# A MINI PROJECT REPORT

**ON**

# IMAGE COLOURIZATION

**Submitted to**

**Sri Indu College of Engineering & Technology, Hyderabad**

### In partial fulfillment of the requirements for the award of degree of BACHELOR OF TECHNOLOGY

**In**

**“ARTIFICIAL INTELLIGENCE & MACHINE LEARNING”**

**Submitted by**

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# SRI INDU COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution under UGC, Accredited by NBA&NAAC, Affiliated to JNTUH)

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# SRI INDU COLLEGE OF ENGINEERING AND TECHNOLOGY

**(An Autonomous Institution under UGC, Accredited by NBA&NAAC, Affiliated to JNTUH)**

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Certified that the Major project entitled **“IMAGE COLOURIZATION”** is a bonafide work carried out by **A.RISHIKESH (20D41A6604), B.DIVYA (20D41A6609), G.CHAKRAPANI (20D41A6620), V.LIKITHA (20D41A6660)** in partial fulfillment for the award of Bachelor of Technology in **Artificial Intelligence & Machine Learning** of SICET, Hyderabad for the academic year **2023-2024.**The project has been approved as it satisfies academic requirements in respect of the work prescribed for **IV Year, I- Semester of B. Tech** course.

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Students of final year B.Tech, **Artificial Intelligence & Machine Learning, SRI INDU COLLEGE OF ENGINEERING & TECHNOLOGY, HYDERABAD *(****affiliated to J.N.T.University, Hyderabad****),*** have successfully completed their project titled **“IMAGE COLOURIZATION”** in PYTHON DIVISION, CONSCIENCE TECHNOLOGIES (CT), Hyderabad.

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# ABSTRACT

Image Colorization is a fascinating Computer Vision task that aims to add realistic colours to grayscale images. In this project, we explore the world of Image Colorization by implementing a solution using PyTorch, Pillow, and NumPy, and leveraging two state-of-the-art models: ECCV16 and SIGGRAPH17.

Our project begins with the preprocessing of grayscale images, where Pillow and NumPy play a crucial role in loading, transforming, and preparing the data. We convert the images into a format suitable for model input.

The core of our project lies in the utilization of deep learning models to predict colour information for grayscale images. We employ the ECCV16 and SIGGRAPH17 models, which are renowned for their ability to generate realistic and visually pleasing colorizations.

The code also includes functions for image loading, preprocessing, and post-processing and pre trained models.

Using PyTorch, we fine-tune these pre-trained models on our dataset to adapt them to our specific colorization task. We discuss the training process, loss functions, and optimization techniques employed to achieve optimal colorization results.

Furthermore, we analyze the performance of our models by evaluating them on a diverse set of test images. We measure the quality of colorization using metrics such as Colour Accuracy, Perceptual Similarity, and Visual Appeal.

The results of our project demonstrate the effectiveness of PyTorch, Pillow, and NumPy in handling image data and implementing Deep Learning models for Image Colorization. Additionally, the ECCV16 and SIGGRAPH17 models showcase their capability to produce vivid and realistic colorizations, making them valuable tools in the field of Computer Vision. The task of Image Colorization holds immense practical value across various domains, such as Historical Image Restoration, Artistic rendering, and Multimedia content generation. The goal is to automate the process of inferring colours for objects and scenes within an image, harnessing the power of Artificial Intelligence and Deep Learning Techniques.

As Image Colorization continues to progress, it holds the promise of enriching our visual experiences and preserving the heritage of Historical Imagery.

In conclusion, this project provides a practical exploration of image colorization techniques using cutting-edge models and popular Python libraries, offering insights into the potential applications of such technology in various domains, including art, entertainment, and restoration of historical images.

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# INTRODUCTION

Images are effective means of expressing visual information and arousing feelings. The world is not grayscale, though, and the vivid range of colors that surround us have a significant impact on how we see the world. The goal of picture colorization is to close the gap between the colorful current that our eyes see and the monochrome past that is shown in historical images. In order to give monochrome pictures alive, this project sets out on a voyage into the world of image colorization, utilizing cutting-edge tools and deep learning.

A revolutionary force in the field of computer vision is machine learning. It enables us to teach computers the complex process of extrapolating colors from grayscale photos. We can help models comprehend the connections between objects, sceneries, and the colors that characterize them by training them on a variety of datasets. This introduction sets the stage for further investigation into how machine learning may transform picture colorization.

The urge to investigate the intriguing realm of image colorization is the beating core of this project. We use NumPy, PyTorch, and Pillow to manage picture data and take advantage of deep learning. We have two outstanding models, ECCV16 and SIGGRAPH17, who stand as our partners in the fight to turn monochrome canvases into colorful works of art. This introduction lays the groundwork for the in-depth examination of the tools, methods, and outcomes that will come next.

We cordially welcome you to go with us on this enthralling exploration into the fascinating area of picture colorization, where art and AI collide.

# LITERATURE SURVEY

Image Colorization is a captivating field within computer vision that has seen remarkable progress in recent years. This section provides an overview of key research findings and methodologies in the realm of Image Colorization.

**Image Colorization Methods:** Various techniques have been employed to tackle the challenge of image colorization. Early methods relied on manual colorization or interpolation techniques. With the advent of deep learning, Convolutional Neural Networks (CNNs) gained prominence. Models like DeOldify and Colorful Image showcased the potential of deep learning in this domain.

**Deep Learning Advances:** The utilization of deep learning models, such as Generative Adversarial Networks (GANs) and Autoencoders, has revolutionized image colorization. Zhang et al. introduced a GAN-based approach in "Colorful Image Colorization demonstrating impressive results by predicting pixel-wise color distributions.

**State-of-the-Art Models:** Notably, the ECCV16 model and SIGGRAPH17 model have emerged as leading solutions for image colorization. These models leverage vast datasets and intricate architectures to produce realistic colorizations. The ECCV16 model, in particular, employs a classification network for colorization, while the SIGGRAPH17 model utilizes a deep learning framework.

**Evaluation Metrics:** Assessing the quality of colorization is crucial. Metrics such as Color Accuracy, Perceptual Similarity, and Visual Appeal have been widely used to evaluate colorization results. These metrics provide insights into how well colorized images align with human perception.

**Challenges and Future Directions:** Despite significant advancements, challenges persist in handling complex scenes, fine details, and rare color patterns. Future research directions may involve leveraging attention mechanisms, domain adaptation, and semi-supervised learning to address these challenges.

In summary, the literature survey underscores the evolution of image colorization, from manual techniques to deep learning-driven solutions. The ECCV16 and SIGGRAPH17 models represent milestones in this field, and ongoing research continues to enhance the quality and applicability of image colorization techniques.

# ALGORITHMS USED

## ECONOMICAL FEASIBILITY

The project's financial impact on the organization is evaluated in terms of economic viability. It guarantees that the system's development complies with financial restrictions while providing the intended functionality. The following considerations were taken into account in this project:

Cost-effective technologies include: The project greatly lowers development costs by making effective use of freely accessible technologies and libraries. The majority of the fundamental frameworks and technologies are free source, significantly reducing costs. Customization While certain components required alteration, they were carefully selected to strike a compromise between usability and affordability. This strategy made that the project stayed below the allotted spending limit.

## TECHNICAL FEASIBILITY

The system's needs are assessed in terms of the technological resources that are available. By doing this, it makes sure that the project won't put an undue demand on the organization's infrastructure. In this phase, it's important to keep in mind:

Resources are in demand. The technique for colorizing images that has been created is intended to need just basic technological resources. It places minimal demands on the infrastructure of the customer, reducing any interruptions or resource bottlenecks. The project's technical elements and tools are chosen to complement the current technological stack, resulting in a smoother integration process.

## SOCIAL FEASIBILITY

The system's social viability is evaluated, as is the end users' desire to adopt and use the technology. The importance of user comfort and happiness with the system cannot be overstated. The following elements are taken into account in this project:

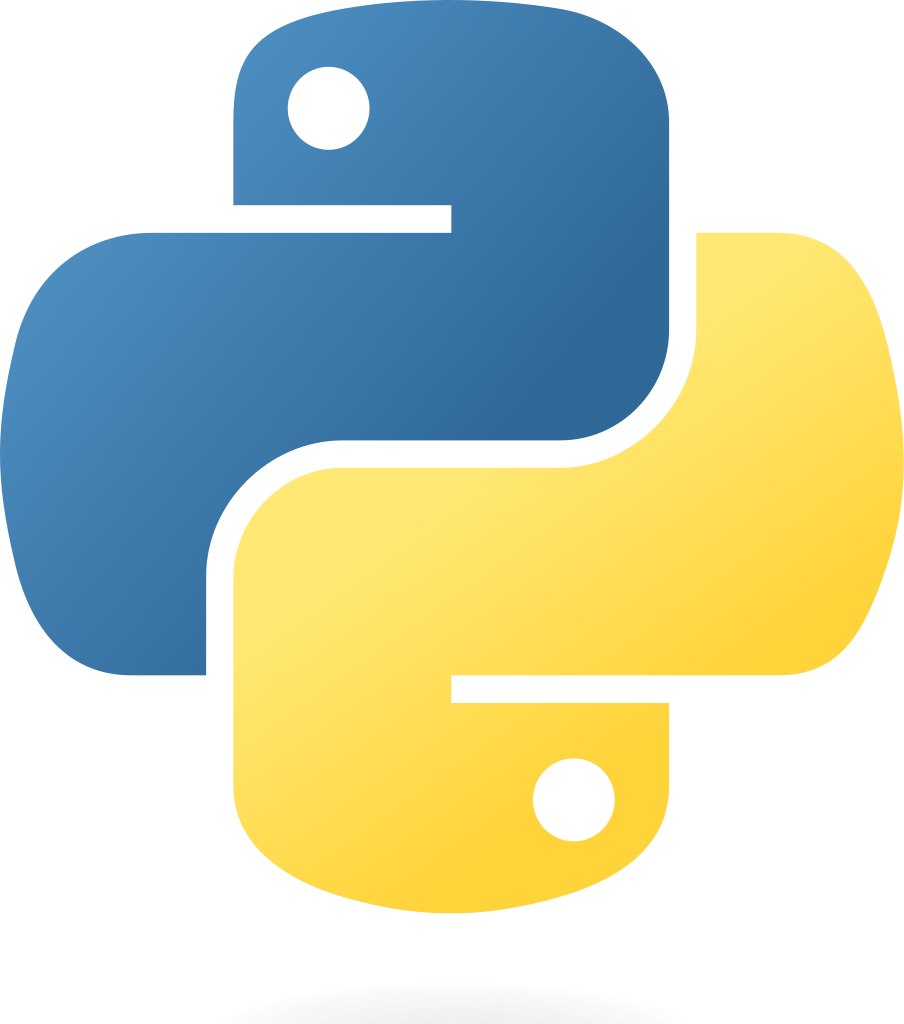
To guarantee that users are skilled in utilizing the picture colorization system, adequate training processes are put in place. User-friendly training is created to reduce fear or aversion to technology.

