CAPSTONE PROJECT (SAP)

ROBOTIC MANIPULATOR FOR ELDER CARE

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HISTORY – PARO Robot and Robotic Walker

- PARO:
  - Developed by AIST in Tokyo, Japan
  - Primary focus is the **psychological** aspect of the patient
  - PARO learns by interaction whether to do an action or not
  - Generally involved with dementia related cases
- Automated Walker:
  - Multiple variations exist (DIY, PAMM, etc.)
  - Primary focus is the **physiological** aspect of the patient
  - Follow the similar working methodology, where the sensors map out the environment and avoid obstacles
  - Generally involved in patients with mobility related cases

A LARGER PICTURE

- Objective is to develop a fully autonomous mobile manipulator
- Robotic arm part of a larger project
- Major project consists of:
  - Autonomous Base – for movement
  - Robotic Arm – for interaction with environment
  - Virtual reality integration
- Can be adapted to any major scenario
- Gateway into integrating robots into our daily lives

OBJECTIVE

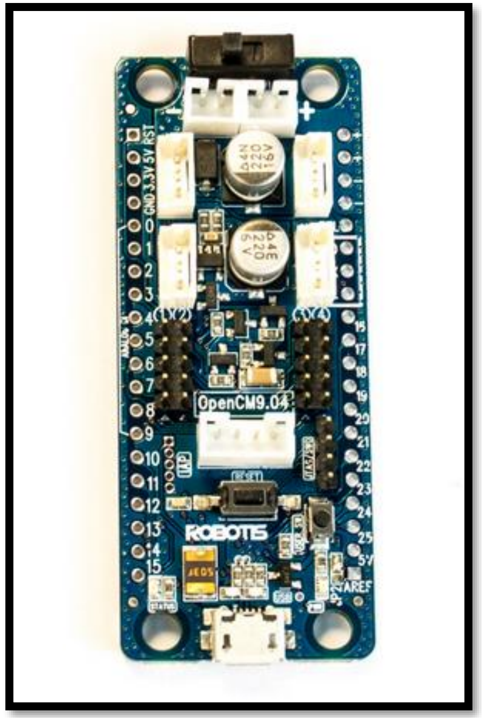
- Involved with Robotic Arm aspect of the project
- Robotic arm does not have any pre-written code or software solution
- Main objective was to develop the driver software using the API
  - Use the code to move the robotic arm
  - Develop an interface for ease of use
- Added objective: develop it as an overall proof-of-concept for the major version of the project

MOTIVATION

- Most of the existing elder care devices discussed are passive in nature (e.g. PARO and robotic walker)
- A fully autonomous <u>versatile</u> solution is yet to be implemented
- Literature survey shows increase in people preferring old age homes
- Shows elders prefer to be surrounded by family and near and dear ones
- Change in perception of elder care:
  - Create a compatible environment with the help of robotic solutions
  - Reduce human intervention in the process (to the extent that it does not affect the elderly person)
  - Preserve the human relationships

