1.1 Sign language understanding

The use of language is an essential component of our daily lives. Without understanding each other's language, communication might be challenging. Different communities employ a variety of languages for communication. The visually challenged utilize sign language as a means of communication [11]. The primary means of communicating in sign language is visual, and signs are used to express sound patterns and meanings. The development of various sign language standards based on regional and ethnic differences has been facilitated by many countries, including Korean Sign Language (KSL), Chinese Sign Language (CSL), Indian Sign Language (ISL), American Sign Language (ASL), British Sign Language (BSL), and Persian Sign Language (PSL) [12]. The hearing and speech challenged may effectively communicate with others who are not affected with the use of sign language recognition technology. The Sign language recognition systems is enhancing societal, private, and academic aspects of communication between those who are impaired and those who are not in a disability in a nation like India [13].

The main issue with ISL is that there isn't a standardized database for the language, no common formatting for ISL, and that there are several variants throughout the nation. Translating certain words becomes too complicated because they have numerous meanings, such as the word "dear," which is particularly tough to deal with since it cannot be directly translated into the specific set of sign language [14]. The research also demonstrates that English's syntax, vocab, and structure are all well established in Indian Sign Language. The solitary hand gesture and the double hand gesture, which represent the tasks that need the most stretching, are two of the several gestures employed in ISL [15].

1.2 Barriers to sign language recognition

The identification in sign language is more difficult since it is multimodal. The handshape, movement, and position are connected with manual aspects whereas the facial appearance, head position, and lip stance are related with non-manual elements in the identification process of sign language. How sign language connects to English words is one of the primary obstacles to sign language recognition [16]. To locate English terms with two distinct meanings is a straightforward test. There would be a symbol with the identical two senses as the English term if ISL signs represented English words. For instance, the English word "right" may signify either "left" or "wrong," depending on the context. There isn't an ISL sign that has these two meanings, however. In ISL, they are conveyed by two distinct signs, exactly as they are in French, Spanish, Russian, Japanese, and the majority of other languages, where they are stated by two distinct words [17].

1.3 Importance of Indian sign language

We all know that language is the primary means of intercultural communication. Languages like Hindi, English, Spanish, and French may be used depending on the nation or area that a person is from. Currently, sign language is utilized as a means of communication by those who are unable to listen and speak. Hand gestures are used to convey ideas and what they want to say [18]. Today, it is impossible to envisage a world without sign language owing to how challenging it would be for individuals to exist without it. Without sign language, individuals will become helpless. People who are unable to listen or speak now have the chance to live better lives in our world because to sign language. Now that they can interpret sign language, they can converse with others. We created an Indian sign language recognition system, which can be deployed in many locations, to enable people to comprehend the language of the Dumb and the Deaf and make their lives more comfortable [19].

1.4 Scope of the Indian sign language

Since we are aware that deaf individuals find it challenging to thrive in environments without sign language interpreters, we have developed this system to help us solve the issues these people face. The ISL detection method may now be used in banks, where a different system can be established for the deaf and dumb [20]. A separate screen can be mounted on the wall and will be visible to all bank employees while they are at work. Now, when a person enters a bank, they may go straight to the special system that has been established for them and use gestures to present their questions to the ISL recognition system. The motions will be recognized by the ISL recognition system, and the relevant output will appear on the screen. The public's inquiries may be answered in this manner. The ISL may be used in grocery shops where consumers can place orders using gestures and the ISL recognition system, and the shopkeeper can also place orders using this framework [21].

1.5 Indian sign language recognition system applications

There are many ways to use sign language, and the practice of sign language interpretation is very crucial for the group of people with disabilities. Through the use of computers, this group may communicate with other hearing communities. We may install our computer equipment in banks, railroads, airports, and other public and private locations so that dumb and deaf people can communicate with hearing people using these computers. We may utilize computers as an interaction between these two groups as sign language is solely understood by the deaf and dumb society, but it may be understood by the hearing community. These computers may provide assistance to such a community. It allows for the transcription of motions into

text or speech. Our warriors are able to communicate with one another silently by employing sign language [22][23].

