

# Computation of Gesture Recognition and Applications in Wireless Sensor Networks

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**ABSTRACT:** Gesture movement and acquisition of data is used in many day to day applications and biomedical science. Hearing impairment people communicate with normal people using gesture. Gesture recognition system interprets movement of hand and head via vision based systems and sensor based system. These systems facilitate communication between vocal and non vocal communities. Indian sign language (ISL) system based on data gloves and image processing are significant innovations that aim to acquire data from human wrist and hand. This paper reviews various data gloves, framework, algorithms and its applications

**KEYWORDS:** Data gloves; Image processing; Indian sign language; Gesture recognition.

## I.INTRODUCTION

According to the statistics of the World Federation of the Deaf and World Health Organization, approximately 70 million people in the world are deaf-mute. A total of 360 million people are deaf and 32 million of these individual are children [1].Hearing impairment people cannot read and write in regular language. Sign Language is primary mode of communication for deaf and mute people. Sign Language (SL) varies from country to country and it differs within a country itself.

SL depends primarily on gestures rather than vocal cord to deliver messages, and it is combination of hand movement, wrist movement, facial expressions, finger bend position. Various research is carried out in Indian Sign Language (ISL) in recent decades.ISL is a native language used by Indians. The language has following defects: dynamic hand movements, facial expressions and combination of fingers and wrist. SL is unfamiliar to normal people and hearing impairment people face major difficulties in communicating with abled persons.

Deaf and mute people require a translator for communicating with other individuals. Translator may be a human intervention or any other physical device. Fig 1 represents Indian sign Language alphabets.This paper is organized as follows section II describes various approaches in ISL.Section III describes state of art of Glove systems in various period.The methodology of glove system is described in section IV.Application of glove systems is described in section V.Finally , section VI presents conclusion.

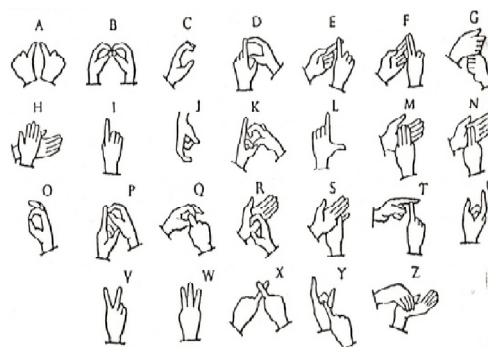


Fig 1 : ISL Alphabets

## II. APPROACHES

ISL follows three approaches namely sensor based, vision based and hybrid based.[2]

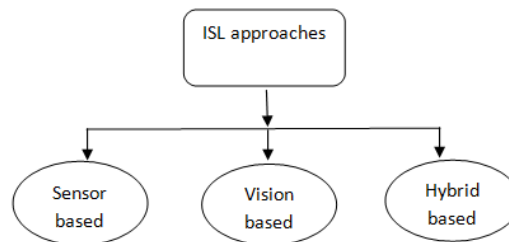


Fig 2: ISL approaches

### A. Vision Based Approach

To obtain necessary input data gestures are performed in front of digital camera. The benefits of this system building cost is less as cameras are integrated with most laptops to provide clear vision and quite cheaper. The limitation of this approach limited field of view of capturing, high computational costs [3]. Fig 3 represents the flowchart for vision based system.

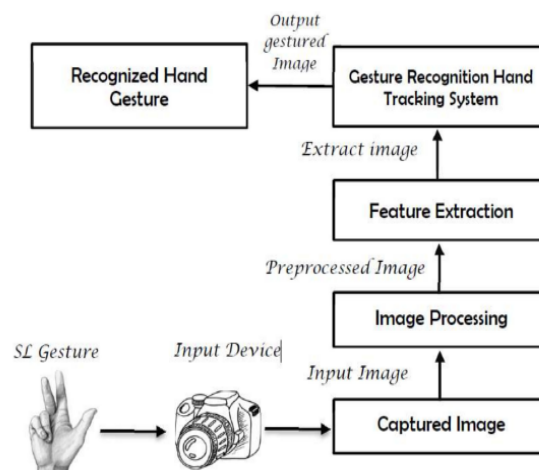


Fig 3: Flowchart for vision based SLR[3]

### B. Sensor based Approach

Data gloves attached with various sensor namely, flex sensors, accelerometers, gyroscope, proximity sensors, abduction sensors, Tactile sensors, Hall Effect Magnetic sensors is an alternative approach for vision based systems. Sensor gloves measure Degrees of Freedom (DOF), orientation of hand, movement of arm, wrist. DOF of a glove can vary from 0 to 22 depending on number of sensors placed in the glove. The major advantage of glove based system is gloves can directly obtain data in terms of voltage values, thus eliminating need to process raw data into meaningful values [4].

