International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

A Prosthetic Hand for Compliance of Human Finger

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Abstract— A loss of hands implies negative psychological and emotional consequences on the person and to those around him or her. Due these difficulties they are unable to perform daily routine work, to overcome these difficulties an assistive hand that supports human hand activities is suggested. This research takes into account all tendons in terms of servomotors and sensors that relates to their varying moment during motion. This mechanism simulates the compliance of human finger so that exoskeleton could realise comfortable and stable grasping. Human finger has intrinsic character about variable compliance. So it is necessary to simulate variable compliance. The proposed system synchronizes human finger motion when power support is not necessary so that human finger could move as if it wore nothing.

Keywords- Prosthetic Hand; Degree of freedom; Servomotor

I. INTRODUCTION

National Health Interview Survey (NHIS) published by Vital and Health Statistics anticipated that one out of every 200 people has an exclusion [1]. One in every 2,000 new born babies will have limb deficiency and over 3,000 people mislay a limb every week. The projected number of people living with limb exclusion will become 3.6 million around the year 2050. In the past several decades, prosthetic hands have been developed by various researchers in various fields. The human hand reproduction with its various functions, appearances, visibility, and weight has become a challenging task now days. Out of recent developments of biomedical, the ergonomic and robotic fields, models of human hand are of great importance. Force and moment balance are important parameters for stable grasping. Since the shape of target object is unknown as well as grasping points is not fixed, compliance of fingertip becomes crucial for stability. The compliance in orthogonal direction is equally important to that of grasping force.

II. BIOMEDICAL MODEL FOR INDEX FINGER

This model is constructed to predict the muscle and tendon forces used while grasping. Hand functions can be divided into two categories i.e. hand immobilizes as an object and other is an object manipulated in the hand. Both static and dynamic analysis of force in the hand need to be focused. The kinematic skeleton of the human finger can be mathematically approximated as ideal revolute joints connected by rigid links. The two interphalangeal joints proximal (PIP) and distal (DIP), are described as hinge joints are capable of flexion and extension. The metacarpophalangeal joint (MP) is a saddle joint capable of both flexion - extension and adduction motions. Every finger in the hand is controlled by no less than six muscles, nine maximum in the fifth and seven in the index finger.

Kinematics is the study of geometry in motion and is restricted to a motion by networks. The strength of the finger is dependent upon the anatomical structure and the maximum effort of each individual muscle involved. A three dimensional model is used to analyze the forces at all three finger joints during tip lateral and ulnar pinch and during grasp.

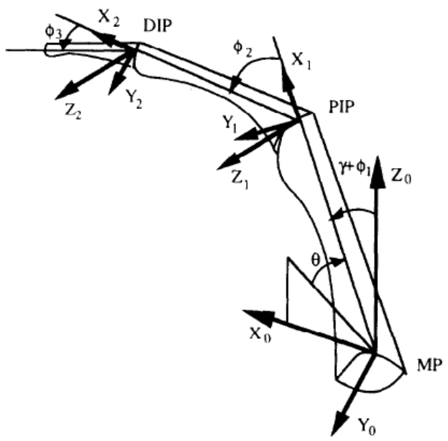

Figure 1. Mechanical assembly of index finger

III. SYSTEM DESCRIPTION

Human hand in the proposed system has vast range of generating force from pinching a small and lightweight object to large force control such as grasping a heavy object. It is designed using LPC1769 ARM Cortex M3 board. This process works on the principle of interfacing servos and sensor. The wireless camera is mounted on prosthetic hand which will keep sending live video to PC kept at control room. Matlab code will read this live video and send it through series of operations like segmentation, RGB to hue, saturation value (HSV) conversion, thresholding. Then the centroids is traced which will recognize the command for object holding. This command is send by serial port where in the control circuitry will interpret the value in relation with force getting exerted on object that is to hold. Size of finger is about 20mm. It consists of 180 degree motion with clockwise and anticlockwise rotation. Its structure would resemble to that of our first finger in size and motion criteria as shown in Figure 1. LPC1769 ARM Cortex M3 board is used as control circuitry. Different parameters such as force, PWM width, and angle of deflection are considered.

A. CAMERA

The high quality ¼ CMOS sensor is key device. Effective pixels are 480K interpolated by 8M pixel still image and 4M pixel video. It consists of 6 LED's for night vision, with brightness controller. Video Effects consist of 10 photo frames and 16 special effects.

