THERMAL IMAGING-ASSIST HAND

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ABSTRACT

The world is full of master slave Telemanipulator where the doctor's masters the console and the assessment arm perform the operations, i.e. these robots are passive robots, what the world needs to focus is that in use of these passive robots we are acquiring doctors for operating these console hence the utilization of the concept of robotics is still not fully utilized ,hence the focus should be on active robots , THERMAL IMAGING-ASSIST HAND use the similar concept of active robotics where this anthropomorphic hand focuses on the autonomous assist and scanning operation. Fingers of TI-AH (THERMAL IMAGING-ASSIST HAND) will work as a transducer as well as a actuator i.e. it will have tactile, force, pressure sensor rooted to it so that the mechanical mechanism of force, pressure and physical presence on the external subject can be maintained, conversely our main focus is on the concept of "blue print of biorobt, scanning and assist performed through it".

Keywords: Bio-robot, Dexterity, Grasp, Thermal imaging

1. Introduction

The recent evolution of robots in medical field is a prime e.g. of the depth in visions of researchers, the theories were earlier limited to the research level however the advancement of technology have provided a platform to represent the theory in clinical application, however to understand newly developed devices initial layout and theory's plays a very important role hence, I introduce a theory and layout of multi performing autonomous device named THERMAL IMAGING-ASSIST HAND, the device can be explain by differentiating TI-AH.TI-AH have an autonomous behavior as a system, the device introduced will work without human interference during the procedure of examination procedure, the only involvement by the human will be prior to the procedure and will perform in the boundary limited by the robot. The minimal human involvement is a necessity as "what to do" should be left to the human and "how to do" to the system. Device is autonomous in relative to the functioning, it can be well thought-out as a closed loop system i.e. feedback present, as we know closed loop system provide a better accuracy due to feedback present and are also reliable hence this fits into our explanation of autonomous performance, by feedback we virtually provide the brain to our system i.e. the vision of performing the assessment of low to high proximity on a limited scale with precision and accuracy. "Assessment" means the analysis performed by the bio-robot; the assessment process is possible via Thermal imaging camera , the camera provide a thorough look of the patient and determine the reason of suffering ,there are times when the patient is unknown of the internal injury suffered by him/her hence the artifact have the ability to touch and grasp however the grasping is limited if exceeded then the spikes which are generated via Electro Mayo graph, these generated spike will cause the buzzer of the control device to go ON when the generated spike differ from the average spike noticed in the age group of the patient. "Hand", the system is actually a combination of Prosthetic hand, EMG, ECG, tubes, laser and other externally driven subsystem, However our prime focus is the Humanoid Robotic hand which have the close dexterity and anthropomorphism than the setup used in industry. Our aim is to showcase the exponential growth of medical robot by introducing assessment robot with feature of detecting muscle disorder by sense of touch and illness or diseases via thermal imaging camera and how all they can be done in a form an anthropomorphic hand.

2. Notion of "Hand" in TI-AH

A. Theoretical approach

Human hands is a multi-tasking component of the body enabling us to do various work ranging from minimal to maximum complexity, in order to understand the morphology of human hand and duplicate the functioning and dexterity of human hand in an prosthetic structure, it is important to understand the shape, structure, dof and also the kinetics and kinematics of it in a 3-D space, The actuation finger mechanism, as well as the type of proprioceptive and exteroceptive sensors to be embedded in the mechanical structure have been selected in order to obtain a high degree of anthropomorphism of the prosthetic artifact [1].As we know the fingers of human hand are bounded by skin(sensory receptor) and hence when the sensation are reproduced via brain ,the skin enable the dynamics of hand, we know that the human body is composed of various soft tissue such as ligament, tendons it is important that the tissue does not get damage d , hence to provide a precision control and prevent tissue damage a force control feedback is to be provided as the biorobt is a closed a loop system the hand is en suite with sensor (probably pressure, force) hence feedback is obtained, the ECG or EMG spike is dependent on the reaction of patient ,when the TI-AH performs its assessment, the important phase in the assessment is when the hand which is inherited with a certain limit of exertion of force, however the resistance level of human body vary from age or size hence when the force is exerted on the body which is connected to EMG and ECG via limb/circular/rectangular electrodes develop spikes, however if the force exceeds the elevated heart beat or the sever neuromuscular contraction may lead to elevation in spike than normal , then it will trigger the buzzer to switch to ON state this command will be signaled to the assessment hand to release itself , the execution should be fast and no delay to be present.

