**VIRTUAL BOARD**

Submitted for the Partial Fulfillment of the Requirements for the Degree of

###### Bachelor of Technology

in Computer Science and Engineering

#### J.C. Bose University of Science and Technology, Faridabad

**Submitted By:**

**Aryan Setia**

**Roll No: 18/CS07**

anangpuria

**Under the Guidance of**

Mrs. Shilpa Gupta

**(Project guide) (Principal)**

**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

**B.S Anangpuria Institute of Technology & Management Alampur, Faridabad**

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Primarily, I would thank God for being able to complete this project with success. Then I will thank my Principal (name of principal) and (subject) teacher, under whose guidance I learned a lot about this project. His suggestions and directions have helped in the completion of this project.

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# Abstract

# Virtual board is a solution for providing a better experience in online mode of education. Online mode of education requires certain gadgets like a LCD White Boards which are able to share our live written notes to the attendees. Our program lessens the gap between a quality online education and economic needs by providing a solution by which teachers are able to write and scribble in the air and write on a “Virtual Board”.

# Our program uses state of the models to detect the target assigned and trace the path it covers in the air and present it on a Virtual White Board, giving a classroom whiteboard like writing experience.

# Writing in air has been one of the most fascinating and challenging research areas in field of image processing and pattern recognition in the recent years. It contributes immensely to the advancement of an automation process and can improve the interface between man and machine in numerous applications.

# Several research works have been focusing on new techniques and methods that would reduce the processing time while providing higher recognition accuracy. Object tracking is considered as an important task within the field of Computer Vision. The invention of faster computers, availability of inexpensive and good quality video cameras and demands of automated video analysis has given popularity to object tracking techniques.

# Generally, video analysis procedure has three major steps: firstly, detecting of the object, secondly tracking its movement from frame to frame and lastly analysing the behaviour of that object. For object tracking, four different issues are taken into account; selection of suitable object representation, feature selection for tracking, object detection and object tracking. In real world, Object tracking algorithms are the primarily part of different applications such as: automatic surveillance, video indexing and vehicle navigation etc. The project takes advantage of this gap and focuses on developing a motion-to-text converter that can potentially serve as software for intelligent wearable devices for writing from the air.

# This project is a reporter of occasional gestures. It will use computer vision to trace the path of the finger. The generated text can also be used for various purposes, such as sending messages, emails, etc. It will be a powerful means of communication for the deaf. It is an effective communication method that reduces mobile and laptop usage by eliminating the need to write.

# Introduction

# Our code is written in Python and the libraries used in this project are OpenCV and Numpy. Both these libraries are used in real world Scientific research. OpenCV is a library consisting of all the famous, complex Neural Networks, Deep Learning Models and Machine Learning Models, making it ideal for the use.

# While Numpy is used widely in Scientific research and calculations. It provides an array like structure in which data can be stored in precisions. These arrays can then be used in Deep Learning models, Graphical processes etc.

# OpenCV is also available in C++ and Java, but for making our solution less complex, and for our future goals regarding this project, we chose Python as our go-to language for this project.

# In the era of digital world, traditional art of writing is being replaced by digital art. Digital art refers to forms of expression and transmission of art form with digital form. Relying on modern science and technology is the distinctive characteristics of the digital manifestation. Traditional art refers to the art form which is created before the digital art.

# From the recipient to analyse, it can simply be divided into visual art, audio art, audio-visual art and audio-visual imaginary art, which includes literature, painting, sculpture, architecture, music, dance, drama and other works of art. Digital art and traditional art are interrelated and interdependent. Social development is not a people's will, but the needs of human life are the main driving force anyway.

# The same situation happens in art. In the present circumstances, digital art and traditional art are inclusive of the symbiotic state, so we need to systematically understand the basic knowledge of the form between digital art and traditional art. The traditional way includes pen and paper, chalk and board method of writing. The essential aim of digital art is of building hand gesture recognition system to write digitally.

# Digital art includes many ways of writing like by using keyboard, touch-screen surface, digital pen, stylus, using electronic hand gloves, etc. But in this system, we are using hand gesture recognition with the use of machine learning algorithm by using python programming, which creates natural interaction between man and machine. With the advancement in technology, the need of development of natural ‘human – computer interaction (HCI)’ [10] systems to replace traditional systems is increasing rapidly.

