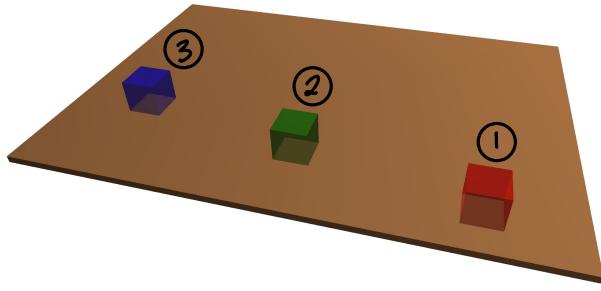


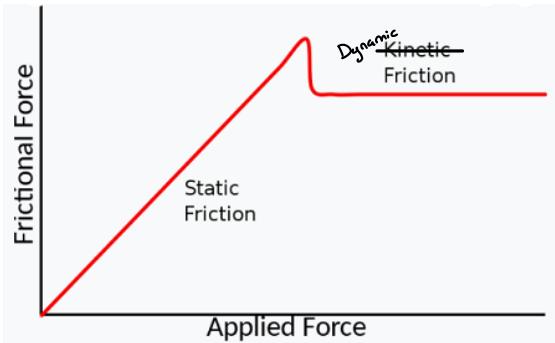
Updated Analysis - 9/6/2023



Assigned Material & Dynamic Properties

Property	Symbol	Cube 1	Cube 2	Cube 3	Units
Mass	m_i	0.3	0.3	0.3	kg
Stiffness	k_i	100	300	700	N/m
Side length	l_i	0.05	0.05	0.05	m
Dynamic Friction	F_{fdi}	1.8	1.8	1.8	N
Static Friction	F_{fsi}	2	2	2	N

Friction Model I Believe
CHAI3D is using:



In CHAI3D (set by former CHARmers):

$$\text{friction}_i = \text{friction}_i = 2 \text{ for } i=1,2,3 \rightarrow F_{fsi}$$

$$\text{dynFriction}_i = 0.9 * \text{friction}_i \rightarrow F_{fdi}$$

Testing Normal Forces by Pressing Cubes into Floor:

- Expected Model: $\vec{N}_i = k_i x_i \hat{z} \quad \vec{V} \approx 0$

No.	Cube #	Goal Penetration [m]	Expected $\ \vec{N}\ $ Force [N]	Actual Penetration [m]	Calculated Virtual $\ \vec{N}\ $ [N]	Back-Calculated Stiffness [N/m]
1	1	0.01	1	0.0091	0.9994	109.8242
2	1	0.03	3	0.0298	3.0599	102.6812
3	1	0.05	5	0.0516	5.1409	99.6298
4	2	0.01	3	0.0107	3.2866	305.2336
5	2	0.03	9	0.0308	9.16	297.4026
6	2	0.05	15	0.0505	15.176	300.5149
7	3	0.01	7	0.0106	7.3355	692.0283
8	3	0.03	21	0.0295	20.616	648.8475
9	3	0.05	35	0.0501	34.76	693.8124

≈ 100
N/m

≈ 300
N/m

≈ 700
N/m

Normal Force Testing Environment:

①

INDEX	THUMB	Graphics Rate:
Stiffness Fc -0.037 0.0388 -0.035 Normal X: Normal Y: Normal Z: Normal Ma -0.037 0.0151 -0.032 0.989 Shear X: Shear Y: Shear Z: Shear Mag -0E-05 -0.036 -0.035 0.0363 Des Pos X Des Pos Y Des Pos Z 0.0356 0.0178 0.0392	Stiffness Fc 0 0 0 Normal X: Normal Y: Normal Z: Normal Ma 0 0 0 0 Shear X: Shear Y: Shear Z: Shear Mag 0 0 0 0 Des Pos X Des Pos Y Des Pos Z 0 0 0 Thumb Pot Desired Thumb 3E-300 0 0 Thumb Pot Pos Stroke: 3E-300	85 4086 Mass Stiffness Box1 0.3 300 Box2 0.3 300 Box3 0.3 300

