

User's Manual 2005-11-16

Closer to Real, **ROBOTIS**



Developer's Guide

Motion Data

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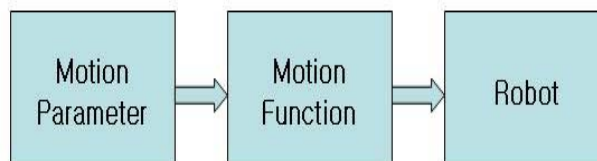
1. Introduction

1-1. Robot control method

Various methods controlling robot are studied until now. So many methods are already developed and experimented. There are motion function based Robotics and Motion data based Robotics classifying the methods. Before explaining these methods, have to know the concept of motion which is often used in multi-joint robot with movement means not form of wheel but joint of form in Robot. . Motion means what Robot shows as an output. In case of Cycloid like humanoid Robot, it means the kinematical output by machinery like a movement. What control Robot mean that it makes this motion in case of wheel type Robot or multi-joint Robot which has a few joint and exterior situation is not important when moving , Motion Function Based Robotics methods is often used.

Motion function based Robotics

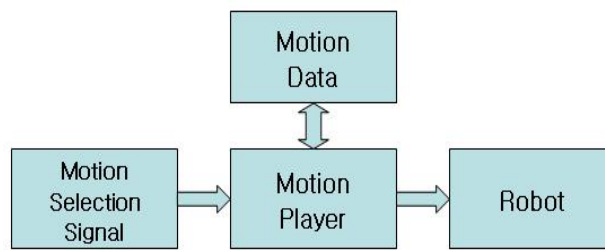
A merit of Motion function based Robotics is easy to control because their is the function which makes motion with a few parameter. But, demerit is very hard to make a motion function related to irregular and non-linear movement.



< Motion function based Robotics >

Motion data based Robotics

Motion data based Robotics method have a merit that almost every movement can be showed easily. on the other hand, the demerit which is hard to make a motion data and needs much saving space and management to express many movements.

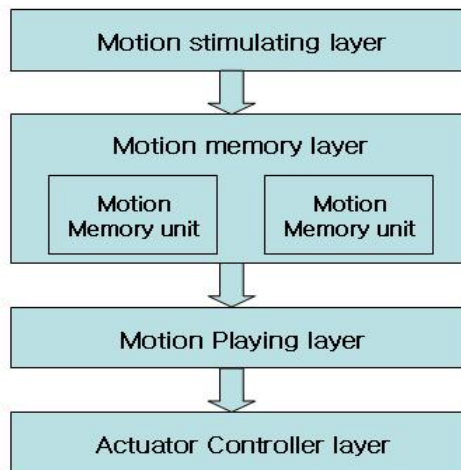


< Motion data based Robotics >

1-2. Motion data based Robotics

Motion data based Robotics system Motion data based Robotics is important that it systemically efficiently make motion data and apply motion data made.

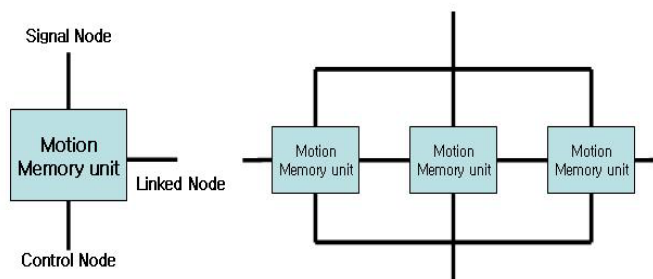
The following is the control system structure.



< Design of Cycloid control system >

Motion memory stimulating layer Is the place producing the command signal for conducting motion data.

Motion memory layer Is the space saving motion data. Motion data exists on memory as the concept of motion memory unit. The motion memory unit can be expressed to concept like next picture.