# This paper's remainder is categorized as follows: Section 2 presents the other pieces of literature that we referred to before working on this project. Section 3 describes the challenges we faced while making this system. In Section 4, we define the problem statement we were solving. Section 5 provides the system methodology and workflow that we followed.

# The subsections of section 5 include - Fingertip Recognition Dataset Creation and Fingertip Recognition Model Training. Section 6 algorithm of workflow

# Motivation

# While taking online classes, our faculty used to write on the white board provided inside a certain application used for conducting online classes. This required them to use there Mouse and Touch-screens, which for the time was understandable, but produced a very de-formed text which was sometimes also hard to understand.

# So, this motivated us to find a solution which is not only practical, but also economically feasible so that it can reach every corner of the country, and help the needy ones in the times of pandemic.

# But identifying the "why" behind the actions you perform can make finding the motivation to do them easier on those days when you’re feeling less-than-inspired.

# Whether you’re dragging yourself to the gym or fighting the mental battle against procrastination at work, making a mental shift to reconnect to your source of motivation can give you the boost to get it done.

Chances are, many of the things you do each day are extrinsically motivated.

According to research of Contemporary research, “Extrinsic motivation is a construct that pertains whenever an activity is done in order to attain some separable outcome.”

Like exercising to lose weight, learning to speak Italian to impress your friends, or getting to work on time to avoid being yelled at by your boss.

“Extrinsic motivation is doing something for the external rewards you get from it. In your career, this can include financial gain, benefits, perks and even avoiding getting fired,” says Shawna Clark, owner of Clark Executive Coaching, a leadership development company.

# Literature Review

# Numpy : - NumPy is the fundamental package for scientific computing in Python. It is a Python library that provides a multidimensional array object, various derived objects (such as masked arrays and matrices), and an assortment of routines for fast operations on arrays, including mathematical, logical, shape manipulation, sorting, selecting, I/O, discrete Fourier transforms, basic linear algebra, basic statistical operations, random simulation and much more.

# OpenCV :- OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

# Deque :- Deque is a linear data structure in which the insertion and deletion operations are performed from both ends. We can say that deque is a generalized version of the queue. Deque can be used both as stack and queue as it allows the insertion and deletion operations on both ends.

# Color Detection :- A technique based on random changing of Hue, Saturation and Special Values to a desired color in a particular image. These particular values are then given to the algorithm so that it only works on a particular color, and treat other colors as disturbance and noice. Robust Hand Recognition with Kinect Sensor :- In [3], the system proposed used the depth and colour information from the Kinect sensor to detect the hand shape. As for gesture recognition, even with the Kinect sensor. It is still a very challenging problem. The resolution of this Kinect sensor is only 640×480. It works well to track a large object, e.g., the human body. But following a tiny thing like a finger is complex.

# LED fitted finger movements :- Authors in [4] suggested a method in which an LED is mounted on the user's finger, and the web camera is used to track the finger. The character drawn is compared with that present in the database. It returns the alphabet that matches the pattern drawn. It requires a redcoloured LED pointed light source is attached to the finger. Also, it is assumed that there is no red-coloured object other than the LED light within the web camera's focus.

# Augmented Desk Interface :- In [5] Augmented segmented desk interface approach for interaction was proposed. This system makes use and a video projector and charge-coupled device (CCD) camera so that using the fingertip; users can operate desktop applications. In this system, each hand performs different tasks. The left hand is used to select radial menus, whereas the right hand is used for selecting objects to be manipulated. It achieves this by using an infrared camera. Determining the fingertip is computationally expensive, so this system defines search windows for fingertips.

1. **Computer Vision :-** Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs — and take actions or make recommendations based on that information. If AI enables computers to think, computer vision enables them to see, observe and understand.

Computer vision works much the same as human vision, except humans have a head start. Human sight has the advantage of lifetimes of context to train how to tell objects apart, how far away they are, whether they are moving and whether there is something wrong in an image.

# Real-Time Gesture Control System :- dThe gesture recognition system uses image processing techniques for detection, segmentation, tracking and recognition of hand gestures for converting it to a meaningful command. The interface being proposed here can be substantially applied towards different applications like image browser, games etc.

# Air Writing :- A technique used to trace out the path of the object which is being tracked in the video frame and used for many purposes like Defense Training etc.