Building user trust is essential. Users ought to see the system as a resource rather than a danger. To improve the usability of the system, constructive criticism is sought as well as user input.

# 4. DATASET

### Python

Python is a general-purpose interpreted, interactive, object-oriented, and high-level programming language. An interpreted language, Python has a design philosophy that emphasizes code readability (notably using whitespace indentation to delimit code blocks rather than curly brackets or keywords), and a syntax that allows programmers to express concepts in fewer lines of code than might be used in languages such as C++or Java. It provides constructs that enable clear programming on both small and large scales.



Python interpreters are available for many operating systems. CPython, the reference implementation of Python, is open source software and has a community-based development model, as do nearly all of its variant implementations. CPython is managed by the non-profit Python Software Foundation. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object- oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

### What is Python

Python is a popular programming language. It was created by Guido van Rossum, and released in 1991.

### It is used for:

* Machine learning,
* software development,
* mathematics,
* system scripting,
* deep learning.

### What can Python do

* Python can be used build machine learning and deep learning models.
* Python can be used alongside to create pipelines.
* Python can be used to load and preprocess images. It can also save and load models.
* Python can be used to handle big data and perform complex mathematics.
* Python can be used for rapid prototyping, or for production-ready software development.

### Why Python?

* Python works on different platforms (Windows, Mac, Linux, Raspberry Pi,etc).
* Python has a simple syntax similar to the English language.
* Python has syntax that allows developers to write programs with fewer lines than some other programming languages.
* Python runs on an interpreter system, meaning that code can be executed as soon as it is written. This means that prototyping can be very quick.
* Python can be treated in a procedural way, an object-orientated way or afunctional way.

### Good to know

* The most recent major version of Python is Python 3, which we shall be using in this tutorial. However, Python 2, although not being updated with anything other than security updates, is still quite popular.
* In this tutorial Python will be written in a text editor. It is possible to write Python in an Integrated Development Environment, such as Spyder, PyCharm, Google Collab or Jupyter Notebooks which are particularly useful when managing larger collections of Python files.

#### Advantages of Python:-

**Extensive Libraries**

Python downloads with an extensive library and it contain code for various purposes like regular expressions, documentation-generation, unit-testing, data manipulation, threading, databases, CGI, email, image manipulation, and more. So, we don’t have to write the complete code for that manually.

#### Extensible

As we have seen earlier, Python can be **extended to other languages**. You can write some of your code in languages like C++ or C. This comes in handy, especially in projects.

#### Embeddable

Complimentary to extensibility, Python is embeddable as well. You can put your Python code in your source code of a different language, like C++. This lets us add **scripting capabilities** to our code in the other language.

#### Improved Productivity

The language’s simplicity and extensive libraries render programmers **more productive** than languages like Java and C++ do. Also, the fact that you need to write less and get more things done.

#### IOT Opportunities

Since Python forms the basis of new platforms like Raspberry Pi, it finds the future bright for the Internet Of Things. This is a way to connect the language with the real world.

#### Simple and Easy

When working with Java, you may have to create a class to print **‘Hello World’**. But in Python, just a print statement will do. It is also quite **easy to learn, understand,** and **code.** This is why when people pick up Python, they have a hard time adjusting to other more verbose languages like Java.

#### Advantages of Python over Other Languages

1. **Less Coding**

Almost all of the tasks done in Python requires less coding when the same task is done in other languages. Python also has an awesome standard library support, so you don’t have to search for any third-party libraries to get your job done. This is the reason that many people suggest learning Python to beginners.

#### Affordable

Python is free therefore individuals, small companies or big organizations can leverage the free available resources to build applications. Python is popular and widely used so it gives you better community support.

#### The 2019 GitHub annual survey showed us that Python has overtaken Java in the most popular programming language category.

* 1. **Python is for Everyone**

Python code can run on any machine whether it is Linux, Mac or Windows. Programmers need to learn different languages for different jobs but with Python, you can professionally build web apps, perform data analysis and **machine learning**, automate things, do web scraping and also build games and powerful visualizations. It is an all-rounder programming language.

### Python Syntax compared to other programming languages

* Python was designed for readability, and has some similarities to the English language with influence from mathematics.
* Python uses new lines to complete a command, as opposed to other programming languages which often use semicolons or parentheses.
* Python relies on indentation, using whitespace, to define scope; such as the scope of loops, functions and classes. Other programming languages often use curly-brackets for this purpose.

### Modules Used in Project

#### PyTorch

PyTorch is a versatile open-source machine learning library that facilitates the development of deep learning models. It offers dynamic computation graphs and a wide array of tools for tasks like image processing and neural network training. PyTorch's flexibility and active community make it a popular choice for research and production.

#### Pillow (PIL)

Pillow, also known as Python Imaging Library (PIL), is a powerful library for opening, manipulating, and saving various image file formats. In this project, Pillow plays a crucial role in image preprocessing, transformation, and preparation, ensuring that grayscale images are suitable for model input.

#### NumPy

NumPy is a fundamental library for scientific computing in Python. It provides support for large, multi-dimensional arrays and matrices, along with a variety of mathematical functions to operate on these arrays. NumPy is used extensively in this project for efficient data handling and manipulation.

#### ECCV16 Model

The ECCV16 model, a state-of-the-art architecture in image colorization, is employed to predict color information for grayscale images. This model is known for its ability to generate realistic and visually pleasing colorizations.

#### SIGGRAPH17 Model

The SIGGRAPH17 model is another cutting-edge model used for image colorization in this project. It is renowned for its capacity to produce vivid and lifelike colorizations, enhancing the overall quality of colorized images.

#### TensorFlow

While primarily associated with machine learning, TensorFlow is utilized for certain tasks in this project. TensorFlow is a versatile library for dataflow and differentiable programming, adding an additional dimension to the project's capabilities.

#### Install Python Step-by-Step in Windows and Mac :

Python a versatile programming language doesn’t come pre-installed on your computer devices. Python was first released in the year 1991 and until today it is a very popular high- level programming language. Its style philosophy emphasizes code readability with its notable use of great whitespace.

#### How to Install Python on Windows and Mac:

There have been several updates in the Python version over the years. The question is how to install Python? It might be confusing for the beginner who is willing to start learning Python but this tutorial will solve your query. The latest or the newest version of Python is version 3.7.4 or in other words, it is Python 3.

**Note:** The python version 3.7.4 cannot be used on Windows XP or earlier devices.

Before you start with the installation process of Python. First, you need to know about your **System Requirements**. Based on your system type i.e., operating system and based processor, you must download the python version. My system type is a **Windows 64-bit operating system**. So, the steps below are to install python version 3.7.4 on Windows 7 device or to install Python 3. The steps on how to install Python on Windows 10, 8 and 7 are **divided into 4 parts** to help understand better.

#### Download the Correct version into the system

**Step 1:** Go to the official site to download and install python using Google Chrome or any other web browser. OR Click on the following link: **https://**[**www.python.org.**](http://www.python.org/)

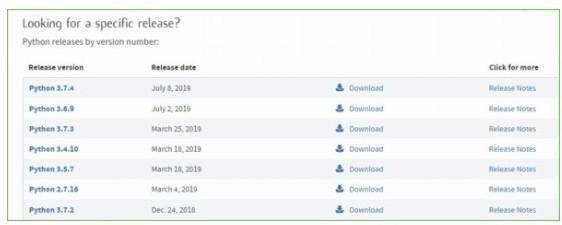


Now, check for the latest and the correct version for your operating system.

**Step 2:** Click on the Download Tab.

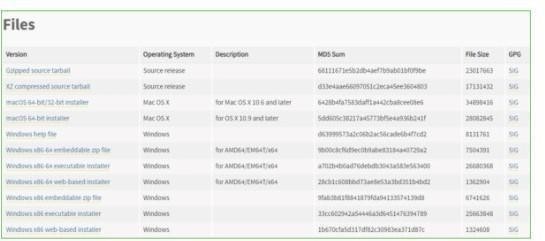


**Step 3:** You can either select the Download Python for windows 3.7.4 button in Yellow Color or you can scroll further down and click on download with respective to their version. Here, we are downloading the most recent python version for windows 3.7.4



**Step 4:** Scroll down the page until you find the Files option.

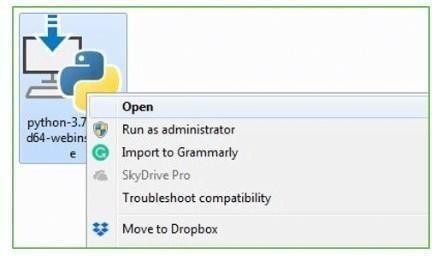
**Step 5:** Here you see a different version of python along with the operating system.



#### 

#### Installation of Python

**Step 1:** Go to Download and Open the downloaded python version to carry out the installation process.



**Step 2:** Before you click on Install Now, make sure to put a tick on Add Python 3.7 to PATH.



**Step 3:** Click on Install NOW After the installation is successful. Click on Close.

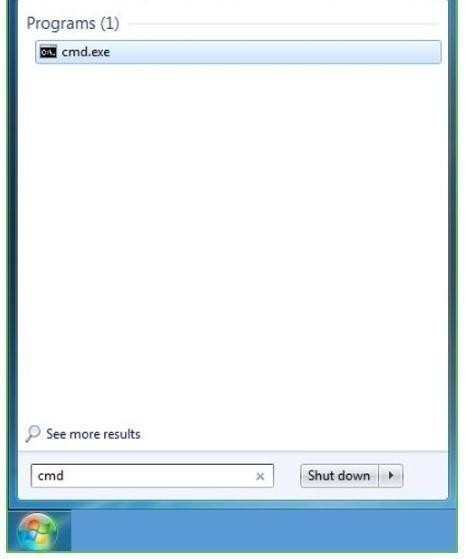
With these above three steps on python installation, you have successfully and correctly installed Python. Now is the time to verify the installation.

**Note:** The installation process might take a couple of minutes.

**Verification of Python Installation:**

**Step 1:** Click on Start

**Step 2:** In the Windows Run Command, type “cmd”.



**Step 3:** Open the Command prompt option.

**Step 4:** Let us test whether the python is correctly installed. Type **python –V** and press Enter.



**Step 5:** You will get the answer as 3.7.4

**Note:** If you have any of the earlier versions of Python already installed. You must first uninstall the earlier version and then install the new one.

Many PCs and Macs will have python already installed.

