



## AGE ESTIMATION USING UTKFACE DATASET BASED ON VARIOUS DEEP LEARNING MODELS

Tanniru Venkata Kailash<sup>1</sup>, Anuradha Misra<sup>2</sup>, Kapil Kumar Gupta<sup>3</sup>,  
Praveen Kumar Misra<sup>4\*</sup>

**Article History:** Received: 17.01.2023

Revised: 30.03.2023

Accepted: 13.06.2023

### Abstract

Age detection using deep learning is an increasingly popular research area that aims to automatically estimate a person's age based on their facial features. This technology has numerous potential applications in fields such as security, marketing, and healthcare. In recent years, significant progress has been made in developing accurate and efficient deep learning models for age detection. These models typically use convolutional neural networks (CNNs) to extract features from facial images and feed them into fully connected layers for age prediction. Various techniques such as data augmentation, transfer learning, and ensemble learning have been employed to improve the performance of these models. However, challenges such as facial expression variability, lighting conditions, and ethnic diversity still need to be addressed to achieve robust age estimation. Overall, age detection using deep learning has the potential to revolutionize a wide range of industries and improve our understanding of the aging process.

Data science is "the idea of bringing together measurements, information examination, software engineering, and their connected techniques" to "comprehend and dissect genuine peculiarities" with information. It utilizes strategies and speculations drawn from many fields with regards to arithmetic, insights, software engineering, data science and area information. In any case, information science is unique in relation to software engineering and data science. Turing Grant champ Jim Dark imagined information science as the "fourth worldview" of science (observational, hypothetical, computational, and presently information driven) and contended that "all that about science is changing a direct result of the effect of data innovation" and the storm of information.

The field of the Machine Learning can also be called as enabling or controlling the computers which makes their predictions successfully by using their past experiences, it has a successful development with the help of increase in the capacity of storage rapidly and processing of the computers power. The methods of Machine Learning had been employed widely in bioinformation also. There are difficulties and much cost in analyzing biologically, and it has the development of Machine Learning sophisticatedly approaching for this area.

In this report we are going to know about the fundamental topics for Machine Learning, like Feature engineering, types of classification of Machine learning, applications related to the Machine learning, history related to Machine Learning, and we will learn about deep learning which is a subset of Machine learning, Tools of deep learning, what is perceptron, structure of neural network, Activation functions, Optimizers, CNN, RNN and finally we will know about Face recognition using TensorFlow.

Deep learning is a subset of AI that utilizes numerical capabilities to plan contribution to yield. These capabilities can separate non-repetitive data or examples from information, permitting them to lay out a connection among information and result. This is known as learning and the method involved with learning is called preparing.

**Keywords:** Deep learning, Convolution Neural Network, Prediction Models, Age Prediction.

<sup>1</sup>UG student, Department of Computer Science & Engineering, Amity School of Engineering and Technology, Amity University, Lucknow Campus, India,

Email: [tanniru.kailash@student.amity.edu](mailto:tanniru.kailash@student.amity.edu)

<sup>2</sup>Assistant Professor, Department of Computer Science & Engineering, Amity School of Engineering and Technology, Amity University, Lucknow Campus, India,

Email: [amisra@lko.amity.edu](mailto:amisra@lko.amity.edu)

ORCID: 0000-0002-3790-8798

<sup>3</sup>Assistant Professor, Department of Computer Science & Engineering, Amity School of Engineering and Technology, Amity University, Lucknow Campus,

Email: [3kapilkumargupta2007@gmail.com](mailto:kapilkumargupta2007@gmail.com)

ORCID: 0000-0002-8327-1679

<sup>4\*</sup>Assistant Professor & Coordinator, Department of Mathematics and Statistics, Dr.Shakuntala Misra National Rehabilitation University, Lucknow, India

Email: [4praveenkumarmisra@gmail.com](mailto:praveenkumarmisra@gmail.com)

ORCID: 000-0002-3539-2994

**\*Corresponding Author:**

Praveen Kumar Misra<sup>4\*</sup>

<sup>4\*</sup>Assistant Professor & Coordinator, Department of Mathematics and Statistics, Dr.Shakuntala Misra National Rehabilitation University, Lucknow, India

Email: [4praveenkumarmisra@gmail.com](mailto:praveenkumarmisra@gmail.com)

ORCID: 000-0002-3539-2994

**DOI: 10.31838/ecb/2023.12.s3.481**

## 1. INTRODUCTION

The detection of age is a significant area of research due to its potential applications in various fields such as healthcare, security, marketing, and education. Deep learning, a subfield of machine learning, has shown promising results in age detection tasks. This paragraph explores the use of deep learning for age detection, including the techniques, datasets, performance metrics, and limitations associated with this approach.