The specifications are as follows:

- Video Resolution: 2304 x 1728 pixels – 4MP
- Image Resolution: 3264 x 2448 pixels – 8MP
- Frame rate: 30 frames per second
- Color Depth: 24 Bit true color
- Focus: 5cm to infinity
- Built-in high sensitive USB microphone
- Bulit-in snap shot button

Figure 2. USB webcam

B. FORCE SENSITIVE RESISTOR 0.5

This is a force sensitive resistor with a round, 0.5" diameter, sensing area. This FSR will vary its resistance depending on how much pressure is being applied to the sensing area. The harder the force, the lower the resistance. When no pressure is being applied to the FSR its resistance will be larger than 1MΩ. This FSR can sense applied force anywhere in the range of 100g-10kg. Two pins extend from the bottom of the sensor with 0.1" pitch making it bread board friendly. There is a peel-and-stick rubber backing on the other side of the sensing area to mount the FSR. These sensors are simple to set up and great for sensing pressure, but they aren't incredibly accurate. Use them to sense if it's being squeezed, but you may not want to use it as a scale. The dimensions are as follows:

- Overall length: 2.375"
- Overall width: 0.75"
- Sensing diameter:0.5"

Figure 3. Force sensitive resistor

C. SERVOMOTOR

A servo is mechanical device that can be instructed to move the output shaft attached to the servo wheel or arm to a specified position. DC motor is inside the servo box which is mechanically linked to position feedback potentiometer, gear box, electronic feedback control loop circuitry and motor drive electronic circuit.

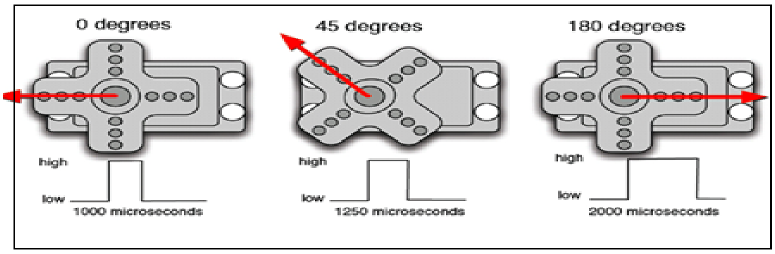

Figure 4. Force sensitive resistor

The RC servos are controlled using pulse width signals (PWM) from external electronic device that generates PWM signal values. These signals sent to servo are translated into position values by electronic inside servo. When servo is instructed to move the on board electronic converts PWM signal into electrical resistance value and DC motor is turned on. The servomotor used is as follows:

- Operating Voltage:4.8V-6.0 V
- Operating Speed: 0.12sec/60 degrees
- Output Torque: 1.6kg/cm 4.8V
- Dimensions: 21.8× 11.8 ×22.7mm Weight: 9gm

IV. EXPERIMENTAL DETAILS

The camera is the key input device of the system. This Wireless Camera is mounted on prosthetic hand which will keep sending live video to PC kept at control room. Matlab code will read this live video and send it through series of operations like segmentation, RGB to HSV conversion, thresholding. Desired image is acquired by obtaining centroids thereby generating command for object holding. The resulting command is used as inputs to the microcontroller and is converted to digital ones by analog comparator embedded in the microcontroller .Those signals are then amplified, and pass them to a high resolution analog to digital converter.