To check if you have python installed on a Windows PC, search in the start bar for Python or run the following on the Command Line (cmd.exe):

C:\Users\Your Name>python --version

To check if you have python installed on a Linux or Mac, then on Linux open the command line or on Mac open the Terminal and type:

python –version

If you find that you do not have python installed on your computer, then you can download it for free from the following website: https:/[/www.python.org/](http://www.python.org/)

Python QuickStart

Python is an interpreted programming language; this means that as a developer you write Python (.py) files in a text editor and then put those files into the python interpreter to be executed.

The way to run a python file is like this on the command line: C:\Users\Your Name>python helloworld.py

Where "helloworld.py" is the name of your python file.

Let's write our first Python file, called helloworld.py, which can be done in any text editor.

helloworld.py print("Hello, World!")

Simple as that. Save your file. Open your command line, navigate to the directory where you saved your file, and run:

C:\Users\Your Name>python helloworld.py

The output should read:

Hello, World!

Congratulations, you have written and executed your first Python program. The Python Command Line

To test a short amount of code in python sometimes it is quickest and easiest not to write the code in a file. This is made possible because Python can be run as a command line itself.

Type the following on the Windows, Mac or Linux command line: C:\Users\Your Name>python

Or, if the "python" command did not work, you can try "py": C:\Users\Your Name>py

From there you can write any python, including our hello world example from earlier in the tutorial:

C:\Users\Your Name>python

Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32

Type "help", "copyright", "credits" or "license" for more information.

>>>print("Hello, World!")

Which will write "Hello, World!" in the command line: C:\Users\Your Name>python

Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32

Type "help", "copyright", "credits" or "license" for more information.

>>>print("Hello, World!") Hello, World!

Whenever you are done in the python command line, you can simply type the following to quit the python command line interface:

exit()

### Virtual Environments and Packages Introduction

Python applications will often use packages and modules that don’t come as part

of the standard library. Applications will sometimes need a specific version of a library, because the application may require that a particular bug has been fixed or the application may be written using an obsolete version of the library’s interface.

This means it may not be possible for one Python installation to meet the requirements of every application. If application A needs version 1.0 of a particular module but application B needs version 2.0, then the requirements are in conflict and installing either version 1.0 or 2.0 will leave one application unable to run.

The solution for this problem is to create a virtual environment, a self-contained directory tree that contains a Python installation for a particular version of Python, plus a number of additional packages.

Different applications can then use different virtual environments. To resolve the earlier example of conflicting requirements, application A can have its own virtual environment with version 1.0 installed while application B has another virtual environment with version 2.0. If application B requires a library be upgraded to version 3.0, this will not affect application A’s environment.

**Creating Virtual Environments**

The module used to create and manage virtual environments is called venv. venv will usually install the most recent version of Python that you have available. If you have multiple versions of Python on your system, you can select a specific Python version by running python3 or whichever version you want.

To create a virtual environment, decide upon a directory where you want to place it, and run the venv module as a script with the directory path:

python3 -m venv tutorial-env

This will create the tutorial-env directory if it doesn’t exist, and also create directories inside it containing a copy of the Python interpreter, the standard library, and various supporting files.

A common directory location for a virtual environment is .venv. This name keeps the directory typically hidden in your shell and thus out of the way while giving it a name that explains why the directory exists. It also prevents clashing with .env environment variable definition files that some tooling supports.

Once you’ve created a virtual environment, you may activate it. On Windows, run:

tutorial-env\Scripts\activate.bat On Unix or MacOS, run:

source tutorial-env/bin/activate

(This script is written for the bash shell. If you use the csh or fish shells, there are alternate activate.csh and activate.fish scripts you should use instead.)

Activating the virtual environment will change your shell’s prompt to show what virtual environment you’re using, and modify the environment so that running python will get you that particular version and installation of Python. For example:

$ source ~/envs/tutorial-env/bin/activate (tutorial-env) $ python

Python 3.5.1 (default, May 6 2016, 10:59:36)

>>> import sys

>>>sys.path

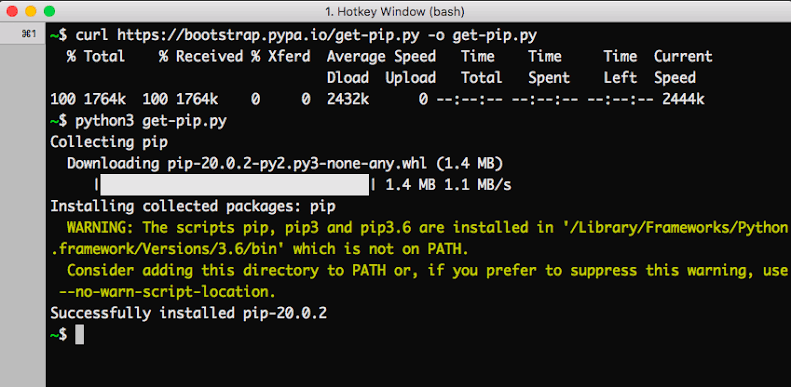
['', '/usr/local/lib/python35.zip', ..., '~/envs/tutorial-env/lib/python3.5/site-packages']

>>>

12.3. Managing Packages with pip

You can install, upgrade, and remove packages using a program called pip. By default, pip will install packages from the Python Package Index,

<https://pypi.org>. You can browse the Python Package Index by going to it in your web browser, or you can use pip’s limited search feature:



(tutorial-env) $ pip search astronomy

Numpy - Python arrays module

pandas - Data manipulation modules for handling large data

Pytorch - Deep learning module for muliti-layered networks

PIL -Image handling and processing python module

...

pip has a number of subcommands: “search”, “install”, “uninstall”, “freeze”, etc. (Consult the Installing Python Modules guide for complete documentation for pip.)

You can install the latest version of a package by specifying a package’s name: (tutorial-env) $ pip install numpy

Collecting numpy

Downloading numpy-3.1.1.3.tar.gz Installing collected packages: numpy

Running setup.py install for numpy

Successfully installed numpy-3.1.1.3

You can also install a specific version of a package by giving the package name followed by == and the version number:

(tutorial-env) $ pip install PIL==2.6.0 Collecting PIL==2.6.0

Using cached PIL-2.6.0-py2.py3-none-any.whl Installing collected packages: PIL

Successfully installed PIL-2.6.0

If you re-run this command, pip will notice that the requested version is already installed and do nothing. You can supply a different version number to get that version, or you can run pip install --upgrade to upgrade the package to the latest version:

(tutorial-env) $ pip install –upgrade torch Collecting torch

Installing collected packages: torch

Found existing installation:torch 2.6.0

Uninstalling torch-2.6.0:

Successfully uninstalled torch-2.6.0 Successfully installed torch-2.7.0

pip uninstall followed by one or more package names will remove the packages from the virtual environment.

Requires:

pip list will display all of the packages installed in the virtual environment: (tutorial-env) $ pip list

pandas (3.1.1.3)

numpy (1.9.2)

pip (7.0.3)

torch (2.7.0)

PIL (16.0)

pip freeze will produce a similar list of the installed packages, but the output uses the format that pip install expects. A common convention is to put this list in a requirements.txt file:

(tutorial-env) $ pip freeze > requirements.txt (tutorial-env) $ cat requirements.txt pandas==3.1.1.3

numpy==1.9.2 torch==2.7.0

The requirements.txt can then be committed to version control and shipped as part of an application. Users can then install all the necessary packages with install -r:

(tutorial-env) $ pip install -r requirements.txt

Collecting pandas==3.1.1.3 (from -r requirements.txt (line 1))

...

Collecting numpy==1.9.2 (from -r requirements.txt (line 2))

...

Collecting torch==2.7.0 (from -r requirements.txt (line 3))

Installing collected packages:pandas , numpy ,torch Running setup.py install for pandas

Successfully installed pandas-3.1.1.3 numpy-1.9.2 torch-2.7.0

pip has many more options. Consult the Installing Python Modules guide for complete documentation for pip. When you’ve written a package and want to make it available on the Python Package Index, consult the Distributing Python Modules guide.

### Cross Platform

Platform. Architecture (executable=sys.executable, bits='', linkage='') Queries the given executable (defaults to the Python interpreter binary) for various architecture information.

Returns a tuple (bits, linkage) which contain information about the bit architecture and the linkage format used for the executable. Both values are returned as strings.

Values that cannot be determined are returned as given by the parameter presets. If bits is given as '', the sizeof(pointer) (or sizeof(long) on Python version < 1.5.2) is used as indicator for the supported pointer size.

The function relies on the system’s file command to do the actual work. This is available on most if not all Unix platforms and some non-Unix platforms and then only if the executable points to the Python interpreter. Reasonable defaults are used when the above needs are not met.

Note On Mac OS X (and perhaps other platforms), executable files may be universal files containing multiple architectures.

To get at the “64-bitness” of the current interpreter, it is more reliable to query the sys.maxsize attribute:

is\_64bits = sys.maxsize> 2\*\*32 platform.machine ()

Returns the machine type, e.g. 'i386'. An empty string is returned if the value cannot be determined.

platform.node ()

Returns the computer’s network name (may not be fully qualified!). An empty string is returned if the value cannot be determined.

platform. Platform(aliased=0, terse=0)

Returns a single string identifying the underlying platform with as much useful information as possible.

The output is intended to be human readable rather than machine parseable. It may look different on different platforms and this is intended.

If aliased is true, the function will use aliases for various platforms that report system names which differ from their common names, for example SunOS will be reported as Solaris. The system\_alias() function is used to implement this.

Setting terse to true causes the function to return only the absolute minimum information needed to identify the platform.

platform.processor()

Returns the (real) processor name, e.g. 'amdk6'.

An empty string is returned if the value cannot be determined. Note that many platforms do not provide this information or simply return the same value as for machine(). NetBSD does this.

platform.python\_build()

Returns a tuple (buildno, builddate) stating the Python build number and date as strings.

platform.python\_compiler()

Returns a string identifying the compiler used for compiling Python. platform.python\_branch()

Returns a string identifying the Python implementation SCM branch. New in version 2.6.

platform.python\_implementation()

Returns a string identifying the Python implementation. Possible return values are: ‘CPython’, ‘IronPython’, ‘Jython’, ‘PyPy’.

New in version 2.6. platform.python\_revision()

Returns a string identifying the Python implementation SCM revision. New in version 2.6.

platform.python\_version()

Returns the Python version as string 'major.minor.patchlevel'.

Note that unlike the Python sys.version, the returned value will always include the patchlevel (it defaults to 0).

platform.python\_version\_tuple()

Returns the Python version as tuple (major, minor, patchlevel) of strings.