The following are a few uses of the Indian sign language recognition system:

1. With the use of this method, hearing impaired and dumb individuals may converse with one other.
2. It aids in the development of a sign language lexicon.
3. It also aids in the empowerment of the Deaf and Deaf people.

Fig - 1: American sign languages

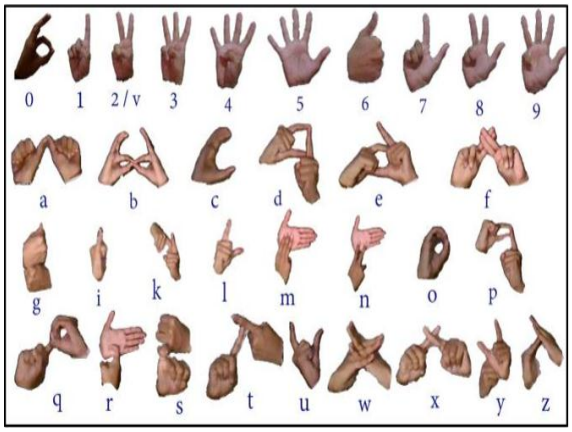

Fig - 2: Indian sign languages

Fig - 3: Some popular sign languages

One of the most useful forms of communication for those who cannot hear or communicate is sign language. Additionally, it helps those who can hear but cannot talk or vice versa. Deaf and dumb human beings can be benefited from sign language. Sign language is a collection of various hand gestures, body postures, and facial and body movements. This unique gesture is used by deaf individuals to convey their ideas [24]. Each hand gesture, face expression, and body movement have a distinct meaning that is attributed to it [25]. Different sign languages are utilized in various regions of the globe. Verbal communication language and culture of any given location have an impact on the sign language there. For instance, American Sign Language (ASL) is used in the USA, but research on Indian sign language has recently begun with the standardization of ISL [26]. There are over 6000 gestures for words that are often used in finger spelling in American Sign Language, which also has its own syntax. 26 movements and single hand are utilized in fingers pronunciations to represent the 26 English letters. The project's goal is to create a system that can translate American Sign Language into text. The sign language gloves are an effective tool for ensuring that conversations have significance [27]. A schematic of the ASL, ISL and common sign languages has been given Fig. 1, 2, and 3, respectively.

Humans often utilize hand gestures to communicate their intentions while interacting with other people or technology. A computer and a person are communicating with one another nonverbally via this medium. An alternate means of communication for voice technology is this. It is a contemporary method that allow computer commands to be executed after being correctly recorded and understood by hand gesture. Real-time applications like automated television controlling [28], automation [29], intelligent monitoring [30], virtual and augmented reality [31], sign language identification [32], entertaining, smart interfaces [33][34], etc. often use human-generated motions or gestures. Gestures are a continual movement that a human can easily perceive but that a computer has a hard time picking up on. Human gestures include motions of the head, hand, arms, fingers, etc. Relative to other human anatomical parts, hands are the best understandable and practical mechanism for Human-Machine Interaction (HMI).

It is separated into two categories: static gestures and dynamic movements. A static gesture is a certain arrangement and stance that is shown by a single picture. And, A dynamic gesture is a mix of stance and a time-related video sequence. A single frame with minimal metadata and low processing effort is used for every static gesture. Dynamic gesture, on the other hand, is better suited for real-time application since it is in the format of video and includes more complicated and significant information. Additionally, this gesture needed high-end gear for training and testing. To focus on hand gesture detection, several researchers have attempted to apply various machine

learning techniques [35]. Hands with fingers, palms, and thumbs are included in this scientific discipline of hand gestures in order to detect, identify, and recognize the gesture. Because of the tiny size relative to other body parts, increased identification difficulty, and frequent self- or object occlusions, hand estimation is particularly challenging. Additionally, it is challenging to build an efficient hand motion detection system. Since numerous investigations have been conducted, hand gesture detection, especially from 2-dimensional video streams using digital cameras, has been reported.

