Real Time Path Planning of Industrial Robots in an Unknown Environment Using Vision

Hariharan Ananthanarayanan

Raul Ordonez, Advisor

University of Dayton,
Dept. of Electrical and Computer Eng.

Motivation:

- Robots are limited in functionality when they have no knowledge of the environment they operate in.
- Industrial manipulators perform pre-programed tasks repeatedly and have no adaptation to change in environment.
- Re-programming manipulators for different tasks involve time and cost.
- Safety concerns.
- Need for fast processors for real-time adaptations to changing environment.

Objective:

- Incorporate visual feedback in an industrial robotic system.
- Real-time path planning of industrial manipulators.
- Adaptability of industrial manipulators to dynamic environments.
- Obstacle avoidance using real-time kinematic calculation.
- Dynamic target tracking using vision.

Problem Statement:

Robots are limited in their functionality when they have no knowledge of the environment they operate in. In order to improve the safety and reliability of industrial robots, sensory perceptions are vital. The problem with the current robotic systems in most industrial settings (such as those in the MRL) is that they can perform a pre-programmed task repeatedly, but cannot adapt to a dynamic environment. This limitation reduces the flexibility and safety of these machines.

References:

1. Online Trajectory Generation: Basic Concepts for Instantaneous Reactions to Unforeseen Events, Torsten Kroger and Friedrich M.Wahl: IEEE Transaction on Robotics vol 26. No 1, February 2010
2. Sensor-Based Online Trajectory Generation for Smoothly Grasping Moving Objects, M.Zhang and M.Buehler, Center for Intelligent Machines, Department of Mechanical Engineering, McGill University.
3. Trajectory Generation for Capturing a Moving Object in Predictable Environment, Tae-Seok Jin, Jin-Woo Park and Jang-Myung Lee: JSME International Journal Series A, vol 47, No 2, 2004
4. Vision Based Online Trajectory Generation and its Application to Catching, Akio Namiki and Masatoshi Ishikawa. Control Problems in Robotics, STAR 4
5. Constrained time-efficient and smooth cubic spline trajectory generation for industrial robots. IEEE Proceedings, 1997
6. Experiments in Hand-Eye Coordination using Active Vision, Won Hong, Massachusetts Institute of Technology
7. A practical approach for minimum-time trajectory planning for industrial robots. Foonyoung Kim, Sung-Rak Kim, Soo-Fong Kim and Dong-Hyeok Kim. An International Journal of Industrial Robot, 37/1

Future Work:

- Track objects in 3D using stereo camera.
- Use vision to resolve redundancy of manipulators and solve its inverse kinematics.
- Use faster algorithms in real-time for smarter path planning and obstacle avoidance.

Method

Image Acquisition/Processing

- Obtain the image in a matrix from the grayscale camera (PT Grey)
- Crop the image to throw away the borders
- Isolate the ball based on its color using thresholding. This parameter is tunable to have a clean Object of interest.
- Clean the image using "bwareaopen".
- Convert to a binary image by assigning 1 to ball and „0"to background.
- Find center of ball by averaging the entire image.
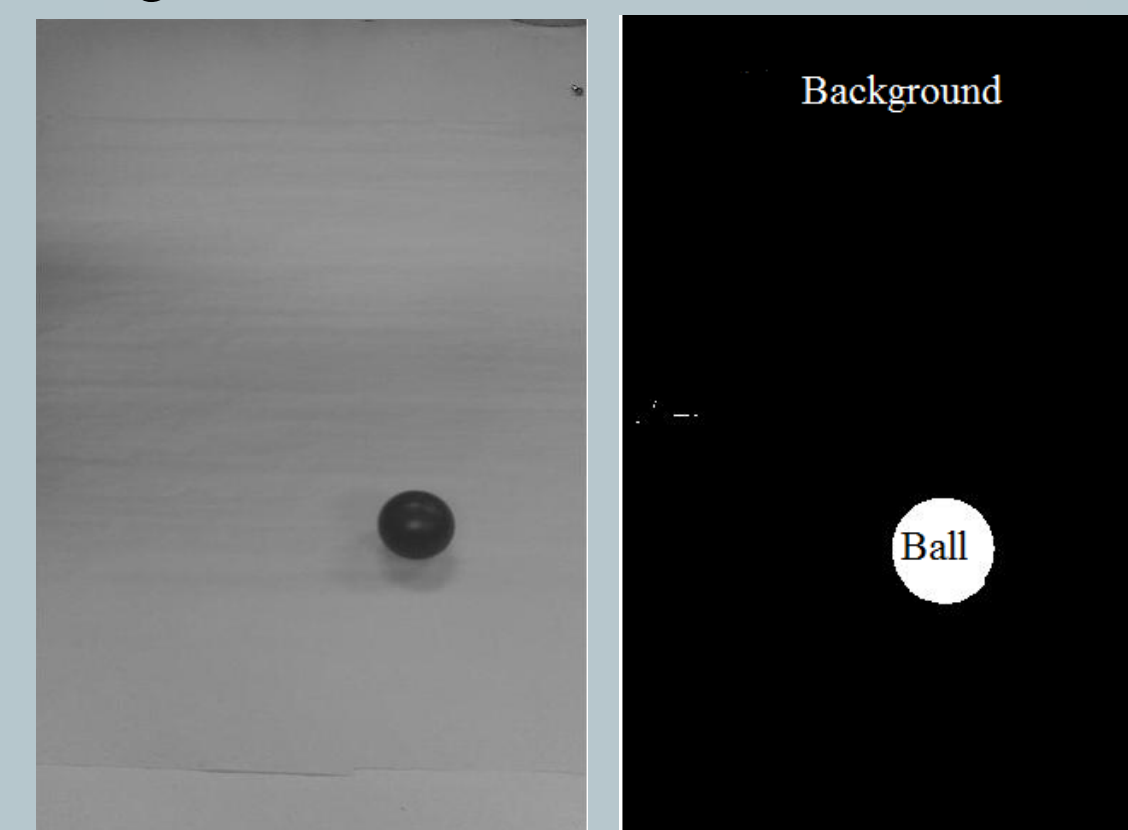
(a) Raw Image   (b) Binary Image