Convolutional neural networks (CNNs) are one of the most widely used deep learning techniques for age detection. These networks are specifically designed to work with images and other grid-like data. Comprising multiple layers, they learn to extract features from input data and use these features to classify the data. In the context of age detection, CNNs can extract facial features from images and use these features to estimate the age of the person in the image.

Recurrent neural networks (RNNs) are another deep learning technique that has been used for age detection. These networks are specifically designed to work with sequential data, such as time series or text data. In the context of age detection, RNNs can learn temporal dependencies in a sequence of facial images and use these dependencies to estimate the age of the person in the sequence.

Generative adversarial networks (GANs) are another deep learning technique that has been used for age detection. These networks comprise two components, a generator network, and a discriminator network. The generator network is trained to generate new data that is like the training data, while the discriminator network is trained to distinguish between the generated data and the training data. In the context of age detection, GANs can generate synthetic facial images that are similar to the training data and use these images to estimate the age of the person in the image.

Researchers typically use large datasets of facial images with age labels to train and evaluate deep learning models for age detection. The Adience

dataset is one of the most commonly used datasets, containing over 26,000 facial images of people of different ages and genders. Other datasets that have been used for age detection include the IMDB-WIKI dataset, which contains over 500,000 facial images of celebrities with age labels, and the CACD dataset, which contains over 160,000 facial images of celebrities with age labels.

Researchers typically use metrics such as mean absolute error (MAE) and accuracy to evaluate the performance of deep learning models for age detection. MAE measures the average absolute difference between the predicted age and the true age, while accuracy measures the percentage of correctly classified images. In general, deep learning models for age detection have achieved high levels of accuracy and low levels of MAE, indicating that they are effective at estimating the age of people from facial images.

However, the use of deep learning for age detection also presents several limitations and challenges. One of the primary limitations is the need for large amounts of labeled data. Deep learning models require substantial amounts of labeled data to learn meaningful representations of the data and achieve high levels of accuracy. Collecting and labeling large amounts of data can be time-consuming and expensive, which can limit the applicability of deep learning models for age detection in some contexts.

Another challenge associated with the use of deep learning for age detection is the need for robustness to variations in lighting, pose, and other factors that can affect the appearance of the face. Deep learning models are sensitive to variations in the input data, and small changes in the input can lead to significant changes in the output. Therefore, deep learning models for age detection must be robust to these variations to achieve accurate age estimates.

## 2. INTRODUCTION TO MACHINE LEARNING

The Machine Learning term was created by a scientist 'Arthur Samuel' in the year of 1959. He is an

American who works in the field of Computer gaming and AI. And he had stated that “AI gives the computers an ability for learning without programming explicitly”.

In the year of 1997, an scientist called ‘Tom Mitchell’ given a mathematical relational type definition that is “an computers program learns from the experience ‘E’ with something task called ‘T’ which is measured by ‘P’ and it again improves the experience ‘E’.”

ML can be called as the one of the best interesting subfields in Artificial intelligence and Computer science also.

If we take an example called throwing a ball for understanding about ML briefly, for example in first attempt we will come to know that we must apply an much force on it, after completion of second attempt we will come to know that we have change some throw angle in it to reach the target. Here what is happening is after completion of every attempt we are learning something, and we are trying to improve our self. That means we are programmed to learn from our experience for better result.

This example follows the proposal of Alan Turing that “Computing Machines and their Intelligence” in which a question that “can machines think “can be replaced with the question “can Machines do what we can do” When we consider the field of Data analytics, ML is used to solve the tuff or complex problems and Algorithms that are lead to Predictions by themselves. This is known as predictive analytics. These analytic models can be useful for researchers to produce ‘reliable, repeatable decisions, and results.

For example, you are decided to go for a vacation, we will go through any travel agencies websites, and we will search an hotel for vacation, when you check for hotels at down you will see a specified title that, “you may also like these hotels!”. This is an example of Machine Learning.

