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A SURVEY ON AIR WRITING CHARACTER RECOGNITION AND TRANSLATION

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Abstract— **Computer systems are increasingly using air-writing recognition since it can be done quickly and intelligently. The term "air-writing acknowledgment apparatus" refers to the use of a stylus to draw an articulated character or expression in free space. This study presents a simple yet effective convolutional neural network-based air-writing recognition method (CNN). It is suggested to use a plausible algorithm tracking hands to reward air-writing circles captured through a web camera. This study provides a straightforward but efficient method for recognizing air-writing that uses deep convolutional neural networks (CNNs). With the aid of hand motions, users can write characters in the air that are subsequently translated into written text using an air writing character recognition and translation technology. Convolutional neural networks (CNN), which are trained to recognise and decipher human hand gestures, power this technology. The device uses a camera to record the hand movements and then runs the data through CNN to identify the characters being typed. The identified characters are then converted into text that may be presented on a screen using text-to-speech technology.**

Keywords— **Convolutional Neural Network (CNN), Air-Writing, Translator, Deep Learning**

I. INTRODUCTION

The capacity of robots to replicate or enhance human intelligence, including logic learning from background, has increased dramatically with the development of synthetic intelligence technologies. Artificial intelligence has long been utilised in computer programmes, but it is now present in a wide variety of products and services. The next iteration of such technology appears to be virtual augmented reality, which uses specialised glasses to project output directly into the users' eyes. It is often believed that using speech recognition is a natural and intuitive method to communicate with technology. Speech recognition does not, however, meet all the requirements for technological communication. To recognise the objects in an image, some digital cameras, for instance, employ artificial-intelligence. The advancement of artificial intelligence technology has led to the creation of several intelligent applications, such as smart TVs and intelligent robots. Dynamic gesture is the most instinctive approach for people to interact with these intelligent systems. There has been a lot of attention in recent years in a technique called gesture recognition that can be used as a communication tool by next-generation technologies. Air writing has recently grown in popularity as one of the most dynamic gestures. The practise of writing letters or words in empty space with hand or finger motions is referred to as "air writing." If the gesture makes any kind of predetermined movement it could be viewed as a particular instance of gesture when done in the air. In user interfaces when the person cannot group on a console, correspond on a touchpad or a touchscreen, or enter language for controlling an intelligent system, air writing is especially helpful [3].

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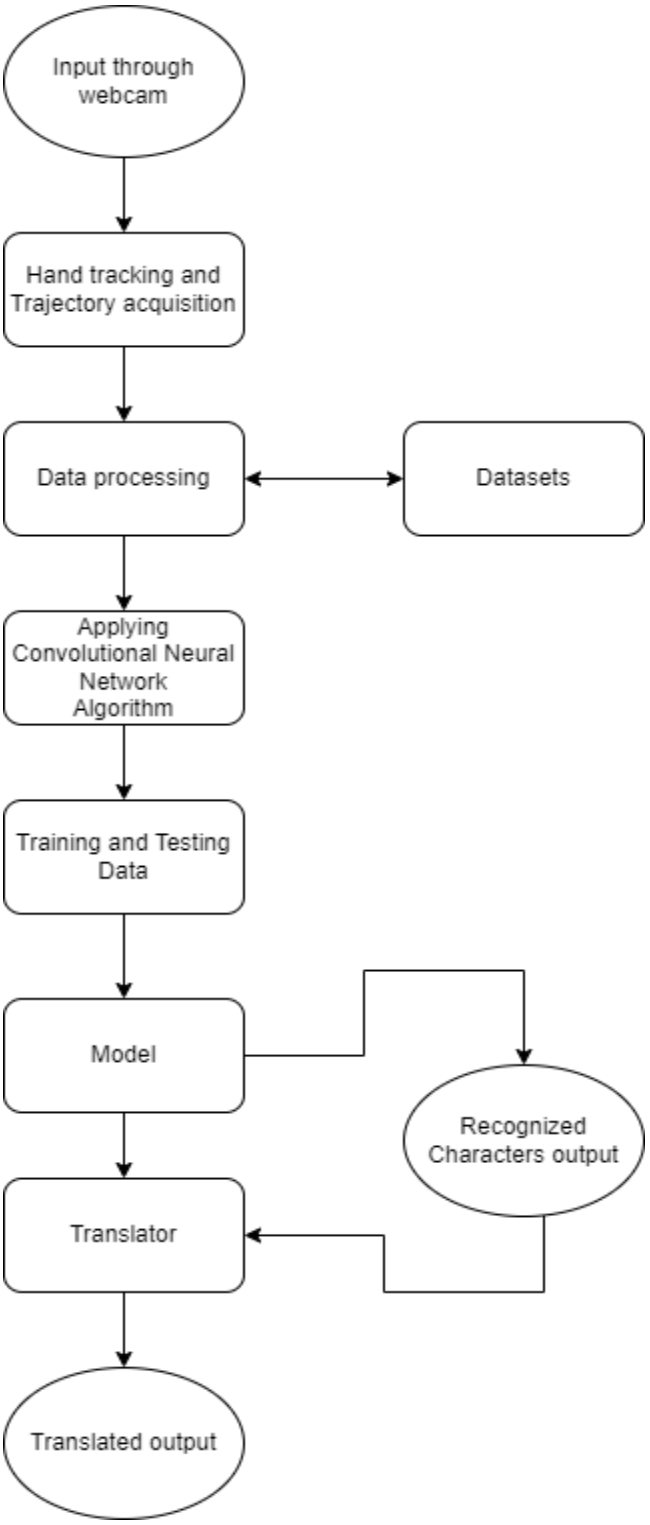