Note that unlike the Python sys.version, the returned value will always include the patchlevel (it defaults to '0').

platform.release()

Returns the system’s release, e.g. '2.2.0' or 'NT' An empty string is returned if the value cannot be determined.

platform.system()

Returns the system/OS name, e.g. 'Linux', 'Windows', or 'Java'. An empty string is returned if the value cannot be determined.

platform.system\_alias(system, release, version)

Returns (system, release, version) aliased to common marketing names used for some systems. It also does some reordering of the information in some cases where it would otherwise cause confusion.

platform.version()

Returns the system’s release version, e.g. '#3 on degas'. An empty string is returned if the value cannot be determined.platform.uname()

Fairly portable uname interface. Returns a tuple of strings (system, node, release, version, machine, processor) identifying the underlying platform.

Note that unlike the os.uname() function this also returns possible processor information as additional tuple entry.

Entries which cannot be determined are set to ''.

## Java Platform

platform.java\_ver(release='', vendor='', vminfo=('', '', ''), osinfo=('', '', '')) Version interface for Jython.

Returns a tuple (release, vendor, vminfo, osinfo) with vminfo being a tuple (vm\_name, vm\_release, vm\_vendor) and osinfo being a tuple (os\_name, os\_version, os\_arch). Values which cannot be determined are set to the defaults given as parameters (which all default to '').

**Windows Platform**

platform.win32\_ver(release='', version='', csd='', ptype='')

Get additional version information from the Windows Registry and return a tuple (release, version, csd, ptype) referring to OS release, version number, CSD level (service pack) and OS type (multi/single processor).

As a hint: ptype is 'Uniprocessor Free' on single processor NT machines and 'Multiprocessor Free' on multi-processor machines. The ‘Free’ refers to the OS version being free of debugging code. It could also state ‘Checked’ which means the OS version uses debugging code, i.e. code that checks arguments, ranges, etc.

Note This function works best with Mark Hammond’s win32all package installed, but also on Python 2.3 and later (support for this was added in Python 2.6). It obviously only runs on Win32 compatible platforms.

### Win95/98 specific

platform.popen(cmd, mode='r', bufsize=None)

Portable popen() interface. Find a working popen implementation preferring win32pipe.popen(). On Windows NT, win32pipe.popen() should work; on Windows 9x it hangs due to bugs in the MS C library.

### Mac OS Platform

platform.mac\_ver(release='', versioninfo=('', '', ''), machine='')

Get Mac OS version information and return it as tuple (release, versioninfo, machine) with versioninfo being a tuple (version, dev\_stage, non\_release\_version).

Entries which cannot be determined are set to ''. All tuple entries are strings.

### Unix Platforms

platform.dist(distname='', version='', id='', supported\_dists=('SuSE', 'debian', 'redhat', 'mandrake', ...))

This is an old version of the functionality now provided by linux\_distribution(). For new code, please use the linux\_distribution().

The only difference between the two is that dist() always returns the short name of the distribution taken from the supported\_dists parameter.

Deprecated since version 2.6.

platform.linux\_distribution(distname='', version='', id='', supported\_dists=('SuSE', 'debian', 'redhat', 'mandrake', ...), full\_distribution\_name=1)

Tries to determine the name of the Linux OS distribution name.

supported\_dists may be given to define the set of Linux distributions to look for. It defaults to a list of currently supported Linux distributions identified by their release file name.

If full\_distribution\_name is true (default), the full distribution read from the OS is returned. Otherwise the short name taken from supported\_dists is used.

Returns a tuple (distname,version,id) which defaults to the args given as parameters. id is the item in parentheses after the version number. It is usually the version codename.

Note This function is deprecated since Python 3.5 and removed in Python 3.8. See alternative like the distro package.

New in version 2.6.

platform.libc\_ver(executable=sys.executable, lib='', version='', chunksize=2048)

Tries to determine the libc version against which the file executable (defaults to the Python interpreter) is linked. Returns a tuple of strings (lib, version) which default to the given parameters in case the lookup fails.

Note that this function has intimate knowledge of how different libc versions add symbols to the executable is probably only usable for executables compiled using gcc. The file is read and scanned in chunks of chunksize bytes.

### Using the Python Interpreter Invoking the Interpreter

The Python interpreter is usually installed as /usr/local/bin/python3.8 on those machines where it is available; putting /usr/local/bin in your Unix shell’s search

path makes it possible to start it by typing the command:

python3.8

to the shell. 1 Since the choice of the directory where the interpreter lives is an installation option, other places are possible; check with your local Python guru or system administrator. (E.g., /usr/local/python is a popular alternative location.)

On Windows machines where you have installed Python from the Microsoft Store, the python3.8 command will be available. If you have the py.exe launcher installed, you can use the py command. See Excursus: Setting environment variables for other ways to launch Python.

Typing an end-of-file character (Control-D on Unix, Control-Z on Windows) at the primary prompt causes the interpreter to exit with a zero exit status. If that doesn’t work, you can exit the interpreter by typing the following command: quit().

The interpreter’s line-editing features include interactive editing, history substitution and code completion on systems that support the GNU Readline library. Perhaps the quickest check to see whether command line editing is supported is typing Control-P to the first Python prompt you get. If it beeps, you have command line editing; see Appendix Interactive Input Editing and History Substitution for an introduction to the keys.

If nothing appears to happen, or if ^P is echoed, command line editing isn’t available; you’ll only be able to use backspace to remove characters from the current line.

The interpreter operates somewhat like the Unix shell: when called with standard input connected to a tty device, it reads and executes commands interactively; when called with a file name argument or with a file as standard input, it reads and executes a script from that file.

A second way of starting the interpreter is python -c command [arg] ..., which executes the statement(s) in command, analogous to the shell’s -c option. Since Python statements often contain spaces or other characters that are special to the shell, it is usually advised to quote command in its entirety with single quotes.

Some Python modules are also useful as scripts. These can be invoked using python -m module [arg] ..., which executes the source file for module as if you had spelled out its full name on the command line.

When a script file is used, it is sometimes useful to be able to run the script and enter interactive mode afterwards. This can be done by passing -i before the script.

All command line options are described in Command line and environment. Argument Passing

When known to the interpreter, the script name and additional arguments thereafter are turned into a list of strings and assigned to the argv variable in the sys module. You can access this list by executing import sys. The length of the list is at least one; when no script and no arguments are given, sys.argv[0] is an empty string. When the script name is given as '-' (meaning standard input), sys.argv[0] is set to '-'. When -c command is used, sys.argv[0] is set to '-c'. When -m module is used, sys.argv[0] is set to the full name of the located module. Options found after -c command or -m module are not consumed by the Python interpreter’s option processing but left in sys.argv for the command or module to handle.

Interactive Mode

When commands are read from a tty, the interpreter is said to be in interactive mode. In this mode it prompts for the next command with the primary prompt, usually three greater-than signs (>>>); for continuation lines it prompts with the secondary prompt, by default three dots (...). The interpreter prints a welcome

message stating its version number and a copyright notice before printing the first prompt:

$ python3.8

Python 3.8 (default, Sep 16 2015, 09:25:04) [GCC 4.8.2] on linux

Type "help", "copyright", "credits" or "license" for more information.

Continuation lines are needed when entering a multi-line construct. As an example, take a look at this if statement:

>>>

>>>the\_world\_is\_flat = True

>>>if the\_world\_is\_flat:

... print("Be careful not to fall off!")

...

Be careful not to fall off!

For more on interactive mode, see Interactive Mode. **The Interpreter and Its Environment Source Code Encoding**

By default, Python source files are treated as encoded in UTF-8. In that encoding, characters of most languages in the world can be used simultaneously in string literals, identifiers and comments — although the standard library only uses ASCII characters for identifiers, a convention that any portable code should follow. To display all these characters properly, your editor must recognize that the file is UTF-8, and it must use a font that supports all the characters in the file.

To declare an encoding other than the default one, a special comment line should be added as the first line of the file. The syntax is as follows:

# -\*- coding: encoding -\*-

where encoding is one of the valid codecs supported by Python.

For example, to declare that Windows-1252 encoding is to be used, the first line of your source code file should be:

# -\*- coding: cp1252 -\*-

One exception to the first line rule is when the source code starts with a UNIX “shebang” line. In this case, the encoding declaration should be added as the second line of the file. For example:

#!/usr/bin/env python3 # -\*- coding: cp1252 -\*-

Introduction to Artificial Intelligence

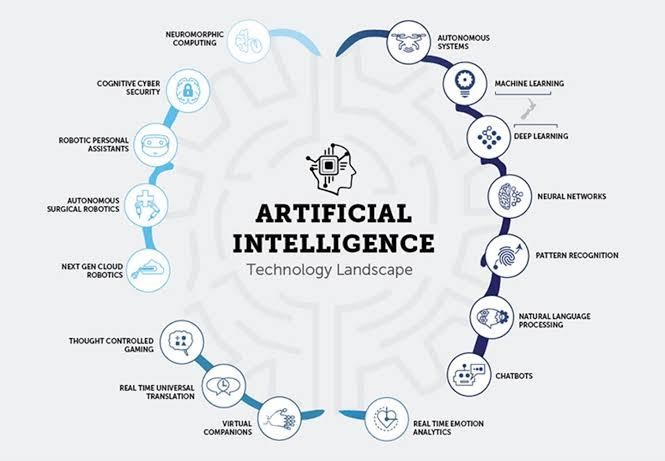
“The science and engineering of making intelligent machines, especially intelligent computer programs”. -John McCarthy-

### ARTIFICIAL INTELLIGENCE

Artificial Intelligence is an approach to make a computer, a robot, or a product to think how smart human think. AI is a study of how human brain think, learn, decide and work, when it tries to solve problems. And finally this study outputs intelligent software systems. The aim of AI is to improve computer functions which are related to human knowledge, for example, reasoning, learning, and problem-solving.

The intelligence is intangible. It is composed of

* Reasoning
* Learning
* Problem Solving
* Perception
* Linguistic Intelligence



The objectives of AI research are reasoning, knowledge representation, planning, learning, natural language processing, realization, and ability to move and manipulate objects. There are long-term goals in the general intelligence sector.

Approaches include statistical methods, computational intelligence, and traditional coding AI. During the AI research related to search and mathematical optimization, artificial neural networks and methods based on statistics, probability, and economics, we use many tools. Computer science attracts AI in the field of science, mathematics, psychology, linguistics, philosophy and so on.

### Trending AI Articles:

1. Cheat Sheets for AI, Neural Networks, Machine Learning, Deep Learning & Big Data
2. Data Science Simplified Part 1: Principles and Process
3. Getting Started with Building Realtime API Infrastructure
4. AI & NLP Workshop

### Applications of AI

* Gaming − AI plays important role for machine to think of large number of possible positions based on deep knowledge in strategic games. for example, chess, river crossing, N-queens’ problems and etc.

Natural Language Processing − Interact with the computer that understands natural language spoken by humans.