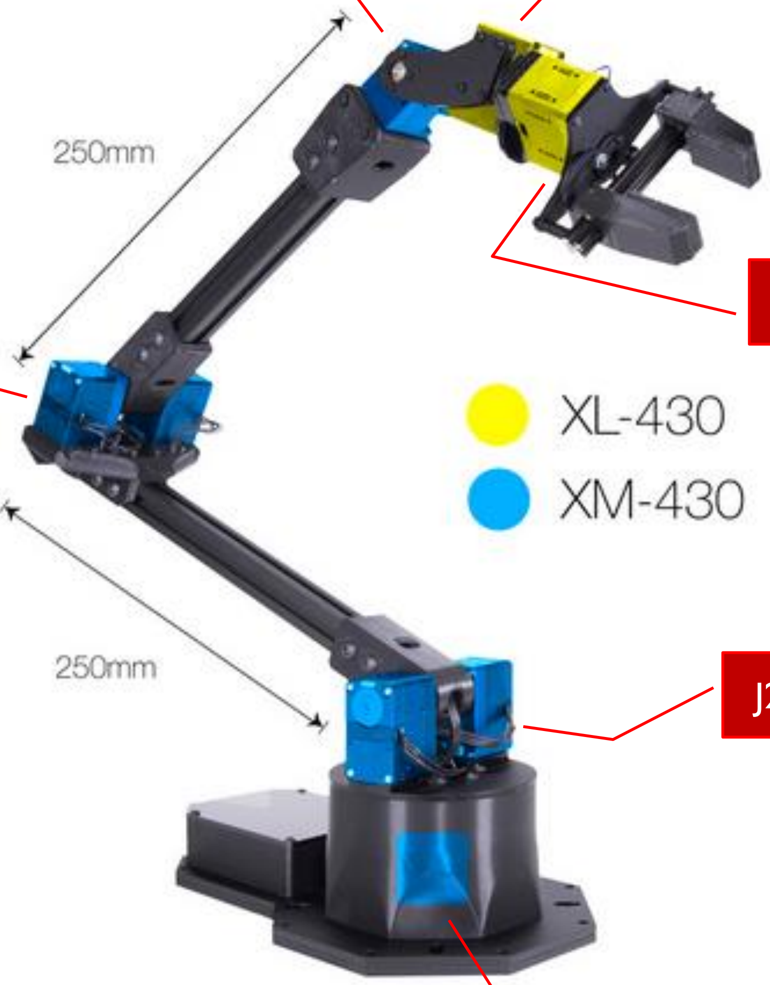
COMPONENTS

WidowX 250 Robotic Arm



OpenCM 9.04-C Board

Dynamixel XL430-W250T and
XM430-W350T

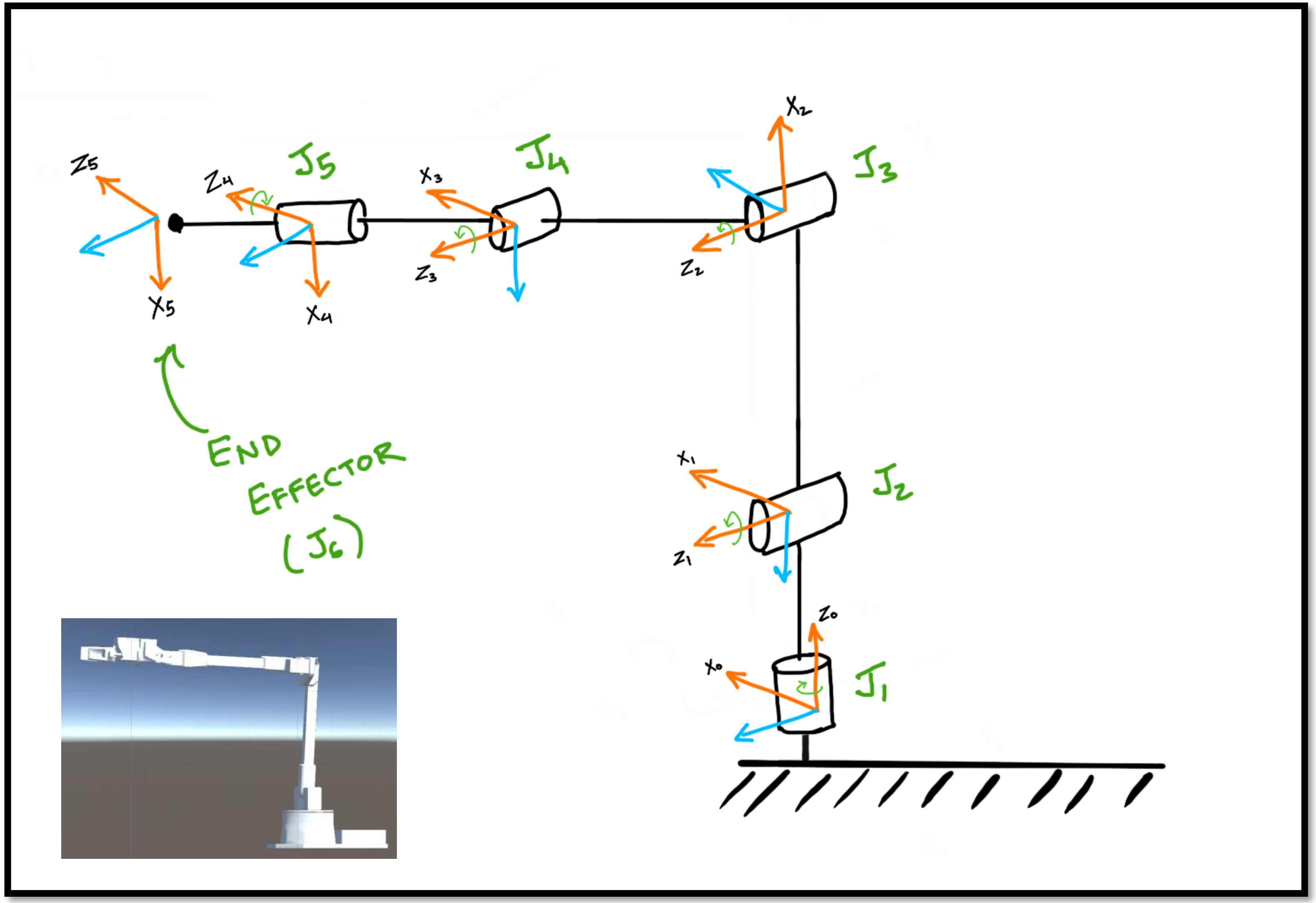


5 Degrees of freedom in terms of human arm movement (7 DoF):

