

# Game Laws of Robot Arm Operation Based on Tele-OP Control

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## Abstract:

By Tele-OP control on remote terminal, the robot arm can work on dangerous area for safe operation. For example, urgently rescue in broken building after earthquake, handle radioactive waste in nuclear power plant, and so on. In this competition, the participants handle robot arm by tele-OP control to imitate in dangerous area. The objectives of this competition try to train related talented person for this special industry.

In this competition, participants have to complete assigned tasks by only seeing the camera video of the robot arm for its operation.

## Competition rules include

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## 1. Robot Arm

Figure 1 is Robot Arm Kinematic Model. Appendix A shows more detail message of the robot arm, including the remote controller for operation.

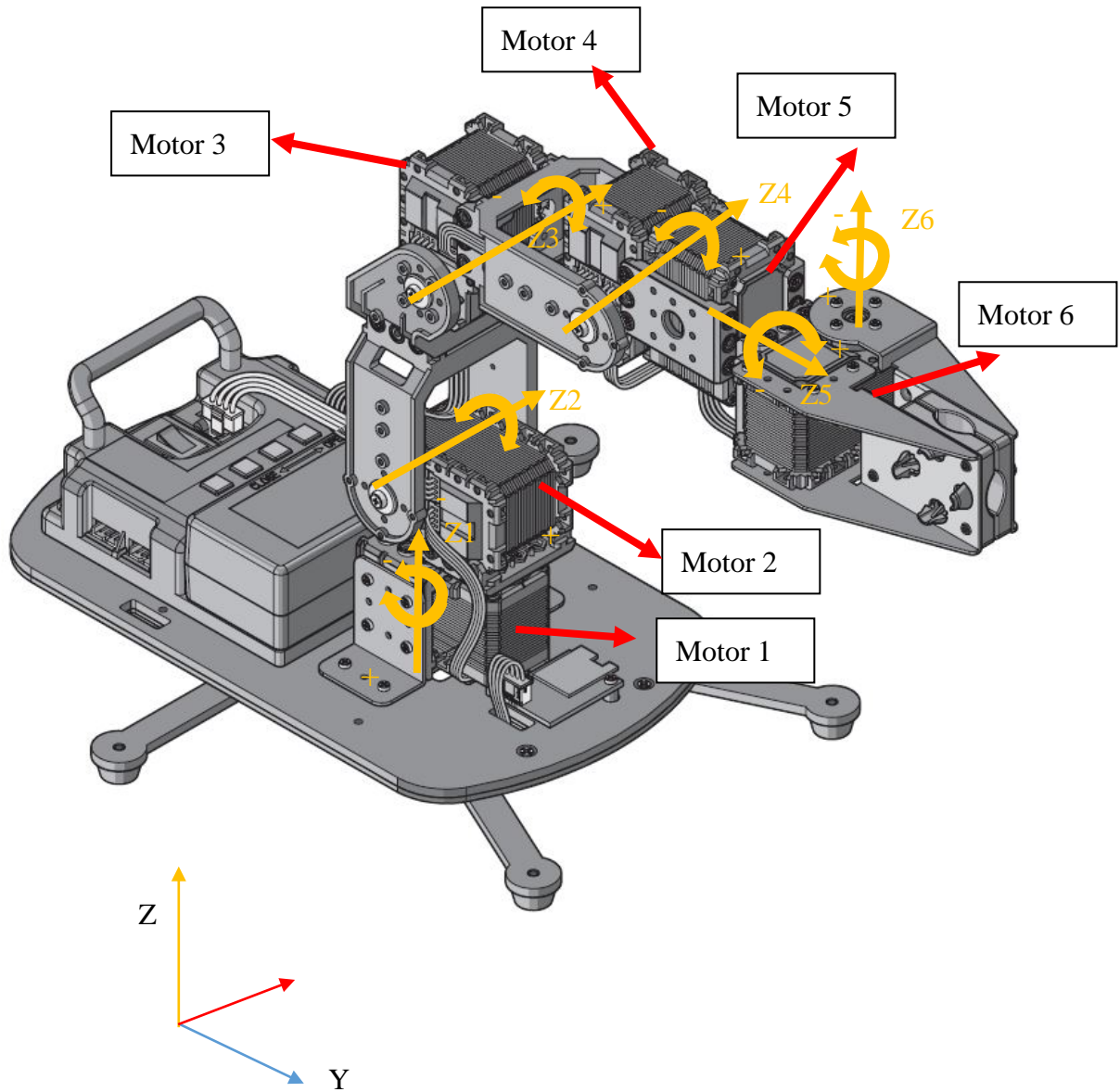


Figure 1 Forward kinematics of robot arm

Participants have remote controller to operate the robot arm for assigned tasks. The software for the terminals of client and servo is described in Appendix B. Participants need to install client software in remote terminal. The servo software is for your reference. Then Participants can understand how the servo computer control the robot arm. You can download the software in client and servo terminals from github as follows:

Client: <https://github.com/HongYu313Lin/Remote-robotic-arm-Client>

Servo: <https://github.com/HongYu313Lin/Remote-robotic-arm-Server>

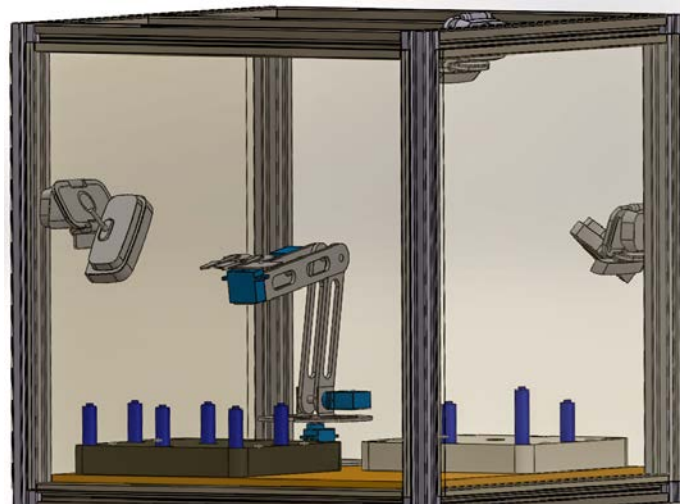


Figure 2 Play field and robot arm. Usually the play field is blocked such that participants only can see the play field and robot arm via cameras.

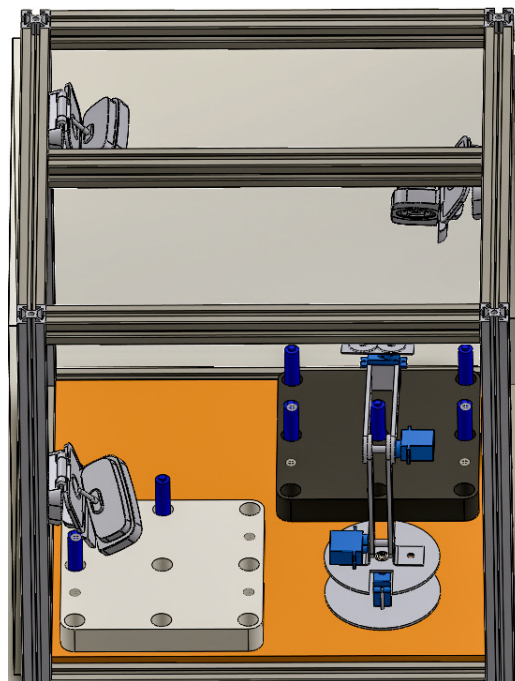


Figure 3 the batteries are picked and placed from black area to white area.

## 2. Play Field

- 2.1 The play field includes the robot arm as shown in Figures 2 and 3, and the operation area is blocked such that the participants cannot see the play field and the robot arm directly. Participants only can see the video of the play field via cameras for robot arm operation. In the play field, there are three cameras at least for the video.

- 2.2 In the play field, participants must operate the robot arm to pick the objects (batteries) and then to place the target position. As shown in Figures 2 and 3, the batteries must be moved from black to white areas.
- 2.3 In the play field, there are three cameras installed at three positions for different view angles as shown in Figure 4.