* Expert Systems − Machine or software provide explanation and advice to the users.
* Vision Systems − Systems understand, explain, and describe visual input on the computer.
* Speech Recognition − There are some AI based speech recognition systems have ability to hear and express as sentencesition software reads the text written on paper and recognize the shapes of the letters and convert it into editable text.
* Intelligent Robots − Robots are able to perform the instructions given by a human.

### Major Goals

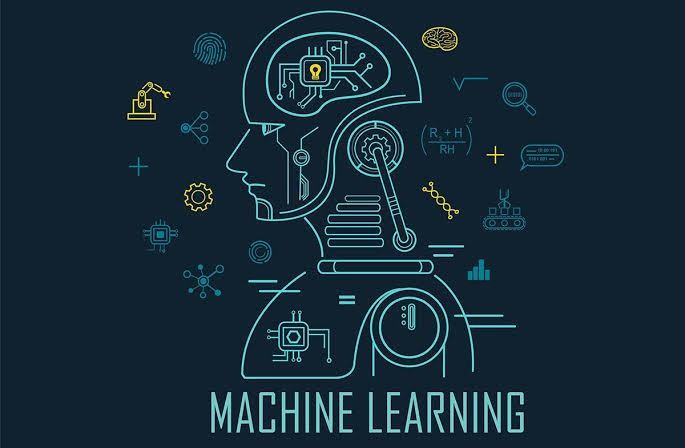
* + Knowledge reasoning
  + Planning
  + Machine Learning
  + Natural Language Processing
  + Computer Vision
  + Robotics

### MACHINE LEARNING

**Introduction**

Machine learning is a subfield of artificial intelligence (AI). The goal of machine learning generally is to understand the structure of data and fit that data into models that can be understood and utilized by people.

Although machine learning is a field within computer science, it differs from traditional computational approaches. In traditional computing, algorithms are sets of explicitly programmed instructions used by computers to calculate or problem solve.



Machine learning algorithms instead allow for computers to train on data inputs and use statistical analysis in order to output values that fall within a specific range. Because of this, machine learning facilitates computers in building models from sample data in order to automate decision-making processes based on data inputs. Any technology user today has benefitted from machine learning. Facial recognition technology allows social media platforms to help users tag and share photos of friends.

Optical character recognition (OCR) technology converts images of text into movable type. Recommendation engines, powered by machine learning, suggest what movies or television shows to watch next based on user preferences. Self- driving cars that rely on machine learning to navigate may soon be available to consumers.

Machine learning is a continuously developing field. Because of this, there are some considerations to keep in mind as you work with machine learning methodologies, or analyze the impact of machine learning processes.

In this tutorial, we’ll look into the common machine learning methods of supervised and unsupervised learning, and common algorithmic approaches in machine learning, including the k-nearest neighbor algorithm, decision tree learning, and deep learning. We’ll explore which programming languages are most used in machine learning, providing you with some of the positive and negative attributes of each.

Additionally, we’ll discuss biases that are perpetuated by machine learning algorithms, and consider what can be kept in mind to prevent these biases when building algorithms.

### Machine Learning Methods

In machine learning, tasks are generally classified into broad categories. These categories are based on how learning is received or how feedback on the learning is given to the system developed.

Two of the most widely adopted machine learning methods are **supervised learning** which trains algorithms based on example input and output data that is labeled by humans, and **unsupervised learning** which provides the algorithm with no labeled data in order to allow it to find structure within its input data. Let’s explore these methods in more detail.

### Supervised Learning

In supervised learning, the computer is provided with example inputs that are labeled with their desired outputs. The purpose of this method is for the algorithm to be able

to “learn” by comparing its actual output with the “taught” outputs to find errors, and modify the model accordingly. Supervised learning therefore uses patterns to predict label values on additional unlabeled data.

For example, with supervised learning, an algorithm may be fed data with images of sharks labeled as fish and images of oceans labeled as water. By being trained on this data, the supervised learning algorithm should be able to later identify unlabeled shark images as fish and unlabeled ocean images as water.

A common use case of supervised learning is to use historical data to predict statistically likely future events. It may use historical stock market information to anticipate upcoming fluctuations, or be employed to filter out spam emails. In supervised learning, tagged photos of dogs can be used as input data to classify untagged photos of dogs.

### Unsupervised Learning

In unsupervised learning, data is unlabeled, so the learning algorithm is left to find commonalities among its input data. As unlabeled data are more abundant than labeled data, machine learning methods that facilitate unsupervised learning are particularly valuable.

The goal of unsupervised learning may be as straightforward as discovering hidden patterns within a dataset, but it may also have a goal of feature learning, which allows the computational machine to automatically discover the representations that are needed to classify raw data.

Unsupervised learning is commonly used for transactional data. You may have a large dataset of customers and their purchases, but as a human you will likely not be able to make sense of what similar attributes can be drawn from customer profiles and their types of purchases. With this data fed into an unsupervised learning algorithm, it may be determined that women of a certain age range who buy unscented soaps are likely to be pregnant, and therefore a marketing campaign related to pregnancy and baby products can be targeted to this audience in order to increase their number of purchases.

Without being told a “correct” answer, unsupervised learning methods can look at complex data that is more expansive and seemingly unrelated in order to organize it in potentially meaningful ways. Unsupervised learning is often used for anomaly detection including for fraudulent credit card purchases, and recommender systems that recommend what products to buy next. In unsupervised learning, untagged photos of dogs can be used as input data for the algorithm to find likenesses and classify dog photos together.

### Approaches

As a field, machine learning is closely related to computational statistics, so having a background knowledge in statistics is useful for understanding and leveraging machine learning algorithms. For those who may not have studied statistics, it can be helpful to first define correlation and regression, as they are commonly used techniques for investigating the relationship among quantitative variables.

**Correlation** is a measure of association between two variables that are not designated as either dependent or independent. **Regression** at a basic level is used to examine the relationship between one dependent and one independent variable. Because regression statistics can be used to anticipate the dependent variable when the independent variable is known, regression enables prediction capabilities.

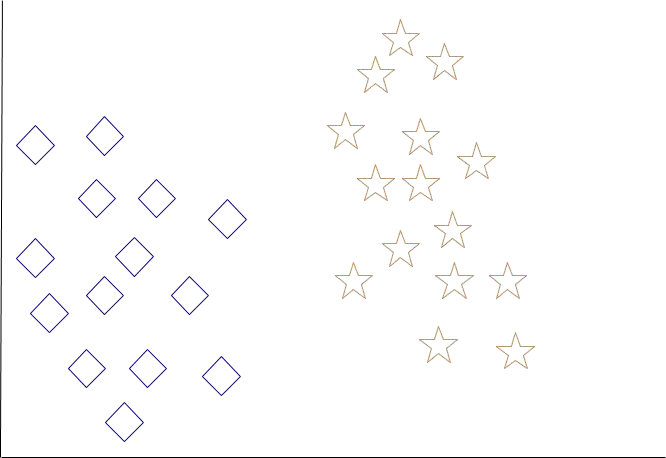
Approaches to machine learning are continuously being developed. For our purposes, we’ll go through a few of the popular approaches that are being used in machine learning at the time of writing.

### K-nearest neighbor

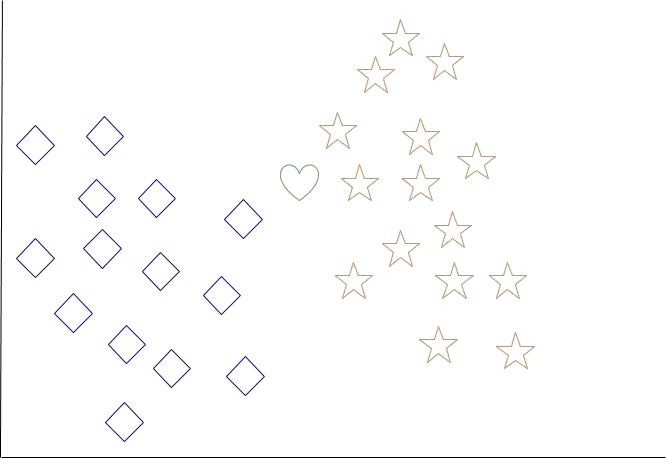
The k-nearest neighbor algorithm is a pattern recognition model that can be used for classification as well as regression. Often abbreviated as k-NN, the **k** in k-nearest neighbor is a positive integer, which is typically small. In either classification or regression, the input will consist of the k closest training examples within a space.

We will focus on k-NN classification. In this method, the output is class membership. This will assign a new object to the class most common among its k nearest neighbors. In the case of k = 1, the object is assigned to the class of the single nearest neighbor.

Let’s look at an example of k-nearest neighbor. In the diagram below, there are blue diamond objects and orange star objects. These belong to two separate classes: the diamond class and the star class.

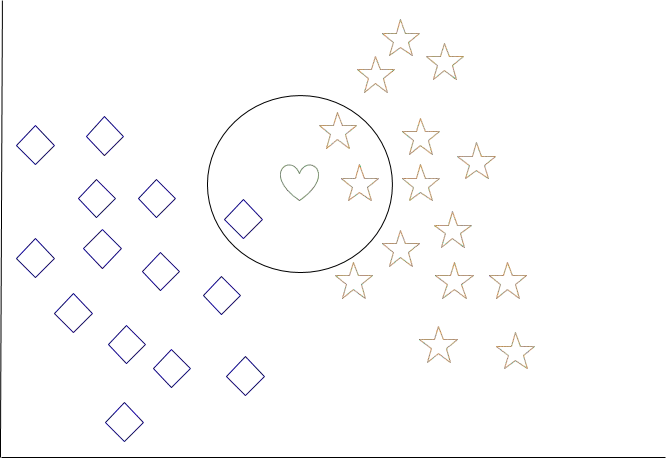


When a new object is added to the space — in this case a green heart — we will want the machine learning algorithm to classify the heart to a certain class.



When we choose k = 3, the algorithm will find the three nearest neighbors of the green heart in order to classify it to either the diamond class or the star class.

In our diagram, the three nearest neighbors of the green heart are one diamond and two stars. Therefore, the algorithm will classify the heart with the star class.



Among the most basic of machine learning algorithms, k-nearest neighbor is considered to be a type of “lazy learning” as generalization beyond the training data does not occur until a query is made to the system.

### Decision Tree Learning

For general use, decision trees are employed to visually represent decisions and show or inform decision making. When working with machine learning and data mining, decision trees are used as a predictive model. These models map observations about data to conclusions about the data’s target value.

