Computer Vision Based Robotic Hand

Prof. Priti Shende, Varun Sakpal, Rahul Pareek and Deep Bhatt.

Dr. D. Y. Patil Institute of Engineering and Technology, Pimpri, Pune –411018
Department of Electronics & Telecommunication Engineering

Abstract - *Computer vision is a field that refers to the methods of acquiring, processing, analyzing, and understanding images. Computer vision is concerned with the extraction of information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data. Computer vision encompasses scene reconstruction, event detection, video tracking, object recognition, object pose estimation, learning, indexing, motion estimation, and image restoration.*

Several tasks relate to motion estimation where an image sequence is processed to produce an estimate of the parameters either at each points in the image or in the 3D scene, or even of the camera that produces the images. Examples of such tasks are: Ego motion, Tracking and Optical flow.

Computer Vision can be implemented using embedded systems to task specific efficient systems.

***Key Words*: Computer Vision, Embedded systems.**

1. INTRODUCTION

Nowadays, robots are increasingly being integrated into working tasks to replace humans especially to perform the repetitive task. In general, robotics can be divided into two areas, industrial and service robotics. Service robot is an operational aid which operates semi- or fully autonomously to perform services useful to the wellbeing of humans and equipment, excluding manufacturing operations. These robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture. Besides, it might be difficult or dangerous for humans to do some specific tasks like picking up explosive chemicals, defusing bombs or in worst case scenario to pick and place the bomb somewhere for containment and for repeated pick and place action in industries. Therefore a robot can be replaced human to do work.

Here in our project, we aim, to reduce human effort with minimal human intervention. Today's systems are reducing in size and cost, we interfaced our prototype of hand with a Raspberry Pi, a mini computer.

Our project provides a secure approach with the aim of lowering risks to human life. These risks include working in hazardous environment like mines, industrial compounds, radioactive areas, etc. Inaccessible areas like outer space, extreme temperature areas, etc can also be interacted with human like precision.

2. PROBLEM STATEMENT

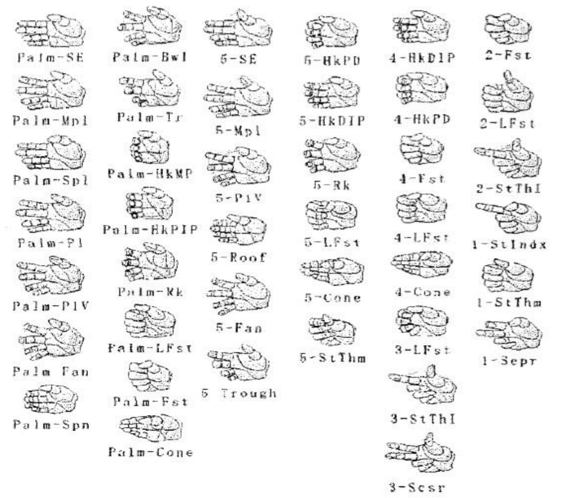
To control the robotic arm which will imitate the movements of a human hand with considerable precision, captured through a camera, with the help of Computer Vision in real-time.

Now-a-days complicated medical procedures are being carried frequently. Such procedures require high precision and speed, which are not being fulfilled due to human limitations. There are lot of manned and unmanned space explorations which require dealing with hostile environments (like rough terrain, unsustainable temperatures, etc.) which is not feasible with existing technology. Some industries deal with hazardous material or environment which brings up the question of human safety. Working in such conditions is not optimum. Handicapped people face many problems in their daily life and there are very few alternatives to overcome them.

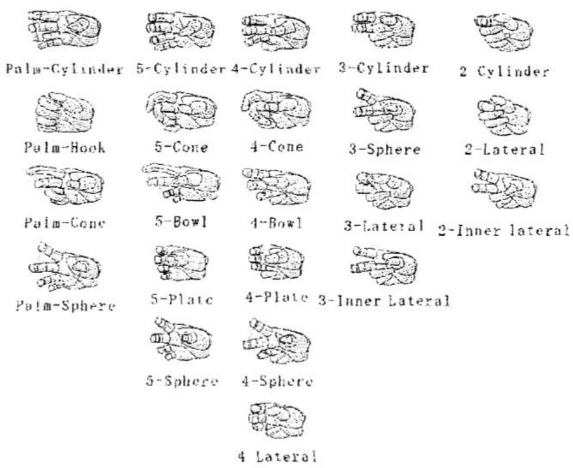
3. LITERATURE SURVEY

In the year 2000, K. Ohnishi, T. Tajima and Y Saito proposed a paper on anthropomorphic hand control for robotic hand-arm system. The aim of their research was to develop an anthropomorphic five digit robotic hand and arm with a hand-arm cooperative control system. They define the human hand to compose an active 21 D.O.F. structure. The hand and arm actions are categorized and analyzed to draw the relation in the upper limb movements. A 16 D.O.F. robotic hand is designed as a test bed for evaluating the hypothesis and to propose a guide for the mechanical design and synchronous sequential multiple motor control for anthropomorphic hand-arm cooperating movements. The design of the robotic hand, the categorization, and the relative networking characteristic of the upper limb joints were discussed. [1]

Degree of freedom of the hand: The D.O.F. of the human hand is conventionally 20. The D.O.F. in this definition is a sum of the D.O.F. of the five digits. However, the existence of the palm is neglected in this theory. The fourth and fifth carpometacarpal joints consist of weak movements of flexion and extension that works simultaneously. This degree of freedom in the palm is counted to the degrees of freedom in the digits, totaling 21. [1]



Non-prehensile contact modes classified into 41 types



Prehension modes classified into 22 types.