B. Mathematical expression

We will understand the mathematical expression of force exertion.

I. FORCE EXERTION[3][4] :

It is important to control the force exerted on the tissue as the tissue may get damage hence the rule which satisfy the theory of force control most is the Kelvin–boltz method [], this is a realistic model which provide necessary disturbance rejection these realistic models were developed as a modification to the elastic model as they were inaccurate in determining control in fast motion as its incapability due to the viscoelastic property of tissue were exposed.

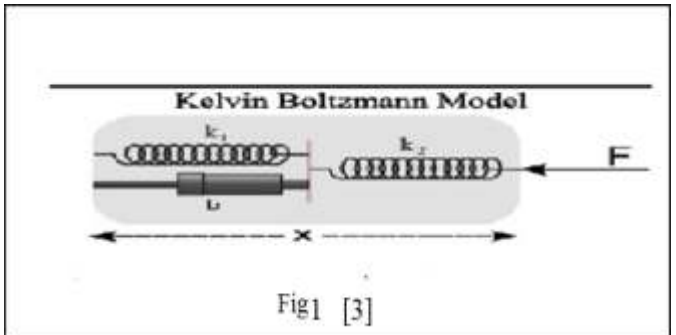

Fig1 [3]

The following test was ex vivo (performed on piece of beef), the following equation came up with the force differential, which gives information regarding transient period.

Equation:-

$$F_e = \gamma \ddot{x} + \beta \dot{x} - \alpha F_e$$

$$\alpha = \frac{b K_2}{K_1 + K_2}$$

$$\beta = \frac{K_1 K_2}{K_1 + K_2}$$

$$\gamma = \frac{b}{K_1 + K_2}$$

Fig 2 [3]

C. Blueprint of TI-AH "Hand"

The design of AS-E hand will be a replica on human hand and will have possibly 15-24 joints and 9 degree of freedom i.e. the finger will be allowed to move up/down, left/right and the thumb will have an extra dof i.e. up/down, left/right, yaw [1][2][5][8]however the difference from the human hand will be in structural part i.e. the human hand normally having 4 fingers and 1 thumb but the TI-AH will have 3 fingers and 1 thumb however the dexterity and anthropomorphism will be maintained ,the less no. of finger enable the assessment hand to have their fingers cover a larger area in 3-d space. The hand composing of under actuated finger is actuated by dc motors. The fingers are composed of 2 one axis joint to connect the phalanx to each other and one universal joint to connect to metacarpal, the thumb has only 1 one axis joint to provide the curl movement this curl movement help to hold substances[1][2][5][8]. The artificial hand is equipped with three incremental encoders (one for each motor), two three-component force sensors (one at the thumb and the other at the index fingertip) and six Hall Effect switches (two on each slider and two on the thumb seizure/adduction mechanism) for the encoder calibration [1].

