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Controlling Artificial Hand Using Smart Glove

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Abstract

The basic artificial hand parts are built by 3D printing technique. Controlling the fingers movement of artificial hand were done by using smart glove equipped with flex sensors. all the system linked with micro controller with Lab view software . The main concept of research concerned with finding and deriving the equations for each artificial hand's finger to get matching between human hand's finger angles and an artificial hand's finger angles. Lab view program is the main program which responsible to implement these equations by using digitals gates in its options. The modification of equation have been done to eliminate the source of errors and make the movements more accurate**.**

Keywords: Smart glove; Flex sensor; Lab view; mathematical modeling; ardunino; 3D printing

INTRODUCTION

Robots are the main elements in different industrial process e.g. welding, material handling and welding since 50years [1].It is an engineering field which assisted to reduce human efforts. The contrivance of robots has helped to increase the Accuracy and frequency in many aspects of process which will be hard to use hands of human. as well as, human interference to supervise the robot through human deeds [2].In this paper, our aim is to make a robotic arm that will copy the actual movements of a human hand. Motion of the hand will vary the potentiometer resistance which is placed on the human arm. This change in resistance produces an equivalent output voltage which is given to the microcontroller. The microcontroller converts this analog signal to digital and produces corresponding PWM signals which are required for the servomotors on the robotic arm to run. Servomotors are connected to the receiver microcontroller. PWM pulses are sent to the receiver controller. The hardware of this project is very user friendly, portable, easy to handle and also very light in weight. It has a very simple design and also very easy to assemble [3]. Making robot arm in three dimensional shape need 3D printer device.3D printer is a machine which is makes three dimensional prototype for any different type shapes. 3D printing technology is evolved by designer and engineers in the business space since 2005 [4]. After assembling all parts for robot artificial hand which are made by 3D printer and connect it with clever glove will control of the volts output from Weinstein bridge by convert it as the servomotors angle's rotates in limits (0-180) degree. To do this multiply these volts by a factor and input it to servomotor which is connect to the robot hand's finger for verifying angle's matching .

DERIVATIVES EQUATION FOR HAND FINGER'S MOVEMENT

Making artificial robot arm by using 3D printing technique and the total parts for this arm were 43 pieces weight 0.65 g taking time approximately 40 hours. The finger robot arm should attach with smart glove (flex sensors covered glove). Flex sensors are analog resistor and it produce volts depend on the principle of voltage divider formula[5].After calculating the analog's volts output for flex sensor should making calibration for each flex to ensure when the flex at (0 degree) the robot hand's finger at (0 degree) too this operation could be done by using lab view program.lab view is the development of a software which contains many components, several of which are required for any type of test, measurement, or control application [6]. A servo motor is an electromechanical device which the motor armature's position could determine by electrical input. In robot implementations, supporting engines are used to transmit the arm of robot to a connected to placement by methods of observers in the auto industrialization line of manufactures and connecting the servo with robot hand's finger in different ways [7].Control the input volts to servo motor for matching angles between glove's side and robot hand's finger side. Verifying match angles depend on the first appear for actual data .It can be divided (model 1, model 2, proposed model 1 and proposed model 2). There are four modules as follows:

- Model 1/ represented in finding of mathematical relations for each of flex angle change and the voltage accompanying this change and the change in servo motor and accompanying angles of robot arm fingers.
- Model 2/ omitting of softness in the threads connecting motors and robot arm fingers.
- Proposed model 1/ finding of a linear relation between the angles of robot arm fingers and the angles of servo motor depending upon the angles of servo motor to change the angles of flex angles, this is done by equaling of (β, Ɛ) equations.
- Proposed model 2/ representing copying of a new equation depending upon the biggest angle the flex reaches linear and robot arm finger (β, A_{χ}), where A stands for the result of division of the biggest angle of robot finger opposite the biggest flex angle. Studying of four or three cases depends on finger's case, for example three cases need to study with thumb finger while there are four cases with ring finger. The " Figure 1" shown below explain the procedure for wire communication ," Figure 2"

explain assembling for experimental work and "Figure 3" shown the procedure for derivative equation for matching movement. The equations listed shown the associate equations for each finger with different model .Where (β) represented the angle for robot finger's angle , (Ɛ) represented angle for servo motor, (α) is the flex's volt and (δ) is the servo motors volt. Equations for each finger are listed.

