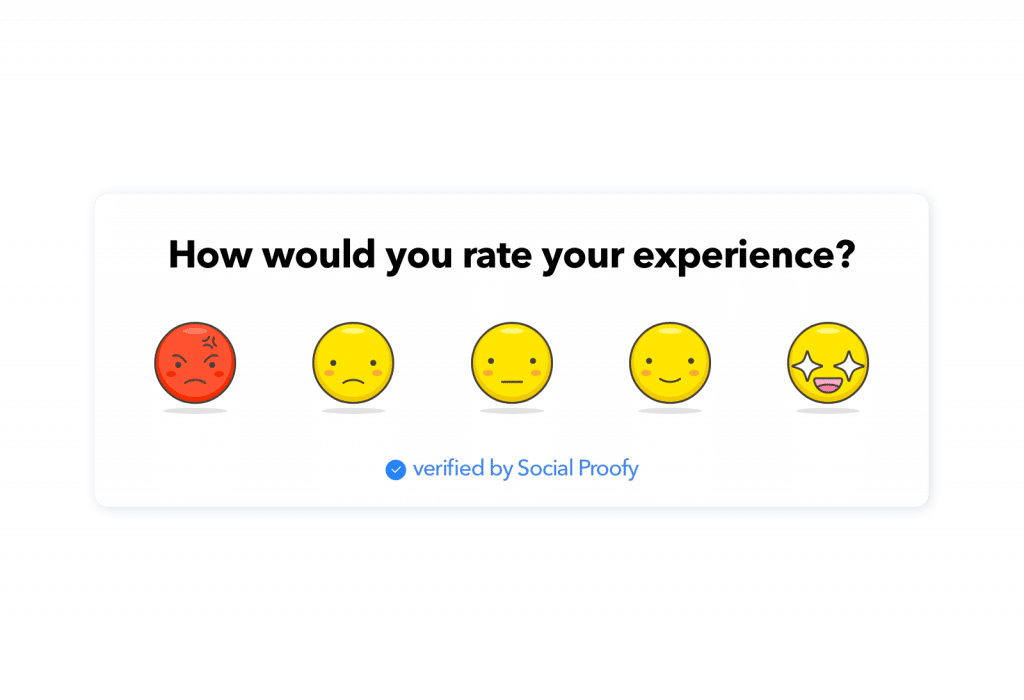


Figure 2 Emoji used in a feedback form

As per the emojipedia.org analysis of over 2.934 billion global tweets between 2017 to 2021, the percentage of tweets with at least one emoji has increased from 13.5% to 21.5%. With the increase of the use of emoji, the demand for newer and customised emoji is increasing. The creation of emoji is a currently is a tedious process of submitting an emoji to Unicode Technical Committee, which takes the final decision for the inclusion, this takes 18-24 months for the complete process Using the state-of-the-art models for generating images using text, we will be able to create new emojis based on the user input.

Prior research has focused on generating facial emojis and emotion based facial emojis. With the state-of-the-art model and architecture, we will be generating not only facial emojis but objects also.

Prior research used techniques like unsupervised learning , Deep Convolution based Generative Adversarial Networks and Conditional Generative Adversarial Networks.

One of the greatest debates on emojis includes whether emoji can be used “as punctuation” or ”after punctuation” which was included in “The Great Emoji Debate”.

In this research we will be creating a state-of-the-art model to generate emojis using emoji content and descriptive information of the emoji and comparing the model with prior models.

We will be looking at the various generative adversarial models :

* VQGAN-CLIP
* TextControl-GAN
* StyleGAN-T

1.2 Problem Statement

Currently the process of creating new emojis is a tedious and time-consuming task which takes a couple of days or months to create and years to get approval from the Unicode Technical Committee. Currently there are only 3,664 emojis as per Unicode standard and the need for need and diverse emoji is increasing. Due to this the current library faces limitations in capturing all the human emotion and experiences. This can lead to miscommunication and inadequate representation of culture and identities.

As per the current trend the use of emoji has been steadily increasing in informal conversation and social media. The need for new emojis to be generated quickly based on the text from the user is high. This issue mostly affects the Gen Z generation as they are the ones who use them mostly during the social media platforms, Messaging apps and content creation. It is important as it can improve the quality of the conversation with improved emotions and objects. This solution will have a huge impact on the conversation by improving the quality of the conversation with new and better emojis which can express emotions and objects accurately.

1.3 Aim and Objectives

The aim of this research is to propose a generative model to generate new emojis is to create a new and diverse design based on textual input from the user and compare it with the baseline and previous models which are visually appealing and useful.

Below are the list of research objectives which will be accomplished in this research:

* To create a generative model that can create new high quality and realistic emojis.
* To generate emoji based on the platform of use.
* To compare between the state-of-the-art generative models.
* To evaluate the performance of the emojis generated using the generative models.
* To finetune the various parameters used in the generative model.

1.4 Research Questions

Generate new realistic emoji in real time based on the textual input from the user.

1.5 Scope of the Study

The scope of a study on generating new emojis are as follows:

* Type of architecture : Generative Adversarial Networks
* Data : <https://huggingface.co/datasets/ChengAoShen/emoji_with_text>
* Input : Short textual input
* Output : 64x64 emoji
* Evaluation techniques :
  + Inception Score (Shmelkov et al., 2018)
  + Fréchet Inception Distance (Shmelkov et al., 2018) (Lee et al., 2023)
  + Learned Perceptual Image Patch Similarity (Lee et al., 2023)
  + Structural Similarity Index (Mittal et al., 2020)

1.6 Significance of the Study

1.6.1 Contributions

* Offer users a wider range of options to accurately express their emotions and experiences using emoji,
* Reflects the variety of individuals and communities.
* Contribute to the development and application of GANs
* Valuable tool for individuals and communities to create custom emojis

1.6.2 Beneficiaries

* Users of social media platforms.
* Content creators like article and blog writers.
* The AI and ML industry.
* Emoji Designers.
* Unicode and emoji organisations like emojipedia.

1.7 Structure of the study

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

GAN or Generative Adversarial Networks belong to generative model family. This model helps to generate new samples from the same distribution from similar sample dataset. Over the last decade, there is significant progress in GAN models. In this chapter we will study the various types of research on GAN and its applications, importance of emoji, various datasets, types and advantages of word embeddings and comparison of various metrics used to test different models.

2.2 GAN and Applications

2.2.1 What is Generative Adversarial Networks?

In 2014 Ian Goodfellow and his colleagues developed the basic GAN model. It was based on zero sum and min max game theory. Here's a simplified explanation of GANs:

* The Forger (Generator): A computer program that starts by making very bad drawings   
  of the emoji
* The Detective (Discriminator): Another computer program that gets shown both real emoji and the Forger's fakes. The Detective tries to tell them apart.

Each time the Detective catches a fake, the Forger learns from its mistakes and tries to make even better fakes. This makes the Detective have to get smarter too.

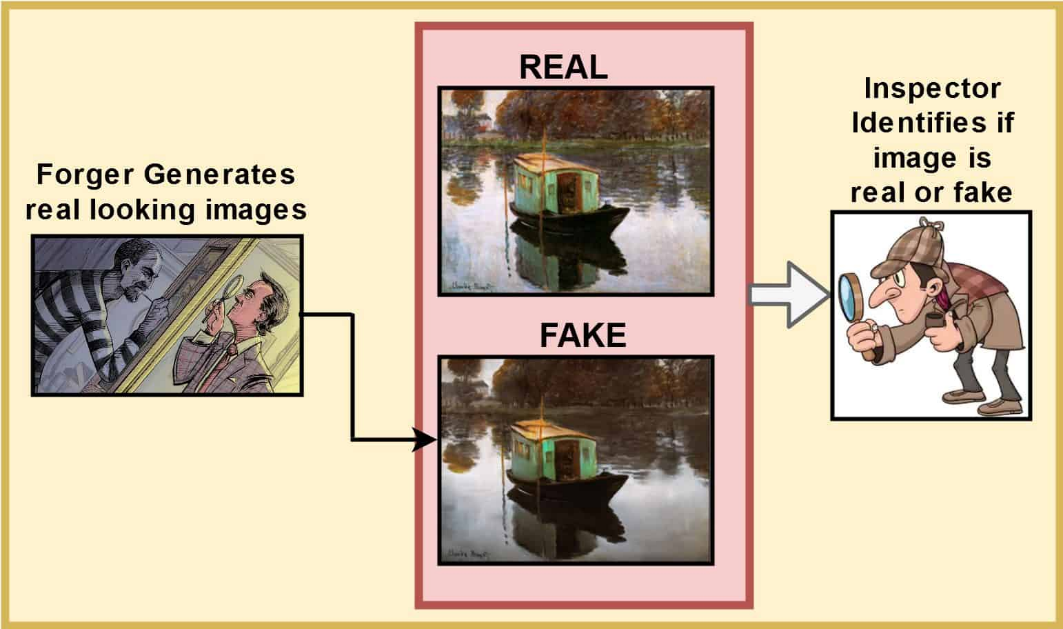


Figure 3 GAN in simplified image

2.2.2 Basic GAN Architecture and Learning

The basic of GAN architecture comprises of one generator and one discriminator. The generator is represented by G and the discriminator is represented by D. The generator takes an input vector z and generate an output which is represented by G(z). Both generator and discriminator consist of neural networks, one to create the required output and other for binary classifier.

