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AI Enhanced Smart Parking Management System

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Our module teachers shared insightful ideas regarding cloud computing and its integration with IOT tools. The successful integration of *AI, IOT*, and *cloud technologies* is a result of thorough research and innovative ideas presented by our module teachers.

A special acknowledgment is reserved for our team members who generously shared unique insights and dedicated their time to contribute to the realization of our project. Their collaborative spirit and unwavering support played a pivotal role in bringing our project to fruition, and we are sincerely thankful for the effective teamwork.

Abstract:

This project focuses on making parking more efficient using Artificial Intelligence. We use hardware components like *Arduino Uno, Ultrasonic Sensors, Servo Motors, LED lights, jumper wires, and resistors*. Alongside, we employ *deep learning models* with *cloud*, *front-end*, and *back-end technologies*.

Parking in busy areas like malls, offices, colleges, and schools can be a hassle. These places often struggle to handle parking efficiently, leading to the hiring of extra staff for checking available parking slots. Our AI Enhanced Smart Parking system aims to address this issue.

The parking gate opens automatically upon detecting a vehicle, and our deep learning model determines if there's available parking space. Users can conveniently check parking availability on their smartphones through cloud integration. This system significantly aids in effective parking management, alleviating the challenges organizations face in monitoring parking spaces without requiring additional staff.

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1. Introduction:

Internet of Things (IoT) projects aim to simplify tasks and enhance convenience by integrating various technologies like sensors, software, and microcontrollers. This combination of technologies is collectively known as IoT. In today's context, IoT seamlessly collaborates with Cloud Computing Technologies, which, in turn, can be integrated with Artificial Intelligence. This integration enables the use of AI technologies alongside IoT devices, facilitated by the exchange of information through cloud technologies.

Our project is all about creating a practical IoT solution called *the AI Enhanced Smart Parking Management System*. We're using sensors, like ultrasonic devices, to detect objects at parking gates and slots. These sensors allow us to control servo motors and LED lights. What makes our system special is the integration of a *deep learning model*, which improves the system's accuracy in *determining parking slot availability*. Users can get *real-time updates* on their smartphones, making it easy for them to find vacant parking spots and enhancing their overall parking experience.

1.1. Current scenario:

The ongoing parking management crisis in Nepal, especially in the Kathmandu Valley, is mainly due to the lack of smart parking systems. The significant increase in registered vehicles, rising from 1.2 million in 2010/11 to 2.9 million in 2017/18 according to the Department of Transport Management (DoTM), has surpassed the development of sufficient infrastructure. Kathmandu Metropolitan City (KMC) asserts only 16,000 parking spaces, significantly insufficient given the rising demand driven by the rapid growth in vehicles. The problem is worsened by frequent parking violations, with over 180,000 instances recorded in 2022 by the Metropolitan Traffic Police Division (MTPD). The absence of smart parking systems contributes to this issue, as manual enforcement struggles to address the widespread disregard for parking regulations. As a result, this aggravates challenges related to traffic congestion and safety. The overall assessment highlights a significant deficit of about 1.58 million parking spaces in the Kathmandu Valley, underscoring the pressing need for the adoption of smart parking systems to effectively manage and optimize available spaces, thereby addressing the challenges posed by the increasing number of vehicles (annapurnaexpress, 2022).

1.2. Problem Statement and Project as a solution:

Parking in Nepal, especially in cities, malls, offices, colleges, and schools, is a significant problem because there isn't a proper parking system for vehicles. This results in vehicles crowding streets and sidewalks, leading to traffic jams and difficulties for pedestrians. Traditional methods of managing parking, such as paper tickets, manual counting, and staff manually checking parking slots, also slow down the process and make it challenging to keep track of available spaces. Additionally, Nepal has been slow in adopting modern parking solutions using technologies like sensors and cameras. The implementation of smart parking technologies is still lacking, and this hinders the effective management of the parking system.

A smart parking system integrated with AI can effectively address parking management challenges. This system utilizes sensors to detect vehicles, automatically opening gates upon detection. Users can conveniently access the system through a smartphone app to view available slots and easily park their vehicles. This eliminates the need for organizations to hire extra staff to assist in finding free slots, as the deep learning model, employing object detection algorithms, efficiently handles this task. The system contributes to crowd management in parking slots, and administrators can effortlessly monitor and guide vehicles using the dedicated app.

