Readme for Gomotion ROS Package

12/23/2016 1:24:00 PM

ROSGomotion.docx

## Abstract

This document discusses the Robot Operating System (ROS) package for gomotion robot joint and Cartesian pose trajectory generation. The Gomotion trajectory generation ROS package is a subset of the gomotion controller library (found at https://github.com/frederickproctor/gomotion ), which contains code for a full real-time motion control system for machine tools or robots. The ROS gomotion package accepts robot destinations as either transform poses (from the tf package) or as a position or velocity values within a JointState representation, represented as a std vector of doubles. Internally, go motion has more functionality, but for the ROS package, functionality is limited to joint and Cartesian pose trajectory generation.

Gomotion trajectory generation has two fundamental motion types: joint and world.

* Gomotion joint trajectory generation generates a motion plan expressed as joint values for each joint in a mechanism. Starting with the current joint values, gomotion takes destination joint values for which a coordinated or uncoordinated plan is generated. A coordinated joint trajectory has all the mechanism joints arrive at the destination position at the same time. An uncoordinated joint trajectory has the joints arrive however long the move is in each axes.
* Gomotion world trajectory generation generates a motion plan given goal destination expressed as a six dimensional "pose" which is combination of 3D position (x,y,z) and an orientation which simply is a series of rotations around axes x,y,z.

WHAT GOMOTION WON'T DO: no obstacle detection, final velocity always zero, no blending.

## Abbreviations

ECP tool's end control point  
KCP kinematic  
TCP tool center point  
EE end effector

## Background

<http://superuser.com/questions/340650/type-math-formulas-in-microsoft-word-the-latex-way>

From [[1]](#footnote-1)A “frame of reference” is a standard relative to which motion and rest may be measured; any set of points or objects that are at rest relative to one another enables us, in principle, to describe the relative motions of bodies. A frame of reference is therefore a purely kinematical device, for the geometrical description of motion without regard to the masses or forces involved. A dynamical account of motion leads to the idea of an “inertial frame,” or a reference frame relative to which motions have distinguished dynamical properties.

Robot motions can be described by some coordinate system or frame of reference. Numerous coordinate systems representations exist. For our purposes, we will called linear transformations.

Positions are vectors that indicate where something is. In the three-dimensional world, three numbers are necessary to indicate position. Internally, Go Motion supports position vectors in several representations: Cartesian, cylindrical and spherical.

The Cartesian representation uses three numbers **x**, **y** and **z** to represent distances from the origin along three perpendicular axes. The cylindrical representation uses three numbers **r**, **theta** and z to represent radial distance away from the origin, angle around the origin and distance up and down from the origin respectively. The spherical representation uses three numbers **theta**,**phi** and **r** to represent angle down from the zenith, angle around the origin and radius from the origin respectively. Go Motion has functions that convert position in one representation position in another representation, so the choice of which representation to use can be made for convenience. Cartesian representations will be assumed unless otherwise specified.

Orientations are vectors that indicate how something is rotated. In the three-dimensional world, three numbers are necessary to indicate orientation. Go Motion supports orientation vectors in several representations: roll, pitch and yaw; Euler angles; quaternions; rotation vectors and rotation matrices. Some of these representations use more than three numbers, exploiting redundancy to make calculations with these representations more efficient. For example, a quaternion uses four numbers, and a rotation matrix uses nine numbers.

Vectors are usually written as a column of numbers enclosed in vertical bars, like this:

|  |  |  |
| --- | --- | --- |
|  | - a vector depicted in its column form | () |

This can be unwieldy in text documentation, so vectors may also be written as a row of numbers enclosed in parentheses, like this:

|  |  |  |
| --- | --- | --- |
|  | - a vector depicted in its row form | () |

The interpretation of a vector depends on the quantity it represents. The vector shown above could mean a translation of 1, 2 and 3 units in the x, y and z directions if the vector were a Cartesian position, or a rotation of 1, 2 and 3 units around the x, y and z directions if the vector were an orientation in roll, pitch and yaw.

Both position and orientation are needed to fully describe where something is and how it is rotated. The combination of position and orientation is called a 'pose'. Poses can be shown in row form like this pose representing a Cartesian position of ( 1 2 3 ) and an orientation in roll, pitch and yaw of ( 30 -30 90 ):

|  |  |  |
| --- | --- | --- |
|  | ( 1 2 3 ; 30 -30 90) | () |

A semicolon is used to separate the position from the orientation.

### Reference Frames

Regardless of the representation chosen, the numbers that indicate position and orientation of an object depend on the established origin. Several origins may be established for convenience, for example one fixed on the world and one that moves with a tool. These origins may differ from each other in both position and orientation. The establishment of the position and orientation of an origin is a 'reference frame'. The term 'coordinate frame' is used interchangeably with 'reference frame'.