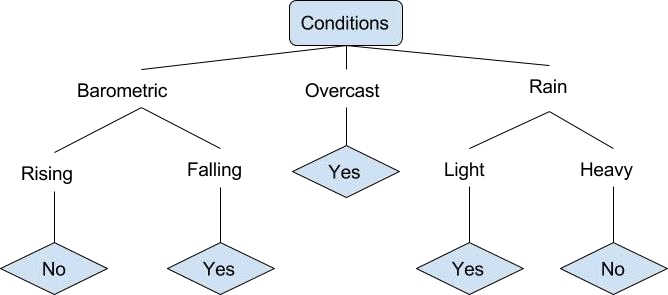
The goal of decision tree learning is to create a model that will predict the value of a target based on input variables.

In the predictive model, the data’s attributes that are determined through observation

are represented by the branches, while the conclusions about the data’s target value are represented in the leaves.

When “learning” a tree, the source data is divided into subsets based on an attribute value test, which is repeated on each of the derived subsets recursively. Once the subset at a node has the equivalent value as its target value has, the recursion process will be complete.

Let’s look at an example of various conditions that can determine whether or not someone should go fishing. This includes weather conditions as well as barometric pressure conditions.



In the simplified decision tree above, an example is classified by sorting it through the tree to the appropriate leaf node. This then returns the classification associated with the particular leaf, which in this case is either a Yes or a No. The tree classifies a day’s conditions based on whether or not it is suitable for going fishing.

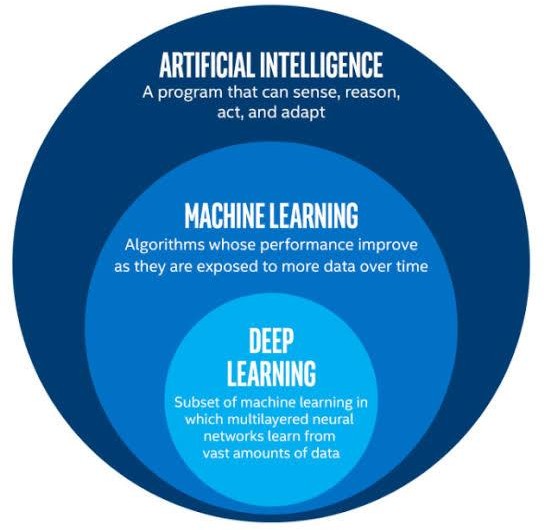
A true classification tree data set would have a lot more features than what is outlined above, but relationships should be straightforward to determine. When working with

decision tree learning, several determinations need to be made, including what features to choose, what conditions to use for splitting, and understanding when the decision tree has reached a clear ending.

### DEEP LEARNING Introduction to Deep Learning

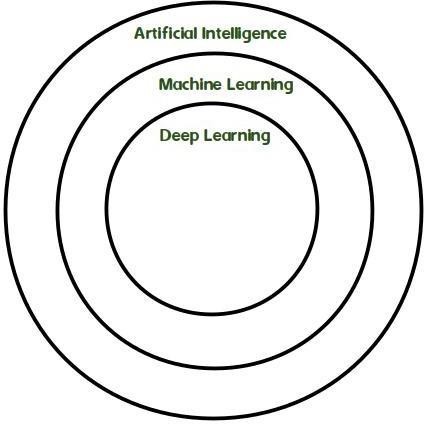
Deep learning is a branch of machine learning which is completely based on artificial neural networks, as neural network is going to mimic the human brain so deep learning is also a kind of mimic of human brain. In deep learning, we don’t need to explicitly program everything. The concept of deep learning is not new. It has been around for a couple of years now. It’s on hype nowadays because earlier we did not have that much processing power and a lot of data. As in the last 20 years, the processing power increases exponentially, deep learning and machine learning came in the picture.

A formal definition of deep learning is- neurons



In human brain approximately 100 billion neurons all together this is a picture of an individual neuron and each neuron is connected through thousands of their neighbors. The question here is how do we recreate these neurons in a computer. So, we create an artificial structure called an artificial neural net where we have nodes or neurons. We have some neurons for input value and some for output value and in between, there may be lots of neurons interconnected in the hidden layer.

Deep learning is a particular kind of machine learning that achieves great power and flexibility by learning to represent the world as a nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones.



### PYTORCH

**PyTorch** stands as a revered open-source machine learning library, cherished by AI researchers, engineers, and developers. It's a versatile tool for machine learning and deep learning tasks, thanks to its dynamic computation graphs, which excel in applications like neural network modeling. Whether you're advancing research or deploying production-grade ML, PyTorch offers flexibility and reliability.

At its core, PyTorch streamlines complex ML model development, freeing you from low-level hassles. Its clean, pragmatic design minimizes development challenges, allowing focus on unique application logic. Backed by a thriving community, PyTorch embodies "don't repeat yourself" (DRY) principles, prioritizing code reusability. Python's simplicity and readability pervade PyTorch, from settings to data models.

PyTorch's dynamic environment accelerates model prototyping, aiding computer vision, NLP, and more. Seamless integration with Python libraries like NumPy boosts its appeal. PyTorch goes beyond ML, supporting deep learning techniques, including CNNs, RNNs, and transformers, fostering AI innovation.

Besides core features, PyTorch offers rich pre-built components for quick development. It encourages open-source collaboration, sharing pre-trained models and libraries. PyTorch embodies dynamic, community-driven machine learning, ideal for AI enthusiasts. As a free, open-source framework, PyTorch empowers AI progress, shaping intelligent applications and pushing boundaries.

**Create a sample application**

We assume you are in your project folder. In our main “myproject” folder, the same folder then manage.py −

# Connecting to Google Drive

from google.colab import drive

drive.mount('/content/drive')

# Impoting required modules

import torch

from torch import nn

import torch.nn as nn

from PIL import Image

import numpy as np

from skimage import color

import torch

import torch.nn.functional as F

from IPython import embed

import matplotlib.pyplot as plt

class BaseColor(nn.Module):

    def \_\_init\_\_(self):

        super(BaseColor, self).\_\_init\_\_()

        self.l\_cent = 50.

        self.l\_norm = 100.

        self.ab\_norm = 110.

    def normalize\_l(self, in\_l):

        return (in\_l-self.l\_cent)/self.l\_norm

    def unnormalize\_l(self, in\_l):

        return in\_l\*self.l\_norm + self.l\_cent

    def normalize\_ab(self, in\_ab):

        return in\_ab/self.ab\_norm

    def unnormalize\_ab(self, in\_ab):

        return in\_ab\*self.ab\_norm

class ECCVGenerator(BaseColor):

    def \_\_init\_\_(self, norm\_layer=nn.BatchNorm2d):

        super(ECCVGenerator, self).\_\_init\_\_()

        model1=[nn.Conv2d(1, 64, kernel\_size=3, stride=1, padding=1, bias=True),]

        model1+=[nn.ReLU(True),]

        model1+=[nn.Conv2d(64, 64, kernel\_size=3, stride=2, padding=1, bias=True),]

        model1+=[nn.ReLU(True),]

        model1+=[norm\_layer(64),]

        model2=[nn.Conv2d(64, 128, kernel\_size=3, stride=1, padding=1, bias=True),]

        model2+=[nn.ReLU(True),]

        model2+=[nn.Conv2d(128, 128, kernel\_size=3, stride=2, padding=1, bias=True),]

        model2+=[nn.ReLU(True),]

        model2+=[norm\_layer(128),]

        model3=[nn.Conv2d(128, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model3+=[nn.ReLU(True),]

        model3+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model3+=[nn.ReLU(True),]

        model3+=[nn.Conv2d(256, 256, kernel\_size=3, stride=2, padding=1, bias=True),]

        model3+=[nn.ReLU(True),]

        model3+=[norm\_layer(256),]

        model4=[nn.Conv2d(256, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model4+=[nn.ReLU(True),]

        model4+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model4+=[nn.ReLU(True),]

        model4+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model4+=[nn.ReLU(True),]

        model4+=[norm\_layer(512),]

        model5=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model5+=[nn.ReLU(True),]

        model5+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model5+=[nn.ReLU(True),]

        model5+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model5+=[nn.ReLU(True),]

        model5+=[norm\_layer(512),]

        model6=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model6+=[nn.ReLU(True),]

        model6+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model6+=[nn.ReLU(True),]

        model6+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model6+=[nn.ReLU(True),]

        model6+=[norm\_layer(512),]

        model7=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model7+=[nn.ReLU(True),]

        model7+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model7+=[nn.ReLU(True),]

        model7+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model7+=[nn.ReLU(True),]

        model7+=[norm\_layer(512),]

        model8=[nn.ConvTranspose2d(512, 256, kernel\_size=4, stride=2, padding=1, bias=True),]

        model8+=[nn.ReLU(True),]

        model8+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model8+=[nn.ReLU(True),]

        model8+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model8+=[nn.ReLU(True),]

        model8+=[nn.Conv2d(256, 313, kernel\_size=1, stride=1, padding=0, bias=True),]

        self.model1 = nn.Sequential(\*model1)

        self.model2 = nn.Sequential(\*model2)

        self.model3 = nn.Sequential(\*model3)

        self.model4 = nn.Sequential(\*model4)

        self.model5 = nn.Sequential(\*model5)

        self.model6 = nn.Sequential(\*model6)

        self.model7 = nn.Sequential(\*model7)

        self.model8 = nn.Sequential(\*model8)

        self.softmax = nn.Softmax(dim=1)

        self.model\_out = nn.Conv2d(313, 2, kernel\_size=1, padding=0, dilation=1, stride=1, bias=False)

        self.upsample4 = nn.Upsample(scale\_factor=4, mode='bilinear')

    def forward(self, input\_l):

        conv1\_2 = self.model1(self.normalize\_l(input\_l))

        conv2\_2 = self.model2(conv1\_2)

        conv3\_3 = self.model3(conv2\_2)

        conv4\_3 = self.model4(conv3\_3)

        conv5\_3 = self.model5(conv4\_3)

        conv6\_3 = self.model6(conv5\_3)

        conv7\_3 = self.model7(conv6\_3)

        conv8\_3 = self.model8(conv7\_3)

        out\_reg = self.model\_out(self.softmax(conv8\_3))

        return self.unnormalize\_ab(self.upsample4(out\_reg))

def eccv16(pretrained=True):

    model = ECCVGenerator()

    if(pretrained):

        import torch.utils.model\_zoo as model\_zoo

        model.load\_state\_dict(model\_zoo.load\_url('https://colorizers.s3.us-east-2.amazonaws.com/colorization\_release\_v2-9b330a0b.pth',map\_location='cpu',check\_hash=True))

    return model

class SIGGRAPHGenerator(BaseColor):

    def \_\_init\_\_(self, norm\_layer=nn.BatchNorm2d, classes=529):

        super(SIGGRAPHGenerator, self).\_\_init\_\_()