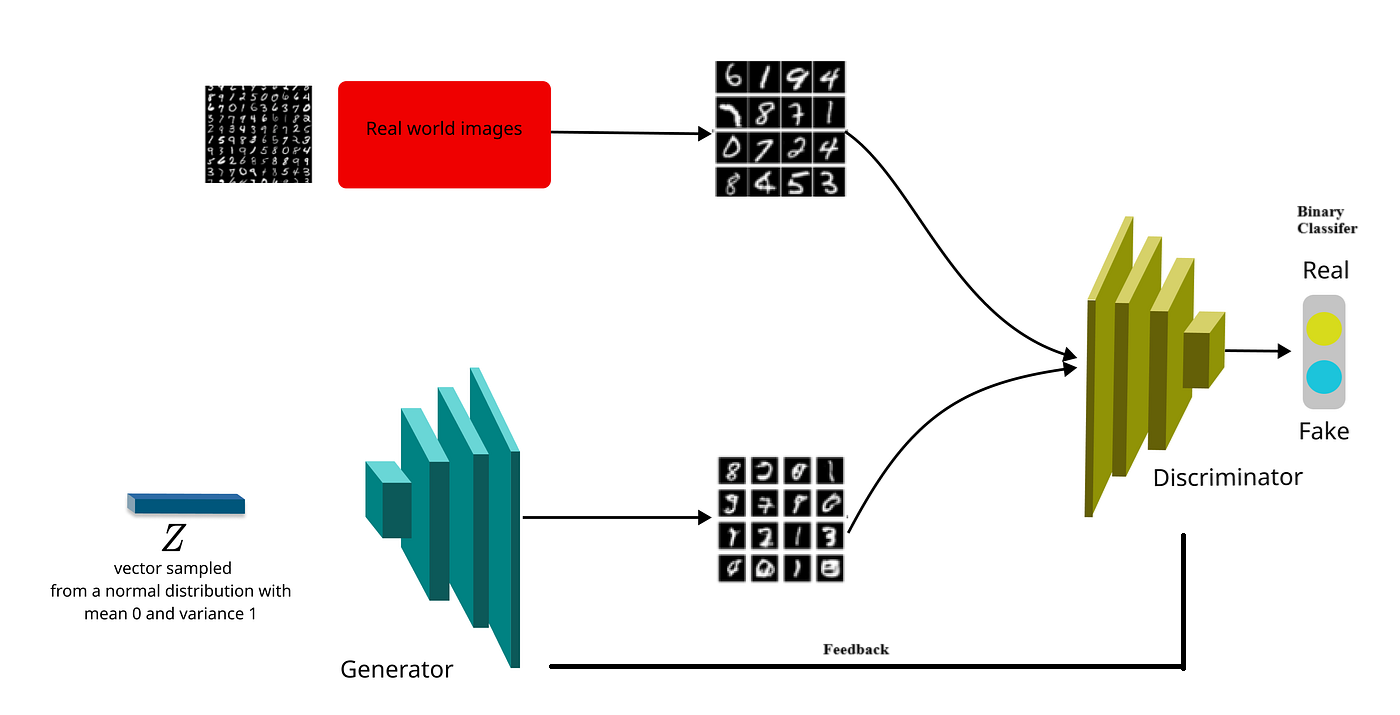


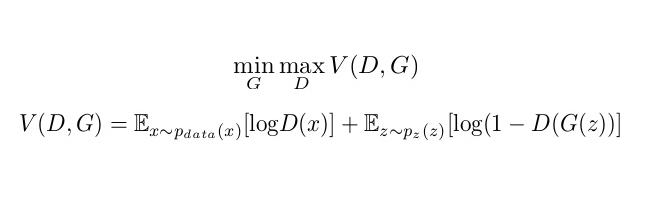
Figure 4 Basic GAN Architecture

The discriminator takes both the real data and the fake data from the generator and tries to decide which one is fake i.e. it models the probability of the fake data is real or not. After each iteration the feedback from the discriminator is sent to the generator to improve the quality of the fake data.

Over a period of time the generator creates better fake data and the discriminator learns identifying the fake images. Both models tries to beat each other due to which the adversarial term come from.

2.2.3 Loss function of GAN

GAN uses minmax loss function to optimize the neural network. The generator minimizes the function and the discriminator maximizes the loss.



Ex – Expected value over all real data samples

D(x) – Probability of discriminator if x is real

G(z) – Generator output

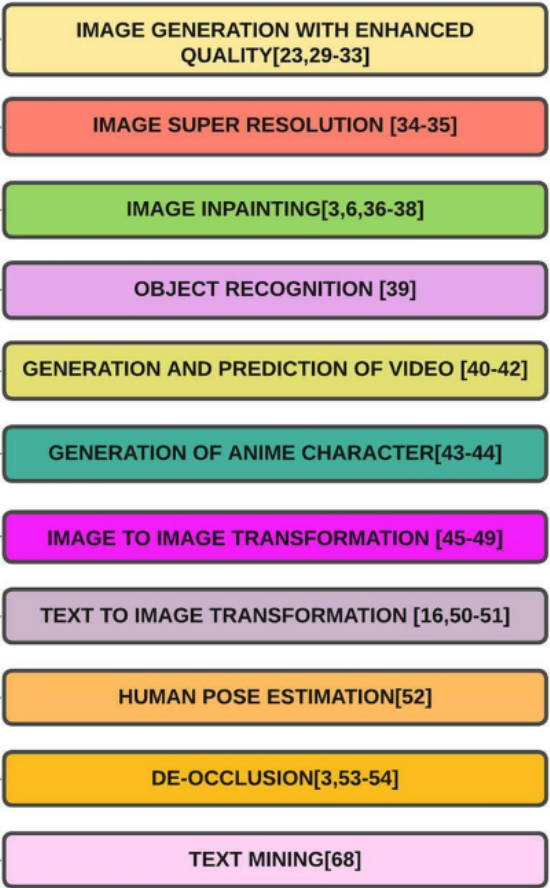
z – Random noise

D(G(z)) – Probability of discriminator generated data is real

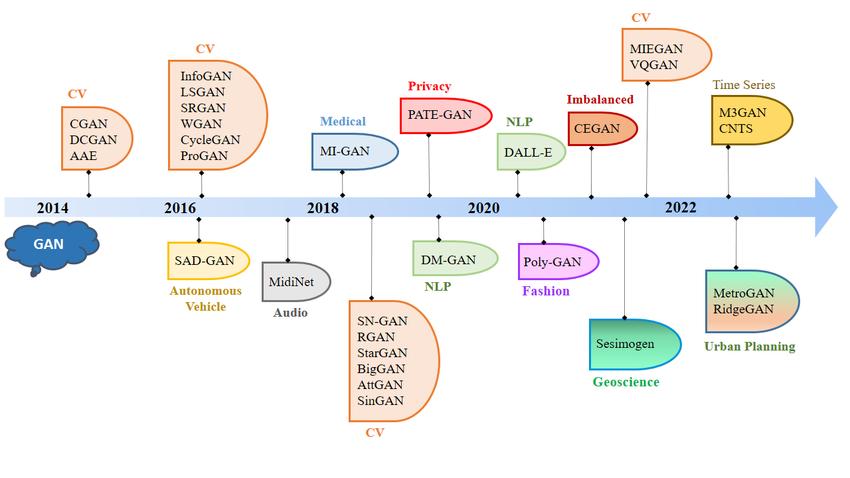
Ez – Expected value over all random data

2.2.3 Application of GAN

TODO



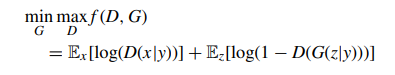
2.3 Research on evolution of GAN

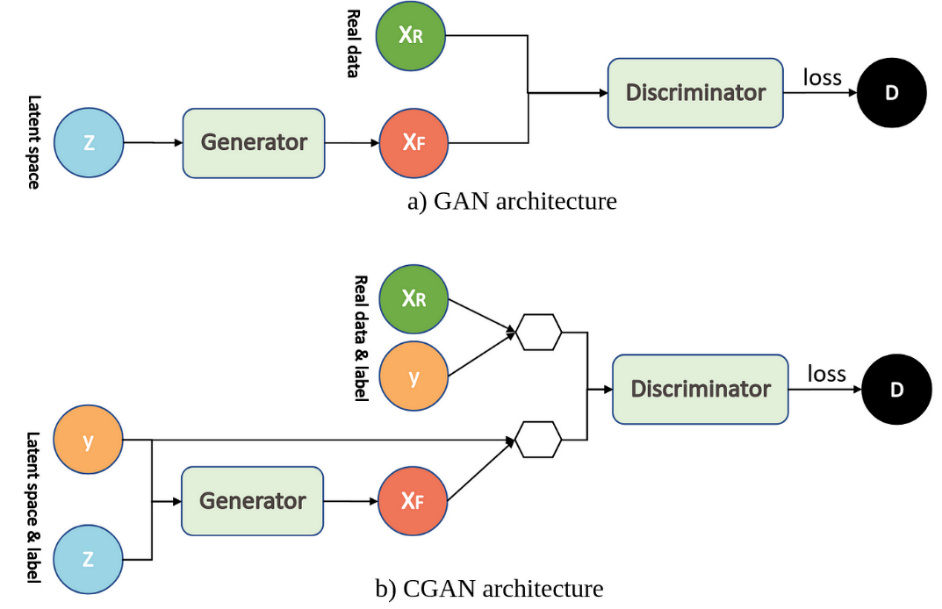


2.3.1 Conditional Generative Adversarial Networks (cGAN)

cGAN are an extension to GAN with additional conditional input along with the noise vector. This gives the generator and discriminator control over the mode of data which is generated. The additional input is denoted by y in the figure below. This can be in any form text, labels or other modalities.

