

PROFESSIONAL TRAINING REPORT - II

entitled

AI Tourism Guide

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering with
specialization in Artificial Intelligence

by

Tanshi Kansal [41612037]



**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
SCHOOL OF COMPUTING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

CATEGORY -1 UNIVERSITY BY UGC

**Accredited with Grade "A++" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

MAY 2024



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BONAFIDE CERTIFICATE

This is to certify that this Professional Training Report is the bonafide work of **Ms. Tanshi Kansal (41612037)** who carried out the project entitled "**AI Tourism Guide**" under my supervision from January 2024 to April 2024.

Internal Guide

Mrs. V. SUBAPRIYA, M.E. (Ph.D)

Head of the Department

Dr. S. VIGNESHWARI, M.E., Ph.D.

Submitted for Viva voce Examination held on 06/05/2024

Internal Examiner

External Examiner

DECLARATION

I, TANSHI KANSAL (Reg. No. 41612037), hereby declare that the Professional Training Report-II entitled "AI Tourism Guide" done by me under the guidance of Mrs. V. SUBAPRIYA, M.E. (Ph.D), is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Computer Science and Engineering with specialization in Artificial Intelligence.

DATE: 06/05/2024

PLACE: CHENNAI



SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to **Board of Management of SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

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I wish to express my thanks to all Teaching and Non-teaching staff members of the **Department of Computer Science and Engineering** who were helpful in many ways for the completion of the project.

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This certificate is awarded to

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for successfully completing the course

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Online Assignments	17.04/25	Proctored Exam	43.5/75
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ABSTRACT

The Chatbot with the name of AI Tourism Guide is an advancement made in the website with the name of VOYAGE – an online tourism guidance system which was developed as a project in the Professional Training – I. Having made the website with all the essentials for an Online Tourism Guidance System, the next step was to advance it with the latest technology. The technology with highest demand in the world right now is the Artificial Intelligence.

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and act like humans. It involves the development of algorithms and computer programs that can perform tasks that typically require human intelligence. AI technology enables computers to analyze vast amounts of data, recognize patterns, and solve complex problems without explicit programming.

Integrating an AI Chatbot into the website would help in answering the frequently asked questions of the website. It will always be available to take those questions and never get tired of answering them. It would also help in the automation and easier manipulation of the website, which is the entire motive of the advancement in the technology across the globe: Make people's lives easier with automation.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Once a year, it is a necessity and a need for every human being to go on a vacation and be able to unwind with family/friends or by himself. The vacation spot can be anywhere from hills to beach to even a historical place. The most important part of such vacations would be to plan out what all places to visit. To plan out the trip, the lack of experience can and will create a huge problem.

A way to solve this problem is to look up the destination on Google and browse the places to visit. But this will create another problem of not knowing how much money should be taken into account which would be spent on the trip, hence, resulting in wrong budget decisions. To kill two birds with one stone and satisfy both of these problems, this website is being made.

The website with the name of VOYAGE is an online tourism guidance system to let the user choose the city of interest based on categories and gain knowledge on the important places/famous tourist's attraction at the chosen city which will help them to plan out the trip to the city. It will also include the amount of money spent on each location to help the user keep their expenses in check and not go over their budget.

The next problem that comes up is of the manual labor. Everything done so far for the website needs to be done by the user manually without any help from the advanced technology that we have gathered around us. To solve this huge issue, this project develops an AI Chatbot with a single aim to help the user manipulate the website with ease and without breaking a sweat.

1.2 SCOPE

The user can choose the city of interest from the list of cities based on categories and gain knowledge on the important places/famous tourist's attraction at the chosen city which will help them to plan out the trip to the city.

Every person needs a vacation at some point in the entire year, whether it may be a worker, a homemaker, or a child. Hence, to plan out these vacations, the knowledge of famous tourist's spots is of a necessity. Also, the budget needs to be given attention as well. This website will be able to satisfy all such needs.

To make it fast and efficient, the user can use this chat-based AI Chatbot in order to go through the options on the entire website without actually going through the entire website in the tap of a button making it easy and a first choice for the user to take in order to search for the desired place.

CHAPTER 2

LITERATURE REVIEW

2.1 TOURISM

Tourism, in a basic definition, can be said to be a travel for pleasure or business, and the commercial activity of providing and supporting such travel.

The World Tourism Organization defines tourism more generally, in terms which go “beyond the common perception of tourism as being limited to holiday activity only”, as people “travelling to and studying in places outside their usual environment for not more than one consecutive year for leisure and not less than 24 hours, business and other purposes”.

Taken from the paper: *The Tourism Industry: An Overview* by Camilleri, M.A. (2017)

Individuals become tourists when they voluntarily leave their normal surroundings, where they reside, to visit another environment. These individuals will usually engage in different activities, regardless of how close or how far this environment (destination) is (Hall, 2008; Holloway & Taylor, 2006; Jafari, 2002). Therefore, tourists are visitors, and what they do whilst visiting another place may be considered as tourism.

Taken from the paper: *Tourism and Environment* by Buckley, R. (2011)

Tourism is both a category of human behavior, and the multitrillion-dollar industry that acts to it. Research on tourism and environment crosses a wide range of social and natural science disciplines, and key contributions are scattered across many fields.

Traditions in tourism research are very different from

those in environmental science. Tourism is a large and long-established industry, but tourism research is relatively small, new, insular and inward looking, with competition between cliques and debate between devotees of different methods.

Taken from the paper: *An Introduction to Tourism* by Leonard J. Lickorish and Carson L. Jenkins, PhD

The problem of definition is a serious and continuing difficulty for analysts of tourism. In particular, the amorphous nature of the tourism industry has made it difficult to evaluate its impact on the economy relative to other sectors in the economy.

Tourism can be domestic (within the traveller's own country) or international, and international tourism has both incoming and outgoing implications on a country's balance of payments.

Global tourism accounts for 8% of global greenhouse-gas emissions. Emissions as well as other significant environmental and social impacts are not always beneficial to local communities and their economies. For this reason, many tourist development organizations have begun to focus on sustainable tourism to mitigate the negative effects caused by the growing impact of tourism.

The United Nations World Tourism Organization emphasized these practices by promoting tourism as part of the Sustainable Development Goals, through programs like the International Year for Sustainable Tourism for Development in 2017, and programs like Tourism for SDGs focusing on how SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production) and SDG 14 (Life Below Water) implicate tourism in creating a sustainable economy.