These methods, however, run into issues such color sensitivities, opacity, cluttered background, lighting shifts, and light variance. Investigators can now take into consideration the 2D scene details thanks to the recently released version of the Microsoft Kinect camera that has a realistic and affordable depth sensor. Furthermore, because of the advanced technology used to create it, the depth sensor is more resistant to variations in light. The recognition method has traditionally been carried out by machine learning algorithms after explicit extraction of the spatial-temporal hand gesture characteristics [36]. Many of the elements were manually built or "hand-crafted" by the user in accordance with the framework to address particular issues like hand size variation and variable illumination. The method of feature extraction in the hand-crafted methodology is problem-oriented. Finding the ideal balance between effectiveness and precision in computers is also necessary for the production of hand-crafted characteristics. Deep learning has brought about a paradigm change in computer vision, however, because to recent advancements in data and processing resources with strong hardware. These deep learning-based algorithms have recently been able to infer meaningful information from movies. Processing this data doesn't need an outside algorithm. Interesting results have also been found in a number of tasks, notably recognition of hand gestures [37]. On the use of hand gesture recognition in our daily lives, a recent review work has shed some light. Some of the frequent uses of hand gesture recognition include robot control, gaming surveillance, and sign language understanding. The main goal of this study is to offer a thorough analysis of hand gesture recognition, which is the core of sign language recognition [38].

There are several hardware methods that are utilized to get data about body location. The majority of trackers are device- or image-based. Gathering the motions is the first phase, and then identifying them is the next. This present research makes an effort to analyze data from flex sensors installed on a glove in order to recognize the motions that are done. Despite a number of flaws in the system, such as uncertainty and noise, the prediction accuracy for the gadget is relatively high. The majority of people who are speech- and hearing-impaired has drastically increased in recent years. To communicate, these folks use their own language. However, we must comprehend their language, which might be challenging at times. By employing flex sensors, whose output is sent to the microcontroller, the project seeks to solve this problem and enable two-way communication. The signals are processed by the microcontroller, which transforms analog impulses into digital signals. The intended output is also presented with the spoken output when the gesture has been further analyzed [39].

In consideration of the academic community's growing interest in gesture recognizing in general and hand gesture identification in particular during the last two decades, a multitude of relevant approaches and tools have evolved. Although several secondary studies have attempted to cover these answers, there are no comprehensive studies in this field of study. The fundamental contribution of this paper is the thorough analysis and compilation of significant findings on hand gesture recognition, supporting technologies, and vision-based hand gesture recognition methods. The primary methods and algorithms for vision-based gesture recognition are also explored in this paper. This paper offers a thorough examination of hand gesture analysis methods, taxonomies for hand gesture identification methods, methodologies and programs, implications, unresolved problems, and possible future research areas.

The literature reviews, polls, and studies on hand gesture recognition are briefly discussed in this sub section. A review of the research on vision-based human motion tracking was done by Moeslund et al. [40]. The review gives a general overview of the four motion capture system procedures of identification, tracking, initiation, and motion analysis. The authors also analyzed and addressed a variety of system functioning features and suggested a number of potential future research avenues to develop this field. Derpanis et al. [41] discussion on hand gesture recognition included a variety of angles. The study focuses on a number of ground-breaking papers in the subjects under discussion, including feature types, classification strategies, gesture set (linguistic) encoding, and hand gesture recognition implementations. Common issues in the field of vision-based hand gesture identification are discussed in the study's conclusion. The survey by Mitra et al. [42] is an analysis of the prior literature with a primary emphasis on hand gestures and facial reactions. Techniques for recognizing facial movement and hand gestures based on vision are presented. This important paper also identifies current difficulties and potential research ramifications. The corpus of information on hand gesture recognition has been reviewed in a literature study by Chaudhary et al. [43]. The primary emphasis of this review is on artificial neural networks, genetic algorithms, and other soft computing-based methodologies. It was discovered that the majority of researchers recognize hands in appearance-based modeling using their fingers. Various sensor and vision-based hand gesture detection algorithms were examined by Corera et al. [44] in addition to current tools. The article covers the

design issues and logical difficulties associated with hand gesture recognition methods. The authors also assess the advantages and disadvantages of sensor- and vision-based approaches.