2. Aims and Objectives:

2.1 Aims:

The main purpose of this project is to *modernize* traditional parking systems using advanced technologies to establish an *automated parking system* for the effective management of vehicles.

2.2 Objectives:

- The system is expected to open the gate automatically once the vehicle is detected by the sensor.

- The system is build using a deep learning model which performs object detection task, for identifying vacant parking spaces.

- The system assists the user through a mobile application to check real-time parking availability.

- The system helps the administrator to look over the vehicle and guide them remotely for parking the vehicle in slots.

3. Background:

3.1. Expected Outcomes and Deliverables:

Our system is divided into two main components. The first part utilizes IoT technologies, such as microcontrollers, sensors, and LEDs, to automate the parking process. When a vehicle is detected by the sensors, the parking gate opens automatically, closing once the vehicle enters. As the vehicle reaches its parking slot, the sensors detect its presence, and an LED indicator lights up, signaling to other vehicles that the slot is occupied. In summary, the primary objective of the first part is to achieve an automated parking system.

<u>The System Architecture for first component is given below:</u>

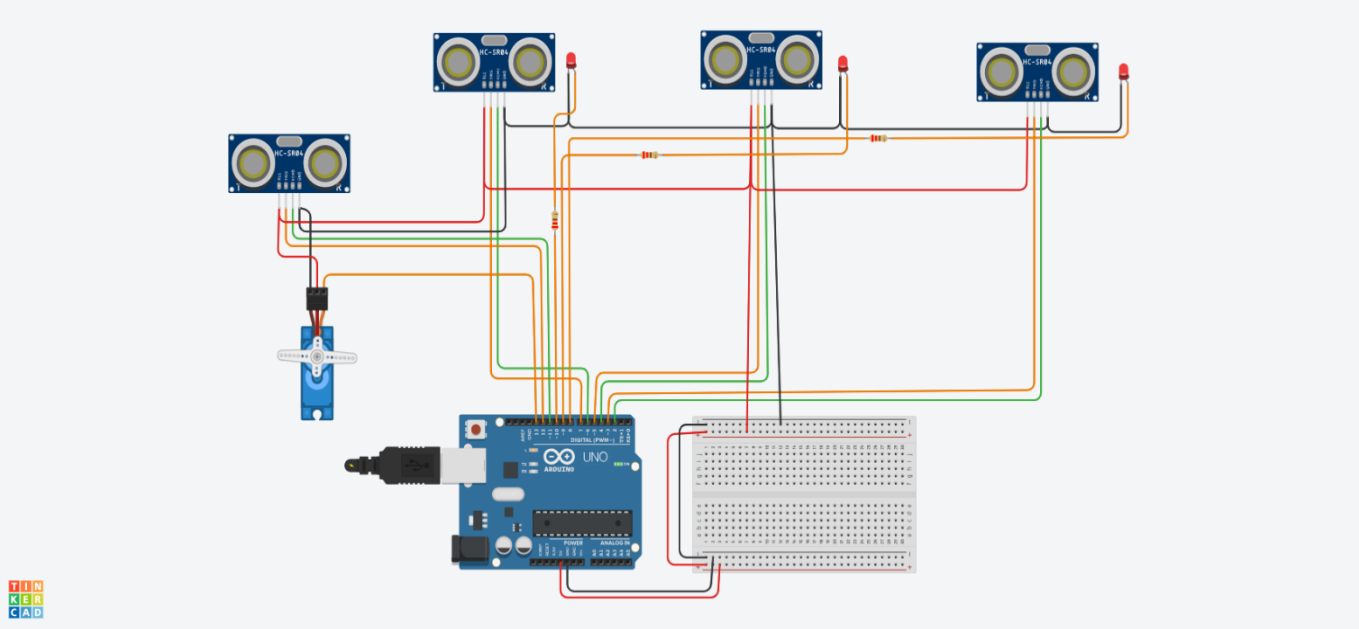

Figure 1: System Architecture for IOT Components

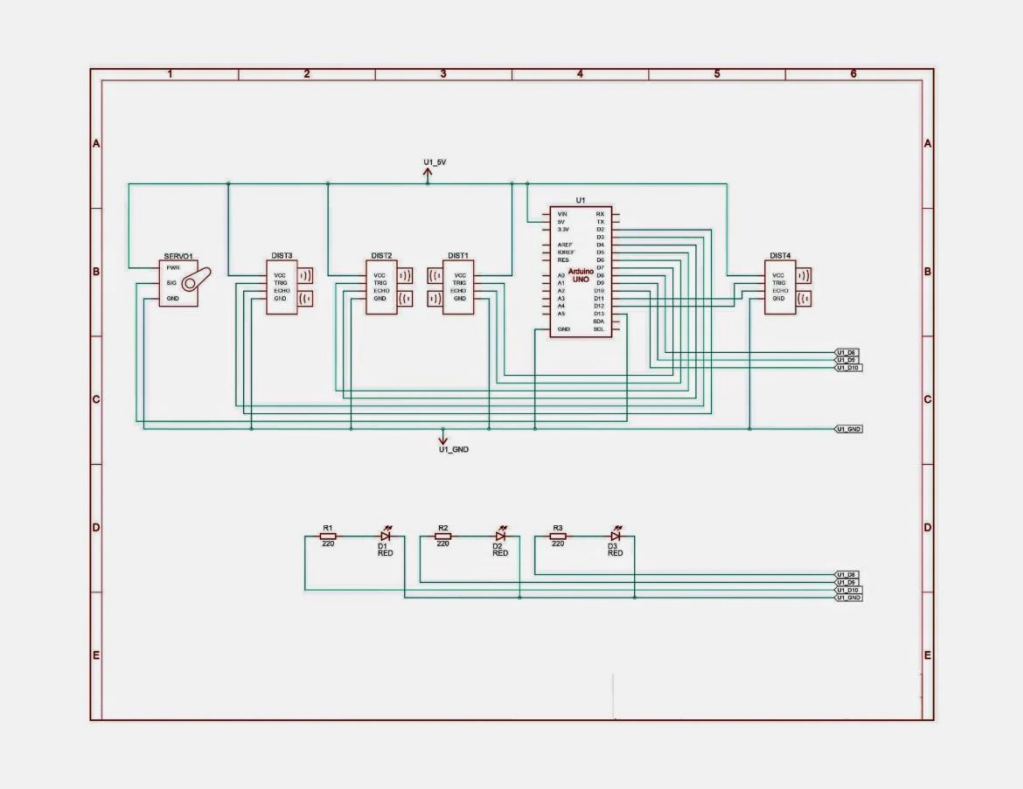