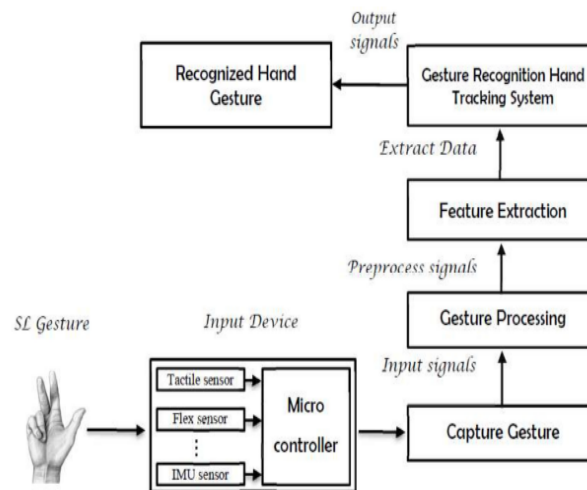


Fig 4: Flowchart for sensor based SLR [4]

Fig 4 represents main phases of sensor based ISL where input is given through data gloves and output is displayed in handheld devices or converted to speech.

### C. Hybrid based Approach

This approach combines both vision based and sensor based systems. Hybrid approach uses mutual error elimination to enhance the overall accuracy and precision. Research has not been carried out in this approach due to the cost of entire setup.

## III. GLOVE SYSTEMS

The first glove based systems were designed in 1970 and since then number of different designs have been proposed. Sensor glove worn by hearing impairment individual is made of Lycra where sensors are sewn. It records data related to motion or configuration of hand. Fig 5 shows hand joints and degree of freedom (DOF) to describe hand motions. The distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints of each finger have 1 DOF each while the metacarpophalangeal (MCP) joints have 2 DOF. The third trapeziometacarpal(TMCP) joint allows thumb to rotate longitudinally as it is brought into opposition with fingers.[5]

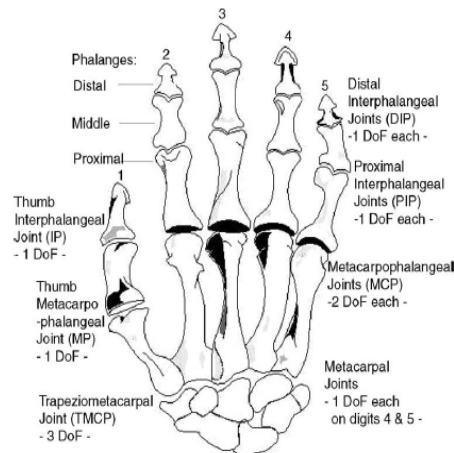


Fig 5: Hand fingers [thumb(1), Index(2), middle(3), ring(4), little(5)] joint and related DOF.

### A. Classification of Gloves

1) **Cyber Glove:** Gloves are embedded with 18 to 22 resistive sensors. The 18-sensor model is equipped with two bend sensors on each finger and four abduction/adduction sensors, sensors measuring thumb crossover, wrist flexion. The 22-sensor model features four additional sensors for measuring DJP joints flexion [6].



Fig 6: Cyber Glove

2) **Human Glove:** Glove system in Fig 7 is equipped with 20 Hall-effect sensors that measures flexion/extension of four fingers MCP, PIP and DIP joints and flexion/extension of the thumb TMCP, metacarpal phalangeal (MP). Glove calibration is similar to cyber glove that is performed through a software package called Graphical Virtual Hand [7].



Fig 7: Human Glove [7].