Fig. 1. Flow chart of proposed air – writing system

But identifying characters created by air-writing is not an easy feat. Most commonly, air-writing is connected to the understanding of sign language or motion gestures. However, there are two types of motion gestures: device-based and device-free. A human can engage with a device without using touch or sound thanks to device-based gesture devices. The technology is able to recognise and interpret movements or actions to determine how to operate. To detect movement,

each gesture control device has a separate motion sensor. For instance, portable pointing devices like motion sensors on watches [72] or inertial sensors fastened to gloves [69]. The device-free method is further suited than the device-based method since consumers do not need to handle any equipment. Once more, the device-free techniques are split into vision-based and radio-based techniques. These many types of 2D or 3D cameras have been used to detect the input images for the vision-based method, which has been developed based on computer vision techniques to recognise hands. The design makes an effort to identify and categorise hand attributes, including skin tone, look of colour, deep learning identification, and more. The latter collects gesture signals using radio sensors like Wifi [67]-[69] or radar. Fine-grained movement distinguishes characters from generic gestures, and different writers can write characters in different ways [60]-[62]. The alphabet and digits are typically written with multiple strokes in pen-and-paper-like systems. In contrast to the traditional writing system, air-writing is unique. Lifting a pen results in much less obvious movements than writing in the air. People are unable to see what they are writing as they could while using paper since they lack about sense of touch. This is because they cannot touch anything, such a pen or a piece of paper touch. This is because they cannot touch anything, such a pen or a piece of paper.

Three types of air-writing can be identified: solitary, connected, air writing. In isolated writing, each letter is sequentially placed in a fictitious field with a predetermined elevation and breadth in an image's field of vision. Similar to writing on paper, connected writing involves writing multiple alphabets from left to right. The final method allows you to write numerous letters consecutively one on top of the other inside the same hypothetical box. We look at this paper's singular writing style [71].

To suggest a some new technique for air-writing recognition that solves these problems and uses a webcam or a normal laptop camera as the VHS input.

Finding the writing hand disguise for the air writing initiation.
Accurate fingertip discovery and shadowing in real-time; and recognising a character line written in the air. Due to a number of comparable elements, like blurred fingertip movements, a cluttered background, and variations in lighting, the work is fairly sensitive.

The main issue has been solved for vision-based methods, but special solutions are required for 2nd and 3D photo sensors. Because it is difficult to watch fingers without markers, 2D camera-based structures commonly incorporate colour markers on the palms to improve growth tracking performance. The hand/finger tracking issue is well handled by 3D camera-based systems employing the intensity data provided by 3D image sensors like Kinect, jump movement Controller (LMC), or Intel RealSense camera.

Using the rapid R-CNN framework for precise hand detection, hand segmentation, and eventually computing the number of lifted fingers based on dimensional characteristics of the hand, we suggest a very new writing hand track detection approach for the beginning of air-writing. This work addresses the aforementioned challenges.[6]

Making use of a brand-new trademark function known as distance-weighted curvature entropy, we suggest a reliable fingertip detection strategy.

As a delineator and to indicate the end of the air-writing gesture, we suggest a fingertip velocity-based termination criterion. In summary, 3D camera-based systems are better able to address the initial issues than systems using 2D cameras. Yet, 3D systems are more expensive and complex.

To keep track of an object using a laptop's webcam and to save the data associated with it. The object can be a fingertip or any particular color, but we chose to track things that were that color. Once we have the information from tracking the item, we use trained CNN to anticipate the information that was previously stored in the void. Convolutional neural networks (CNN) are being used to find the letters or sentences that are being written in the air. As a result, we developed effective deep learning-based algorithms called the convolutional neural network (CNN).

