Intelligent Robotic Arm to Pick and Place Target Object

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Abstract - *Robotics nowadays is becoming more popular due to diverse applications. The system implements Inverse Kinematics of a Robotic Arm and enhances its working using Artificial Intelligence, by means of object tracking. It will help to achieve the goal of picking and placing the desired object. Real-Time system is used to achieve complex hardware functionality. The aim is to design an algorithm and implement it on a robotic arm having an embedded processor. The detected image is then processed to track the object in real time. The information about the object and environment will be stored in the database, by applying the concept of Artificial Intelligence the various possibilities on the robotic arm movement will be calculated. The best solution from the set will be then decided and action will be taken as required. Robotic arms are largely required in factories and labs. Using this concept, man power can be reduced by a great extent and causalities can be avoided in the applications where the jobs are dangerous. Accuracy can be achieved by the implementation of this system.*

Key Words: **Robotic Arm, Object Detection, Object Tracking, Locator Checker Scaler (LCS), Cubature Kalman Filter (CKF), Inverse Kinematics.**

1. INTRODUCTION

Robotic arm is a boon to industrial development in this era. Many manufacturing processes which contribute to the magnanimous products involve use of robotic arm. Robotic arm has rotational motion and linear motion to perform the task. The working of robotic arm is crucial as it involves many joints and movement of robotic arm is dependent on the movement of individual joint. The individual movement of robotic arm joint is characterized by inverse kinematics. In robotics, inverse kinematics makes use of the kinematics equations to determine the joint parameters that provide a desired position for each of the robot's end-effectors.

Object detection is a computer technology which is related to computer vision and image processing. Object tracking has its base in object detection. For industrial applications where, automotive assembly line has different types of components, the use of object detection allows proper segregation of those components. Object tracking is the process of locating a moving object (or multiple objects) over time using a camera. The main component of object tracking which helps to trace the object is video frame. With each successive video frame, object is tracked. To perform object tracking an algorithm analyzes sequential video frames and outputs the movement of targets between the frames.

2. IMPORTANCE AND SIGNIFICANCE

The work done by Robotic Arm replaces the need for humans to do the specified task. Due to this, the risks involved in handling the system can be avoided such as human injury. The system is agile to variety of tasks in which machine learning plays an important role. With this robust system, the accuracy of the task performed is increased. The system is autonomous. Hence, the time of operations involved in working is reduced. In this era of automation, any system should be designed such as to increase throughput of the system. The proposed system considers this current requirement.

3. SURVEYED RESEARCH

Shihabudheen and Pillai in [3] suggests

- Incorporating the concept of fuzzy logic into neural networks
- Training algorithm of extreme learning machine, evolutionary extreme learning machine and evolutionary fuzzy extreme learning machine.
- EF-ELM to predict the inverse kinematic solution of the robotic arm.

Muhammad and Saif in [5] suggests

- Effectively control end effector of a robotic manipulator.
- The inverse kinematic is based on triangulation method.
- The triangle always be able to form by connecting two neighboring links with imaginary lines.

Sento, Srisuk and Kitjaidure in [1] suggests

- Feature extraction algorithm using the Microsoft Kinect sensor to create the target position in 3-dimensional Cartesian coordinate.
- Inverse kinematic algorithm to convert the Cartesian coordinate into the joint angles.
- Controller algorithm.
- The 4-joint robotic arm. To evaluate the performances, the Matlab program is used to implement the overall system.

Zhang, Li et al. in [4] suggests

- Part-based trackers for single object by dividing the image into local patches to track the moving object seamlessly.
- With the help of Spatio-Temporal Context, considering the output of base tracking algorithm, a Gaussian Mixture Model (GMM) is first used to model the distribution of the movement of local patches relative to the gravity center of the tracked object.
- Then, the GMM is combined with the chosen base tracker in a boosting framework, which gives an efficient integrated scheme for the tracking task.

Han-Ul and Chang-Su in [2] suggests

- Spatially ordered and weighted patch (SOWP), to represent the appearance of an object faithfully and suppress background information in a bounding box systematically.
- LCS tracker, which incorporate the locator, the checker, and the scaler to achieve robust tracking

4. PROPOSED SYSTEM

4.1 Inverse kinematics and controller algorithm for robotic arm movement

Papers [1], [3] and [5] discuss about the robotic arm movement which includes inverse kinematics and controller algorithm. For movement of robotic arm, [3] encapsulates the system of evolutionary fuzzy extreme learning machine which predicts the inverse kinematics of robotic arm. In this method minimum root mean square error is observed. [5] proposes a simple geometric based inverse kinematics system having 6 degrees of freedom robotic arm. The effectiveness of proposed system is shown by results, but accuracy is compromised. [1] involves use of inverse kinematics to convert Cartesian coordinated to joint angles. The cubature Kalman filter (CKF) is used along with neural network to optimize the proposed controller performance.

4.2 Object tracking and detection

Papers [2] and [4] discuss about various algorithms used for object tracking and detection. [2] explains the Adaptive Local Movement Modeling (ALMM) for study of local movement distribution of image patches defining the object to track. Gaussian Mixture Model (GMM) uses the output of first stage to study the distribution of the movement of local patches relative to the gravity center of tracked objects. [4] describes the object by dividing the bounding box of target object into multiple patches and describe them with color and gradient histograms. The spatially ordered and weighted patch uses tracking algorithm involving locator, checker and scaler.