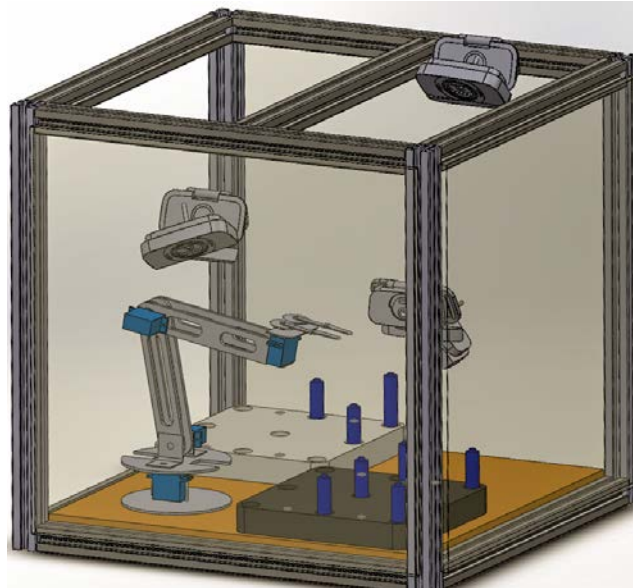


Figure 4 Three Cameras at three positions for different view angles.

### 3. Competition Method

- 3.1 After a whistle from referee, the participants can start operate the remote controller. The participants must operate the robot arm to pick the objects from original area and then to place on target area. The objects only placed in the hole on the target area can get score.
- 3.2 Every participant has same operation time. If being successful to place the objects in the hole in the competition time, the participants can get score.
- 3.3 During the competition, the participants can call stopping the game. After the permission of referee, the competition can be stop a period time which is decided by referee because of the total competition time. The referee have right to decide how much time of calling stopping. The referee has right to stop the game because the competition cannot progress.
- 3.4 The score points of every participant are counted by the number of objects put in the hole.
- 3.5 The ranking of the competition is followed by the score points gotten by participants. If two or more getting same score points, the participant making use of less time win the game.

### 4. Violation

- 4.1 During operating robot arm, the participants only can see the video from the cameras installed in the play field. It's not allowed to make use of other way. If the participants use other way to see the robot arm, referee have the right to stop. If the participants don't want to stop, referees have the right to cancel this game.
- 4.2 During operating robot arm, the participants don't allow to talk to other people. If the participants don't stop the talk, referees have right to cancel this game.
- 4.3 When starting the game, the participants must start robot arm operating. If the participants cannot start, referee start countdown. If the time of countdown is over, referees have the right to cancel this game. All of the teams have same time of countdown that is decided by referees.

5. Score Points

- 5.1 In every game, successfully putting battery in the hole gets point. The participants getting more points win the game. If getting points are same, the participant spending less time wins the game.
- 5.2 Putting one battery in one hole getting 1 Point. If three batteries are put in the holes that can be connected to one line, the participant get special bonus, 3 point. As shown in Figure 5, there are two connection lines in the game. The participant gets 6 points for special bonus. In addition to 5 points because of five batteries in the holes, the participant gets 11 point in total.

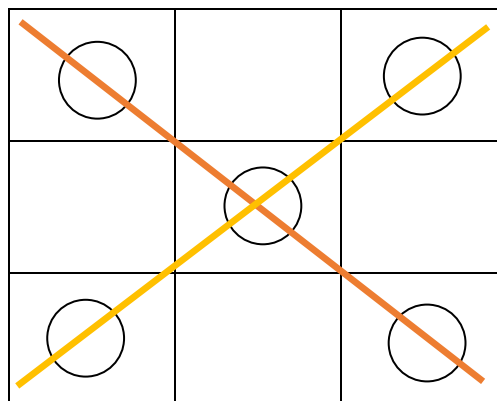


Figure 5 Putting 5 targets in the holes gets 5 points, and two connection lines get 6 points (3 points per connection line). Thus, the total points are 11.

- 5.3 The score points of all participants are put in a ranking table as shown Table 1. Table 1 includes the spending time of all participants.