②

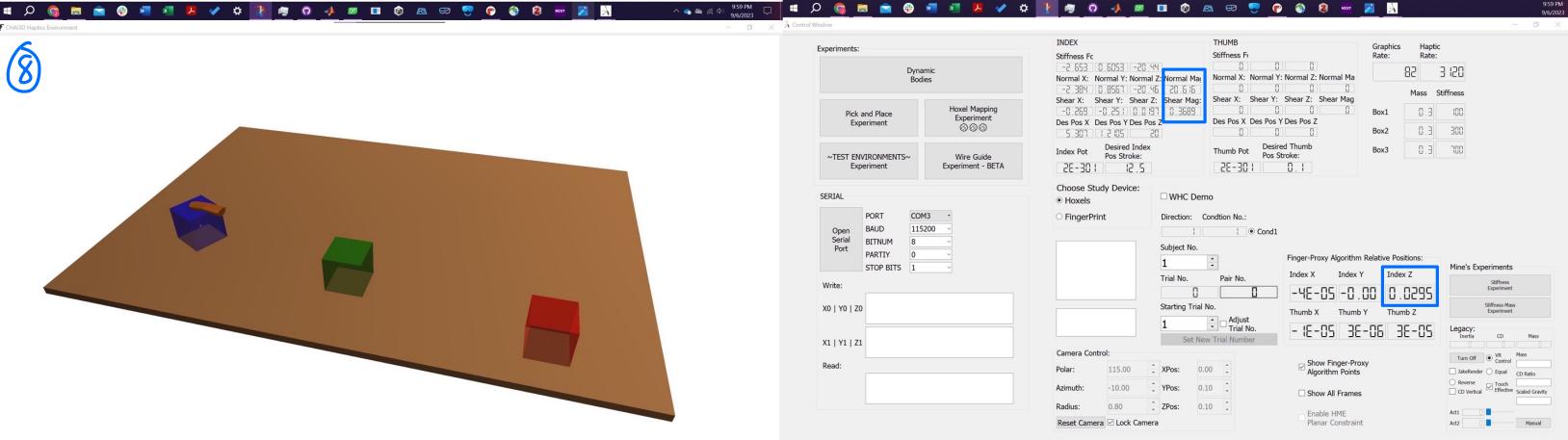
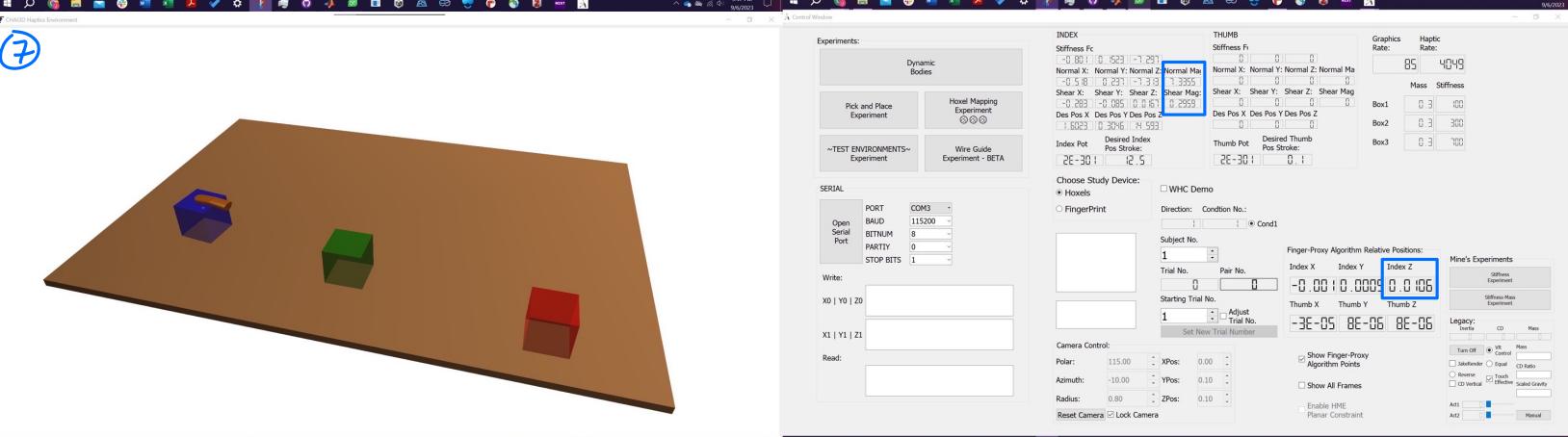
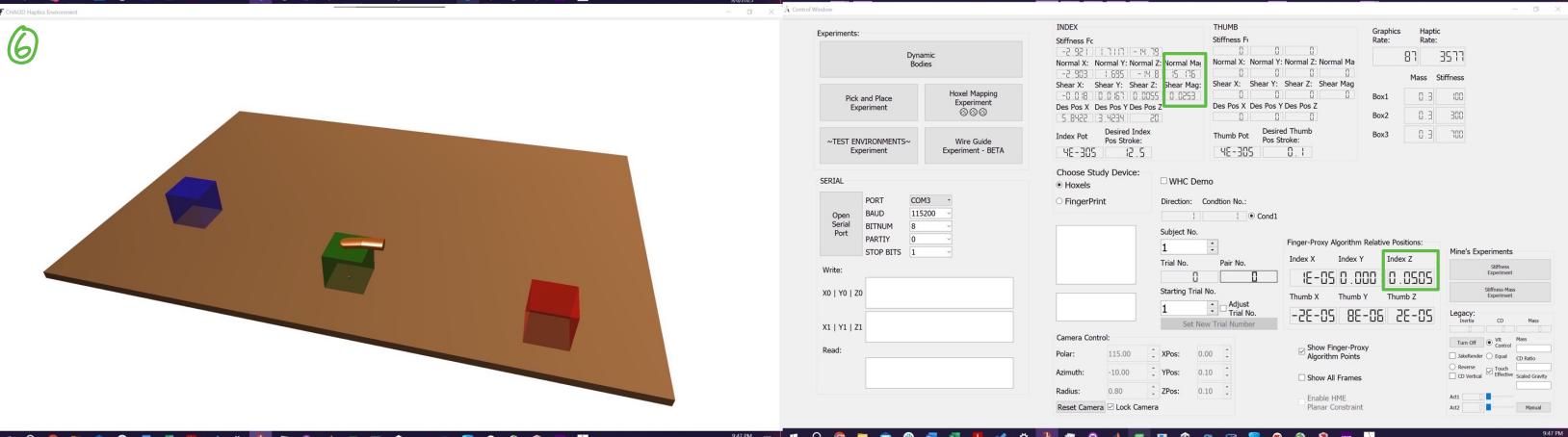
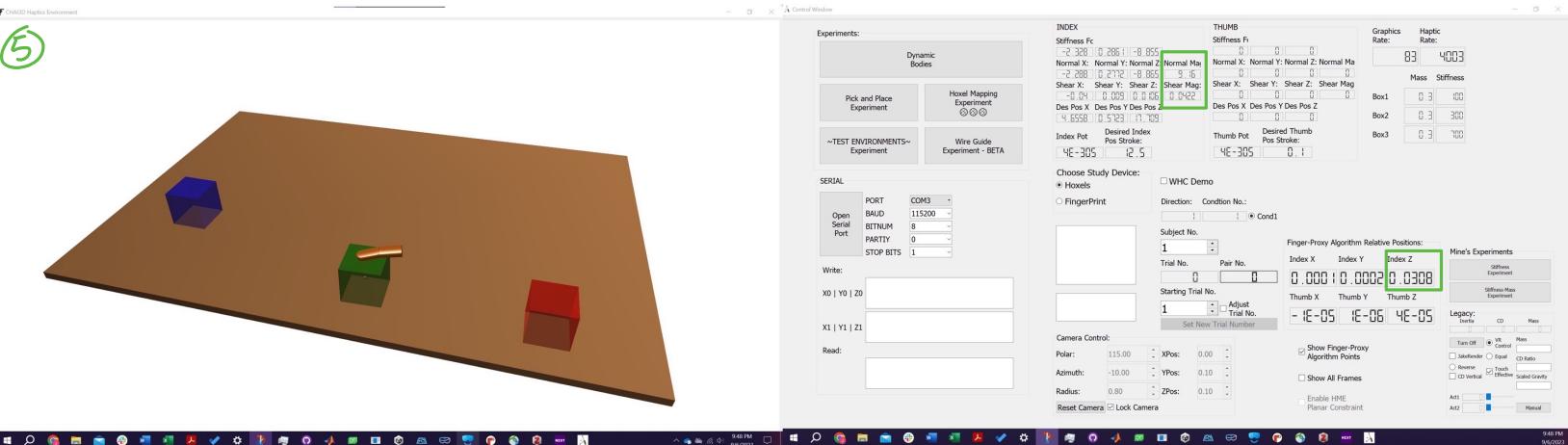
INDEX	THUMB	Graphics Rate:
Stiffness Fc -0.037 0.0483 -0.034 Normal X: Normal Y: Normal Z: Normal Ma -0.037 0.0483 -0.034 0.989 Shear X: Shear Y: Shear Z: Shear Mag 0.0385 -0.035 -0.035 0.0359 Des Pos X Des Pos Y Des Pos Z 0.0356 0.0236 0.0398	Stiffness Fc 0 0 0 Normal X: Normal Y: Normal Z: Normal Ma 0 0 0 0 Shear X: Shear Y: Shear Z: Shear Mag 0 0 0 0 Des Pos X Des Pos Y Des Pos Z 0 0 0 Thumb Pot Desired Thumb 2E-305 0 0 Thumb Pot Pos Stroke: 2E-305	92 4109 Mass Stiffness Box1 0.3 300 Box2 0.3 300 Box3 0.3 300