Thum $181.8\alpha - 463.3 = \chi$ **(1)**

- **Model 1** $\beta = 3.\chi - 50$ **(2)**
- **Model 2** $\beta = 4.5\chi + 10$ **(3)**
- **Proposed model** $\beta = 0.95\chi + 11.9$ **(4)**

Index $114\alpha - 207.84 = \chi$ **(5)**

- **Model 1** $\beta = 3.5\chi - 8$ **(6)**
- **Model 2** $\beta = 1.13\chi - 10.2$ **(7)**

Middle $152.2\alpha - 108.49 = \chi$ **(8)**

- **Model 1** $\beta = 3.4\chi - 34$ **(9)**
- **Model 2** $\beta = 2.8\chi - 10$ **(10)**
- **Proposed model 1** $\beta = 1.01\chi + 2.5$ **(11)**

Ring $97.48\alpha - 205.72 = \chi$ **(12)**

- **Model 1** $\beta = 2.5\chi - 40$ **(13)**
- **Model 2** $\beta = 2.3\chi + 2$ **(14)**
- **Proposedmodel** $\beta = 1.03\chi + 5.36$ **(15)**

Pinky $145.27\alpha - 450.39 = \chi$ **(16)**

- **Model 1** $\beta = 2.485\chi + 19.52$ **(17)**
- **Model 2** $\beta = 0.89\chi + 3.5$ **(18)**

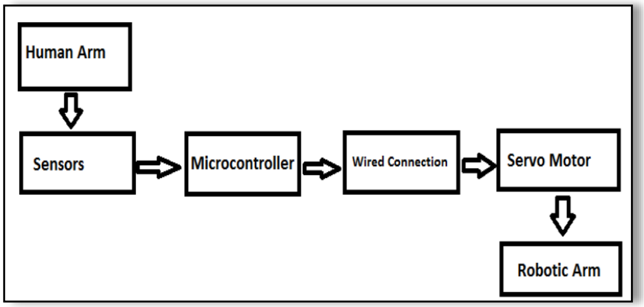

Figure. 1. Block diagram for control robot arm [2].

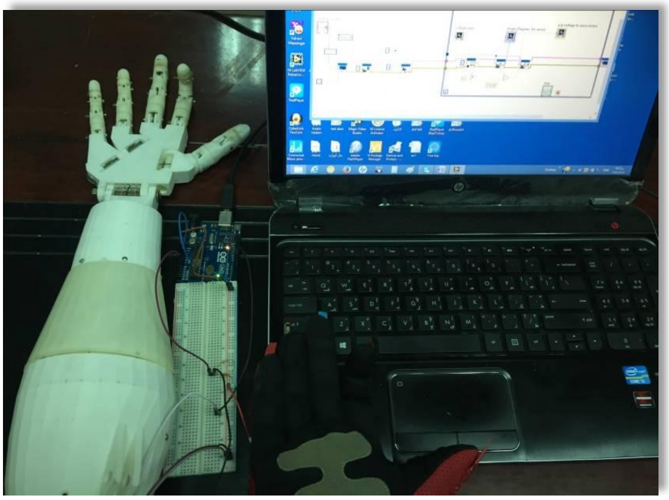

Figure. 2. Assembling tools for controlling robot arm.

Figure. 3. Clever glove (flex sensor attach with glove

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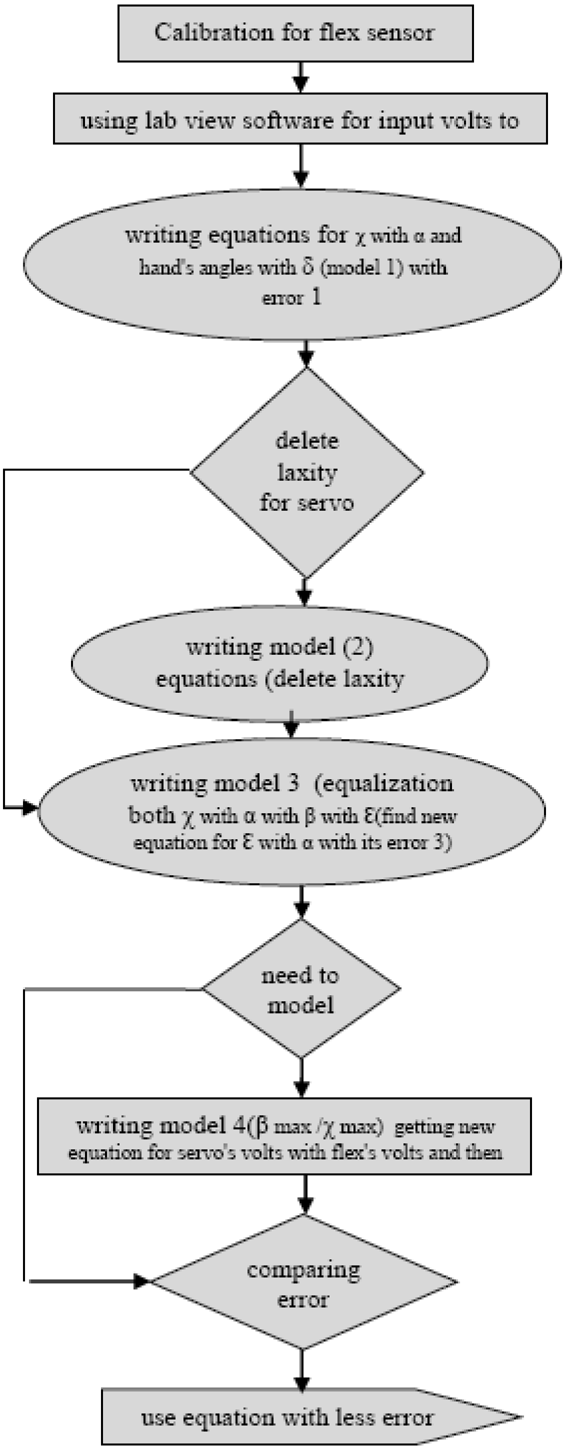