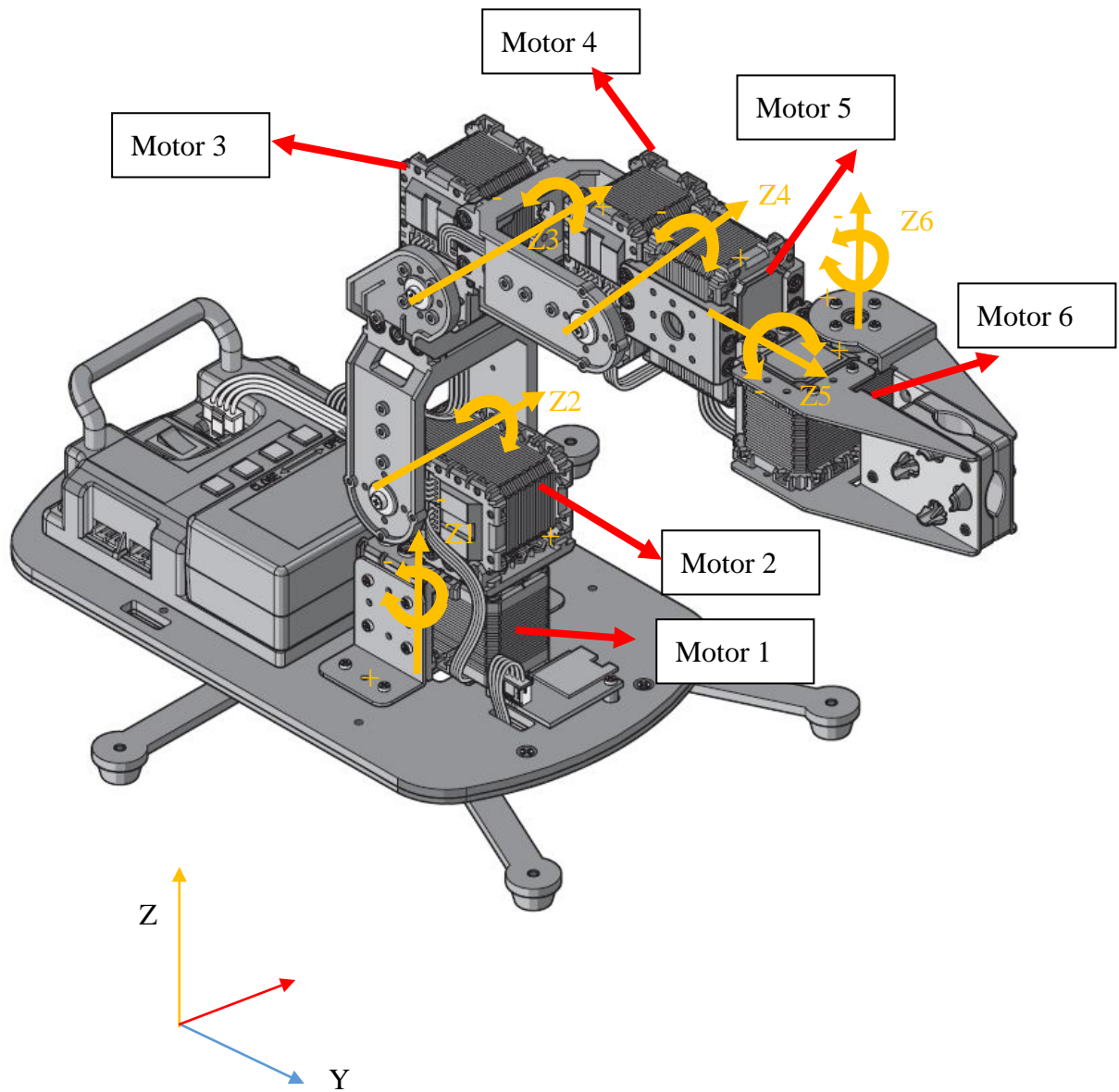
Table 1 the ranking table of participants get score points

Ranking	Score Points	Time
1		

2		
3		
4		
5		
6		
7		
8, 9, ...		