Tourism has reached new dimensions with the emerging industry of space tourism as well as the current industry with cruise ships, there are many different ways of tourism. Another potential new tourism industry is virtual tourism.

2.2 AI CHATBOT

In the modern Era of technology, Chatbots is the next big thing in the era of conversational services. Chatbots is a virtual person who can effectively talk to any human being using interactive textual skills. Currently, there are many cloud base Chatbots services which are available for the development and improvement of the chatbot sector such as IBM Watson, Microsoft bot, AWS Lambda, Heroku and many others.

Taken from the paper: *Programming challenges of Chatbot: Current and Future Prospective* by AM Rahman, Abdullah Al Mamun and Alma Islam

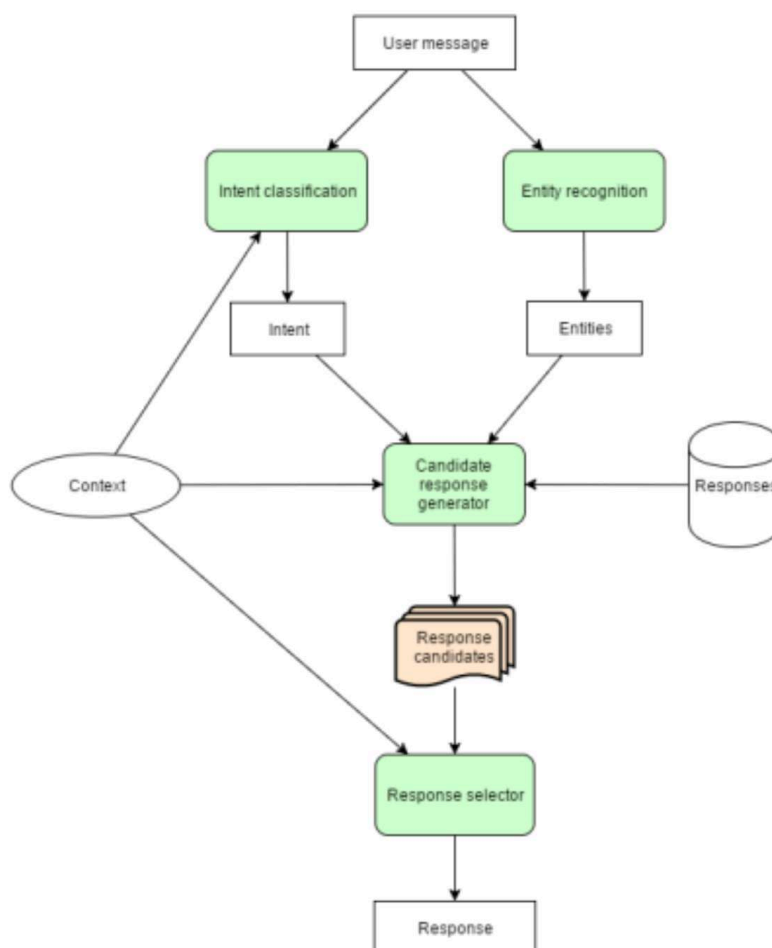


Fig 2.1 AI Chatbot Architecture

A chatbot is an instant messaging account that able to provide services using instant messaging frameworks with the aim of providing conversational services to users in an efficient manner. A chatbot is fast with less confusing web and mobile application which is easy to install as there is no need to have installation packages. These packages are easy to manage and distribute.

Taken from the paper: *AI Chatbot Design during an Epidemic like the Novel Coronavirus* by Gopi Battineni, Nalini Chintalapudi and Francesco Amenta

After the rise of web and mobile apps, virtual chatbot applications are the latest inventions of digital design. These applications are well known for automatic conversational agents that run on computer programming or a kind of artificial intelligence (AI) interaction between the users and machines with the intervention of natural language processing (NLP).

Chatbots are potentially referred to as the most promising and advanced form of human-machine interactions. Eventually, these virtual agents are getting involved in the main global sectors such as healthcare, banking, education, agriculture, etc.

Taken from the paper: *Artificial Intelligence (AI) Chatbot as Language Learning Medium: An inquiry* by Nuria Haristiani

Chatbot is a computer program or artificial intelligence which carries out conversations through audio or text, and interact with users in a particular domain or topic by giving intelligent responses in natural language. Chatbot for general purposes and for educational purposes have been developed. After the rise of web and mobile apps, virtual chatbot applications are the latest inventions of digital design.

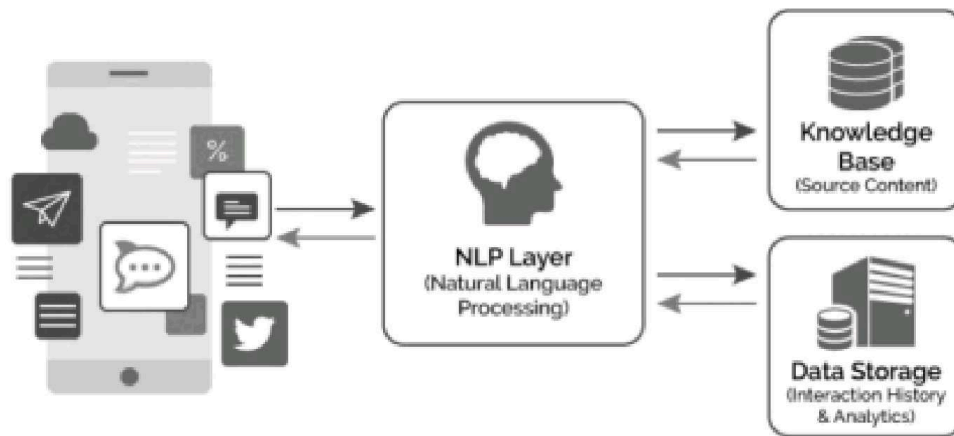


Fig 2.2 The Mechanism of Chatbot

The basic mechanism of chatbot begins with the message sent by the user. The message then processed by NLP (Natural Language Processing), and chatbot responded by replying to the message according to the existing database. For example, when a user sent “how are you?” message, chatbot will look for answers that match this question in the database such as “I am fine”, “Great!” etc.

CHAPTER 3

REQUIREMENTS ANALYSIS

3.1 OBJECTIVE

The travel industry has transformed, bringing about technological evolution. Travel was considered the privilege of the wealthy until technology, and leading travel companies changed the concept making the process easy and accessible to people.

