Prototype of an Automated Multilevel Car Parking System

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Abstract - *The project focuses on the design and fabrication of a prototype with an automated parking system. The search for a vacant parking space and retrieval of the car from the parking space is carried out in this system by collecting data from sensors, processing the data by a microcontroller, and sending the instructions to the actuators to perform the operations. The data collected from the sensors was processed using an Arduino Mega2560 board with an embedded ATmega2560 microcontroller IC. The intensity of light in each parking space compartment was measured using LDRs. The data was then sent to stepper motors acting as actuators, which engaged linear lead screws and gears to perform the operations specified by the user.*

***Keywords*- sensors, microcontroller, actuators, processed, intensity.**

1 INTRODUCTION

Different countries' parking systems have progressed from traditional to multi-story, and from multi-story to automated. The world has advanced in the field of automation to produce products on a large scale to solve the timing crisis and complete tasks with ease. The automation era has caused a revolutionary change in several sectors, and we wanted to implement the idea of an Automated Multilevel Car Parking system for creating a parking system that uses less space, consumes less time, and eliminates the need for a manual operator to control the system's process. As we all know, for a driver to park a car in a parking space, he or she must first look for a vacant spot. In addition, traditional parking systems take up a lot of space in densely populated cities, affecting both the land and the economy. As a result, an efficient system was required to solve these problems, and we came up with the idea of designing a prototype that would take up less space and perform the operations on its own. By parking cars in this manner, the ground area and capacity of the garage can be used more efficiently. This system will allow more cars to be parked in the same space, reduce the space required to park the same number of cars or allow parking where there was previously none. The prototype works by utilizing LDRs, an Arduino Mega2560 board as a controller, and stepper motors as actuators. The lead screw mechanism will be powered by stepper motors, which will drive the mechanical system via gears. LDRs will measure the physical quantity and send the signals to the controller. The controller will process the data from the sensors and provide digital input to the actuators based on the instructions. The actuators will carry out the operations required for parking or retrieving the car from the parking slot.

2 LITERATURE REVIEW

The parking problem in major cities causes urban planning to be distorted. The increase in the number of off-street parking spaces close to or beside each building separates the structures. Parking on the side of the road also causes complications for pedestrians. Because of the concentration of activities and amenities in commercial building areas, government institutions, and district centers, an effective system for parking a large number of cars in a small space is required. The underestimation of parking requests in the same area is a major problem in urban areas. This is attributable to an increase in the number of people owning cars in affluent and middle-class households. By 2021, the number of cars owned by corporations and people in India had increased by 40 million [1]. If there is a suitable calculation for automobile demand in a certain location and a proper plan for constructing an effective car parking system, the problem can be solved [2]. Because different cities have varied household environments, different population counts, and diverse building infrastructures, different strategies are utilized or can be employed in different city settings. Traditional parking systems are the most extensively utilized way of parking in urban areas (KERB parking). The automobiles are parked off-street, which takes up a lot of room and makes finding a spare space in the same neighborhood difficult. Drivers who are unable to locate a vacant parking space are forced to park on the street, which is prohibited. In the majority of district centers, a multi-story parking system is in use. Vehicles are parked on different floors of a building in this type of system. These floors are reached via external or internal means such as ramps or other similar structures. This type of system is known as Puzzle type multistorey car parking because the cars are parked on platforms that can be moved vertically and horizontally. Certain functions of the system require a skilled operator to perform while retrieving a specific car. It takes a long time for an individual to keep up with the number of cars that need to be parked in such a system. At some point, a manually operated system will result in human error. Thus, replacing such a system with automatic control will solve parking issues such as searching for a vacant parking spot, the time required for parking and retrieving, and the need for a skilled operator. Many Indian cities require the development of such systems in their corporate institutions and district centers. Developing such a fully automatic system on a large scale will undoubtedly increase costs, but it will eliminate issues related to the area, driver cruising, and parking time.