The loss function for cGAN can be represented as:



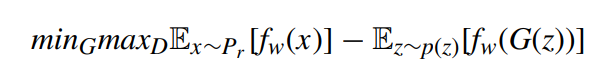


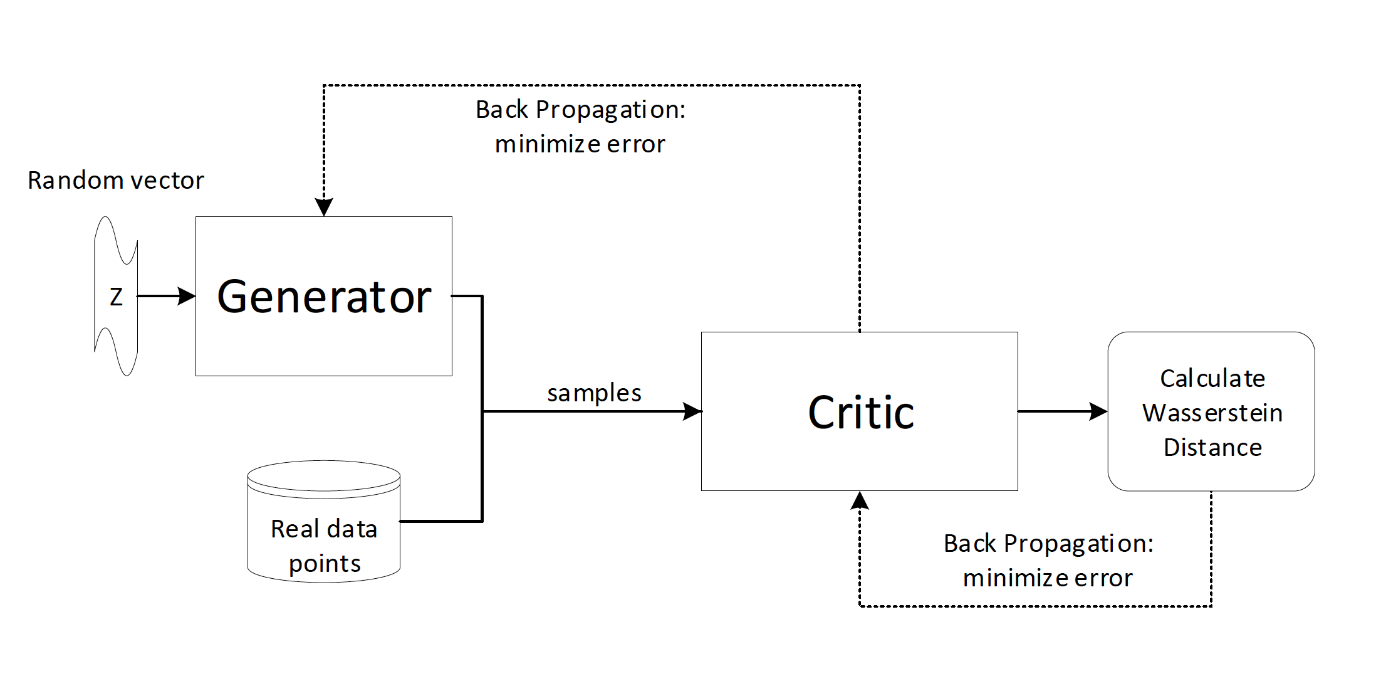
2.3.2 Wasserstein Generative Adversarial Networks (WGAN)

WGAN proposed a new approach to training GAN that addressed some of the inherent challenges of traditional GANs like instability and mode collapse. Instead of using the traditional divergence to measure the difference between the generated and real data it employs the Wasserstein distance. This provides a measure of distance for distributions that may not overlap significantly. It captures how much work is needed to change one distribution into another making it more stable during training.

To ensure that the discriminator/critic maintains the condition required for the Wasserstein distance the weights of the discriminator are constrained to a fixed range which prevents them from growing too big which could lead to instability. The use of Wasserstein distance and weight clipping helps mitigate common problems seen in traditional GAN training, such as mode collapse, where the model generates limited varieties of outputs. WGAN’s framework allows for smoother gradients, leading to more stable learning dynamics.

The loss function for WGAN can be represented as:





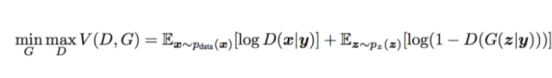
2.3.3 Deep Convolution Generative Adversarial Networks (DCGAN)

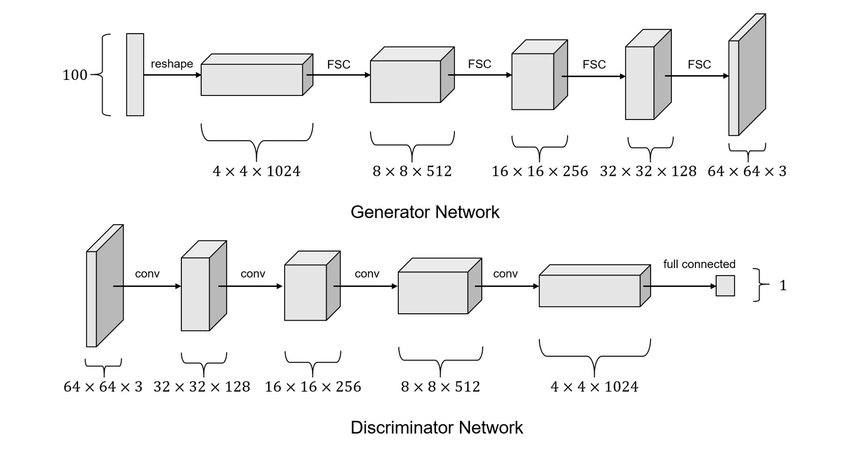
DCGANs use deep convolutional neural networks for both the Generator and Discriminator models. The original GAN architecture used only multi-layer perceptron’s or MLPs.

The key features of the DCGANs neural network architecture are:

* The Generator, convolutions are replaced with transposed convolutions, so the representation at each layer of the Generator is successively larger, as it maps from a low-dimensional latent vector onto a high-dimensional image. Replacing any pooling layers with strided convolutions (Discriminator) and fractional-strided convolutions (Generator).
* Use batch normalization in both the Generator and the Discriminator.
* Use ReLU activation in Generator for all layers except for the output, which uses Tanh. Use LeakyReLU activation in the Discriminator for all layers.
* Adam optimizer instead of SGD with momentum.

The loss function for WGAN can be represented as:



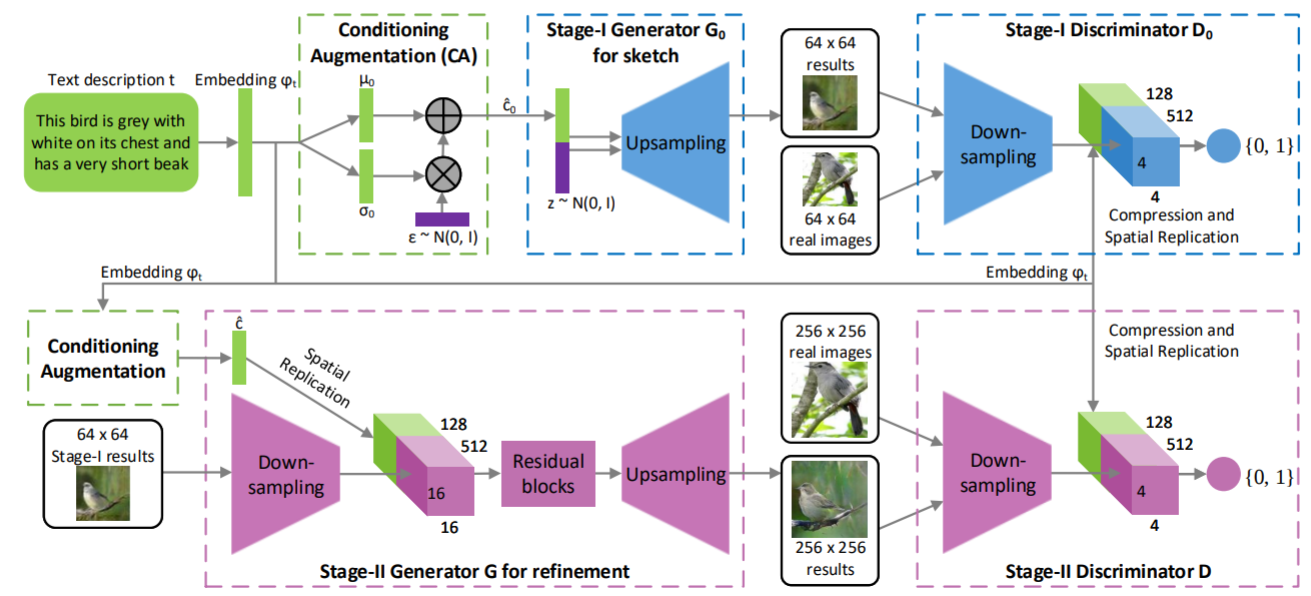


2.3.4 Stacked Generative Adversarial Networks (StackGAN)

StackGAN is a framework designed specifically for generating high-resolution images from textual descriptions. It tackles the challenge of producing detailed images while maintaining coherence with the provided textual input.

