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DEPARTMENT OF SOFTWARE ENGINEER

CSE 457 REPORT

DEEP DREAM

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ABSTRACT

This report presents an overview of Deep Dream, a neural network-based image processing technique developed by Google. By using a combination of technical documentation and available resources for Deep Dream on Google, this objective covers the historical background, purpose, operational principles of Deep Dream and its applications. Through analysis and implementation of Deep Dream, this report aims to illustrate how this technique enhances and manipulates images by iteratively modifying them to highlight patterns detected by a convolutional neural network.

The historical background section delves into the origins of Deep Dream, tracing its development within Google's research labs and its connection to advancements in neural network architectures. The purpose of Deep Dream is examined, particularly its role in visualising the internal workings of neural networks, providing insights into how these networks interpret and understand images.

Operational principles are discussed in detail, explaining the process of using a pre-trained convolutional neural network to iteratively adjust an image, amplifying the features that the network recognizes. This process, often referred to as "inceptionism," reveals the layers of abstraction within the neural network and demonstrates the network's perception at various levels.

The report also explores a wide range of applications for Deep Dream, from artistic and creative uses in generating dream-like, surreal images to practical applications in understanding and debugging neural networks. By visualising the features that networks respond to, researchers and engineers can gain a better understanding of model behaviour, which can inform the development of more robust and interpretable AI systems.

In conclusion, this report underscores the significance of Deep Dream not only as a tool for artistic expression but also as a valuable resource for advancing the field of neural network research and improving our understanding of deep learning models.

ACKNOWLEDGEMENT

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A. INTRODUCTION

Motivation

In the dynamic landscape of artificial intelligence and computer vision, the concept of "Deep Dream" has emerged as a captivating intersection of artistry and technology. Originating as a visualisation tool to elucidate the inner workings of deep neural networks, Deep Dream has transcended its utilitarian roots to become a fascinating avenue for artistic expression and exploration. By harnessing the power of deep learning algorithms, Deep Dream imbues images with surreal and hallucinatory qualities, offering a glimpse into the intricate processes of machine perception and cognition. The allure of Deep Dream lies in its ability to unveil hidden patterns and features within images, unveiling a realm of imagination and creativity that transcends conventional visual representations.

Work Distribution

This project epitomises a collaborative endeavour, with each team member contributing unique perspectives and skills to ensure a comprehensive exploration of Deep Dream technology:

Research and Literature Review: All team members undertook an extensive review of existing literature and resources pertaining to Deep Dream, elucidating its origins, underlying principles, and diverse applications.

Implementation and Experimentation: Specific responsibilities for implementing Deep Dream algorithms and conducting experiments were divided among team members, leveraging frameworks such as TensorFlow and PyTorch.

Artistic Interpretation and Visualization: All team members delved into the artistic interpretation of Deep Dream outputs, exploring techniques to enhance visual aesthetics and evoke emotive responses.

Technical Documentation and Analysis: All team members focused on documenting technical details, analysing algorithmic intricacies, and elucidating the underlying mechanics of Deep Dream transformations.

Project Coordination and Review: Oversight of project timelines, coordination of collaborative efforts, and final review of project deliverables were managed by designated team members.

Project Overview

The overarching goal of this project is to provide an in-depth exploration of Deep Dream technology, spanning its conceptual foundations, practical implementations, artistic implications, and potential future directions. The structure of the project encompasses:

- **Introduction:** Setting the stage with an exploration of the motivations behind Deep Dream, delineating the distribution of work among team members, and offering a brief overview of the project's objectives.
- **Conceptual Framework:** Delving into the theoretical underpinnings of Deep Dream, elucidating its conceptual framework, and examining the role of deep neural networks in generating transformative visualisations. Implementation and Experimentation: Detailing the technical implementation of Deep Dream algorithms, exploring variations in network architectures, optimization techniques, and parameter tuning.
- **Artistic Exploration:** Venturing into the artistic realm of Deep Dream, showcasing creative interpretations, aesthetic enhancements, and the emotive impact of transformed images.
- **Applications and Future Directions:** Surveying the diverse applications of Deep Dream across domains such as art, entertainment, scientific visualisation, and beyond, while speculating on potential future advancements and innovations.
- **Conclusion:** Summarising key insights gleaned from the project, reflecting on the transformative potential of Deep Dream technology, and contemplating its broader implications for society and culture.