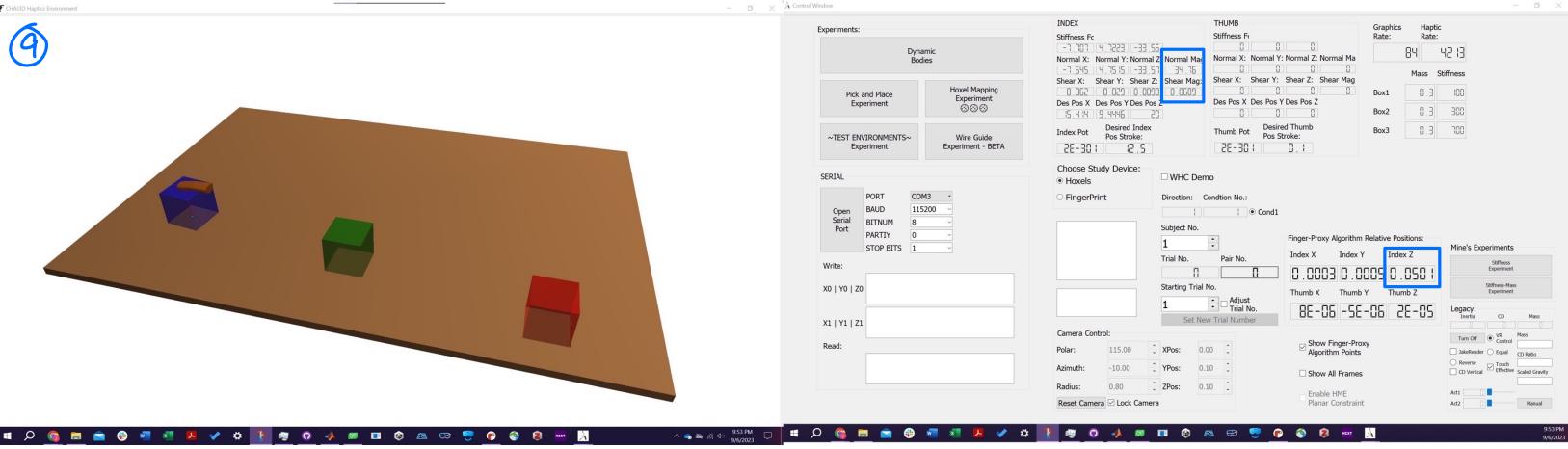
③

INDEX	THUMB	Graphics Rate:
Stiffness Fc -0.037 0.0238 -0.026 Normal X: Normal Y: Normal Z: Normal Ma -0.037 0.0483 -0.034 0.989 Shear X: Shear Y: Shear Z: Shear Mag -0.031 -0.021 0.021 0.0255 Des Pos X Des Pos Y Des Pos Z 0.0371 0.028 0.0393	Stiffness Fc 0 0 0 Normal X: Normal Y: Normal Z: Normal Ma 0 0 0 0 Shear X: Shear Y: Shear Z: Shear Mag 0 0 0 0 Des Pos X Des Pos Y Des Pos Z 0 0 0 Thumb Pot Desired Thumb 4E-307 0 0 Thumb Pot Pos Stroke: 4E-307	96 4144 Mass Stiffness Box1 0.3 300 Box2 0.3 300 Box3 0.3 300

④

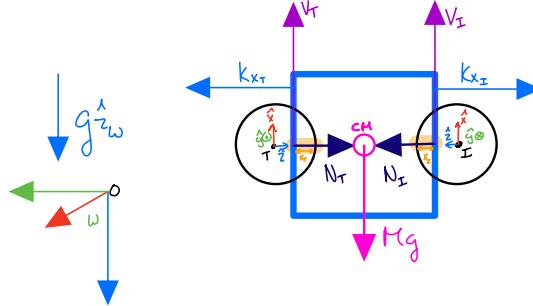
INDEX	THUMB	Graphics Rate:
Stiffness Fc -0.037 0.536 -0.089 Normal X: Normal Y: Normal Z: Normal Ma -0.037 0.4795 -0.032 0.989 Shear X: Shear Y: Shear Z: Shear Mag 0.0383 0.0281 0.0212 0.0353 Des Pos X Des Pos Y Des Pos Z 0.0383 0.0281 0.0212 0.0353	Stiffness Fc 0 0 0 Normal X: Normal Y: Normal Z: Normal Ma 0 0 0 0 Shear