3 PROPOSED METHODOLOGY

The system consists of two parts Parking and Retrieving. The flowchart explains the working of the whole system. The system has four stages of operation in which Stage-1 contains the selection of the process to be performed, Stage-2 contains the working of LDR sensors that will sense the vacant space in the parking process and sense the occupied space for a particular car in retrieving process after pressing the toggle switch. During retrieving if no switch is pressed the program for retrieving the car will be not executed as shown in figure-. In Stage-3 there will be some functions carried out by actuators depending on instructions provided by the microcontroller and at last Stage-4 in which the motors will operate the gears and linear screw mechanism to move in X, Y, and Z-axis directions.

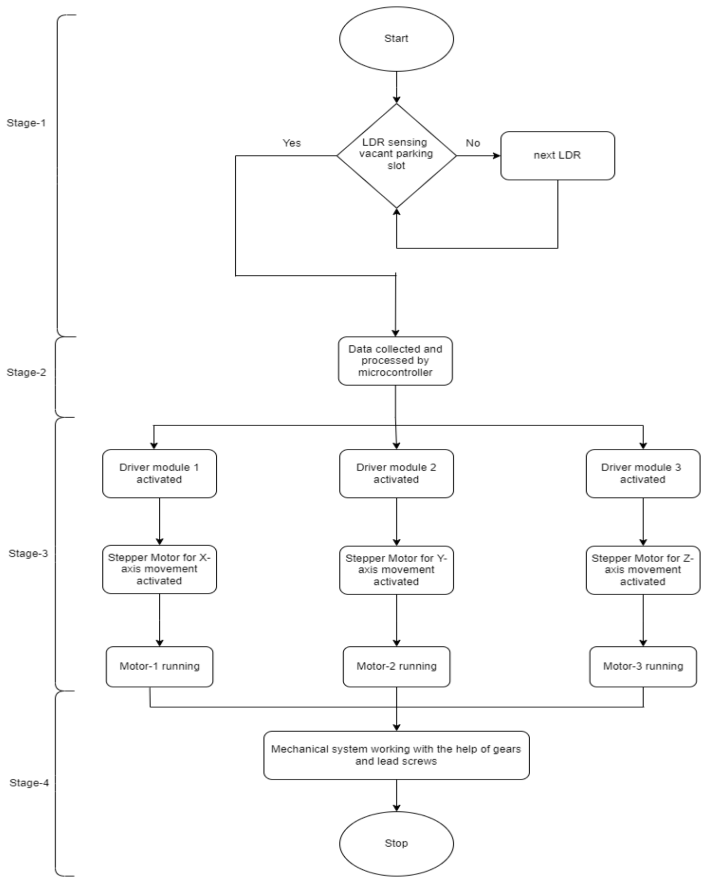

Figure 1- Parking system Flowchart

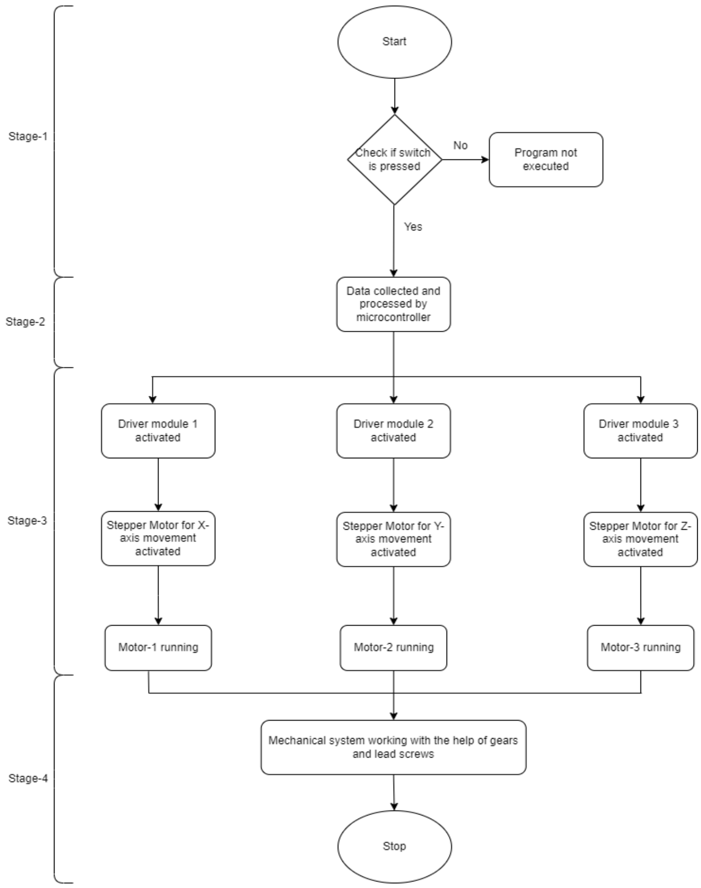

Figure 2- Retrieving system Flowchart

4 HARDWARE SETUP

4.1 Lead Screw and Flexible coupling

Figure 3- Lead screw and nut

A mechanical linear actuator, such as a lead screw, converts rotational motion into linear motion. Its operation is based on the screw shaft and nut threads sliding together with no ball bearings in between. Flexible couplings are intended to accommodate a wide range of load conditions. Because no single type of coupling can provide a universal solution to all coupling problems, numerous designs are available, each with construction features to accommodate one or more types of application requirements.

4.2 Worm Drive

Figure 4- Worm drive

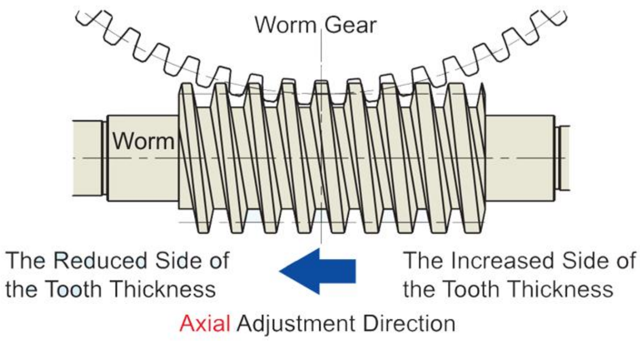

Figure 5- Worm drive notations

A worm drive is a gear arrangement in which a worm (a screw-shaped gear) meshes with a worm wheel (similar to a spur gear). The two components are also known as the worm screw and worm gear. With a single-start worm, the worm wheel advances by one tooth for every 360° turn of the worm.