Modern travellers are tech-savvy and meticulous planners and not random wanderers. Web application development services are making it easy for travellers to seek the best deals for their next holiday.

The tourism and travel industry has become more accessible than ever. The internet has made it easier to research, plan and book trips, all with just a few clicks. You can find everything from flights, hotels, and restaurants to car rentals and local experiences online.

A tourism or travel website serves as an information hub for prospective travellers planning a getaway. Today, people travel for a range of experiences – babymoos, staycations, voluntourism or leisure.

A chatbot is a computer program that stimulates human conversation with an end user. Not all chatbots are equipped with artificial intelligence (AI), but modern chatbots increasingly use conventional AI techniques such as natural language processing (NLP) to understand user questions and automate responses to them.

Chatbots are primarily used to provide 24/7 customer support. They can handle a large volume of queries simultaneously, ensuring prompt responses and assistance.

3.2 REQUIREMENTS

An AI chatbot involves several considerations, both technical and non-technical. Starting with a discovery phase to collect and analyze information about the project. The next step is to clarify the chatbot's goals, limitations, and overall scope.

Key technologies include Natural Language Processing (NLP) which enables the chatbot to understand and generate human-like responses and Artificial Intelligence (AI) which enhances the chatbot's ability to learn and adapt.

The next step is to train the chatbot's AI model using relevant data which involves data collection which gathers conversational data to train the chatbot; Model Training which uses machine learning techniques to improve the chatbot's performance; and; Fine Tuning which continuously refines the model based on user interactions.

The last step is to test the chatbot to ensure it performs as expected. It is needed to be tested for accuracy to verify that the chatbot understands user queries correctly; robustness to assess how well it handles unexpected inputs; and; security to ensure data privacy and protection.

In conclusion, a well-structured chatbot requires thorough planning and alignment. It also needs deep knowledge of a programming language: Python.

Python is a high-level, general purpose programming language. It is a multi-paradigm programming language. Object-oriented programming and structured programming are fully supported, and many of the features support functional programming and aspect-oriented programming (including metaprogramming and metaobjects).

3.2.1 HARDWARE REQUIREMENTS

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware.

The following hardware will be required in order to make and run the website with chatbot flawlessly:

1. Hard Disk Space: Minimum 30 GB or higher
2. Graphics Card: A better graphics card is recommended for better performance.
3. Internet: Must have a good internet connection (if not using the local host)

3.2.2 SOFTWARE REQUIREMENTS

Software requirements deal with defining software resource requirements and prerequisites that need to be installed on a computer to provide optimal functioning of an application.

The following software will be required in order to make and run the website flawlessly:

1. Memory: 8 GB RAM or higher
2. Operating System: Windows 8 or higher, MAC OS, Linux
3. Processor: Intel Core i5 or a better processor

CHAPTER 4

DESIGN DESCRIPTION OF PROPOSED PROJECT

4.1 PROPOSED PRODUCT

Tourism has turned out to be an economic booster contributing to the economic development of many countries over the last few decades. People see holidays as a necessity, and not as luxury in the present scenario.

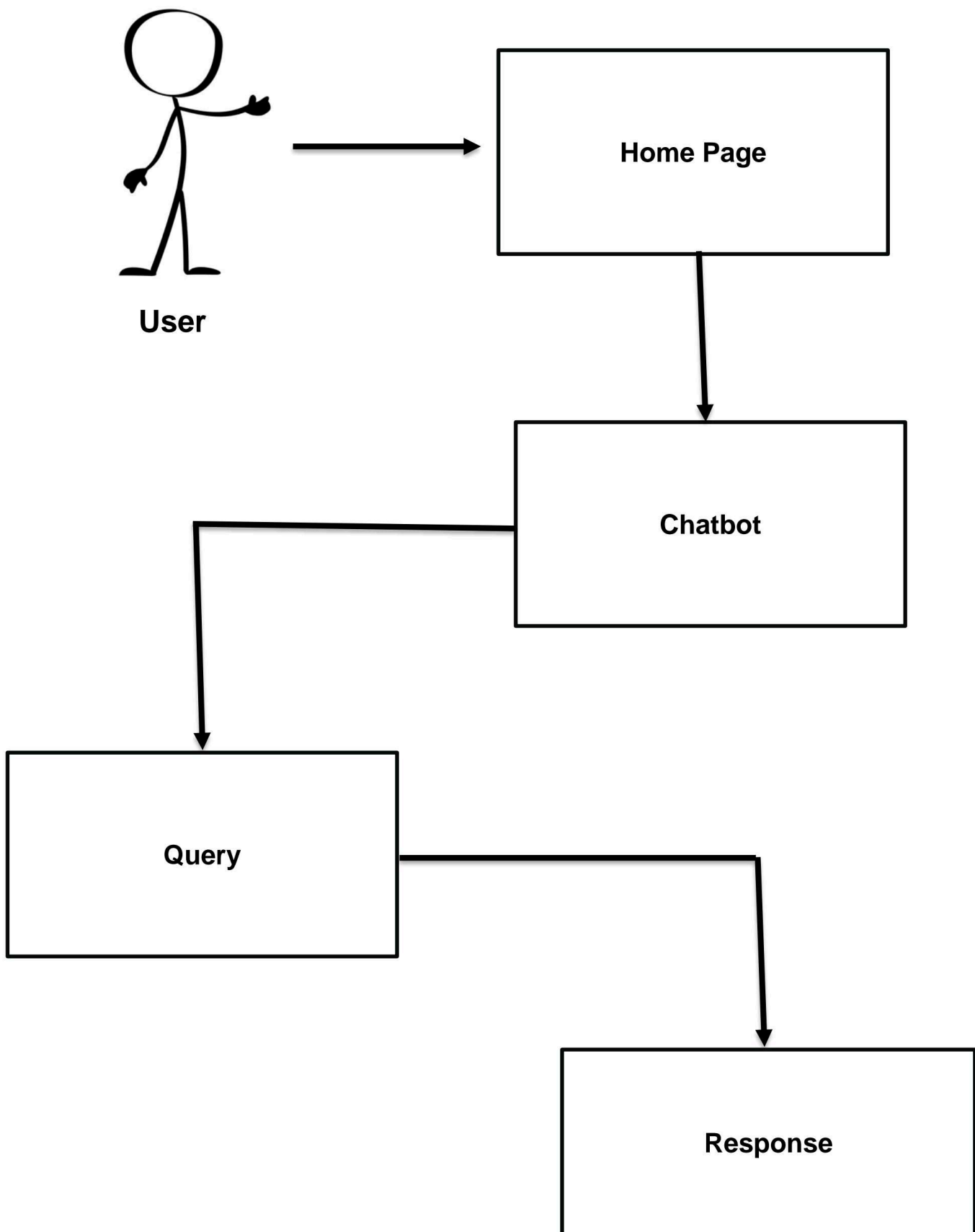
Tourism calls for coordination and cooperation between travel agents, tour operators, and tourists. Tourism has a few major elements – destinations, attractions, sites, accommodation, and all ancillary services.