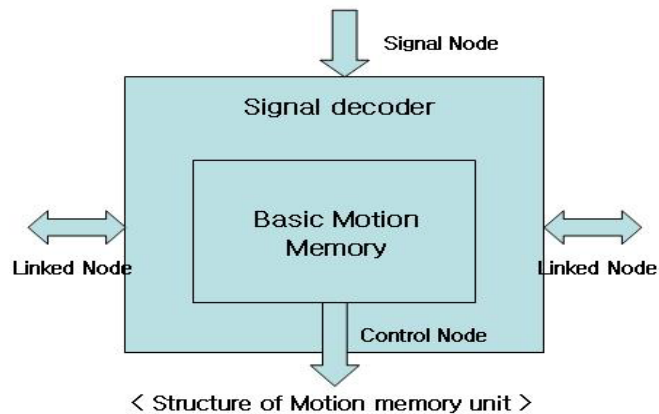


< Motion memory unit >

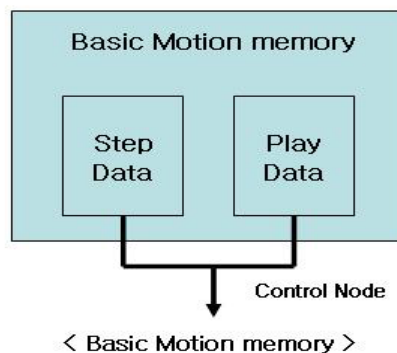
Motion memory has a node connect outside and there are linked mode connect motion memory unit, signal node receiving command signal, and control signal comes out from control node. High class motion memory stimulating layer is connected to signal node and low-class motion playing layer is connected to control node. Linked node is connected between

motion memory units. In the position of User, how to connect linked node will be the problems that makes various movements of Robot.

Motion memory unit The most basic and important things in Motion data based Robotics is how to architect Motion memory unit. Motion memory unit is a module that remembers the most basic one among Robot' s movements. So, as the mix of basic various motions can be made through realizing and connecting motion memory unit.

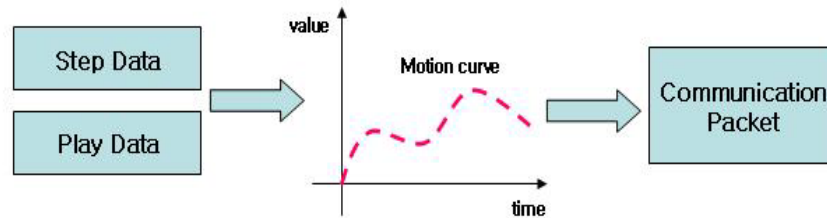


In Motion memory, there is a signal decoder that decides to select which linked node as a movement path interpreting command signal and basic motion memory which remember basic motions. In basic motion memory, play data for motion player and step data which consists of joint value when the Robot stops exists. After all users can make basic motions through producing play data and step data and make a Robot motion connecting linked node between motion memory units.



Motion playing layer Motion memory unit is the layer which control actuator controller

receiving control signal from motion memory unit. The main work on this layer is to transfer the continuous motion curve restoring motion data received from motion memory unit to the actuator controller.



< Concept of Motion Player >

Actuator controller layer

At present, Actuator controller is Dynamixel. The role of actuator controller is operating the actuator actually after receiving motion data. Dynamixel is an architected smart actuator that conducts efficiently this role.

2. Motion Data Format

2-1. Motion Page

Motion Page	What multi-joint Robot moves means that conduct continuously moving behavior by especial joint angle with proper speed and acceleration through memory joint. This is called to Motion and needs a special form to save this motion for moving multi-joint robot.
Motion512	Multi-joint robot based on CM-2 apply motion 512 that defining motion page of 512 byte format. Until now the motion page was not standardized but motion 512 is a motion page format which can be adopted to use various services so that it is enough to manage various types of multi-joint Robot based on motion 512. The followings are program related to motion 512
RobotisTerminal.exe	Has the functions that show the data on screen which comes through USB or serial port as a kind of null-modem communication program working on window system at PC or transport the input character from keyboard to port there is a function which can download and upload
Edit.hex	Is an editor of motion 512 which operating by downloading on multi-joint Robot and user can edit contents Motion 512 through Robotics terminal at PC.
VisualEditor.exe	Can edit motion 512 using visual editor.exe at PC at the state that Edit.Hex is downloaded in Robot. Robotics Terminal is text mode so that unacquainted person is uncomfortable for editing, but visual editor can show Robot to three-dimensional circles so that a beginner can edit motion conveniently
Play.hex	Play.hex is programs which can make Robot restore the edited motions. After downloading play.hex in Robot, User can play the motion through remote controller or PC. All programs above can be adapted to multi-joint Robot composed of Dynamixel.