4.3 Bevel gear

Figure 6- Bevel gears

A bevel gear is a toothed rotating machine element that is used to transfer mechanical energy or shaft power between intersecting shafts that are perpendicular or at an angle. The axis of rotation of the shaft power alters as a result. Aside from this function, bevel gears can also increase or decrease torque while causing the angular speed to change in the opposite direction. A pinion and crown wheel is represented by a frustum. Teeth are milled into its lateral side, which interlocks with other gears with their own set of teeth. The driver gear is responsible for transmitting shaft power, whereas the driven gear is responsible for receiving power. To produce a mechanical advantage, the number of teeth on the driver and driven gears are usually different.

5 ELECTRICAL SETUP

5.1 5.1 Stepper Motor NEMA-17

Figure 7- Stepper Motor NEMA 17

A brushless, synchronous electric motor that translates digital pulses into mechanical shaft rotation is known as a stepper motor. When powered by a sequentially switched DC power supply, its normal shaft motion consists of discrete angular movements of practically uniform magnitude. It's especially well-suited to applications in which control signals are shown as digital pulses rather than analog voltages. When a stepper motor drive or translator receives a digital pulse, the motor increments one precise angle of motion. The step movement becomes continuous rotation because the frequency of the digital pulses increases. Stepper motors with a 1.8-degree step angle (200 steps/revolution) and a 1.7 x 1.7-inch faceplate are known as NEMA 17 stepper motors. NEMA 17 steppers feature a higher torque than smaller variations like NEMA 14 and a recommended driving voltage of 12-24V. These steppers are RoHS compliant as well.