Going away from the home environment is not something people will do without any reason. Here is a list of most common factors that motivate the people to travel away from home:

1. To spend holidays leisurely.
2. To visit friends and relatives.
3. To attend business and professional engagements.
4. To get health treatment.
5. To undertake religious pilgrimages.
6. Any other personal motives.

To make the entire process easier to be carried out, let the user plan the trip with all the necessities, make the user experience effortless and seamless, and to make everything better; the technology of Artificial Intelligence has been utilized.

4.1.1 IDEATION MAP



4.1.2 VARIOUS STAGES

The process of creating a website is not a hard one. It can be done easily if the skills are known and the developer is ready to implement them with an interest. Here are the stages of making a website in general and specific details which are followed in the generation of AI Chatbot for VOYAGE:

Stage 1:

First step in making an AI Chatbot for a tourism website is always determining what goals are needed to be fulfilled and what purpose is the chatbot made to serve. For VOYAGE specifically, the goal is that it delivers the required knowledge on the tourist's spots to the user without much hassle.

Stage 2:

Next stage in generating a chatbot is to learn the scope of the website. What scope it holds in real-time applications. Specifically, for VOYAGE, it is built to serve the people planning to visit one of the 12 cities included in the website.

Stage 3:

The third stage in the creation of any chatbot is designing it. It is important to design out how the chatbot is intended to look to the user. The textual and visual design of the chatbot for website VOYAGE is discussed in the upcoming topics of this document.

Stage 4:

The next step in making a chatbot is acquiring the content put in the website. For VOYAGE chatbot, the content required to be put in includes the names, the descriptions, and other details related to the famous spots/tourist's attractions.

Stage 5:

Now that everything is acquired about the chatbot, it is time to make the chatbot. Coding is the main part that brings the amazing ideas of a great chatbot into real life.

Stage 6:

The last stage in the making of the chatbot is to test and debug the code made. Before the website reaches the user, it should be tested to make sure there are no errors. If any error occurs during the testing phase, the code can be changed and it can be made sure that the site looks as intended and contains all the information needed.

4.1.3 DESIGN STRUCTURE

The AI chatbot made for the website VOYAGE is the chatbot that is designed to look like chatting with a human. This design gives the user a homely feel in order to ask the queries with more freedom of mind and any question the user desire.

For each prompt that the user makes, the chatbot gives an answer to match and answer the question prompted by the user. This helps the user in clarifying the doubts with a click of a button.

4.2 ARCHITECTURE OF THE PRODUCT

The images of the places people wish to visit, beckon their minds. The one constant in those images is that they associate the name of a place with its defining architectural style or monuments.

The architecture of a region represents its identity and heritage. Their images imprint effortlessly in the minds of the locals and the visitors alike. This makes the architecture of the area an avoidable part of the tourism industry.

Architecture and tourism when synergized open new avenues to the socio-economic development of the region. This symbolic existence gave birth to the concept of 'The Architecture of Tourism'.

If architecture holds such importance in the field of tourism, it will hold the same, if not more, importance in the case of an AI Chatbot of a tourism website. Following is how the architecture can be described of the AI Chatbot of the website VOYAGE:

The chatbot is having a colour scheme that goes perfect with the theme of greenery.

Background colour is taken to be: RGB (2, 40, 49) [Hex: #022831]

Header colour is taken to be: RGB (180, 211, 48) [Hex: #B4D330]

A chatbot is nothing without a header, hence, each page of the website is having a header on top which acts a top navigation bar as well. Using this navigation bar, the user can go to Home page whenever he wants to.

The main chatting area with the chatbot will look like any other messaging application

A visual design of the intended design for the page can be given as:

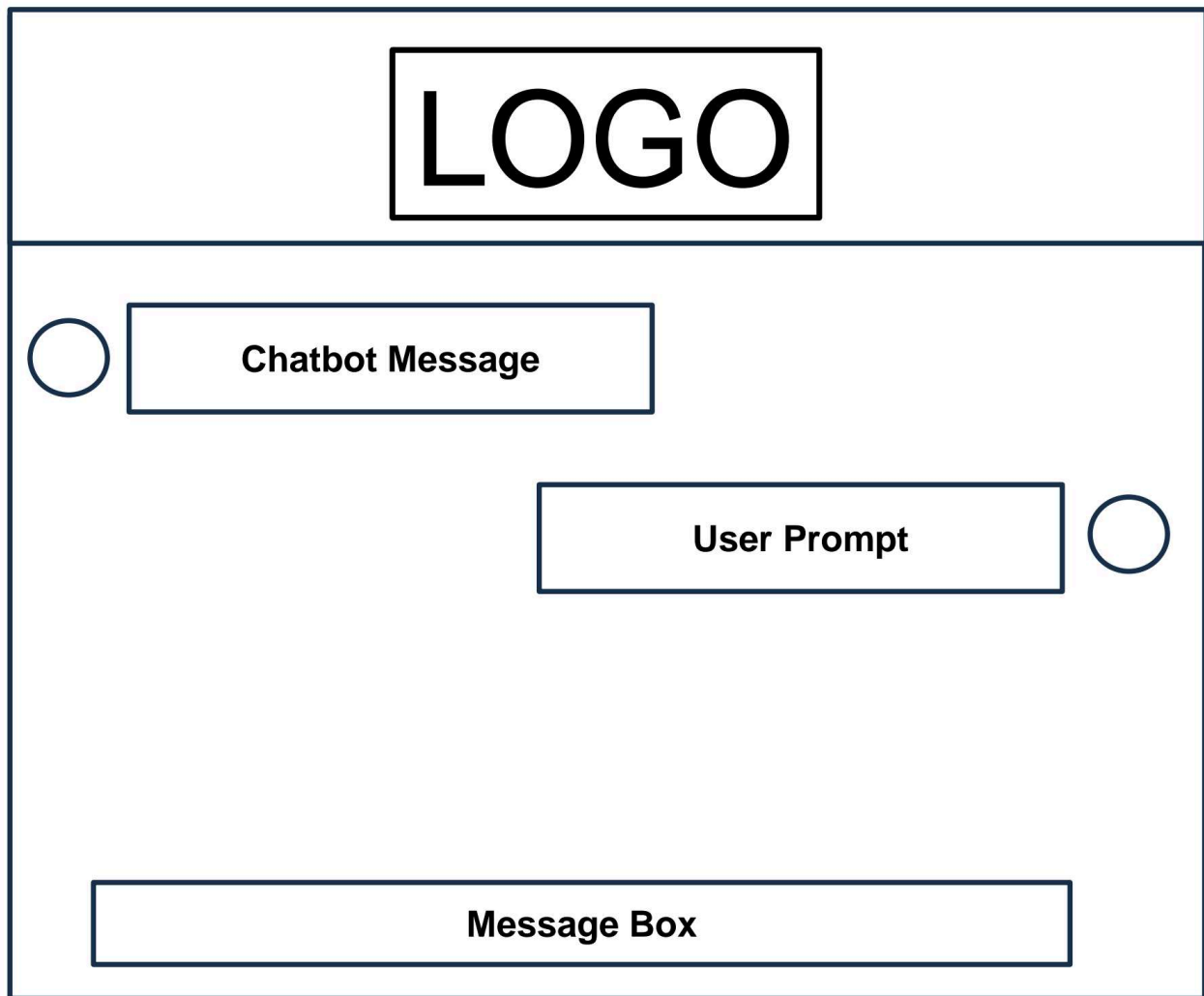


Fig 4.1 Architecture of TGuide

4.2.1 FEATURES

VOYAGE is a website which lists out a bunch of cities and/or categories to choose from which will lead to the page dedicated to that specific city.

This page will list out all the famous tourist's attraction along with a short description of what is famous there. Hence, giving the user a full travel guide of what important places to visit while visiting the city of interest.

Major features of VOYAGE will include listing out three categories (Beach, Hills, Historical) and 12 different cities skillfully placed under each categorization and a separate page with just the cities.

A separate page dedicated to each city is also included in the website which has a list of tourist's spots, a short description of them along with a photo and other details.

To navigate through the website without any hazard and go to the page desired without going through all the trouble of finding the page, the user can just chat with the AI Chatbot which will lead the user to the page of the desired city.

4.2.2 PROGRAMMING LANGUAGES AND TOOLS

The basic necessities to make any software or a website are the programming languages and tools. The developer must be skilled in the required programming languages and tools to be able to make the website as intended. For the AI Chatbot for the website VOYAGE, following are the programming languages and tools required for the developer to be skilled in:

Programming Languages required: Python

Tools required: Visual Studio Code (VS Code)

CHAPTER 5

CONCLUSION

After going through all the articles and websites that makes use of AI Chatbots, one thing is clear that AI Chatbot is important, more important than most people realise. AI Chatbots plays a crucial role in various aspects of business and customer interactions. Chatbots do not need sleep, unlike humans.

Chatbots engage users in real-time, guiding them through their user journey. By providing relevant information and assistance, chatbots improve conversion rates. Chatbots handle multiple conversations simultaneously, scaling effortlessly. They reduce wait times, ensuring efficient customer service even during peak hours.

AI chatbots analyze user data and tailor responses based on individual preferences. Personalized interactions lead to higher customer engagement. AI chatbots understand a variety of keywords and phrases and learn from the visitor's input.

To summarize, for the travel and tourism website VOYAGE, the AI Chatbot will help in processing customer needs of the destination and give a better insight on the options for the user.

CHAPTER 6

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APPENDIX

[A] SOURCE CODE

Following is the Python Code that has made this project possible:

```
# import the required modules

from chatterbot import ChatBot
from chatterbot.trainers import ListTrainer

# define the chatbot

TGuide = ChatBot("Your Tourism Guide")

# training the chatbot on custom data

trainer = ListTrainer(TGuide)

trainer.train([
    "Hi",
    "Hello",
    "Hey",
    "What's up?",
])

trainer.train([
    "Categories",
    "Hills, Historical, Beach",
])

trainer.train([
    "Categories",
    "Hills, Historical, Beach",
])

trainer.train([
    "Cities",
    "Agra, Andaman, Coorg, Darjeeling, Goa, Jaipur, Kodaikanal,
    Mussoorie, Mysore, Ooty, Pondicherry, Shimla",
])
```

```

trainer.train([
    "Hills",
    "Coorg, Darjeeling, Kodaikanal, Mussoorie, Ooty, Shimla",
])

trainer.train([
    "Historical",
    "Agra, Jaipur, Mysore",
])

trainer.train([
    "Beach",
    "Andaman, Goa, Pondicherry",
])

# executing the chatbot based on the user input

print("\n\n\n\n\n\n\n")
print("Hello there! I'm your Tourism Guide disguised as a
ChatBot!\n\n\nHow can I help you today?\n\n")
exitcond = ("Exit", "Quit", "Thank You", "Thanks for the help")
while True:
    query = input()
    if query in exitcond:
        print("\nGlad I could be of help!\n\nCall me if you ever need
me!\n")
        break
    else:
        print(f"{TGuide.get_response(query)}")
        print("\n")