Data and Code

Motion 512 is a kind of data. Many laboratory group tried multi-joint motion as codes not data types. That is, express walking as a form of kinetics function or express the snake's movement as a trigonometrically function. It is very meaningful trial as there is limitation to express all motions of multi-joint Robot. Especially, behaviors people do like Dance, greeting and waving have to be solved as the side to recognized gestures not dynamic interpretation. The application which situations the recognized gesture can output and how they play adapting to environment is another field which the scholars study deeply, any way certainly needs a format which saves those gestures and motion 512 is one of data format.

The present of Motion512

Motion 512 is a very low level data format. So the possibility of application is very big. At present, we provide the editor and the player which support play back way saving the robots every joint as the fixed pose and play them connected.

The future of Motion512

Edit form and play form must be continuously updated for the motion 512's more beneficial role. At first, merging between motions 512, import to other program and export function will have to be prepared and page speed and amplitude can be changed variously and needs a development of player which can pay back the inertia which arises from them. If these players development are done, we can freely change the walking speed and pace by motion 512 page and express various rotation radiuses. When turning the direction, the function motion production by code and naturally merge them comes true. For example, if camera's pan-tilt code operate in the middle of walking motion, the player which produce motions real time walk looking around have to be developed.

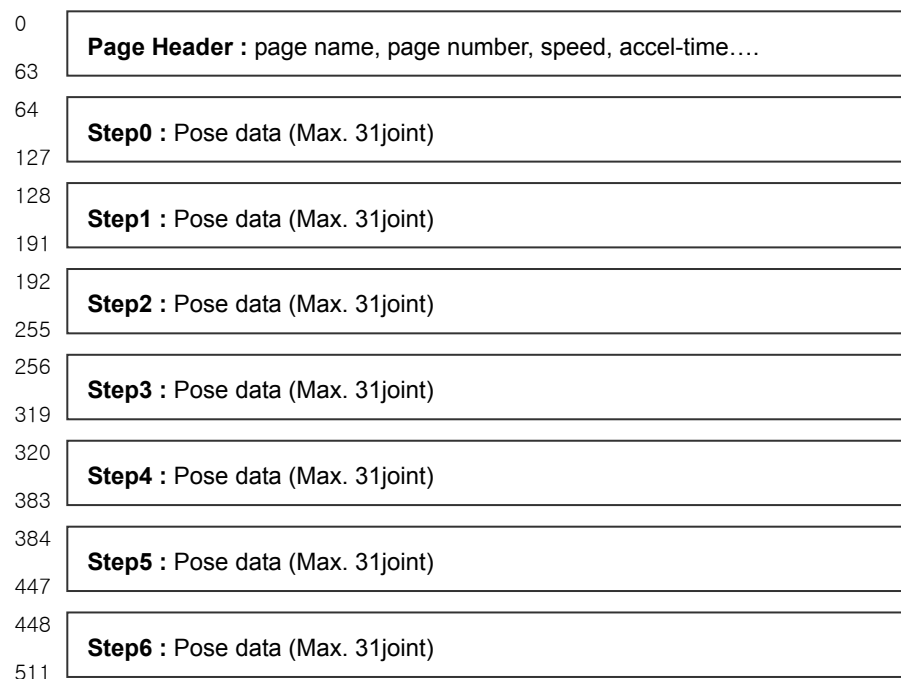
The definition of Motion512

Motion 512 is just the definition of table and the editor and player are engineering closed to development rather than research. Each motion 512, editor and player does not have any technical meaning. It will be useful tool which people who makes high-value Robot can reduce time and money

2-1-1. Format of Motion512

64 Byte Block

Motion 512 consists of total 512 byte and consists of eight blocks which each block has 64 byte size. The first block includes the page name, control way, speed, acceleration and retardation information. The rest seven blocks express the robot poses. The Robot's first block is called header like next picture, rest blocks expressing other pose are named to step.



Header

The following are header components.

