Introduction to Robot Modeling(ENPM662)

7-DOF Cobot Arm for Pick and Place Operation

Final-Project Proposal

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Project 2-Proposal

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Introduction and Organization:

Cobots (Collaborative robots) are leading industrial revolution and making factories smart. Contrary to traditional industrial robots, collaborative or cooperating robots, or cobots, can work alongside people in the same environment without any precautions. The cobot's sensors and cameras ensure that it will never harm its human coworkers. On the other hand, traditional industrial robots need safety fences and other security measures. They perform labor-intensive, boring, or hazardous tasks that humans find difficult or harmful. The collaborative robot increases productivity and streamlines procedures in this way.

Kuka developed world's first cobot, LBR iiwa, and that will be our inspiration for the project. We are going to use the Cobot for the pick and place operation. The task will be to pick a specific roll of paper from a stack of multiple types of rolls and then load the roll on one of the two packaging machines. This will reduce the loading time and removes the human dependency of the operation, making it suitable for factories that run 24 hours.

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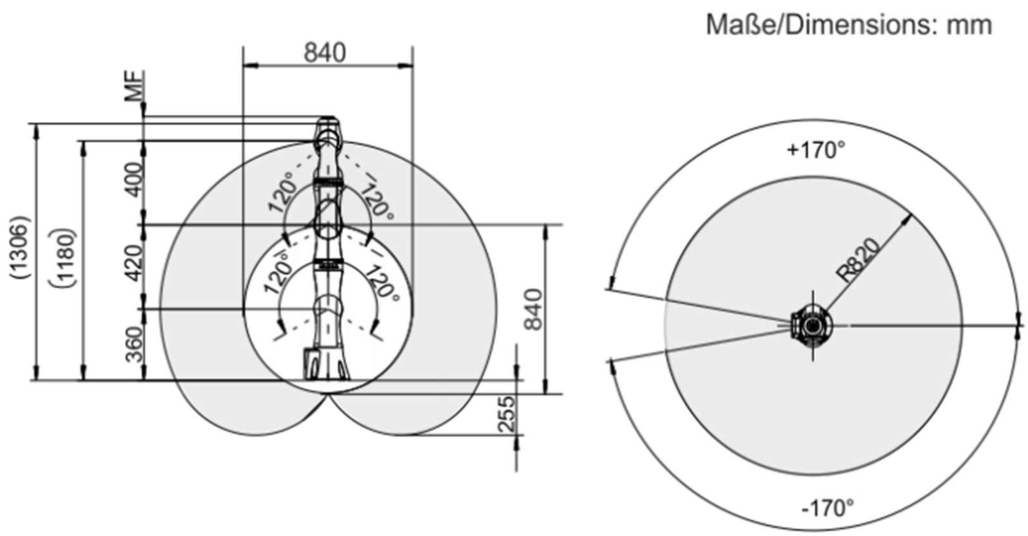
Motivation:

Cobots are ubiquitous in the industries, they have a wide range of applications. Especially KUKA robots, they pioneered the Cobot industry and are present in every possible industry application. Pick and place operation being the most used applications of the cobot in the industry, hence understanding and modelling our cobot for this operation was our priority.

We both are interested into the Industrial Robotic and we wanted to choose a real-life application of the Cobot. The application of the pick and place operation that we selected for the project is an extant application in the food processing and packaging company.

Robot Description:

1. Dimensions:



2. Maximum Reach: 820 mm

The robotic arm's "reach," as the name implies, is a measurement of how far it can extend when fully extended. It thereby establishes the boundaries of the robot's work area. It's crucial to remember that the reach only provides a general idea of the robot's workspace.

3. Rated Payload: 14 kg

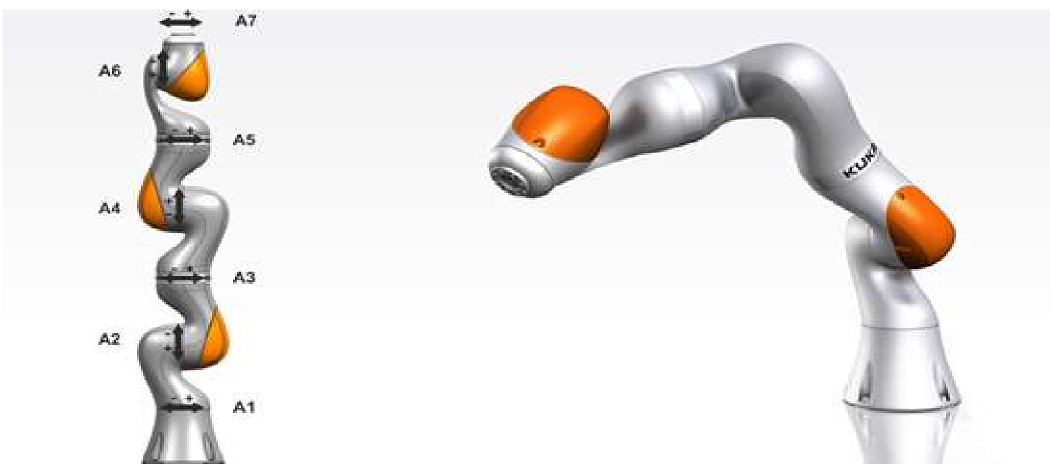
The amount of mass that a robot's wrist can support is referred to as its payload capacity. Many people mistakenly believe that payload just refers to the weight of the objects the robot is handling, but it also includes any brackets and end-of-arm tools (EOATs) that are attached to the robot wrist.

