Pinocchio Cheat Sheet

Get started

easy install	conda install -c conda-forge pinocchio
import	import pinocchio as pin
	from pinocchio.utils import *
documentation	pin.Model?

Spatial quantities

Transforms

SE3	aMb = pin.SE3(aRb,apb)
unit transformation	M = pin.SE3(1) or pin.SE3.Identity()
random transformation	pin.SE3.Random()
rotation matrix	M.rotation
translation vector	M.translation
SE3 inverse	bMa = aMb.inverse()
SE3 action	aMc = aMb * bMc
action matrix	aXb = aMb.action
homegeneous matrix	aHb = aMb.homogeneous
log operation SE3 → 6D	pin.log(M)
exp operation	pin.exp(M)

Spatial Velocity

Motion	m = pin.Motion(v,w)
linear acceleration	m.linear
angular acceleration	m.angular
SE3 action	v_a = aMb * v_b

Spatial Acceleration

used in algorithms	a = $(\dot{\omega}, \dot{v}_O)$
get classical acceleration	a' = a + $(0, \omega \times v_O)$
	pin.classicAcceleration(v,a, [aMb])

Spatial Force

Force	f = pin.Force(l,n)
linear force	f.linear
torque	f.angular
SE3 action	f_a = aMb * f_b

Spatial Inertia

Inertia	Y = pin.Inertia(mass,com,I)
mass	Y.mass
center of mass pos.	Y.lever
rotational inertia	Y.inertia

Geometry

Quaternion	quat = pin.Quaternion(R)
Angle Axis	aa = pin.AngleAxis(angle,axis)

Useful converters

SE3 → (x,y,z,quat)	pin.se3ToXYZQUAT(M)
(x,y,z,quat) → SE3	pin.XYZQUATToSE3(vec)

Data

Data related to the model	data = pin.Data(model)
	data = model.createData()
joint data	data.joints
joint/[frame] placements	data.oMi /[data.oMf]
joint velocities	data.v
joint accelerations	data.a
joint forces	data.f
mass matrix	data.M
non linear effects	data.nle
centroidal momentum	data.hg
centroidal matrix	data.Ag
centroidal inertia	data.Ig

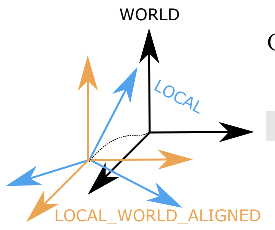
Model

Model of the kinematic tree	model = pin.Model()
model name	model.name
joint names	model.names
joint models	model.joints
joint placements	model.placements
link inertias	model.inertias
frames	model.frames
# position variables	model.nq
# velocity variables	model.nv
Methods	use ? to get doc and input arguments
add joint	model.addJoint
append body	model.appendBodyToJoint
add frame	model.addFrame
append child into parent model	model.appendModel
build reduced body	model.buildReducedModel

Parsers

load an URDF file	pin.buildModelFromUrdf(filename,[root_joint])
load a SDF file	pin.buildModelFromSdf(filename,[root_joint], root_link_name,parent_guidance)

Reference Frames



Coordinate system (CS)

WORLD	world CS
LOCAL	local CS of the joint
LOCAL_WORLD_ALIGNED	local CS aligned with WORLD axis

Frames

placement of all operational frames	pin.updateFramePlacements(model, data)
current frame placements wrt origin	data.oMf
frame veloctiy	pin.getFrameVelocity(model, data, frame_id, ref_frame)
frame acceleration	pin.getFrameAcceleration(model, data, frame_id, ref_frame)
frame acceleration	pin.getFrameClassicalAcceleration(model, data, frame_id, ref_frame)
frames placement	pin.framesForwardKinematics(model, data, q)
frame jacobian	pin.computeFrameJacobian(model, data, q, frame_id, ref_frame)
frame jacobian time variation	pin.frameJacobianTimeVariation(model, data, q, v, frame_id, ref_frame)
partial derivatives of the spatial velocity	pin.getFrameVelocityDerivatives(model, data, frame_id, ref_frame)
partial derivatives of the spatial velocity	pin.getFrameVelocityDerivatives(model, data, joint_id, placement ref_frame)
partial derivatives of the spatial acceleration	pin.getFrameVelocityDerivatives(model, data, frame_id, ref_frame)
partial derivatives of the spatial acceleration	pin.getFrameAccelerationDerivatives (model, data, joint_id, placement ref_frame)

Configuration

random configuration	pin.randomConfiguration(model, [lower_bound, upper_bound])
neutral configuration	pin.neutral(model)
normalized configuration	pin.normalize(model, q)
difference configurations	pin.difference(model, q1, q2)
distance configurations	pin.distance(model, q1, q2)
squared distance configurations	pin.squareDistance(model, q1, q2)
interpolate configuration	pin.interpolate(model, q1, q2, alpha)
integrate configuration	pin.integrate(model, q, v)
partial derivatives of difference	pin.dDifference(model, q1, q2, [arg_pos])
partial derivatives of integration	pin.dIntegrate(model, q, v, [arg_pos])

Collision

placement collision obj	pin.updateGeometryPlacements(model, data, geometry_model, geometry_data, [q])
collisions detection for all pairs	pin.computeCollisions(model, data, geometry_model, geometry_data, q)
collisions detection for a pair	pin.computeCollisions(geometry_model, geometry_data, pair_index)
distance from collision	pin.computeDistance(geometry_model, geometry_data, [pair_index])
distance from collision each pair	pin.computeDistances([model, data], geometry_model, geometry_data, [q])
geometry volume radius	pin.computeBodyRadius(model, geometry_model, geometry_data
BroadPhase	pin.computeCollisions(broadphase_manager, callback)
	pin.computeCollisions(broadphase_manager, stop_at_first_collision)
+ forward kinmetatics to update geometry placements	pin.computeCollisions(model, data, broadphase_manager, q, stop_at_first_collision)

