

## Development of a New Multi-Fingered Robot Hand Using Ultrasonic Motors and Its Control System

(Byoung-Ho Kim, Sang-Rok Oh, Bum-Jae You, Il-Hong Suh, and Hyouk-Ryeol Choi)

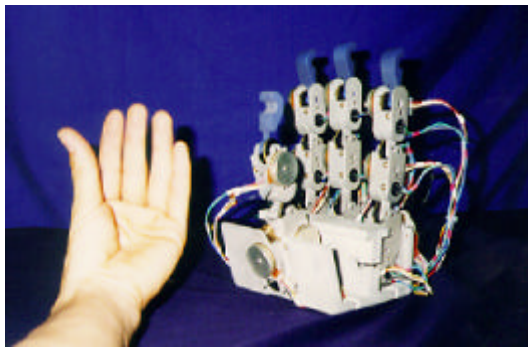
**Abstract** : In this paper, a new multi-fingered robot hand using ultrasonic motors and its control system are developed. The developed robot hand has four fingers and fifteen articulated joints. The distal joint of each finger is directly driven by ultrasonic motor and all joints except the distal joint has low transmission gear mechanism with the motor. The developed robot hand has several advantages in size compared to a hand using conventional DC motors, and in performance compared to a hand using tendons to drive joints. A VME-bus based hand control system and ultrasonic motor driver are also developed. The performance of the hand is confirmed by using the developed control system in real-time.

**Keywords** : multi-fingered robot hand, ultrasonic motor.

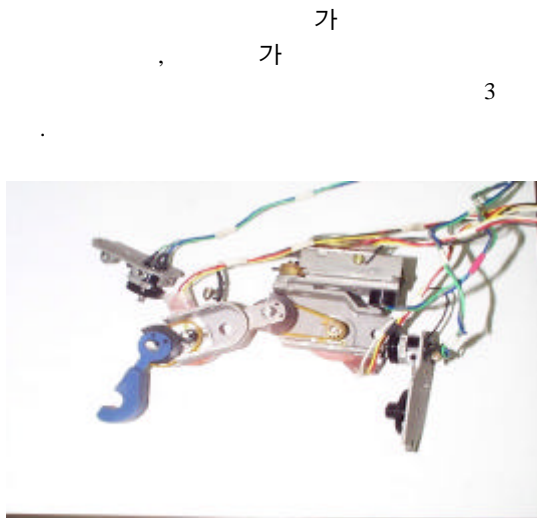
### I.

가 (actuators) 가  
 가 가  
 [1- 8]. [7][8].  
 ( , DC )  
 가 가  
 , Jacobsen [1] 4 가 가  
 가 Utah/MIT Hand 가 Toshiba Hand  
 (tendon) Hashimoto [4] DC  
 , 4 DC  
 Loucks[2] Stanford/JPL Hand DC  
 (mechanism) 가  
 가 3 가  
 가 Anthrobot- 2 Hand[3] 5 가  
 가 가 4 가 15  
 Hand[4] 4 가 Toshiba 가 (distal  
 (wire- driven) 4 joint)  
 . Barrett Hand[5]  
 3 4  
 7 가  
 가 Lee Choi [6]  
 가 VME  
 VME  
 가 가 가  
 : 1999. 11. 20., : 2000. 2. 8.  
 : /  
 :  
 :  
 : DC  
 가 DC  
 , 가  
 가 가  
 DC 가

1. 가  
 II.  
 1. 가  
 , 4 가 , 15  
 , 1 [8]. 가  
 2 가



1. Fig.. 1. The developed multi-fingered robot hand.



2. 가  
 Fig. 2. Internal structure of thumb.