The Stack GAN consists of the following components:

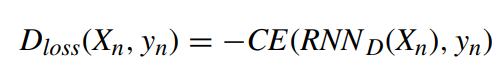
* The variable input is converted into a fixed length vector embedding.
* The Stage 1 generator takes the textual input and generates a low-resolution image output.
* The Stage 2 generator takes the textual input along with the low-resolution image generated by the Stage 1 and generate a high-resolution image output.
* Stage 1 and Stage 2 discriminator

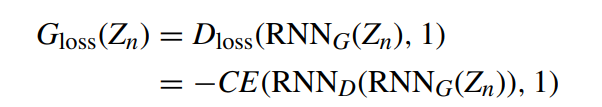


2.3.5 Recurrent Generative Adversarial Networks (RGAN) and Recurrent Conditional Generative Adversarial Networks (RCGAN)

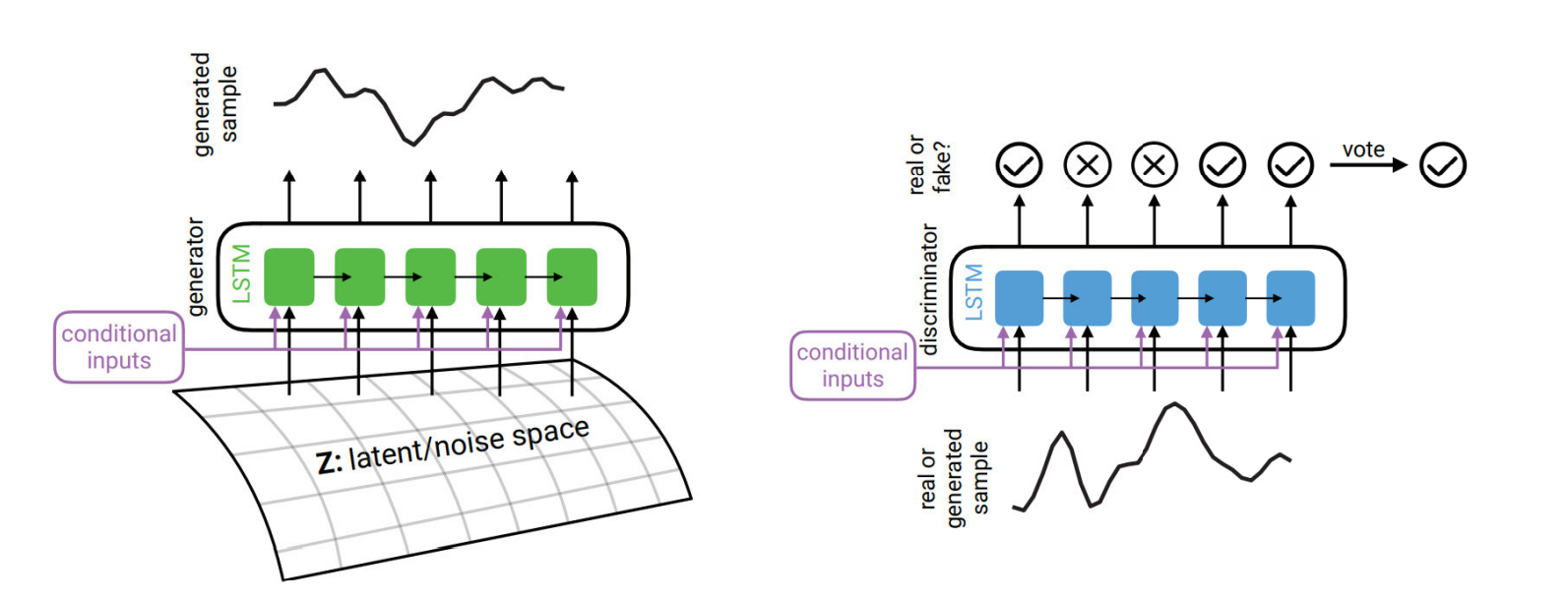
RGAN and RCGAN is used to generate a sequence of data. It use recurrent neural networks for both the Generator and Discriminator models which is the main difference with the DCGAN. Here the RNNs can be a Long Short-Term Memory (LTSM) or Gated Recurrent Unit (GRU) which captures the temporal dependency of input. In case of RCGAN the generator and discriminator receives an addition auxiliary input. Many experiments show effective results while using RGAN and RCGAN for time series data.

The loss function for RCGAN can be represented as:





Where Xn and yn are the input and zn is the random noise vector



2.3 Research on Emoji and its Importance

Emoji despite being more common in digital communication, is often dependent on characteristics, motives for using them and the context in which they are used (Cavalheiro et al., 2023). Over the past couple of years there has been extensive research in the use and importance of emojis in every life activity. Below are few of the recent research with description and findings:

* The research by (Cavalheiro et al., 2023) try to find the relationship of frequency of the emoji with relationship and individual characteristics. The research also found personal reasons to be one of the relates to high emoji frequency. The research also found age to be directly correlated with emoji frequency which was unexpected.
* The research by (Erle et al., 2022) discusses a creation of emojis in digital communication with the help of their model. The research also found that the emojis can depict the facial expression of the human.
* The research by (Lefebvre et al., 2024) is about the influence of emoji during tip suggestion with the tipping percentage. The research also found significant positive effects of emoji during the tipping.
* The research by (Kennison et al., 2024) relates the personal characteristics with the emojis used in the conversation. The research also found that the men used emojis less often than women. The research also found that users may me using emojis in place of word and used less dictionary words.

2.3 Research on Emoji Dataset

There are very limited datasets for emojis which are labelled and have quality images. Below are the datasets considered which were considered during the start of the research.

* Emoji-dataset on Hugging Face by valhalla

<https://huggingface.co/datasets/valhalla/emoji-dataset>

* Full Emoji Database on Kaggle by ELIAS DABBAS  
  <https://www.kaggle.com/datasets/eliasdabbas/emoji-data-descriptions-codepoints/data>
* Emoji-with-text on Hugging Face by ChengAoShen

<https://huggingface.co/datasets/ChengAoShen/emoji_with_text>

Finalized the 3rd dataset as the quality of the images was good and every image had their respective label.

2.4 Research on Emoji Generation

With the evolution generative models and the importance of emoji there has been couple of research done in the field of emoji generation. It has been noticed that most of the research has been around facial emojis and with a very limited set of them. Below are few of the recent research with description:

* The research (Mittal et al., 2020) uses supervised learning with multimodal input to GAN with U-Net like architecture for the generator to generate realistic hand drawn emojis. This research even though was able to generate the emojis it required the user to draw a rough sketch with the emotion to be given as input, also the dataset used had to be augmented from the facial emojis which don’t depict the real dataset.
* The research (Lee et al., 2023) creates a model which can generate emojis based on emotional degree for more complex and detailed usage on online conversations (Lee et al., 2023). The research uses conditional GAN for the experiment and also compares it with other baseline models. This
* The research (Tang, 2023) used unsupervised learning to generate new emojis using DCGAN which is a combination of Convolution Neural Network and Generative Adversarial Network. This research faced many challenges like after 1000 epochs the accuracy flattens out. The emojis generated where quite blurry and the user had no control over the emojis generated due to unsupervised learning.
* The research (Xu, 2021) used unsupervised learning with optimization techniques with Adam Optimizer to generate new emojis.
* The research (Peng and Zhao, 2021) used an encoder–decoder model, to predict the sequence of emojis based on short text. This research was able to correlate the emojis generated. The model was also able to learn the semantics between the emoji and text description.

Although the above research where able to generate emojis but most of this research had sparse data and limited the scope to generate facial emojis.

2.5 Research on Word Embeddings:

According to the research by (Asudani et al., 2023) the first preference should be given to domain specific embeddings. The research also compares the performance of the various word embedding techniques.

Word embeddings are word representation as vectors in a continuous vector space. This captures semantic relationships between words, making it easier for models to process text. Here’s concepts and techniques used in word embeddings:

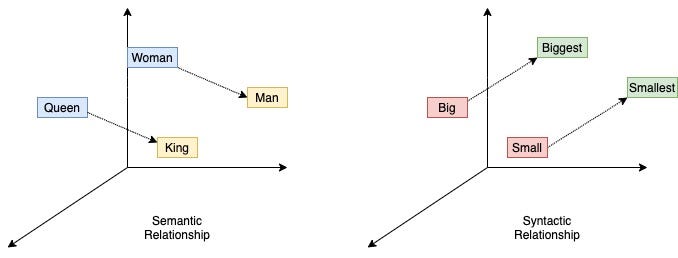
2.5.1 Key Concepts:

* Vector Space Model: In this model, words are mapped to points in a high-dimensional space, where similar words are located close to each other.
* Dimensionality: Commonly, embeddings are created with dimensions ranging from 50 to 300, balancing performance and computational efficiency.
* Semantic Relationships: Word embeddings can capture various relationships, such as:
  + Synonymy (e.g., "king" and "queen")
  + Analogies (e.g., "man" is to "woman" as "king" is to "queen")

2.5.2 Popular Techniques:

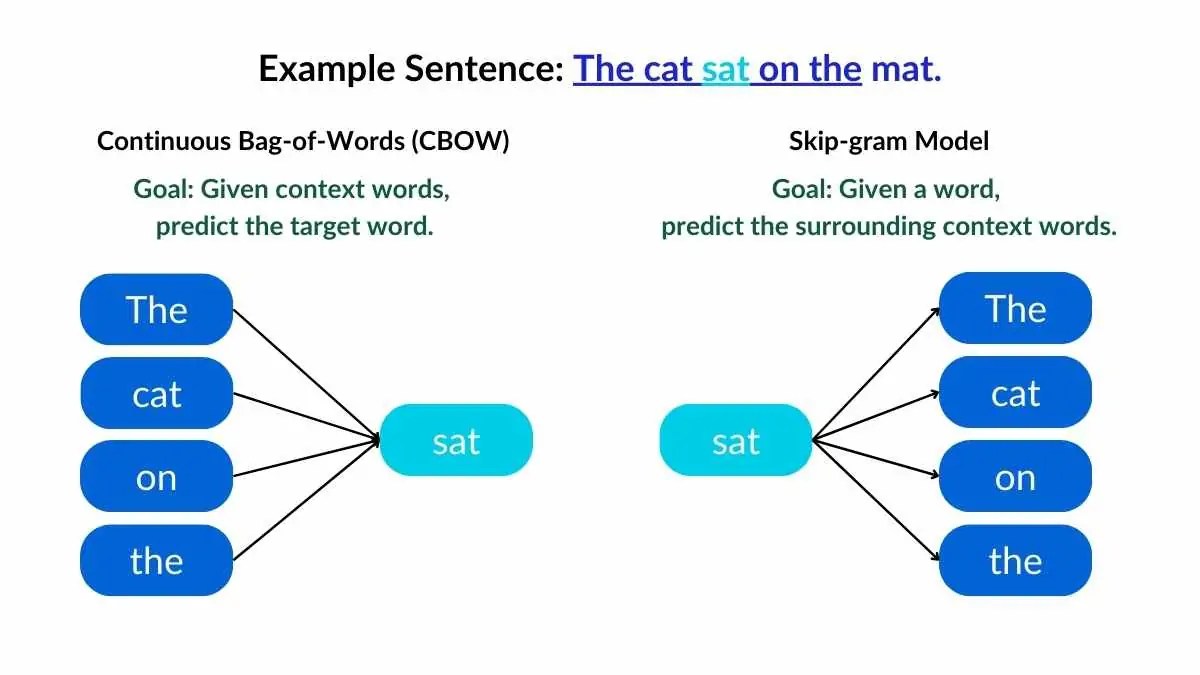
2.5.2.1 Word2Vec

It is a popular technique for natural language processing that transforms words into numerical vectors. Developed by a team at Google led by Tomas Mikolov, Word2Vec captures semantic relationships between words, enabling computers to understand text better.