- Shoulder Pitch
- Arm Yaw
- Elbow Pitch
- Wrist Yaw
- Wrist Roll
- Thumb Pinch* (can be considered as 6th DoF)

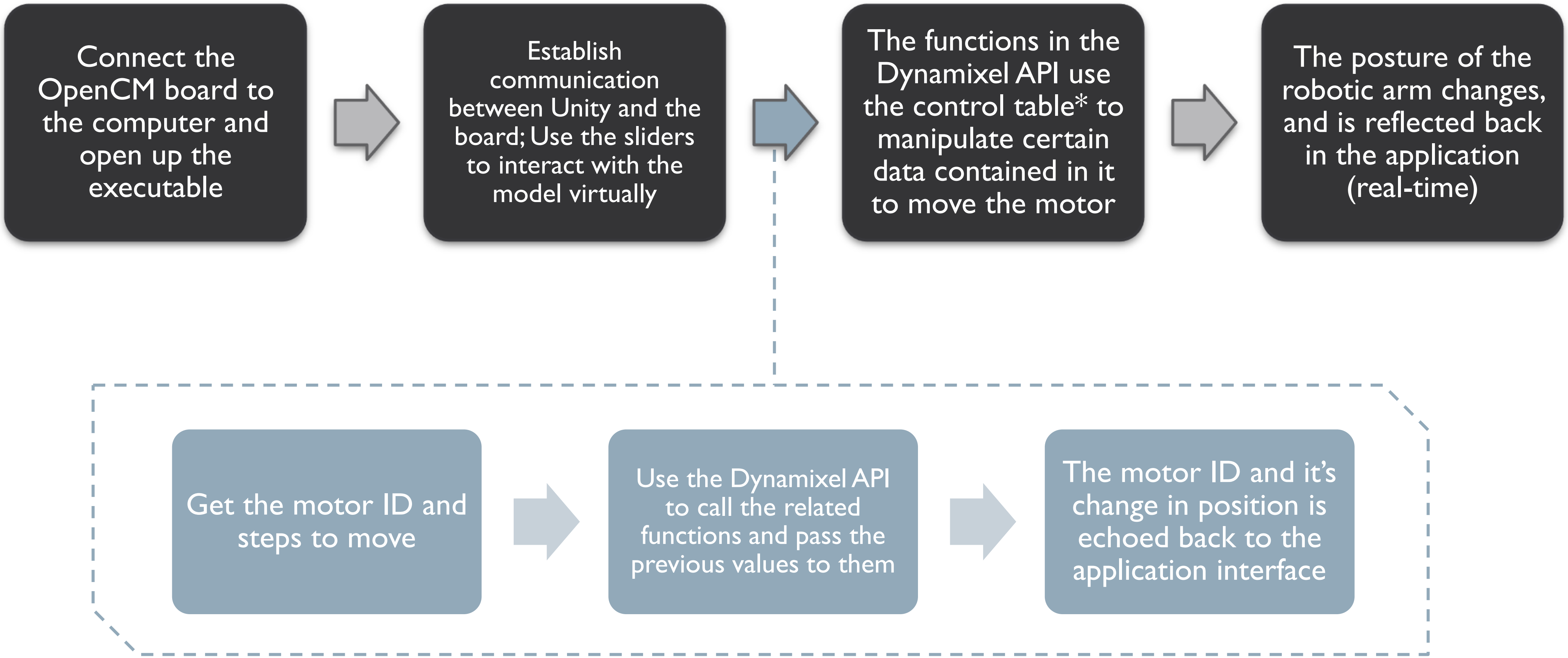
Robotic arm has lesser DoF but larger span and reach.