2. RESEARCH STRATEGIES

This section of the study highlights the present research needs by specifying the investigation topics and associated keywords.

2.1 Questions from literature reviews

The issue of identifying and demonstrating hand motion recognition techniques is not new. Different strategies, procedures, and techniques have been created throughout time to demonstrate the components of hand gesture recognition. The following SLR research issues will be addressed in this study:

The following research questions will be addressed by this SLR:

Q1. What current techniques and supporting technologies are available for hand gesture recognition?

Findings from addressing the research questions. This part should address the research queries created to achieve the objectives of the study. Interacting and communicating with people may be done via gestures. Recognizing gestures demonstrates one's capacity to discern the message another person is trying to convey. Gesture recognition is the practice of identifying human gestures by computers. The physical movement of one's fingers, arms, hands, or torso may convey a gesture and convey a message [45].

Gesture recognition has been used in computer science to understand and analyze human gestures using mathematical algorithms. Although they may be made with the whole body, gestures usually start with the hands or the face. Gestures are expressive, meaningful bodily motions that include physical actions of the fingers, hands, arms, head, face, or torso, according to research by Mitra and Acharya [46]. In comparison to a machine's capacity for information recognition, the human perception of body motions is distinct from and more spontaneous. Through the use of senses including hearing and vision, humans are better able to detect gestures on the spot.

2.2 Hand gestures

Compared to other body parts, the hand is the one that is used for gesturing the most. As a result, the hand is the ideal communication tool and candidate for HCI integration. Natural and efficient non-verbal communication using a computer interface is made possible by human hand movements. Hand gestures are the expressive gesture signs of the hands, arms, or fingers. Hand gesture recognition includes both static motions with complicated backgrounds and dynamic gestures that interact with both computers and people. The hand serves as the machine's input directly; no intermediary medium is required for the communication function of gesture recognition [47].

2.2.1 Methods to analyze hand gesture

Sensor-based analysis and vision-based analysis are the two main kinds of hand gesture analysis methodologies that are utilized to recognize hand gestures. In order to make hand gestures, the first solution calls for the integration of visual or mechanical sensors in gloves that also carries electrical signals incorporated in the finger's flexor muscles. Using an additional sensor, the hand position may be determined. Then, a specific glove with signal-receiving capabilities is attached to an auditory or magnetic sensor. To transmit information pertinent to hand position identification, this glove is linked to a software toolbox [48]. The second category of methods, referred to as "vision-based analysis," rely on the way in which individuals pick up on cues from their surroundings. This approach extracts several attributes generated from specific photos using a variety of extraction methods. Most methods for recognizing hand gestures use mechanical sensors, which is often employed to regulate signals from the environment and surrounds. Communication systems that merely utilize signals include mechanical senses as well. The application of mechanical sensors for hand gesture identification, on the other hand, is associated with a few problems with the accuracy and dependability of the data acquired as well as potential noise from electromagnetic equipment. The process of gesture engagement may be facilitated by visual perception [49].

2.2.2 Technology Required for Recognizing Hand Gestures

Gesture Recognition is a term used to describe the process of analyzing and translating hand motions into meaningful instructions. Therefore, the major objective of hand gesture recognition is to develop a platform that can detect human hand gestures as inputs and that can then utilize these gestures to understand and examine information in order to generate output data that is in accordance with specific criteria supplied in the input. There are two categories of hand gesture recognition technologies: 1. Sensor-based and 2. Vision-based methods exist [50].

i. Sensor-based technologies

Sensor-based technologies depend on tools for user interactions and other real-world objects that relies on technological advancements. A schematic of various sensors for gesture recognition has been used in Fig. 4.