# Neural Network :- A neural network is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates. In this sense, neural networks refer to systems of neurons, either organic or artificial in nature. Neural networks can adapt to changing input; so the network generates the best possible result without needing to redesign the output criteria. The concept of neural networks, which has its roots in [artificial intelligence](https://www.investopedia.com/alternative-investments-4427781), is swiftly gaining popularity in the development of [trading systems.](https://www.investopedia.com/articles/trading/11/automated-trading-systems.asp)

1. **Machine learning (ML) :-** is the study of computer [algorithms](https://en.wikipedia.org/wiki/Algorithm) that improve automatically through experience and by the use of data.[[1]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-1) It is seen as a part of [artificial intelligence](https://en.wikipedia.org/wiki/Artificial_intelligence). Machine learning algorithms build a model based on sample data, known as [training data](https://en.wikipedia.org/wiki/Training_data), in order to make predictions or decisions without being explicitly programmed to do so.[[2]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-2) Machine learning algorithms are used in a wide variety of applications, such as in medicine, [email filtering](https://en.wikipedia.org/wiki/Email_filtering), [speech recognition](https://en.wikipedia.org/wiki/Speech_recognition), and [computer vision](https://en.wikipedia.org/wiki/Computer_vision), where it is difficult or unfeasible to develop conventional algorithms to perform the needed tasks.[[3]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-tvt-3)

A subset of machine learning is closely related to [computational statistics](https://en.wikipedia.org/wiki/Computational_statistics), which focuses on making predictions using computers; but not all machine learning is statistical learning. The study of [mathematical optimization](https://en.wikipedia.org/wiki/Mathematical_optimization) delivers methods, theory and application domains to the field of machine learning. [Data mining](https://en.wikipedia.org/wiki/Data_mining) is a related field of study, focusing on [exploratory data analysis](https://en.wikipedia.org/wiki/Exploratory_data_analysis) through [unsupervised learning](https://en.wikipedia.org/wiki/Unsupervised_learning).[[5]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-5)[[6]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-6) Some implementations of machine learning use data and [neural networks](https://en.wikipedia.org/wiki/Neural_networks) in a way that mimics the working of a biological brain.[[7]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-7)[[8]](https://en.wikipedia.org/wiki/Machine_learning#cite_note-8) In its application across business problems, machine learning is also referred to as [predictive analytics](https://en.wikipedia.org/wiki/Predictive_analytics).

# Methodologies

# Our approach is quite simple for this problem. We set our color trackbars to a particular color, and then give these values to the algorithm which then takes only this particular set color as an input and treat every other color as noise or disturbance. Then the color is tracked in the video and its path is traced and put in a deque, which gets cleared as soon as it fills up, releasing memory and making it stable. The video is also a set of images which are run inside a loop at 30 frames per second.

# This all results in a video in which the path is traced and it appears as a continuous line or scribble. This simulates the condition of writing on a board.

# In the era of digital world, traditional art of writing is being replaced by digital art. Digital art refers to forms of expression and transmission of art form with digital form. Relying on modern science and technology is the distinctive characteristics of the digital manifestation. Traditional art refers to the art form which is created before the digital art. From the recipient to analyse, it can simply be divided into visual art, audio art, audio-visual art and audio-visual imaginary art, which includes literature, painting, sculpture, architecture, music, dance, drama and other works of art. Digital art and traditional art are interrelated and interdependent.

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OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc. OpenCV has more than 47 thousand people of user community and estimated number of downloads exceeding [18 million](https://sourceforge.net/projects/opencvlibrary/files/stats/timeline?dates=2001-09-20+to+2019-01-30). The library is used extensively in companies, research groups and by governmental bodies.

Along with well-established companies like Google, Yahoo, Microsoft, Intel, IBM, Sony, Honda, Toyota that employ the library, there are many startups such as Applied Minds, VideoSurf, and Zeitera, that make extensive use of OpenCV.

OpenCV’s deployed uses span the range from stitching streetview images together, detecting intrusions in surveillance video in Israel, monitoring mine equipment in China, helping robots navigate and pick up objects at Willow Garage, detection of swimming pool drowning accidents in Europe, running interactive art in Spain and New York, checking runways for debris in Turkey, inspecting labels on products in factories around the world on to rapid face detection in Japan.