The two training models :

* CBOW (Continuous Bag of Words) - This model used for learning word embeddings, which are dense vector representations of words that capture their semantic and syntactic properties.
* Skip-Gram – This model uses a target word to predict its surrounding context words. It’s particularly effective for learning rare words.

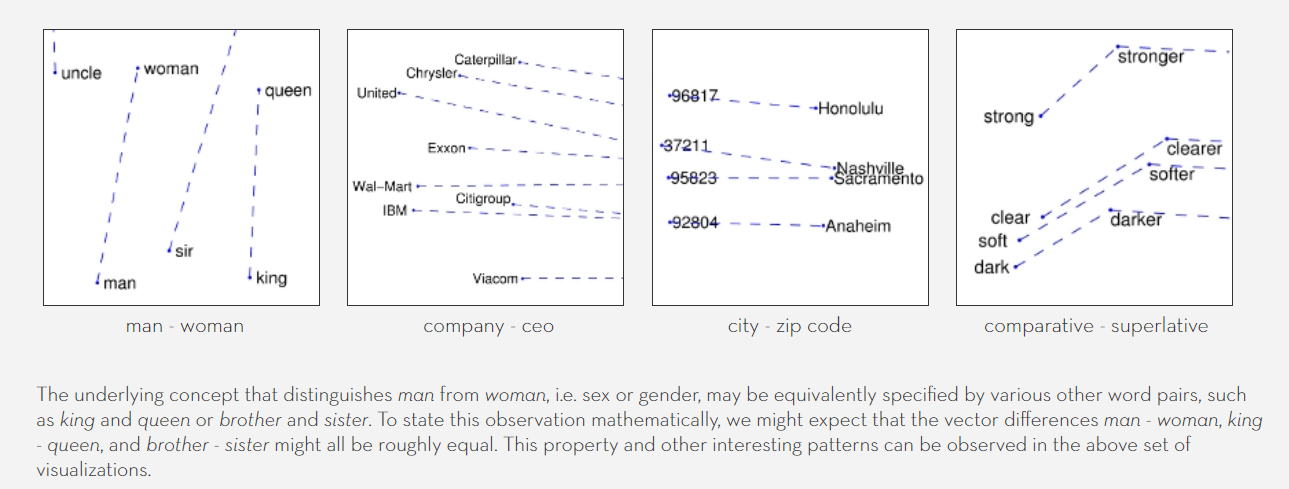


2.5.2.2 GloVe (Global Vectors for Word Representation)

Global Vectors for Word Representation (GloVe) is developed by researchers at Stanford. It is an unsupervised learning algorithm for obtaining vector representations for words. It captures the global statistical information of a sentence in a meaningful way.

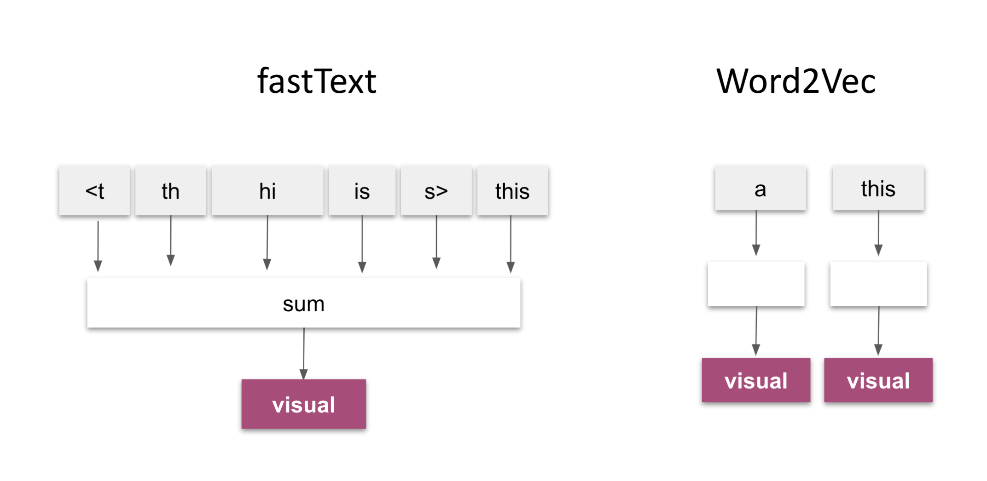
GloVe's use of global co-occurrence information allows it to generate embeddings that reflect broader semantic relationships. It uses euclidean distance or  cosine similarity to measuring the linguistic or semantic similarity of the corresponding words.

The output word vectors perform well on various NLP tasks, including analogy and similarity tasks.



2.5.2.3 FastText

FastText is a sophisticated Word embedding model recently introduced by Facebooks AI Research(FAIR) team performed substantially better than traditional word embeddings by considering subwords. It represents words as a bag of character n-grams (e.g., for the word "apple" it would use "app", "ppl", and "le"). That makes it learn the morphology of word construction and based on its pieces what an English word means. For each word, the model averages the vectors of its n-grams to create a vector for the word, which allows it to embed words that potentially were not even observed during training.



2.5.2.4 ELMo (Embeddings from Language Models)

ELMo is a deep learning model created by the Allen Institute for AI that generates word embeddings. These word embeddings are deep contextualized word representations based on a pre-trained bidirectional language model biLMs.Unlike traditional word embeddings, it captures context in a more sophisticated way.

It creates embeddings based on context of the word. This means that the same word can have different representations depending on its usage in a sentence.

ELMo utilizes a bidirectional Long Short-Term Memory network where it efficiently uses all layers of the bidirectional language model.

ELMo is trained on 1 billion tokens due to which it generates state-of-the-art embedding with contextually aware word representations.

2.5.2.5 BERT (Bidirectional Encoder Representations from Transformers)

BERT is developed by Google and is know for the versatility and performance with benchmark results on GLUE and SQuAD datasets.

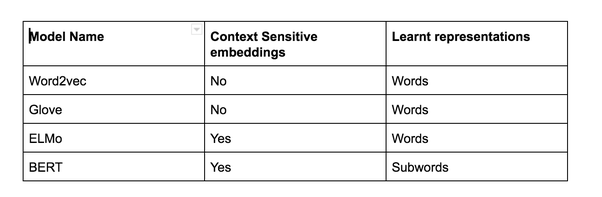
It processes text in both directions simultaneously which allows it to capture the full context of a word based on all surrounding words, increasing its understanding of language.

Its encoder utilize self-attention mechanisms which enable the model to weigh the importance of different words in a sentence leading to better representations.

It is trained on large datasets like Wikipedia and BooksCorpus and can be fine-tuned on specific downstream tasks like sentiment analysis and question answering.

It also produces dynamic embeddings based on the context of the word similar to ELMo

Below is the comparison between the different embeddings :



**2.6 Research on Methodology Specific to Text to Image Generation**

Below are the recent methodologies in the text to image domain developed on top of generative adversarial network architecture.

|  |  |  |
| --- | --- | --- |
| **Methodology** | **Use** | **Description** |
| **Attn-GAN** (Xu et al., 2018) | Text to Image Generation | The research proposes a new GAN with multistage refinement using attention. Each of this multistage attention model gets the most relevant word vectors for generating sub-regions of the image (Xu et al., 2018). |
| **Stack-GAN** (Dhivya and Navas, 2020) | Image Generation based on text | The research proposes the use of multiple GAN stacked on top of each other to generate high resolution photo realistic images (Trevisan de Souza et al., 2023). |
| **Style-CLIP**(Patashnik et al., 2021) | Text-guided image editing | This research proposes CLIP embeddings to allow image editing. The CLIP embeddings share the same latent space hence we can directly compare the text with the images (Trevisan de Souza et al., 2023). |
| **VQGAN-CLIP**(Crowson et al., 2022) | Text-to-image synthesis | This research proposes a model where an encoder is used to create a latent vector which is used by the decoder to create the image. It also uses CLIP embedding with optimization techniques to have high similarity with the text prompt. (Trevisan de Souza et al., 2023). |
| **TextControl-GAN** (Ku and Lee, 2023) | Text to Image | The research proposes a neural network as regressor to learn the textual features. The research also uses data augmentation techniques to increase the performance(Ku and Lee, 2023). |
| **StyleGAN-T**(Sauer et al., 2023) | Text-to-image synthesis | This research proposes a model build from Style GAN-XL mentioned before. The network size of the model is increased to include text information from CLIP encoders.  (Trevisan de Souza et al., 2023). |

Table 1 Related works on Methodologies

2.8 Research on Evaluation metrics for GAN

We can measure the image quality the following metrics are used

* Inception Score (Shmelkov et al., 2018)

It was proposed in 2016 by Salimnas et al where the pretrained InceptionNet model was used to capture the properties of the generated samples. It is used to measure the quality of the images generated by comparing it with the real images from the dataset.

It calculates the KL divergence between the conditional label distribution of sample and marginal distribution of all samples. It access two characteristics mainly one image quality and another image diversity. Inception Score can be represented as :

Exp(Ex[KL(p(y|x)||p(y))])

Where :

p(y|x) – conditional label distribution

p(y) – marginal distribution

KL – Kullback-Leibler

* Fréchet Inception Distance (Shmelkov et al., 2018) (Lee et al., 2023)

It was proposed in 2017 by M Heusel. It is the measure to check how real the image generated are. The score tells how far the generated data vector is from real data vector. InceptionNet model is used to capture and embed features of an input image.