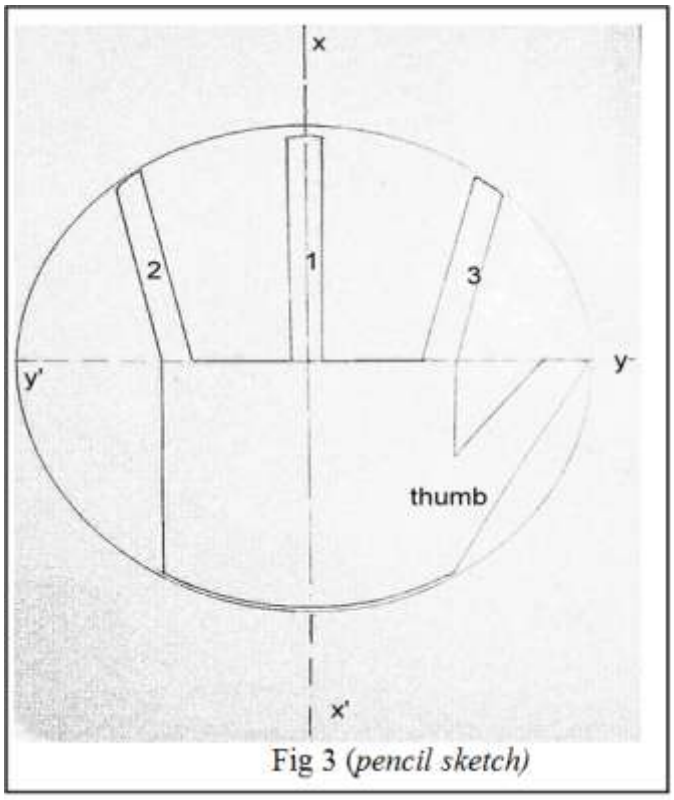

Fig 3 *(pencil sketch)*

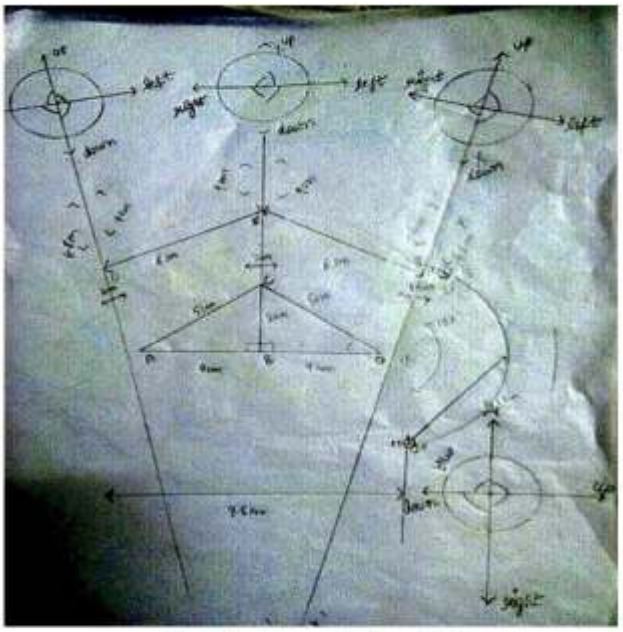

Fig 4 *(pencil sketch)*

The above 2 figure show the mathematical pictorial representation via pencil sketch of the TI-AH bio robot, *the figure depicted and the measurement shown are model to what measurement needs to be taken in the designing of the actual artifact. Fig1 suggest the 3 finger and 1 thumb theory proposed, where the fingers are marked as 1/2/3 ,assume a circle of radius of 9.5cm, an axis is drawn through the first finger which divide the circle in four half, figure 2 shows the measurement part this actually defines the spacing between the 2 distant phalanx, phalanx and thumb, the Triangle ACOBA is actually a combination of 2 right angle triangle, the distance between the axis drawn from the middle of finger 1 and first end of finger 2 is calculated via Pythagoras theorem ,here in the finger the calculated distance between the 2 marked AC 5 cm, also the distance between the axis drawn through the middle of the 2 fingers marked DD` 6 cm ,this gives the idea about the width of individual finger which is 1 cm identical to one another, the length however will not be the same as the finger 1 will play a dominant role, it can be understood that the finger 1 and a thumb play a dual role in grasping and the other 2 finger plays a supporting role ,the finger 1 is of length 9cm from both sides whereas the finger 2/3 will have 7cm and 6.8 cm, hence finger 2 and finger 3 are proportioned. the width of the palm is 9.5cm, the designing and positioning of thumb is by drawing an arc from O which at M and N on finger 3 and when measured from O`yields 168° with respect to finger 3, hence through we measure the distance up to the axis drawn through the centre of the circle, the point M marks the origin of thumb.