Through a multidimensional exploration of Deep Dream, this project endeavours to unravel the intricate interplay between artificial intelligence, creativity, and perception, offering a glimpse into the boundless possibilities of machine-assisted imagination.

B. DEEP DREAM OVERVIEW AND APPLICATION

I. INTRODUCTION

1. What is Deep Dream?

"DeepDream is a computer vision program that uses a convolutional neural network to find and enhance patterns in images via algorithmic pareidolia, thus creating a dream-like appearance reminiscent of a psychedelic experience in the deliberately over-processed images." (Wikipedia contributors, 2023)

2. Purpose of Deep Dream

To provide insights into how neural networks perceive and process visual information. To create surreal and hallucinogenic images.

II. HISTORICAL BACKGROUND

DeepDream was created in 2015 by Google researchers, led by Alexander Mordvintsev who invented Google Deep Dream.

The concept of neural networks "dreaming" became popular with Google's DeepDream in 2015. Though the idea is older and similar methods existed, Google's open-source release led to the creation of various tools for users to transform their photos.

III. HOW DEEP DREAM WORKS

Humans identify things they see by processing visual information in the brain, comparing it with stored memories, and using contextual clues.

Deep dream uses Convolutional Neural Network (CNN) to identify and amplify features in images at various layers of the network. It uses CNN to process images which are somewhat analogous to how our brain works.

1. What is Convolutional Neural Network (CNN)?

A Convolutional Neural Network (CNN) is a deep learning model that uses filters to automatically detect and learn features from images for tasks like recognition and classification.

In Deep Dream, CNN serves as a tool to identify and enhance specific features within an image, leveraging the network's learned knowledge to create visually striking and surreal outputs.

2. How exactly does DeepDream work?

In this project, we use the resources of TensorFlow about DeepDream to explain and implement the methods.

"DeepDream is an experiment that visualises the patterns learned by a neural network. Similar to when a child watches clouds and tries to interpret random shapes, DeepDream over-interprets and enhances the patterns it sees in an image.

It does so by forwarding an image through the network, then calculating the gradient of the image with respect to the activations of a particular layer. The image is then modified to increase these activations, enhancing the patterns seen by the network, and resulting in a dream-like image. This process was dubbed "Inceptionism" (a reference to InceptionNet, and the movie Inception)." (*DeepDream*, n.d.)