It has C++, Python, Java and MATLAB interfaces and supports Windows, Linux, [Android](https://opencv.org/opencv/android/) and Mac OS. OpenCV leans mostly towards real-time vision applications and takes advantage of MMX and SSE instructions when available. A full-featured [CUDA](https://opencv.org/opencv/cuda/)and [OpenCL](https://opencv.org/opencv/opencl/) interfaces are being actively developed right now. There are over 500 algorithms and about 10 times as many functions that compose or support those algorithms. OpenCV is written natively in C++ and has a templated interface that works seamlessly with STL containers.

# Challenges faced

# Challenges are a part of life, and we also faced some challenges during this project. The main challenge was to find the particular color which would be widely available and would be easy enough to get its values from the trackbar.

# After a lot of Hit and Trial methods and brain storming sessions, we came to a conclusion that “Red” color is most suitable for this purpose, and is easily available with every Teaching Faculty. Being the least frequency color, it is also easy for the algorithm to track and recognize the color.

# Fingertip detection The existing system only works with your fingers, and there are no highlighters, paints, or relatives. Identifying and characterizing an object such as a finger from an RGB image without a depth sensor is a great challenge.

# Lack of pen up and pen down motion The system uses a single RGB camera to write from above. Since depth sensing is not possible, up and down pen movements cannot be followed. Therefore, the fingertip's entire trajectory is traced, and the resulting image would be absurd and not recognized by the model. The difference between hand written and air written ‘G’ is shown in Figure 1.

**Background**:- The background of the object also plays a significant role in Face detection. The result might not the same outdoor as compared to what is produces indoors because the factor - affecting its performance-change as soon as the locations change

# Controlling the real-time system Using real-time hand gestures to change the system from one state to another requires a lot of code care. Also, the user must know many movements to control his plan adequately.

# Results

# The result of all the sleepless nights, buggy codes and brain-storming sessions was a beautifully aligned program which stands up to what it was supposed to be. The program only recognizes “Red color” and treats every other color as a noise and ignores it completely.

# The code runs flawlessly on every other machine without any error, and is also ready to be deployed.

# Paper wastage is not scarce news. We waste a lot of paper in scribbling, writing, drawing, etc.… Some basic facts include - 5 liters of water on average are required to make one A4 size paper, 93% of writing is from trees, 50% of business waste is paper, 25% landfill is paper, and the list goes on. Paper wastage is harming the environment by using water and trees and creates tons of garbage.

# Air Writing can quickly solve these issues. It will act as a communication tool for people with hearing impairment. Their air-written text can be presented using AR or converted to speech.

# One can quickly write in the air and continue with your work without much distraction. Additionally, writing in the air does not require paper. Everything is stored electronically.

# . Fingertip Detection Model: Air writing can be merely achieved using a stylus or airpens that have a unique colour [2]. The system, though, makes use of fingertip. We believe people should be able to write in the air without the pain of carrying a stylus. We have used Deep Learning algorithms to detect fingertip in every frame, generating a list of coordinates.

# B. Techniques of Fingertip Recognition Dataset Creation: a. Video to Images: In this approach, two-second videos of a person's hand motion were captured in different environments.

# These videos were then broken into 30 separate images, as shown in Figure 3. We collected 2000 images in total. This dataset was labeled manually using LabelImg[13]. The best model trained on this dataset yielded an accuracy of 99%.

# However, since the generated 30 images were from the same video and the same environment, the dataset was monotonous. Hence, the model didn't work well for discrete backgrounds from the ones in the dataset.

# Conclusion

# Conclusion of the project comes out to be that we actually developed a program as we imagined and documented earlier. It was a really enlightening experience and was also quite a journey. We have learned a lot about current technologies, new technologies, researched a lot about various things in the environment which can be taken as a disturbance in the video signal.

# The system has the potential to challenge traditional writing methods. It eradicates the need to carry a mobile phone in hand to jot down notes, providing a simple onthe-go way to do the same. It will also serve a great purpose in helping especially abled people communicate easily. Even senior citizens or people who find it difficult to use keyboards will able to use system effortlessly. Extending the functionality, system can also be used to control IoT devices shortly.

# Drawing in the air can also be made possible. The system will be an excellent software for smart wearables using which people could better interact with the digital world. Augmented Reality can make text come alive. There are some limitations of the system which can be improved in the future. Firstly, using a handwriting recognizer in place of a character recognizer will allow the user to write word by word, making writing faster.