Suppose if you want to create a program of predicting the traffic signals patterns, in the case of busy Intersection called task’s’ the Machine Learning data with algorithm learns from the past traffic patterns called experience ‘E’. If the program learned perfectly from past, it will perform perfectly in future predictions also called performances”.

There are so many highly complex real world problems in the world, by inventing specialized algorithms, they will solve them perfectly every time. The example complex problems which can be included in Machine Learning are “is this cancer?”, “will that person likes sports?”. The problems like these models are excellent targets for ML.

### Classification Of Machine Learning

There are three main types of classifications in MACHINE LEARNING. These classifications are classified based on the nature of the learning, which are as following:

**Supervised Learning** is also known as for example take a function called  $Y=f(X)$ , where  $x$  is called input variables and  $y$  is called an output variable. The above function is an algorithm. It learns to map the function from input to the output.

The goal of this algorithm is to a map so that the above function so if that we give a new input data ( $x$ ) we can get the variables of the output ( $y$ ) for that given data.

This type of process is known as Supervised Learning because the algorithms process learns from the data can called as teacher, the algorithms automatically make predictions on the training data, and it will be corrected by teacher. This Learning will stop when it reaches the perfect level of performance.

It is also known as labelled data learning. If we give the input to the computer as the weight of one-rupee Indian currency is 3 grams, French currency is 7grams and in German currency is 5 grams. Now if we give an empty coin of 3 grams it identifies as one-rupee Indian currency.

**Unsupervised learning** also known as when we consider a algorithm, if it trying to learn plain examples without any type of response, and again leaving to the algorithm to find out or to determine the Data patterns on its own. These types of algorithms can be tends to redesign or restructure the data into something else like it may represent the new series of Un correlated value.

It is also known as unlabeled data learning because it clusters the given input data. It will give an unknown output and it don’t contain training data set. It will resemble with the methods of human beings to figure out certain objects, for example observation of degree of similarity between the two objects. Marketing automation which is an example of Recommendation system is based on the Unsupervised Learning.

In this type of Learning it learns from the errors. Because it is added with an penalty. So we can say that errors help you to learn. These penalties can add Cost, Loss of Time,Pain e.t.c., this Learning works on the principle of feedback, a best example for Reinforcement Learning is computer playing the video games by itself.

Simply reinforcement learning is a reward base learning or it works on the principle of feedback. For example if we give dog image to the computer if it gives the output as it is cat then we have give feedback that no it is a dog, after that give another type dog image. It learns and give that it is a dog. This is called reinforcement learning.

### 3. INTRODUCTION TO DEEP LEARNING

Deep learning is a part of AI that is totally founded on fake brain organizations, on the grounds that the brain

organization will in the copy of an humanic cerebellum, so profound is the learning of the an sort of impersonation of the humanic mind. In dl, do not have to program the everything expressly done. As processing power increments dramatically throughout the course of recent years, profound learning and AI have entered the scene.

Deep learning is an exceptional sort of AI that accomplishes of the extraordinary an power and to the perfect adaptability on doing by figuring the out of how address to the world in the scenario as a settled of us can order of different ideas, with damn every perfect idea is incorrect to characterized the on doing comparable to came as less complex ideas and more dynamic portrayals registered with concerning respect to less the unique any another ones.

### Perceptron

The Perceptron was introduced by Direct Rosenblatt in 1957. He proposed a Perceptron learning rule considering the principal MCP neuron. Perceptron is an estimation for coordinated learning of matched classifiers. This estimation grants neurons to learn and manage the parts in the arrangement set one by one.

Perceptron is ordered into two kinds; those are Single layer perceptron and multi-facet perceptron

Single layer - Single layer perceptron's can learn just straightly detachable examples

Multi-facet - multi-facet perceptron's or feedforward brain networks with at least two layers have the more prominent handling power which is otherwise called a total brain organization.

Perceptron Learning Decide states that the calculation would naturally become familiar with the ideal weight coefficients. The information highlights are then increased with these loads to decide whether a neuron fires or not.