Center of Mass

total mass of model	pin.computeTotalMass(model, [data])
mass of each subtree	pin.computeSubtreeMasses(model, data)
center of mass (COM)	pin.centerOfMass(model, data, q, [v, a],[compute_subtree_com])
Jacobian COM	pin.jacobianCenterOfMass(model, data, [q],[compute_subtree_com])

Energy

FK and kinetic Energy	pin.computeKineticEnergy(model, data, [q, v])
FK and potential Energy	pin.computePotentialEnergy(model, data, [q, v])
FK and mechanical Energy	pin.computeMechanicalEnergy(model, data, [q, v])

Kinematics

forward kinematics (FK)	pin.forwardKinematics(model, data, q, [v,[a]])
FK derivatives	pin.computeForwardKinematicsDerivatives(model, data, q, v, a)
$\left[\frac{\partial v}{\partial q}, \frac{\partial v}{\partial \dot{q}}\right]^{WORLD}$	pin.getJointVelocityDerivatives(model, data, joint_id,pin.ReferenceFrame.WORLD)
$\left[\frac{\partial v}{\partial q}, \frac{\partial a}{\partial q}, \frac{\partial a}{\partial \dot{q}}\right]^{LOCAL}$	pin.getJointAccelerationDerivatives(model, data, joint_id,pin.ReferenceFrame.LOCAL)

Jacobian

full model Jacobian → data.J	pin.computeJointJacobians(model, data, [q])
joint Jacobian	pin.getJointJacobian(model, data, joint_id, ref_frame)
full model dJ/dt	pin.computeJointJacobiansTimeVariation(model, data, q, v)
joint dJ/dt	pin.getJointJacobianTimeVariation(model, data, joint_id, ref_frame)

Forward Dynamics

Articulated-Body Algorithm $\ddot{q}$	pin.aba(model, data, q, v, tau, [f_ext])
Joint Space Inertia Matrix Inv	pin.computeMinverse(model, data, [q])
Composite Rigid-Body Algorithm	pin.crba(model, data, q)

Inverse Dynamics

Recursive Newton-Euler Algorithm	pin.rnea(model, data, q, v, a, [f_ext])
generalized gravity	pin.computeGeneralizedGravity(model, data, q)
dtau_dq, dtau_dv, dtau_da	pin.computeRNEADerivatives(model, data, q, v, a, [f_ext])

Centroidal

Centroidal momentum	pin.computeCentroidalMomentum(model, data, [q, v])
Centroidal momentum + time derivatives	pin.computeCentroidalMomentumTimeVariation(model, data, [q, v, a])

General

all terms (check doc)	pin.computeAllTerms(model, data, q, v)

Kinematic Regressor

kinematic regressor	pin.computeJointKinematicRegressor(model, data, joint_id, ref_frame, [placement])
kinematic regressor	pin.computeFrameKinematicRegressor(model, data, frame_id, ref_frame)

Regressor

static regressor	pin.computeStaticRegressor(model, data, q)
body regressor	pin.bodyRegressor(velocity, acceleration)
body attached to joint regressor	pin.jointBodyRegressor(model, data, joint_id)
body attached to frame regressor	pin.frameBodyRegressor(model, data, frame_id)
joint torque regressor	pin.computeJointTorqueRegressor(model, data, q, v, a)

Contact Jacobian

kinematic Jacobian of constraint model	pin.getConstraintJacobian(model, data, contact_model, contact_data)
kinematic Jacobian of set of constraint models	pin.getConstraintJacobian(model, data, contact_models, contact_datas)

Contact Dynamics

constrained dynamics with contacts	pin.forwardDynamics(model, data, [q, v,] tau, constraint_jacobian, constraint_drift, damping)
impact dynamics with contacts	pin.impulseDynamics(model, data, [q,] v_before, constraint_jacobian, restitution_coefficient, damping)
inverse of the constraint matrix	pin.computeKKTContactDynamicMatrixInverse(model, data, q, constraint_jac, damping)

Constraint Dynamics

allocate memory	pin.initConstraintDynamics(model, data, contact_models)
forward dynamics with contact constraints	pin.constraintDynamics(model, data, q, v, tau, contact_models, contact_datas, [prox_settings])
derivatives of the forward dynamics with kinematic constraints	pin.computeConstraintDynamicsDerivatives(model, data, contact_models, contact_datas, prox_settings)

Impulse Dynamics

impulse dynamics with contact constraints	pin.impulseDynamics(model, data, q, v, contact_models, contact_datas, r_coeff, mu)
impulse dynamics derivatives	pin.computeImpulseDynamicsDerivatives(model, data, contact_models, contact_datas, r_coeff, prox_settings)

Cholesky

Cholesky decomposition of the joint space inertia matrix	pin.cholesky.decompose(model, data)
x of $Mx = y$	pin.cholesky.solve(model, data, v)
inverse of the joint space inertia matrix	pin.cholesky.computeMinv(model, data)

Viewer

Get started

create viewer	mv = pin.visualize.MeshcatVisualizer
load model	viz = mv(model, collision_model, visual_model)
initialize	viz.initViewer(loadModel=True)
display	viz.display(q)

Add basic shapes

sphere	viz.viewer[name].set_object(meshcat.geometry.Sphere(size), material)
box	viz.viewer[name].set_object(meshcat.geometry.Box([sizex, sizey, sizez]), material)

Display

change placement of geometry [name]	viz.viewer[name].set_transform(meshcat_transform(xyzquat_placement))