Individual finger yields 2 dof (up/down, left/right) and thumb 3 dof (left/right, up/down, yaw) hence the system gives us 9 dof. The thumb has an extra dof and 1 one axis joint solely to provide the hand curl movement. Fig 3 shows the rundown of fig1and fig2, therefore providing us with the blueprint of the ti-ah. "Remember the actual hand will not be mirror image of the figure 3 the figure however establishes the idea of the type of spacing required between the finger and also the position and origin."The human hand perform function such as grasping, sensing, movement and more, similar function this biorobt also do, however to grasp the finger should be aluminum molded i.e. Aluminum Speedal they have a cylindrical shape[1] in order to control and have accuracy for grasp and the contact area with the object. The palm is composed of three components, namely the outside Shell, the inside frame, and the inside shell, all made of carbon fiber. This material conveys high strength and light weight to the structure. Main artificial hand's measured features are as follow [1]:

Weight: 250 gm (palm, three fingers, abduction/adduction

Thumb mechanism with its dc motor) + 70 gm (optional Extra two fingers)/ Maximum cylindrical grasping force: 35 N/Maximum tip-to-tip

grasping force: 15 N/Maximum closing time: 6s, the understanding of the algorithm should be in such a way that the robotic machine respond infinitely fast to the algorithm to avoid delay, as the delay in the movement may result in the hazardous result while the robotic operation take place. Thumb joint abduction/adduction range: 0 - 120 /Finger joint flexion range: 0 –90 .Each finger is actuated by one dc motor (1727 006C FAULHABER with IE2-512 encoder and 16/7 14:1 gearbox) Located in the forearm, which pulls a cable through a linear slider connected to the motor through a lead screw .Controlling and driving the device has an estimated total weight of about 600 gm. [1] [4] [5]. It is worth for noticing that the overall weight of the hand plus forearm modules is below 1000 gram, which is an acceptable value for both prosthetic and robotic applications.

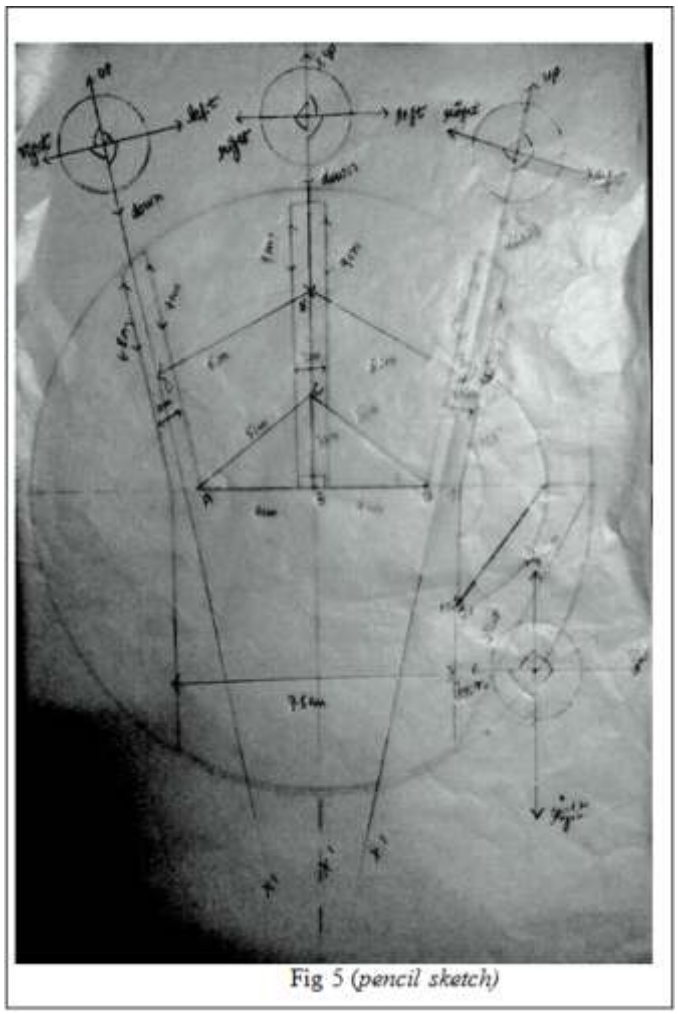

Fig 5 (*pencil sketch*)

