**ME192 Lab 4 – Vision Guided Robot Picking Operation**

10-15-14

**Project Description**

Set up a V+ robot vision program with which either the SCARA robot or the Adept six axis robot in the lab is used to pick up a round and a square peg from a target area and place them in a peg holder block. The pegs may be placed in the target area as the robot requests and the peg holder is placed in a second target area. The program is built on the V+ program from Lab 3 which identifies and locates the objects placed in the target areas.

**Learning Objectives**

* The basics of vision guided robot pick-up and placement operation involving mixed parts presented in random orientation.
* The interactions of location transformations involving robot gripper location and tool offset, a moving or fixed position camera, work table, and variable part location and orientation.
* Working with IO signals to actuate the gripper and other external devices such as relays, motor starters, and PLCs.

**Project Goal**

Development of a vision-guided object pickup operation leading to the term project (Lab 5) in which the motion of the manipulator arm is controlled pick up the objects moving on a conveyor and the robot controller tracking the conveyor movement with a built-in or external encoder. In this lab, the objects are stationary, whereas, in Lab 5 they move on a conveyor so a precise motion control of the robot arm is required.

**Project Tasks**

***Vision Guided Picking***

Use the results from Lab 3 in picking up a round peg and a square peg from a target area (Area 1) and placing them on a peg holder block in Area 2. The XY pick location and the gripper angle must be passed on by the Lab 3 program acting as a subroutine. The gripper angle offset and the Z pickup height must be taught once on the first pick up operation. Use “PROMPT” or “TYPE-PAUSE-PROCEED” commands to ask the operator to manually move the robot gripper to the first pickup position after the camera locates the object. Once set, the angle and the pickup height will remain the same in subsequent pickup operations.

***Additional Instructions***

1. Use the attached program segments for combing the camera offset data and the object location and orientation in the picture frame to derive the pickup or dropoff location and the gripper roll angle.
2. The camera for the six axis robot is mounted on a stand, not on the robot axis, and the camera position is calibrated accordingly. Do not disturb the set up as recalibration for the camera offset may be required if the camera stand is moved.
3. The program sequence should be such that the robot asks the operator to place one or two objects in Area 1 in each pickup cycle and a peg holder block in Area 2. Use “PROMPT” or “TYPE-PAUSE-PROCEED” commands for an operator response.
4. Use a method to pick up the objects that are placed close together without knocking one off. A simple method is picking the round peg first at a right angle to the center to center line.
5. Use “TIMER” function for time delay for trigger, etc. for a detached camera. Use “DELAY” function for an attached camera.
6. Set the camera aperture or iris to minimize the shadows of the object on the bottom surface. Ask the instructor to check the min-max settings for the object pixel size and the threshold for binary conversion.

**Project Report -** Due Monday November 3

The report must contain a short operation description, a set of transformation equations that the robot should have used, a program list with comments, and a team activity log sheet. Demonstrate the program to the instructor. 90% of the grade will be based on the program functionality and the completeness of the report. 10% will be from a quiz on the lab program set up.

**10% Extra Credit work**

After the project work is completed. Replace the geometric shape tests (VRULERI, VFIND.LINE, VFIND.ARC) with object identification and locating via sample image acquisition. The work will require some team research and experiment. The extra credit work may be submitted within two weeks of the due date of the Lab 4 report for a retro credit. The project team may use this object identification and locating method in pursing the Lab 5 project.

**Special Lecture – Optional Attendance**

A jump start on ladder logic and Programmable Logic Controller – For a possible PLC application in Lab 5 by select project teams.

**Program segments - Vision guided pick up for Lab 4**

1. *To strip the Z and the gripper angle from the offset gripper location*

MOVE grip.loc ; Move to the offset gripper location

BREAK

WAIT.EVENT , 1 ; Wait ‘til the motion stops

HERE #grip1.loc ; Precision location

DECOMPOSE jt[1] = #grip1.loc ; Decompose into joint values

SET ref.loc = grip.loc : TRANS( , , -JT[3], , ,-JT[4]) ; Strip the Z and the angle value

1. *To incorporate the XY offset values and the roll angle into the gripper location*

SET xy.loc = ref.loc : to.cam : obj.loc ; xy.loc = the absolute XY object coordinates.

; to.cam = XY camera offset

; obj.loc = XY coord. of the object on the frame

SET xyr.loc = xy.loc : RZ(rz ± 45) ; Append the desired grip angle in absolute term.

; RZ(rz ± 45) = JT[1] + JT[2] + 180 –(rz ± 45)

; rz = Diagonal angle of the square (round) peg

1. *To incorporate the picking height into the pick location and to compensate for any roll offset.*

TYPE “Set the desired grip height and enter PRO to continue”

PAUSE ; Manually set the grip height and angle on a square peg. Then, type PRO.

HERE #gripper ; To teach the height and the offset angle.

DECOMPOSE jt[1]=#gripper ; Extract the gripper joint values.

SET P1 = xyr.loc : TRANS( , , jt[3], , , jt[4] ) ; P1 = Add the height and the roll offset.

1. *Two ways to have the robot arm wait for an input signal 1 for its next move.*

WAIT SIGNAL(1001)  ; Indefinite wait

WHILE SIGNAL(-1001) DO /../ END ; /…./ may be DEPART -50 / DEPART 50 / END

**Locations for Vision Guided Picking**

CAM.REF – Camera reference location. This is the position of the Z axis where the camera is set to see the objects to pick up. The location is set constant for a field of view. There may be multiple CAM.REF locations. For example, the CAM.REF for a drop off location would be different from that for a pick up location.

TO.CAM – This is the distance transformation between the Z axis and the camera mounted on the Z axis. It is created by a camera calibration. It stays constant and is loaded by calling LOAD.AREA from VSETUP. TO.CAM is a 12 element transformation vector which contains both rotation and translation data.

OBJ.LOC – This is the location transformation of an object found in a camera frame. The result gives the Cartesian XY coordinates with respect to the robot frame. The Z pickup height and the pickup roll angel are taken out. Make certain that OBJ.LOC is stripped of its Z and roll angle values. If necessary, use the DECOMPOSE instruction to take out the Z and roll values.

XYR.LOC – This location is OBJ.LOC with the object orientation angle added. The value is expressed in the robot frame. If the gripper is mounted directly under the Z axis and the gripper opens at 90 degrees to the X axis, this would be the actual pick up location.

PICK.LOC – This specifies where (XYZ) and how (grip angle) the gripper will pick up the object if there is no obstruction around the object. On the first pick in the camera frame area, the operator must teach the robot the height, any XY offset of the gripper from the Z axis center, and any rotation of the gripper from the zero position. This is accomplished by temporarily halting the program execution and manually bring the gripper to the pickup location with required rotation. This location offset remains constant for the area of interest in subsequent pick up operation.

The easiest way of defining this “delta location” is:

HERE XYR.LOC:DEL.LOC ; Del.Loc is defined in terms of XYR.Loc

Once DEL.LOC is determined, the subsequent pickup locations will be defined by

SET PICK.LOC = XYR.LOC:DEL.LOC

***Location Transformations***

**Frames:**

1. Robot frame (Base frame)
2. Z axis frame with the Z and roll angle stripped off.
3. Camera frame with XY and object orientation. (The camera may be mounted on the Z axis or on a stand. The camera offset TO.CAM from its base applies to both cases.)
4. Gripper frame with pickup height and constant angular offset. (If the gripper is offset from the Z axis.)

***Express the above locations in a transformation equation.***

.