3. DIP  
 (Distal InterPhalangeal), PIP(Proximal Inter Phalangeal), MCP(MetaCarpal Phalangeal), CMC(Carpo MetaCarpal). 가 1 ,  
 가 2 . 1, 4,  
 8, 12 가 Y  
 , X-Z

1. Table 1. DOF of the robot hand.

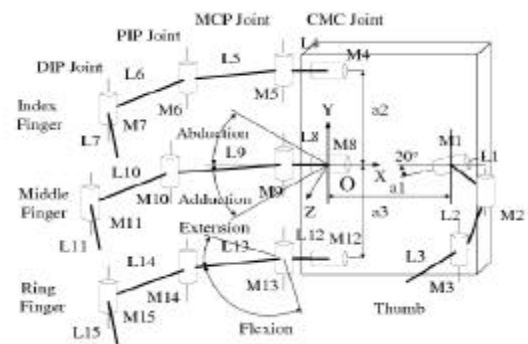
	Flexion- Extension	Adduction- Abduction
가	2	1
가	3	1
가	3	1
가	3	1

2. Table 2. Link parameters of the robot hand.

	(mm)
L1	7
L4, L8, L12	7
L9	62
L3, L7, L11, L15	35
L2, L5, L13	56
L6, L10, L14	41
a1	80
a2, a3	45

3. 가 ( : ).  
 Table 3. Motion range for each finger(unit: degree).

	DIP		PIP		MCP		CMC	
	F	E	F	E	F	E	Add	Abd
	-	-	90	70	90	70	45	45
	90	70	90	70	90	70	45	45
	90	70	90	70	90	70	45	45
	90	70	90	70	90	70	45	45



3. Fig. 3. Kinematic structure of the robot hand.

가 가 X-Z  
 (flexion and  
 extension) , X-Y

(adduction and abduction) 3  
 3 F E  
 2.  
 USR30- B3 , 4  
 가 가  
 (gear mechanism) 2  
 (spur gear)  
 5  
 (potentiometer, FCP12A)

4. (USR30- B3)

Table 4. Specification. for the ultrasonic motor (USR30- B3).

(KHz)	50
(Vrms)	110
(Nm)	0.05
(Nm)	0.1
(Nm)	0.1
(W)	1.3
(rpm)	250
	CW, CCW
(msec)	1
(g)	20

5.

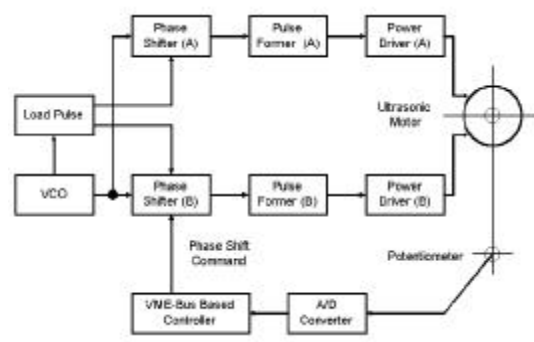
Table 5. Transmission ratio of the robot hand.

	DIP	PIP	MCP	CMC
가	-	3:1	9:1	2:1
가	1:1	3:1	9:1	2:1
가	1:1	3:1	9:1	2:1
가	1:1	3:1	9:1	2:1

III.

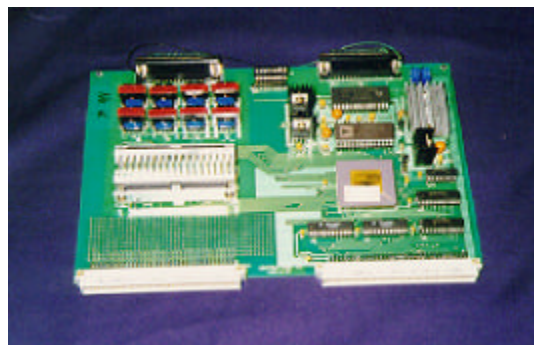
1.  
 , 가 , 가 ,  
 가 ,  
 가 가  
 [9][10].

, VME  
 Gate Array) 4  
 , 4  
 VME  
 (pulse shifter) (pulse former) 5  
 - 90o +90o  
 가 가  
 4 가 가  
 VME



4.