Figure 2: Detailed Circuit diagram of IOT Components

The second part of our system incorporates Cloud and Artificial Intelligence Technology. In this section, parking spaces are identified using cameras, and the data is transmitted to a deep learning model responsible for detecting vehicles in parking slots. The deep learning model communicates the details of available spaces to the cloud. Users can access real-time parking availability information on their smartphones through a dedicated application connected to the cloud.

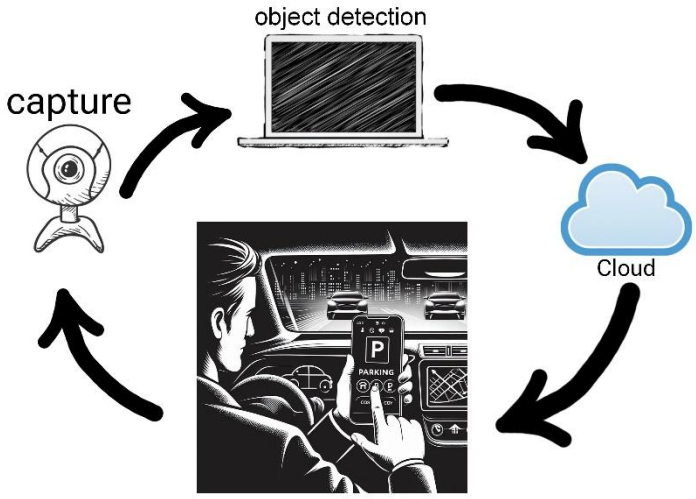

Figure 3: Flow Diagram of Interaction of AI, Cloud and User

3.2 Requirement Analysis:

3.2.1 Hardware Components :

In creating the AI Enhanced Smart Parking Management System, we employed various hardware components which are as follows :

- ***Arduino Uno***
- ***ultrasonic sensors***
- ***servo motors***
- ***LED lights***
- ***jumper wires***
- ***resistors***

3.2.2: Software's

In creating the AI Enhanced Smart Parking Management System, we employed various software which are as follows :

- ***Arduino IDE***
- ***Tinkercad***
- ***Jupyter Notebook***
- ***Microsoft Word***

4. Individual Contribution plan:

Five people are teaming up for this project, and each person has a unique role. We divided the tasks among them because the project has many parts. This way, it's simpler to give each person their own specific job. Here Click on the Table for an in-depth breakdown of the specific responsibilities assigned to each team member in the project.