When several reference frames are being used, they are denoted as identifiers in braces, for example,

|  |  |  |
| --- | --- | --- |
|  | {A} - a reference frame called 'A'.  {world} - the world reference frame.  {tool} - the world reference frame. | () |

To convert the representation of a pose in one reference frame to its representation in another, one needs to know the position and orientation of one origin with respect to the other. This difference between the two origins is called a 'transform'.

Poses and transforms are similar things; both include position and orientation. Whether something is a pose or a transform depends on how one is using it. Poses are used to indicate the position and orientation of things with respect to an established reference frame. Transforms are used to indicate the position and orientation of reference frames with respect to other reference frames. If a 'thing' happens to be a reference frame, its pose is its transform.

## Math Nomenclature

The letter P is used to denote positions and the letter **R** is used to denote orientations. As usual, trailing subscripts denote the identity of quantities, for example,

|  |  |  |
| --- | --- | --- |
|  | Phand - the position of the hand | () |

.

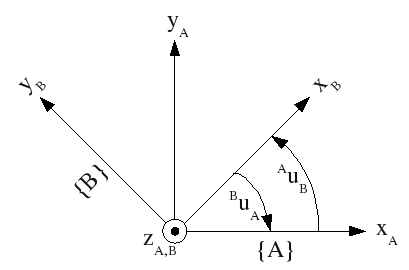
Or

|  |  |  |
| --- | --- | --- |
|  | Rhead - the orientation of the head | () |

Leading superscripts denote the reference frame in which the quantity is expressed, for example,

|  |  |  |
| --- | --- | --- |
|  | APhand - the position of the hand with respect to the {A} reference frame  BRhead - the orientation of the head with respect to the {B} reference frame | () |

The figure below shows a rotation of reference frame {B} with respect to reference frame {A} by an angle **u**. Note that the rotation can be viewed as a rotation of {B} with respect to {A}, denoted AuB, or as a rotation of {A} with respect to {B}, denoted BuA. The heads of arrows are attached to the 'of the' frames, while the tails of arrows are based on the 'with respect to' frames. Angles are taken as positive according the right hand rule, so in this figure AuB is a positive number of about 45 degrees, while BuA is a negative number of the same magnitude.



*Figure* 1.

Transforms from one reference frame to another are denoted with leading subscripts and superscripts. The leading subscript denotes the original frame, and the leading superscript denotes the new frame. If a transform is purely rotation, it is denoted with an **R**, for example,

|  |  |  |
| --- | --- | --- |
| BAR | a rotation from the {A} frame to the {B} frame | () |

If a transform includes both a rotation and a translation, it is denoted with a T, for example,

|  |  |  |
| --- | --- | --- |
| worldtoolT | a transform from the {tool} frame to the {world} frame | () |

To convert a quantity from one frame to another, pre-multiply the quantity by the transform. Algebraically, the leading subscript of the transform must match the leading superscript of the quantity, for example,

|  |  |  |
| --- | --- | --- |
|  | BP = BAR \* AP | () |

This is read, 'the position with respect to the B frame is the rotation from the A frame to the B frame times the position with respect to the A frame.' Another example is,

|  |  |  |
| --- | --- | --- |
|  | worldP = worldtoolT \* toolP | () |

This is read, 'the position with respect to the world frame is the transform from the tool frame to the world frame times the position with respect to the tool frame.'

One can generate a rotational transform by defining an orientation vector with the appropriate angles. If using a roll, pitch and yaw representation, the rotational transforms in the figure above (each about the **z** axis) is a yaw:

|  |  |  |
| --- | --- | --- |
|  | = ARB | () |
|  | = BRA | () |

and negative angles work as well, for

|  |  |  |
| --- | --- | --- |
|  | = ARB | () |

## Examples

Given a reference frame {B} rotated 30 degrees with respect to the **z** axis of reference frame {A}, as in Figure 1 above, transform from points in the {B} frame to points in the {A} frame like this:

go\_rpy rot;

go\_cart pt\_in\_b;

go\_cart pt\_in\_a;

// The angle of {B} with respect to {A} is 30 degrees.

// Go uses angles in radians.

rot.r = 0, rot.p = 0, rot.y = [GO\_TO\_RAD](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d7\d2c\gomath_8h.html#a257fd1bdbb4294c1bf1d2c34bfeaba42)(30);

pt\_in\_b.x = 1, pt\_in\_b.y = 2, pt\_in\_b.z = 3;

// Multiply a transform and a point to get a new point.