Fig. 4.. Block diagram for driving ultrasonic motor.



5.

Fig. 5. Board for driving ultrasonic motor.

2.

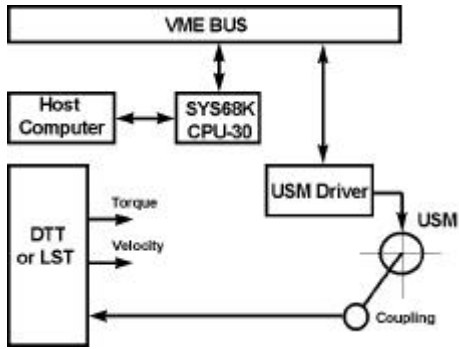
6 VME  
 6 DTT(Dynamic Torque Tester: Model PT- 2300, Protec Co.)

10

가  
가 가

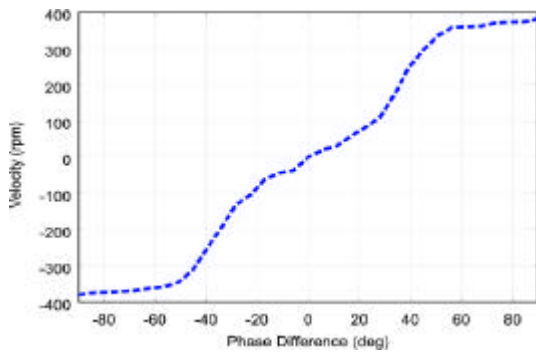
3. VME

8



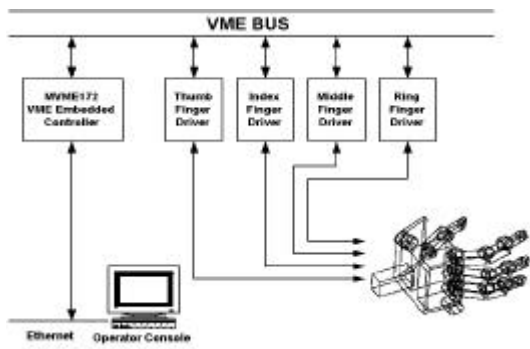
6.

Fig. 6. Block diagram for measuring the characteristic of ultrasonic motor.



7.

Fig. 7. Phase difference vs. velocity curve of ultrasonic motor.



8. VME

Fig. 8. VME-bus based robot hand control system block diagram.



9. VME

Fig. 9. VME-bus based robot hand control system.

VME 32bits CPU 가

4 가

(multi-tasking) VxWorks[11]

9

가

4

VME

2

IV.

1)

(gate function), 2)

(ramp function), 3)

(sinusoidal function) 가

10

10[msec]

9

10

10

(Task

Planner) 가

가

(PID)

PID

가

(320, 0.015, 0.7)

(80, 0.015, 0.5)

