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A Survey on Drawing using Hand Gestures for Classroom Learning

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Abstract:

Artistic expression has long been recognized as a powerful conduit for human emotions, allowing individuals to convey complex feelings, thoughts, and moods. To engage students and promote efficient learning in today's quickly changing educational environment, integrating technology into traditional classroom settings has become more and more important. Using hand gesture recognition technology to improve learning in the classroom is one cutting-edge strategy that has gained popularity recently. In order to encourage active involvement, increase accessibility, and create a dynamic and engaging learning environment, this project abstract investigates the integration of hand gesture-based interaction in the classroom. In hand gesture-based interaction, cameras and sensors are used to track and decipher the hand gestures and motions made by instructors or pupils. Then, in the context of education, these gestures may result in a variety of actions or reactions. This project's main goal is to look into the advantages and disadvantages of using such technology in schools.

Keywords: Gesture-Based Interaction, Computer Vision, Human-Computer Interaction, Real-Time Feedback, Machine Learning

I. INTRODUCTION

The phrase "Drawing using Hand gesture" often refers to an application in computer vision and image processing that lets users use their fingers or a digital pen to paint or sketch in the air. Usually, to do this, a camera or other sensors are used to follow the movement of the drawing tool and then instantly render the painting on a screen. Virtual reality apps, digital painting software, and interactive art exhibits all frequently employ this technology.

The painting using hand gesture and mouse controlling algorithms can be used in online teaching. Teachers should be able to draw on ppt using hand movements. So, the painting using hand gesture should be a universal functionality. Collaborative teaching can be the future development of the project.

1. Hand Gesture Recognition (HGR) using Finite State Machine

According to FSM, The travel and speed of the trajectory within a predetermined variance range are characterized by spatial-temporal information of a state and its neighbouring states. The training data for this model was captured by recording different gesture which were continuously repeated. Seven gestures were recorded for this model**.** There is region assigned to each state. And each gesture generates as unique wave. The region is defined as $\mu^{\rho}{}_{s} = E(x^{\rho})$ and covariance matrix $\Sigma_s = E((x^{\rho} - \mu^{\rho})^T((x^{\rho} - \mu^{\rho})))$. The recognition of the gesture is done using the Mahalanobis distance:

$$D(x^{\rho}, S) = sqrt((x^{\rho} - \mu^{\rho})\ \Sigma_s^{-1}\ (x^{\rho} - \mu^{\rho})^r)$$

. A gesture is essentially described as an ordered series of states in the spatial-temporal domain. Each state S has parameters $< \mu^{\rho}{}_{s}, \Sigma_s, d_s, T_s^{min}, T_s^{max} >$ to specify the spatial-temporal information captured by it, where μ_s is the 2D centroid of a state, Σ_s is the 2x2 spatial covariance matrix, d_s is the distance threshold, and $[\ T_s^{min}, T_s^{max}\ ]$ is a duration interval.[3]

2. Hidden Markov Model (HMM), IOHMM and LCS Algorithm

One of the many pattern recognition issues for which Hidden Markov Models (HMMs) have been widely used is hand gesture detection. HMMs are thought to represent an underlying Markov process with hidden states. In the context of hand gesture recognition, HMMs can be used to simulate the sequential nature of hand motions, enabling the system to recognise and classify different gestures based on the sequences of observed hand movements.

The main component of HMM are State Space, Observation symbols, Transition probability matrix and Emission probability matrix. Where state space represents the hidden states of system at time t, Transition probability matrix represents the probability of getting state s2 after state s1 and Emission probability matrix represents the probability of emitting specific observation symbols given each hidden state. In HMM model for training phase Baum-Welch algorithm is used and for Recognition phase Viterbi algorithm is used. The use of HMM in hand gesture recognition can be utilised for various applications like Sign language recognition and gesture-based control system. Making user friendly UI and control system compatible with this model is the future development. IOHMM model is the updated model of HMM. Input-Output Hidden Markov Model (IOHMM). IOHMM components are similar to HMM model with additional components like Output emission probability matrix and input symbol probability matrix. The IOHMM can be defined using tuple (S, V, U, A, B, C, π). The probability calculations are done using forward and backward algorithm but they are designed to handle input symbols.

IOHMM mode has improved the scope of HMM model. The main applications of IOHMM model are speech recognition and natural language processing.

LCS algorithm stands for least common subsequence algorithm. It is uncommon to classify the LCS algorithm, which is widely employed in biology and computer science, as a machine learning method. On the other hand, it can be used as a preprocessing stage for some machine learning applications with sequence data. With the use of this technique, one may determine which sequence in a set has the longest shared subsequence. [4] The length of the longest common subsequence is used to train the model which can be further used in hand gesture recognition. This algorithm is used for preprocessing which can be used to enhance the previously existing models for recognition of hand gesture.