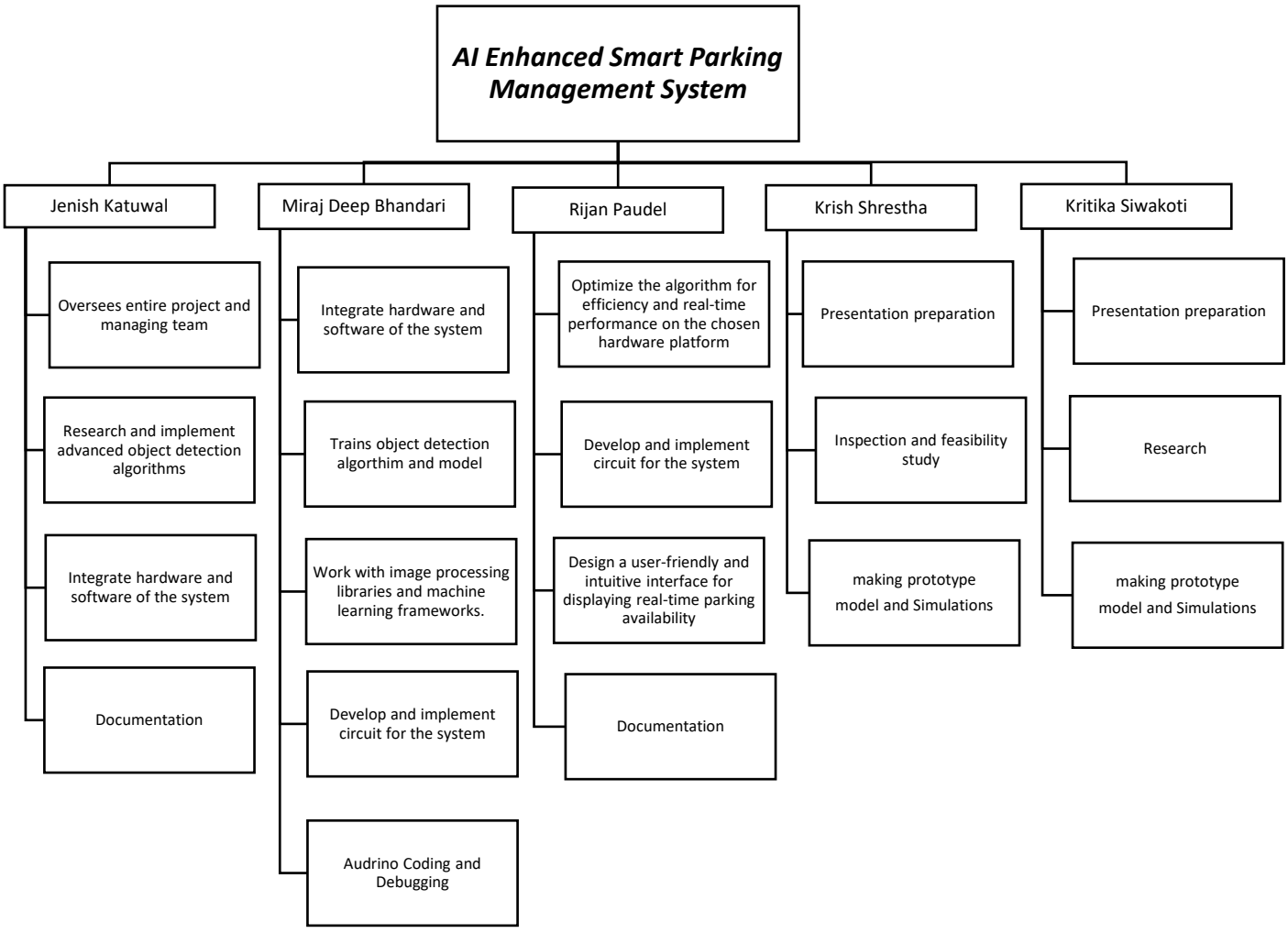

Figure 4: Individual Contribution Plan

5.Conclusion:

The automated functionality of our *AI Enhanced Smart Parking Management System* simplifies the parking process through user-friendly technology. Specially designed sensors identify vehicles at parking gates, automatically opening them without manual assistance. Simultaneously, cameras capture images of parking spaces, and an intelligent system analyzes these images to determine space occupancy.

