Open Loop Dynamic Library

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Contents

Chapter 1

Class Index

1.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 3

File Index

3.1 File List

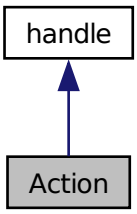
Here is a list of all files with brief descriptions:

Chapter 4

Class Documentation

4.1 Action Class Reference

Inheritance diagram for Action:



Public Member Functions

- function Action (in Name, in varargin)

  Action Class constructor.

- function Get_Info (in obj, in Info)

Public Attributes

- Property Action_Name
- Property Action_Point
- Property Action_Base
- Property Action_Vector

4.1.1 Constructor & Destructor Documentation

4.1.1.1 function Action (in *Name,* in *varargin*)

Action Class constructor.

Parameters

obj,: System in which to introduce a new action

Name,: Name of the new action

Point,: Point (object) of application of the action.

Base,: Base (object) in which the action components are given.

Vector,: Components of the Action. The action components can me symbolic or double and they are given by 3 torque components and 3 force components. Eg: [Mx;My;Mz;Fx;Fy;Fz].

4.1.2 Member Function Documentation

4.1.2.1 function Get_Info (in *obj,* in *Info*)

4.1.3 Member Data Documentation

4.1.3.1 Property Action_Base

4.1.3.2 Property Action_Name

4.1.3.3 Property Action_Point

4.1.3.4 Property Action_Vector

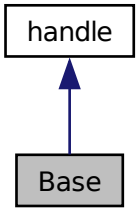
The documentation for this class was generated from the following file:

- C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Action/Action.m

4.2 Base Class Reference

Base Class for the creation of orthonormal vectorial bases.

Inheritance diagram for Base:



Public Member Functions

- function Base (in Name, in varargin)

  Base Class constructor.

- function Get_Info (in obj, in Info)

  Get_Info is a public function to get the properties of the Base objects.

Static Public Member Functions

- static function Rotation_Change_Base_Matrix (in axis, in angle)

  Rotation_Change_Base_Matrix is a Static function that calculates a matrix to change the components of a vector in a moving base (BM) to a fixed base (BF).

Public Attributes

- Property Base_Name

  String that indicates the name of the base object.

- Property Axis_Labels

  [3x1] symbolic array that represents the labels for the vectors of the base.

- Property M_B_E

  [3x3] symbolic or double array that represents the matrix to change the coordinates of a vector in the canonical base (E) to the actual base (B).

4.2.1 Detailed Description

Base Class for the creation of orthonormal vectorial bases.

4.2.2 Constructor & Destructor Documentation

4.2.2.1 function Base (in *Name,* in *varargin*)

Base Class constructor.

The Base constructor can initialize the object in one of two ways: either as the canonical basis $[1, 0, 0]$, $[0, 1, 0]$, and $[0, 0, 1]$, or through rotation with respect to another base. This means that the base can be directly set to the standard orthonormal basis vectors, which are the default coordinate axes, or it can be created by rotating an already existing base.

Parameters

Name

axis_labels(optional) [3x1] symbolic array that contains the labels of the 3 vectors that represents the base. If this parameter is not specified the default axis_labels will be $[x, y, z]^T$.

father_base(optional) The parent Base object defines the base from which the constructor will create a new Base object. From this parent base, a new base is generated through a simple rotation. The simple rotation can only be performed in the direction indicated by the right-hand rule for each of the vectors of the parent base. If father_base parameter is not defined, the default parent base is $[1, 0, 0]$, $[0, 1, 0]$, and $[0, 0, 1]$.

axis_rotation(optional) The simple rotation can only be performed in the direction indicated by the right-hand rule for each of the vectors of the parent base. The axis_rotation parameter defines the rotation axis with a string "1", "2" or "3" defining the parent basis vector to use. If axis_rotation parameter is not defined, the default axis of rotation "1".

angle_rotation(optional) Symbolic or double parameter that defines the angle of rotation (in radians) of the new base. If angle_rotation parameter is not defined the default angle of rotation is 0.

Returns

Instance of the Rigid_Body class.

4.2.3 Member Function Documentation

4.2.3.1 function Get_Info (in *obj,* in *Info*)

Get_Info is a public function to get the properties of the Base objects.

4.2.3.2 static function Rotation_Change_Base_Matrix (in *axis,* in *angle*) `[static]`

Rotation_Change_Base_Matrix is a Static function that calculates a matrix to change the components of a vector in a moving base (BM) to a fixed base (BF).

Parameters

axis,: Father base axis of rotation. String that indicates which father base vector use to calculate the rotation.

angle,: Symbolic or double parameter which indicates the angle of rotation in radians.

4.2.4 Member Data Documentation

4.2.4.1 Property Axis_Labels

[3x1] symbolic array that represents the labels for the vectors of the base.

4.2.4.2 Property Base_Name

String that indicates the name of the base object.

4.2.4.3 Property M_B_E

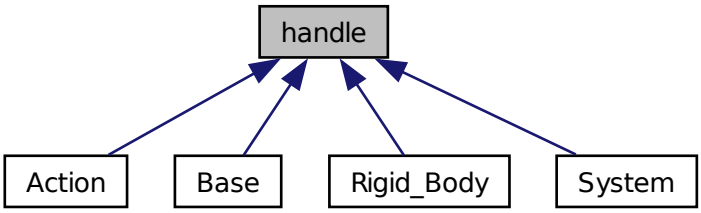
[3x3] symbolic or double array that represents the matrix to change the coordinates of a vector in the canonical base (E) to the actual base (B).

The documentation for this class was generated from the following file:

- C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Base/Base.m

4.3 handle Class Reference

Inheritance diagram for handle:



The documentation for this class was generated from the following file:

- C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Action/Action.m

4.4 Point Class Reference

Public Member Functions

- function Point (in Name, in varargin)
  Point Class Constructor.
- function Get_Info (in obj, in Info)

Public Attributes

- Property Point_Name
- Property Point_Coordinates_From_Canonical

4.4.1 Constructor & Destructor Documentation

4.4.1.1 function Point (in *Name,* in *varargin*)

Point Class Constructor.