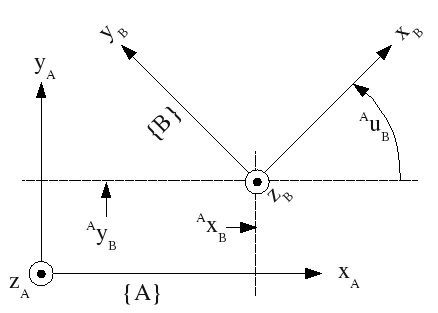
[go\_rpy\_cart\_mult](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d1\d0f\namespacegomotion.html#ac89b091b7958b0916f0bfffc89022751)(&rot, &pt\_in\_b, &pt\_in\_a);

go\_cart\_print(&pt\_in\_a);

will print the position of the point in the {A} frame:

-0.133975 2.232051 3.000000

Here is a more complex example of a full transform, including both translation and rotation.



*Figure* 2.

The frame {B} is translated and rotated with respect to {A}. AxB is the amount of translation of {B} in the **x** direction of {A}. Likewise, AyB is the amount of translation of {B} in the **y** direction of {A}.AuB is the rotation of the {B} frame about the **z** axis of the {A} frame.

To convert points in the {B} frame to points in the {A} frame, do this:

go\_pose pose;

go\_rpy rot;

go\_cart pt\_in\_b;

go\_cart pt\_in\_a;

// The translation of {B} with respect to {A} is about (2 1 0).

pose.tran.x = 2, pose.tran.y = 1, pose.tran.z = 0;

// The angle of {B} wrt {A} is about 30 degrees, made into radians.

rot.r = 0, rot.p = 0, rot.y = [GO\_TO\_RAD](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d7\d2c\gomath_8h.html#a257fd1bdbb4294c1bf1d2c34bfeaba42)(30);

// A 'go\_pose' uses quaternions for rotations, so we have to

// convert a roll-pitch-yaw to a quaternion.

[go\_rpy\_quat\_convert](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d1\d0f\namespacegomotion.html#a220f82039af859bfd9413107e7fbdf13)(&rot, &pose.rot);

pt\_in\_b.x = 1, pt\_in\_b.y = 2, pt\_in\_b.z = 3;

// Multiply a transform and a point to get a new point.

[go\_pose\_cart\_mult](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d1\d0f\namespacegomotion.html#a8fddcbebee69b64a2536721c33087e3c)(&pose, &pt\_in\_b, &pt\_in\_a);

go\_cart\_print(&pt\_in\_a);

This gives the transformed point in the {A} frame as

1.866025 3.232051 3.000000

## Coordinate frames

Coordinate frames are used to represent a series of transformation from the base robot frame into the last robot frame, known as wrist, end effector or tool frame. Terminology for understanding the motion control is based on Craig Chapter 1. [CRIAG]

For a 6 degree of robot with its base frame at (0,0,0) and the last frame at the wrist the following series of transformation define the robot.

|  |  |  |
| --- | --- | --- |
|  | 0T6 = 0T1 x 1T2 x 2T3 x 3T4 x 5T6 | () |

Coordinate frames are important if one needs to understand how to represent a robot with or without a tool or with different tools and/or in different positions in the world coordinate frame. Using a transformation one can move the robot around in the world coordinate system.

|  |  |  |
| --- | --- | --- |
|  | WTEE =WT0 x 0T6 x 6TEE | () |

Where the terminology is WT0 is the world to base frame transformation, 0T6 is the robot base to wristtransformation, and 6TEE is the wrist to tool transformation. Assuming is in the world coordinate system, the kinematic forward and inverse (FK and IK) solver we used, was ikfast.

The tool transform is specified as the position and orientation of the tool's end control point, ECP, with respect to the kinematic control point, KCP.

The kinematics functions relate the joints to the "kinematic control point" KCP. The forward kinematics calculate the KCP from the joint values, and the inverse kinematics calculate the joint values from the KCP.

Often one would like to add another transform from the KCP to an application "end control point" ECP. This is commonly called the "tool transform," with the KCP called the "wrist frame" and the ECP called the "tool frame". As tools are placed on the manipulator, the tool transform changes. 0TK is the KCP. This is the frame of the kinematics functions, where the 0 means the world coordinate system.

* 0TE is the ECP. This is the frame of motion control, program coordinates, position limits, home position and the display.
* KTE is the tool transform. The tool transform is specified as the position and orientation of the tool's end control point, ECP, with respect to the kinematic control point, KCP,

|  |  |  |
| --- | --- | --- |
|  |  |  |

KTE = | KRE x KPEorg|

i.e., the position and orientation of the tool tip expressed with respect to the kinematic control point (aka wrist frame).

