

Inverse Kinematics Calculation

Introduction

Inverse kinematics refers to the use of the kinematics analysis of a mechanism or (robot) manipulator to determine the motion of all joints that provide a desired position of the end-effector. In this application we will demonstrate how this is done in the software SAM. Three steps will be shown:

- 1. Inverse kinematics to calculate joint motions that lead to the desired end-effector motion
- 2. Exporting joint motions and importing these in a new model
- 3. Regular forward kinematics & kinetostatics to determine driving torques/power and reaction/joint forces.

Modelling Steps

Build Model

The model in this example consists of two beam plus a rotational sensor (element 3)



Define motion of node 3: x-motion (spline)

0.000 1.000 2.000 3.000 4.000
Velocity [mm/s]
0.000 1.000 2.000 3.000 4.000 Acceleration (mm/s2)
0.000

Define motion of node 3: y-motion (spline)

				Displacement [mm]
Linear Polynome 5th	Quadratic order File	Cycloidal Spline Trapezo	Polynome345 oidal-1 Trapezoidal-2	400.000 300.000 200.000 100.000 0.000
Points	Time	Value		
1	0.000	0.000		0.000 1.000 2.000 3.000 4.000
2	1.000	0.000		Velocity [mm/s]
3	2.000	400.000		400.000
4	3.000	400.000		200.000
5	4.000	0.000		0.000
				-200.000
			-	-400.000
Intervals 10	D (© Natural C C Clamped	ubic Cubic 0.000	•	-400.000
Intervals 10 Add	0 © Natural C C Clamped	Cubic 0.000	[mm/s] Modify	-400.000 0.000 1.000 2.000 3.000 4.000 Acceleration [mm/s2]
Intervals 10 Add	O O	Cubic 0.000	[0.000 [mm/s] Modify	-400.000 0.000 Acceleration [mm/s2]
Intervals 10 Add ist of actual c	Natural C Clamped urve-parts:	Cubic 0.000	0.000 [mm/s]	-400.000 0.000 Acceleration [mm/s2] 500.000 0.000
Intervals 10 Add .ist of actual c Ir Type Spline 01	0 Clamped	Cubic 0.000 Insert Time 4.000	0.000 [mm/s]	-400.000 0.000 Acceleration (mm/s2) 500.000 -500.000
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Select results of element 1: AR(1), AV(1) and AA(1) & Export to BaseMotorMotion.txt

Export Results		×
Layout	Decimal Format	Column Sequence / Selection
C Standard	Fixed Point	✓ Time
√ Header	C Floating Point	$\forall Ai(1)$ $\forall Av(1)$ $\forall Aa(1)$
Motion Format	Precision	
Selected items are valid,	Listing	
SAM	Show Listing	
		OK Cancel

Clear selection

Select results of element 3: AR(3), AV(3) and AA(3) & Export to ElbowMotorMotion.txt

E	xport Results				23
Γ	Layout	Decimal Format		Column Sequence / Selection	
	○ Standard	Fixed Point		✓ Time	
	✓ Header	C Floating Point		✓ A(3) ✓ A∨(3)	▲ ▼
	Motion Format	Precision	3	M Aa(3)	
	Selected items are valid, sequence is set to default for SAM	Listing			
				ОК	Cancel

Application Note: Inverse Kinematics (v1.0).doc

Save SAM file to New Name: InverseKinematics(part2) Delete x- and y-motion at node 3 Apply input motion ANGLE at base motor using File: BASEMOTORMOTION.TXT

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Apply input motion RELATIVE ANGLE to elbow motor using file: ELBOWMOTORMOTION.TXT Make sure that the sequence in which the elements are selected when defining the relative angle actuator is IDENTICAL to the sequence in which the rotational sensor was defined, because otherwise the elbow motor is turning in the wrong direction and the resulting path of node 3 will be incorrect.

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Display the resulting motion of node 3

This should now be identical to the starting situation, but driven by base and elbow actuation.



Add a mass of 10kg to node 3 and switch gravity ON



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Calculate and plot the required driving torque and power of the base motor.

Calculate and plot joint forces in Fx and Fy of element 2 in node 2d



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Conclusion

SAM provides easy support to perform an inverse kinematics calculation, export the results of individual joint movements and import these again for a forward kinematics calculation in which driving torque, driving power and reaction/joint forces can be analyzed.