Point objects can be created by two different ways. A point is created in an absolute way if the point coordinates are given with respect the canonical point.

Parameters

Name,: String that defines the name of the object

point_coordinates,: [3 x 1] dobule or symbolic array that defines the position of the point with respect the absolute point (canonical point [0,0,0]).

The second way of creating a point is with respect a coordinate system. A coordinate system is defined by a base and a point, and the new point is given by its position with respect to the father point with the father_base components.

Parameters

Name,: String that defines the name of the object.

father_point,: Father Point object.

father_base,: Father Base object.

point_coordinates,: [3 x 1] dobule or symbolic array that defines the position of the point with respect the relative coordinate system (Father_Point and Father_Base).

4.4.2 Member Function Documentation

4.4.2.1 function Get_Info (in *obj,* in *Info*)

4.4.3 Member Data Documentation

4.4.3.1 Property Point_Coordinates_From_Canonical

4.4.3.2 Property Point_Name

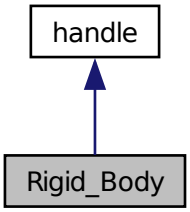
The documentation for this class was generated from the following file:

- C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Point/Point.m

4.5 Rigid_Body Class Reference

Rigid Body Class for the creation of Rigid Body objects.

Inheritance diagram for Rigid_Body:



Public Member Functions

- function Rigid_Body (in Name, in varargin)

  Rigid_Body Class Constructor.

- function Get_Info (in obj, in Info, in varargin)

  The Get_Info method in the Rigid_Body class gets information of the rigid body object depending on the input parameter.

Public Attributes

- Property Rigid_Body_Name

  Public properties for Rigid Body Class.

- Property G_Point_From_Canonical

  [3x1] symbolic or double array that represents the position of the center of mass from the canonical point (in the System Class this point is named "Canonical").

- Property Rigid_Body_Base

  Rigid Body base represented by the Base Class.

- Property Mass

  Symbolic or double scalar that represents the mass of the Rigid Body Object.

- Property Inertial_Tensor

  [3x3] symbolic or double array. This array represent the inertial tensor of the Rigid Body Object.

4.5.1 Detailed Description

Rigid Body Class for the creation of Rigid Body objects.

4.5.2 Constructor & Destructor Documentation

4.5.2.1 function Rigid_Body (in *Name,* in *varargin*)

Rigid_Body Class Constructor.

The Rigid_Body Constructor can initialize the object by defining the parameters of a rigid body.

Parameters

name String variable that defines the name of the rigid body.

G_Point [3x1] symbolic or double array that contains the position of the center of mass of the rigid body.

Base Base object that represents the base that is connected with the rigid body.

Mass Symbolic or double scalar that represents the total mass of the rigid body.

Inertial_Tensor [3x3] symbolic or double array that represents the inertial tensor of the rigid body. If this array is a zero [3 x 3] array the object is a particle.

4.5.3 Member Function Documentation

4.5.3.1 function Get_Info (in *obj,* in *Info,* in *varargin*)

The Get_Info method in the Rigid_Body class gets information of the rigid body object depending on the input parameter.

Parameters

Name Every Rigid_Body object has an asociated name with it. The Name option gives the name of the current rigid body object.

G_Point_From_Canonical The movement of a rigid body is given by its center of mass. This option gives the [3 x 1] symbolic or double array of the center of mass of the rigid body.

Rigid_Body_Base This option gives the base object that it is associated to the rigid body.

Inertial_Tensor This option gives the [3 x 3] array that represents inertial tensor $\mathbf{I}$ of the rigid body.

Absolute_Velocity As the position $\mathbf{r}$ of the rigid body center of mass is given in the canonical reference frame (and the canonical point) the velocity can be calculated as the first derivative respect to time of the position vector $\mathbf{v} = \frac{d\mathbf{r}}{dt}$. This option makes the differentiation of the position vector and returns the absolute velocity.

Absolute_Acceleration As the position $\mathbf{r}$ of the rigid body center of mass is given in the canonical reference frame (and the canonical point) the acceleration can be calculated as the second derivative respect to time of the position vector $\mathbf{a} = \frac{d^2\mathbf{r}}{dt^2}$. This option makes the second derivative of the position vector and returns the absolute acceleration.

Absolute_Angular_Velocity The angular velocity of the rigid body is given by the components of the skew-symmetric matrix $[\mathbf{S}]^T[\dot{\mathbf{S}}]$, where $\mathbf{S}$ is the change of base matrix from the rigid body base to the canonical base. The components of the skew-symmetric matrix give the components of the angular velocity vector in the Rigid Body reference frame as $\{\mathbf{\Omega_R}(\mathbf{BM})\}_{BM}$. This option calculates the vector components of the angular velocity in the Rigid Body reference frame and then returns the vector components in the canonical reference frame $\{\mathbf{\Omega_R}(\mathbf{BM})\}_R$.

Virtual_Velocities In a holonomic system the real and virtual velocities can be expressed in terms of the generalized coordinates of the system. This equations for the lineal and angular velocity are given by $\mathbf{v_i} = \sum_k \frac{\partial \mathbf{v_i}}{\partial \dot{q_k}}\dot{q_k}$ and $\mathbf{\Omega_i} = \sum_k \frac{\partial \mathbf{\Omega_i}}{\partial \dot{q_k}}\dot{q_k}$, where i represents the rigid body and k the

generalized coordinates. This equations can be rewritten as $\mathbf{v_i} = \sum_k \mathbf{b_k^i} \dot{q}_k$ and $\mathbf{\Omega_i} = \sum_k \mathbf{c_k^i} \dot{q}_k$. The option Virtual_Velocities in the Get_Info function gives the symbolic array $\left[\mathbf{c_k^i}, \mathbf{b_k^i}\right]^T$ for the specific rigid body object i and a generalized coordinate q_k.