Trajectory Generation & Real-time Path Planning

- Define boundaries and get the robot position at each corner. Get the corresponding (x,y) co-ordinates of ball .
- Using this data, determine the projective co-ordinate transformation from camera frame to robot frame. This involves both rotation and translation between the two frames.
- Transfer (x,y) co-ordinates of ball to dSpace using CLIB.
- Process co-ordinates through transformation to find robot EE position.
- Feed position to path planner.
- Path planner breaks up path to the smallest possible motion for each execution cycle and transfers the positions back to the application.
- Application commands the robot to move through MOTOCOM.
- The dSpace determines the current position of the EE in real-time through FK. The path planning parameter can be adjusted in real-time to minimize the error between the ball and robot EE.
- The FK can also be used to avoid collision or restrict the robot EE within boundaries.

Limitations

- Sharing of information between the application and real-time hardware introduces a delay.
- MOTOCOM interface introduces a significant amount of delay as commands are executed sequentially one at a time. Commands cannot be interrupted until completely executed by the robot.
- Huge movements of the ball cannot be tracked perfectly.
- Lighting conditions may alter the image and affect the position co-ordinates as in any imaging application.

Flow of Algorithm
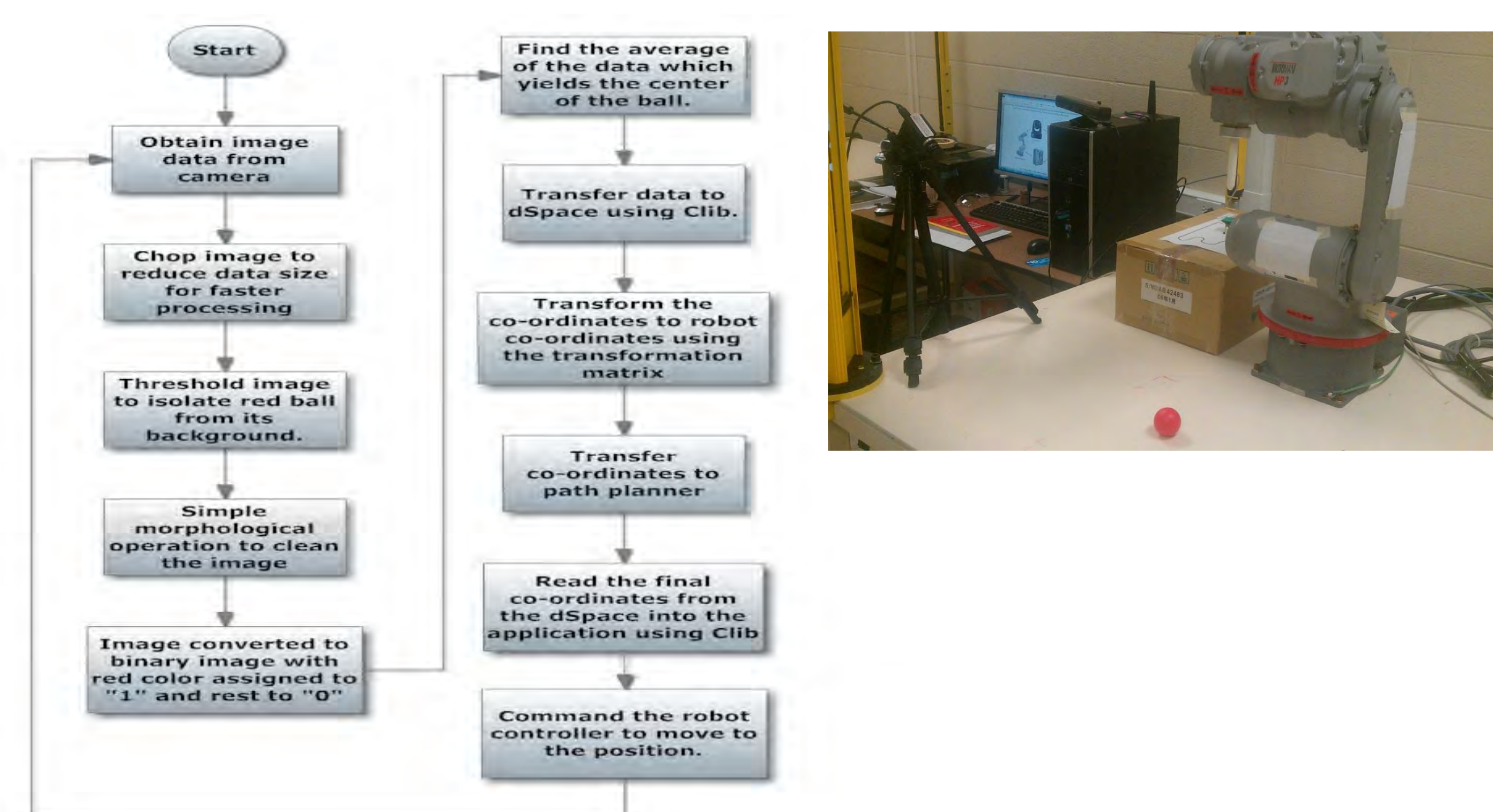
Forward Kinematics (FK) in dSpace
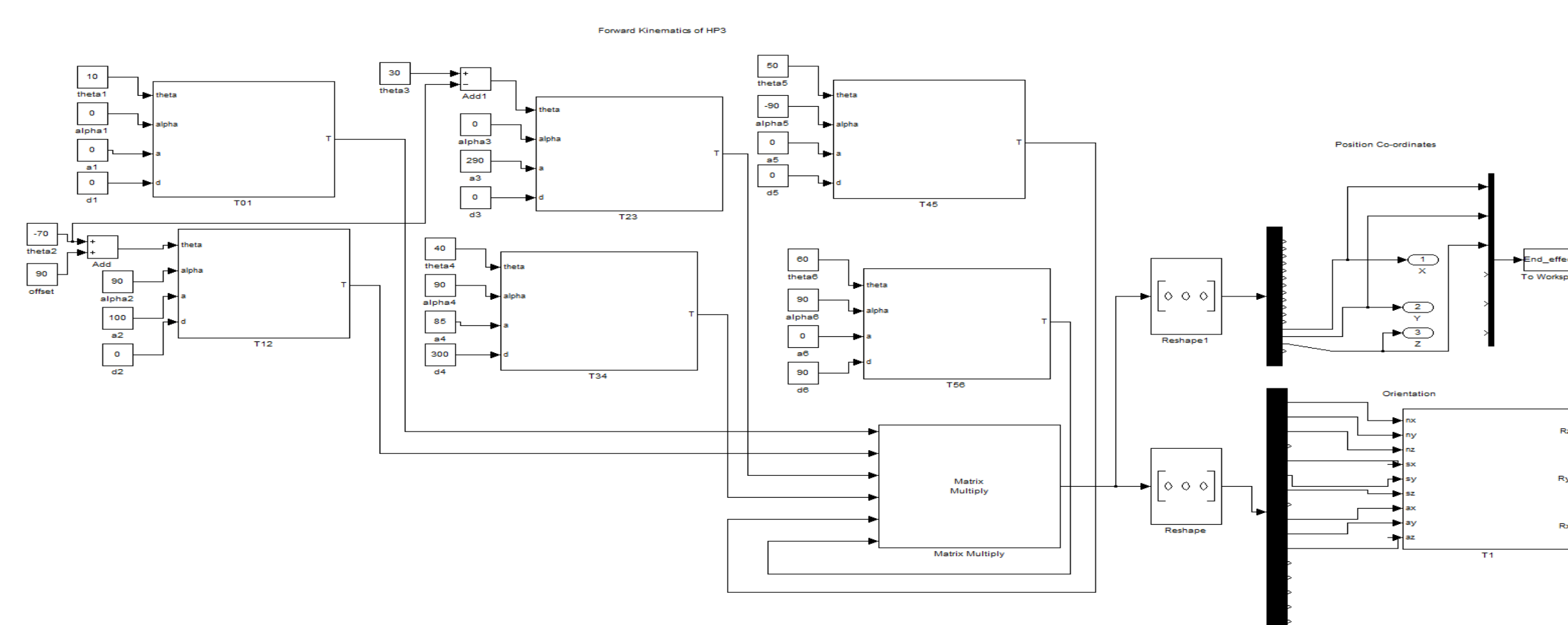
Conclusions

Significance:

- Faster computation and real-time processing.
- Parameter adjustment in real-time to regulate error.
- Simple image processing techniques.
- Shape based control and not color based.

Usefulness:

- Provides adaptation to industrial robots in an unknown environment.
- Improves reliability and safety of a robotic system.
- Adaptability reduces downtime and costs.

Improvements:

- Slower controller response to commands.
- Lighting conditions affect detection of object of interest.
- Latency in data acquisition, processing, communication and execution.