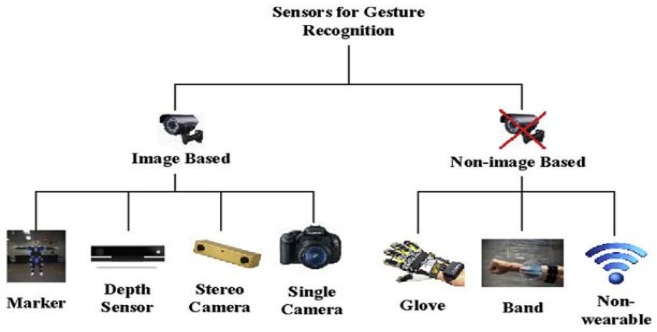

Fig - 4: Different types of gesture recognition sensors

a. Various sensors for gesture recognition

The glove technique makes use of sensors to record the location and movements of the hands. The motion sensors on the hand are responsible for detecting the user's hand, while the sensors on the gloves are responsible for determining the proper coordinates of where the user's palm and fingers are located. This method is laborious since the user must be physically linked to the computer. An illustration of a sensor-based technique is the data glove [51]. The advantages of this strategy include highly accurate and quick response times. In Fig. 5 a glove consisting of sensors has been shown.

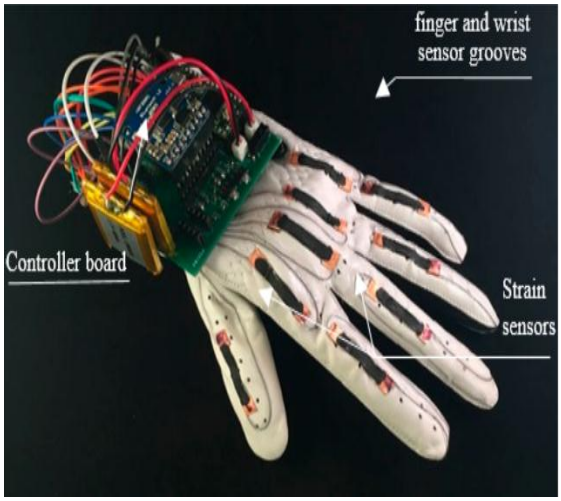

Fig - 5: Sensors based data gloves

The drawback of this strategy is that data gloves are prohibitively costly, need the use of the whole hardware toolbox, and are rigid in character. Therefore, the vision-based technique was developed in order to get over this restriction.

ii. Marked coloured glove approach

A schematic has been added in Fig. 6 related to the coloured marked hand glove recognition system. According to this method, the glove that the human hand will wear is coloured-coded to guide the operation of monitoring the hand and finding the palm and fingers that will supply the precise geometric characteristics that lead to the fabrication of the prosthetic hand [52].

Fig - 6: Colour marker based hand gesture recognition.

iii. Vision-based technology

For a recognition system to function naturally, a camera is all that is needed to capture a picture. In real-time applications, that is more beneficial [53]. Although this approach seems straightforward, there are several obstacles to overcome when using it, including a complicated backdrop, varying lighting, and other objects with different skin tones holding the hand item. Technologies that rely on vision deals with the aspects of an image such as texture and colour that are necessary for gesture recognition. Following picture pre-processing, various strategies have developed for recognizing hand objects. Steps for the execution of programs have been shown in Fig. 7, which shows initiation from the image capturing to the gesture recognition step.