3. Virtual painting with hand gesture recognition

Air-writing is the practice of using hand or finger movements to create linguistic symbols or phrases in a blank area. Here, characters or words are recognized using data from six-degrees-of-freedom hand movements.

The steps in machine learning for painting using hand gesture are image frame acquisition, hand segmentation, tracking, feature extraction, classification and displaying the output on the screen. Hand segmentation is the most important part as the more accurately the hand points are detected the more will be the accuracy of the model.

The main challenges observed during implementing these applications were the restriction of drawing on a particular canvas, which restrict the user to draw on a particular area. So, the main future scope of this project is to make the drawing application universal. The second challenge which was observed was to make the user-friendly platform. The pen up and pen down application is difficult to handle and is important while teaching.

4. Mouse Control using hand gesture

A computer mouse interface based on two-dimensional hand gestures is presented by their research. The method involves detecting hand movements by using coordinate detection techniques based on cameras. This method is primarily concerned with quickly and efficiently generating a virtual device with a webcam. Each input image's centroid is found by the system, and since hand movements directly influence the centroid, this idea is applied to move the pointer on a computer screen.

The main issue for this application is the lack of utilization of these applications. Simple steps can be done using mouse easily, so there is no special need of this applications. So, our project will be mainly be using the mouse controlling algorithm for classroom learning.

5. The integration of Mouse control and painting using hand gesture

The main goal of this project is to use mouse controlling algorithm for classroom learning. The painting using hand gesture has restrictions of drawing on a particular canvas only. And the mouse controlling algorithm can be used to manipulate different application on desktop. So the ability of mouse controlling algorithm to control ppt on screen can be used with the painting using hand gesture algorithm to make the eLearning easy.

Making this concept user-friendly will be the other difficulty our project will attempt to solve. To address the pen up and pen down problem, a user-friendly platform is needed. So, a user-friendly UI will be designed to make the teacher student interaction more interesting.

The future scope of our project will be to implement collaborative canvas writing which can be used by students for interactive online teaching. The project can be further used as extension with google chrome in future.

6. Calculations to find the accuracy of the model

Methods to find the accuracy of a hand gesture model using ‘Ground truth’, Gesture Draw and Mouse Draw techniques to draw a square. Where the distance of each point from its expected position is measured to find the error and hence the final accuracy.

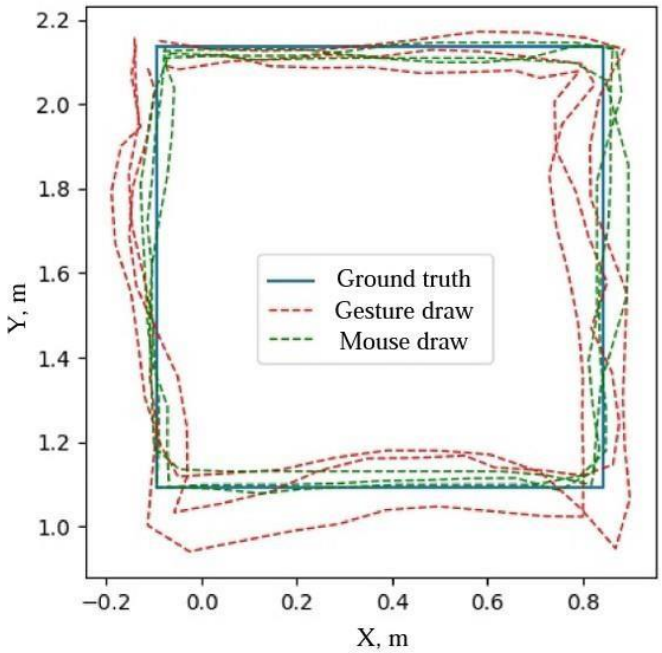

Figure 1. Accuracy of the model

II. LITERATURE SURVEY

Pengyu Hong suggested a model, Finite State Machine (FSM) which was the algorithm used to detect seven gestures [3]. Recognition of the gesture is not based on image recognition where the images are being stored but instead the states are being used. When all the state matches for a particular amount of time then the gesture is recognized. This information can be represented using the equation

$$C=<s_k, t>$$

The model was trained using a game called Simon says. Here the user used to do different hand gesture as said and then it was checked whether the model is able to detect those gesture. Feedback was given to the model and it was trained.