Denavit-Hartenberg (DH) Frame Assignment



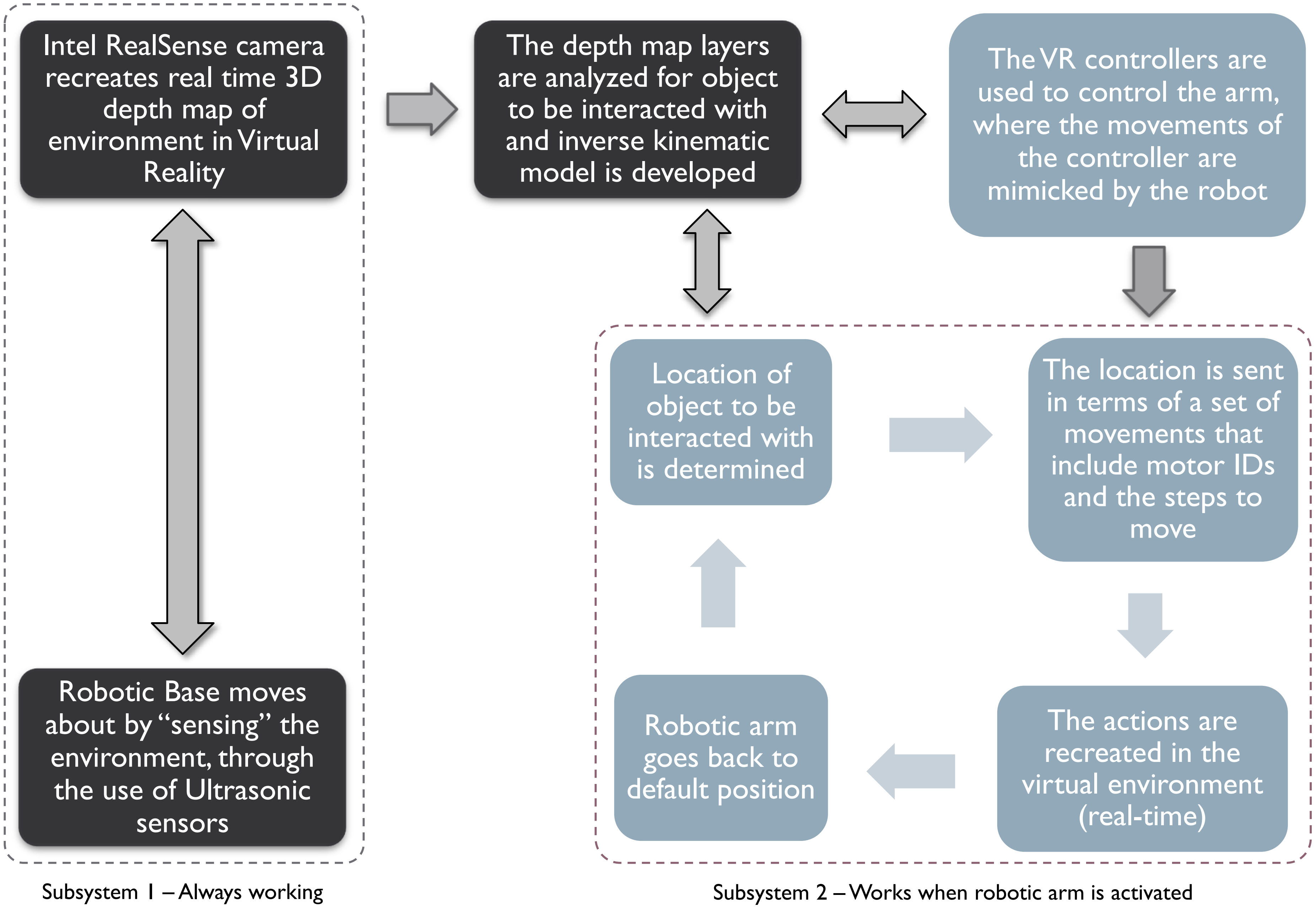
WORKING

Overview of Robotic Arm (WidowX 250)



**The Control Table is a structure of data implemented in the Dynamixel, that is stored in the EEPROM and RAM of the internal microcontroller unit.*

Overview of the Autonomous Mobile Manipulator



SOLUTION BREAKDOWN

- The functioning of the Robotic Arm is controlled by an Arduino based driver code, that is burned onto the onboard OpenCM9.04C control board:
  - Gets the input from the user (whether in the form of slider value or real world data)
  - Accesses the Dynamixel SDK
  - Passes the values to the function as input parameters
  - Reads the current status of the Dynamixel servos

- Next phase is to establish a control solution through an interface
  - Unity3D is the engine used
  - Sample scene created that opens up serial communication
  - Button clicked → Selects the motor ID; Slider moved → Steps to move
  - Values sent through serial communication to OpenCM9.04
  - These values act as the input parameters for the driver code

