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An Approach towards Dactylology with Motor Controlled Artificial Arm

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ABSTRACT: One particular application of gesture-based systems is to implement a speaking aid for the dumb. For this to happen, it requires modelling of a dactylological artificial hand by incorporating study of the hand movement for the dumb people. In this aspect the Finger and Wrist position with Degrees Of Freedom (D.O.F) is calculated, the prototype model representation of the dactylological artificial hand is done .The different positions of the motors in the hand is shown for letters and numbers, the motor movement database for generating any signal is attached. The driving Algorithm and the process flow graph for the stepper motor controlled artificial hand is implemented .This attempt would provide flexibility in communication with the dumb people who are not capable to communicate with the physical world verbally. Moreover, an attempt is taken on furnishing the hardware implementation of producing an ideal Dactylological Artificial hand which tends to be a pre-innovative work in the varied field of artificial intelligence.

KEYWORDS: Dactylology, Displacement Angle, D.O.F., Step Angle and Stepper motor.

I. INTRODUCTION

The term DACTYLOLOGY mainly belongs to the science of manual sign language, as for use in communicating with deaf Dactylology [1] (or finger spelling) is the presentation of letters of a writing System and sometimes numeral system using only the hands. These Manual alphabets have been used in deaf education and subsequently been adopted as a distinct part of a number of sign languages around the world. In Greek, Roman and Assyrian [2] countries, the body and Hands are used to represent alphabets and certainly finger calculus System was widespread. Later on, European monk shave made use of Manual communication including alphabetic gesture[3]. Our main aim of having a MECHATRONIC arm is for sign languages that is frequently used by deaf and dumb people so that they can make conversation . The mechanical hand that has been build on features like naturally Complaints fingers and thumbs and a variety of grip patterns for Versatility and unrivalled performance. It can independently actuate each finger and can realize fundamental motions, such as holding, Grasping and communication as well. This article includes a precise study on finger and wrist position with D.O.F., prototype model representation of dactylology represented artificial arm Dactylology representation with motor controlled arm database, driving algorithm with process flowchart, and a pictorial representation of human artificial arm.

II. STUDY ON FINGER AND WRIST POSITION WITH DOF

A. Study on Finger Position with DOF: Human finger are made with 3 parts, which Attached with 2 joints. Each part can be moved maximum 90 º clockwise. The position of each part after 90° rotation is shown below:

STEP 1:

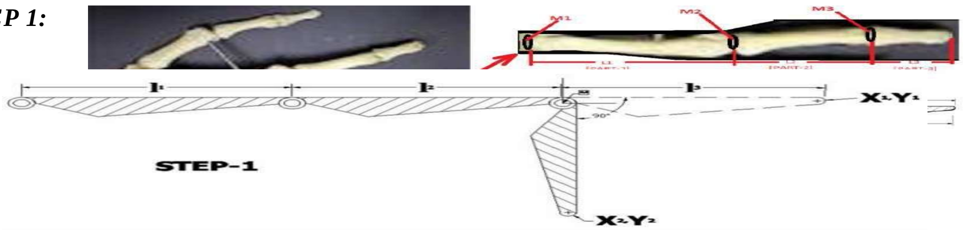

Fig 1: ***Finger Position with DOF***

In this step"part3" is rotated 90º clockwise & change it's Position from (X1, Y1) to (X2, Y2), when coordinate at M3 position. In that caseX1=L3, Y1=0&Ø=90º.In this step remaining Parts are fixed.
Mathematically:

$$\begin{bmatrix} x1 \\ y1 \\ 1 \end{bmatrix} = R12$$

$$\therefore \; R12 = \begin{bmatrix} cos\phi & -\sin\phi & 0 \\ sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} x2 \\ y2 \\ 1 \end{bmatrix} \qquad (1)$$

$$= \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} L3 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -L3 \\ 1 \end{bmatrix}$$

$\therefore X2=0$

$Y2= -L3$

STEP-2:

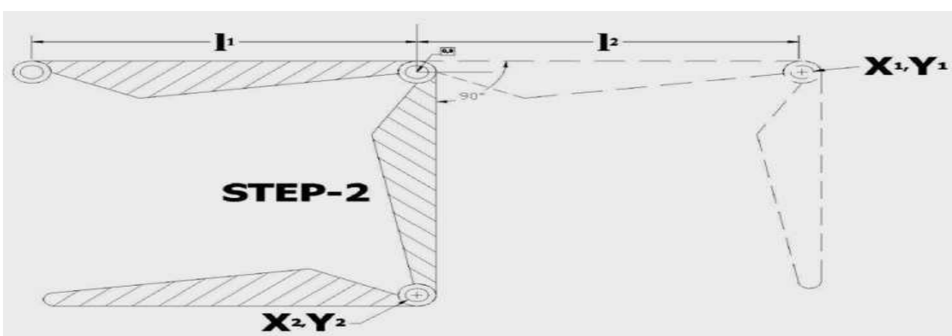

Fig 2: ***Finger Position after 90º clockwise rotation at M2 position***

In this step"part2"is rotated 90º clockwise & change it's Position from (X1,Y1) to (X2,Y2),when coordinate at M2 position[5].In that caseX1=L2,Y1=0&Ø=90º.In this step remaining Parts are fixed.Though'part3'moves its position, because Mathematically:

$$\begin{bmatrix} x1 \\ y1 \\ 1 \end{bmatrix} = R12$$

$$\therefore\ R12 = \begin{bmatrix} cos\phi & -\sin\phi & 0 \\ sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} x2 \\ y2 \\ 1 \end{bmatrix} \qquad (2)$$

$$= \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} L2 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -L2 \\ 1 \end{bmatrix}$$

$\therefore X2=0$

$Y2= -L2$

STEP 3:

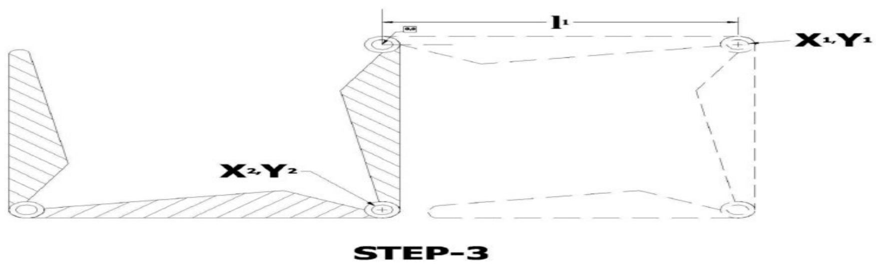

Fig 3: ***Finger Position after 90º clockwise rotation at M1 position***

In this step "part 1" is rotated 90º clockwise & changes its Position from (X1, Y1) to (X2, Y2), when coordinate at M1 position. In that caseX1=L2, Y1=0&Ø=90º.In this step remaining Parts are fixed.Though'part3'&'part2'moves its position, because it's attached with'part1' by M3 & M2 respectively.

Mathematically:

$$\begin{bmatrix} x1 \\ y1 \\ 1 \end{bmatrix} = R12$$

$$\therefore\ R12 = \begin{bmatrix} cos\phi & -\sin\phi & 0 \\ sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} x2 \\ y2 \\ 1 \end{bmatrix} \qquad (3)$$

$$= \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} L1 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -L1 \\ 1 \end{bmatrix}$$

$\therefore X2=0$

$Y2= -L1$

B. Study on Wrist Position with DOF : In a human hand wrist can move palm up & down Artificial robot hand can move its 45º up & 45º down. The position after changing is show in below:

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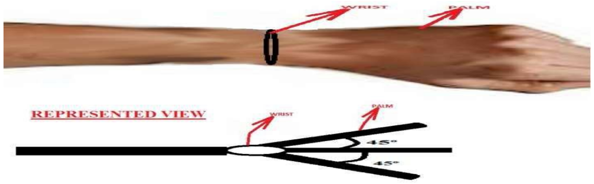

Fig 4: ***Wrist Position with DOF***

STEP 1: In this step palm is moved by wrist, upward Direction in 45º.In this case palm position can change from (X1, Y1) to (X2, Y2), when coordinate at the position of wrist.