To go from the ECP to the KCP, we postmultiply the ECP by the inverse tool transform to get the KCP:

|  |  |  |
| --- | --- | --- |
|  | 0TK = 0TE \* ETK |  |

that is,

|  |  |  |
| --- | --- | --- |
|  | ECP \* inverse tool transform = KCP( |  |

or in code as go\_pose\_pose\_mult(&ECP, &tool\_transform\_inv, &KCP). Results from the forward kinematics functions are in the KCP, and must be transformed into the ECP when sent out as status. To go from the KCP to the ECP, we postmultiply the KCP by the tool transform to get the ECP:

|  |  |  |
| --- | --- | --- |
|  | 0ET = 0KT \* KET | () |

that is,

|  |  |  |
| --- | --- | --- |
|  | KCP \* tool transform = ECP | () |

or in code as go\_pose\_pose\_mult(&KCP, &tool\_transform, &ECP). Changing the tool transform is tricky. Even the motion queue is empty and the controller is holding the ECP constant, changing the tool transform will cause a jump in the KCP and a corresponding jump in the joint values coming out of the inverse kinematics. To handle this, we need to change the ECP when changing the tool transform:

|  |  |  |
| --- | --- | --- |
|  | 0KT \* KEnewT = 0EnewT  , KCP \* new tool transform = new ECP | () |

When the tool is changed, you would see a jump in the displayed position, but no jump in actual position. To avoid inconsistencies between points on the motion queue in various ECPs, the tool transform can only be changed when the motion queue is empty. The configuration state table for changing the tool transform ensures this, then updates the queue position with the new ECP.

The ECP is in the traj status buffer as 'cmd\_position'. The KCP is in the traj status buffer as 'kcp'. The tool transform and inverse are in the traj settings buffer as 'tool\_transform' and 'tool\_transform\_inv'. To convert from a pose A in the ECP to the pose in the KCP, premultiply by the tool transform:

|  |  |  |
| --- | --- | --- |
|  | KA = KET \* EA | () |

## TRAJ Trajectory Planning Algorithms

Trajectory planning functions abbreviations:

* CV means constant velocity, CA means constant acceleration,
* CJ means constant jerk.

The Go Motion trajectory planning algorithms are based on smooth velocity profiling with bounded speed, acceleration and jerk, called "constant jerk" or "S-curve" velocity profiling. This gives smoother control than "trapezoidal" velocity profiling, which transitions occur instantaneously between acceleration and no acceleration and incurs spikes in unbounded jerk.

Constant-jerk (CJ) profiling is shown in Figure 1, a plot of the speed versus time. There are 7 phases to the motion. Phase 1 is a jerk phase, where the acceleration varies smoothly from 0 at time 0 to a1 at time t1 following the jerk (change in acceleration per unit time) j0. Phase 2 is an acceleration phase, with constant acceleration a1 throughout. Phase 3 is a jerk phase (or de-jerk phase) with constant (negative) jerk slowing down the acceleration from a1 to 0. Phase 4 is a constant speed phase at speed v3. Phase 5 is a constant-jerk counterpart to phase 3, where the deceleration varies smoothly from 0 to -a1. Phase 6 is a constant-acceleration counterpart to phase 2. Phase 7 is a constant-jerk counterpart to phase 1, where the deceleration varies smoothly from -a1 to 0 and motion stops.

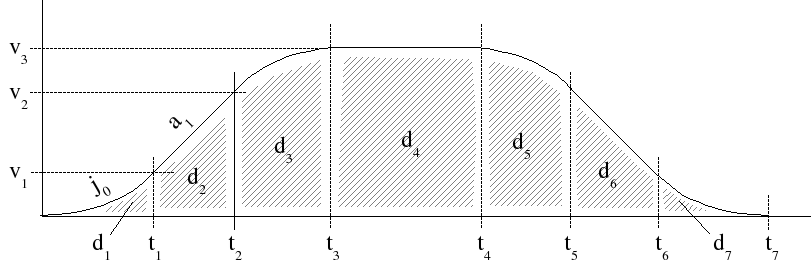
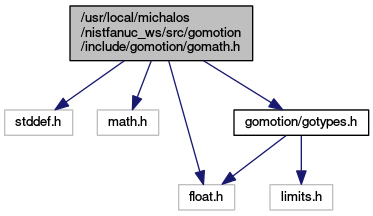


Figure Constant jerk velocity profiling.

Declarations for pose math functions.