```

[B] OUTPUT

```
Command Prompt
Microsoft Windows [Version 10.0.22631.3447]
(c) Microsoft Corporation. All rights reserved.

C:\Users\tanishi kansal>cd C:\Users\tanishi kansal\OneDrive\Desktop\Study\Sem 6\Interdisciplinary Project\AI ChatBot

C:\Users\tanishi kansal\OneDrive\Desktop\Study\Sem 6\Interdisciplinary Project\AI ChatBot>python TGuide.py
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data] C:\Users\tanishi kansal\AppData\Roaming\nltk_data...
[nltk_data] Package averaged_perceptron_tagger is already up-to-
[nltk_data] date!
[nltk_data] Downloading package punkt to C:\Users\tanishi
[nltk_data] kansal\AppData\Roaming\nltk_data...
[nltk_data] Package punkt is already up-to-date!
[nltk_data] Downloading package stopwords to C:\Users\tanishi
[nltk_data] kansal\AppData\Roaming\nltk_data...
[nltk_data] Package stopwords is already up-to-date!
List Trainer: [#####] 100%
List Trainer: [#####] 100%
List Trainer: [#####] 100%
List Trainer: [#####] 100%
List Trainer: [#####] 100%
List Trainer: [#####] 100%
```

```
Command Prompt

Hello there! I'm your Tourism Guide disguised as a ChatBot!

How can I help you today?

Hi
Hello

Hello
Hey

Cities
Agra, Andaman, Coorg, Darjeeling, Goa, Jaipur, Kodaikanal, Mussoorie, Ooty, Pondicherry, Shimla

Categories
Hills, Historical, Beach

Hills
Coorg, Darjeeling, Kodaikanal, Mussoorie, Ooty, Shimla
```

```
Command Prompt
Cities
Agra, Andaman, Coorg, Darjeeling, Goa, Jaipur, Kodaikanal, Mussoorie, Ooty, Pondicherry, Shimla

Categories
Hills, Historical, Beach

Hills
Coorg, Darjeeling, Kodaikanal, Mussoorie, Ooty, Shimla

Historical
Agra, Jaipur, Mysore

Beach
Andaman, Goa, Pondicherry

Thanks for the help
Glad I could be of help!
Call me if you ever need me!

C:\Users\tanshi kansal\OneDrive\Desktop\Study\Sem 6\Interdisciplinary Project\AI ChatBot>
```

Forward and Inverse Kinematics of Various Robots

Tanshi Kansal
BE CSE with AI and Robotics
Sathyabama Institute of Science
and Technology
Chennai, India
tanshithegreat@gmail.com

Abstract—Kinematics is the science of geometry in motion. Kinematics pertains to the motion of bodies in a robotics mechanism without regard to the forces/torques that cause the motion. Robot kinematics refers to the analytical study of the motion of a robot manipulator. Formulating the suitable kinematics models for a robot mechanism is very crucial for analyzing the behavior of industrial manipulators. To be able to control the kinematic model in design of the control algorithm. In robotics, the kinematic descriptions of manipulators and their assigned tasks are utilized to set up the fundamental equations for dynamics and control. Forward kinematics refers to the use of the kinematic equations of a robot to compute the position of the end-effector from specified values for the joint parameters. Inverse kinematics involves solving for the joint variables of a robot when we know the position and orientation of its end effector (relative to its base frame) and all the geometric link parameters. The objective of this paper is to explore forward and inverse kinematics of various robots that have been developed in the industry.

Keywords—Kinematics, Robot Kinematics, Forward Kinematics, Inverse Kinematics, Degree of Freedom, 2DoF, 3DoF, 4DoF

I. INTRODUCTION

Kinematics is the science of geometry in motion. It is restricted to a pure geometrical description of motion by means of position, orientation, and their time derivatives. Kinematics pertains to the motion of bodies in a robotics mechanism without regard to the forces/torques that cause the motion. Since robotic mechanisms are by their very essence designed for motion, kinematics is the most fundamental aspect of robot design, analysis, control, and simulation.

The robotics community has focused on efficiently applying different representations of position and orientation and their derivatives with respect to time to solve foundational kinematics problem. There are two important aspects in kinematic analysis of robots: the Forward Kinematics problem and the Inverse Kinematics problem.

Forward kinematics refers to the use of the kinematic equations of a robot to compute the position of the end-effector from specified values for the joint parameters. Inverse Kinematics involves solving for the joint variables of a robot when we know the position and orientation of its end effector (relative to its base frame) and all the geometric link parameters.

II. LITERATURE REVIEW

In the field of robotics, forward and inverse kinematic analysis play crucial roles in understanding the motion and control of different types of robots. These analyses allow researchers and engineers to determine the positions, orientations, velocities, and accelerations of a robot's end effector or individual joints. By studying the kinematics of a robot, one can gain insight into how it moves and interacts with its environment.

Furthermore, forward kinematics involves determining the position and orientation of the end effector given the joint angles or joint displacements. Inverse kinematics, on the other hand, involves finding the joint angles or joint displacements necessary to achieve a desired end effector position and orientation.

Researchers have used various approaches and tools to conduct forward and inverse kinematic analyses on different types of robots. Some examples include parallel manipulators, mobile operation robots, and redundant manipulators.

The first source discusses the analysis of transmission angle in a specific type of parallel manipulator with three joints and two moving links. The second source focuses on the design and prototyping of a dual-motor joint mechanism for manipulators used in power distribution line tasks.

The third source explores the application of forward and inverse kinematics in the optimization of a new manipulator design. The fourth source presents a comprehensive approach to evaluating the kinematic performance of parallel manipulators using transmission angles.

Overall, these sources contribute to the understanding of forward and inverse kinematic analysis in various robots. They demonstrate different applications and methodologies used in the field, highlighting the importance of accurate kinematic analysis for the efficient robot motion planning and control.

These sources provide valuable insights into the forward and inverse kinematic analysis of various robots. The fifth source discusses the simultaneous solution of inverse kinematics and inverse dynamics for redundant manipulators, showcasing a scheme for real-time joint trajectory design and feedforward control torque computation.

These sources collectively illustrate the significance and applications of forward and inverse kinematics analysis in robotics. They provide insights into the mathematical calculations needed to determine the configuration and motion of robot arms, as well as the evaluation of kinematic performance and optimization of mechanical designs.

Additionally, they address the challenges related to labor intensity, risk, and reliability in artificial live working and highlight the development of mobile operation robots specifically designed for power distribution line maintenance tasks.

These sources serve as valuable references for researchers and practitioners in the field of robotics, providing a comprehensive understanding of forward and inverse kinematic analysis in various robot applications. Overall, these sources contribute to the understanding of forward and inverse kinematic analysis in various robot applications.

The reviewed sources provide valuable insights into the forward and inverse kinematic analysis of various robots. They discuss different applications and methodologies used in the field, highlighting the importance of accurate kinematic analysis for efficient robot motion planning and control.

III. KINEMATICS OF ROBOT SYSTEMS

A. Position representation of 2 DoF robot manipulator in 2 dimensions

A robot manipulator having 2 DoF, the degree of freedom which is decided by its number of joints namely, 1 and 2 is shown in Fig.1.