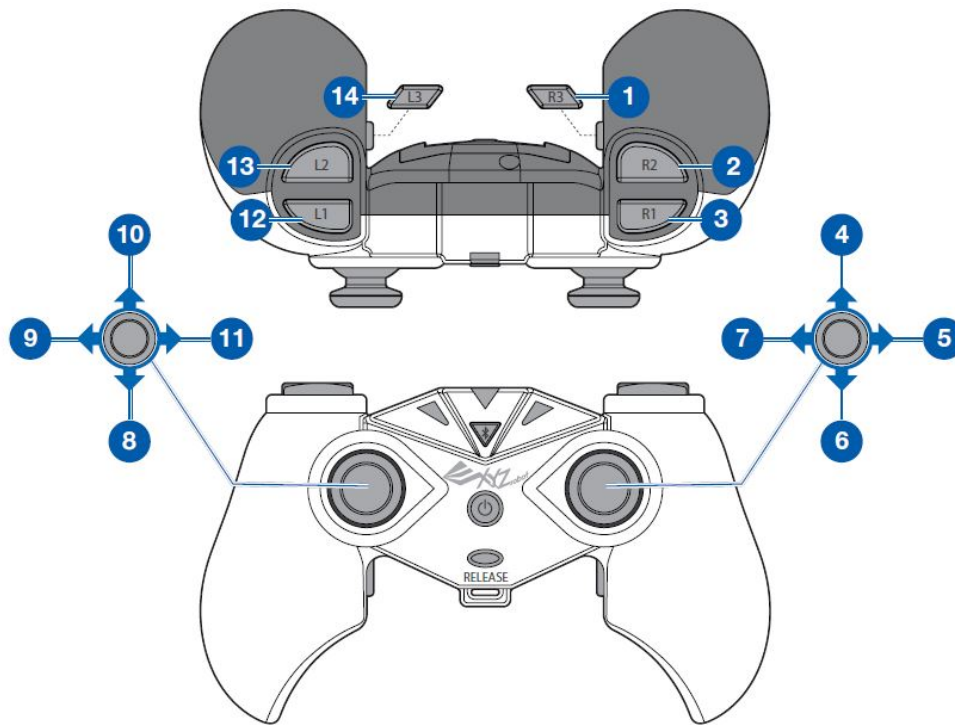
# Appendix A: Robot Arm Operation Manual

Robot Arm Kinematic Model:





## Menu of Joystick Controller



### Operation description:

- 1). Direction 9 and 11 in left joystick controls motor No. 1. Direction 9 controls robot arm turn left (motor reverse), and direction 11 controls robot arm turn right (motor forward). Direction 8 and 10 controls motor No. 2. Direction 8 controls robot arm turn up (motor reverse), and direction 10 controls robot arm turn down (motor forward).
- 2). Direction 7 and 5 of right joystick controls motor No. 3. Direction 7 controls robot arm extending (motor forward), and direction 5 controls robot arm retracting (motor reverse). Direction 4 and 6 of right joystick controls motor No. 4. Direction 4 controls robot arm extending (motor forward), and direction 6 controls robot arm retracting (motor reverse).
- 3). L1(button 12) and L2(button 13) controls motor No. 5. L1 controls gripper turn left (Motor reverse), and L2 control gripper turn right (motor forward).
- 4). R1(button 3) and R2(button 2) control motor No. 6. R1 control gripper clamping (motor reverse), and R2 controls gripper relaxed



(motor forward).

- 5). L3 (button 14) and R3 (button 1) controls No. 1 at assigned angles. L3 control robot arm turn left at 90 degree (motor reverse), and R3 controls robot arm turn right at 90 degree ( motor forward).

## Appendix B: Software

The participants need to download the software from github for the competition. There are two software as follows:

Client: <https://github.com/HongYu313Lin/Remote-robotic-arm-Client>

Servo: <https://github.com/HongYu313Lin/Remote-robotic-arm-Server>

The software in client terminal is installed at participants' computer for control of the robot arm in play field on servo terminal. The software in servo terminal is used to let participants know how to operate the robot arm. The following describes the software in detail.