#include <stddef.h>  
#include <math.h>  
#include <float.h>  
#include "[**gomotion/gotypes.h**](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d7\d44\gotypes_8h_source.html)"

Include dependency graph for gomath.h:



**Trajectory Planning Algorithms**

The Go Motion trajectory planning algorithms are based on smooth velocity profiling with bounded speed, acceleration and jerk, called "constant jerk" or "S-curve" velocity profiling. This gives smoother control than "trapezoidal" velocity profiling, which transitions instantaneously between acceleration and no acceleration and incurs spikes in unbounded jerk.

Constant-jerk (CJ) profiling is shown in Figure 1, a plot of the speed versus time. There are 7 phases to the motion. Phase 1 is a jerk phase, where the acceleration varies smoothly from 0 at time 0 to *a1* at time *t1* following the jerk (change in acceleration per unit time) *j0*. Phase 2 is an acceleration phase, with constant acceleration *a1* throughout. Phase 3 is a jerk phase (or de-jerk phase) with constant (negative) jerk slowing down the acceleration from *a1* to 0. Phase 4 is a constant speed phase at speed *v3*. Phase 5 is a constant-jerk counterpart to phase 3, where the deceleration varies smoothly from 0 to *-a1*. Phase 6 is a constant-acceleration counterpart to phase 2. Phase 7 is a constant-jerk counterpart to phase 1, where the deceleration varies smoothly from *-a1* to 0 and motion stops.

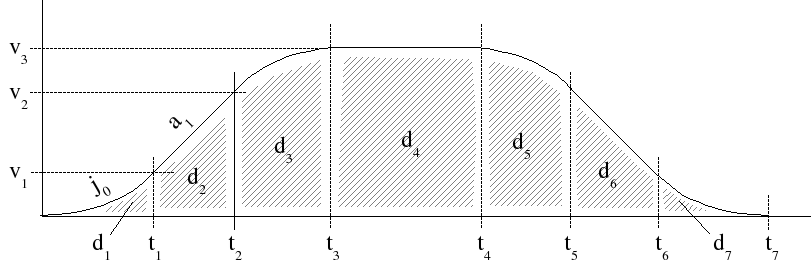
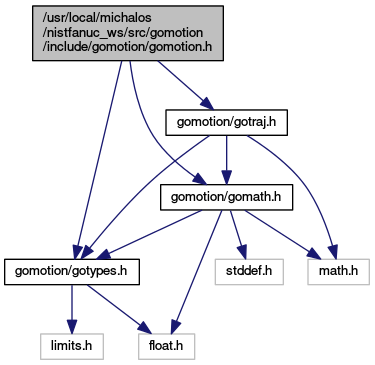


Figure 1. Constant jerk velocity profiling.

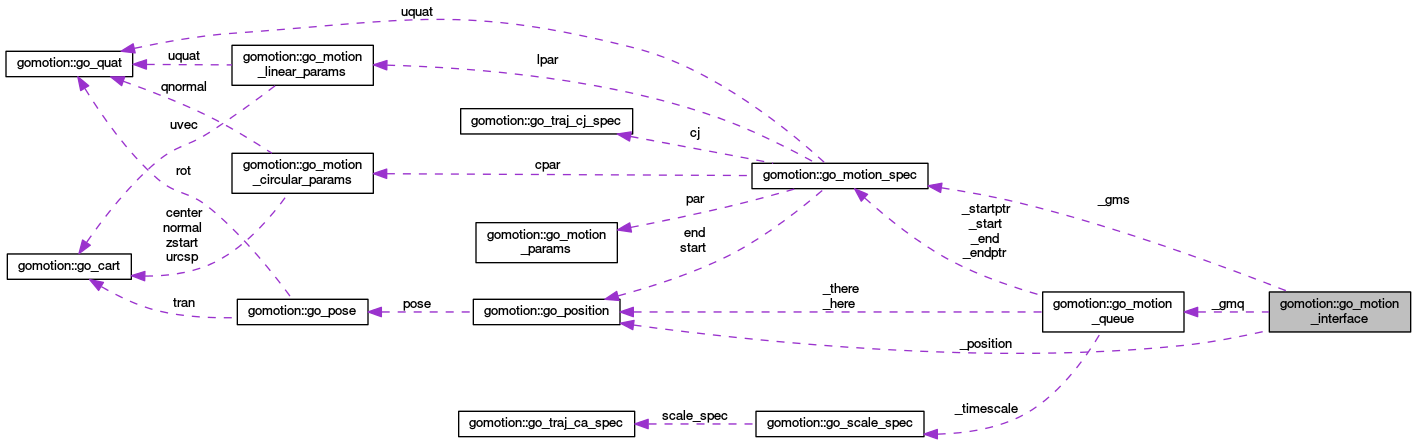
Declarations for motion queue manipulation. [More...](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d3\df0\gomotion_8h.html#details)