5.2 5.2 Stepper Motor Driver DRV8825

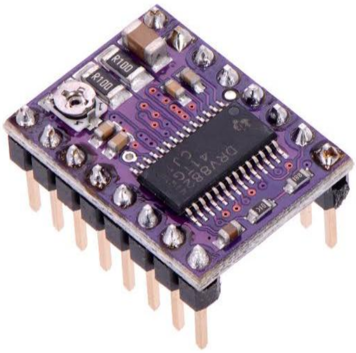

Figure 8- DRV8825 driver module

The DRV8825 is a two-H-bridge driver motor driver with a micro-stepping indexer. The driver has a 45 V and 2.5 A maximum output capacity. It has full, 1/2, 1/4, 1/8, 1/16, and 1/32-step modes for bipolar stepper motors. Based on established criteria, the control also finds the appropriate speed curve for the system. The stepper motor is then given step commands in the form of pulses. The stepper motor driver's task is to translate command pulses into actual motor driving steps.

5.3 5.3 Light Dependent Resistor (LDR)

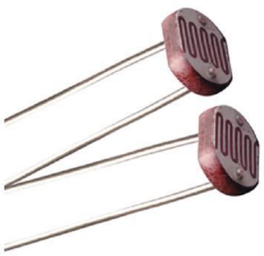

Figure 9- Light Dependent Resistor (LDR)

Photoresistors, also known as light-dependent resistors (LDRs), are light-sensitive devices that are commonly used to detect the presence or absence of light, as well as to measure the intensity of light. Their resistance is quite high in the dark, sometimes up to 1 M, but when exposed to light, the resistance reduces rapidly, perhaps down to a few ohms, depending on the light intensity. LDRs are nonlinear devices with a sensitivity that varies with the wavelength of light.

5.4 5.4 Arduino Mega 2560

Figure 10- Arduino Mega 2560

In comparison to other Arduino creator boards, the Arduino Mega 2560 is an exceptional developer board dedicated to constructing large applications. The ATmega2560 microprocessor, which operates at a frequency of 16 MHz, is housed on the board. 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports), a USB connection, a power jack, an ICSP header, and a reset button are all found on the board.

6 WORKING

Figure 11- Simplified block diagram

6.1 Sensors

Transducers that translate physical quantities into analog electrical quantities are known as sensors. Our system's sensors are divided into two categories: parking and recovering the vehicle. While parking the car, the system will first detect the intensity of light falling on it using LDR. When a car is parked on the platform, the LDR detects darkness and generates a megaohm output, indicating that the parking slot is occupied. The low intensity indicates that the parking place is unoccupied. The Arduino Mega 2560 board will collect the analog output from the sensors. The driver must hit the switch corresponding to that slot when retrieving the car parked in the parking place, which will transmit an analog current signal to the Arduino Mega 2560. There will be six switches for six parking spaces, each with a sequential number allocated in the system.

6.2 Controller

The controller is a device that collects and processes all sensor data and controls the functions of actuators based on the user's commands. We used the Arduino Mega 2560 board, which features a microcontroller IC called ATmega2560 that can do the following actions, to control such sophisticated tasks in the system. The analog signal from the sensors will be transmitted to the microcontroller board. The board will detect the space and send signals to the stepper driver module following the microcontroller's instructions. The DRV8825 stepper driver module was utilized to control the signals sent to the stepper motor. A suitable voltage will be provided by the driver module.

6.3 Actuators

The actuators will carry out the commands issued by the controllers. For both parking and retrieving the car, the entire system must move in the X, Y, and Z axes. Three stepper motors with three stepper drivers, four lead screws and nuts, flexible couplings, a set of bevel gears, and a worm drive are employed as actuators. The components are connected to operate the system in the X, Y, and Z directions separately.