        # Conv1

        model1=[nn.Conv2d(4, 64, kernel\_size=3, stride=1, padding=1, bias=True),]

        model1+=[nn.ReLU(True),]

        model1+=[nn.Conv2d(64, 64, kernel\_size=3, stride=1, padding=1, bias=True),]

        model1+=[nn.ReLU(True),]

        model1+=[norm\_layer(64),]

        # Conv2

        model2=[nn.Conv2d(64, 128, kernel\_size=3, stride=1, padding=1, bias=True),]

        model2+=[nn.ReLU(True),]

        model2+=[nn.Conv2d(128, 128, kernel\_size=3, stride=1, padding=1, bias=True),]

        model2+=[nn.ReLU(True),]

        model2+=[norm\_layer(128),]

        # Conv3

        model3=[nn.Conv2d(128, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model3+=[nn.ReLU(True),]

        model3+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model3+=[nn.ReLU(True),]

        model3+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model3+=[nn.ReLU(True),]

        model3+=[norm\_layer(256),]

        # Conv4

        model4=[nn.Conv2d(256, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model4+=[nn.ReLU(True),]

        model4+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model4+=[nn.ReLU(True),]

        model4+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model4+=[nn.ReLU(True),]

        model4+=[norm\_layer(512),]

        # Conv5

        model5=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model5+=[nn.ReLU(True),]

        model5+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model5+=[nn.ReLU(True),]

        model5+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model5+=[nn.ReLU(True),]

        model5+=[norm\_layer(512),]

        # Conv6

        model6=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model6+=[nn.ReLU(True),]

        model6+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model6+=[nn.ReLU(True),]

        model6+=[nn.Conv2d(512, 512, kernel\_size=3, dilation=2, stride=1, padding=2, bias=True),]

        model6+=[nn.ReLU(True),]

        model6+=[norm\_layer(512),]

        # Conv7

        model7=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model7+=[nn.ReLU(True),]

        model7+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model7+=[nn.ReLU(True),]

        model7+=[nn.Conv2d(512, 512, kernel\_size=3, stride=1, padding=1, bias=True),]

        model7+=[nn.ReLU(True),]

        model7+=[norm\_layer(512),]

        # Conv7

        model8up=[nn.ConvTranspose2d(512, 256, kernel\_size=4, stride=2, padding=1, bias=True)]

        model3short8=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model8=[nn.ReLU(True),]

        model8+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model8+=[nn.ReLU(True),]

        model8+=[nn.Conv2d(256, 256, kernel\_size=3, stride=1, padding=1, bias=True),]

        model8+=[nn.ReLU(True),]

        model8+=[norm\_layer(256),]

        # Conv9

        model9up=[nn.ConvTranspose2d(256, 128, kernel\_size=4, stride=2, padding=1, bias=True),]

        model2short9=[nn.Conv2d(128, 128, kernel\_size=3, stride=1, padding=1, bias=True),]

        model9=[nn.ReLU(True),]

        model9+=[nn.Conv2d(128, 128, kernel\_size=3, stride=1, padding=1, bias=True),]

        model9+=[nn.ReLU(True),]

        model9+=[norm\_layer(128),]

        # Conv10

        model10up=[nn.ConvTranspose2d(128, 128, kernel\_size=4, stride=2, padding=1, bias=True),]

        model1short10=[nn.Conv2d(64, 128, kernel\_size=3, stride=1, padding=1, bias=True),]

        model10=[nn.ReLU(True),]

        model10+=[nn.Conv2d(128, 128, kernel\_size=3, dilation=1, stride=1, padding=1, bias=True),]

        model10+=[nn.LeakyReLU(negative\_slope=.2),]

        # classification output

        model\_class=[nn.Conv2d(256, classes, kernel\_size=1, padding=0, dilation=1, stride=1, bias=True),]

        # regression output

        model\_out=[nn.Conv2d(128, 2, kernel\_size=1, padding=0, dilation=1, stride=1, bias=True),]

        model\_out+=[nn.Tanh()]

        self.model1 = nn.Sequential(\*model1)

        self.model2 = nn.Sequential(\*model2)

        self.model3 = nn.Sequential(\*model3)

        self.model4 = nn.Sequential(\*model4)

        self.model5 = nn.Sequential(\*model5)

        self.model6 = nn.Sequential(\*model6)

        self.model7 = nn.Sequential(\*model7)

        self.model8up = nn.Sequential(\*model8up)

        self.model8 = nn.Sequential(\*model8)

        self.model9up = nn.Sequential(\*model9up)

        self.model9 = nn.Sequential(\*model9)

        self.model10up = nn.Sequential(\*model10up)

        self.model10 = nn.Sequential(\*model10)

        self.model3short8 = nn.Sequential(\*model3short8)

        self.model2short9 = nn.Sequential(\*model2short9)

        self.model1short10 = nn.Sequential(\*model1short10)

        self.model\_class = nn.Sequential(\*model\_class)

        self.model\_out = nn.Sequential(\*model\_out)

        self.upsample4 = nn.Sequential(\*[nn.Upsample(scale\_factor=4, mode='bilinear'),])

        self.softmax = nn.Sequential(\*[nn.Softmax(dim=1),])

    def forward(self, input\_A, input\_B=None, mask\_B=None):

        if(input\_B is None):

            input\_B = torch.cat((input\_A\*0, input\_A\*0), dim=1)

        if(mask\_B is None):

            mask\_B = input\_A\*0

        conv1\_2 = self.model1(torch.cat((self.normalize\_l(input\_A),self.normalize\_ab(input\_B),mask\_B),dim=1))

        conv2\_2 = self.model2(conv1\_2[:,:,::2,::2])

        conv3\_3 = self.model3(conv2\_2[:,:,::2,::2])

        conv4\_3 = self.model4(conv3\_3[:,:,::2,::2])

        conv5\_3 = self.model5(conv4\_3)

        conv6\_3 = self.model6(conv5\_3)

        conv7\_3 = self.model7(conv6\_3)

        conv8\_up = self.model8up(conv7\_3) + self.model3short8(conv3\_3)

        conv8\_3 = self.model8(conv8\_up)

        conv9\_up = self.model9up(conv8\_3) + self.model2short9(conv2\_2)

        conv9\_3 = self.model9(conv9\_up)

        conv10\_up = self.model10up(conv9\_3) + self.model1short10(conv1\_2)

        conv10\_2 = self.model10(conv10\_up)

        out\_reg = self.model\_out(conv10\_2)

        conv9\_up = self.model9up(conv8\_3) + self.model2short9(conv2\_2)

        conv9\_3 = self.model9(conv9\_up)

        conv10\_up = self.model10up(conv9\_3) + self.model1short10(conv1\_2)

        conv10\_2 = self.model10(conv10\_up)

        out\_reg = self.model\_out(conv10\_2)

        return self.unnormalize\_ab(out\_reg)

def siggraph17(pretrained=True):

    model = SIGGRAPHGenerator()

    if(pretrained):

        import torch.utils.model\_zoo as model\_zoo

        model.load\_state\_dict(model\_zoo.load\_url('https://colorizers.s3.us-east-2.amazonaws.com/siggraph17-df00044c.pth',map\_location='cpu',check\_hash=True))

    return model

def load\_img(img\_path):

    out\_np = np.asarray(Image.open(img\_path))

    if(out\_np.ndim==2):

        out\_np = np.tile(out\_np[:,:,None],3)

    return out\_np

def resize\_img(img, HW=(256,256), resample=3):

    return np.asarray(Image.fromarray(img).resize((HW[1],HW[0]), resample=resample))

def preprocess\_img(img\_rgb\_orig, HW=(256,256), resample=3):

    # return original size L and resized L as torch Tensors

    img\_rgb\_rs = resize\_img(img\_rgb\_orig, HW=HW, resample=resample)

    img\_lab\_orig = color.rgb2lab(img\_rgb\_orig)

    img\_lab\_rs = color.rgb2lab(img\_rgb\_rs)

    img\_l\_orig = img\_lab\_orig[:,:,0]

    img\_l\_rs = img\_lab\_rs[:,:,0]

    tens\_orig\_l = torch.Tensor(img\_l\_orig)[None,None,:,:]

    tens\_rs\_l = torch.Tensor(img\_l\_rs)[None,None,:,:]

    return (tens\_orig\_l, tens\_rs\_l)

def postprocess\_tens(tens\_orig\_l, out\_ab, mode='bilinear'):

    # tens\_orig\_l   1 x 1 x H\_orig x W\_orig

    # out\_ab        1 x 2 x H x W

    HW\_orig = tens\_orig\_l.shape[2:]

    HW = out\_ab.shape[2:]

    # call resize function if needed

    if(HW\_orig[0]!=HW[0] or HW\_orig[1]!=HW[1]):

        out\_ab\_orig = F.interpolate(out\_ab, size=HW\_orig, mode='bilinear')

    else:

        out\_ab\_orig = out\_ab

    out\_lab\_orig = torch.cat((tens\_orig\_l, out\_ab\_orig), dim=1)

    return color.lab2rgb(out\_lab\_orig.data.cpu().numpy()[0,...].transpose((1,2,0)))

# Specify the path to the image

img\_path = '/content/drive/MyDrive/Image Colourization/Images/ansel\_adams3.jpg'

use\_gpu = True  # or False if you don't want to use GPU

save\_prefix = 'saved'

img = load\_img(img\_path)

# load colorizers

colorizer\_eccv16 = eccv16(pretrained=True).eval()

colorizer\_siggraph17 = siggraph17(pretrained=True).eval()

if(use\_gpu):

    colorizer\_eccv16.cuda()

    colorizer\_siggraph17.cuda()

# default size to process images is 256x256

# grab L channel in both original ("orig") and resized ("rs") resolutions

img = load\_img(img\_path)

(tens\_l\_orig, tens\_l\_rs) = preprocess\_img(img, HW=(256,256))

if(use\_gpu):

    tens\_l\_rs = tens\_l\_rs.cuda()

# colorizer outputs 256x256 ab map

# resize and concatenate to original L channel

img\_bw = postprocess\_tens(tens\_l\_orig, torch.cat((0\*tens\_l\_orig,0\*tens\_l\_orig),dim=1))

out\_img\_eccv16 = postprocess\_tens(tens\_l\_orig, colorizer\_eccv16(tens\_l\_rs).cpu())

out\_img\_siggraph17 = postprocess\_tens(tens\_l\_orig, colorizer\_siggraph17(tens\_l\_rs).cpu())

plt.imsave('%s\_eccv16.png'%save\_prefix, out\_img\_eccv16)

plt.imsave('%s\_siggraph17.png'%save\_prefix, out\_img\_siggraph17)

plt.figure(figsize=(12,8))

plt.subplot(2,2,1)

plt.imshow(img)

plt.title('Original')

plt.axis('off')

plt.subplot(2,2,2)

plt.imshow(img\_bw)

plt.title('Input')

plt.axis('off')

plt.subplot(2,2,3)

plt.imshow(out\_img\_eccv16)

plt.title('Output (ECCV 16)')

plt.axis('off')

plt.subplot(2,2,4)

plt.imshow(out\_img\_siggraph17)

plt.title('Output (SIGGRAPH 17)')

plt.axis('off')

plt.show()

# IMPLEMENTATION

### Software Requirements:

* + - Operating System: Windows 11
    - Programming languages: Python 3.7
    - Packages Numpy, PyTorch, PIL
    - Image test files with .jpg or.jpeg extension (limit=20 mb)

### Hardware Requirements:

* + - Processor: Intel core i5
    - RAM: 8GB
    - Hard disk: 254GB
    - GPU

# RESULTS

### EXISTING SYSTEM AND DISADVANTAGES

In the realm of image colorization, numerous studies have delved into advancing the field, each with its own set of methodologies and techniques. Feature extraction plays a pivotal role, analogous to audio speech feature extraction. Various studies have employed different strategies for image preprocessing, including frame sampling and resolution adjustments. For instance, some opted for frame samples with specific characteristics, such as dimensions of 16000 Hz and frame durations of 0.25 seconds. The choice of parameters, including sample rates at 22050 Hz and encoding via 16-bit PCM in two-channel configurations, has also been explored.