Figure. 4. Flowchart for executing matching angle in lab view soft ware

Where β : Represented angle for robot hand finger.
χ: Represented angle for flex sensor at glove.
Ɛ: Represented angle for servo motor .
α : Represented flex sensor volt
δ: Represented the volt for servo motor .

RESULTS

The figures and tables shown below the actual data for each finger in various models.

Thumb Finger :

Table 1. Results for thumb fingers for all models

β : Represented angle for robot hand finger.
χ: Represented angle for flex sensor at glove.
Ɛ: Represented angle for servo motor .

Model	χ °	Ɛ °	β°	Error%
Model 1	**0**	**0**	**0**	**#**
	10	**18**	**0**	**#**
	20	**32.4**	**0**	**#**
	30	**36**	**50**	**0.4**
	40	**46.8**	**80**	**0.5**
	50	**64.8**	**90**	**0.444**
	60	**72**	**90**	**0.333**
	70	**108**	**90**	**0.222**
	80	**144**	**90**	**0.111**
	90	**180**	**90**	**0**
Model 2	**0**	**32.4**	**0**	**#**
	10	**50.4**	**75**	**0.866**
	20	**64.8**	**90**	**0.777**
	30	**68.4**	**90**	**0.666**
	40	**79.2**	**90**	**0.555**
	50	**97.2**	**90**	**0.444**
	60	**104.4**	**90**	**0.333**
	70	**140.4**	**90**	**0.222**
	80	**176.4**	**90**	**0.11**
	90	**212.4**	**90**	**0**
Proposed 1	**0**	**33.196**	**0**	**1**
	10	**36.404**	**20**	**0.069**
	20	**38.97**	**30**	**0.154**
	30	**39.611**	**50**	**0.799**
	40	**41.536**	**60**	**0.804**
	50	**44.743**	**65**	**0.535**
	60	**46.026**	**70**	**0.522**

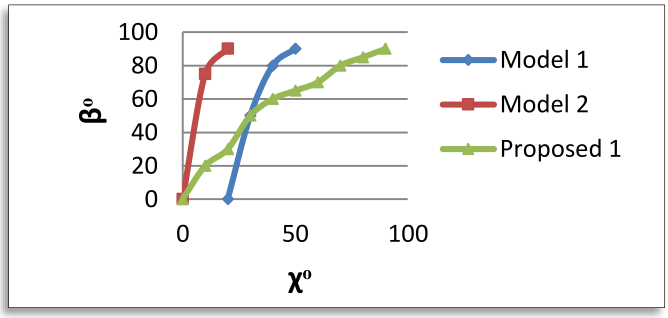

Figure 5. All models for thumb finger.

Index Finger :

Table 2. Results for index fingers for all models:

β : Represented angle for robot hand finger.
χ: Represented angle for flex sensor at glove.
Ɛ: Represented angle for servo motor.

