POP-EYE

GC Points – 300

Final Date – 02/09/2018

Venue – Robotics Club Room, New SAC

Time – 17:00

Last Updated – 04: 00 | 12/09/2018

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Problem Statement: -

Before reading the statement, please read carefully the information given below -

1. **Robotic Arm**: A structurally human like arm made of links (rigid bodies) joined generally by revolute(revolving) and prismatic(sliding) joints with a hand (end effector ex-for drilling, grabbing) at the end to perform some specified task.

In this problem
- we challenge you to build a system comprising of a **robotic arm and a vision subsystem** capable of reaching **without human intervention** from a given starting position to a specified position **on a plane** with its hand (endpoint) with as much accuracy and speed as attainable.
- To test the arm, it will be provided with targets(balloons) on plane on a testing setup (table top) which it has to reach with its hand
- All the targets will be placed inside a circular area on the plane
- The arm will be based at the center of the circular area
- A target is made of a pair of balloons placed symmetrically about the center of the area
- The base of the arm will be stationary at the center of the testing setup.
- A camera will be placed above the testing setup at a constant height, providing raw images of the target plane from the top.
- The controller **device(laptop)** for operating the arm will not be judged, however the vision subsystem will be indirectly judged for its accuracy and speed by judging the arm for the same

General Rules for the game –

Structure
1. The arm structure should not extend beyond the 20 cm(diameter) cylindrical volume before starting of each round, however it can freely extend between attempts.
2. Violation of the Rule 1 will be penalized as mentioned below-
    o If any part of the arm is strictly greater than 20 cm diameter but strictly less 24 cm, straight 200 marks will be deducted from the marks gained by the violator at the end of the complete game.
    o If any part of the arm is equal to or greater than 24 cm diameter but less than 30 cm, straight 400 marks will be deducted from the marks gained by the violator at the end of the complete game.
    o The marks deduction in above two violations are independently judged
3. The base of the arm cannot be attached to the ground in any way. The base of the arm has to be stable and heavy enough to support the arm.
4. The arm cannot take support from the testing setup (table).
5. Violation of Rule 3 and Rule 4 will lead to straight disqualification of the candidate.
6. The arm structure cannot be modified, once the testing of the arm starts.

Timing

7. If during any round, the arm remains stationary for more than 3 minutes while being tested then the candidate must accept the completion of the round and move on to the next iteration of the round (for round 1) or the next round.

Starting Position

8. A starting position (square 9cm X 9cm, black) will be marked on the target area before starting of first round. This starting position remains fixed for all further rounds.
9. The arm can be positioned at the starting mark manually before starting of each round.

Camera & Laptop

10. The images must be acquired by a laptop which will also host the vision subsystem and the controller programs (if any).
11. The laptop or controller will not be provided with any internet connection

Timing

12. A 20-minute time window will be given to each candidate before starting of Round 1 to setup the arm. For all later rounds, a time window of 5 minutes will be given.

Targets

13. The balloons given as targets on the target plane will approximately resemble a circle when seen from the top.
14. The balloon size will be around 5 cm in diameter with a maximum deviation of 1cm.
15. The balloons will be attached to the table top using either Double Sided Tape or One Sided Tape or Adhesive Glue.
16. For each round, the balloons placed on the target area will be removed only after the completion of the round.
17. To successfully pop a target (pair of diametrically opposite balloons), the two diametrically opposite balloons must be popped consecutively.
18. To successfully pop a target, each of the balloons have to be popped by the physical contact of the arm.

19. In case of any dispute, the decision of the club secretary will be final.

Testing Setup: -

- The setup will be in form of a table of height 20 cm. The game will be played on the top surface of the table.
- The surface will have below mentioned features:
  - Square shaped with dimensions of 1m X 1m
  - Four 10cm X 10cm black colored squares to mark the corners
  - Light blue colored (tentatively) annular ring of inner diameter 30 cm and outer diameter of 90 cm for placing the targets
  - Circular cut out of diameter 20 cm for placing the arm structure
- A camera placed directly over the table center at a constant height
- Small sized balloons with roughly same diameter will be used as targets

See the drawings below to get a clear idea -
* NOTE: All dimensions in the drawing are in mm