Kinetic_Energy This option returns the kinetic energy of the rigid body.

A_Matrix The first component (1,1) of the $[A]$ matrix of a rigid body is gonna be $-m\mathbf{b_1}^T\mathbf{b_1} - [\mathbf{Ic_1}]^T\mathbf{c_1}$. In this expression m is the mass of the rigid body, $\mathbf{I}$ is the inertial tensor of the rigid body and $\mathbf{b_1}$ and $\mathbf{c_1}$ are the virtual displacements of the rigid body with respect to the first generalized coordinate. This option returns the symbolic or double $[n \times n]$ matrix $[A]$.

d_A_Matrix This option gives the derivative matrix of matrix $[\mathbf{A}]$.

4.5.4 Member Data Documentation

4.5.4.1 Property G_Point_From_Canonical

[3x1] symbolic or double array that represents the position of the center of mass from the canonical point (in the System Class this point is named "Canonical").

4.5.4.2 Property Inertial_Tensor

[3x3] symbolic or double array. This array represent the inertial tensor of the Rigid Body Object.

4.5.4.3 Property Mass

Symbolic or double scalar that represents the mass of the Rigid Body Object.

4.5.4.4 Property Rigid_Body_Base

Rigid Body base represented by the Base Class.

4.5.4.5 Property Rigid_Body_Name

Public properties for Rigid Body Class.

Name of Rigid Body. This property is a String class variable representing que name of the Rigid Body Object.

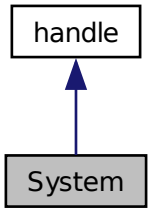
The documentation for this class was generated from the following file:

- C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Rigid_Body/Rigid_Body.m

4.6 System Class Reference

System Class for the creation of System objects.

Inheritance diagram for System:



Public Member Functions

- function System (in Name)
- function unify_system (in obj)

  The function unify_system creates the function handles for the calculation of virtual displacements of the system. This virtual displacements are used to calculate the matrix $[\mathbf{A}]$ *(function Get_A_tk_xk), its derivative* $\frac{d}{dt}[\mathbf{A}]$ *(function Get_d_A_tk_xk) and the generalized actions* τ *(function Get_tau_tk_xk and function Get_input_tk_xk).*

- function unify_symbolic_system (in obj)

  The unify_symbolic_system function calculates the matrix $[\mathbf{A}]$*, its derivative* $\frac{d}{dt}[\mathbf{A}]$ *and the generalized actions* τ *(the generalized actions are given by the inputs and other external actions). The system of equations is presented as* $[\mathbf{A}]\ddot{\mathbf{q}} = \mathbf{b}$ *where the vector* $\mathbf{b}$ *has been calculated as* $\mathbf{b} = -\frac{d}{dt}[\mathbf{A}]\dot{\mathbf{q}} + \tau$*. As the system of equations presented is of second order the function also returns the reduced system of equations to a first order system of equations* $[\mathbf{u}, \mathbf{v}, \dot{\mathbf{v}}]^T = [\mathbf{q}, \dot{\mathbf{q}}, \ddot{\mathbf{q}}]^T$*. This way the reduced system of equations is* $[[\mathbf{A_u}]\mathbf{v}, \mathbf{u}]^T = [\mathbf{b_{uv}}, \mathbf{v}]^T$ *where* $\mathbf{A_u} = \mathbf{A}(\mathbf{u})$ *and* $\mathbf{b_{uv}} = \mathbf{b}(\mathbf{u}, \mathbf{v})$*.*

- function dot_A_dot_q (in obj)
- function Get_A_tk_xk (in obj, in tk, in xk)

  dot_A_dot_q function gives the [N x 1] array that represents the $[\dot{A}]\dot{\vec{q}}$ *term of the EOM.*

- function Get_d_A_tk_xk (in obj, in tk, in xk)

  The function Get_A_tk_xk calculates the value of the A matrix in a x_k *configuration at time* t_k*.*

- function Get_tau_tk_xk (in obj, in tk, in xk)
- function Get_input_tk_xk (in obj, in tk, in xk, in external_vars_k)

  The function Get_input_tk_xk calculates the value of the generalized inputs (generalized forces of the inputs) in a $[x_k, x_{external_k}]^T$ *configuration at time* t_k*.*

- function Lagrangian_Rigth_Hand_Side (in obj)

  The function Lagrangian_Rigth_Hand_Side returns the vector $\mathbf{b} = -\frac{d}{dt}[\mathbf{A}]\dot{\mathbf{q}} + \tau$ *of the* $[\mathbf{A}]\ddot{\mathbf{q}} = \mathbf{b}$ *system of equations.*

- function Create_New_Base (in obj, in Name, in varargin)

  Base introduction in System.

- function Get_Base_Info (in obj, in Info, in varargin)
- function Change_Basis_Matrix (in obj, in Base_1, in Base_2)

  Given some vector components in a Base_1 the Change_Basis_Matrix function gives the vector components in base Base_2.

- function Angular_Velocity (in obj, in Base_1, in Base_2, in Base_Components)

  Angular_Velocity function gives the angular velocity vector from Base_1 to Base_2.

- function Create_New_Point (in obj, in Name, in Coordinate_System, in Coordinates)

  Point introduction in System.

- function Get_Two_Points_Vector (in obj, in Start_Point, in End_Point)

  The function Get_Two_Points_Vector returns the vector componenents from Start_Point to End_Point in the Canonical base.

- function Get_Two_Points_Vector_Base (in obj, in Start_Point, in End_Point, in Base)

  The Get_Two_Points_Vector_Base function returns the vector componenents from Start_Point to End_Point in any base.