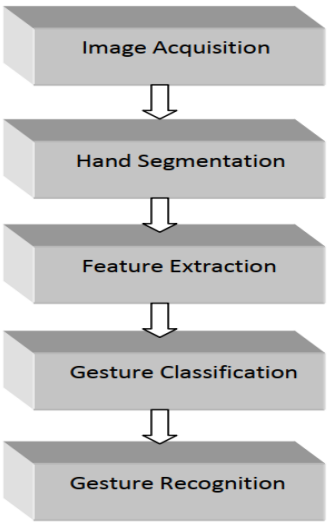

Fig.-7: Vision based hand gesture recognition system

iv. Appearance based approaches

This method involves modelling the aesthetic appeal of the input hand picture utilizing morphological operations, which is then matched to the extraction of features of the stored image. Especially in comparison to a 3D model-based technique, this method is simpler and offers real-time performance. This strategy's general aim is to look for areas in a picture that are skin-coloured. Many studies have been conducted recently that use invariant characteristics, such as the Ad boost learning method rather of modelling the whole hand, one may identify specific locations and regions on the hand by using this invariant property. The advantage of this approach is that it solves the occlusion issue [54].

v. 3D model-based approaches

Fig - 8: 3D model-based approaches.

This method uses a 3D model to analyze and simulate the geometry of the hand as depicted in Fig. 8. A depth variable is provided to the 3D model to increase accuracy since some data is lost during the 2D projection [3]. Volumetric and skeleton models are the two types of 3D models. Those two models had limitations while they were being designed. Because it deals with the 3D model's foundational look of the user's hand, volumetric models are employed in real world applications. This system's enormous dimensionality parameters, which force the designer to operate in three dimensions, are the fundamental design challenge [55].

vi. Colour based recognition

Based on several coloured indicators as shown in Fig. 9, this design is used to monitor the mobility of the body or specific body components. Users may magnify, rotate, sketch, and scribble on onscreen keyboards by mounting the Red, Green, Blue, and yellow-coloured markers, which are used to communicate with the virtual prototypes. This type offers more versatility [56].

Fig -9: Colour based recognition system

vii. Skeletal based Recognition

Fig - 10: 3D Skeletal based Model

By restricting the variables, the skeletal modeling fixes the issues with the volumetric model. The sparse erosion will result in more efficiency. The feature optimization is intricate. Compressive sense is employed to retrieve the sparse signals from a small number of observations, which helps to save resources [57]. A schematic of 3-D skeletal based has been depicted in Fig. 10.

viii. Representations techniques of vision-based gesture

The motions of diverse human body gestures may be described by a variety of paradigms and depictions of gestures. The 3D Prototype and Appearance-based techniques are the two primary methods for representing gestures, as shown in Fig. 11.

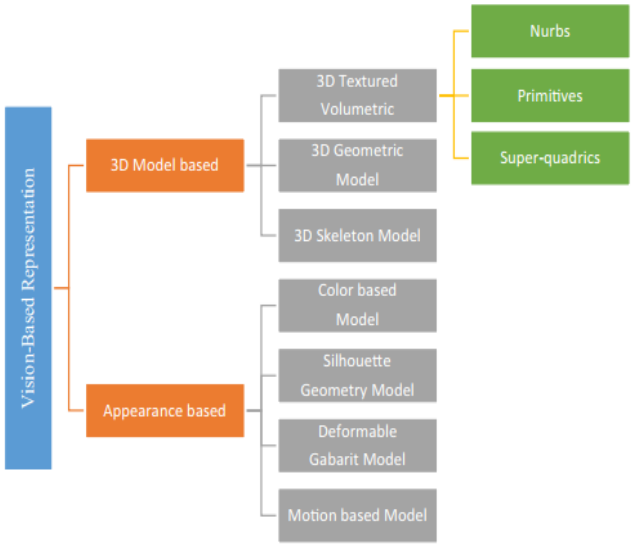

Fig -11: Representation of vision-based hand recognition techniques

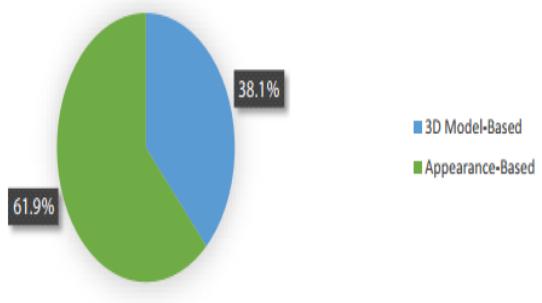

Fig -12: Statistical data of the use of 3D prototype and appearance-based techniques