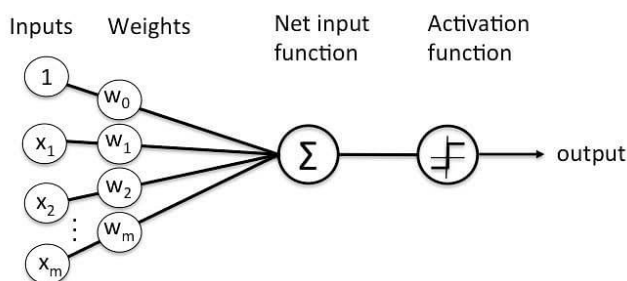


Fig1. Working of a perceptron

### Layers In Neural Network

A brain network is worked by layers which will be attached like at stack. In the underneath given picture the in an upward direction spotted lines address the layers. There are complete three sorts of layers in a brain organization.

Input Layer-First is the info layer. This layer will acknowledge the information and pass it to the remainder of the organization.

Hidden Layer - The second kind of layer is known as the secret layer. A brain network has it is possible that at least one secret layers. In the above case, the number is 1. The secret layers are liable for the predominant presentation and intricacy of brain organizations. They carry out various roles simultaneously, like information change, programmed component creation, and so on.

Output Layer - The last kind of layer is the result layer. The result layer contains the outcome or result of the issue. The crude pictures are passed to the info layer, and we get the result in the result layer.

### Tools used for implementing Neural Networks

TensorFlow is a profound learning device that was written in exceptionally improved C++ and CUDA (Nvidia's GPU programming language) and gives connection points to dialects like Python, Java, Go. It

is an open source library created by the tech monster Google to run profound learning applications easily.

TensorFlow makes it simple for amateurs and even specialists to fabricate AI models for portable, web, work area and cloud.

### 1.Keras

Keras is an undeniable level brain network Programming interface that is equipped for running on top of TensorFlow or Theano. It is written in Python and was grown fundamentally to empower quicker trial and error. The Keras profound learning library makes prototyping simpler and quicker for the client utilizing particularity, moderation, and simple extensibility.

Keras is a profound learning device that upholds repetitive organizations and convolutional networks separately and in blend of both. It likewise upholds preparing with various sources of info and results. It follows best practices to decrease mental burden by offering criticism when any blunder is recognized.

### 2. Torch

Torch is a strong open source program that utilizes the LuaJIT prearranging language and C/CUDA execution. In the event that you utilize this profound learning apparatus, you will actually want to exploit

its strong elements, for example, different schedules for ordering, rendering, cutting, astounding point of interaction to C by means of LuaJIT, brain organization. It offers quick and proficient GPU support and is not difficult to implant, making it simple to work with iOS, Android, FPGA.

### 3. H2O.ai

H2O is a profound gaining device that was worked starting from the earliest stage in Java and expands on consistent joining with other open source items like Apache Hadoop and Flash. It has a simple to-utilize online UI and is greatly versatile in enormous information examination.

H2O, an open source profound learning instrument, upholds the most generally utilized AI calculations. It is a quick, versatile AI application interface utilized for profound learning, flexible organization, strategic relapse, slope supporting; to give some examples. H2O makes it more straightforward for anybody to utilize AI calculations and prescient examination to take care of any business issue.

### 4. DeepLearningKit

DeepLearningKit is an open source profound learning device for Apple iOS, operating system X, tvOS, and so on. The principal thought behind its creation was to help pre-prepared models on all Apple gadgets that have a GPU. This profound learning apparatus is created in Quick and can be utilized on GPU gadgets to perform profound learning estimations with low idleness. DeepLearningKit additionally upholds convolutional brain organizations. His vision is to help other profound learning devices like Light and TensorFlow.

Facial acknowledgment is a strategy for distinguishing or affirming an individual's character in light of their face. Facial acknowledgment frameworks can be utilized to recognize individuals in photographs, recordings, or progressively.

Facial acknowledgment is a class of biometric security. Different types of biometric programming incorporate voice acknowledgment, unique finger impression acknowledgment, and retinal or iris acknowledgment. The innovation is basically utilized for security and policing, however there is developing interest in other application regions.

Many individuals are know about the FaceID facial acknowledgment innovation used to open iPhones (albeit this is only a facial acknowledgment application). As opposed to depending on a colossal information base of photographs to decide a singular's character, facial acknowledgment regularly basically distinguishes and perceives the person as the sole proprietor of the gadget, restricting admittance to different clients.