- function Get_Point_Info (in obj, in Info, in varargin)
- function Create_New_Coordinate_System (in obj, in Name, in Point_Name, in Base_Name)

  The Create_New_Coordinate_System function introduces a new coordinate system in the System object.

- function Get_Coordinate_System_Info (in obj, in Info, in varargin)
- function Create_New_Rigid_Body (in obj, in Name, in varargin)

  Create_New_Rigid_Body is a function uses the methods of the class Rigid_Body to create a Rigid Body object.

- function Get_Rigid_Body_Info (in obj, in Info, in varargin)
- function Get_Virtual_Velocity_q_Component (in obj, in Name, in q)

  The Get_Virtual_Velocity_q_Component function provides the $\left[\mathbf{c}_{\mathbf{k}}^{\mathbf{i}}, \mathbf{b}_{\mathbf{k}}^{\mathbf{i}}\right]^T$ *array given by the Get_Info function of the Rigid_Body class.*

- function Get_Virtual_Velocity_q_uv_handle (in obj, in Name)

  The Get_Virtual_Velocity_q_uv_handle function provides the $\left[\mathbf{c}_{\mathbf{k}}^{\mathbf{i}}, \mathbf{b}_{\mathbf{k}}^{\mathbf{i}}\right]^T$ *array given by the Get_Info function of the Rigid_Body class in the variables* $[\mathbf{u}, \mathbf{v}]^T$ *of the order reduction.*

- function Get_A_Matrix_Handle (in obj, in Name)

  The function Get_A_Matrix_Handle creates a $[1 \times 5]$ *cell matrix for one rigid body in the system and helps the calculation of the* $[A]$ *values.*

- function Get_System_Virtual_Velocity_q_uv_handle (in obj)
- function Get_System_A_Matrix_Handles (in obj)

  The function Get_System_A_Matrix_Handles creates a $[n_{RB} \times 2]$ *cell matrix, where* n_{RB} *is the number of rigid bodies in the system.*

- function Get_Transformation_Matrix_Handle (in obj, in Name)

  The function Get_Transformation_Matrix_Handle gives the function handle for the calculation of the Transformation Matrix (T) of one of the rigid bodies in the system.

- function Get_System_Transformation_Matrix_Handle (in obj)

  The function Get_System_Transformation_Matrix_Handle returns a $[n_{RB} \times 3]$ *array of cells that contains the Symbolic matrices and function handles of all of the rigid bodies transformation matrices in the system, where* n_{RB} *is the number of rigid bodies in the system.*

- function Get_Kinetic_Energy_Quadratic_Matrix (in obj, in Name)
- function Get_d_Kinetic_Energy_Quadratic_Matrix (in obj, in Name)

  The function Get_Kinetic_Energy_Quadratic_Matrix gets the $[A]$ *matrix of a rigid body in the system.*

- function Get_System_Kinetic_Energy_Quadratic_Matrix (in obj)

  The function Get_d_Kinetic_Energy_Quadratic_Matrix gets the $[\dot{A}]$ *matrix of a rigid body in the system.*

- function Get_System_d_Kinetic_Energy_Quadratic_Matrix (in obj)

  The function Get_System_Kinetic_Energy_Quadratic_Matrix gets the $[A]$ *matrix of the whole system.*

- function Create_New_Action (in obj, in Name, in varargin)

  The Create_New_Action function introduces a new action in the current system.

- function Get_Action_Info (in obj, in Info, in varargin)
- function Get_Action_in_G (in obj, in Name)
- function Get_Generalized_Action (in obj, in Name)

  Get_Action_in_G is a function that takes the Name of an Action in the System and gives the analogous Action in the center of mass G of the rigid body.

- function Get_System_Generalized_Actions (in obj)

  The Get_Generalized_Action function gives the [N x 1] array that represents the contribution of an Action to the EOM.

- function Create_New_Generalized_Coordinate (in obj, in Name, in Symbol)

  Create_New_Generalized_Coordinate is a function that includes in the system one generalized coordinate.

- function Get_Generalized_Coordinates_Info (in obj, in Info, in varargin)

Static Public Member Functions

- static function order_reduction (in A, in q, in d_q)

  The function order_reduction gets a symbolic array with $\mathbf{q}$ *and* $\dot{\mathbf{q}}$ *variables and gives an array with the change of variables* $[\mathbf{u}, \mathbf{v}]^T = [\mathbf{q}, \dot{\mathbf{q}}]^T$.

Public Attributes

- Property System_Name

  String that defines the name of the system.

- Property q_variables

  [n x 1] symbolic array that contains the generalized coordinates of the system.

- Property Virtual_Velocity_Components_fun_handles

  [n x 1] handle of the functions that calculate the virtual displacements components.

- Property A_Matrix_Fun_Handles

  [n x n] handle of the functions that calculate the A matrix.

- Property u
- Property v
- Property Transformation_Matrix_Handles
- Property A
- Property A_uv
- Property d_A
- Property d_A_uv
- Property q
- Property uv
- Property vu
- Property b
- Property b_uv
- Property System_Bases
- Property System_Points
- Property System_Coordinate_Systems
- Property System_Rigid_Bodies
- Property System_Actions
- Property System_Generalized_Coordinates
- Property System_Inputs

Private Member Functions

- function System_Create_Bases_Table (in obj)

  The System_Create_Bases_Table function creates a table of all of the bases in the system.

- function System_Create_Points_Table (in obj)

  The System_Create_Points_Table function creates a table of all of the points in the system.

- function System_Create_Canonical_Coordinate_System (in obj)

  This function creates a Canonical Coordinate System with the Canonical Base and the Canonical Point.

- function System_Create_Coordinate_System_Table (in obj)

  The System_Create_Coordinate_System_Table function creates a table of all of the coordinate systems in the system.

- function System_Create_Rigid_Body_Table (in obj)

  The System_Create_Rigid_Body_Table function creates a table of all of the points in the system.

