GEORGIA INSTITUTE OF TECHNOLOGY
George W. Woodruff School of Mechanical Engineering
ME 2110 - Creative Decisions and Design
Fall 2018

Introductory Design Project: Robotic Labeling End Effector

Your goal is to design an end-effector to automate process of applying information labels in and around the car body. The end-effector is to be installed on a robotic arm (like, the UR-5 robot: https://www.universal-robots.com/products/ur5-robot/). The raw material fed to the end-effector will be a sheet of labels with the label data and the label edges pre-engraved. The system should be able to peel the labels and apply them to specific areas in and around the car body.

Figure 1 shows a photo of typical sheets of labels currently handled by an operator. The individual labels are manually peeled, and applied around the car body. The goal of this project is to design a system to automate the task of peeling and applying the stickers. Assume that the sequence, size and shape of individual labels is already known and so your end-effector does not need to have any scanning or vision system to determine the size and shape of the labels to be peeled and applied at a specific location on the car body. Furthermore, remember that the label blank is somewhat flexible, so your design should consider this characteristic.

The system should have the following qualities:

1. Compatible with a UR5 robotic arm (refer technical specifications later in Figure 2)
2. Safely peel labels of different shapes and sizes without damaging them
3. Accurately place labels at desired locations within the car
4. End-effector should be able to apply stickers on a concave shaped curved surface with a radius of curvature of 500mm.
5. Ergonomic for a human to interact with the system
6. Any other needs your team identifies

During the early phase of the design process, you should strive to thoroughly understand the customer needs. You should also thoroughly investigate related products and incorporate the best features from them into your design. Individual Houses of Quality (HoQ) must be created by each individual team member for Homework #1. Collaboration on the individual HoQ assignment is permitted, but each student must submit their own version and their own written discussion of the HoQ.

1) Deliverables due at the end of studio in Week 3

i) Draft Executive Summary on Problem Understanding

Review the project brief, technical specifications of the robot (UR-5) and conduct a relevant prior art search. Some suggestions for search topics are end-effector design, automatic labeling systems, etc. Write up a brief executive summary of the problem understanding tasks completed in the studio. Discuss and solicit feedback from section instructor and/or TA.

2) Deliverables due at the beginning of studio in Week 5

i) Updated Project Executive Summary

An updated executive summary that takes into consideration the comments provided to you by your instructor and TA. The summary should be a maximum of one page in length. Discuss the major insights (*i.e.*, what are promising ideas or things to improve upon from the existing market, as well as outcomes from the HoQ).

ii) A presentation on design tools (PowerPoint, 1 person, 5 min)

Describe the design problem, as your team understands it. Describe or summarize a selection of existing good solutions from which your company might distinguish itself. Display a House of Quality to discuss the primary customer needs and specifications that your team will focus on. Present a function tree and point out the most difficult functions to achieve. Clearly present any assumptions that you make in your design. Summarize your work by stating the most important design objectives. Do not present any preliminary design ideas.

During studio week #5, you will develop the morph chart and create design concepts for the robotic end effector.

3) Deliverables due at the beginning of studio in Week 6

i) A presentation on your final design (PowerPoint, 1 person, 7 min)

ii) A report containing the following:

1. Executive Summary for the design project
2. Introduction defining customer needs and engineering requirements (refer function tree, HoQ, morph chart, etc.)
3. Summary of prior-art search
4. Presentation of 4 design concepts (1 per team member, labeled by team member)
5. Final Design Overview giving a detailed description of your design including quality sketches (preferably computer-generated) that show its parts and how it operates. The discussion should include:
    a. Why you chose your design from among the other designs.
    b. The advantages and disadvantages of your chosen design.
6. Final Specification Sheet
7. Conclusions
8. Appendix to include supporting information for the prior-art
    a. A list of relevant literature, including websites, publications and patents. Document these using IEEE reference format.

The report should include a maximum of **four pages** of text (not including the executive summary), plus as many figures and tables as necessary. The executive summary should be less than **one page**. Please submit one hard copy in class and submit a second copy via Canvas.

Figure 1: Photos of Sample Labels Sheets.

UNIVERSAL ROBOTS

Technical details

UR5

Performance

Repeatability	±0.1 mm / ±0.0039 in (4 mils)
Ambient temperature range	0-50°
Power consumption	Min 90W, Typical 150W, Max 325W
Collaboration operation	15 advanced adjustable safety functions. TÜV NORD Approved Safety Function Tested in accordance with: EN ISO 13849:2008 PL d

Specification

Payload	5 kg / 11 lbs
Reach	850 mm / 33.5 in
Degrees of freedom	6 rotating joints
Programming	Polyscope graphical user interface on 12 inch touchscreen with mounting

Movement

Axis movement robot arm	Working range	Maximum speed
Base	± 360°	± 180°/Sec.
Shoulder	± 360°	± 180°/Sec.
Elbow	± 360°	± 180°/Sec.
Wrist 1	± 360°	± 180°/Sec.
Wrist 2	± 360°	± 180°/Sec.
Wrist 3	± 360°	± 180°/Sec.
Typical tool		1 m/Sec. / 39.4 in/Sec.

Features

IP classification	IP54
ISO Class Cleanroom	5
Noise	72dB
Robot mounting	Any
I/O ports	Digital in 2 Digital out 2 Analog in 2 Analog out 0
I/O power supply in tool	12 V/24 V 600 mA in tool

Physical

Footprint	Ø 149mm
Materials	Aluminium, PP plastics
Tool connector type	M8
Cable length robot arm	6 m / 236 in
Weight with cable	18,4 kg / 40.6 lbs

CONTROL BOX

Features

IP classification	IP20
ISO Class Cleanroom	6
Noise	<65dB(A)
I/O ports	Digital in 16 Digital out 16 Analog in 2 Analog out 2
I/O power supply	24V 2A
Communication	TCP/IP 100Mbit, Modbus TCP, Profinet, EthernetIP
Power source	100-240 VAC, 50-60 Hz
Ambient temperature range	0-50°

Physical

Control box size (WxHxD)	475mm x 423mm x 268mm / 18.7 x 16.7 x 10.6 in
Weight	15 kg / 33.1 lbs
Materials	Steel

TEACH PENDANT

Features

IP classification	IP20

Physical

Materials	Aluminium, PP
Weight	1,5 kg / 3.3 lbs
Cable length	4,5 m / 177 in

Figure 2: Technical Specs of a UR-5 Robot (from https://www.universal-robots.com/products/ur5-robot/). Hard copy of the standard, EN ISO 13849 is available with the GT Library for reference.