A statistical study of the use of 3D prototype and appearance-based techniques in vision-based gesture identification is shown in Fig. 12. Here, it appears that the scientific community favors appearance-based methods over 3D model approach and vision-based methods for gesture detection. 38.1% of the academic publications discussed 3D model-based techniques, while 61.9% of the articles discussed appearance-based techniques [58].

Q2. What are the many situations in which hand gestures for interactivity are used commercially available programs, equipment, and application domains?

Systems for recognizing hand gestures using vision are crucial for several everyday tasks.

2.3 Domains of applications

This subsection addresses some disciplines that require gesture interactions since gesture recognition is crucial in many different fields [59]. Fig. 13 shows the possible application of hand gesture interaction system.

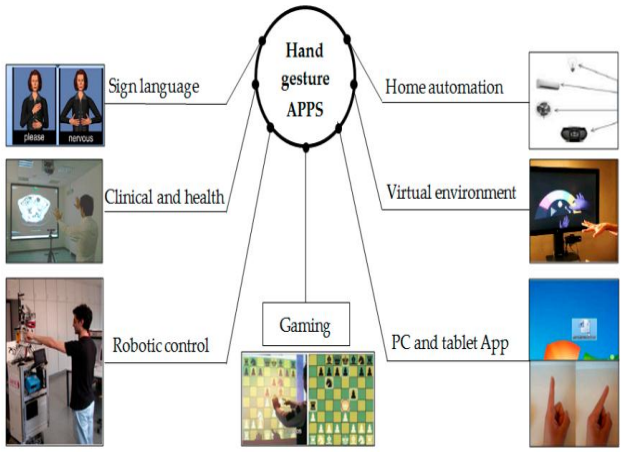

Fig -13: Application of hand gesture interaction system

a) Virtual reality: Increasing real-world applications and virtual gestures both have helped to drive significant growth for computer hardware.

b) Surgical Clinic: The Kinect technology is often utilized in hospitals to streamline operations owing to increasing workload. The many functionalities, such as move, modify, and zoom in on Ct scanners, MRIs, and other diagnostic pictures, will be operated by the physicians using the hand gesture system.

c) Programs for desktop and tablet computers: Gestures are utilized in these applications to provide an alternative kind of interactivity to that produced by the keyboard and mice.

d) Sign Language: The use of signs as a means of communications is seen as an essential component of interpersonal communication. This is due to the fact that sign language is seen to have a stronger structural foundation and is better suited for test beds used in algorithmic computer vision. Furthermore, it may be said that using such algorithms will help persons with impairments communicate with one another. The literature has paid a lot of attention to how sign language for the deaf encourages the utilization of gestures [60].

2.4 Primary shortcomings and difficulties in vision-based gesture recognition

According to the current assessment, investigation on gesture recognition and vision-based approaches typically encounters a number of open problems and difficulties. The research of hand gesture identification is now confronting a number of difficulties, including the identification of invariant characteristics, transition models between gestures, minimum sign language recognition units, automated recognition unit segments, recognition

approaches with scalability regarding vocabulary, secondary information, signer independence and mixed gestures verification, etc.

The static gesture recognition based on vision is thus the current trend in hand gesture recognition and primarily has the following two technological challenges:

1. Difficulties detecting targets Target detection involves extracting the item of interest from the visual stream by capturing the target against a complicated backdrop. The separation of the human hand region from other backdrop areas in a picture is always a challenge for vision-based hand gesture identification systems, mostly because of the variability of the background and unanticipated environmental elements.