PAGE_NAME : Address 0 ~13
Reserved : Address 14~19
PAGE_STEP : Address 20
PLAY_CODE : Address 21
PAGE_SPEED : Address 22
DXL_SETUP : Address 23
ACCEL_TIME : Address 24
NEXT_PAGE : Address 25
EXIT_PAGE : Address 26
LINKED_PAGE1 : Address 26
LINKED_PAGE1_PLAY_CODE : Address 28
LINKED_PAGE2 : Address 29
LINKED_PAGE2_PLAY_CODE : Address 30
PAGE_CHECKSUM : Address 31
Reserved : Address 32~63

Step Structure

Each step consist of total 64 bytes and has information about 31 joints.
The follows are structure

Offset+Address 0 : Dynamixel' s Position (Angle) Value of ID 0
Offset+Address 2 : Dynamixel' s Position (Angle) Value of ID 1
Offset+Address 4 : Dynamixel' s Position (Angle) Value of ID 2
Offset+Address 6 : Dynamixel' s Position (Angle) Value of ID 3
Offset+Address 8 : Dynamixel' s Position (Angle) Value of ID 4
Offset+Address 10 : Dynamixel' s Position (Angle) Value of ID 5
Offset+Address 12 : Dynamixel' s Position (Angle) Value of ID 6
Offset+Address 14 : Dynamixel' s Position (Angle) Value of ID 7
Offset+Address 16 : Dynamixel' s Position (Angle) Value of ID 8
Offset+Address 18 : Dynamixel' s Position (Angle) Value of ID 9
Offset+Address 20 : Dynamixel' s Position (Angle) Value of ID 10
Offset+Address 22 : Dynamixel' s Position (Angle) Value of ID 11
Offset+Address 24 : Dynamixel' s Position (Angle) Value of ID 12
Offset+Address 26 : Dynamixel' s Position (Angle) Value of ID 13
Offset+Address 28 : Dynamixel' s Position (Angle) Value of ID 14
Offset+Address 30 : Dynamixel' s Position (Angle) Value of ID 15
Offset+Address 32 : Dynamixel' s Position (Angle) Value of ID 16
Offset+Address 34 : Dynamixel' s Position (Angle) Value of ID 17
Offset+Address 36 : Dynamixel' s Position (Angle) Value of ID 18
Offset+Address 38 : Dynamixel' s Position (Angle) Value of ID 19
Offset+Address 40 : Dynamixel' s Position (Angle) Value of ID 20
Offset+Address 42 : Dynamixel' s Position (Angle) Value of ID 21
Offset+Address 44 : Dynamixel' s Position (Angle) Value of ID 22
Offset+Address 46 : Dynamixel' s Position (Angle) Value of ID 23
Offset+Address 48 : Dynamixel' s Position (Angle) Value of ID 24
Offset+Address 50 : Dynamixel' s Position (Angle) Value of ID 25
Offset+Address 52 : Dynamixel' s Position (Angle) Value of ID 26
Offset+Address 54 : Dynamixel' s Position (Angle) Value of ID 27
Offset+Address 56 : Dynamixel' s Position (Angle) Value of ID 28
Offset+Address 58 : Dynamixel' s Position (Angle) Value of ID 29
Offset+Address 60 : Dynamixel' s Position (Angle) Value of ID 30
Offset+Address 62 : Step pause time
Offset+Address 63 : Step speed

Position value is 10bit value and works on 2byte. Two bytes are LSB and MSB in sequence. For example when the maximum value is 0X3ff, it marks on 0xff and 0x03 in sequence.

2-1-2. Motion512 in CM-2 Memory

Motion Page Block The CM-2 has 128Kb size flash memory, CM-2 use some portion of the memory as a storage saving motion page. The merit of this structure is that can separately control motion data which are related to Data and control runtime related to code among robot controlling programs. This mean that one of motion data can adapt to another robot and well-made motion data can be continuously updated. CM-2 allotted 64 Kb size memories for motion page. This portion is the size which motion 512(512byte) can save 128 pieces.

Address	Category	Role
0X00000 0X0BFFF	User territory	Application Program
0X0C000 0X0DFFF	Dynamixel Firmware	The space which CM-2 is using during Dynamixel Firmware's updateing (had better be empty)
0X0E000 0X1DFFF	Motion Data	Territory where the Motion Data of robot is saved (Motion Page exists)
0X1E000 0X1FFFF	Boot Loader	Boot Loader which has downloading and Memory checking function.(Purchasing CM-2, provide it which is written)

Download Motion If you do not want to make motion page newly and hope to use one made before make the motion data downloading in CM-2. Downloading Motion page, use the CM-2' s boot loader and Robotis terminal program. The way downloading to CM-2 refers to the related manual. The thing to be careful downloading motion page, have to set-up well the start-address. If you are downloading motion page at the wrong address, it makes the existing programs to be erased. Motion page starting address is 0x0E000 referring to CM-2 memory map. You indicate CM-2 memory size for start address and size and update whole motion page territory and can also update some part of motion page.