As well as opening telephones, facial acknowledgment works by matching the essences of individuals who

pass before an exceptional camera to pictures of individuals on your watchlist. Watchlists can incorporate pictures of anybody, even the people who are not associated with cheating, and the pictures can emerge out of anyplace, even from their virtual entertainment accounts. Facial innovation frameworks might shift, however by and large work as follows:

#### Stage 1: Face Recognition

The camera perceives and finds pictures of countenances, either alone or in a group. The picture can show an individual confronting front or profile.

#### Stage 2: Face Investigation

Then, facial pictures are caught and examined. Most facial acknowledgment advances depend on 2D pictures instead of 3D pictures. This is on the grounds that 2D pictures can measure up more helpfully with public photographs or photographs in a data set. The product peruses the state of your face. Significant variables incorporate the distance between the eyes, the profundity of the eye attachments, the separation from the temple to the jawline, the state of the cheekbones, the forms of the lips, ears and jaw.

The objective is to distinguish key facial elements to recognize faces.

#### Stage 3: Convert Picture to mathematical Information

face catch process changes over simple data (the face) into a progression of computerized data (information) in view of the individual's facial elements. Facial examination basically transforms into a numerical recipe. Numeric codes are called faceprints. Every individual has an exceptional facial print, very much like their thumbprint is remarkable.

#### Stage 4: Find Matches

Then, at that point, balance the headshot with a data base of other known faces. For example, the FBI approaches up to 650 million photos from various government informational collections. On Facebook, any photo marked with a singular's name ends up being significant for Facebook's informational collection and can similarly be used for facial affirmation. In case the face print matches the image in the facial affirmation informational collection, a decision is made of all biometric assessments, facial affirmation is considered the most typical. Normally, this gives off an impression of being genuine, since we for the most part see ourselves as well as others by our faces instead of our thumbprints or irises. It is evaluated that most of the complete people are introduced to facial affirmation advancement reliably. In this project we are using a architecture called Siamese network, this network will take two images for training process with labels 0 or 1. We will make three datasets one will contain our image with different angles, second one will contain our images

only same as first one, third one contain the images of other people. All these datasets have 500 images each. Now randomly we will take the image from first dataset and combine with second and third datasets, if the first image and second image are belonging to same person then we will give the label as 1 otherwise we will give the label as 0. Like this we will make a dataset and we use keras sub modelling and custom training loop topics to create our model which works same as the Siamese model and we will start the training process. After training completes, we can use the same model for face recognition, first we have to collect the images of the authorized user and we will store it in a folder, after that we will take a image input and send it with every image the authorized person has saved and if it is having atleast 80% threshold then it will print as person is authorized otherwise it will print it as not authorized.

Facial recognition is a method of identifying or confirming a person's identity based on their face. Facial recognition systems can be used to identify people in photos, videos, or in real time.

Facial acknowledgment is a classification of biometric security. Different types of biometric programming incorporate voice acknowledgment, unique finger impression acknowledgment, and retinal or iris acknowledgment. The innovation is principally utilized for security and policing, yet there is developing interest in other application regions.

Applications of Machine Learning in Robots

#### Computer Vision:

The computer vision can also be called as CV is defined as the field of study in the development of the techniques to enable the futures of computer for example to make the computers 'see' and to make the computer to understand the information in the digital images and in photos and videos. The concept of this CV is seen as simple because it can be easily solved by the people, even very young child can also be able to identify the content in images.

It to a great extent stays an unsolved issue put together both with respect to the restricted comprehension of natural vision and in light of the multifaceted nature of vision recognition in a dynamic and about boundlessly fluctuating physical world.

#### Self Supervised Learning:

Self supervised Learning is a type of learning in which it tries to enable the robots for the generation of their own examples to train in order to improve their performance. This training can be include training with priority, and data sensor range also.

These robots are been incorporated and the optical devices which are included in robot can detect or reject the objects, identifying the objects like fruits, vegetables, obstacles in the way, analyzing the objects in 3D, and to modeling the dynamics of vehicles.

The best and concrete example of this type of Learning is Watch Bot, in which it uses an 3D sensor, a computerized system, camera for visualization, and a laser pointer to visualize the normal activities of human. We can consider some more examples of Self supervised Learning in Robotic Technology can include the algorithm for road detection with a camera fixed to view front and a monocular Camera with a probabilistically distribution of road model.

#### Assistive And Medical Technologies”

In this application robots are the major role. An Assistive Robot is a robot that can be able to sense and to process the very sensitive information and it will perform their actions that can be helpful to disabled people. For example Movement Therapy Robot can be benefitted for helpful in Therapeutically. Both of these advances sre restricted to the lab, because they are related to high cost for most of the hospitals.