Mathematically:

$$\begin{bmatrix} x1 \\ y1 \\ 1 \end{bmatrix} = R12$$

$$\therefore\ R12 = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} x2 \\ y2 \\ 1 \end{bmatrix} \qquad (4)$$

$$= \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & 0 \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} L1 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} L1/\sqrt{2} \\ L1/\sqrt{2} \\ 1 \end{bmatrix}$$

$$\therefore X2 = L1/\sqrt{2}$$

$$Y2 = L1/\sqrt{2}$$

STEP-2: In this step palm is moved by wrist, upward Direction in 45º.In this case palm position can change from (X1, Y1) to (X2, Y2), when coordinate at the position of wrist.

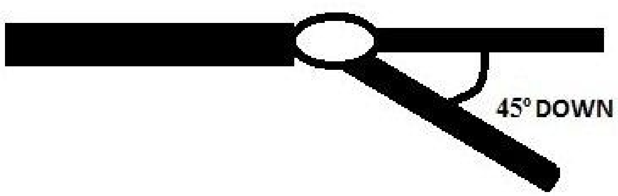

Fig 5: ***Wrist Position with upward Direction in 45º***

Mathematically:

$$\begin{bmatrix} x1 \\ y1 \\ 1 \end{bmatrix} = R12$$

$$\therefore\ R12 = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} x2 \\ y2 \\ 1 \end{bmatrix} \qquad (5)$$

$$= \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ -1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} L1 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} L1/\sqrt{2} \\ -L1/\sqrt{2} \\ 1 \end{bmatrix}$$

$$\therefore X2 = L1/\sqrt{2}$$

$$Y2 = -L1/\sqrt{2}$$

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III. PROTOTYPE MODEL REPRESENTATION OF DACTYLOLOGY REPRESENTED ARTIFICIAL ARM

The artificial hand is configured by using a PIC microcontroller & a special kind of motor that is called the Stepper Motor. In this Exploration Fifteen (15) Stepper Motors [5] of Different Classes at Different Joints are used. [A Stepper Motor is an Electromechanical Device which converts Electrical Pulses into Discrete Mechanical Movements. The Speed of the Motor Shaft Rotation is Directly Related to the Frequency of the Input Pulses and the Length of the Rotation is Directly Related to Number of Input Pulses Applied. There are Three Types of Stepper Motors 1.Variable-Reluctance (VR) 2. Permanent-Magnet (PM) 3.Hybrid (HB)] Hybrid Motor (Stepping Angle=3.6 to 0.9 degree &100 to 400Steps/Revolution) is used for the Major Joint like Wrist [Carpomrtacarpal Joint] because it is very Expensive & Powerful. And for the Minor Joints like the Joints of the Finger, the Permanent-Magnet Motors (Stepping Angle=3.6 to0.9 degree & 48 to 24Steps/Revolution) are Used, this Type of Motors are comparatively cheaper. There are several modes of operation of the Stepper Motor. The following are the most common deriving modes-1.WaveDrive (1Phaseon) 2.Full Step Drive (2Phaseson) 3.Half Step Drive (1&2Phases on) 4.Microstepping (Continuously Varying Motor Current) [6]

A. *Mathematical Analysis of Step and Displacements angle of Stepper Motor:*

The Step Angle and Displacement Angle of the Stepper Motor Could be calculated by the following formulas. The Step Angle =360/(N*P)= 360 /N[where, N=N*P]Where, N Number of Equivalent Poles Per Phase= Number of Rotor poles . P Number of phases. N=Total Number of Poles for All Phases Together[10].The Displacement Angle= (Z/2*Pi)*Sin (T/T) [where Pi=3.14] Where=Rotor Tooth Pitch .T=Load Torque. T=Motor's Rated Holding the Position of the Stepper Motors with their corresponding Position are Tabulated Below. [8]