Model	χ º	Ɛ º	βº	Error%
Model 1	0	0	0	0
	10	18	10	0
	20	36	70	0.714
	30	54	75	0.6
	40	72	130	0.692
	50	90	130	0.615
	60	104.4	130	0.538
	70	108	130	0.461
	80	126	130	0.384
	90	144	130	0.307
	100	162	130	0.23
Proposed model 1	0	2.977	0	0
	10	9.311	0	0
	20	15.644	0	0
	30	21.977	30	0
	40	28.311	40	0
	50	34.644	50	0
	60	39.711	60	0
	70	40.977	70	0
	80	47.311	80	0
	90	53.644	90	0
	100	59.977	100	0

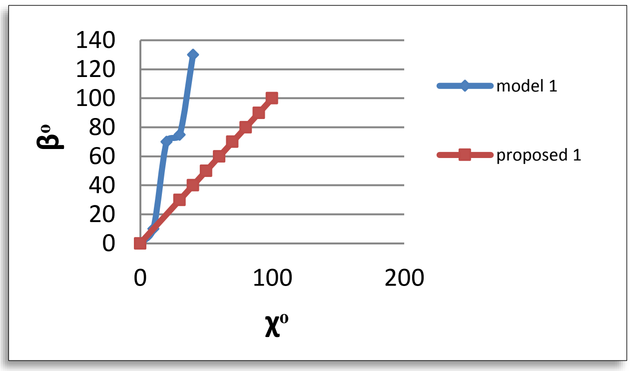

Figure 6. All models for index finger.

Middle Finger :

Table 3. Results for middle finger for all models.

β : Represented angle for robot hand finger.
χ: Represented angle for flex sensor at glove.
Ɛ: Represented angle for servo motor.

Model	χ º	Ɛ º	βº	Error%
Model 1	0	0	0	#
	10	6.315	0	#
	20	31.578	10	1
	30	63.156	100	0.7
	40	85.26	110	0.636
	50	94.734	120	0.583
	60	126.312	120	0.5
	70	151.574	120	0.416
	80	157.89	120	0.333
	90	173.679	120	0.25
	100	179.994	120	0.166
Model 2	0	6.101	0	#
	10	12.203	10	0
	20	36.609	35	0.4285
	30	67.117	100	0.7
	40	88.473	110	0.636
	50	97.625	120	0.583
	60	128.133	120	0.5
	70	152.54	120	0.416
	80	158.641	120	0.333
	90	173.895	120	0.25
	100	179.997	120	0.166
Proposed model 1	0	6.615	0	0
	10	8.927	10	0
	20	18.175	15	0.333
	30	29.734	30	0
	40	37.826	40	0
	50	41.294	50	0
	60	52.853	60	0
	70	62.101	85	0.176
	80	64.413	90	0.111
	90	70.193	100	0.1
	100	72.504	105	0.047

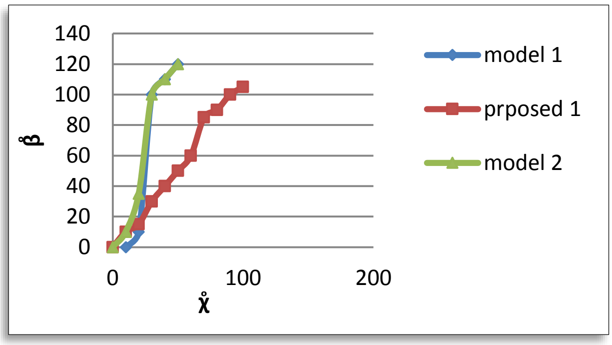

Figure 7. All models for middle finge.

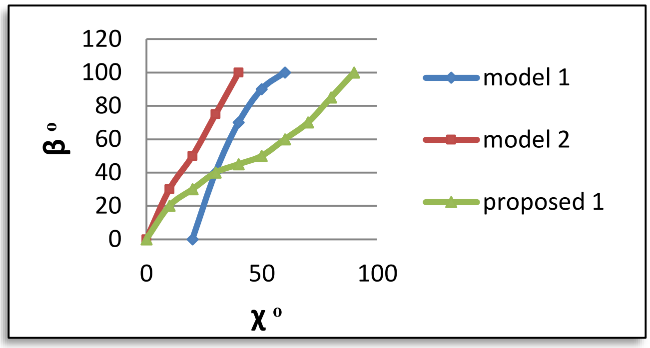

Figure 8. All models for ring finger.

RING (ANNULAR) FINGER

Table 4. Results for ring fingers for all models.

β : Represented angle for robot hand finger.
χ: Represented angle for flex sensor at glove.
Ɛ: Represented angle for servo motor.