X: Shear Y: Shear Z: Shear Mag 0 0 0 0 Des Pos X Des Pos Y Des Pos Z 0 0 0 Thumb Pot Desired Thumb 4E-305 0 0 Thumb Pot Pos Stroke: 4E-305	93 4224 Mass Stiffness Box1 0.3 300 Box2 0.3 300 Box3 0.3 300





Testing Shear Forces:

- Expected Model
(from ideal scenario):



In static equilibrium two-finger grasp:

$$Mg = V_I + V_T = (0.3 \text{ kg} \times 9.81 \text{ m/s}^2) = 2.943 \text{ N}$$

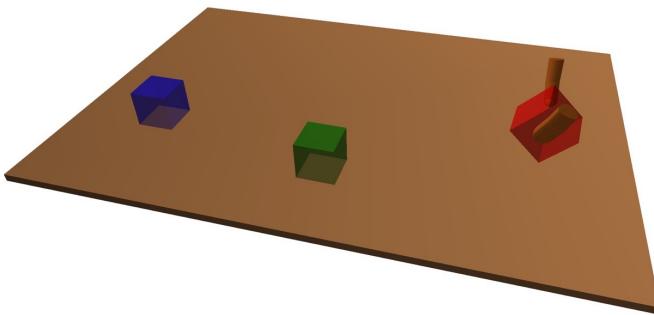
To confirm, check the total shear is close to the expected value for varying mass values

$$\text{Test 10: } \begin{cases} V_I = 1.3424 \text{ N} \\ V_T = 1.5454 \text{ N} \end{cases} \Rightarrow 2.8878 \text{ N} \text{ for } m_1 = 0.3 \text{ kg}$$

No.	Mass [kg]	V_I [N]	V_T [N]	Total [N]	Expected Mg [N]
10	0.3	1.3424	1.5454	2.8878	2.943 ✓
11	0.5	3.004	1.9708	4.9748	4.9050 ✓
12	0.7	4.564	2.3394	6.8670	6.8670 ✓

Shear Force Testing Environment:

(10)



Control Window

Experiments:

- Dynamic Bodies
- Pick and Place Experiment
- Hoxel Mapping Experiment
- ~TEST ENVIRONMENTS~ Experiment
- Wire Guide Experiment - BETA

SERIAL

Open Serial Port	PORT BAUD	COM3
	BITNUM	115200
	PARTITY	8
	STOP BITS	1

Write:
X0 | Y0 | Z0
X1 | Y1 | Z1
Read:

INDEX

Stiffness Fc	Normal X: Normal Y: Normal Z:	Shear X: Shear Y: Shear Z:	Shear Map
0.1656 0.1656 -3.51	Normal X: Normal Y: Normal Z:	Normal X: Normal Y: Normal Z:	Normal X: Normal Y: Normal Z:
-0.1656 0.1656 1.289	0.3659 -1.623	0.3659 -1.623	0.3659 -1.623
0.3659 -1.623	0.3659 -1.623	0.3659 -1.623	0.3659 -1.623
Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z
0.9251 0.9281 3.1311	0.8018 0.3132 4.296	0.8018 0.3132 4.296	0.8018 0.3132 4.296
Index Pot Desired Index	Desired Pos Stroke:	Desired Pos Stroke:	Desired Pos Stroke:
2E-30 6.5	2E-30 6.5	2E-30 6.5	2E-30 6.5

Choose Study Device:
• Hoxels
○ FingerPrint

Direction: Condition No.: Cond1

Subject No. 1 Trial No. Pair No. 9999 9999 9999 9999

Starting Trial No. 1 Adjust Trial No. Set New Trial Number

Camera Control:
Polar: 115.00 XPos: 0.00
Azimuth: -10.00 YPos: 0.10
Radius: 0.80 ZPos: 0.10
Reset Camera Lock Camera

Finger-Proxy Algorithm Relative Positions:
Index X Index Y Index Z
9999 9999 9999

THUMB Graphics Rate: 91 3414 Mass Stiffness Box1 0.3 300

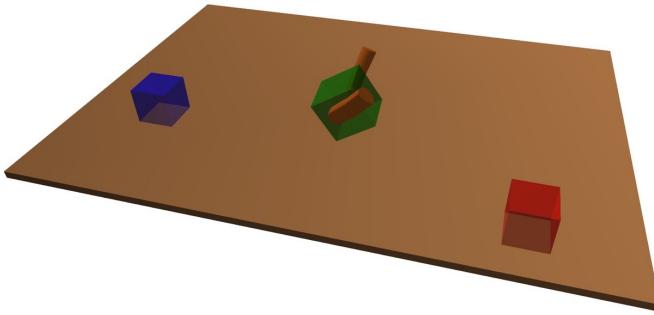
Box2 0.3 300

Box3 0.3 700

Mine's Experiments

Legacy: Turn Off VR Control Mass
Jabende: Equal CD Ratio
Reverse: Touch Effective Scaled Gravity
CD Vertical
Add1 Add2 Manual

(11)



Control Window

Experiments:

- Dynamic Bodies
- Pick and Place Experiment
- Hoxel Mapping Experiment
- ~TEST ENVIRONMENTS~ Experiment
- Wire Guide Experiment - BETA

SERIAL

Open Serial Port	PORT BAUD	COM3
	BITNUM	115200
	PARTITY	8
	STOP BITS	1

Write:
X0 | Y0 | Z0
X1 | Y1 | Z1
Read:

INDEX

Stiffness Fc	Normal X: Normal Y: Normal Z:	Shear X: Shear Y: Shear Z:	Shear Map
0.1659 0.1656 -3.51	Normal X: Normal Y: Normal Z:	Normal X: Normal Y: Normal Z:	Normal X: Normal Y: Normal Z:
-1.1659 0.1656 2.289	0.3659 -1.623	0.3659 -1.623	0.3659 -1.623
2.2894 1.633 0.829	0.3659 -1.623	0.3659 -1.623	0.3659 -1.623
Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z
0.9251 0.9281 3.1311	0.8018 0.3132 4.296	0.8018 0.3132 4.296	0.8018 0.3132 4.296
Index Pot Desired Index	Desired Pos Stroke:	Desired Pos Stroke:	Desired Pos Stroke:
4E-308 12.5	4E-308 12.5	4E-308 12.5	4E-308 12.5