The fictitious container restricts the scope of writing. It lessens the range of alphabets input changes, including those related to function, scale, or spinning of the printed image. The strain of the upcoming processing is lessened as a result. However, from the perspective of the user, this strategy results in discomfort and writing constraints for clients.

In this paper, we present a single low-cost second net diagram-based, straightforward. Our approach conveniently addresses the first three problems. a CNN-based reputation-building air-writing tool that makes use of a free online diagram, it reaches actual-time popularity. It performs better than conventional methods that rely on written or photographic input.

Building a system that includes detection, and recognition phases. In contrast to other systems, in which users require to complete a word, it permits advanced decoding while the user is writing. The benefits include minimal hardware volume, low latency, cheap computational cost, compact size and heightened sensitivity, no risk to individual privacy, and excellent environmental robustness.

This paper is organized as follows:
Chapter I gives a brief introduction to the paper. Chapter II discusses the existing techniques for air writing. Chapter III describes the literature survey in detail with a table. Finally, the conclusions and references are given in chapters IV and V.

II. EXISTING METHODS FOR AIR – WRITING:

Multiple systems have either utilized specialized detectors or attached a camera, which increases the overall cost of the system to enforce relinquishment of systems is confined. To beaten this problem, use a videotape camera to apply an air-writing system that can be used in any device similar to laptops, TVs, etc. which are conforming to an erected

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videotape camera. After that's the information, the stoner writes the integer character in the air in front of a web camera, and the camcorder captures the air-written characters and provide when the Convolutional Neural Network schedule for character revelation. The Convolutional Neural Network module consists of a model for handwritten character recognition, written in the air.

This computer system includes three stages-accession, data processing, and a neural network. The system is done through a web camera. The ground for this algorithm is the air jotting recognition system, which presents a new hand- tracking algorithm to calculate the line of characters/integers that a marijuana smoker wrote in the air. These data are used to learn a Convolutional Neural Network model in the training phase. The CNN model consists of three subcastes - input subcaste, hidden subcaste, and affair subcaste- respectively. During the vaticination, the system captures data from a web camera and predicts the output using the learned models. The CNN model was trained with this captured dataset.

A. Hand Detection:

The system for hand shadowing is realized by the use of image analysis to discover the target fingertip through video footage. This library provides enough functions and installations so that we can reuse our image with computer vision algorithms, thus resulting in the discovery of the line of the target hand. OpenCV an open-source computer vision library also allows us to track and save its position throughout the videotape.

B. Fingertip Detection:

Writing letters or words in empty space is known as air writing by movement of the fingers or hand with no handheld device. Fingertip detection is performed by an inbuilt camera. By using this hand segmentation and detection are done.

C. Normalization:

Changing the range of pixel intensities is a typical task in image processing called normalisation. By reducing variances, it primarily aims to transform
an input image into a set of values that are more recognisable or normal to the senses.

D. Data processing:

An image is passed through a series of convolutional layers, which uprooted the features of the image and used it as input to a trained classifier. The classifier compares the input with the pattern and finds out the matching order for input.

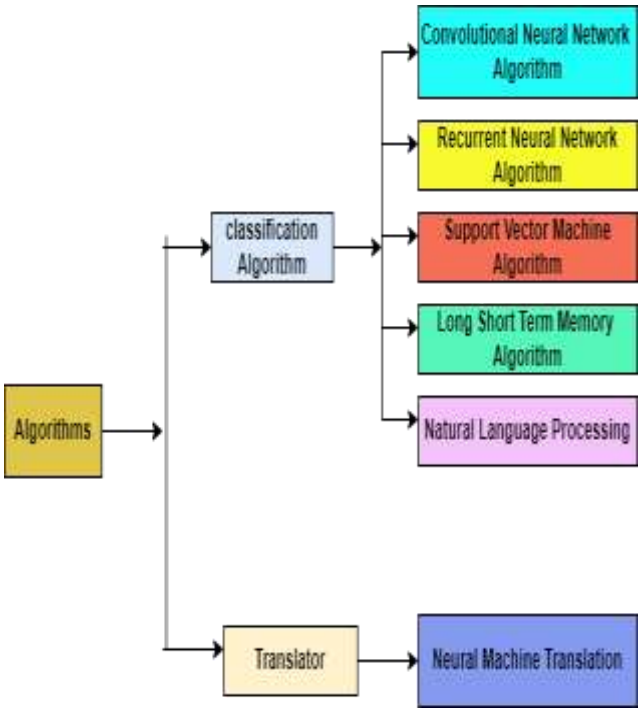

Fig. 2. Block diagram of algorithms used in system

E. Trajectory Acquisition:

Studies have been done on the reflection and movement of a hand a very long time, but it's still only delicate task if real-time and robustness prosecution be needed. A line-grounded jotting system is writing a word or character by moving a cutlet or hand. Where typical pen-up and pen-down writing systems aren't employed, it is largely applicable. The depth camera tracking the fingertip gathers 3D circles for the air-writing detection system. The neighbour and root point that is closest restatement were used to homogenize better point selection using the line test was done on a different dataset.