Being,

- L_1 is the link length of link 1
- L_2 is the link length of link 2
- θ_1 is the angle between L_1 and the base
- θ_2 is the angle between L_1 and L_2
- $r_1(x_1, y_1)$ is the position of L_1
- $r_2(x_2, y_2)$ is the position of L_2
- $r(x, y)$ is the position of end effector

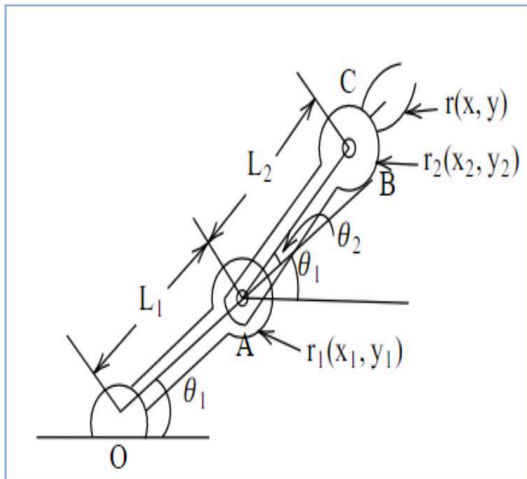


Fig.1. Position representation of 2 DoF robot manipulator

In order to find the position of Link L_1 , it is known that

$$\begin{aligned}\sin \theta_1 &= y_1 / L_1 \\ \Rightarrow y_1 &= L_1 \sin \theta_1 \\ \cos \theta_1 &= x_1 / L_1 \\ \Rightarrow x_1 &= L_1 \cos \theta_1\end{aligned}$$

Hence the position of link L_1 as the coordinates of x and y can be written as

$$r_1 = (L_1 \cos \theta_1, L_1 \sin \theta_1) \quad (1)$$

Similarly, to find the position of Link L_2 , it is clear that

$$\begin{aligned}\sin(\theta_1 + \theta_2) &= y_2 / L_2 \\ \Rightarrow y_2 &= L_2 \sin(\theta_1 + \theta_2) \\ \cos(\theta_1 + \theta_2) &= x_2 / L_2 \\ \Rightarrow x_2 &= L_2 \cos(\theta_1 + \theta_2)\end{aligned}$$

Hence the position of link L_2 as the coordinates of x and y can be written as

$$r_2 = [L_2 \cos(\theta_1 + \theta_2), L_2 \sin(\theta_1 + \theta_2)] \quad (2)$$

By vector addition of r_1 and r_2

$$r = [L_1 \cos \theta_1 + L_2 \cos(\theta_1 + \theta_2), L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2)] \quad (3)$$

where,

$$\Rightarrow x = L_1 \cos \theta_1 + L_2 \cos(\theta_1 + \theta_2)$$

$$\Rightarrow y = L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2)$$

Squaring and adding x and y :

$$x^2 + y^2 = [L_1 \cos \theta_1 + L_2 \cos(\theta_1 + \theta_2)]^2 + [L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2)]^2$$

$$\Rightarrow L_1^2 + L_2^2 + 2L_1L_2[\cos \theta_1 \cos(\theta_1 + \theta_2) + \sin \theta_1 \sin(\theta_1 + \theta_2)]$$

$$\Rightarrow L_1^2 + L_2^2 + 2L_1L_2 \cos \theta_2 \quad (4)$$

$$\because \cos(A-B) = \cos A \cos B + \sin A \sin B$$

$$\cos \theta_2 = (x^2 + y^2 - L_1^2 - L_2^2) / (2L_1L_2) \quad (5)$$

B. Direct/Forward kinematics of 2DoF robot manipulator

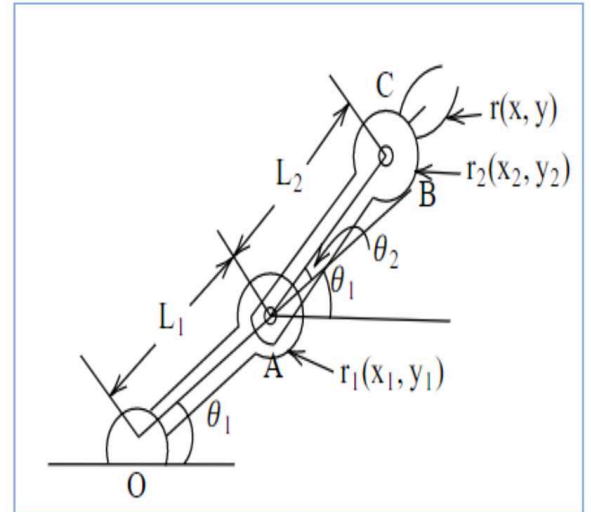


Fig.2. Direct kinematics

Here in the above diagram Fig.2., the triangle, $\angle CAB$ makes the angle θ_2 .

Point O is the extension of CA to join the first joint

$$\alpha = \theta_1 - \theta_2 \quad (6)$$

$$\beta = \theta_1 + \theta_2 \quad (7)$$

Considering, $\triangle ABC$: $\sin \theta_2 = BC/AC$

$$= BC/L_2$$

$$\Rightarrow BC = L_2 \sin \theta_2 \quad (8)$$

$$\cos \theta_2 = AB/AC$$

$$= AB/L_2$$

$$\Rightarrow AB = L_2 \cos \theta_2 \quad (9)$$

$$\tan \alpha = BC/OB$$

$$\begin{aligned} &= BC/(OA+AB) \\ \Rightarrow \tan \alpha &= L_2 \sin \theta_2 / (L_1 + L_2 \cos \theta_2) \end{aligned} \quad (10)$$

$$\tan \beta = y/x \quad (11)$$

C. Position representation of 3 DoF in 2 dimensions

A robot manipulator having 3 DoF, the degree of freedom which is decided by its number of joints namely 1, 2 and 3 is shown in Fig 3.