### Definition

- Communication Speed 100 ms. If no any command is sent to servo in 100ms, then the client sends command code 0 to servo (stop the robot arm action but keep the network connection).
- If no command is sent to servo in 2 second, then the client breaks the network connection automatically.
- The definition of motor rotation direction
  - Forward: increasing encoder value. The active axis is rotated on inverse clockwise.
  - Reverse: Decreasing encoder value. The active axis is rotated on clockwise.
- The definition of joint motor numbers of robot arm:
  - The joint motor numbers is defined by the order from base frame. As shown in Fig. B1, the motor on the base frame is no. 1, the link is connected to joint motor no. 2, and so on. The final joint is the motor of end effect and is no. 6.

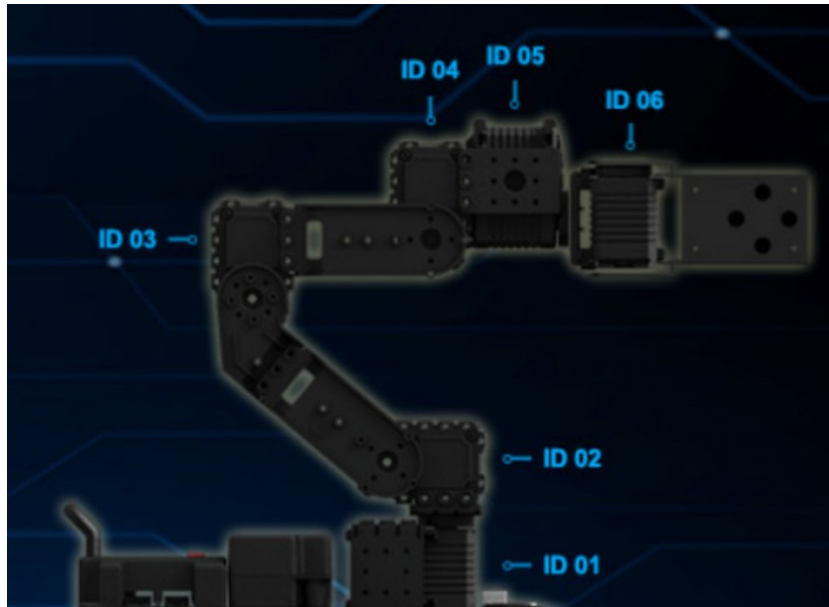


Fig. B1 The definition of joint motor numbers of the robot arm.

- The table of command code as shown in Table 1. Fig. B2 is the example program to execute the command using mouse for control of robot arm via internet.

Table B1 Command Code

Code	Command	Explanation
0	Ping	Stop robot action but keep connection
1	Release	Release motor torque(break power)
2	Power	Enable motor torque
3	L1	Motor No. 5 forward
4	L2	Motor No. 5 reverse
5	L3	Motor No. 1 forward toward its boundary, and don't influence other motors
6	R1	Motor No. 6 forward, Open clutch
7	R2	Motor No. 6 reverse, Close clutch
8	R3	Motor No. 1 forward toward its boundary, and don't influence other motors
9	LJLS	Motor No. 1 forward (Left Joystick Left Side)
10	LJRS	Motor No. 1 reverse (Left Joystick Right Side)
11	LJU	Motor No. 2 forward (Left Joystick Up)
12	LJD	Motor No. 2 reverse (Left Joystick Down)
13	RJLS	Motor No. 3 reverse (Right Joystick Left Side)
14	RJRS	Motor No. 3 forward (Right Joystick Right Side)
15	RJU	Motor No. 4 forward (Right Joystick Up)

16	RJD	Motor No. 4 reverse (Right Joystick Down)
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Fig. B2 The interface of joystick simulator. Using mouse to push the bottom will send corresponding command code.

- Fig. B3 is the application program to connect the robot arm via internet. After assigning proper IP address and Port number, and select AutoJoy, you will be able to connect the robot arm via simulation and exact joystick. Note that after participants register for Tele-OP robot arm competition, we will give everyone a different Port number.