- function System_Create_Canonical_action (in obj)

  This function creates a null action $[0, 0, 0, 0, 0, 0]$ *named Canonical.*

- function System_Create_Action_Table (in obj)

  The System_Create_Action_Table function creates a table of all of the external Actions in the system.

- function System_Create_Generalized_Coordinates_Table (in obj)

  The System_Create_Generalized_Coordinates_Table function creates a table of all of the generalized coordinates in the system.

Static Private Member Functions

- static function System_Create_Canonical_Base ()

  This function creates a Canonical base $[1,0,0]$, $[0,1,0]$, $[0,0,1]$.

- static function System_Create_Canonical_Point ()

  This function creates a Canonical Point $[0,0,0]$.

- static function System_Create_Canonical_Rigid_Body ()

  This function creates a Canonical Rigid Body (all default settings).

Private Attributes

- Property System_Canonical_Base
- Property System_Canonical_Point
- Property System_Canonical_Coordinate_System
- Property System_Canonical_Rigid_Body
- Property System_Canonical_Action

  The function Get_System_Kinetic_Energy_Quadratic_Matrix gets the $[\dot{A}]$ *matrix of the whole system.*

- Property System_Canonical_Generalized_Coordinate
- Property System_Canonical_Input

4.6.1 Detailed Description

System Class for the creation of System objects.

4.6.2 Constructor & Destructor Documentation

4.6.2.1 function System (in *Name*)

4.6.3 Member Function Documentation

4.6.3.1 function Angular_Velocity (in *obj,* in *Base_1,* in *Base_2,* in *Base_Components*)

Angular_Velocity function gives the angular velocity vector from Base_1 to Base_2.

The given vector components can be represented in the Base_Components base.

Parameters

Base_1,: Base object that represent the fixed frame

Base_2,: Base object that represent the moving frame

Base_Components,: Base object in which the components will be given.

4.6.3.2 function Change_Basis_Matrix (in *obj,* in *Base_1,* in *Base_2*)

Given some vector components in a Base_1 the Change_Basis_Matrix function gives the vector components in base Base_2.

Parameters

Base_1,: Base object that represent the fixed frame

Base_2,: Base object that represent the moving frame

4.6.3.3 function Create_New_Action (in *obj,* in *Name,* in *varargin*)

The Create_New_Action function introduces a new action in the current system.

Parameters

obj,: System in which to introduce a new action

Name,: Name of the new action

Point,: Point of application of the action. The point is given by its String Name and has to be introduced previously in the System.

Base,: Base in which the action components are given. The Base is given by its String Name and has to be introduced previously in the System.

Rigid_Body,: Rigid Body to which the action applies. The Rigid_Body is given by its String Name and has to be introduced previously in the System.

Vector,: Components of the Action. The action components can me symbolic or double and they are given by 3 torque components and 3 force components. Eg: [Mx;My;Mz;Fx;Fy;Fz].

4.6.3.4 function Create_New_Base (in *obj,* in *Name,* in *varargin*)

Base introduction in System.

This function creates a Base object with the same inputs that the Base Class requires. This base is introduced in the System object.

Parameters

obj,: System object

Name

axis_labels(optional),: [3x1] symbolic array that contains the labels of the 3 vectors that represents the base. If this parameter is not specified the default axis_labels will be $[x, y, z]^T$.

father_base(optional),: The parent Base object defines the base from which the constructor will create a new Base object. From this parent base, a new base is generated through a simple rotation. The simple rotation can only be performed in the direction indicated by the right-hand rule for each of the vectors of the parent base. If father_base parameter is not defined, the default parent base is $[1, 0, 0]$, $[0, 1, 0]$, and $[0, 0, 1]$.

axis_rotation(optional),: The simple rotation can only be performed in the direction indicated by the right-hand rule for each of the vectors of the parent base. The axis_rotation parameter defines the rotation axis with a string "1", "2" or "3" defining the parent basis vector to use. If axis_rotation parameter is not defined, the default axis of rotation "1".

angle_rotation(optional),: Symbolic or double parameter that defines the angle of rotation (in radians) of the new base. If angle_rotation parameter is not defined the default angle of rotation is 0.

4.6.3.5 function Create_New_Coordinate_System (in *obj,* in *Name,* in *Point_Name,* in *Base_Name*)

The Create_New_Coordinate_System function introduces a new coordinate system in the System object.

This Coordinte System is given by a Point and a Base object.

Parameters

Name,: Name given to the new coordinate system.

Point_Name,: Point Name (String) of the Point used to create the new coordinate system.

Base_Name,: Base Name (String) of the Base used to create the new coordinate system.

4.6.3.6 function Create_New_Generalized_Coordinate (in *obj,* in *Name,* in *Symbol*)

Create_New_Generalized_Coordinate is a function that includes in the system one generalized coordinate.

Parameters

obj,: System object in which to include the new generalized coordinate.

Name,: Generalized coordinate name (string).

Symbol,: Generalized coordinate symbol (symbolic variable)

4.6.3.7 function Create_New_Point (in *obj,* in *Name,* in *Coordinate_System,* in *Coordinates*)

Point introduction in System.

This function creates a Point object with the same inputs that the Point Class requires. This base is introduced in the System object.

Parameters

Name,: String that defines the name of the object

point_coordinates,: [3 x 1] dobule or symbolic array that defines the position of the point with respect the absolute point (canonical point [0,0,0]).

The second way of creating a point is with respect a coordinate system. A coordinate system is defined by a base and a point, and the new point is given by its position with respect to the father point with the father_base components.

Parameters

Name,: String that defines the name of the object.

father_point,: Father Point (String).

father_base,: Father Base (String).

point_coordinates,: [3 x 1] dobule or symbolic array that defines the position of the point with respect the relative coordinate system (Father_Point and Father_Base).

4.6.3.8 function Create_New_Rigid_Body (in *obj,* in *Name,* in *varargin*)

Create_New_Rigid_Body is a function uses the methods of the class Rigid_Body to create a Rigid Body object.