#include "[**gomotion/gotypes.h**](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d7\d44\gotypes_8h_source.html)"  
#include "[**gomotion/gomath.h**](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d7\d2c\gomath_8h_source.html)"  
#include "[**gomotion/gotraj.h**](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d7\dc0\gotraj_8h_source.html)"

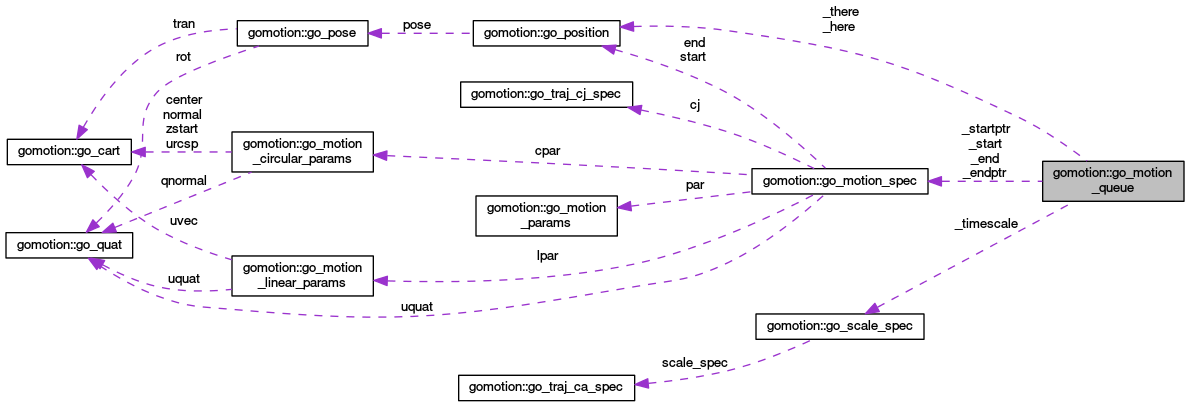
Include dependency graph for gomotion.h:



# Gomotion ROS Package

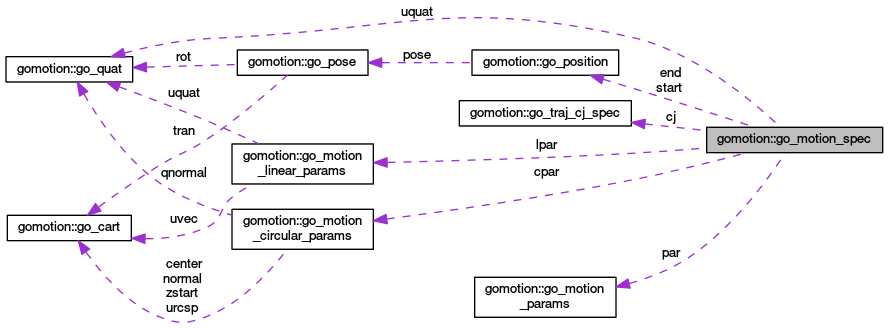


Collaboration diagram for gomotion::go\_motion\_queue:



#include <[**gomotion.h**](file:///X:\src\github\johnmichaloski\ROS\nistfanuc_ws\src\gomotion\doc\doxygen\html\d3\df0\gomotion_8h_source.html)>

Collaboration diagram for gomotion::go\_motion\_spec:



Setpoints to Servo are always in Servo's original startup coordinate system (CS). As an example, assume Servo starts out at 5.5. Servo's \a input\_latch is some point in the original CS, say 17. That is, the joint moved from 5.5 to 17 and there it saw a home condition. After the stop, the joint will have moved some extra distance, say to 17.1. Traj has a nominal value for the joint home, say 29. Traj wants to call 29 what Servo calls 17.

The difference between Servo's home in the original CS, here 17, and Traj's nominal home, here 29, is an offset, here 12. Traj needs to add 12 to Servo's position values to get values in Traj's homed CS.

When a joint is homed, Traj needs to add the offset to Servo positions when reading them, and subtract this offset to setpoints to Servo when writing them.

Servo will guarantee that \a inputOffset and \a homed are set simultaneously, so it's safe for Traj to check the \a homed flag and then add/subtract inputs/outputs based on that.

The homing sequence is as follows: Traj should begin by sending \a servo\_cmd\_servo commands with a constant setpoint to hold position, and the \a home flag cleared. Traj waits until the \a homing flag is cleared in the joint servo status. The \a homing flag is simply an echo of Traj's \home flag. Any homing action in Servo will be abandoned. When Servo sees the \a home flag set, and its \a homing flag clear, it requests a homing action if necessary from the external interface, and clears its \a homed flag.