200

10
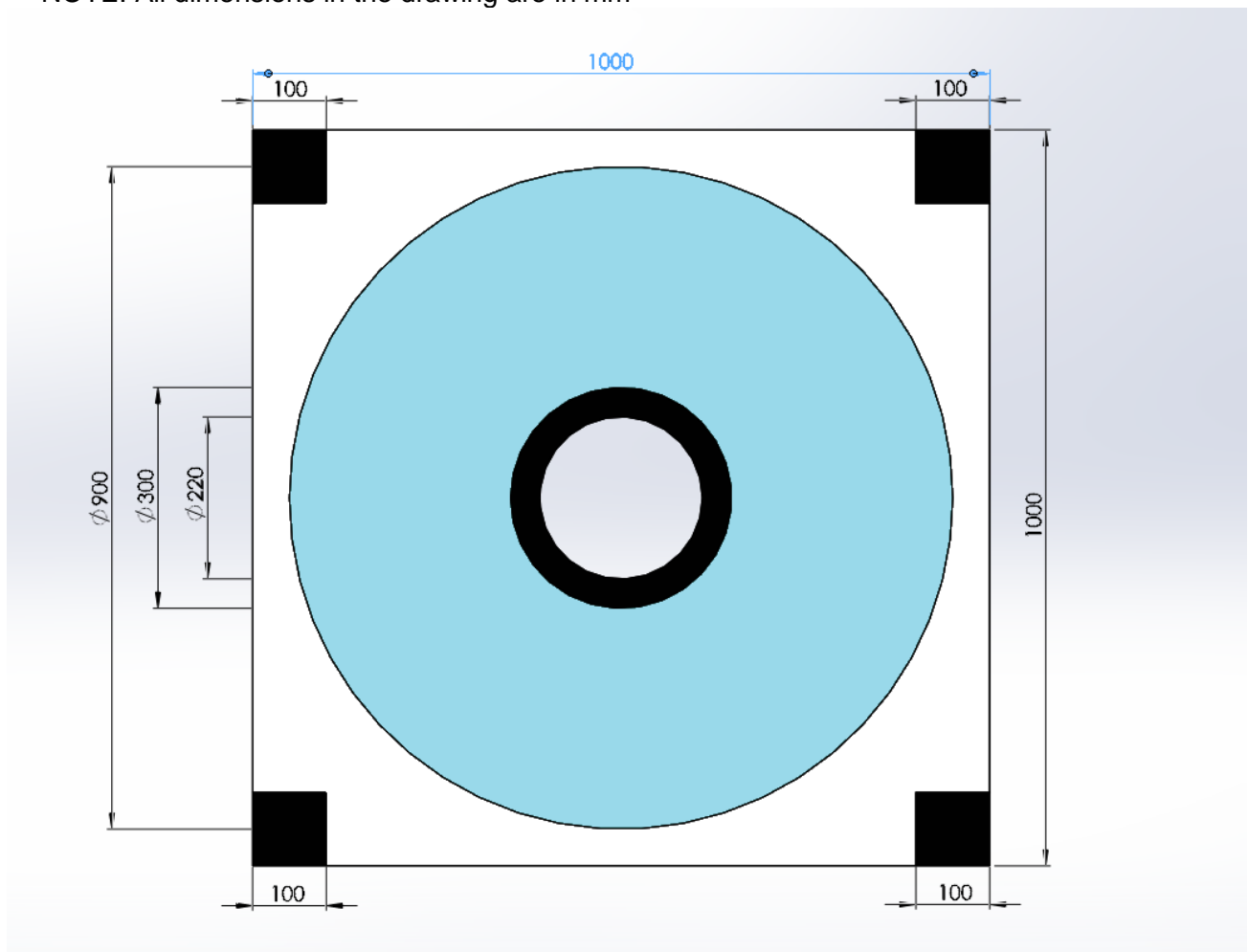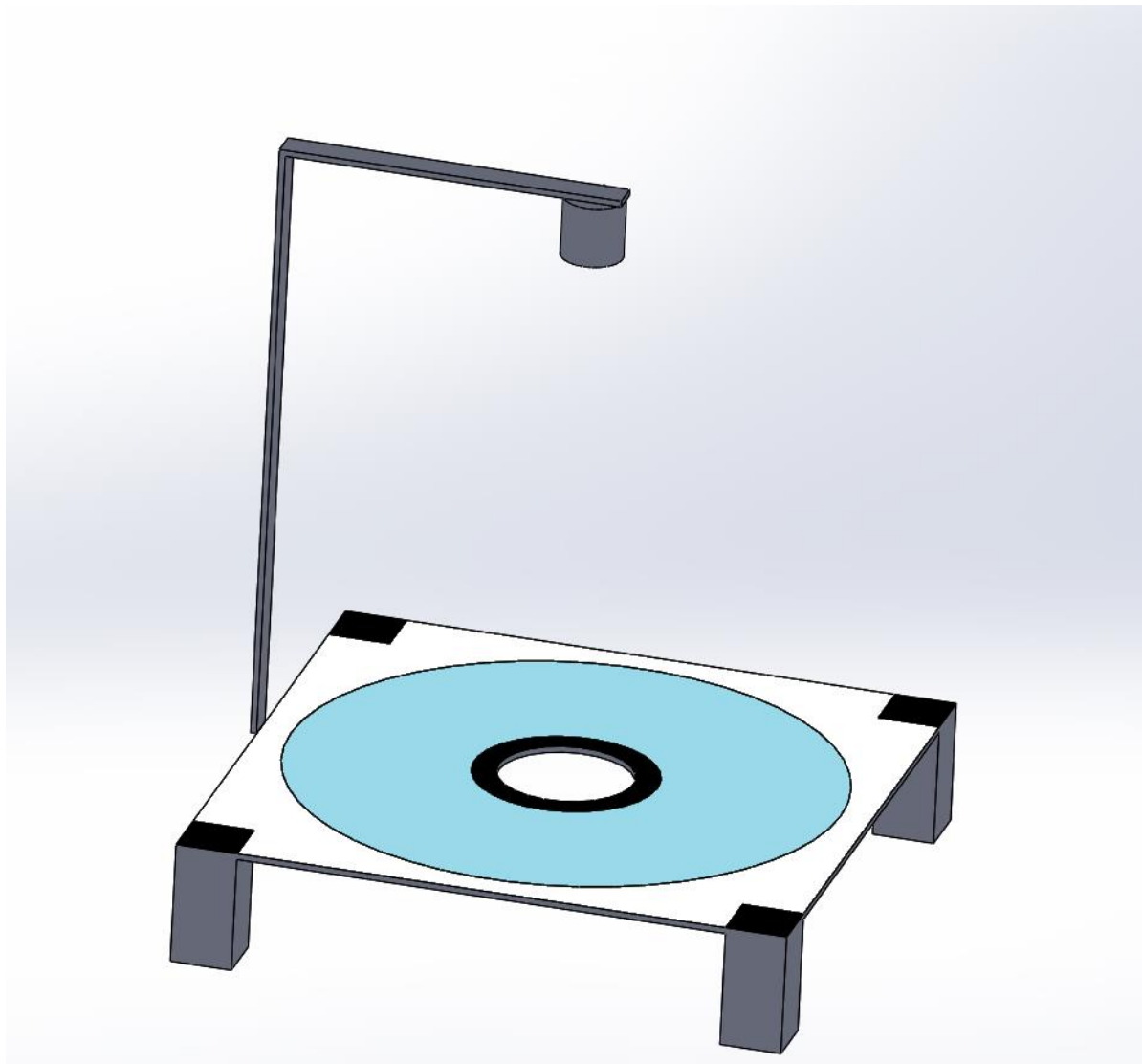
Structure of the Game:

All robotic arms will be judged by three rounds - Basic Functionality Test, Accuracy Test and Speed & Overall Performance Test.

- **Round 1 - Basic Functionality Check:**
    - *Overview* - This is an elimination round. Qualify this round to gain qualification points and proceed further into next rounds. Each contestant will be given five chances to complete the objective of this round.
    - *Gameplay and Rules*- Two 15cm X 15cm square areas will be marked at diametrically opposite positions in red color. The arm has to start from the starting point and reach any one of the areas, stay inside the area for a time period of at least 't' seconds then reach its diametrically opposite point and stay inside for a time period of at least 't' seconds. Reaching the area means that the endpoint of the arm, when projected perpendicularly on the target plane must be inside the area. The value of 't' mentioned above will be constant and will be declared before the round.
    - *Marks distribution*-
      Arm shows movement – 50 marks
      Completion of the objective – 100 marks
    - Marks needed to qualify the round – 150 marks

- **Round 2 - Accuracy Check:**
    - *Overview* - This round aims to test the accuracy of the arm in performing the given task. The contestant will be given the choice to set the accuracy level for their system to test against. Increment in points during the round will be proportional to the accuracy level chosen. This round is not an elimination round. Only one attempt will be given to complete the round.
    - *Gameplay and Rules*- The contestant has to choose the number of pairs of balloons to be placed on the target area (Min- 2 targets or 4 balloons, Max- 12 targets or 24 balloons). Depending upon the choice of accuracy, different colors of balloons (Red, Blue, Green and Yellow) will be used for targets. Contestants are asked to pop targets of same color in the sequence Red-Blue-Green-Yellow. Points will be awarded only for the balloons in the correct order i.e. only those red targets which are popped before blue targets will be awarded.
    - *Marks distribution*- 50 points per target (in order). Max- 600

- **Round 3 - Speed & Overall Performance Check:**
    - *Overview*- This round will test the speed of the system in completing the task while also checking extreme and difficult targets. Achieve as many targets as possible out of maximum 5 targets (10 balloons) in a specified time interval. Not an elimination round.
    - Gameplay and Rules-
        o Part 1 - The arm, for each attempt has to start from the starting mark and pop a target (pair of balloons) set to test difficult and extreme cases. A maximum of 5 targets will be given.
        o Part 2 - The arm has to start from the starting mark, pop a target and return back to the starting point in order to complete an attempt. Make as

many successful attempts as possible in the time limit. The time limit wiil be declared before the start of the event.