6.3.1 X-axis operation

Figure 12- Structure for x-axis operation

The first stepper motor is meshed with the lead screw through a connection to operate the system in the X-axis direction. The lead screw nut will be moved by the stepper motor, which will accomplish the appropriate revolutions. A platform is built around the nut, which is supported by two shafts and moves with the nut. For every revolution of the motor, the nut will travel 8mm. After 200 steps, the NEMA 17 stepper motor completes its one revolution.

6.3.2 Y-axis operation

Figure 13- Top view and isometric view of the y-axis operation structure.

A second stepper motor with two lead screw mechanisms is utilized to operate the system in the Y-axis direction, holding the system that moves in the X-axis direction. The lifting plate will be moved vertically to reach the first and second floors of parking with this system. The bevel gear set installed on the shaft is connected to the stepper motor. At the end of the shaft, two worm screws are linked, which rotate the mesh worm gears, which are connected to lead screws. The rotation of each set will result in the system going upwards or downwards, depending on the conclusion.

6.3.3 Z-axis operation

The lifting plate must move in the Z direction when it is in motion. Flexible coupling in this setup connects a lead screw and nut to the third stepper motor. The lifting plate is coupled to a mechanism that travels 8mm around the nut after each motor turn.

7 STEPS INVOLVED IN COMPLETING TH PROTOTYPE

7.1 Modelling the system in Fusion-360

We were able to visualize the system's operation using real parameters after designing it in software. The software-designed system went through several iterations before being chosen as the best design. The design iterations were clearer about the aspects that can affect the system after animating the entire system.

7.2 Selection and obtainment of materials

The materials needed to build the parking box were meticulously examined to ensure that the system would be both rigid and cost-effective. Because acrylic fiber sheet is a clear plastic material with exceptional strength, rigidity, and optical clarity, it was chosen for use in the construction of the block. We didn't go for wood as it is a hygroscopic substance, which implies it will absorb nearby condensable vapors and release moisture into the air below the fiber saturation point. Abiotic degradation (mild fungus, bacteria, and insects) and biotic degradation (mild fungi, bacteria, and insects) are both possible in wood (Sun, wind, water, certain chemicals, and fire). A wooden block would have required outfitting, which would have raised the cost, but acrylic sheets do not require such considerations. Acrylic sheets are also thirty times stronger than glass and thus significantly less expensive. Examining the benefits and qualities of acrylic sheets, we were able to make an informed decision about which material to use. A wooden block would have required outfitting, which would have raised the cost, but acrylic sheets do not require such considerations.

Following the material selection for the block, we moved on to the material selection for the vertical mechanism. The mechanism will work in both the X and Y axes, according to the design. As a result, we constructed the frame using L-shaped mild steel angles. The motors were mounted to the frame using NEMA-17 stepper motor mounting brackets. In addition, the horizontal frame for the X-axis movement was coupled to the Z-axis movement, which is the movement of the lifting plate.

7.3 Manufacturing

This phase entails fabricating a prototype in a workshop using purchased materials and creating a Prototype model from a software model. Assembling the whole system in the workshop with the installation of brackets and motors.

8 ASSEMBLING AND PROGRAMMING

Electronic components were used to put the constructed system together. Jumper wires were used to link the Arduino Mega 2560 board to the motor drivers. LDRs, switches, and LEDs were all installed as part of the electrical system. The Arduino Mega 2560 board was used to link everything. The system was then programmed using the Arduino IDE software, which included the necessary instructions for X, Y, and Z-axis movement.

9 CONCLUSION

A multilevel automated car parking model was built, and all of the pieces were successfully fabricated, installed, and tested. This sort of parking technology will allow automobiles to be parked in a more compact space. The Automatic Car Parking System allows automobiles to be parked on successive floors, saving space. Automation also has an advantage in that it reduces the amount of manual intervention required, resulting in fewer issues.

10 ACKNOWLEDGMENT

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