2. Challenges with target identification Understanding hand gestures helps to clarify the broad implications related to hand posture and movement. The essential technique for recognizing hand gestures is to extract geometric invariant aspects in light of the hand gesture's subsequent properties.

3. Since the hand is a flexible entity, comparable movements may vary greatly from one another while yet sharing a great deal of similarities. The human hand has more than 20 degrees of freedom, and it may move in a variety of intricate ways. As a result, similar gestures done by different persons may differ from those produced by the same person at a different time or location.

4. Since identifying finger characteristics is a crucial component of hand gesture recognition, the hand includes a lot of duplicate information. One such redundant information is the palm feature.

3. FUTURE RESEARCH DIRECTIONS AND TRENDS

We were able to identify a number of potential study avenues and research subjects that may be investigated further based on our analysis and inspection of more than 150 papers. The main developments and directions in research for gesture recognition are shown in Fig. 14. First, SLs contain unique grammatical rules that have not been well studied in relation to their equivalent spoken languages. Although there have been relatively few research efforts in this area, it may be a future avenue for hand gesture detection problems. Therefore, research into and incorporation of sign language morphological norms into spoken expressions may be beneficial for prospective sign language recognition systems. Second, creating hybrid techniques is a current trend in many domains that may be researched and used in hand gesture detection.

Development of hybrid systems incorporating various algorithms and approaches, as well as non-homogeneous sensors, such as Kinect, innovative gloves, image sensors, detectors, etc., is thus urgently needed. This is regarded as another worthwhile study topic in the area of recognition of hand gestures.

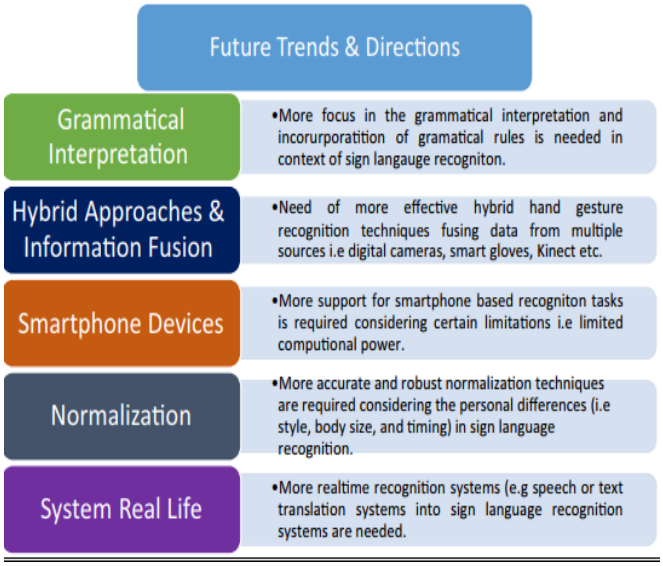

Fig -14: Future research trends and directions

4. CONCLUSION

The general public, people with physical disabilities, those playing 3D games, and people communicating nonverbally with computers or other people may all use hand gesture detection systems. There is a need for study since hand gesture recognition systems are being used more and more. This article provides a critical analysis of the many approaches employed nowadays. The hand gesture recognition system's generic key elements and technique are detailed. The categorization, monitoring, extraction of features, and gesture detection methods are briefly compared. Developing highly effective and intelligent Human-Computer Interfaces (HCI) requires the use of vision-based gesture recognition algorithms. Techniques for recognizing hand gestures have become a popular kind of HCI.

There has been a noticeable change in study focus toward the understanding of sign language. This research also outlined prospective uses for hand gesture recognition technologies as well as the difficulties in this field from three angles: system, environmental, and gesture-specific difficulties. The findings of this systematic review also suggested several possible future study topics, including the urgent need for a focus on linguistic interpretations, hybrid methodologies, smart phones, standardization, and real-world systems.

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