TABLE I: Name of the Motors with their Position

SERIAL NUMBER	NAME OF THE MOTOR	POSITION OF THE MOTOR IN HAND	TYPE OF THE MOTOR	RANGE OF ANGLE(Degree)
1.	M_0	Wrist[Carpomrtacarpal Joint]	Hybrid(HB)	0-180
2.	M_1	Thumb[Interphalenjal Joint]	Permanent Magnet(PM)	0-90
3.	M_2	Thumb[Proximalinterphalangeal Joint]	Permanent Magnet(PM)	0-90
4.	M_3	Index[Metacarpophalenges Joint]	Permanent Magnet(PM)	0-90
5.	M_4	Index[Proximalinterphalangeal Joint]	Permanent Magnet(PM)	0-90
6.	M_5	Index[Distalinterphalengeal Joint]	Permanent Magnet(PM)	0-90
7.	M_6	Middle[Metacarpophalenges Joint]	Permanent Magnet(PM)	0-90

A. *Methodology of the total Dactylological system:*

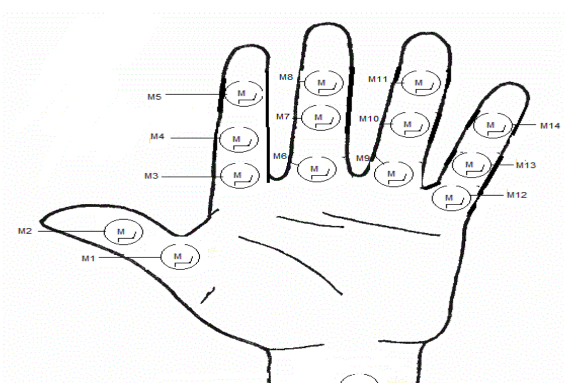

Fig 6: ***Position of Different motors in the Hand***

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From the PIC Microcontroller terminals are taken out, these terminals are connected with the port selection block, which selects the ports of the PIC Microcontroller as per the requirement. The Stepper Motors at Different Positions in the hand[4] are connected with the port selection block through the Interfacing Device. Two Different power supplies are connected with Interfacing Device and Microcontroller. A Ground connection is taken out from the PIC Microcontroller. If the translator is used, it is possible to translate text into gestures that a hearing impaired can understand[11].

III. DACTYLOLOGY REPRESENTATION WITH MOTOR CONTROLLED ARM DATABASE

To generate any particular signal, the angle of rotation of the Stepper motors could be thoroughly understood from the following database and the signal jesters are also depicted. [9]

TABLEII: DATABASE OF DRIVING MOTOR MOVEMENT FOR DACTYLOLOGY

1	Hand Position	Hand Picture	Rotation													
2																
3			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
4																
5	A		0	0	90	90	90	90	90	90	90	90	90	90	90	90
6	B		90	0	0	0	0	0	0	0	0	0	0	0	0	0
7	C		0	0	0	90	0	0	90	0	0	90	0	0	90	0
8	D		0	90	0	0	0	0	90	90	0	90	90	0	90	90
9	E		90	0	0	90	90	0	90	90	0	90	90	0	90	90
10	F		0	0	0	90	90	0	0	0	0	0	0	0	0	0
11	G		0	0	0	0	0	90	90	90	90	90	90	90	90	0
12	H		90	0	0	0	0	0	0	0	0	90	0	0	90	0
13	I		90	90	90	90	90	90	90	90	90	90	90	0	0	0
14	J		90	90	90	90	90	90	90	90	90	90	90	90	0	0
15	K		0	0	0	0	0	0	0	0	90	90	90	90	90	90
16	L		0	0	0	0	0	90	90	90	90	90	90	90	90	90
17	M		0	90	90	90	0	90	90	0	90	90	0	90	90	0
18	N		0	0	90	90	0	90	90	0	90	90	0	90	90	0
19	O		0	0	0	90	0	0	90	0	0	90	0	0	90	0
20	P		0	0	0	0	0	90	0	0	90	0	0	90	0	0

1	Hand Position	Hand Picture	Rotation													
2																
3			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
14	J		90	90	90	90	90	90	90	90	90	90	90	90	0	0
15	K		0	0	0	0	0	0	0	0	90	90	90	90	90	90
16	L		0	0	0	0	0	90	90	90	90	90	90	90	90	90
17	M		0	90	90	90	0	90	90	0	90	90	0	90	90	0
18	N		0	0	90	90	0	90	90	0	90	90	0	90	90	0
19	O		0	0	0	90	0	0	90	0	0	90	0	0	90	0
20	P		0	0	0	0	0	90	0	0	90	0	0	90	0	0