Breakdown of the driver code's function:

- A DynamixelWorkbench object is created (dxl_wb); this is the object that allows us to utilize the built in functions present in the Workbench (basically the SDK)
- jointMode(id, velocity, acceleration, log) is used to develop a profile for the specific Dynamixel servo, as to how it needs to operate
- jPositions[idx] is an array that stores the number of steps to be moved to the respective ID (basically a simple implementation of the std::map container in C++)
- goalPositions(id, jPositions[id]) is responsible for setting the specific servo to its targeted step value
- getPresentPositionData(id, associated data) is responsible for getting the details of the servo in question; can include details such as ID, model, present position, last target position, etc.

There are the two main controller functions responsible for sending the values to the OpenCM9.04 and reading the data the Arduino code's output:

- WriteToArm() gets the ID and Position from the RotateWithSlider.cs script (through the RotatorScript gameobject)
- Communicate(dxl_id, dxl_pos) basically takes in the previous values as input parameters and sends them to the OpenCM board, in the format of the input that the Serial Monitor would give (e.g. "2 100" means move motor with ID = 2 to position 200)
- Communicate(dxl_id, dxl_pos) is also responsible for reading the output that the serial monitor provides

Dynamixel SDK Function Definitions

6. 2. 78. bool jointMode(uint8_t id, int32_t velocity = 0, int32_t acceleration = 0, const char **log = NULL)

Description

Set joint mode to a Dynamixel. You can simply set joint mode to any Dynamixel. After joint mode successfully set, torque will be on. The velocity and acceleration parameters will be used argument to make profile.

Input

1. `id` : Set Dynamixel ID
2. `velocity` : Set profile velocity
3. `acceleration` : Set profile acceleration

Output

If writeByteTxRx instruction set successfully work, return true. If not, return false

6. 2. 81. bool goalPosition(uint8_t id, int32_t value, const char **log = NULL)

Description

Set position to a Dynamixel

Input

1. `id` : Set Dynamixel ID
2. `value` : Set 32-bit raw value

Output

If writeByteTxRx instruction set successfully work, return true. If not, return false

6. 2. 85. bool getPresentPositionData(uint8_t id, int32_t* data, const char **log = NULL)