F. Convolutional Neural Network:

Convolutional Neural Networks can be used for a variety of tasks. Due to its convolution and pooling layers, the standard CNN network contains a lot of calculations; it is capable of identifying and classifying objects visually by first processing the images.[7] The CNN contains the layer as follows:

Input Layer: Images are read in here. In the hidden layer, feature extraction is performed with a line of convolutional layer

Convolution Layer: This layer is used to extract features. Reducing the spatial dimensionality can
help reduce distractions for readers. The output of this layer is a pooled featured map, which helps reduce the visual noise.

Activation Layer: This layer introduces non linearity in the system. It's also called a classification layer, and it's used as a classifier in the CNN algorithm.

Output Layer: This is also called as the final layer, and it's used as finders for classifying objects in the CNN algorithm

III. LITERATURE SURVEY

A literature review is an important part of exploration that collects and analyzes information about the literature on a particular content. In a literature review, authors generally identify applicable workshop, epitomize their main findings, and punctuate their advantages and limitations. Algorithms used in the literature are also described along with the performance criteria used to estimate them.

Table I: The table 1 below describes the literature including author, title of the paper, algorithms and techniques, limitations, advantages, and performance

IV.CONCLUSION

After conducting a research in several applications, after taking into account all the information in the introductory part and came up with a solution. In this paper, we suggest deep CNNs for recognizing air-writing digits and unique direction signals for control akin to a smart TV. With the development of a reliable air-writing trajectory acquisition technique based on a web camera, sophisticated finger-tracking methods are bypassed in favour of simple hand tracking. This technology enables users to write characters in the air using hand gestures and also restate them into written text using convolutional neural networks. It captures hand movements in real-time and processes them through the CNN algorithm to recognize the characters being written with high delicacy. Farther exploration in this area could lead to advancements in the delicacy, speed, and usability of air writing character recognition and restatement systems, making them more extensively accessible and useful for a variety of operations[11].

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TABLE I: LITERATURE SURVEY

Author	**Title**	**Technology And Algorithm**	**Performance Criteria**	**Advantages**	**Limitations**	**Reference**
B.-H. Juang, G.AlRegib, and M. Chen	Modeling and Recognition of Characters, Words, and Linking Motions in Air-Writing Part 1 [1]	HMM, motion trajectory models, ligature models, Re-estimated Character models,Ligature Models [1]	word error rate = 0.8%, letter-based recognition=1.9%	Percentage text encoding, percentage improve recognition by decoding user types.	-	[1], [2], [3], [4]
B.-H. Juang, G.AlRegib, and M. Chen	Part 2 of Air-Writing Recognition: Identifying Writing Activity in Continuous Stream of Motion Data [5]	Technology (GMM and HMM) Algorithms (Window-Based Approach)	precision	Create an aerial writing system that includes both discovery, recognition stages, allowing recognition of how the recognized note portion	The letter I itself is easily broken and cannot be found.[5]	[5]