A multivariant Gaussian is used to summarize the embeddings by calculating mean and covariance for generated and real data. FID can be represented as :

FID(r,g) = ||ur-ug||22 + Tr(∑r + ∑g – 2((∑r∑g)1/2)

Where :

(ur, ∑r) – empirical mean and empirical covariance of real data

(ug, ∑g) – empirical mean and empirical covariance of generated data

* Learned Perceptual Image Patch Similarity (Lee et al., 2023)

It was proposed in 2018 by proposed by Richard Zhang and his collaborators. It evaluates the similarity between images which is particularly useful in tasks involving image generation. It is the distance measured between the patches in the latent space.

LPIPS can be represented as :

LPIPS(I1​,I2​)= ∑1​ wl​⋅d(fl(I1​),fl(I2​))

Where :

l – Indexes the layers of the CNN

wl – Learned weights for each layer, which adjust the importance of features extracted from different layers

d(.) – Distance metric (often L2 distance) computed on the feature maps

* Structural Similarity Index (Mittal et al., 2020)

It measures the degradation of the image quality

2.7 Challenges in GAN

Though Generative Adversarial Networks have made significant contribution in various applications but they face several challenges some of them are -

* The generator produces a limited variety of outputs, focusing on a few modes of the data distribution while ignoring others.
* GANs is very difficult to train. The balance between the generator and discriminator is very crucial and can be disrupted .
* The performance of GANs is very sensitive to its hyperparameters, such as learning rates, batch sizes, and network architectures which making tuning a challenging task.
* Training GAN requires huge resources in both RAM and VRAM.
* The discriminators can overfit on training data which makes it harder for the generator to learn.

Addressing these challenges continues to be an active area of research in the field of machine learning and deep learning.

2.8 Discussion

2.9 Summary

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Methodology

In this chapter we will be going through the end-to-end architecture which included data preprocessing, data transformation, the state-of-the-art methodology and the evaluation metrics used in the research.

3.1.1 Introduction

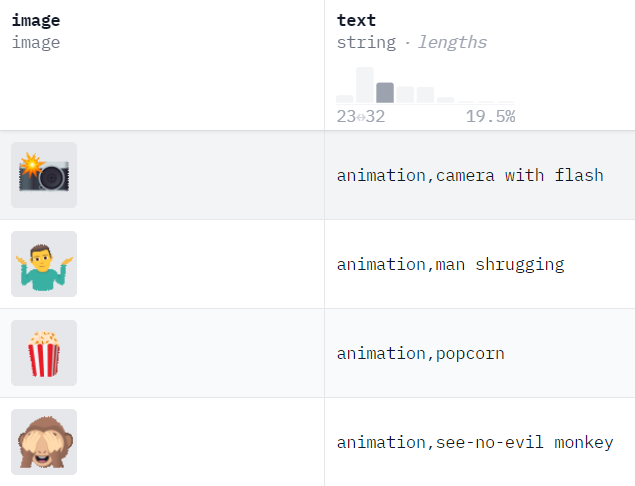
Here's a simplified explanation of GANs:

* The Forger (Generator): A computer program that starts by making very bad drawings   
  of the emoji
* The Detective (Discriminator): Another computer program that gets shown both real emoji and the Forger's fakes. The Detective tries to tell them apart.

Each time the Detective catches a fake, the Forger learns from its mistakes and tries to make even better fakes. This makes the Detective have to get smarter too.

3.1.2 Dataset description

The dataset (ChengAo Shen and Siyuan Mu, 2023) is uploaded on Hugging face. This dataset consists of 47200 emojis with the text description. Each image is of shape 64\*64 and has RGBA channels. Description text format : app or company, emoji content, description information



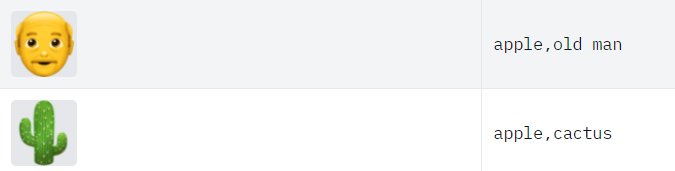
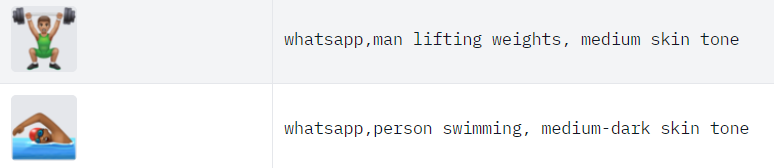


Figure 5 Dataset sample

3.1.3 Data preprocessing

The dataset doesn't require any cleaning or filtering as it has already been done by the author of the dataset. All the emoji are of the shape 64x64x4 where 4 is the number of channels which represent RGBA (Red, Green, Blue, Alpha) which can be converted to RGB(Red, Green, Blue) format. The text description will be split into 3 columns: app/company, emoji content, description information using regular expressions. These 3 columns will be processed to remove stop word and name entity recognition will be used to identify the company and keywords from the description. The dataset will be organised and divided into 3 parts for training, testing and validation.

3.1.4 Transformation

* Latent Space Manipulation  
  Latent space is the hidden layers in the architecture which can be seen as compressed input. As proposed in (Yang et al., 2021) we can use latent space factorization or manipulations to change the attributes of the image.
* Word to Vector  
  The text description for the emojis will be converted to vector representation.  
  They capture the meaning and their usage.
* Clip embedding

The images and text vectors share the same latent space which is helpful in direct comparison of the both

3.1.5 Models ()

Below are the recent shortlisted state of the art model which we will be using and comparing to generate the emojis using the textual input.

|  |  |
| --- | --- |
| **Methodology** | **Description** |
| **VQGAN-CLIP** (Crowson et al., 2022) | This research proposes a model where an encoder is used to create a latent vector which is used by the decoder to create the image. It also uses CLIP embedding with optimization techniques to have high similarity with the text prompt. (Trevisan de Souza et al., 2023). |
| **TextControl-GAN** (Ku and Lee, 2023) | The research proposes a neural network as regressor to learn the textual features. The research also uses data augmentation techniques to increase the performance(Ku and Lee, 2023). |
| **StyleGAN-T** (Sauer et al., 2023) | This research proposes a model build from Style GAN-XL mentioned before. The network size of the model is increased to include text information from CLIP encoders.  (Trevisan de Souza et al., 2023). |

Table 2 State-of-the-art model to be used for emoji generation

3.1.6 High Level Flow Diagram

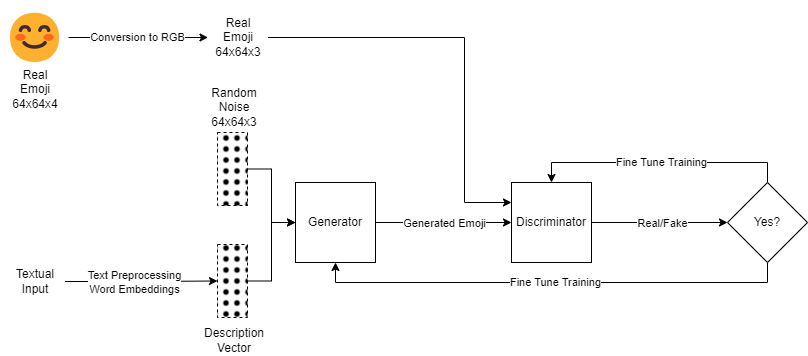


Figure 6 High Level Flow Diagram

3.1.7 Evaluation metrics

We can measure the image quality the following metrics are used

* Inception Score (Shmelkov et al., 2018)   
  It is used to measure the quality of the images generated by comparing it with the real images from the dataset.
* Fréchet Inception Distance (Shmelkov et al., 2018) (Lee et al., 2023)

It is the measure to check how real the image generated are.

* Learned Perceptual Image Patch Similarity (Lee et al., 2023)

It is the distance measured between the patches in the latent space.

* Structural Similarity Index (Mittal et al., 2020)

It measures the degradation of the image quality

CHAPTER 4

ANALYSIS

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4.2 Dataset Description

4.3 Data Preparation

4.3.1 Elimination of Variables

4.3.2 Transformation into Categorical Variables

4.3.3 Identification of missing values

4.3.4 Univariate analysis

4.3.5 Treatment of missing values

4.3.6 Splitting of original dataset

Hyperparameter and the best parameters

4.4 Exploratory Data Analysis (Bivariate analysis)

4.4.1 Chi-square test

4.5 Data Visualization

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CHAPTER 5

5.1 Introduction

5.2 Interpretation of Visualizations

5.3 Evaluation of Sampling Methods and Results

5.4 Testing on Validation Dataset

5.6 Summary

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

6.2 Discussion and Conclusion

6.3 Contribution to knowledge

6.4 Future Recommendations

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APPENDIX A: RESEARCH PROPOSAL

emoji generation based on textual input using generative adversarial networks

DARSHIL AJAY PAREKH

Research Proposal

FEBRUARY 2024

Abstract

With the increase in popularity with its wide variety of uses, emojis have become so necessary and important that sending or responding to a message and commenting or reacting to a post on social media without emoji seems to be impossible. Emoji represents emotions, culture, age, gender, actions, gesture, expressions, sports, foods, places and objects.

Despite the importance the number of emojis are countable and finite in quantity. In this research we will be creating a generative model to generate new unique emojis using short text for more complex and distinction emojis

We will be using the state-of-the-art generative models which consist of mainly two-part generator and discriminator. The generator and discriminator will work one after the other. First the generator will be trained to generate new emojis and after couple of rounds the discriminator will be trained to detect is the emoji is fake or real. This is followed by generator and discriminator rounds. This process continues until the discriminator is not able to detect is the emoji is fake.

This will help the community to generate wide variety of emojis based on the requirement rather than choosing from a finite set of emojis.