Choose Study Device:
• Hoxels
○ FingerPrint

Direction: Condition No.: Cond1

Subject No. 1 Trial No. Pair No. 9999 9999 9999 9999

Starting Trial No. 1 Adjust Trial No. Set New Trial Number

Camera Control:
Polar: 115.00 XPos: 0.00
Azimuth: -10.00 YPos: 0.10
Radius: 0.80 ZPos: 0.10
Reset Camera Lock Camera

Finger-Proxy Algorithm Relative Positions:
Index X Index Y Index Z
9999 9999 9999

THUMB Graphics Rate: 91 3414 Mass Stiffness Box1 0.3 300

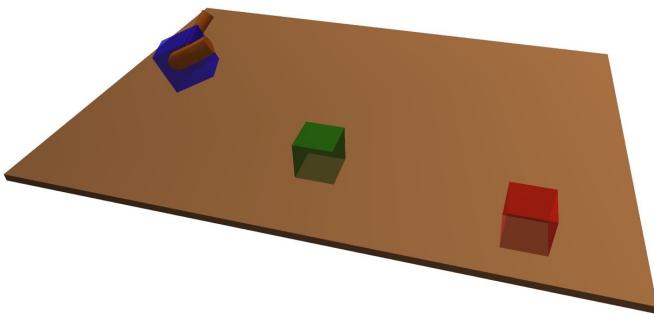
Box2 0.5 300

Box3 0.7 700

Mine's Experiments

Legacy: Turn Off VR Control Mass
Jabende: Equal CD Ratio
Reverse: Touch Effective Scaled Gravity
CD Vertical
Add1 Add2 Manual

(12)



Control Window

Experiments:

- Dynamic Bodies
- Pick and Place Experiment
- Hoxel Mapping Experiment
- ~TEST ENVIRONMENTS~ Experiment
- Wire Guide Experiment - BETA

SERIAL

Open Serial Port	PORT BAUD	COM3
	BITNUM	115200
	PARTITY	8
	STOP BITS	1

Write:
X0 | Y0 | Z0
X1 | Y1 | Z1
Read:

INDEX

Stiffness Fc	Normal X: Normal Y: Normal Z:	Shear X: Shear Y: Shear Z:	Shear Map
-0.598 0.9284 -0.761	Normal X: Normal Y: Normal Z:	Normal X: Normal Y: Normal Z:	Normal X: Normal Y: Normal Z:
-1.598 0.9284 -0.761	0.3659 -1.623	0.3659 -1.623	0.3659 -1.623
0.3659 -1.623	0.3659 -1.623	0.3659 -1.623	0.3659 -1.623
Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z	Des Pos X Des Pos Y Des Pos Z
0.8981 0.2365 9.5615	0.2396 -0.185 2.358	0.2396 -0.185 2.358	0.2396 -0.185 2.358
Index Pot Desired Index	Desired Pos Stroke:	Desired Pos Stroke:	Desired Pos Stroke:
IE-291 12.5	IE-291 12.5	IE-291 12.5	IE-291 12.5

Choose Study Device:
• Hoxels
○ FingerPrint

Direction: Condition No.: Cond1

Subject No. 1 Trial No. Pair No. 9999 9999 9999 9999

Starting Trial No. 1 Adjust Trial No. Set New Trial Number

Camera Control:
Polar: 115.00 XPos: 0.00
Azimuth: -10.00 YPos: 0.10
Radius: 0.80 ZPos: 0.10
Reset Camera Lock Camera

Finger-Proxy Algorithm Relative Positions:
Index X Index Y Index Z
9999 9999 9999

THUMB Graphics Rate: 88 3085 Mass Stiffness Box1 0.3 300

Box2 0.5 300

Box3 0.7 700

Mine's Experiments

Legacy: Turn Off VR Control Mass
Jabende: Equal CD Ratio
Reverse: Touch Effective Scaled Gravity
CD Vertical
Add1 Add2 Manual