The main difference between this model and HMM model is in HMM model the gestures are stored somewhere to compare for but in FSM the wave generated because of the gesture is matched. The future development of this model is using this approach in different applications such as Simon Says

Different techniques can be used for painting using hand gesture some of them were analysed by Reddy, V. Shiva Narayana, K. Kavya, and D. Sudheer Reddy[7] in which it was concluded by the machine learning approach has the highest accuracy of 96%, hand gloves method with 75% and computer vision method with 83% accuracy. In hand gloves method the gloves were made from daily stuff like black clothes and ping pong ball and the centre of ping pong ball was taken as marker.

Sande et al. suggested with the use of a hand gesture recognition system, the current virtual mouse control system primarily provides features for the hand gesture-based virtual mouse, including scroll-down, left-click, and right-click. Although there are many different hand recognition systems available, most of them use static hand recognition, which recognises hand shapes and assigns actions based on those identifications. As such, this method produces a large number of unclear situations and a limited set of possible courses of action. As technology develops, there are more and more options available besides using a mouse.

By using hand gestures to manage several mouse activities, such as scrolling, left and right clicking, and other mouse features, Thakur and colleagues (2017) suggested a system that increases operational efficiency, dependability, and user engagement.

It is observed by Qianqian, Liu, et al. that the most challenging part of online teaching is interaction with student as blackboard is not available online. And most of the teachers cannot afford the tools used to write on screen. So, by using mouse controlling algorithm and painting using hand gesture this process can be made cheap and convenient to use.

Table II: Summary Study on Painting using hand gesture for classroom learning

Paper	Context used	Conclusion
7]	Glove Based Approach, Computer Vision Approach, Machine Learning Approach	Machine learning can be used for painting using hand gesture which has 96% accuracy. **Analysis:** The machine learning approach for painting using hand gesture s the most efficient method.
8]	Air Writing, six-degrees-of-freedom hand movements	Air-writing is the practice of using hand or finger movements to create inguistic symbols or phrases in a blank area. Here, characters or words are ecognized using data from six-degrees-of-freedom hand movements. **Advantages:** The air writing using hand gesture has various applications which improve human computer interaction.
9]	ping-pong ball gloves, Houghs Transformation	Create a glove with ping pong ball attached to it, then map the motion of all to predefined gesture. Houghs Transformation can be used to find the egion with circular shape. **Future development:** The accuracy of the glove-based method can be mproved further.

4]	Hand Segmentation	Hand Segmentation is the process of differentiating the hand from an image of a video. One of the methods for hand segmentation is thresholding grayscale image processing. We can use MediaPipe for recognizing hand in image.
10]	Accuracy of model, Gesture Draw Approach, Mouse Draw Approach	Methods to find the accuracy of a hand gesture model using 'Ground truth', Gesture Draw and Mouse Draw techniques to draw a square. Where the distance of each point from its expected position is measured to find the error and hence the final accuracy. **Future development:** The mouse controlling algorithm can be used to make painting using hand gesture universal.
3]	Gesture Mapping	Effective ways to make the hand gesture recognition system more convenient to use. There are various hand gestures, we can map this hand gesture with different functionality to make our model easy to use and understand. **Future development:** The use of gesture mapping can be used to make user friendly platform
11]	Test scenarios for painting using hand gesture	The applications of hand gesture model and different test scenarios to check the efficiency of the model. The test scenarios include the blur image, dark image, light image etc. **Future Development:** The efficiency for test cases such as blur image, dark image should be improved
12]	HMM	HMM, a statistical model known as the Hidden Markov Model (HMM) is used to explain the probabilistic connection between a series of observations and a series of hidden states.
17]	Challenges in Online teaching	The reason for the poor online teaching effect where we found that insufficient teaching resources and platform or tools is one of the main problems that teachers face while teaching online.
1]	Pen up, pend down issue	The challenges faced during painting using hand gesture. The main challenge faced was pen up and pen down issue. The system writes from above using a single RGB camera. Up and down pen movements are impossible to follow because depth detection is not available. **Challenges**: The pen up and pen down issue should be resolved in future

III. CONCLUSION

We may conclude from all the above-mentioned study that accuracy in free-hand detection without the need for gloves can be attained through the use of a machine learning approach. Although glove-based technology is accurate, it costs $12,000 to wear a glove with sensors built in, thus most users cannot afford to buy one for their regular tasks. The suggested technique makes it easier and more affordable for the user to carry out hand gestures. Another strategy that has been mentioned is vision-based, which is based on the computer vision technology and is more accurate than the glove-based approach, although it is difficult to go around obstacles if they arise. As a result, we may simply remove any kind of obstacle, including cost, noise, and haar-like classifiers, by utilising machine learning. We can quickly expand the functionality of our software using this method. With small modification to the proposed system, it can be used in many other fields. In other words, it can replace every existing user interacting devices.

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