So that Machine Learning is an example of assistive and medical technologies application. The scientists are led to the creation of an robot called STAR. The total abbreviation of STAR is “SMART TISSUE AUTONOMOUS ROBOT”. This robot is designed to stich the pig intestines with perfect precision and reliability compared to the great human Surgeons. Scientists, physicians and researchers all says that this star robot is not only the replacement of the surgeons from surgery, it is foreseeable future it can handle the emergency cases also, but this robot can only stich the similar type of sensitive and delicate surgeries only

#### Machine Learning In Surgical:

The topic Machine Learning in Surgical is related to Assistive and Medical technologies application of machine learning.

The applications of robotic technology in surgery field called Machine Learning in Surgical has began in the year of 1980s only and it is rapidly grown. The topic of Integration of AI in the field of ML in surgical is still unknown and new. The classification of applications of AI which are involving in the sector of surgical robotics are classified as:

AUTO MATION OF SUTURING  
MACHINE LEARNING FOR THE EVALUATING  
OF SURGICAL SKILLS  
MACHINE LEARNING FOR  
THEIMPROVMENTATION OF SURGICAL  
ROBOTICS MATERIALS  
MACHINE LEARNING FOR THE SURGICAL  
WORKFLOW OF MODELING

These applications can provide an complete best information about the Machine Learning and AI in the Surgical specialty.

#### Auto Mation Of Suturing

Suturing is defined as it is a process of sewing the wound or Incision by using threads, it is a type of surgery, the important part of surgery is Incision and it will take a more time, means it is time consuming factor of surgery. So that the concept of automation in suturing is being potentially decreases the lengths of procedures of surgery and Fatigue of surgeons. This can be particularly called as telesurgery. If there is any lagging between commands of the surgeons or in the responses of the robot while doing surgery can cause complication.

In the year of 2013 at California in the Berkeley University a researchers team worked and researched on the application of Automation Of Suturing which are executed by robots. They created an algorithm and for testing, they simulated that algorithm on two robots. The names of the robots are 'Raven2' Robot, and another one is 'PR2' Robot. The first one is designed for LaproscopicSurgery while the second robot is applicable for various applications of the Robotics.

The team of researchers were given the successful suturing rate of robots that is approximately 87 percentage. When researchers increases the tuffness (complexity) of the Suturing the accuracy performance of the robot decreased.

We know that already the automatedly working tools are available in Market, there is a strong believe that after some years complete Automation will be there in surgeries which are performed on humanbeing. The best example of Suturing Robot is STAR Robot we will know about it now.

#### Star Robot

The team of researchers who are from Hopkins University created and developed a Robotic surgical system known as the STAR Robot. The full form of star is 'SMART TISSUE AUTO NOMOUS ROBOT'. This Star Robot system contains 3D computerImagening, and sensors which can help the Robot in the process of Suturing.

The performance of the STAR robot is compared with 6 number of humanSurgeons in different types of aspects. They are openSurgery, LaparoscopicSurgery and RobotAssistedSurgery.

In the case of soft tissue surgeries which are performed in America in the field of abdominalSurgeries, complication were happened, it may in the form of leakage around the wound. It would be occur in like 20 to 30 percentage in human Surgeries. Physicians are strongly believing that to reduce these type of complications we can use the STAR ROBOT.

Making huge scope brain networks with numerous layers is additionally utilized. To address profound learning or AI issues like characterization, insight, figuring out, disclosure, expectation, and creation, TensorFlow is the right profound learning apparatus for you.

#### Activation Functions in Neural networks

Since it has become so obvious how a brain network consolidates various sources of info utilizing loads, we should continue on toward the last part of a neuron called the enactment capability. Up until this point we've basically added a few weighted inputs and determined some result, and that result can peruse from short endlessness to limitlessness.

Be that as it may, this can be tested much of the time. Assume we first need to gauge an individual's age from their level, weight, and cholesterol level, and afterward group the individual as old or not in view of whether they are more seasoned than 60 years.