Let's demonstrate this method following steps below:
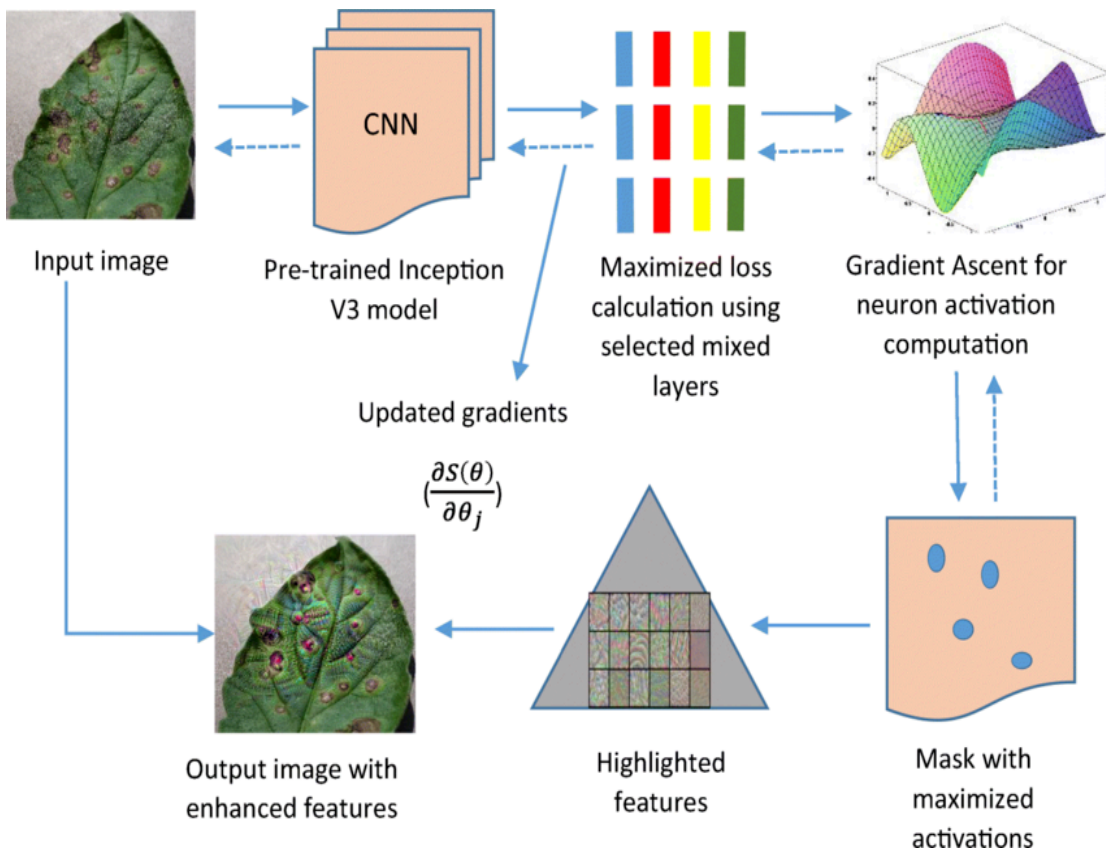
1. Choose an image to dream-ify

Firstly, people provide the image that you want to DeepDream-ify. There are no specific requirements when inputting images into DeepDream, but for better results we should use images with less compression, higher resolution and quality.

2. Prepare the feature extraction model

DeepDream uses a pre-trained CNN on a massive dataset of images. This CNN has learned to identify patterns and features in images. The convolutional neural network scans the image, looking for patterns it recognizes based on its training.

"The idea in DeepDream is to choose a layer (or layers) and maximise the "loss" in a way that the image increasingly "excites" the layers. The complexity of the features incorporated depends on layers chosen by you, i.e, lower layers produce strokes or simple patterns, while deeper layers give sophisticated features in images, or even whole objects." (*DeepDream*, n.d.)

Google provides several pre-trained deep learning models and layers for users to use in DeepDream projects and related applications such as Inception, Mobilenet, Resnet, VGG. And in this project, we use InceptionV3 which is similar to the model originally used in DeepDream.

3. Calculate the loss

The loss in DeepDream is calculated by summing the activations in the selected layers. To ensure that contributions from larger layers do not overshadow those from smaller layers, the loss is normalised at each layer. Typically, loss is a metric you aim to minimise using gradient descent. However, in DeepDream, this loss is maximised using gradient ascent.

4. Gradient ascent

After calculating the loss for the selected layers, the next step is to compute the gradients with respect to the image and then add these gradients to the original image.

Incorporating the gradients into the image amplifies the patterns recognized by the network. With each iteration, the image evolves to increasingly stimulate the activations of specific layers within the network.

After that DeepDream tweaks the image to make those recognized patterns even more prominent. It essentially exaggerates what the network finds important.

5. Main loop

In the next step, this process is repeated over and over again, each time enhancing the features the network finds most interesting. The more it iterates, the more the image takes on a dream-like, psychedelic quality.

6. Taking it up in octave

To produce more intricate and visually appealing results, DeepDream uses a technique called octaves. The image is processed at multiple scales:

The image is downsampled (reduced in size) to create a pyramid of images (octaves).The process of gradient ascent is applied to each octave starting from the smallest scale and progressively moving to larger scales.

At each scale, the enhanced image from the previous octave is used as the starting point for the next, allowing finer details to emerge.