**3) 5DT Data Glove:** The first commercialized 5 dimension technology comes in several versions. 5DT glove in Fig 8 is equipped with optical-fiber flexor sensors. One end of each fiber loop is connected to a LED, while light returning from other end is sensed by a photo transistor. The glove measures the finger bending indirectly based on intensity of returned light. Gesture "0" is defined as all the fingers closed and gesture "15" as all the fingers open. [7]



Fig 8: 5DT Data Glove

**4) Pinch Glove:** The glove in Fig 9 uses electrical contacts at finger tips, on back of fingers or in palm. When two or more electrical contacts meet, a conductive path is completed and posture is formed [7].



Fig 9: Pinch Glove [7]

**5) Didji Glove:** Ten capacitive bend sensors are used to record finger flexion. The sensor consists of two layers of conductive polymer separated by a dielectric. Each layer is comb-shaped [7]



Fig 10: Didji glove [7]

#### IV. METHODOLOGY

**1. Input Unit:** Acquire data using various sensors namely, flex sensors, contact sensors and inertial measurement unit (IMU).

**a) Sensors to detect finger bend:** Flex sensor technology is based on carbon elements and finger bend position. Flex sensors are very thin and light weight. It is available in two different sizes 2.2 inches and 4.5 inches. When

the substrate is bent, the sensor produces a output related to bend radius. If radius is small the higher resistance is obtained [8]



Fig 11: Flex Sensor

Tactile sensor also known as force sensitive resistor. Sensors are coated with robust polymer thick film device where resistance changes when force is applied. When there is no pressure the sensors act as a open circuit and when pressure increases the resistance decreases[9]. Sensor represented in Fig 12 is 0.5 inch.



Fig 12 Tactile sensor [9]

Hall Effect magnetic sensor (HEMS) Figs out the shape of the finger by an applied magnetic field and to determine the voltage variation over an electrical conductor. A HEM in Fig 13 generates 0.1-0.4v output [9].



Fig 13 Hall Effect Magnetic sensor [10]

**b. Sensors to detect hand and wrist orientation:** To detect hand and wrist movements of ISL gestures 3-axis Accelerometer (ACC) sensor is used. Fig14 depicts ADXL335 a thin, small, low power 3-axis accelerometer with signal conditioned voltage outputs. The surface of accelerometer is made of poly-silicon micro machined structure built on top of silicon wafer. A differential capacitor is attached to moving mass, measures the deflection of the structure. Acceleration unbalances the capacitor resulting in sensor output with amplitude proportional to acceleration experienced.



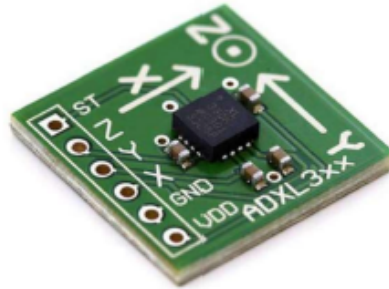


Fig 14: 3-axis ACC sensor [11]

Merging a 3-axis gyroscope with 3-axis accelerometer on same board it is suitable for measuring tracked motion and angular velocity. Fig 15 represents MPU 6050 a chip containing 6 degree of freedom with tri axis gyroscope and tri axis accelerometer. The accelerometer reading is interpreted by microcontroller unit (MCU) using 16-bit Analog to Digital Conversion.

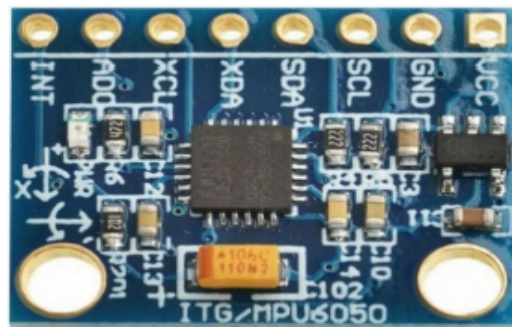


Fig 15:3-axis ACC with 3-axis Gyroscope [12]

Further adding a 3-axis magnetometer to a 3-axis ACC and 3-axis gyroscope will result in a 9-axis inertial measurement unit(IMU).A magnetic field sensor is a small scale micro electro mechanical system(MEMS) device for detecting and measuring magnetic fields.[13]

**2. Processing Unit:** A high performance microcontroller gathers data from sensors.8-bit AVR microcontroller is based on reduced instruction set computer(RISC).Most commonly used processor in recent research is based on Arduino Nano,Uno,Mega etc. Fig 16 represents Arduino Uno microcontroller with 14 digital inputs/outputs,6 analog inputs ,a 16 MHz quartz crystal and USB connection.