Description

Get present position from a Dynamixel

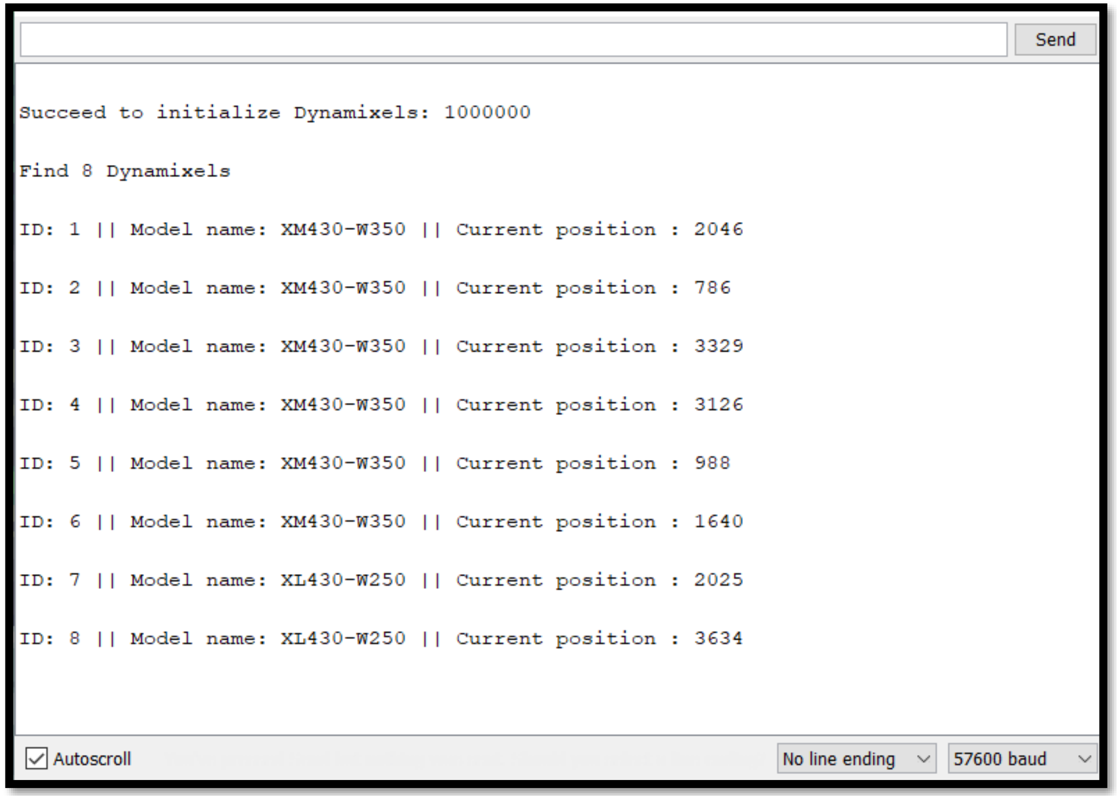
Input

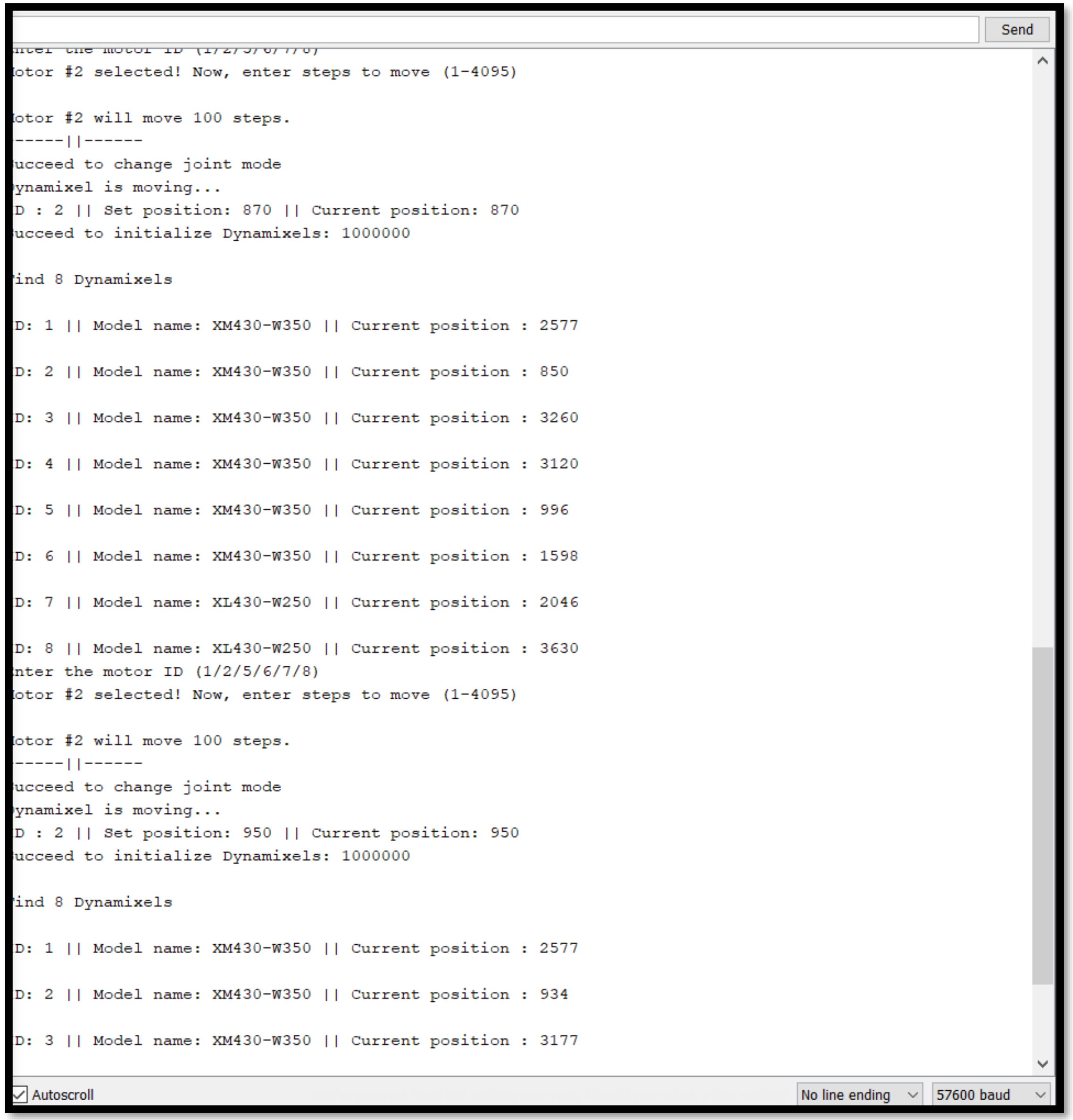
1. `id` : Set Dynamixel ID
2. `data` : Get 32-bit raw data