4. Number of Axes: 7

The number of a robot's moveable joints is often referred to as its degrees of freedom. For example, a robot with three movable joints will have three axes and three degrees of freedom, a robot with four moveable joints will have four axes, and so on.

5. Weight: approx. 29.9 kg

6. Joints: The robot have 7 revolute joints



7. Range of each joint:

Range of motion	
A1	±170 °
A2	±120 °
A3	±170 °
A4	±120 °
A5	±170 °
A6	±120 °
A7	±175 °

8. Material: Aluminium

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Robot Appropriateness for the task :

For our task, we have to pick a roll of the package that weighs 10kgs and load it to the packaging machine that will be at a distance of 600mm from the robot. The KUKA model that we choose can lift the weight up to 14kgs and have a Maximum Reach of 820 mm. Moreover, our model has 7 joints hence 7DOF. To reach a position in a workspace from every angle, at least 6 degrees of freedom are required. With more than six joints, a robot can reach the same location at the same angle in multiple ways, making our robot more dexterous. This makes our selected robot a perfect match for the pick and place operation.

Scope Description:

Fallback:

1. Designing a 7 DOF robot arm with all revolute joints.
2. End effector would be a rigid block attached to the last link and for the validation we will make this end effector to travel to the picking object and then to the packaging machine.
3. We will just stream the camera feed but will not automate the robot using Image processing.
4. Control the robot using teleop.

Ambitious:

1. Design the end effector to pick the roll and place it in the packaging machine,
2. Use computer vision techniques to command the robot to pick the roll based on its color and loading it in appropriate machine.
3. Control the robot using python scripts.

Scope Appropriateness:

Being most used application in the industry, Robotic arm and its pick and place application will give us a chance to apply the knowledge we learnt in the course on the relevant problem. Implementing this project, we will apply our understandings of Forward and inverse kinematics principles, CAD modelling, and ROS implementation to a real-world application.

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Model Assumptions:

1. The robot is non-mobile and it is fixed to the ground.
2. The gripper is designed to pick the required roll and load this on the packing machine.
3. All the links of the robot are assumed to be rigid.
4. External disturbances are not taken into considerations.

Approach to performing the work:

Important aspects to the project execution:

1. Kinematic and dynamic modelling of the Robot:
   For the purpose of Kinematic and dynamic modelling of the Robot, we are going to use the DH parameter convention from the Spong book.

2. Creating a 3D Model of the arm:
   We are going to use Solidworks for the 3D modelling of the arm. Being the ubiquitous industrial cobot, we were able to get the dimensions of the arm from the KUKA website. And we will be designing the 3D model using these drawings. Using URDF, we will import this model in the ROS package.

3. Building ROS package:
   Once we get export from URDF tool, we will integrate the Camera package into the URDF file using Xacro. For this purpose, we will be using the camera ROS package and different resources available on the official ROS website :
   http://wiki.ros.org/Sensors/Cameras
   We will use MoveIt ros package for the pick and place operation:
   http://docs.ros.org/en/kinetic/api/moveit

4. Simulation using Gazebo and Rviz:
   Simulate the pick and place operation inside Gazebo environment.

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Milestones with timeline :

1. Idea brainstorming and Pre-proposal: 15 Oct-20 Oct
2. Scope finalization and final project proposal: 20 Oct-6 Nov
3. Kinematic and dynamic modelling of the Robot: 3 Nov-7 Nov
4. Creating a 3D Model of the arm: 7 Nov-12 Nov
5. Building ROS package: 13 Nov-25 Nov
6. Simulation using Gazebo and Rviz for Validation: 26 Nov-3 Dec
7. Making the final report: 4 Dec-5 Dec

Validation Plan:

We are going to simulate a work environment in the Gazebo, where we will have our cobot fixed to the ground and two packaging machines in the workspace of the robot. There will be three different rolls, for the sake of simulation we are going to use three cylinders of different colors (red, blue and green). To validate the operation of pick and place, we will move the arm to the roll and then move the arm to the desired packing machine (We will not demonstrate the gripper operation). We will stream the continuous feed from the camera using Rviz.

References:

1. https://my.solidworks.com/training/catalog
2. https://www.kuka.com/en-us/products/robotics-systems/industrial-robots
3. https://www.ros.org/
4. https://gazebosim.org/home
5. https://moveit.ros.org/