Fig 16 :Arduino Uno microcontroller.[14]

**3. Output Unit:** Vocal community users interact with output device to understand gestures of hearing impairment people. Common output devices used in research are liquid-crystal display (LCD), Smartphone and Bluetooth speakers.

## V. APPLICATIONS

This section surveys applications of glove based systems in several areas.

### A. Classical Applications

1) **Design and Manufacturing:** In this area, glove-based systems are used to interact with computer-generated environments. Using a computer screen or a head mounted display, the user, who can be located either on site or remotely over the Internet [15],[16].

Following the Virtual Environment Display System, a National Aeronautics and Space Administration (NASA) virtual reality pioneering project of the mid 1980s [17], a variety of similar systems were proposed over the years. Tinmith was developed at the University of South Australia for assisting in the design of outdoor and indoor environments. The user could capture a 3-D graphical models for existing outdoor conditions, for example, a building, and integrate them with virtual reality models of indoor environments. Pinch Gloves control the menu system allowing the user to select options from menu. Interactive synthesis of spherical mechanisms (ISIS) and VR Spatial were developed at Iowa State University. These systems assist in the designing of spherical mechanisms. Users are allowed to walk into a 3-D space, synthesize the mechanism, and they are allowed to move around the space to evaluate the mechanism's motion. Interaction with this effective systems was performed through a combination of gestures recorded with Pinch Gloves and selections from 3-D menus.

3-D modeling is major application of glove-based systems in the design and manufacturing area. Software for 3-D modeling is typically used by architects, industrial designers, and fine artists to visualize 3-D shapes, often at a late stage of design after pencil sketches have been drawn. Gloves allow creation of 3-D shapes directly using hands, which may make the design process more natural and easier since its earlier stages [18]. Weiner and Ganapathy first implemented this concept. Hand gestures performed by the user is captured by a Data Glove to create B-spline-based 3-D models. Fingertips were used to specify the position of a series of control points for the curve [19].

A similar system was Surface Drawing. As the user moved the hand wearing a Cyber Glove, the trail of its motion was recorded by a computer as a stroke. The strokes obtained through surface drawing could be combined to construct complex shapes. Different configurations of the hand resulted in strokes with different features. For example, drawing with the fingertip allowed very small details to be added; this mode was activated by putting the hand in a pointing posture; bending the hand changed the curvature of the strokes [20].

2) **Information Visualization:** Bryson and Levit from NASA showed the feasibility of this concept with the virtual wind tunnel in the late 1980s. Users could visualize a simulated airflow around an aircraft. Using a Data Glove, the receiver could "grab" onto one or more streamlines of the fluid flow, move them, and observe the changes in the flow, which were calculated and visualized by supercomputers in real time [19].

3) **Robotics:** Glove-based systems can potentially make robot programming a central issue in robotics more natural and easier, particularly when methods based on teleoperation or automatic programming are used [19]. This works efficiently for multi-DoF systems that require the control of a large number of joints, which is difficult to accomplish with standard control techniques. In automatic programming, the robot learns its behavior automatically, for example, "observing" a demonstration performed by a human [19]. This method is receiving growing attention as robots are increasingly used in non structured environments, in tasks unpredictable *a priori*, and by non specialized personnel.

4) **Sign Language Understanding:** After the pioneering project of Grimes with the Digital Entry Data Glove, many projects used glove-based systems for automatic understanding of gestural languages used by the deaf community [19]. The systems developed in these projects differed in characteristics such as number of classifiable signs, which could range from a few dozen to several thousand, types of signs, which could be either static or wavy, and percentage of signs correctly classified.



## VI. CONCLUSION

While further research directions remain open to discussion, this paper has made it clear that the breadth of sensors and types of gloves used in gesture recognition system. Sign languages across the world have certain rule and certain grammar for their sentence formation. It would be handy to develop a translation system which is capable of interpreting different sign language.

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