This research will help to generate high quality and diverse emojis. It will also help the tech community with the comparison of the different GAN models with different evaluation metrics.

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LIST OF ABBREVIATIONS

GAN Generative Adversarial Network

VQGAN Vector Quantized Generative Adversarial Network

DCGAN Deep Convolution Generative Adversarial Network

CLIP Contrastive Language-Image Pre-Training

AI Artificial Intelligence

ML Machine Learning

RGB Red Green Blue

RGBA Red Green Blue Alpha

1. Background

Emoji is a visual representation of human interaction based on Human emotions, living beings, objects and symbols. These are in widespread use across the internet such as in textual messaging application, social media platforms which are known as informal modes of communication. Below is an image about the most frequently used emojis during informal modes of communication.

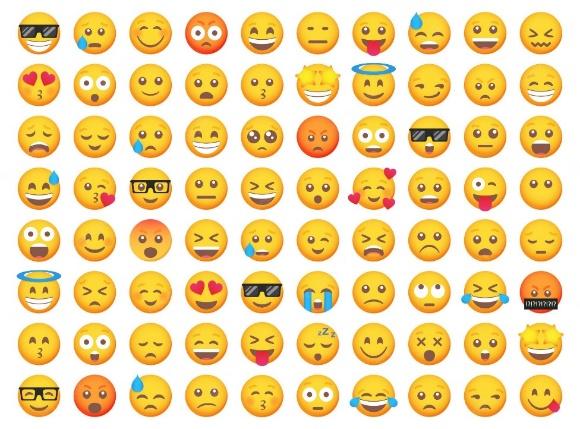


Figure 7 Sample emojis used frequently in informal communication.

According to (Kennison et al., 2024) emojis represent faces with human expressions, objects, animals, and actions.

Emojis are often used to in replacement of words, thus acting as a part of communication and language (Provine et al., 2007). As per the research (Urumutta Hewage et al., 2021) the emojis are static images which are often preserved as human like emotion and expressions. Further, as per (Erle et al., 2022) the communication has greater emotional intensity when we communicated to people using emojis rather than without emojis.

Other application of emojis other than informal communication includes

* Rating/Feedback Form : The feedback forms using emoji instead of stars or numbers. The research has found that the chances of the user giving feedback is higher when emojis are used.
* Providing a Reaction : These days most online applications or websites provide emojis to react to a post, blog, article or tweet.
  + Thumbs up and down emojis are used to like and dislike.
  + Facial emojis are used to express feeling like surprise, wow or shocked.

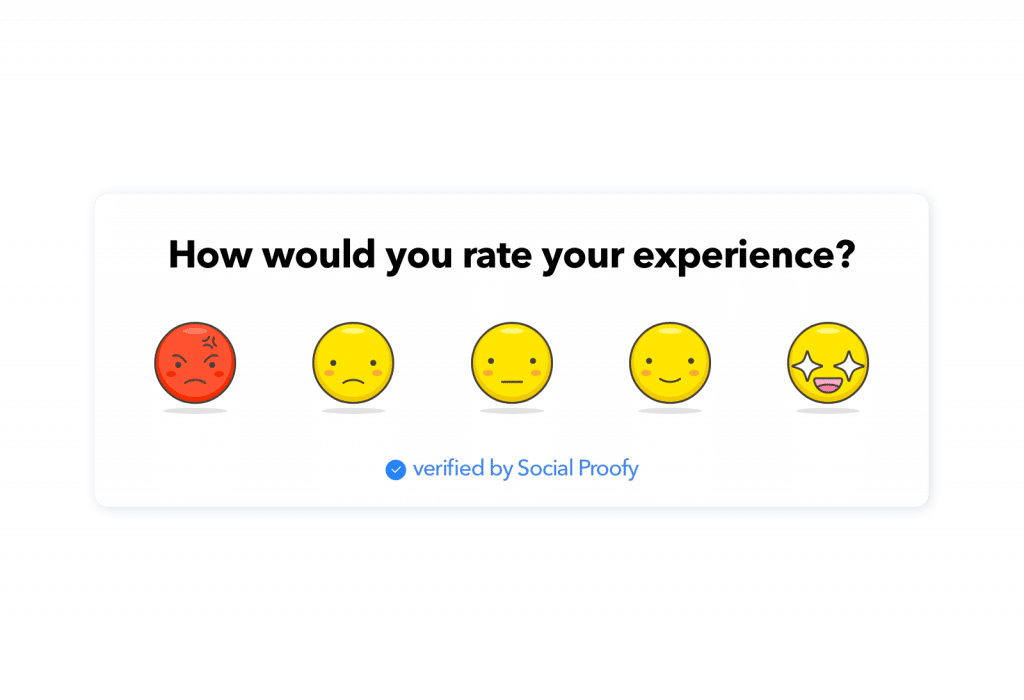


Figure 8 Emoji used in a feedback form

As per the emojipedia.org analysis of over 2.934 billion global tweets between 2017 to 2021, the percentage of tweets with at least one emoji has increased from 13.5% to 21.5%. With the increase of the use of emoji, the demand for newer and customised emoji is increasing. The creation of emoji is a currently is a tedious process of submitting an emoji to Unicode Technical Committee, which takes the final decision for the inclusion, this takes 18-24 months for the complete process Using the state-of-the-art models for generating images using text, we will be able to create new emojis based on the user input.

Prior research has focused on generating facial emojis and emotion based facial emojis. With the state-of-the-art model and architecture, we will be generating not only facial emojis but objects also.

Prior research used techniques like unsupervised learning , Deep Convolution based Generative Adversarial Networks and Conditional Generative Adversarial Networks.

One of the greatest debates on emojis includes whether emoji can be used “as punctuation” or ”after punctuation” which was included in “The Great Emoji Debate”.

In this research we will be creating a state-of-the-art model to generate emojis using emoji content and descriptive information of the emoji and comparing the model with prior models.

We will be looking at the various generative adversarial models :

* VQGAN-CLIP
* TextControl-GAN
* StyleGAN-T

**2. Problem Statement and Related Work**

2.1 Problem Statement

Currently the process of creating new emojis is a tedious and time-consuming task which takes a couple of days or months to create and years to get approval from the Unicode Technical Committee. Currently there are only 3,664 emojis as per Unicode standard and the need for need and diverse emoji is increasing. Due to this the current library faces limitations in capturing all the human emotion and experiences. This can lead to miscommunication and inadequate representation of culture and identities.

As per the current trend the use of emoji has been steadily increasing in informal conversation and social media. The need for new emojis to be generated quickly based on the text from the user is high. This issue mostly affects the Gen Z generation as they are the ones who use them mostly during the social media platforms, Messaging apps and content creation. It is important as it can improve the quality of the conversation with improved emotions and objects. This solution will have a huge impact on the conversation by improving the quality of the conversation with new and better emojis which can express emotions and objects accurately.

2.2 Related Work

2.2.1 Research on Emoji and its Importance

Emoji despite being more common in digital communication, is often dependent on characteristics, motives for using them and the context in which they are used (Cavalheiro et al., 2023). Over the past couple of years there has been extensive research in the use and importance of emojis in every life activity. Below are few of the recent research with description and findings:

* The research by (Cavalheiro et al., 2023) try to find the relationship of frequency of the emoji with relationship and individual characteristics. The research also found personal reasons to be one of the relates to high emoji frequency. The research also found age to be directly correlated with emoji frequency which was unexpected.
* The research by (Erle et al., 2022) discusses a creation of emojis in digital communication with the help of their model. The research also found that the emojis can depict the facial expression of the human.
* The research by (Lefebvre et al., 2024) is about the influence of emoji during tip suggestion with the tipping percentage. The research also found significant positive effects of emoji during the tipping.
* The research by (Kennison et al., 2024) relates the personal characteristics with the emojis used in the conversation. The research also found that the men used emojis less often than women. The research also found that users may me using emojis in place of word and used less dictionary words.

**2.2.2 Research on Emoji Generation**

With the evolution generative models and the importance of emoji there has been couple of research done in the field of emoji generation. It has been noticed that most of the research has been around facial emojis and with a very limited set of them. Below are few of the recent research with description:

* The research (Mittal et al., 2020) uses supervised learning with multimodal input to GAN with U-Net like architecture for the generator to generate realistic hand drawn emojis. This research even though was able to generate the emojis it required the user to draw a rough sketch with the emotion to be given as input, also the dataset used had to be augmented from the facial emojis which don’t depict the real dataset.
* The research (Lee et al., 2023) creates a model which can generate emojis based on emotional degree for more complex and detailed usage on online conversations (Lee et al., 2023). The research uses conditional GAN for the experiment and also compares it with other baseline models. This
* The research (Tang, 2023) used unsupervised learning to generate new emojis using DCGAN which is a combination of Convolution Neural Network and Generative Adversarial Network. This research faced many challenges like after 1000 epochs the accuracy flattens out. The emojis generated where quite blurry and the user had no control over the emojis generated due to unsupervised learning.
* The research (Xu, 2021) used unsupervised learning with optimization techniques with Adam Optimizer to generate new emojis.
* The research (Peng and Zhao, 2021) used an encoder–decoder model, to predict the sequence of emojis based on short text. This research was able to correlate the emojis generated. The model was also able to learn the semantics between the emoji and text description.

Although the above research where able to generate emojis but most of this research had sparse data and limited the scope to generate facial emojis.

2.2.3 Research on Word Embeddings:

According to the research by (Asudani et al., 2023) the first preference should be given to domain specific embeddings. The research also compares the performance of the various word embedding techniques.