Fig 3.1: Different modes of movements

A humanoid hand with a palm joint was designed based on the biomechatronical design, by concentrating on studying the human and implementing the characteristics to the mechanism and control design. A human-like movement control was introduced by studying the human hand usage in the manipulation. The humanoid hand, however, is not supported to fully function when it is not mounted on an arm. The hand is design to mount on an 8-DOF robotic arm to fully perform its effect in manipulation. The digits and palm are to be controlled cooperatively based on the sequential flow studied from the relation. The feedback sensory information is to be integrated to the hand and arm control. The hypothesis of the control system is to be tested on the multiple degree of freedom arm and hand. [1]

In year 2014, Kazuki Mitsui and Ryuta Ozawa presented a paper on Design of a tendon-driven robotic hand with an embedded camera. This paper designs a new five-fingered robotic hand with a camera. Several morphological features of the human hand are integrated to improve the appearance of the hand. The drive system of this hand is under-actuated to eliminate the weight of the hand and to embed all the actuators inside the palm. Despite of this under-actuation, this hand can grasp objects in several different ways. In addition, the two different transmissions are adopted to drive the fingers according to their roles. These transmissions help not only to improve drive efficiency but also to secure the space of the embedded camera. [2]

In this paper they designed a robotic hand with a camera to observe an object in front of the palm. This robotic hand was designed based on the under-actuated tendon-driven robotic generates larger maximum torque while this mechanism is not suitable for precise motion control. Therefore, this mechanism is suitable for controlling the rest of the fingers that are mainly used for power grasp. This mechanism also helped to secure the space for embedding the camera inside the palm because it eliminated the springs for antagonistic tendons. They confirmed that the camera could observe an object in front of the palm, where the index finger and the thumb can pinch an object. The camera could be blind when the hand grasp a dirt object with the palm. They will secure the basic grasping functions independent of the camera and basically use it to support the functions, e.g., by determining the moment where the hand starts grasping. It might be difficult to detect the distance between the palm and an object using only single camera. Thus, they will also add other sensors such as proximal sensors in addition to the camera. They developed a system for object recognition to determine the moment of grasps using the embedded camera. [2]

In year 1999, Jakub Segen and Senthil Kumar, Bell Laboratories published a paper on Shadow Gestures: 3D Hand Pose Estimation using a Single Camera. This paper describes a system that uses a camera and a point light source to track a user's hand in three dimensions. Using depth cues obtained from projections of the hand and its shadow, the system computes the 3D position and orientation of two fingers (thumb and pointing finger). The system recognizes one dynamic and two static gestures. Recognition and pose estimation are user independent and robust. The system operates at the rate of 60 Hz and can be used as an intuitive input interface to applications that require multi-dimensional control. Examples include 30 flythru's, object manipulation and computer games. [3]

4. BLOCK DIAGRAM

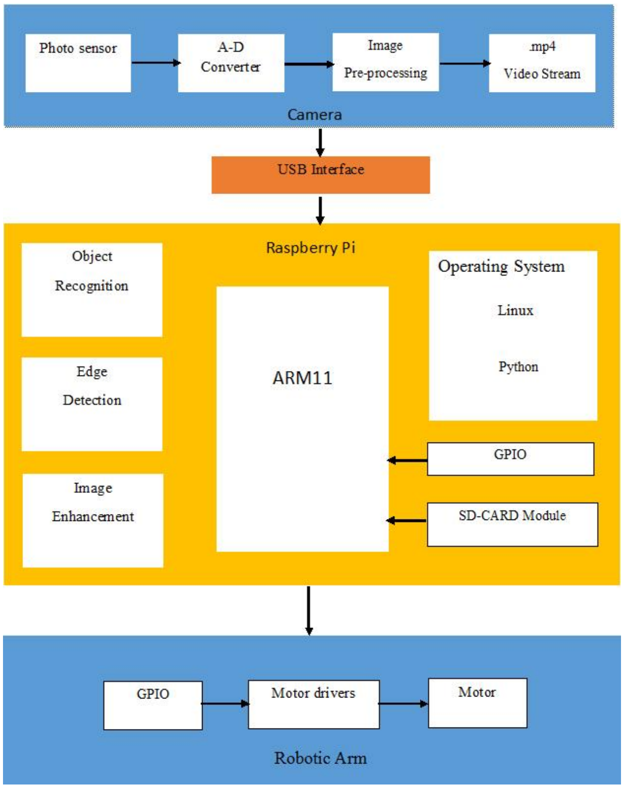


Fig4.1. Block diagram.