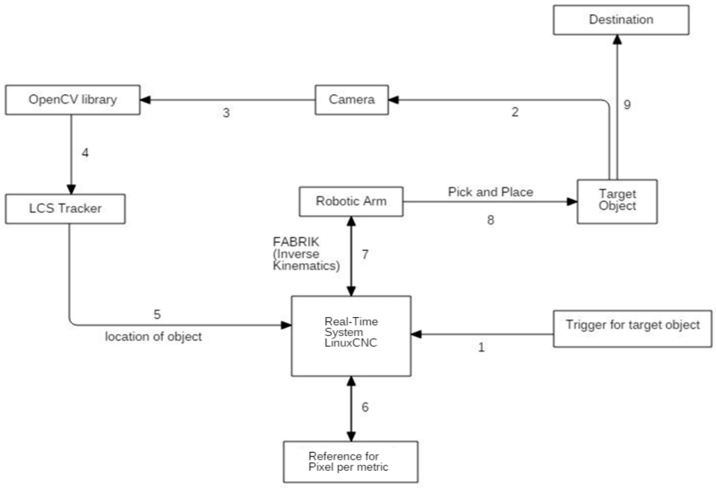

Fig-1: Architecture Diagram

5. IMPLEMENTATION

The selected algorithms are chosen according to the efficiency of the algorithms along with their practicality. The algorithms for movement of robotic arm are inverse kinematics [6] and controller. For object detection and tracking [7] is Locator Checker Selector (LCS) tracking algorithm using SOWP Descriptor.

5.1 Inverse Kinematics Algorithm

The target objects 3-demensionals Cartesian space is transformed into the spherical coordinate system and further into 2-dimensional Cartesian space which represents the target. The Robotic Arm system consists of 4 links having 5 joint positions p_i, i = 1, 2, 3, 4, 5. The robotic arm has 4 angle θ_i, i = 1, 2, 3, 4 where θ_1 is the turntable joint angle and θ_2, θ_3 and θ_4 are the angle at the joint positions p_2, p_3 and p_4 respectively. If the distance between the base and the target is greater than the inner joint length then the target position is far from end effector otherwise the target is in the region. In the first case the angle calculation for each joint position is done recursively. Firstly, the end link is placed on the line created between the target and previous joint point wherein the end-effector is coincident with the target position. The angle between the line created and the previous position is calculated. The same procedure is followed for remaining links where the new joint position is the target position for the next iteration. After calculating all the joint angles, it is used for the robotic arm movement.

5.2 Controller Algorithm

Neural network PID controller minimizes the error and the cubature Kalman filter to improve the controller performances including speed of the convergence and system stability. The combined system CKF-NNPID comprises two loop operations in which external loop is a neural network PID controller producing the control input for the robotic arm. The internal loop optimizes the updated weights by the cubature Kalman filter. After meeting certain the calculation will exit from the internal loop to external loop and then the external loop will continually update the weight until gaining the system criteria.

5.3 SWOP descriptor

Let x = (c, w, h) denotes the state of the target object, where c = center coordinates, w = weight and h = height of the target, these states of the target in x are encoded in a feature vector φ(x). Feature extraction or state description have major impact on the performance of tracker. So, it is necessary to use an effective method for feature extraction to track the object. To extract the features of target SOWP descriptor is used which works by extracting multiple low-level features and structural information in a state of the target object. This information is called as specially ordered patch. Further, an adaptive foreground weighting scheme applies weights to the SOP descriptor to generate SOWP descriptor.

5.4 LCS Tracker

The LCS tracker is comprised of Locator, Checker and Scaler. Firstly, the center position of the target in the current frame is calculated by the locator according to its previous state. Then it is determined that is it safe to adjust the scale of the target in the current film by checker. Further the size of the target is estimated such that it can adapt the scale variations which is performed by the scaler. Hence, the LCS tracker keeps updating the locator, checker and scaler to track the object in a frame.

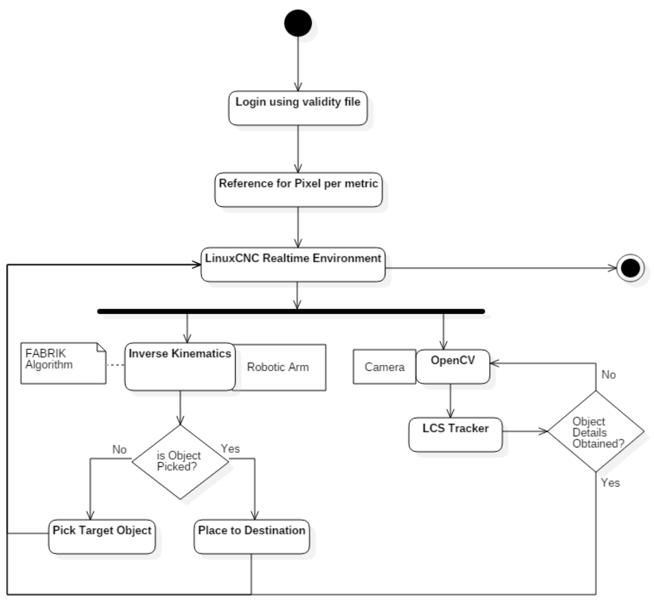

Fig-2 Flow Diagram

6. CONCLUSION

This paper gives a study to demonstrate the system design and operational details of the robotic arm to pick and place target objects, using LCS Tracker to track the location of the target object. The LCS tracker provides robust scale estimation, such that real-time tracking is improved. The location tracked will be used to find out the joint angles of the Robotic Arm. Controller then drives the joints of the arm to reach target position. Controller is based on multi-loop calculation by combining gradient algorithm with Cubature Kalman filter (CKF) optimizes the performance of the controller. Robotic Arm is very essential to automate an environment with some constraints, as end effector of robotic arm is capable of reaching at critical locations. This autonomous system will directly affect the automation process providing reliable solution. This design will increase the stability of the system, errors will be minimized and increase the response of the system, i.e it will increase overall performance of the system.

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