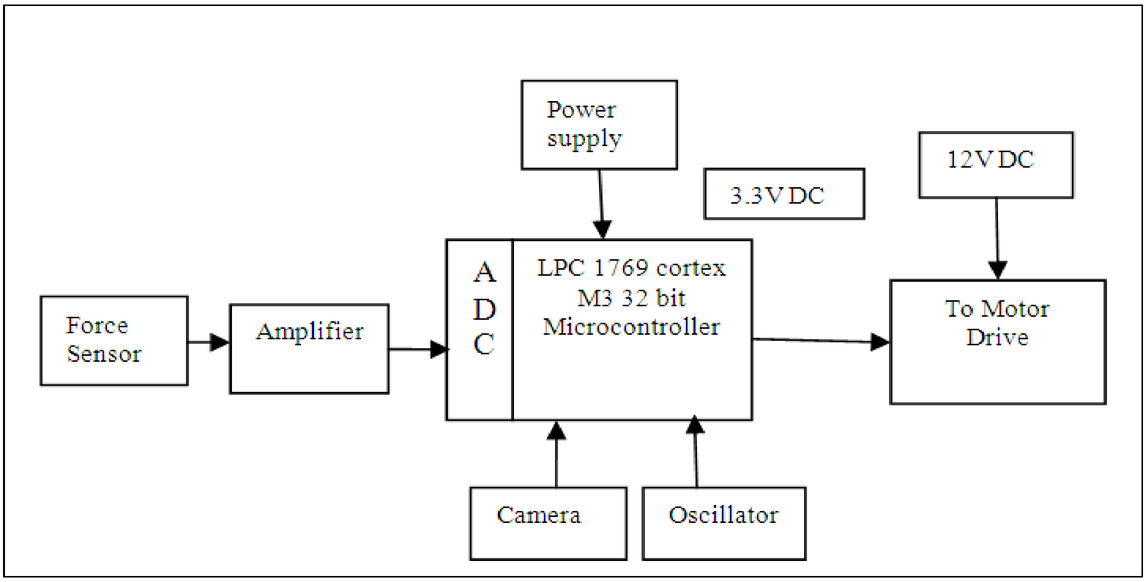

Figure 5. Block diagram

The ADC then outputs the signals over a serial peripheral interface (SPI) to the microcontroller. According to the digital signals, the program built in the microcontroller can make precise decisions and then output PWM signals to control the R/C servomotor to drive the prosthetic hand.