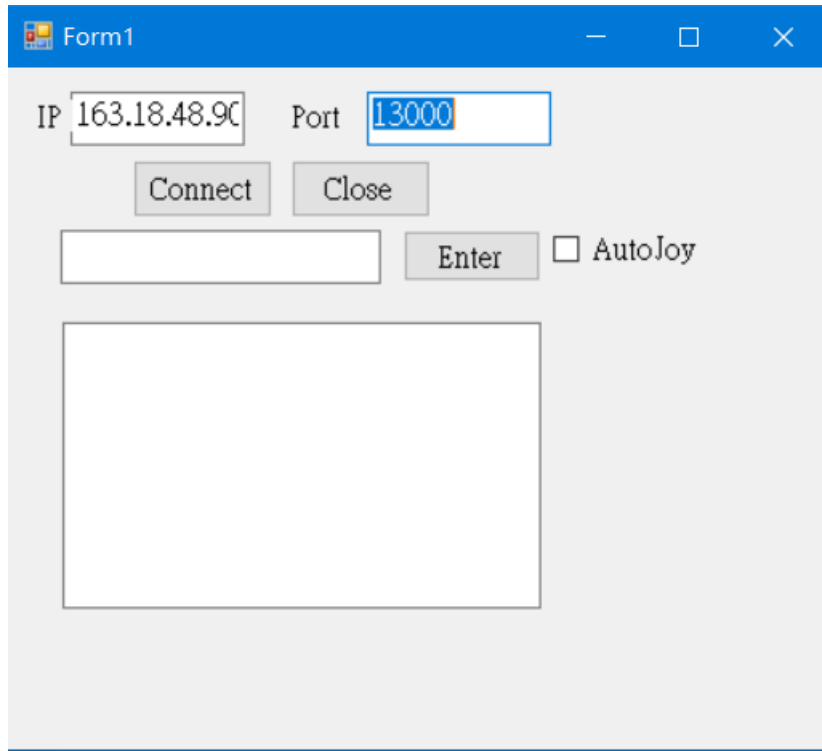


Fig. B3 TCP/IP interface.

- If you have one joystick, you can operate the robot arm based on Tele operation after executing the application program. Fig. B4 is the interface. We have test joysticks Logitech Gamepad F310 and SONY Model CUH-ZCT2G successfully.

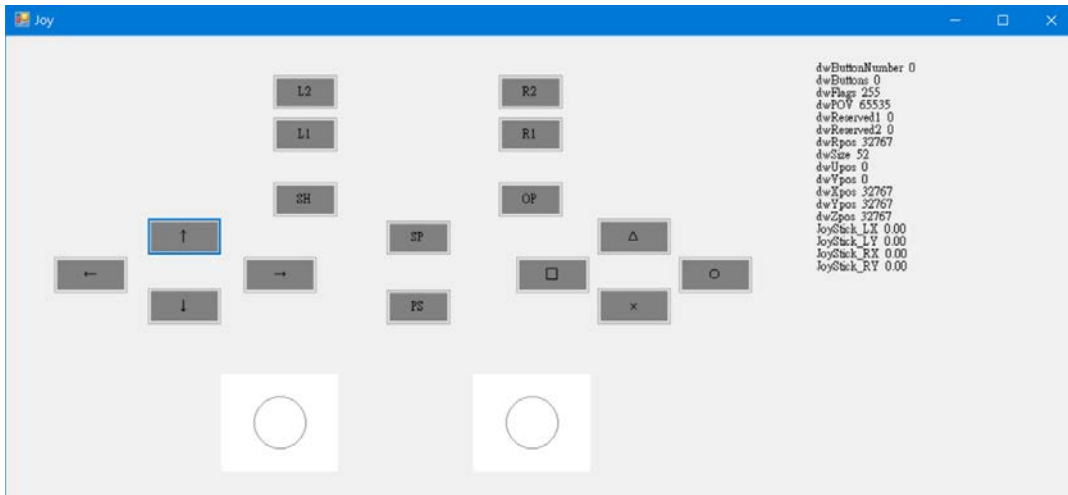


Fig. B4 The interface of exact joystick.