#### 4. CONCLUSION

The main motive of this research work is to create an efficient CNN model that estimates the intensity of a cyclone image using INSAT-3D images, and that should have less loss compared to older ones. To improve the performance of CNN model, authors had added few additional methods like Batch normalization, Lasso regression, Data augmentation, Drop out layers, Early stopping, etc.. so that it can estimate the intensity of cyclone efficiently. The best CNN model had achieved RMSE of 10.02 kts. Authors had started this research work for implementing a CNN model on estimating intensity of cyclone, because change in the climate can make a lot of natural damages that damages a lot of people's life, those are unpredictable. Natural disasters like these cyclones are very hard to predict and can cause damage to a lot of infrastructure. So with the help of this prediction of intensity people can know at what extent the prevention should be taken.

#### 5. REFERENCES

- Chinmoy kar, Ashirvad Kumar, Sreeparna Banerjee. (2019). Tropical cyclone intensity detection by geometric features of cyclone images and multilayer perceptron. 2019 SN Applied Sciences. <https://doi.org/10.1007/s42452-019-1134-8>
- Manil Maskey, Rahul Ramachandram, Muthukumar Ramasubramanian, Iksha Gurung, Brian Freitag, Aaron Kaulfus, Dre Bollinger, Dan Cecil, JJ Miller. (2020). Deepti: Deep Learning-based Tropical Cyclone Intensity Estimation System. 2020 IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. <https://doi.org/10.1109/JSTARS.2020.3011907>
- Buo-Fu Chen, Boyo Chen, Hsuan-Tien Lin, Russell L. Elsberry. (2019). Estimating Tropical Cyclone Intensity by Satellite Imagery Utilizing Convolutional Neural Networks. 2019

- American Meteorological Society.  
<https://doi.org/10.1175/WAF-D-18-0136.1>
- Juhyun Lee, Jungho Im, Dong-Hyun Cha, Haemi Park, Seongmun Sim. (2019). Tropical Cyclone Intensity Estimation Using Multi-Dimensional Convolutional Neural Networks from Geostationary Satellite Data. 2019 Multidisciplinary Digital Publishing Institute (MDPI). <https://dx.doi.org/10.3390/rs12010108>
- Koushik Biswas, Sandeep Kumar, Ashish Kumar pandey. (2021). Tropical cyclone intensity estimations over the Indian ocean using Machine Learning. 2021 Atmospheric and Oceanic Physics. <https://doi.org/10.48550/arXiv.2107.05573>
- Chong Wang, Gang Zheng, Xiaofeng Li, Qing Xu, Bin Liu, Jun Zhang. (2021). Tropical Cyclone Intensity Estimation From Geostationary Satellite Imagery Using Deep Convolutional Neural Networks. 2021 IEEE Transactions on Geoscience and Remote Sensing. <https://doi.org/10.1109/TGRS.2021.3066299>
- Gholamreza Fetanat Haghighi. (2013). Tropical Cyclone Intensity Estimation Using Temporal And Spatial Features From Satellite Data. 2013 North Carolina Agricultural and Technical State University. <https://digital.library.ncat.edu/dissertations/121>
- Boyo Chen, Buo-Fu Chen, Yun-Nung Chen. (2021). Real-time Tropical Cyclone Intensity Estimation by Handling Temporally Heterogenous Satellite Data. 2021 AAAI Conference on Association for the Advancement of Artificial Intelligence. <https://doi.org/10.1609/aaai.v35i17.17729>
- Yu-Ju Lee, David Hall, Quan Liu, Wen-Wei Liao, Ming-Chun Huang. (2021). Interpretable tropical cyclone intensity estimation using Dvorak-inspired machine learning techniques. 2021 Engineering Applications of Artificial Intelligence. <https://doi.org/10.1016/j.engappai.2021.104233>
- M. Swarna, N. Sudhakar, N. Vadaparthi. (2021). An effective tropical cyclone intensity estimation model using Convolutional Neural Networks. 2021 Quarterly Journal of Meteorology, Hydrology and Geophysics. <https://doi.org/10.54302/mausam.v72i2.616>
- Jayanthi Devaraj, Sumathi Ganesan, Rajvikram Madurai Elavarasan, Umashankar Subramaniam. (2021). A Novel Deep Learning Based Model for Tropical Intensity Estimation and Post-Disaster Management of Hurricanes. 2021 Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/app11094129>
- Institute of Meteorological Satellite Studies, Space Science and Engineering Center, University of Wisconsin-Madison. <http://tropic.ssec.wisc.edu/>