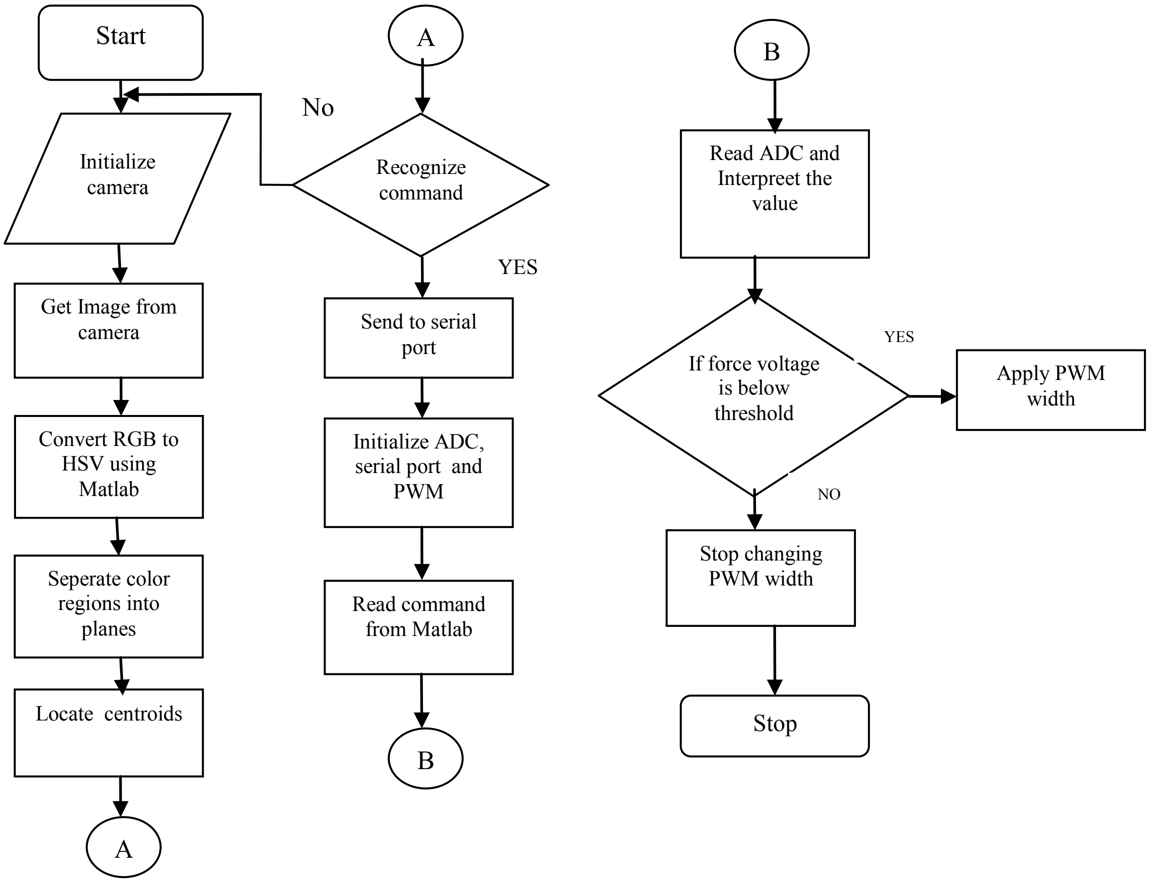

Figure 6. Flow chart

Thresholding selects upper and lower range for each image channel .It parttitions the image into foreground and background.These ranges determine binary image. The three planes are anded together to produce output image from tool. If the intensity of grey level at each point (x, y) of the given image is viewed, the mass of (x, y) can be used to determine the centroids. This can be done by calculating order spatial moments around x axis and y axis and the 0^{th} order central moment of the binary image. The 0^{th} order central moment of the binary image is equal to white area of image in pixel.

- X co-ordinate of position of centre of object = First order spatial moment around x axis / 0^{th} order central Moment
- Y co-ordinate of position of centre of object = First order spatial moment around y axis / 0^{th} order central Moment

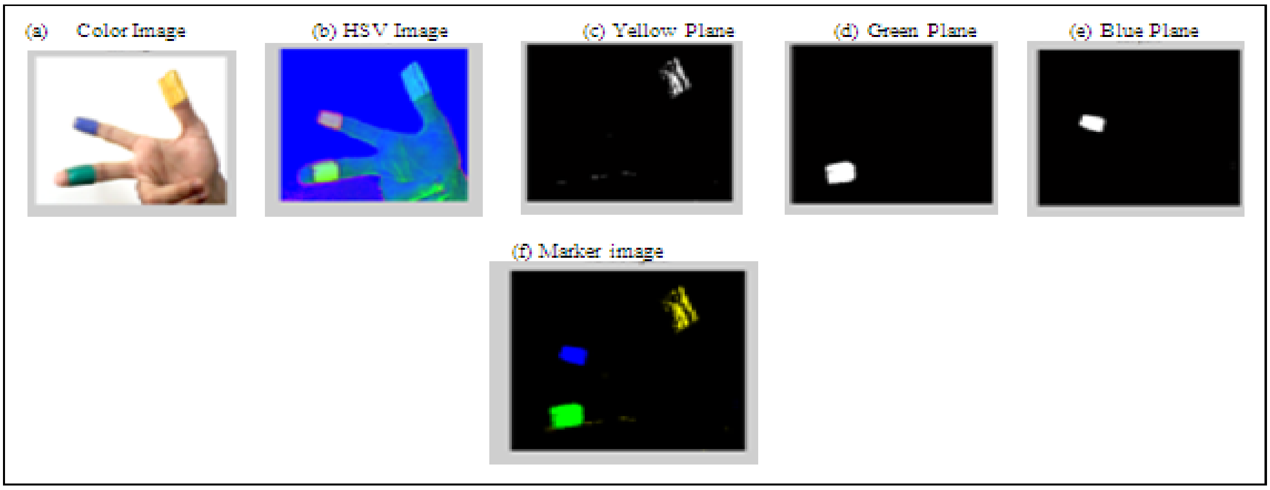

Figure 7. Image plane

V. RESULTS AND DISCUSSIONS

The proposed system consists of camera driven mechanism for holding and grasping of an object. Color vision can be processed using RGB color space or HSV color space. HSV color model is preferred in the situations where color description plays an integral role. HSV describes image using familiar comparison such as color, vibrancy and brightness. Hue represents color, saturation represents vibrancy and value represents brightness of color.

VI. CONCLUSIONS AND FUTURE SCOPE

The proposed technique performs segmentation and decomposes RGB into HSV .Then these results are combined whose centroids can be used for recognizing the command for holding the object. This command is applied through serial port to microcontroller will which turn on PWM to rotate motor. The future work includes developing a system that supports grasping force that is proportional to human grasping force which synchronizes with human finger motion. The wireless system or personal computer can be used to simulate variable compliance so that grasping stability and dexterity is conserved.

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