5. WORKING

Camera (Image Acquisition & Pre-processing)

Digital imaging or digital image acquisition is the creation of digital images, such as of a physical scene or of the interior structure of an object.

The term is often assumed to imply or include the processing, compression, storage, printing, and display of such images.

A camera may work with the light of the visible spectrum or with other portions of the electromagnetic spectrum. A still camera is an optical device which creates a single image of an object or scene, and records it on an electronic sensor or photographic film. All cameras use the same basic design: light enters an enclosed box through a converging lens and an image is recorded on a light-sensitive medium. A display, often a liquid crystal display (LCD), permits the user to view scene to be recorded and settings such as ISO speed, exposure, and shutter speed.

A movie camera or a video camera operates similarly to a still camera, except it records a series of static images in rapid succession, commonly at a rate of 24 frames per second. When the images are combined and displayed in order, the illusion of motion is achieved.

Image Processing Unit

Image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image.

Several techniques are used to manipulate digital images. Some of them are image segmentation, edge detection, noise filtering, object detection, etc. These techniques assist us in approximation of movement of the human hand.

The processing unit used by this system is Raspberry Pi minicomputer. The Raspberry Pi supports floating point operations required in image processing techniques and algorithms.

The Raspberry Pi also has a PWM module for efficient motor control.

Robotic Arm

A robotic arm is a mechatronic system. Mechatronic**s** is a multidisciplinary field of engineering that includes a combination of systems engineering, mechanical engineering, electrical engineering, telecommunications engineering, control engineering and computer engineering. The robotic arm will employ elements from mechanical and electronics engineering. The design is based on actual model of a human hand.

The motors will facilitate the movements of the hand elements according to the images captured and processed by the preceding modules.

The motors are driven by motor driver ICs for enhanced control and precision.

Python

Python is a widely used general-purpose, high-level programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. The language provides constructs intended to enable clear programs on both a small and large scale.

Python supports multiple programming paradigm including object-oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library.

Python has a support for a computer vision library called the **OpenCV.** This library supports basic and advanced image processing and computer vision functions

6. APPLICATIONS

The main application of such a system is a human like interface in remote areas. Hazardous environments like outer space, coal mines etc. demand a human like precision which can be provided by our system.

It can provide a hassle free and truly augmented reality experience to game users or exponents of advanced human-computer interaction. A complicated medical procedure requires great precision and accuracy. But it can get ruined due to unavoidable human errors. Our system can eliminate such errors by removing shivering of hands in human surgeons. The surgeons can direct the hand which can carry out the procedure without shivering, thus eliminating the unavoidable errors.

7. CHALLENGES AND DRAWBACKS

The main advantage of using such a system is that it leads a better human-computer interface (HCI). Computer vision is generally thought of as a high level operation requiring advanced processing power. So using an embedded system like Raspberry Pi, the high cost overhead is eliminated. The Raspberry Pi gives the same processing ability as a general purpose machine with considerably less cost. Computer Vision encompasses a broader field of image processing thus moving away from conventional human-computer interaction techniques and making the system act smartly. The robotic hand also features an ergonomic design.

The main disadvantage of the system is complicated design. The design involving the hand and its interfacing with the Raspberry Pi involves considerable complexity. The system is also vulnerable to the lighting conditions. A dimly lit hand might be hard to recognize because of the limited ability of the image acquisition apparatus. Therefore a well-lit environment is also a necessary prerequisite in image acquisition. Therefore the main shortcoming is a complex design.

8. CONCLUSION

By implementing this idea, robotic hand imitates the hand movements in real-time. The robotic hand movements are expected to be precise and accurate. The system is also expected to be adaptable with different input parameters. The Raspberry Pi is expected to perform the image processing algorithms in a very short time so as to keep the system as real-time as possible.

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BIOGRAPHIES

Prof.Priti Shende, Working as an Assistant Professor at E&TC Department in Dr D.Y.Patil Institute of Engineering and Technology, Pimpri from 27-11-2001.Total Teaching experience of 15 years in same institute. Total 4 paper published, 2 international and 2 national. Attended several workshops.

Varun Sakpal, born in 1995, in Maharashtra, India. Pursuing BE in Electronics and Telecommunication Engineering from Dr.D.Y.Patil Institute of Engineering and Technology, Pimpri. His areas of interest are Embedded systems, AI, Programming Langauages & computer networks.

Rahul Pareek, born in 1994, in Maharashtra, India. Pursuing BE in Electronics and Telecommunication Engineering from Dr.D.Y.Patil Institute of Engineering and Technology, Pimpri. His areas of interest are Embeded systems, AI, Operating Systems & computer networks.

Deep Bhatt, born in 1994, in Maharashtra, India. Pursuing BE in Electronics and Telecommunication Engineering from Dr.D.Y.Patil Institute of Engineering and Technology, Pimpri. His areas of interest are Embedded systems , AI, Image Processing & computer networks.