Parameters

name,: String that defines the name of the rigid body.

G_Point,: Center of mass of the rigid body from the canonical point OG. Symbolic or double [3 x 1] array.

Base,: Base object that defines the kinematic base linked with the rigid body.

Mass,: Symbolic or double scalar that represents the total mass of the rigid body.

Intertial_Tensor,: [3 x 3] symbolic or double variable that represents the inertial tensor of the rigid body. A zero [3 x 3] array represents a particle.

4.6.3.9 function dot_A_dot_q (in *obj*)

4.6.3.10 function Get_A_Matrix_Handle (in *obj,* in *Name*)

The function Get_A_Matrix_Handle creates a $[1 \times 5]$ cell matrix for one rigid body in the system and helps the calculation of the $[A]$ values.

The cell arrays columns are: name of the rigid body (string), mass of the rigid body (double number), inertial tensor of the rigid body ($[3 \times 3]$ double array), $[n \times n]$ cell array used to get the $[A]$ matrix and a $[n \times n]$ cell array used to get the $[\dot{A}]$ matrix. The value of n is the number of generalized coordinates in the system (the degrees of freedom in a holonomic system).

Parameters

Name Name of the rigid body (string)

Each of the components of the $[n \times n]$ cell array contains the function handles to get the numeric values of the $[A]$ and $[\dot{A}]$ matrices. For example, the first component (1,1) of the $[A]$ matrix of a rigid body is gonna be $-m\mathbf{b_1}^T\mathbf{b_1} - [\mathbf{Ic_1}]^T\mathbf{c_1}$. In this expression m is the mass of the rigid body, $\mathbf{I}$ is the inertial tensor of the rigid body and $\mathbf{b_1}$ and $\mathbf{c_1}$ are the virtual displacements of the rigid body with respect to the first generalized coordinate. The $[n \times n]$ cell array gives the handles to calculate the virtual displacements $\mathbf{b_1}$ and $\mathbf{c_1}$ and in which order the product should be done. With this handles, the mass, and the inertial tensor, the numerical (1,1) component of the $[A]$ matrix can be calculated. Analogous methodology is used for the other components and also for the $[\dot{A}]$ matrix aswell.

4.6.3.11 function Get_A_tk_xk (in *obj,* in *tk,* in *xk*)

dot_A_dot_q function gives the [N x 1] array that represents the $[\dot{A}]\dot{\vec{q}}$ term of the EOM.

This function is used for the calculation of the RHS terms.

Parameters

obj System

4.6.3.12 function Get_Action_in_G (in *obj,* in *Name*)

4.6.3.13 function Get_Action_Info (in *obj,* in *Info,* in *varargin*)

4.6.3.14 function Get_Base_Info (in *obj,* in *Info,* in *varargin*)

4.6.3.15 function Get_Coordinate_System_Info (in *obj,* in *Info,* in *varargin*)

4.6.3.16 function Get_d_A_tk_xk (in *obj,* in *tk,* in *xk*)

The function Get_A_tk_xk calculates the value of the A matrix in a x_k configuration at time t_k.

Parameters

obj System

tk time t_k

xk configuration x_k

4.6.3.17 function Get_d_Kinetic_Energy_Quadratic_Matrix (in *obj,* in *Name*)

The function Get_Kinetic_Energy_Quadratic_Matrix gets the $[A]$ matrix of a rigid body in the system.

This function uses the Get_Info function of the Rigid_Body class with the A_Matrix option to get the A matrix.

Parameters

Name Name of the rigid body.

4.6.3.18 function Get_Generalized_Action (in *obj,* in *Name*)

Get_Action_in_G is a function that takes the Name of an Action in the System and gives the analogous Action in the center of mass G of the rigid body.

Parameters

Name Name of the action.

4.6.3.19 function Get_Generalized_Coordinates_Info (in *obj,* in *Info,* in *varargin*)

4.6.3.20 function Get_input_tk_xk (in *obj,* in *tk,* in *xk,* in *external_vars_k*)

The function Get_input_tk_xk calculates the value of the generalized inputs (generalized forces of the inputs) in a $[x_k, x_{external_k}]^T$ configuration at time t_k.

Parameters

obj System

tk time t_k

xk configuration x_k

4.6.3.21 function Get_Kinetic_Energy_Quadratic_Matrix (in *obj,* in *Name*)

4.6.3.22 function Get_Point_Info (in *obj,* in *Info,* in *varargin*)

4.6.3.23 function Get_Rigid_Body_Info (in *obj,* in *Info,* in *varargin*)

4.6.3.24 function Get_System_A_Matrix_Handles (in *obj*)

The function Get_System_A_Matrix_Handles creates a $[n_{RB} \times 2]$ cell matrix, where n_{RB} is the number of rigid bodies in the system.

This cell arrays give the function handles and parameters to calculate the $[A]$ and $[\dot{A}]$ matrices. This matrices represent the contribution of the inertial forces to the EOM.

Parameters

obj System

4.6.3.25 function Get_System_d_Kinetic_Energy_Quadratic_Matrix (in *obj*)

The function Get_System_Kinetic_Energy_Quadratic_Matrix gets the $[A]$ matrix of the whole system.

This function uses the Get_Kinetic_Energy_Quadratic_Matrix function and the system rigid body table to merge all the individual matrices.

4.6.3.26 function Get_System_Generalized_Actions (in *obj*)

The Get_Generalized_Action function gives the [N x 1] array that represents the contribution of an Action to the EOM.

Generally this components are known as generalized forces.

Parameters

Name Name of the Action The Get_System_Generalized_Actions function gives the [N x 1] array that represents the contribution of all Actions of the System to the EOM. Generally this components are known as generalized forces.

obj System

4.6.3.27 function Get_System_Kinetic_Energy_Quadratic_Matrix (in *obj*)

The function Get_d_Kinetic_Energy_Quadratic_Matrix gets the $[\dot{A}]$ matrix of a rigid body in the system.