Upload Motion Saves it after uploading the CM-2' s motion data when you back up motion page made. Using CM-2 boot loader and Robotics, it is possible page uploading like motion page' s downloading way. Refer to the related

manual which related to uploading the memory contents of CM-2. The thing have to be careful is that uploading motion page is to set up start-address and uploading memory size. Refer to the CM-2 memory map the way to set-up start-address. In reference, motion page territory is 0x0E000 to 0x1DFFF memory size have to be smaller than 64kB which is maximum size of motion page territory and bigger than 512 byte which is motion 512 size. User can back up. All motion page territory can also back up some motion page.

2-2. Edit Motion Page

- Editing tool** To put Robot motion into motion page needs an editor. the program for motion page edit exists in CM-2, that is Edit.hex. When CM-2 transformed to Edit mode, it is a state to edit Robot Motion page. But this function can conduct in Pc because CM-2 has no input/output device. Editing tool is a program on PC which communicates with CM-2' s edit mode. Users can use Robotis Terminal and visual Editor as a editing tool. Motion page editor conducts text based editing which use robotics terminal and graphic base edit which use visual editor. To use these tool. Need to understand about edit mode. Refer to the related manual about those explanations.
- User editing tool** Editing tool has to be used to edit motion page but the user can make the tool. If users want to make his or her own editing tool, it needs a edit.hex which run CM-2 as edit mode and develop communication program working on PC. The details for this development refer to the related manual. In here, the important issues which users must know editing motion page will be explained.
- Edit step** There must be a step to make a wanted motion for being a perfect motion page which can operate Robot. In step, there is the position of Dynamixel which express robot' s pose , pause-time which control the step interval and speed. At first, consisting of pose after reading the position value of Dynamixel at the moment wanted and set up speed and pause-time to make the connection of step be nature
- Edit page header** Accomplishing step editing does not make a perfect motion page. So many data exists to express characteristics of motion page in header. It can be a perfect motion page to set up those values well. In page header, there are the information for motion play, page connection information for connecting between motion pages and page management information for managing motion page.

Motion play Information	<p>CM-2 play mode produce Robot motion base on contents of motion page.</p> <p>The program running play mode in CM-2 is play.hex. In play mode, the contents of stem is basically enough to make robot motion. But use additional information for more correct and active motion production. This information is motion play information existing on motion page. Motion page information affects all of step in motion page. There are page speeds, Acceleration time, page step, DXL set up as motion play information. What each value means refer to the related manual.</p>
Page connection Information	<p>Motion page are total 128 pieces in CM-2' s memory. Motion page which connect to each other as linked list type can make various Robot motion, the information to connect each other by linked list type is the page connection information. Motion page connection structure is not composed of one path type which consists of one node but multi path type consisting of multi-node. This structure has a merit that mixture of few motion page can make various motions. Because each motion page have many nodes, it needs an information which node be selected. This information is remote controller code. Remote controller code is exterior interface which help the limitation of Robot which can not select on himself. After motion page refer to remocon code value, decide through which node to move another motion page. Page connection information is link to next, link to exit, linked page 1 and linked page 2. When remocon code is stop code which is special state, the moving path is link to exit and in case of other remocon code. The moving path is linked page1, linked page. In case it is the same as the remocon code of the first call, move to "Link to next." In summary, there is four-path information to move other page. And there are four remocon codes that one is fixed as stop code and the other three codes can be set up reference to remocon code table 8.</p>
Page management Information	<p>For user needs a special information to control because it exist 128 pieces of motion page, address, page number, page name are exist as management information in motion page header. Address is the place motion page exist on CM-2 memory page number is the index value from 0 to 128Page number is used to move between motion page in CM-2 edit mode. Each motion page save motions of robot and exist page name that</p>

is memory space which can easily name each motion page for users to know which motion is saved.