21	Q		0	0	90	0	0	90	90	90	90	90	90	90	90	90
22	R		90	90	90	0	0	0	0	0	90	90	90	90	90	90
23	S		90	90	90	90	90	90	90	90	90	90	90	90	90	90
24	T		0	90	90	90	90	90	90	90	90	90	90	90	90	90

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25	U		0	90	0	0	0	0	0	0	0	90	90	90	90	90
26	V		0	90	0	0	0	0	0	0	0	90	90	90	90	90
27	W		0	90	0	0	0	0	0	0	0	0	0	0	90	90
28	X		90	90	0	90	90	90	90	90	90	90	90	90	90	90
29	Y		0	0	90	90	90	90	90	90	90	90	90	0	0	0
30	Z		90	90	0	0	0	90	90	90	90	90	90	90	90	90
31	1		0	90	0	0	0	90	90	90	90	90	90	90	90	90
32	2		0	90	0	0	0	0	0	0	90	90	90	90	90	90
33	3		0	0	0	0	0	0	0	0	90	90	90	90	90	90
34	4		0	90	0	0	0	0	0	0	0	0	0	0	0	0
35	5		0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	6		0	90	0	0	0	0	0	0	0	0	0	0	90	90
37	7		0	90	0	0	0	0	0	0	0	90	90	0	0	0
38	8		0	90	0	0	0	0	90	90	0	0	0	0	0	0
39	9		0	90	0	90	90	0	0	0	0	0	0	0	0	0
40	0		0	0	90	90	90	90	90	90	90	90	90	90	90	90

The M0 Motor of the Wrist is Always Fixed for the Generation of The Signals which are shown in the Database.

IV. DRIVING ALGORITHM AND PROCESS FLOW GRAPH OF MOTOR CONTROLLED ARTIFICIAL ARM

V. The Artificial Hand Movement could be understood with the help of the following Algorithm[7].

STEP1:- Read the audio Command.
STEP2:- Convert the audio command to machine level code.
STEP3:- Compare with the reference Database.
STEP4:- Check the Rotating Angle of All the Motors.
STEP5:-Adjust the Rotating Angle of the Motors if Required.
STEP6:- Control the Motor Control System.
STEP7:- Control the Gear Control System.
STEP8:- Move the Different Parts of the artificial Hand.

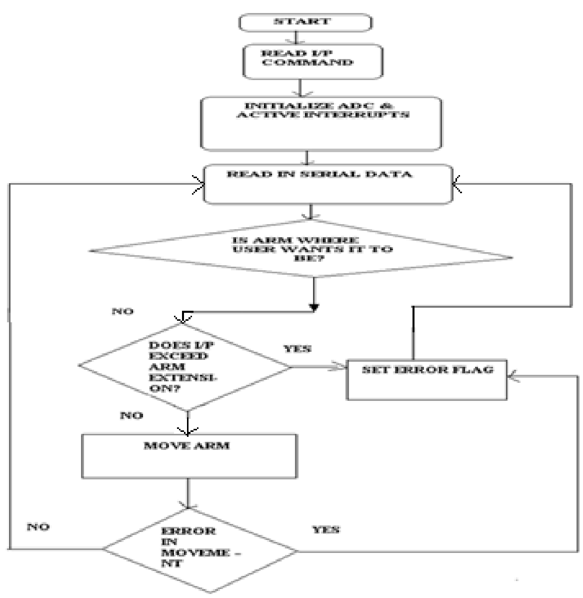

Fig 7: ***Flow graph of Motor Controlled artificial arm***

V. CONCLUSION

In this exploration, it is aimed to highlight on the implementation of the artificial arm that is capable of generating the finger spelling (Dactylology).In this particular field the research works has not been carried out enormously. This implementation would be very helpful to communicate with the dumb people, these devices will generate a signal jester according to the voice command, the teaching could be arranged by this artificial hand. This artificial arm would be also very helpful for the dumb people to feel the effect of a live movie.We will try to integrate all the recognition modules to implement a practical speaking aid for the deaf persons.

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