Output

If writeByteTxRx instruction set successfully work, return true. If not, return false

RESULTS

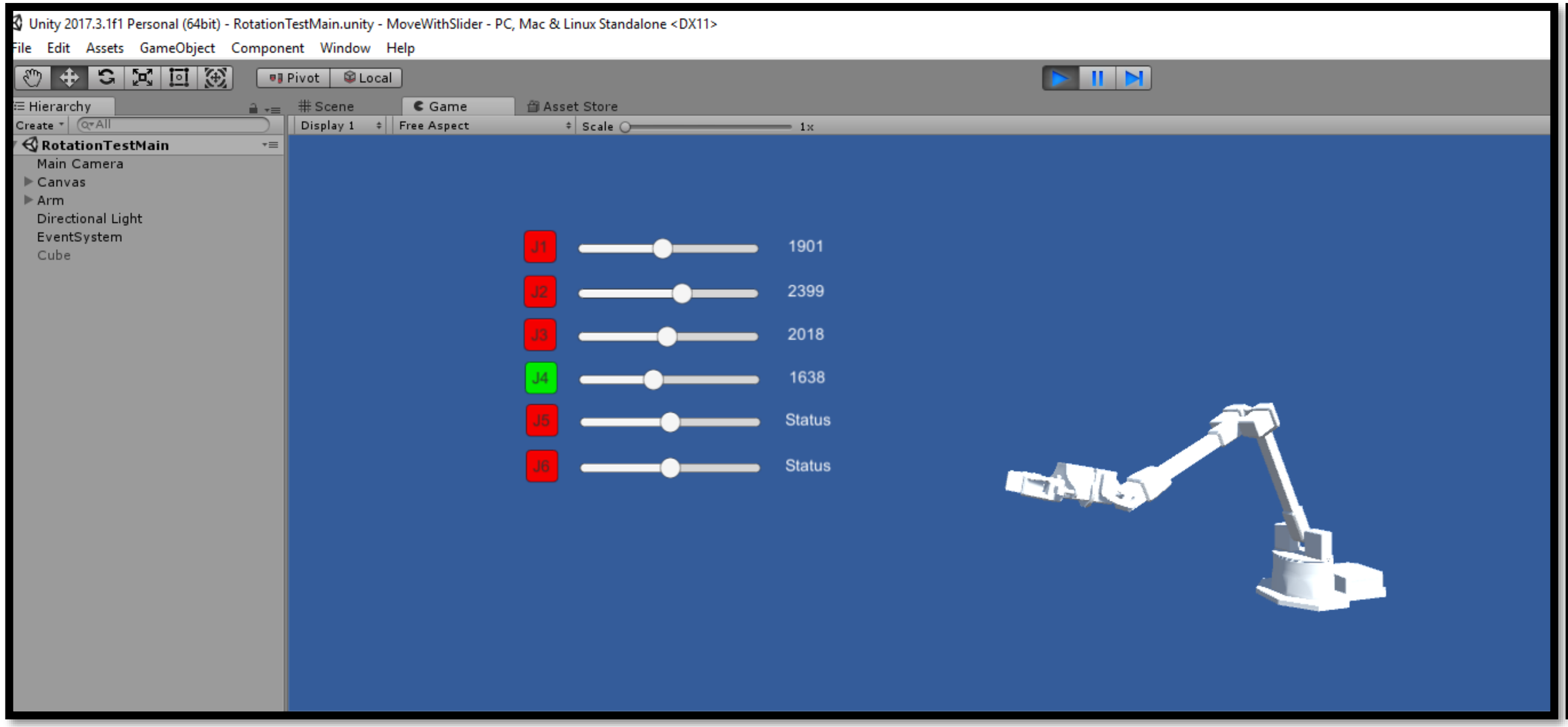


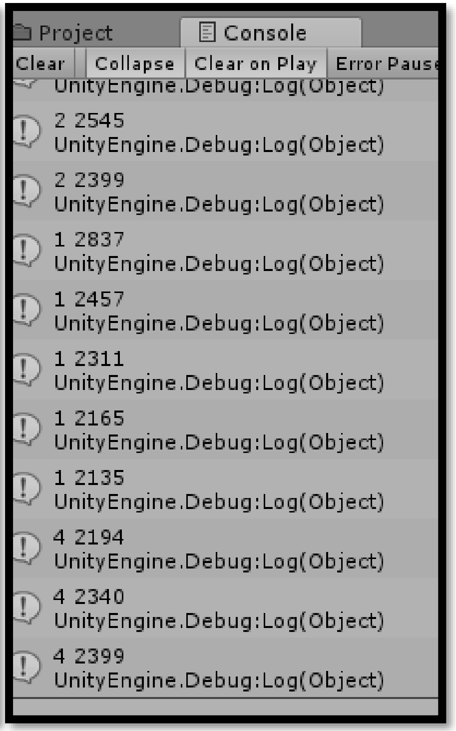


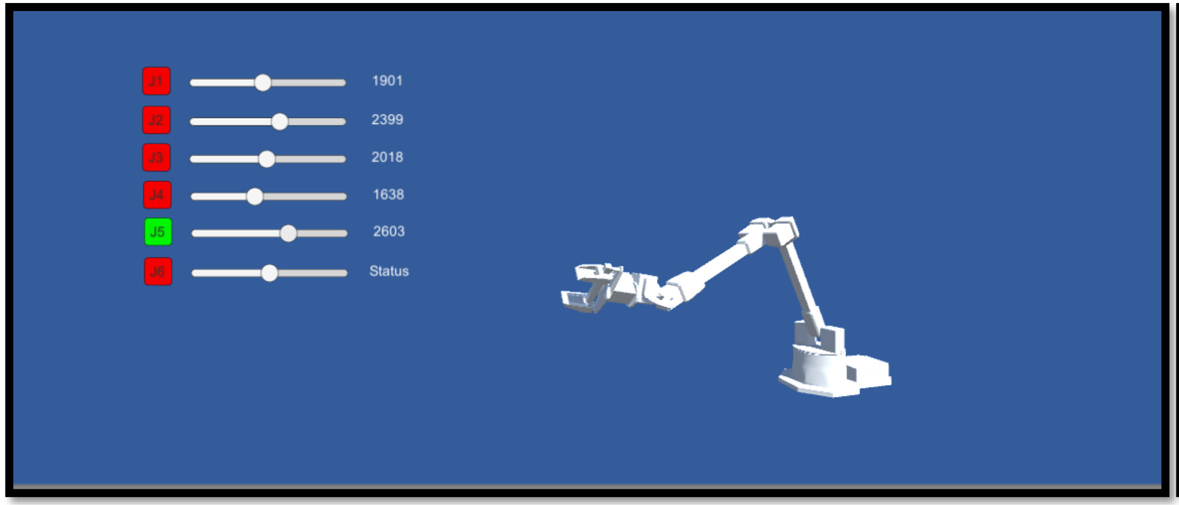
The above figure shows the initial calculation the Arduino code does in the driver code – it finds out the total number of Dynamixels and their current position (in terms of steps)

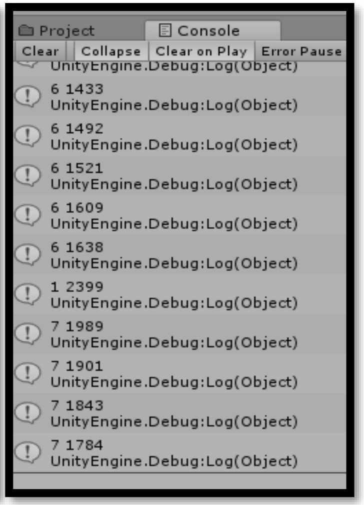
The figure on the right shows how an individual motor can be selected and moved by a certain number of steps (the steps to move later becomes the delta value)

A few different positions being tested for the robotic arm.









The Unity Game window where the updates can be seen real time, and the console displays the information being outputted to the Serial monitor of the OpenCM.

FUTURE SCOPE

- Designed with 3 aspects in mind: versatility, adaptability, and modularity
- Foundations laid in such a way that the concept and design Mobile Manipulator can be specifically **adapted** and applied in industries such as medical sector, production, construction, defense, etc.
- **Versatility** can be achieved within the current application; such as custom tailoring the manipulator for specific elderly people, such as:
  - Helps to do household chores and clean up after
  - Helps to provide, keep track of, and restock medication
- **Modularity** means being able to change and improve parts on the fly:
  - 3D printable parts
  - Various devices (such as tablets, RasPi controlled devices, etc.) can be connected

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THANK YOU

Questions?