This function uses the Get_Info function of the Rigid_Body class with the d_A_Matrix option to get the A matrix.

Parameters

Name Name of the rigid body.

4.6.3.28 function Get_System_Transformation_Matrix_Handle (in *obj*)

The function Get_System_Transformation_Matrix_Handle returns a $[n_{RB} \times 3]$ array of cells that contains the Symbolic matrices and function handles of all of the rigid bodies transformation matrices in the system, where n_{RB} is the number of rigid bodies in the system.

The first column of the cells represent the name (string) of each rigid body, the second contains the Symbolic Transformation Matrix and the third one keeps the function handle for the numerical calculation of the transformation matrix.

4.6.3.29 function Get_System_Virtual_Velocity_q_uv_handle (in *obj*)

4.6.3.30 function Get_tau_tk_xk (in *obj,* in *tk,* in *xk*)

4.6.3.31 function Get_Transformation_Matrix_Handle (in *obj,* in *Name*)

The function Get_Transformation_Matrix_Handle gives the function handle for the calculation of the Transformation Matrix (T) of one of the rigid bodies in the system.

This transformation matrix is given in the reduced order variables $[\mathbf{u}, \mathbf{v}]^T$.

Parameters

Name

Return values

T_uv Symbolic Transformation Matrix (T).

T_fun_handle Function handle of the Transformation Matrix (T).

4.6.3.32 function Get_Two_Points_Vector (in *obj,* in *Start_Point,* in *End_Point*)

The function Get_Two_Points_Vector returns the vector componenents from Start_Point to End_Point in the Canonical base.

Parameters

Start_Point The initial point.

End_Point The end point.

Return values

out $[3 \times 1]$ position vector

4.6.3.33 function Get_Two_Points_Vector_Base (in *obj,* in *Start_Point,* in *End_Point,* in *Base*)

The Get_Two_Points_Vector_Base function returns the vector componenents from Start_Point to End_-Point in any base.

Parameters

Start_Point The initial point.

End_Point The end point.

Base Components base (String).

Return values

out $[3 \times 1]$ position vector

4.6.3.34 function Get_Virtual_Velocity_q_Component (in *obj,* in *Name,* in *q*)

The Get_Virtual_Velocity_q_Component function provides the $\left[\mathbf{c_k^i}, \mathbf{b_k^i}\right]^T$ array given by the Get_Info function of the Rigid_Body class.

Parameters

Name Name of the rigid body.

q Generalized coordinate

4.6.3.35 function Get_Virtual_Velocity_q_uv_handle (in *obj,* in *Name*)

The Get_Virtual_Velocity_q_uv_handle function provides the $\left[\mathbf{c_k^i}, \mathbf{b_k^i}\right]^T$ array given by the Get_Info function of the Rigid_Body class in the variables $[\mathbf{u}, \mathbf{v}]^T$ of the order reduction.

This function saves for each of the generalized coordinates in the system a function in the folder fun_-handles in the work directory.

Parameters

Name Name of the rigid body.

4.6.3.36 function Lagrangian_Rigth_Hand_Side (in *obj*)

The function Lagrangian_Rigth_Hand_Side returns the vector $\mathbf{b} = -\frac{d}{dt}\left[\mathbf{A}\right]\dot{\mathbf{q}} + \tau$ of the $\left[\mathbf{A}\right]\ddot{\mathbf{q}} = \mathbf{b}$ system of equations.

4.6.3.37 static function order_reduction (in *A,* in *q,* in *d_q*) `[static]`

The function order_reduction gets a symbolic array with $\mathbf{q}$ and $\dot{\mathbf{q}}$ variables and gives an array with the change of variables $[\mathbf{u}, \mathbf{v}]^T = [\mathbf{q}, \dot{\mathbf{q}}]^T$.

4.6.3.38 function System_Create_Action_Table (in *obj*) `[private]`

The System_Create_Action_Table function creates a table of all of the external Actions in the system.

The table has 3 columns: Action_Name(string variable), Rigid_Body (Rigid_Body class variable) and Action(Action class variable). Each time the user introduces a new Action in the system the table is updated and a new Action is added.

4.6.3.39 function System_Create_Bases_Table (in *obj*) [private]

The System_Create_Bases_Table function creates a table of all of the bases in the system.

The table has 2 columns: Name(string variable) and Base (Base class variable). Each time the user introduces a base in the system the table is updated and a new base is added.

4.6.3.40 function System_Create_Canonical_action (in *obj*) [private]

This function creates a null action $[0, 0, 0, 0, 0, 0]$ named Canonical.

This Canonical Action is needed for the first time creation of the Action table.

4.6.3.41 static function System_Create_Canonical_Base ( ) [static, private]

This function creates a Canonical base $[1, 0, 0]$, $[0, 1, 0]$, $[0, 0, 1]$.

This Canonical Base is needed for the first time creation of the Base table.

4.6.3.42 function System_Create_Canonical_Coordinate_System (in *obj*) [private]

This function creates a Canonical Coordinate System with the Canonical Base and the Canonical Point.

This Canonical Coordinate System is needed for the first time creation of the Coordinate System table.

4.6.3.43 static function System_Create_Canonical_Point ( ) [static, private]

This function creates a Canonical Point $[0, 0, 0]$.

This Canonical Point is needed for the first time creation of the Points table.

4.6.3.44 static function System_Create_Canonical_Rigid_Body ( ) [static, private]

This function creates a Canonical Rigid Body (all default settings).

This Canonical Rigid Body is needed for the first time creation of the Rigid Bodies table.

4.6.3.45 function System_Create_Coordinate_System_Table (in *obj*) [private]

The System_Create_Coordinate_System_Table function creates a table of all of the coordinate systems in the system.