Model	χ °	Ɛ °	β°	Error%
Model 1	**0**	**0**	**0**	**#**
	10	**40**	**0**	**#**
	20	**80**	**0**	**#**
	30	**96**	**40**	**0.25**
	40	**120**	**70**	**0.428**
	50	**140**	**90**	**0.444**
	60	**154**	**100**	**0.4**
	70	**160**	**100**	**0.3**
	80	**174**	**100**	**0.2**
	90	**180**	**100**	**0.1**
Model 2	**0**	**64.285**	**0**	**#**
	10	**89.999**	**30**	**0.666**
	20	**115.713**	**50**	**0.6**
	30	**125.998**	**75**	**0.6**
	40	**141.427**	**100**	**0.6**
	50	**154.284**	**100**	**0.5**
	60	**163.283**	**100**	**0.4**
	70	**167.141**	**100**	**0.3**
	80	**176.14**	**100**	**0.2**
	90	**179.998**	**100**	**0.1**
Proposed model 1	**0**	**57.522**	**0**	**0**
	10	**74.101**	**20**	**0.5**
	20	**90.679**	**30**	**0.333**
	30	**97.31**	**40**	**0.25**
	40	**107.257**	**45**	**0.111**
	50	**115.546**	**50**	**0**
	60	**121.349**	**60**	**0**
	70	**123.835**	**70**	**0**
	80	**129.638**	**85**	**0.058**
	90	**132.125**	**100**	**0.1**

Pinky Finger :

Table 5. Results for pinky finger for all models.

β : Represented angle for robot hand finger.
χ: Represented angle for flex sensor at glove.
Ɛ: Represented angle for servo motor.

Model	χ °	Ɛ °	β°	Error%
Model 1	**0**	**0**	**0**	**#**
	10	**51.428**	**60**	**0.833**
	20	**77.142**	**70**	**0.714**
	30	**90**	**110**	**0.727**
	40	**102.857**	**120**	**0.666**
	50	**123.428**	**130**	**0.615**
	60	**128.571**	**130**	**0.538**
	70	**156.857**	**130**	**0.461**
	80	**169.714**	**130**	**0.384**
	90	**177.428**	**130**	**0.307**
	100	**180**	**130**	**0.23**
Proposed Model 1	**0**	**0**	**0**	**0**
	10	**12.93**	**10**	**0**
	20	**26.257**	**20**	**0**
	30	**32.921**	**30**	**0**
	40	**39.585**	**45**	**0.111**
	50	**50.247**	**55**	**0.09**
	60	**52.912**	**60**	**0**
	70	**67.573**	**65**	**0.076**
	80	**74.236**	**68**	**0.176**
	90	**78.235**	**85**	**0.058**
	100	**79.567**	**90**	**0.111**

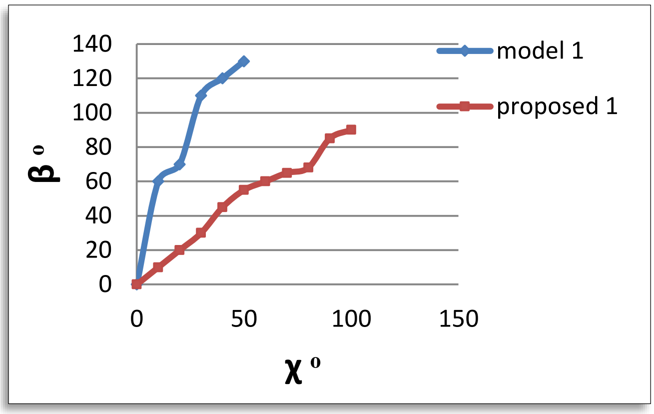

Figure 9. All models for pinky finger.

DISCUSSION

- With the first module there is a difference between the smart glove fingers angle and artificial hand angle fingers angle have been noticed due to a primary voltage accompanying with the flex sensor .
- At the second module, the primary voltage reading of smart glove have been eliminated by modifying the relations between smart glove fingers angle and artificial hand angle fingers, but the results still keeping errors due to limitation of movement of artificial hand fingers and non similarities in dimensions between the glove and artificial hand fingers .
- At the third module, trying to minimize the errors at the previous readings have been processed, finding a new relation depending upon (χ^{o} , $\mathcal{E}^{o}$) and amending the relation between (Vf) and ,(Θm) according to the former assumption, that's why we notice that the decreasing in assumption ratio very much and that the relation between them is a linear.
- The fourth module has been proposed according to the relation state that the highest angle for each fingers achieved by (χ^{o} , $\mathcal{E}^{o}$) have been matched, since the primary angle is zero degree for each, while the final angle is depending upon the biggest angle could be obtained by (χ^{o} , β^{o}).

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