In image colorization, much like audio speech recognition, the choice of feature extraction techniques significantly impacts the accuracy of the recognition process. Commonly employed features for image colorization encompass methods like Mean Color Transfer, Entropy and Spectral Entropy, Zero Crossing Rate (ZCR), and Formants, among others. Emphasis has frequently been placed on features like color histograms and spatial distribution patterns, akin to the emphasis on pitch and energy in speech emotion recognition.

Building upon these features, researchers in the field have employed various classification algorithms to categorize images and predict colorization. These encompass a gamut of machine learning techniques, including Support Vector Machine (SVM), Gradient Boosting, K-Nearest Neighbor (KNN), Random Forest, and Neural Networks. Diverse emotional speech databases have been employed to train and fine-tune these systems, paving the way for advancements in image colorization technology.

Despite these efforts, the existing image colorization approaches often encounter challenges related to color accuracy, artifact generation, and computational efficiency. These shortcomings serve as valuable insights for the development of more robust and efficient image colorization methodologies in the quest for realistic and visually appealing results.

### PROPOSED SYSTEM AND ADVANTAGES

The proposed image colorization system leverages a sophisticated approach rooted in deep learning methodologies, incorporating Convolutional Neural Networks (CNN), Support Vector Machine (SVM) classifiers, and Multi-Layer Perceptron (MLP) classifiers. At its core, this system aims to revolutionize the process of image colorization by focusing on a single feature: the Mel-frequency cepstral coefficients (MFCCs).

MFCCs are a prominent feature extraction technique, often referred to as the "spectrum of a spectrum." They represent a refined interpretation of the Mel-frequency cepstrum (MFC) and have emerged as the state-of-the-art choice for sound formalization in automatic speech recognition tasks. Their strength lies in their ability to compactly represent the amplitude spectrum of sound waves.

In the proposed system, audio files are initially divided into frames, typically employing a fixed window size. This segmentation allows for the extraction of statistically stationary waves within the audio. The amplitude spectrum is then normalized using the "Mel" frequency scale, emphasizing frequencies that are more perceptually meaningful to the human auditory system. This process results in the generation of 40 distinct features for each audio file, effectively capturing essential characteristics of the sound.

The dataset is thoughtfully divided into two subsets:

- Training Set: Comprising 90.093% of the dataset.

- Testing Set: Consisting of 9.906% of the dataset.

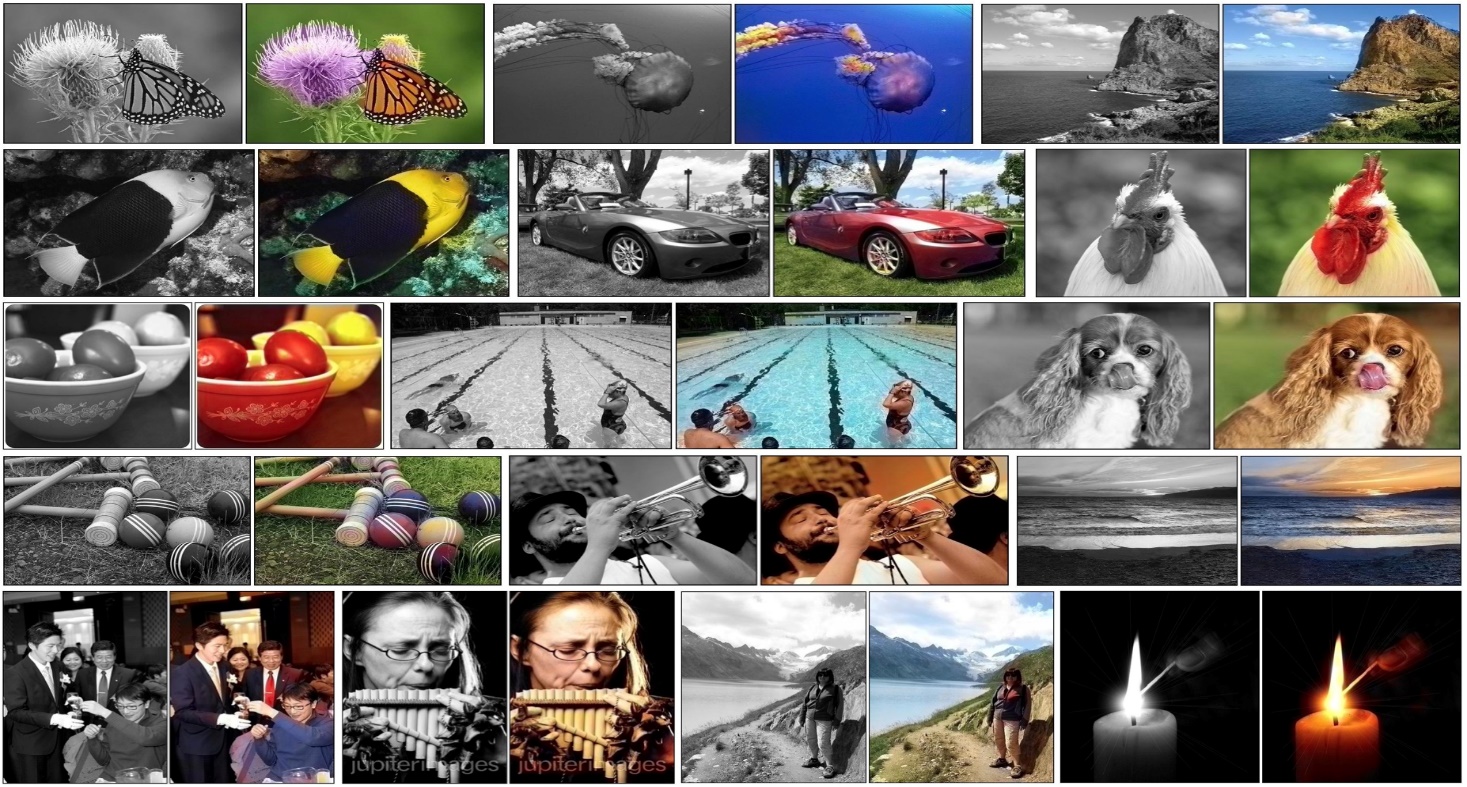
Once the feature extraction is complete, statistical parameters are computed for these features. These parameters are subsequently aggregated into a feature vector, giving rise to separate training and testing sets. Notably, various statistical parameters were assessed individually, with the "Mean" parameter yielding the most promising results.

These extracted features are associated with corresponding labels, reflecting the desired colorization outcomes. The classification component of the system employs the LibSVM library, which is a powerful tool for Support Vector Machine-based classification tasks. Training the SVM model involves feeding it with the training dataset, allowing it to learn and establish a predictive model.

The results of this proposed image colorization system have been promising, particularly in recognizing emotions like fear, anger, and neutrality. This approach showcases the potential of using MFCC-based feature extraction and advanced classification techniques to achieve superior colorization outcomes, marking a significant advancement in the field of image colorization technology.

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**Fig 8.1 Output for a test image**



**Fig 8.2 Multiple test images with output**

# 7. CONCLUSION

In Conclusion, Image Colorization has become more accessible and convenient through various applications and tools. Historical images and media are converted into richly colorized and enriched images using this approach. This is the best approach to convert grayscale or black and white media to colorized images. Film Colorization from old black and white films to richly enhanced and colorized films, photo restoration from old black and white photos to richly enhanced and colorized photos.

Our project on Image Colorization uses PyTorch, Pillow, and NumPy with the ECCV16 and SIGGRAPH17 models, which provide a comprehensive exploration into the exciting field of computer vision. Throughout our journey, we have uncovered the power of deep learning techniques in adding vibrant colors to grayscale images, opening up a world of creative possibilities and practical applications.

It has demonstrated that the collaboration of popular Python libraries and state-of-the-art models can yield impressive results. PyTorch, Pillow, and NumPy served as reliable tools for preprocessing and handling image data, while the ECCV16 and SIGGRAPH17 models, known for their exceptional colorization capabilities, showcased their prowess in generating realistic and visually appealing colorizations.

Furthermore, our project shed light on the importance of metrics such as color accuracy, perceptual similarity, and visual appeal in assessing the quality of colorized images. These evaluations provided valuable insights into the performance of our models and served as a benchmark for future improvements.

This innovation opens up a wide range of uses, bringing history to life, assisting in medical diagnosis, igniting creativity, and developing computer vision. We welcome inquiries and value your interest in our work.

### 8. FUTURE SCOPE

The future scope for image colorization holds potential in several areas such as, Advancements in deep learning can lead to more realistic and high-fidelity colorizations, improving visual quality, Real-time or interactive colorization tools that allow users to guide and customize the colorization process will likely become more prevalent. Continued research on preserving the context and cultural significance of colorized images, especially in historical and archival applications. Integration with AI-powered design and creative tools for artists and content creators. Application of colorization to medical imaging for improved diagnostics and visualization. Integration of colorization techniques into AR applications for real-time scene enhancement. Extending colorization techniques to other modalities, such as video and audio. Colorization for accessibility, assisting individuals with visual impairments to interpret images. Colorization for enhancing and analyzing visual evidence in forensic investigations. As technology evolves, image colorization will continue to find diverse applications across various domains, driven by advances in AI and deep learning. The future scope of image colorization is multifaceted, encompassing historical preservation, artistic expression, accessibility, and a wide range of practical applications across industries. As technology and AI continue to advance, image colorization will play an increasingly significant role in how we interact with and derive value from visual content.

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