				affects the recognition effect [5]		
Y. Luo, J. Liu, Waseda University Tokyo, Japan	Identification of Writing Activity in Continuous Stream of Motion Data, Part 2 of Air-Writing Recognition [6]	MEMS with DTW	73% overall character accuracy, high recognition accuracy, and significantly improved system robustness, character accuracy =84.6%, number accuracy = 98.2%, character (“A”to“Z”) accuracy = 64 %. [7]	Small hardware volume, low latency, low computational cost, improved sensitivity, and high robustness to environmental conditions [7]	The DTW-based system will be a competitive option for severe circumstances, especially where time and sample quantity are constraints.	[6], [7], [8]
N. Yan 1,2, P. W. 1,2, J. Lin 2, F. Wang 2, and J. Xiu2; and H. Xu 1,2	An Air-Writing Gesture Tracking Approach Using a 24 GHz SIMO Radar SoC [6]	1.signal model of FMCW radar 2.Radar parameter signal 3.Targert detection and tracking RTS algorithm [13]	comparing the three smoothing algorithms, the RTS smoothing. Validation Accuracy: 97.6%	Used to solve the problem of drawing characters on flat areas [14]	Camera Base, RFID - Base, Wifi - Base, Motion Sensor	[6], [9], [10], [11], [12], [13], [14]
You-Shen Lo1, C. Hsieh1, J. Y. Chen2, and S. K. Tang2	Recognition of Airwriting Using Deep Convolutional Neural Networks [15]	CNN algorithm, camshaft algorithm, skin pixel detection algorithm, face detection algorithm, gradient descent optimization algorithm, (MBGD) the algorithm, Adam algorithm [15]	CNN achieves excellent performance with over 99% recognition rate. [16]	-	-	[15], [16]
A. Santra and M. Arslan	Using a network of radars to recognise airwriting for human-machine interface [19]	LSTM, BLSTM, Conv LSTM Algorithm, Alpha-Beta Tracking Algorithm, Signal Processing Algorithm, Single Target Tracking/Smoothing Algorithm [20]	Performance of digits, drawn characters = 98:33 accuracy. Improved training data and classification accuracy = 4-5% on average	Does not work with depth or motion sensors. You need to let the system know the end of your character by removing the hand marker from the virtual board.[21]	-	[17], [18], [19], [20], [21], [22]

Y. Xue and S. Xu	Modeling and Recognition of Air-Writing Characters Using Modified CHMM [23]	HCI Technology, Viterbi Algorithm, Baum-Welch Algorithm, EM Algorithm, Baum-Welch Algorithm [26]	-	High Performance = 87.52% and 97.42% for TOP-1 and TOP-3, Best Accuracy = 95.91% and 99.58%.	DB1 has no write limits, but DB2 and DB3 have limits at varying levels. [25]	[23], [24], [25], [26], [27], [28]
Md. A. Alam 2, M. Y. A. 1, S. Md Imtiaz 1, and N. Kim 1 are the other members of the team.	Recognizing airwriting using a depth sensor and deep neural networks [29]	gradient descent, HMM, LSTM, CNN, BLSTM algorithms	Accuracy = 99.06%, 99.17%. Accuracy was determined at LSTM = 99.17% and 99.32%	Its straightforward writing style offers a number of advantages over gesture-based solutions. [33]	-	[29], [30], [31], [32], [33], [34]
A. D. Prosad, S. Kard, S. Mukherjee, Sk. A. Ahmed, and P. P. Roy	Tracking and Detecting Fingertips to Recognize Air-Writing in Videos [35]	R-CNN framework, CNN, HMM, LSTM, GMM	Character recognition accuracy = 96.11 %	-	-	[35], [36], [37], [37], [38], [39], [40]
S. Xu, L. Jin, Z. Feng, X. Zhang, Z. Ye,	Finger-Writing-In-The-Air Kinect Sensor System [41]	HCI, GMM, dual-mode switching algorithm	Over all accuracy rate = 90%	Advantages of Kinect depth information is robust to environmental changes and overlapping thresholding or Gaussian segmentation [41]	-	[41], [42], [43]
V. Joseph, N. Suvarna, A. Talpade, and Z. Mendonca	Recognition of Visual Gestures for Writing Air Text [45]	CNN, gesture recognition, neural network training algorithms, Gaussian blur, and doorstep algorithms, convex hull algorithms [44]	Accuracy	-	-	[44], [45], [46], [47], [48], [49], [50], [51], [52]

P. Ramasamy, Dr. R. S.	A Cheap Air Writing System That Uses a Web Camera to Transform Finger Actions into Text [53]	Gesture recognition mathematical algorithms	-	-	-	[53], [54], [55], [56]
K. Kritsis, V. Katsouros, and G. Bastas	Deep Convolutional and Recurrent Neural Network Architectures for Air-Writing Recognition [57]	gesture recognition, DL, LSTM, CNN, TCN	-	-	Limitations of two different approaches and tested neural architectures.	[57], [58], [59], [60], [61], [62], [63]
A. Santra and M. Arslan	Using a network of radars to recognise characters in airwriting for human-machine interface [64]	TOF technology, dual-mode algorithms, signal, CNN and LSTM algorithms	The time-series trajectory approach's classification performance uses LSTM, BLSTM, and Conv LSTM with CTC loss functions.66]	-	-	[64], [65], [66], [67], [68], [69]
S. Honda and T. Asano	Character handwriting gestures on a visual interface system [70]	Recognition Algorithm	-	An advantage of multi-camera systems is that gestures can be recognized regardless of their original orientation. [71]	-	[70], [71], [72]