All collected data is transmitted to the cloud for easy access from anywhere. Users can conveniently check real-time parking space availability through a straightforward mobile app. This feature enhances the parking experience by providing up-to-date information on vacant spots.

Administrators also get benefit from the system. Using the app, they can remotely monitor the parking lot, guide drivers to available spaces, and address issues without physical presence. This streamlined approach improves the efficiency of parking management. In summary, the automated system not only enhances user experience by offering real-time parking information but also provides administrators with a valuable tool for effective remote management, marking a significant advancement in parking systems.

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7. Appendix:

Hardware

7.1 Arduino Uno: The Arduino Uno is an open-source microcontroller board based on the Atmega328P microcontroller. It features digital and analog input/output pins, a USB interface for programming and power, and is widely used for prototyping and creating interactive electronic projects (Seager, 2001).

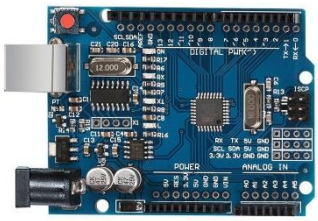

Figure 5: Figure of Arduino Uno

7.2 Ultrasonic Sensor: A transducer device that emits high-frequency ultrasonic waves and detects their reflections to measure distances or detect objects. It operates based on the principle of sending and receiving ultrasonic signals, with applications ranging from proximity sensing in robotics to measuring distances in industrial and automotive systems (Nakamura, 2012).

Figure 6: Figure of Ultrasonic Sensor

7.3 Servo Motor: A servo motor is a specialized motor that uses feedback for precise control of its rotational or linear position. It consists of a motor, a feedback sensor, and a control circuit. The feedback system continuously monitors the actual position of the motor and adjusts it to match the desired position (Kusuda, 1999).

Figure 7: Figure of Servo Motor

7.4 LED Light: LED stands for "light-emitting diode." LED lights are a type of lighting technology that uses semiconductor devices to emit light when an electric current passes through them. Unlike traditional incandescent bulbs, which use a filament to produce light, LEDs generate light through the movement of electrons in a semiconductor material (Lee and Kwon, 2015).

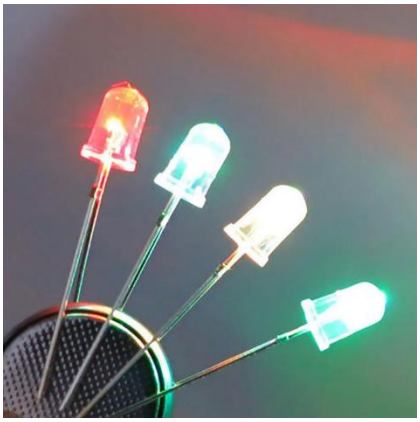

Figure 8: Figure of LEDs

7.5 Jumper Wires: Jumper wires are electrical wires used to create connections between different components on a breadboard or within an electronic circuit. They are typically insulated wires with connectors on either end that can be easily inserted into the holes of a breadboard or connected to the pins of electronic components (Nakamura, 2012)..

Figure 9: Figure of Jumper Wires

7.6 Resistors: Resistors are electronic components designed to introduce a specific amount of electrical resistance into a circuit. Resistance is a property that opposes the flow of electric current. Resistors are commonly used in electronic circuits to control the amount of current, divide voltages, and protect components(Electronics Notes, n.d.).

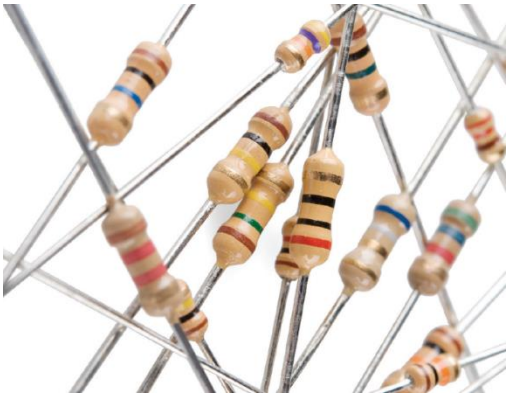

Figure 10: Figure of Resistors

7.7 Breadboard:

A breadboard is a fundamental tool used in electronics for prototyping and testing circuits without the need for soldering. It provides a platform for engineers, hobbyists, and students to quickly and easily connect electronic components, such as resistors, capacitors, and integrated circuits, to create temporary circuits (Electronics Notes, n.d.).