# Secondly, hand-gestures with a pause can be used to control the real-time system as done by [1] instead of using the number of fingertips. Thirdly, our system sometimes recognizes fingertips in the background and changes their state. Air-writing systems should only obey their master's control gestures and should not be misled by people around. Also, we used the EMNIST dataset, which is not a proper air-character dataset.

# Upcoming object detection algorithms such as YOLO v3 can improve fingertip recognition accuracy and speed. In the future, advances in Artificial Intelligence will enhance the efficiency of air-writing.

# A picture containing graphical user interface Description automatically generated

**Algorithm:**

1. Start reading the frames and convert the captured frames to HSV color space (Easy for color detection).
2. Prepare the canvas frame and put the respective ink buttons on it.
3. Adjust the track bar values for finding the mask of the colored marker.
4. Preprocess the mask with morphological operations (Eroding and dilation).
5. Detect the contours, find the center coordinates of largest contour and keep storing them in the array for successive frames (Arrays for drawing points on canvas).
6. Finally draw the points stored in an array on the frames and canvas.

# Text Description automatically generated

# Future Scope

# We saved the good part for the end. In the initial documentation of our project, we had a vision to make this project run on Android and Iphone. For this, we chose Unity Studio for the app development. While choosing the technology stack, we wanted to make things as easy and fun as possible, so we chose Python as our programming language, as it is compatible with Unity, and also Unity has plugin features for OpenCV. This all motivated us for finalizing this technology stack, and in the near coming future, we will build an App for Android as a Beta version to test it to its full capacity, and after it stands out on our set standards, we will release it on Google Playstore for the masses.

# With over two million downloads per week, OpenCV is the most popular open source computer vision library in the world. It implements over 2500 optimized algorithms, works on all major operating systems, is available in multiple languages and is free for commercial use. This talk will primarily provide a technical update on OpenCV: What’s new in OpenCV 4.0? What is the Graph API? Why are we so excited about the Deep Neural Network (DNN) module in OpenCV? (Short answer: It is one of the fastest inference engines on the CPU.) We will also share plans for the future of OpenCV, including new algorithms that we plan to add through the Google Summer of Code this year. We will also briefly share info on the new Open Source Vision Foundation (OSVF), and on OpenCV’s sister organizations, CARLA and Open3D, and some of the initiatives planned by these organizations.

The mounting applications of computer vision and machine vision are revitalizing the current work architecture. According to the market and markets report, [the computer vision market is expected to rise to USD 17.4 billion by 2024](https://www.marketsandmarkets.com/Market-Reports/computer-vision-market-186494767.html). The vision-based robotic system and application-specific computer vision systems are transforming the workplace through its emerging technologies. It includes video surveillance, vision-based biometric authentication, digital documentation, etc.

To keep up the competitive spirit and encourage employees, the employers are mounting the integration of intelligent systems. The comprehensive approach of integrating digital technologies to reinvent the employees’ experience is paving the way for a productive and adaptive workforce.

# Changing dynamics around the globe are demanding new changes in the current workforce. And with passing time, the employees are seeking new ways of performing assigned work.

# During the digital transformation phase, these two factors call for new talent and organization strategies. By putting up computer vision at the heart of industry operations and human intelligence to strive for competitiveness, the industries are scaling up the opportunities.

# Redesigning the organization’s architecture is adding advantages to maximize the workforce outputs and making industries more agile.

# The transformation of today’s workforce is creating a virtual work experience that meets employees’ expectations and employer’s demands.

# The below mentioned are different ways of how computer vision, artificial intelligence, and data science technologies mapping the future of the work.

3D facial recognition is now owning digital document signing space. What if we tell you that you can use your face id to sign digital documents?

With FaceReg, a sophisticated biometric authentication system, you can sign digital documents enabling your face id as verification identity. It reduces online frauds and confirms the signatory is authorized by the user in person and it has a higher level of credibility.

It is a known fact that Computer vision advances biometric authentication traditional practice. Up-gradation technology is transforming the work architecture that we use today.

Integrated this technology provides security, reliability, and credibility over other biometric applications.

The application of facial recognition is more than a trend today. As industries undergo digital transformation and customer preferences evolve, data science integrated facial authentication software is a necessity today.

FaceReg, our on-demand facial recognition solution, can provide quick but advanced data science capabilities that meet the new challenges and explore new opportunities ahead.

# Graphical user interface Description automatically generated

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