**2.2.4 Research on Text to Image Generation Methodology**

Below are the recent methodologies in the text to image domain developed on top of generative adversarial network architecture.

|  |  |  |
| --- | --- | --- |
| **Methodology** | **Use** | **Description** |
| **Attn-GAN** (Xu et al., 2018) | Text to Image Generation | The research proposes a new GAN with multistage refinement using attention. Each of this multistage attention model gets the most relevant word vectors for generating sub-regions of the image (Xu et al., 2018). |
| **Stack-GAN** (Dhivya and Navas, 2020) | Image Generation based on text | The research proposes the use of multiple GAN stacked on top of each other to generate high resolution photo realistic images (Trevisan de Souza et al., 2023). |
| **Style-CLIP**(Patashnik et al., 2021) | Text-guided image editing | This research proposes CLIP embeddings to allow image editing. The CLIP embeddings share the same latent space hence we can directly compare the text with the images (Trevisan de Souza et al., 2023). |
| **VQGAN-CLIP**(Crowson et al., 2022) | Text-to-image synthesis | This research proposes a model where an encoder is used to create a latent vector which is used by the decoder to create the image. It also uses CLIP embedding with optimization techniques to have high similarity with the text prompt. (Trevisan de Souza et al., 2023). |
| **TextControl-GAN** (Ku and Lee, 2023) | Text to Image | The research proposes a neural network as regressor to learn the textual features. The research also uses data augmentation techniques to increase the performance(Ku and Lee, 2023). |
| **StyleGAN-T**(Sauer et al., 2023) | Text-to-image synthesis | This research proposes a model build from Style GAN-XL mentioned before. The network size of the model is increased to include text information from CLIP encoders.  (Trevisan de Souza et al., 2023). |

Table 1 Related works on Methodologies

3. Research Questions

3.1 Research Questions

Generate new realistic emoji in real time based on the textual input from the user.

4. Aim and Objectives

The aim of this research is to propose a generative model to generate new emojis is to create a new and diverse design based on textual input from the user and compare it with the baseline and previous models which are visually appealing and useful.

Below are the list of research objectives which will be accomplished in this research:

* To create a generative model that can create new high quality and realistic emojis.
* To generate emoji based on the platform of use.
* To compare between the state-of-the-art generative models.
* To evaluate the performance of the emojis generated using the generative models.
* To finetune the various parameters used in the generative model.

5. Significance of the Study

5.1 Contributions

* Offer users a wider range of options to accurately express their emotions and experiences using emoji,
* Reflects the variety of individuals and communities.
* Contribute to the development and application of GANs
* Valuable tool for individuals and communities to create custom emojis

5.2 Beneficiaries

* Users of social media platforms.
* Content creators like article and blog writers.
* The AI and ML industry.
* Emoji Designers.
* Unicode and emoji organisations like emojipedia.

6. Scope of the Study

The scope of a study on generating new emojis are as follows:

* Type of architecture : Generative Adversarial Networks
* Data : <https://huggingface.co/datasets/ChengAoShen/emoji_with_text>
* Input : Short textual input
* Output : 64x64 emoji
* Evaluation techniques :
  + Inception Score (Shmelkov et al., 2018)
  + Fréchet Inception Distance (Shmelkov et al., 2018) (Lee et al., 2023)
  + Learned Perceptual Image Patch Similarity (Lee et al., 2023)
  + Structural Similarity Index (Mittal et al., 2020)

7. Research Methodology

In this section we will be going through the end-to-end architecture which included data preprocessing, data transformation, the state-of-the-art methodology and the evaluation metrics used in the research.

7.1 Introduction

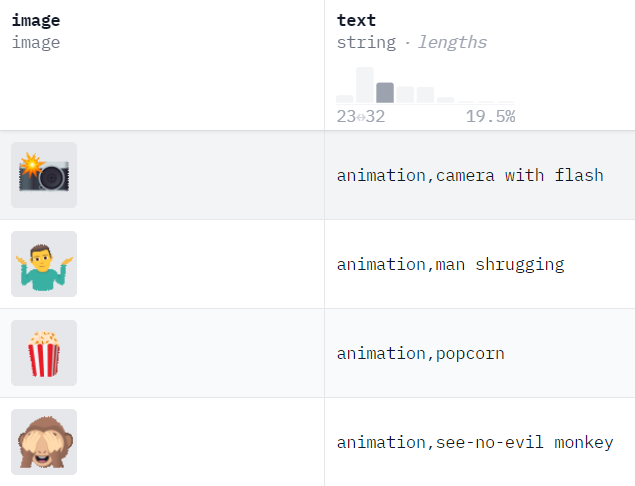
Here's a simplified explanation of GANs:

* The Forger (Generator): A computer program that starts by making very bad drawings   
  of the emoji
* The Detective (Discriminator): Another computer program that gets shown both real emoji and the Forger's fakes. The Detective tries to tell them apart.

Each time the Detective catches a fake, the Forger learns from its mistakes and tries to make even better fakes. This makes the Detective have to get smarter too.

7.2 Dataset description

The dataset (ChengAo Shen and Siyuan Mu, 2023) is uploaded on Hugging face. This dataset consists of 47200 emojis with the text description. Each image is of shape 64\*64 and has RGBA channels. Description text format : app or company, emoji content, description information



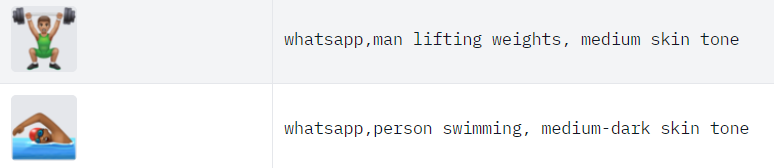
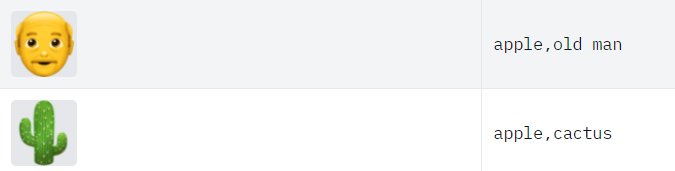
 

Figure 9 Dataset sample

7.3 Data preprocessing

The dataset doesn't require any cleaning or filtering as it has already been done by the author of the dataset. All the emoji are of the shape 64x64x4 where 4 is the number of channels which represent RGBA (Red, Green, Blue, Alpha) which can be converted to RGB(Red, Green, Blue) format. The text description will be split into 3 columns: app/company, emoji content, description information using regular expressions. These 3 columns will be processed to remove stop word and name entity recognition will be used to identify the company and keywords from the description. The dataset will be organised and divided into 3 parts for training, testing and validation.

7.4 Transformation

* Latent Space Manipulation  
  Latent space is the hidden layers in the architecture which can be seen as compressed input. As proposed in (Yang et al., 2021) we can use latent space factorization or manipulations to change the attributes of the image.
* Word to Vector  
  The text description for the emojis will be converted to vector representation.  
  They capture the meaning and their usage.
* Clip embedding

The images and text vectors share the same latent space which is helpful in direct comparison of the both

7.5 Models

Below are the recent shortlisted state of the art model which we will be using and comparing to generate the emojis using the textual input.

|  |  |
| --- | --- |
| **Methodology** | **Description** |
| **VQGAN-CLIP** (Crowson et al., 2022) | This research proposes a model where an encoder is used to create a latent vector which is used by the decoder to create the image. It also uses CLIP embedding with optimization techniques to have high similarity with the text prompt. (Trevisan de Souza et al., 2023). |
| **TextControl-GAN** (Ku and Lee, 2023) | The research proposes a neural network as regressor to learn the textual features. The research also uses data augmentation techniques to increase the performance(Ku and Lee, 2023). |
| **StyleGAN-T** (Sauer et al., 2023) | This research proposes a model build from Style GAN-XL mentioned before. The network size of the model is increased to include text information from CLIP encoders.  (Trevisan de Souza et al., 2023). |

Table 2 State-of-the-art model to be used for emoji generation

7.6 High Level Flow Diagram

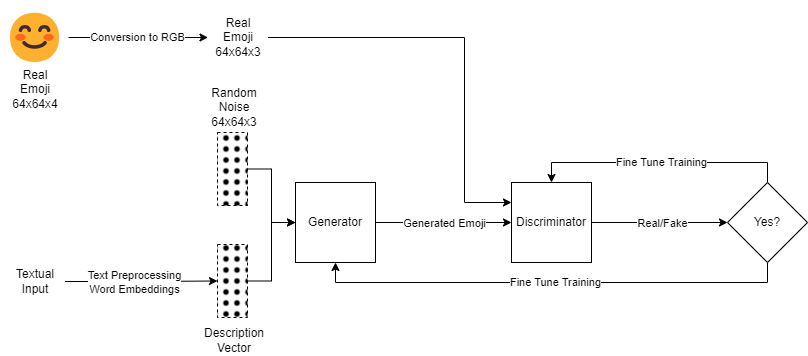


Figure 10 High Level Flow Diagram

7.7 Evaluation metrics

We can measure the image quality the following metrics are used

* Inception Score (Shmelkov et al., 2018)   
  It is used to measure the quality of the images generated by comparing it with the real images from the dataset.
* Fréchet Inception Distance (Shmelkov et al., 2018) (Lee et al., 2023)

It is the measure to check how real the image generated are.

* Learned Perceptual Image Patch Similarity (Lee et al., 2023)

It is the distance measured between the patches in the latent space.

* Structural Similarity Index (Mittal et al., 2020)

It measures the degradation of the image quality

8. Requirements or Resources

Initially the data preprocessing, analysis, model creation and partial training will be done on local laptops and for the final training of the complete dataset and validation will be done on cloud VMs

8.1 Hardware Requirement

* Intel i7 processor
* 16gb RAM
* 4gb Video RAM/GPU
* 1 cloud VM with 1 Nvidia A100 GPU

8.2 Software, Web Services and Libraries Requirement

Below are the list of software requirements

* Python 3.12.2
* JupyterLab
* Microsoft Azure/GCP
* PyTorch
* Numpy
* Pandas
* Scikit-learn
* Tensorflow
* Keras
* Matplotlib

9. Research Plan



Figure 11 Research Plan

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