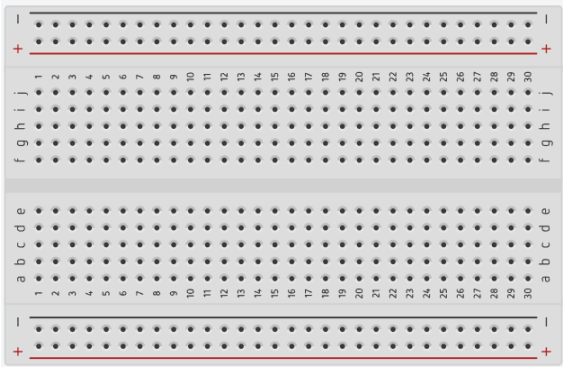

Figure 11: Figure of Breadboard

Software

7.8 Arduino IDE: Arduino IDE is an open-source software for writing, compiling, and uploading code to Arduino microcontroller boards. It supports various Arduino models, providing a user-friendly platform for IoT development.

7.9 Tinkercad: Tinkercad is a user-friendly online platform designed for 3D design and electronics projects. It simplifies the creation of digital prototypes through its intuitive drag-and-drop interface. Widely embraced by beginners and hobbyists in the IoT community, Tinkercad facilitates the easy design of 3D models and simulation of circuits, making it an accessible tool for bringing creative ideas to life virtually (all3dp, 2022).

7.10 Jupyter Notebook: Jupyter Notebook is an open-source, web-based application enabling interactive coding, data analysis, and visualization. Widely used with its support for multiple languages, especially Python, it's a go-to tool for IoT projects and machine learning tasks (Silaparasetty, 2020).

7.11 Microsoft Word: Microsoft Word, or MS Word, is a widely-used word processing software by Microsoft. Known for its user-friendly interface and versatile features, it simplifies document creation and editing, making it essential in professional and academic settings.

Breakdown of individual tasks assigned to each team :

Team Member	Responsibilities
Jenish Katuwal:	• **Project Oversight:** As the project manager, Jenish is responsible for overseeing the entire project, ensuring that it aligns with goals and stays on schedule. • **Team Management**: Manages and coordinates the project team, ensuring effective communication and collaboration. • **Algorithm Implementation:** Leads the implementation of advanced object detection algorithms for identifying parking spaces. • **System Integration:** Integrates both hardware and software components to create a cohesive and functional smart parking system. • **Documentation**: Handles the documentation process, including project plans, progress reports, and technical documentation.

Miraj Deep Bhandari:	• **Hardware and Software Integration:** Integrates hardware components (sensors, microcontrollers) with software for a unified smart parking system. • **Machine Learning:** Trains and fine-tunes machine learning models for object detection, a crucial aspect of identifying available parking spaces. • **Image Processing:** Utilizes image processing techniques to enhance the accuracy and efficiency of parking space detection. • **Circuit Development:** Designs and implements the electronic circuits necessary for the functioning of the smart parking system. • **Arduino Coding:** Writes and debugs code for the Arduino microcontroller, a key component in the hardware setup.
Rijan Paudel:	• **Algorithm Optimization:** Optimizes the object detection algorithm to ensure it operates efficiently and in real-time on the selected hardware. • **Circuit Design:** Designs the electronic circuits needed for the smart parking system, considering factors like power consumption and reliability.

	• **User Interface Design**: Creates an intuitive and user-friendly interface for displaying real-time parking availability to users. • **Documentation:** Manages documentation related to algorithm optimization, circuit design, and user interface development.
Krish Shrestha:	• **Presentations:** Prepares presentations to communicate project updates, findings, and results to stakeholders and team members. • **Inspection and Feasibility Study:** Conducts inspections and feasibility studies to evaluate the practicality and viability of the smart parking system. • **Prototype Development:** Creates a prototype model of the smart parking system and conducts simulations to validate its functionality.
Kritika Siwakoti:	• **Presentations**: Similar to Krish, Kritika prepares and delivers presentations to effectively communicate project information.

	• **Research:** Conducts research on relevant technologies, industry best practices, and emerging trends to inform decision-making. • **Prototype Development:** Works on creating a prototype model of the smart parking system, performing simulations to test and validate its design.

Table 1: Individual Contribution Plan Table