When Servo sees the homing condition met by the external interface, it saves the latched position to the \a input\_latch in its status, sets the \a homed flag and leaves the \a homing flag set so that it won't re-initiate a home. When Traj sees the \a homed flag set for a joint, it stops the motion for that joint.

Gomotion world trajectory generation moves the mechanism to the end goal pose, which is expressed in world coordinates. If a time in seconds is given and is positive, the move will be scaled to take that amount of time if possible or longer if the system is constrained by max velocity, acceleration and jerk. If time is not positive, then the motion parameters tv, ta, tj, rv, ra and rj are used for the translational and rotational vel, accel and jerk, respectively.

The following d, v, a, j are the distance, velocity, acceleration and jerk for each joint, in meters for prismatic joints, and radians for rotational joints. The distance value 'd' is absolute, and can be positive or negative. The parameter values 'v', 'a' and 'j' must be positive

The ROS package gomotion is a library that you link against when you are compiling. You start the use of ROS package gomotion by including it in your Package.xml declaration file, for example, the following XML snippet is necessary to include the gomotion package:

?xml version="1.0" encoding="UTF-8"?>

<package>

<name>yourpackage</name>

<build\_depend>gomotion</build\_depend>

. . .

<run\_depend>gomotion</run\_depend>

You will need to modify the CMakeLists.txt that the ROS build manager "catkin" uses to build your ROS package. Below you will need to find the gomotion package and let the gomotion library be found using CATKIN\_DEPENDS, and not explicitly linking against the gomotion library. Below is a snippet of the addition to CMakeLists.txt to make gomotion library part of the include and link in the make of your package. Note, I had to add ${catkin\_LIBRARIES} AND remove the reference to the shared library libgomotion.so.

cmake\_minimum\_required(VERSION 2.8.3)

project(yourpackage)

find\_package(catkin REQUIRED COMPONENTS

. . .

gomotion

)

catkin\_package(

INCLUDE\_DIRS

include

# include/${PROJECT\_NAME}/CrclXsd

LIBRARIES

CATKIN\_DEPENDS

. . .

Gomotion

)

target\_link\_libraries(yourpackage

# I had to add ${catkin\_LIBRARIES} AND remove the reference to the shared library

# libgomotion.so

${catkin\_LIBRARIES}

${Boost\_LIBRARIES}

)

Once you have the gomotion dependencies in place, you are ready to use the trajectory generator. First, you include the gomotion header file and then declare a GoMotion trajectory generator.

#include <gomotion/gomove.h>

GoMotion go;

Gomotion can handle joint or Cartesian pose. In ROS, there are several ways to describe a kinematic pose, but we will use tf::Pose from the transform package.

tf::Pose finalpose = Conversion::Convert<geometry\_msgs::Pose, tf::Pose>(cmd.finalpose);

tf::Pose goalpose = finalpose \* \_nc->invGripperPose();

If 'totalt' is positive, then it is the time for the move. Otherwise, it's automatically computed from the vel, acc and jerk, the usual case. Here we set 'totalt' to zero to get the usual case.

At the heart of the gomotion trajectory generation is a motion queue that maintains a sequential list poses or joint values to move through. These motions are represented by the internal gomotion

The queue motion can handle either joints or pose, so it depends upon whether you are doing joint interpolation or world coordinate interpolation. In the ROS gomotion package, specifying the gomotion coordinate system is done with either a call to InitJoints or a call to InitPose, which get mapped internally into gomotion queue set\_type()). Once you have committed to Depending on the ROS gomotion init call, the internal gomotion queued is filled with either joints[] or poses accordingly.

gomotion specification

For joint specified motion, either the motion specs (phase times, distances) for each joint, or total time allotted to all the joints motion is and in so doing, the maximum time computed and retained. This maximum time will be used to scale all the joint motions so that they arrive at the same time (if specified), and internally in the gomotion will be the overall time 'totalt' for the motion.

struct GoMotionParams {

GoMotionParams(double \_vel, double \_acc, double \_jerk) :

vel(\_vel), acc(\_acc),jerk(\_jerk)

{

}

double vel; /\*< max vel for each motion \*/

double acc; /\*< max accel for each motion \*/

double jerk; /\*< max jerk for each motion \*/

};

class GoMotion {

public:

GoMotion();

int Init(JointState here, double deltat);

int InitPose(tf::Pose here, tf::Pose there,

double deltat,

gomotion::GoMotionParams tparams,

gomotion::GoMotionParams rparams);

int InitJoints(JointState here, JointState there,

double deltat,

gomotion::GoMotionParams params);

int InitUJoints(JointState here, JointState there,

double deltat,

gomotion::GoMotionParams params);

void AppendPose(tf::Pose);

tf::Pose NextPose();