Notations: **DRAL:-** Detail Reinjection after Loss
DDF:- Deep Dream features
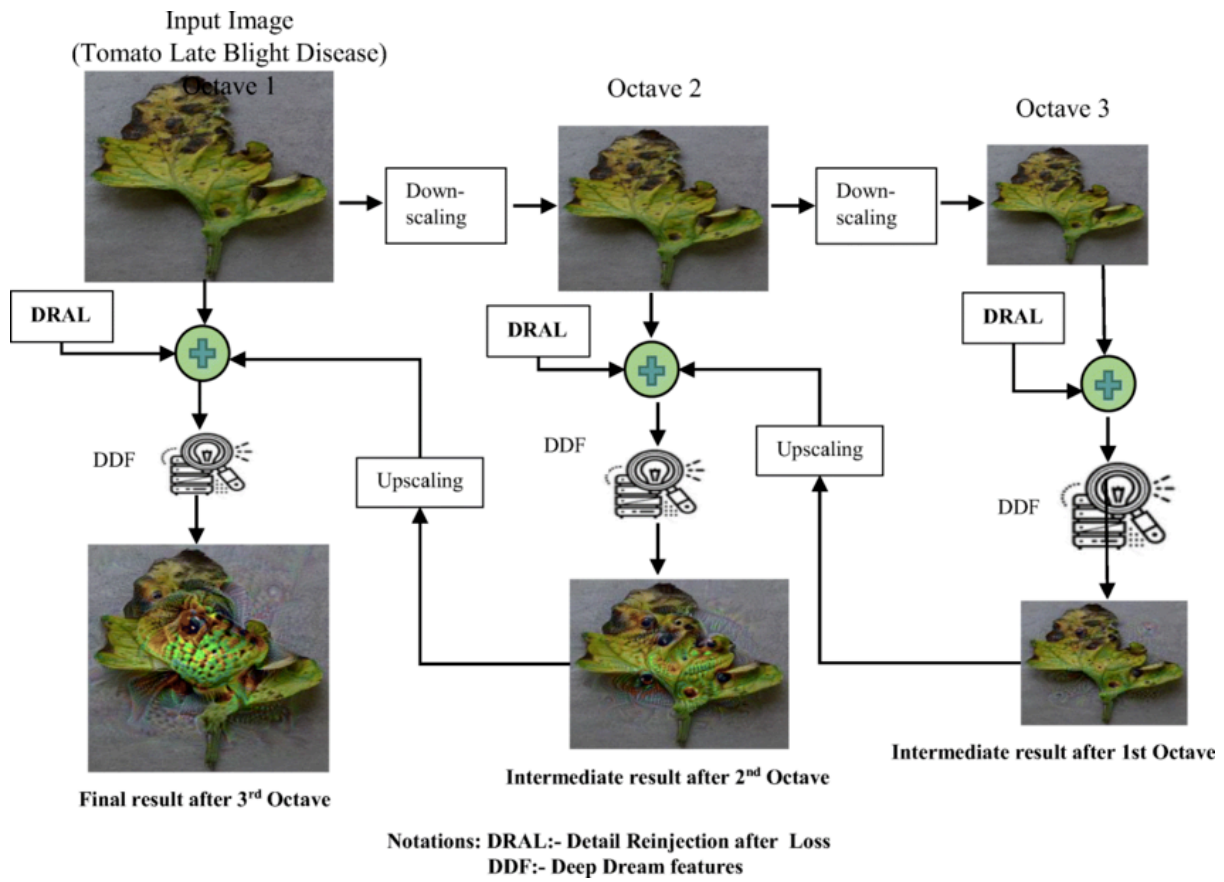
ORIGINAL IMAGE:

DEEPDREAM IMAGE:

IV.   APPLICATIONS OF DEEP DREAM

1. In art and creativity

- Artists can use Deep Dream as a tool to enhance and exaggerate patterns, textures, and features within images. From that, they can create their unique and surreal artworks. "In 2015, Tyka was a coauthor of the groundbreaking paper Inceptionism: Going Deeper Into Neural Networks, which introduced an exciting new approach to image processing using neural networks. The Deep Dream aesthetic caused a stir in the media and swiftly evolved into a distinct artistic subgenre." (Mike Tyka – Artist Profile (Photos, Videos, Exhibitions) — AIArtists.org, n.d.)