The table has 2 columns: Point_Name(string variable) and Base_Name (string variable). Each time the user introduces a new coordinate system in the system the table is updated and a new coordinate system is added.

4.6.3.46 function System_Create_Generalized_Coordinates_Table (in *obj*) [private]

The System_Create_Generalized_Coordinates_Table function creates a table of all of the generalized coordinates in the system.

The table has 2 columns: Generalized_Coordinate_Name(string variable) and Generalized_Coordinate_-Symbol (symbolic class variable). Each time the user introduces a new generalized coordinate in the system the table is updated and a new generalized coordinate is added.

4.6.3.47 function System_Create_Points_Table (in *obj*) [private]

The System_Create_Points_Table function creates a table of all of the points in the system.

The table has 2 columns: Name(string variable) and Point (Point class variable). Each time the user introduces a point in the system the table is updated and a new point is added.

4.6.3.48 function System_Create_Rigid_Body_Table (in *obj*) [private]

The System_Create_Rigid_Body_Table function creates a table of all of the points in the system.

The table has 4 columns: Rigid_Body_Name(string variable), Point_Name (string variable), Base_-Name(string variable) and Rigid_Body(Rigid_Body class variable) . Each time the user introduces a rigid body in the system the table is updated and a new rigid body is added.

4.6.3.49 function unify_symbolic_system (in *obj*)

The unify_symbolic_system function calculates the matrix $[\mathbf{A}]$, its derivative $\frac{d}{dt}[\mathbf{A}]$ and the generalized actions τ (the generalized actions are given by the inputs and other external actions). The system of equations is presented as $[\mathbf{A}]\,\ddot{\mathbf{q}} = \mathbf{b}$ where the vector $\mathbf{b}$ has been calculated as $\mathbf{b} = -\frac{d}{dt}[\mathbf{A}]\,\dot{\mathbf{q}} + \tau$. As the system of equations presented is of second order the function also returns the reduced system of equations to a first order system of equations $[\mathbf{u}, \mathbf{v}, \dot{\mathbf{v}}]^T = [\mathbf{q}, \dot{\mathbf{q}}, \ddot{\mathbf{q}}]^T$. This way the reduced system of equations is $[[\mathbf{A_u}]\,\mathbf{v}, \mathbf{u}]^T = [\mathbf{b_{uv}}, \mathbf{v}]^T$ where $\mathbf{A_u} = \mathbf{A}(\mathbf{u})$ and $\mathbf{b_{uv}} = \mathbf{b}(\mathbf{u}, \mathbf{v})$.

4.6.3.50 function unify_system (in *obj*)

The function unify_system creates the function handles for the calculation of virtual displacements of the system. This virtual displacements are used to calculate the matrix $[\mathbf{A}]$ (function Get_A_tk_xk), its derivative $\frac{d}{dt}[\mathbf{A}]$ (function Get_d_A_tk_xk) and the generalized actions τ (function Get_tau_tk_xk and function Get_input_tk_xk).

4.6.4 Member Data Documentation

4.6.4.1 Property A

4.6.4.2 Property A_Matrix_Fun_Handles

[n x n] handle of the functions that calculate the A matrix.

4.6.4.3 Property A_uv

4.6.4.4 Property b

4.6.4.5 Property b_uv

4.6.4.6 Property d_A

4.6.4.7 Property d_A_uv

4.6.4.8 Property q

4.6.4.9 Property q_variables

[n x 1] symbolic array that contains the generalized coordinates of the system.

4.6.4.10 Property System_Actions

4.6.4.11 Property System_Bases

4.6.4.12 Property System_Canonical_Action `[private]`

The function Get_System_Kinetic_Energy_Quadratic_Matrix gets the $[\dot{A}]$ matrix of the whole system.

This function uses the Get_d_Kinetic_Energy_Quadratic_Matrix function and the system rigid body table to merge all the individual matrices.

4.6.4.13 Property System_Canonical_Base `[private]`

4.6.4.14 Property System_Canonical_Coordinate_System `[private]`

4.6.4.15 Property System_Canonical_Generalized_Coordinate `[private]`

4.6.4.16 Property System_Canonical_Input `[private]`

4.6.4.17 Property System_Canonical_Point `[private]`

4.6.4.18 Property System_Canonical_Rigid_Body `[private]`

4.6.4.19 Property System_Coordinate_Systems

4.6.4.20 Property System_Generalized_Coordinates

4.6.4.21 Property System_Inputs

4.6.4.22 Property System_Name

String that defines the name of the system.

4.6.4.23 Property System_Points

4.6.4.24 Property System_Rigid_Bodies

4.6.4.25 Property Transformation_Matrix_Handles

4.6.4.26 Property u

4.6.4.27 Property uv

4.6.4.28 Property v

4.6.4.29 Property Virtual_Velocity_Components_fun_handles

[n x 1] handle of the functions that calculate the virtual displacements components.

4.6.4.30 Property vu

The documentation for this class was generated from the following file:

- C:/DoxygenMatlab/+Dynamic_Library/System.m

Chapter 5

File Documentation

5.1 C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Action/Action.m File Reference

Classes

- class Action

5.2 C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Base/Base.m File Reference

Base Class description.

Classes

- class Base

  Base Class for the creation of orthonormal vectorial bases.

5.2.1 Detailed Description

Base Class description.

5.3 C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Point/Point.m File Reference

Classes

- class Point

5.4 C:/DoxygenMatlab/+Dynamic_Library/+Classes/@Rigid_Body/Rigid_Body.m File Reference

Rigid Body Class description.

Classes

- class Rigid_Body

  Rigid Body Class for the creation of Rigid Body objects.

5.4.1 Detailed Description

Rigid Body Class description.

5.5 C:/DoxygenMatlab/+Dynamic_Library/System.m File Reference

System Class description.

Classes

- class System

  System Class for the creation of System objects.

5.5.1 Detailed Description

System Class description.

Index