JointState NextJoints();

bool IsDone();

void InitStop(); // Then use next pose or net joints

protected:

boost::shared\_ptr<go\_motion\_interface> pgm;

size\_t num\_joints;

};

int GoInterpreter::ParseJointCommand(RCS::CanonCmd cmd, RCS::CanonCmd &outcmd,

RCS::CanonWorldModel instatus, RCS::CanonWorldModel &outstatus) {

try {

cmd.joints = \_kinematics->UpdateJointState(cmd.jointnum, instatus.currentjoints, cmd.joints);

if (cmd.CommandNum() != \_lastcmdid) {

\_lastcmdid = cmd.CommandNum();

\_go->InitJoints(instatus.currentjoints, cmd.joints, this->\_nc->CycleTime(),

gomotion::GoMotionParams(1.0, 10.0, 100.0)); // 1 meter/sec

}

outcmd = cmd;

outcmd.joints = \_go->NextJoints();

} catch (std::exception & e) {

LOG\_DEBUG << "Exception in GoInterpreter::ParseCommand() thread: " << e.what() << "\n";

cmd.crclcommand = CanonCmdType::CANON\_STOP\_MOTION;

cmd.opmessage = e.what();

cmd.stoptype = CanonStopMotionType::NORMAL;

outcmd = cmd;

return CanonStatusType::CANON\_ERROR;

}

if (\_go->IsDone())

return CanonStatusType::CANON\_DONE;

else

return CanonStatusType::CANON\_WORKING;

}

int GoInterpreter::ParseWorldCommand(RCS::CanonCmd cmd, RCS::CanonCmd &outcmd,

RCS::CanonWorldModel instatus, RCS::CanonWorldModel &outstatus) {

try {

tf::Pose finalpose = Conversion::Convert<geometry\_msgs::Pose, tf::Pose>(cmd.finalpose);

// Need to subtract off tool offset from robot wrist or final tcp

//tf::Pose goalpose = finalpose \* \_nc->invGripperPose();

// Need to translate goal pose from world coordinates into robot coordinates

//goalpose = \_nc->invBasePose() \* goalpose;

//tf::Pose goalpose = finalpose;

tf::Pose lastpose=\_kinematics->FK(\_nc->status.currentjoints.position);

tf::Pose curpose=\_nc->basePose() \*

lastpose \*

\_nc->gripperPose();

if (cmd.CommandNum() != \_lastcmdid) {

\_lastcmdid = cmd.CommandNum();

\_go->InitPose(curpose, finalpose, this->\_nc->CycleTime(),

gomotion::GoMotionParams(1.0, 10.0, 100.0),

gomotion::GoMotionParams(.1, 1.0, 10.0)); // 1 meter/sec

// \_go->AppendPose(lastpose); // NO WAY~!

}

tf::Pose goalpose =\_nc->invBasePose() \* finalpose \* \_nc->invGripperPose();

tf::Pose gopose = \_go->NextPose() ;

tf::Pose nextpose = \_nc->invBasePose() \* gopose \* \_nc->invGripperPose();

JointState goaljoints;

goaljoints.position = \_kinematics->IK(goalpose, Subset(\_nc->status.currentjoints.position, \_nc->Kinematics()->NumJoints()));

cmd.joints.position = \_kinematics->IK(nextpose, Subset(\_nc->status.currentjoints.position, \_nc->Kinematics()->NumJoints()));

\_kinematics->IK(lastpose, Subset(\_nc->status.currentjoints.position, \_nc->Kinematics()->NumJoints()));

WORLDLOG << " Goal Joints =" << VectorDump<double>(goaljoints.position).c\_str() << "\n";

WORLDLOG << " Current Joints =" << VectorDump<double>(\_nc->status.currentjoints.position).c\_str() << "\n";

WORLDLOG << " Commanded Joints=" << VectorDump<double>(cmd.joints.position).c\_str() << "\n";

cmd.joints.name = \_kinematics->JointNames();

cmd.crclcommand = CanonCmdType::CANON\_MOVE\_JOINT;

outcmd = cmd;

if (\_go->IsDone())

return CanonStatusType::CANON\_DONE;

else

return CanonStatusType::CANON\_WORKING;

} catch (std::exception & e) {

LOG\_DEBUG << "Exception in GoInterpreter::ParseCommand() thread: " << e.what() << "\n";

cmd.crclcommand = CanonCmdType::CANON\_STOP\_MOTION;

cmd.opmessage = e.what();

cmd.stoptype = CanonStopMotionType::NORMAL;

outcmd = cmd;

return CanonStatusType::CANON\_ERROR;

}

}

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