- In 2017, it was used for Foster the People's music video for the song "Doing It for the Money".

- Besides that, it also is a tool for exploring human and machine creativity. It utilises neural networks to generate hallucinogenic and surreal images by enhancing patterns within images. Users can input any image, and DeepDream algorithmically enhances and iterates upon patterns it detects, producing visually striking and often bizarre results. This process blends human input (the choice of initial image) with machine-generated creativity (the algorithm's interpretation and enhancement), showcasing a collaborative exploration of creativity between humans and AI.

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2. **In research and Education**

- **Helps in understanding the inner workings of neural networks.**

"A 2021 study that used neuroscientific evidence to show similarities between DeepDream and real psychedelic experiences was published in the journal Entropy. Human subjects' electroencephalography (EEG) was captured by the authors while they watched a movie clip and its DeepDream-generated equivalent in passive vision. They discovered that watching DeepDream video increased the EEG signal's entropy and the degree of functional connectivity between different brain regions, both of which are recognized indicators of genuine psychedelic experience." (Wikipedia contributors, 2023)

- **Educational tool for illustrating neural network concepts.**

"In 2017, a research group out of the University of Sussex created a Hallucination Machine, allowing users to explore virtual reality environments to mimic the experience of psychoactive substances and/or psychopathological conditions." (Wikipedia contributors, 2023)

C. CONCLUSION

Deep Dream represents a captivating convergence of artificial intelligence, computer vision, and artistic expression, offering a fascinating glimpse into the inner workings of deep neural networks and the boundless potential of machine-assisted creativity. Throughout this project, we have embarked on a multifaceted exploration of Deep Dream technology, spanning its conceptual foundations, practical implementations, artistic interpretations, and future horizons.

The journey through Deep Dream has underscored its transformative potential in reshaping our perception of visual imagery. By leveraging deep learning algorithms, Deep Dream transcends conventional representations to unveil hidden patterns, textures, and features within images, imbuing them with surreal and dreamlike qualities. This transformative process not only illuminates the intricate mechanisms of machine perception but also offers a lens through which to explore the depths of imagination and creativity.

In our exploration, we have delved into the theoretical underpinnings of Deep Dream, unravelling its conceptual framework and elucidating the role of deep neural networks in generating captivating visual transformations. Through practical implementations and experimentation, we have navigated the technical intricacies of Deep Dream algorithms, exploring diverse network architectures, optimization strategies, and parameter configurations to unlock its full potential.

Beyond its technical intricacies, Deep Dream transcends into the realm of artistry, offering a canvas for creative expression and interpretation. By manipulating and enhancing Deep Dream outputs, we have ventured into the artistic domain, exploring techniques to evoke emotional responses, enhance visual aesthetics, and transcend traditional boundaries of representation.

The applications of Deep Dream extend far beyond the realms of art and technology, permeating diverse domains such as entertainment, scientific visualisation, and beyond. Its potential to inspire innovation and creativity is profound, offering novel avenues for expression and exploration across various disciplines.

As we conclude this project, it is evident that Deep Dream stands as a testament to the symbiotic relationship between human creativity and artificial intelligence. The insights gleaned from our exploration deepen our understanding of this transformative technology and pave the way for future advancements and applications. Sustained investigation and innovation within the realm of Deep Dream are imperative to unlock its full potential and harness its transformative power for the betterment of society and culture.

In essence, Deep Dream represents more than just a technological tool—it is a gateway to a realm of endless possibilities, where imagination knows no bounds and creativity knows no limits. As we embark on this journey of exploration and discovery, let us continue to push the boundaries of innovation and creativity, unlocking new vistas of understanding and reshaping the world around us.

D. REFERENCE

DeepDream. (n.d.). TensorFlow. https://www.tensorflow.org/tutorials/generative/deepdream

Wikipedia contributors. (2023, December 22). *DeepDream*. Wikipedia.

https://en.wikipedia.org/wiki/DeepDream