D. Outline of grasping "TI-AH"

The artificial artifact resembling to human hand has three phalanxes and two dof, motion of one phalanx is directly coupled the second phalanx, hence the finger cannot use all its phalanxes to exert force when the object is up for grab therefore to understand the theory of grasping by exertion of force by finger with the phalanx present having two dof, a quasi-static model was theorized [6] [7] [8] [9].

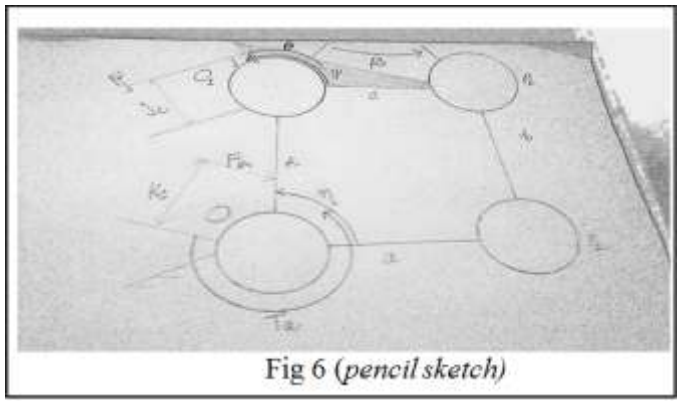

Fig 6 (*pencil sketch*)

The figure provide the relation between the input actuator Torque and the forces exerted on the object

Input and the output virtual powers, one obtains

$$t^{T}\omega_a = f^{T}v \quad [7]$$

"t" is the input torque vector exerted by the actuator and the spring.

" a" is the corresponding velocity vector

≈FΔis the vector of contact forces,

≈vΔis the velocity of the contact points projected onto the respective normal of the phalanxes. However Contact forces are assumed to be normal to the phalanges and without friction. The theory explained that the projected velocities of the contact points can be simply expressed as the product of a Jacobian matrix JT and the derivatives of the phalanx joint coordinates

$$v = J_T \Theta \quad [7]$$

Through differential calculus, one can also relate vector a
To the derivatives of the phalanx joint coordinates defined previously with an actuation Jacobian matrix JA.

Hence $\Theta = J_A \, a$.

Finally, one obtains which was the equation established to provide a practical relationship between the actuator torques and contact forces.

$$f = \{J_T^{-T} J_A^{-T}\} * t \quad [7]$$

This theory is supportive for proceedings in our layout of ≈tiahΔas the autonomous hand will perform the function of grasping and this function should be precise and accurate as it will be performed on human, here the concept of force exertion i.e. kelvin-boltz method work in partnership with the quasi static model ,hence we could now analyze the force exerted by the finger when it comes in contact with the human subject to determine the unnoticeable pain suffered by the subject, the exertion of force will be by a finger with three phalanx and two dof.

3. Understanding the Thermal imaging camera:-

Infrared thermography can help in detection of elevated body temperature when a person is suffering from illness[10][11] and also when a person have any internal tissue damage or muscle tear which cannot be detected externally it can be observed via infrared thermography as it show a deviation in color i.e. it display a temperature change. To understand more we consider a e.g. of airport where thermal imaging camera are rooted with security system, it scan individual passing the security checks and the observer is observing through real time image display on the computer whenever it detect any elevated body temperature or abnormal behavior of human body then a buzzer is triggered by the observer, to separate the suffering patient from the queue for further examination, consequently we use this theory in thermal imaging assist hand whereas the name suggest the system will have the thermal imaging camera inherited to the system hence perform a thorough scan of human body and help in detection of illness by feeding a real time image to screen , on the other side the hand which consist of both robotic grasp will perform its own function and will help in determining unnoticeable pain , whereas the internal activity of muscle can be seen through feed provided by the thermal camera. The thermal imaging camera is inbred with ATC feature which in addition to calculating relative temperature readings, it automatically adjusts the generation of visible and audible alarms, thereby greatly improving the screening reliability. It is important to understand that for a precise result it is recommended that subjects and camera should be at a fixed distance. In general, a distance of 1 to 1.6 meters away from the camera lens allows the entire scan and hence provides image display [11].