10  $[G_f^q]$

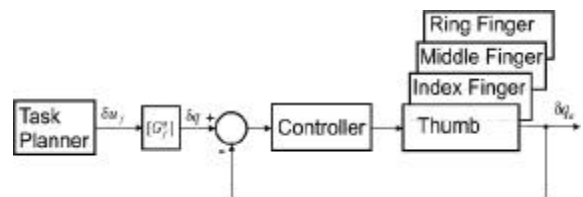
가

가

11, 12,

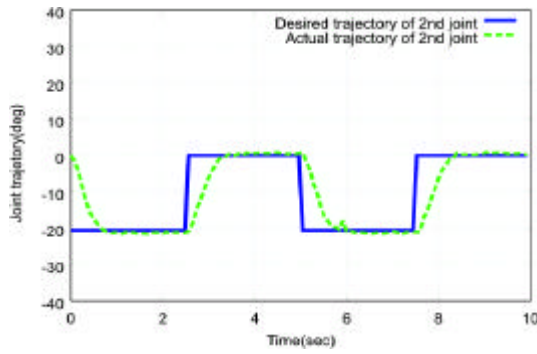
13

가



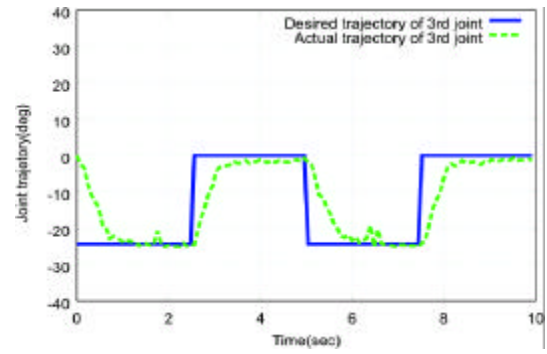
10.

Fig. 10. Control block diagram for the developed robot hand.



11. ( 2).

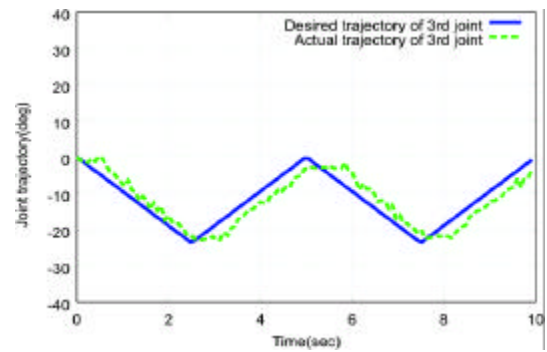
Fig. 11. Response to gate function(2nd joint).



14. ( 3).

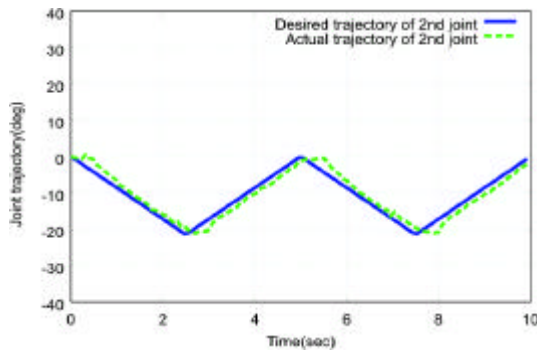
Fig. 14. Response to gate function(3rd joint).

14, 15, 16  
가  
가  
가  
가



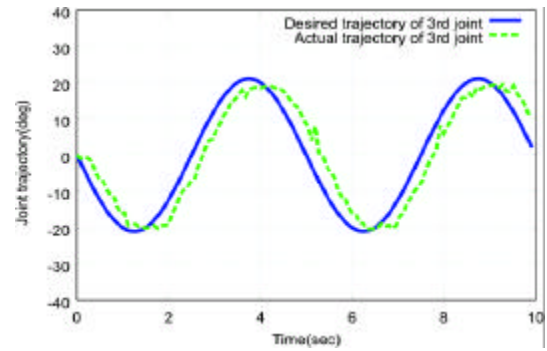
15. ( 3).

Fig. 15. Response to ramp function(3rd joint).



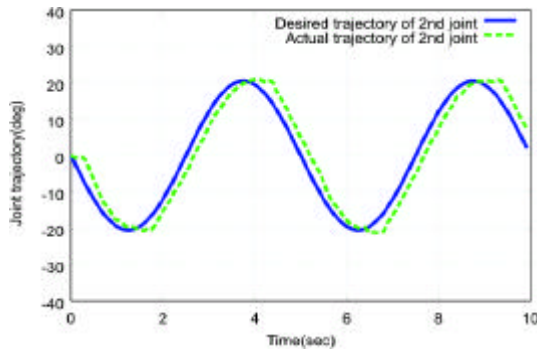
12. ( 2).

Fig. 12. Response to ramp function(2nd joint).



16. ( 3).

Fig. 16. Response to sinusoidal function(3rd joint).



13. ( 2).

Fig. 13. Response to sinusoidal function(2nd joint).

V.

가  
가

DC

가  
 VME  
 가

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