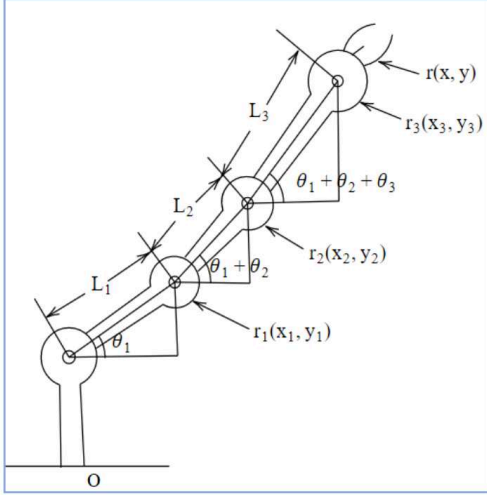


Fig.3. Position representation of 3 DoF robot manipulator Being,

- L_1 is the link length of link 1
- L_2 is the link length of link 2
- L_3 is the link length of link 3
- θ_1 is the angle between L_1 and the base
- θ_2 is the angle between L_1 and L_2
- θ_2 is the angle between L_2 and L_3
- $r_1(x_1, y_1)$ is the position of L_1
- $r_2(x_2, y_2)$ is the position of L_2
- $r_3(x_3, y_3)$ is the position of L_2
- $r(x, y)$ is the position of end effector

In order to find the position of Link L_1 , it is known that

$$\begin{aligned} \sin \theta_1 &= y_1/L_1 \\ \Rightarrow y_1 &= L_1 \sin \theta_1 \\ \cos \theta_1 &= x_1/L_1 \\ \Rightarrow x_1 &= L_1 \cos \theta_1 \end{aligned}$$

Hence the position of link L_1 as the coordinates of x and y can be written as

$$r_1 = (L_1 \cos \theta_1, L_1 \sin \theta_1) \quad (12)$$

Similarly, to find the position of Link L_2 , it is clear that

$$\begin{aligned} \sin(\theta_1 + \theta_2) &= y_2/L_2 \\ \Rightarrow y_2 &= L_2 \sin(\theta_1 + \theta_2) \\ \cos(\theta_1 + \theta_2) &= x_2/L_2 \\ \Rightarrow x_2 &= L_2 \cos(\theta_1 + \theta_2) \end{aligned}$$

Hence the position of link L_2 as the coordinates of x and y can be written as

$$r_2 = [L_2 \cos(\theta_1 + \theta_2), L_2 \sin(\theta_1 + \theta_2)] \quad (13)$$

In order to find the position of Link L_3 , it is known that

$$\begin{aligned} \sin(\theta_1 + \theta_2 + \theta_3) &= y_3/L_3 \\ \Rightarrow y_3 &= L_3 \sin(\theta_1 + \theta_2 + \theta_3) \\ \cos(\theta_1 + \theta_2 + \theta_3) &= x_3/L_3 \\ \Rightarrow x_3 &= L_3 \cos(\theta_1 + \theta_2 + \theta_3) \end{aligned}$$

Hence the position of link L_3 as the coordinates of x and y can be written as

$$r_3 = [L_3 \cos(\theta_1 + \theta_2 + \theta_3), L_3 \sin(\theta_1 + \theta_2 + \theta_3)] \quad (14)$$

By the vector addition of r_1 , r_2 and r_3

$$\begin{aligned} r &= [L_1 \cos \theta_1 + L_2 \cos(\theta_1 + \theta_2) + L_3 \cos(\theta_1 + \theta_2 + \theta_3), \\ &L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2) + L_3 \sin(\theta_1 + \theta_2 + \theta_3)] \quad (15) \\ \Rightarrow x &= L_1 \cos \theta_1 + L_2 \cos(\theta_1 + \theta_2) + L_3 \cos(\theta_1 + \theta_2 + \theta_3) \\ \Rightarrow y &= L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2) + L_3 \sin(\theta_1 + \theta_2 + \theta_3) \end{aligned}$$

D. Position representation of 4 DoF in 3 dimensions

A robot manipulator having 4 DoF, the degree of freedom which is decided by its number of joints namely 1, 2, 3 and 4 is shown in Fig.4.

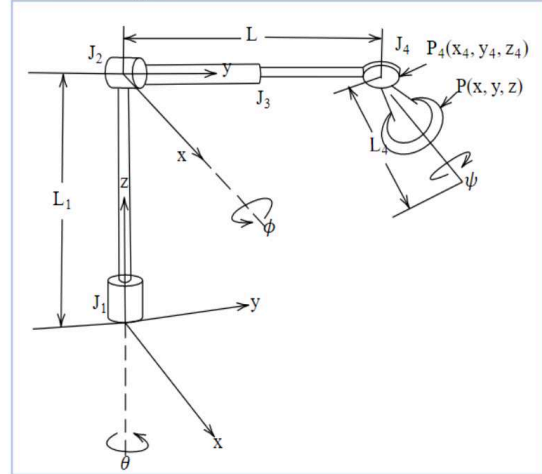


Fig.4. Position representation of 4 DoF robot manipulator

Let

θ is the angle of rotation of J_1 in xz plane perpendicular to y axis

ϕ is the angle of rotation of J_2 in xy plane perpendicular to z axis

ψ is the angle of rotation of J_4 in xy plane perpendicular to z axis and parallel to ϕ

L_1 is the link length from J_1 to J_2

L is the link length from J_2 to J_4

$$\Rightarrow L = L_2 + L_3$$

L_4 is the link length from J_4 to end effector

$P_4(x_4, y_4, z_4)$ is the position of J_4

$P(x, y, z)$ is the position of end effector

To find $P(x)$:

$$\begin{aligned} \cos \phi &= x/L \\ \Rightarrow x &= L \cos \phi \\ \cos \psi &= x/L_4 \\ \Rightarrow x &= L_4 \cos \psi \end{aligned}$$

The x coordinate is given by its component with respect the angle θ is the summation of its component in ϕ direction and in ψ direction.

And hence, $x = \cos\theta (L\cos\phi + L_4\cos\psi)$

Similarly for finding P(y) and P(z):

The y coordinate is given by its component with respect the angle θ is the summation of its component in ϕ direction and in ψ direction (y component in ϕ + y component in ψ)

$$y = \sin\theta (L\cos\phi + L_4\cos\psi)$$

Likewise, z coordinate with its component in θ is given by the addition of z component in ϕ and its component in ψ

Hence, $z = L_1 + L\sin\phi + L_4\sin\psi$

$$\Rightarrow x = \cos\theta (L\cos\phi + L_4\cos\psi)$$

CONCLUSION

This paper is a combination of a few of the existing robots, describing their workings along with the mathematical analysis that includes the development of forward and inverse kinematics. The process of calculating the forward and inverse kinematics of any robot gives the basic idea of how the robot should be moved in order to achieve the desired position and orientation of the end effector.

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