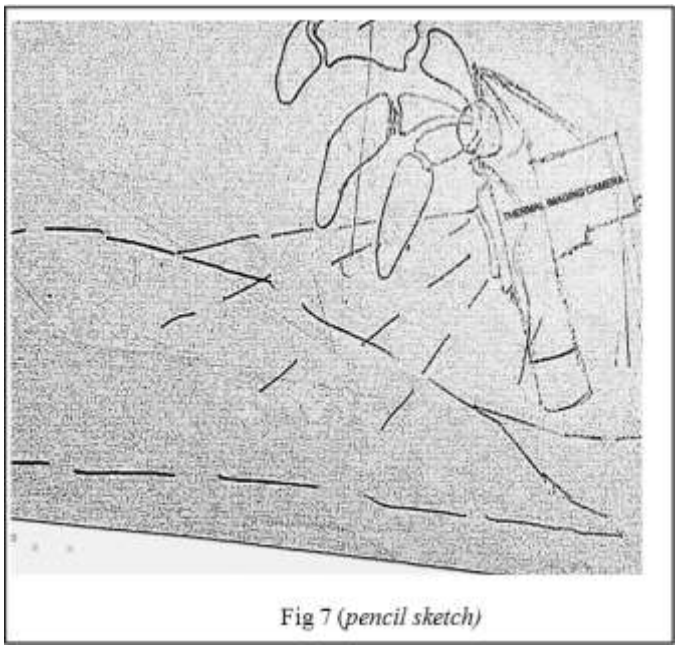

Fig 7 (*pencil sketch*)

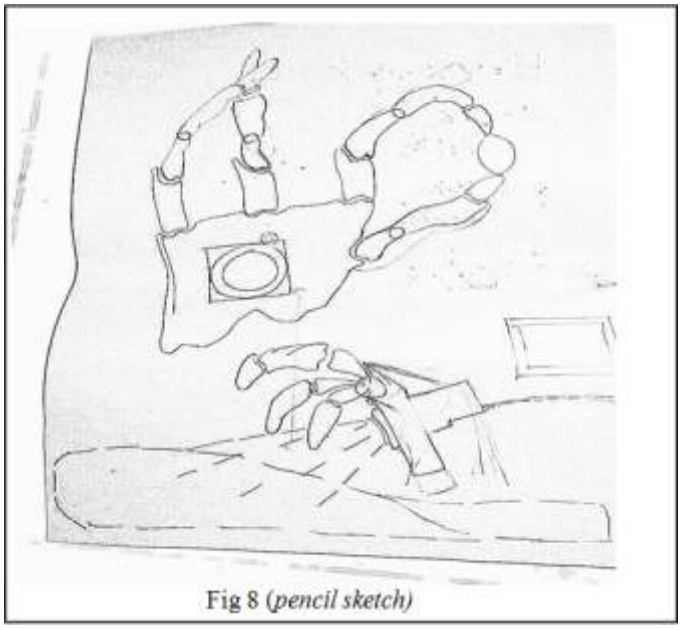

Fig 8 (*pencil sketch*)

4. Present Scenario:-

If we consider present situation in which a lot of time is taken in procedure of determining diseases, muscle disorder hence by TI-AH we can cut short the time taken also it exceeds the growth of the concept of bio-robot and there autonomous behavior as in present situation for even a mild checkup we require a doctor, hence why not gives this opportunity to an artificial artifact which can detect and analyze the unnoticeable disease. Current situation in which lots of doctor is channelized in mild complex challenges can be reduced via TI-AH.

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