- Marks Distribution-
  - Part 1 - (no of successful attempts * 20 points), Max Points = 100
  - Part 2 - (no of successful attempts * 20 points), Max Points = 100
- **Round 4 – Tie Breaker:**
  - *Overview*- This round will be conducted only if multiple candidates score equal marks at the end of Round 3.
  - *Gameplay and Rules*-
    - Each candidate obtaining equal marks will play Round 2 and Round 3 iteratively, until they score unequal marks either at the end of Round 2 or Round 3.
    - The marks will be checked for equality at the end of Round 2 and again at the end of Round 3.
    - The marks scored in this round only contribute in deciding the ranks of candidates obtaining equal marks. All these candidates get the same marks as they scored before starting Round 4.
  - *Marks Distribution –*
    - The marks obtained in this round do not contribute to the marks of the game.

NOTE: Every candidate not able to successfully qualify Round 1 will not be allowed compete further in the game.

List of Extreme & Difficult Cases for Round 3: -

This list in not exhaustive. Other cases, if any will be declared before the starting of the event.

Three mandatory cases will test for -

- Two targets placed as close as possible in terms of the angle
- Two targets placed as close as possible in terms of the radius
- Two targets placed at the limiting values of the radius.

NOTE: Targets are a pair of balloons placed at diametrically opposite positions.

Generation of Positions for Target Placement: -

To place a target an angle and a radius value is needed. The positive angle is measured from the radial line passing through the starting mark in anticlockwise sense.

NOTE: The targets positions will be generated by the organizers.

1. Qualification Round:
   - Radius: Matlab's randi function will be used to generate a radius value belonging to the range [20, 40].
   - Angle: Matlab's randi function will be used to generate a valid angle (0 – 360 degrees, both inclusive).
   - Color: Matlab's randi function will be used to generate an integer belonging to the range [1,4], whose elements map to Red, Blue, Green and Yellow.
2. Accuracy Check Round:
   - Angle: Let a candidate choose n number of targets (2n balloons).
     - A list will be made containing angles as given below –
       [0, PI/n, 2PI/n, 3PI/n, ….., PI, ……2PI]
     - 'n' integers will be generated from the range [0,2n], where each integer represents an index in the above mentioned list. The angles corresponding to the indices will be chosen for target placement.
   - Color: Let a candidate choose n number of targets (2n balloons).
     Let $n = 4m + r$, where $r = n \% 4$, then –
     - There will be m targets of each color
     - The remaining r targets will be chosen by generating a random number from the range [1,4], using Matlab's randi function, where the range maps to Red, Blue, Green and Yellow.
     - The sequence of all the colors will be randomly permuted using Matlab's randperm function and mapped one to one against the angles generated previously.
   - Radius: Let a candidate choose n number of targets (2n balloons)
     - 'n' integer values belonging to the range [18, 42] will be generated in sequence using Matlab's randi function and will be mapped one to one against the angles generated previously.
3. Speed & Overall Performance Check:
   - Part 1:
     - Apart from the three mandatory cases, remaining two will be chosen randomly from the list of Difficult Cases by randomly choosing an index from the list, using Matlab's randi function.
     - Parameters not fixed by the case itself will be generated randomly as explained for Round 2.
   - Part 2:
     - 5 positions will be generated as explained for Round 2.

NOTE: For each round, all the required positions will be generated at once before the round. The candidate has to be present during the process.

Game Rank to Kriti Points Mapping:

Rank obtained in the game will be mapped to kriti points as per below mentioned scheme: -

Note: **Marks** wherever mentioned refer to marks gained in the game while **points** wherever mentioned refer to **GC Points i.e. Kriti Points**

Game Marks Distribution:

Participation Marks	50 marks
Qualification/ Round 1 Marks	150 marks
Round 2 Marks(Max)	600 marks
Round 3 Marks(Max)	200 marks

Note: Any deductions for rule violations and marks awarding schemes for each round are mentioned in the corresponding round (Structure of the Game) or the general rules.

Kriti Marks Distribution:

Let GCP denote GC Points allocated for this event.

- First Game Rank => GCP x 100%
- Second Game Rank => GCP x 85%
- Third Game Rank => GCP x 65%
- Fourth Game Rank => GCP x 40%

Helpful Resources:

1. https://en.wikipedia.org/wiki/Robotic_arm
2. https://in.mathworks.com/help/matlab/ref/randperm.html
3. https://in.mathworks.com/help/matlab/ref/randi.html
4. https://in.mathworks.com/help/matlab/random-number-generation.html
5. 360 Degree Servo Motors
6. https://docs.opencv.org/3.4.0/d9/df8/tutorial_root.html
7. https://docs.opencv.org/3.4.0/index.html
8. https://en.wikipedia.org/wiki/Robot_kinematics
9. https://www.arduino.cc/en/Main/Tutorials