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Automated Wireless EV Charging Station Using Image Processing

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Abstract: For electric vehicles, the development of wireless charging technologies has increased significantly in the past ten years. In this work, we offer a wireless power transmission and image processing-based electric vehicle charging system. Our purpose is to provide EV charging facilities in places like tourist hotspots, shopping complexes, by the side of streets and highways where the authorities do not have to bother about grid connection and extended infrastructure.

Different methods of Wireless Power Transfer (WPT) comprise inductive coupling, resonant inductive coupling, capacitive coupling, and magnetic coupling. In this paper we use inductive coupling method since (i) it is capable of transferring power in medium to high level applications (ii) gap between transmitting and receiving coil is greater than 10cm (iii) medium is through air. Thus, making it the most feasible method to use in Electric Vehicles.

Moreover, a payment window is used to pay for the service; it accepts cash notes and charges the car for the time determined according to the denomination it detects. Feature extraction techniques provided by OpenCV include Harris Corner Detection, SIFT, SURF, ORB, FAST and BRIEF. Among these ORB is the most efficient algorithm to be used in this paper. Brute Force Matcher as well as FLANN based Matcher are utilized in feature matching. In this paper BFMatcher will be implemented.

Index Terms **– Electric Vehicles, Wireless Charging, Mutual Induction, Image Processing, CNN**

I.INTRODUCTION

Electric vehicles contribute to the development of cleaner and greener cities. Furthermore, with increased efficiency and cost savings, EVs are now on par with fuel-powered vehicles. The increased demand for EVs necessitates the development of a solution for charging outside the home. Since power grid connections and extended infrastructure cannot be made available everywhere, efficient, automated, and compact charging points must be installed throughout the city. [9]

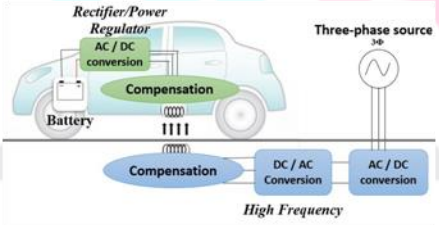

Fig.1 wireless charging

Unlike conventional petrol pumps, EV charging should not require any manual assistance. So, we install a small window that accepts cash notes, detects its denomination, and checks its originality using Image Processing[9] thereby charging the vehicle for the appropriate time. Image Processing can be performed using MATLAB[8] as well as Python[8]. MATLAB is a closed-source, proprietary software[8]. Python is freely available and open-source software that is used as an interpreted programming language. This means that Python programmes can be converted to all common CPU architectures and operating systems with just small platform-specific changes. There are Python distributions for microcontrollers like the Raspberry Pi and Arduino. Python uses OpenCV library to perform DIP tasks [9][9]. Using OpenCV methods, it is possible to accomplish various tasks such as searching for similar images in a database, detecting and recognizing faces, categorizing human movements in videos, identifying objects, tracking moving objects, and recognizing faces.

1.1 DIFFERENT ALGORITMS FOR FEATURE EXTRACTION

1.1.1 Harris Corner Detection - Corner detection algorithm aids in locating the corners in a picture. Usually, two or more edges come together to form a corner. The boundaries of an image may or may not be defined by these corners. The Harris corner identification algorithm is employed in this case. It aids in highlighting the corners of each component in a colour image. This increases the effectiveness of detection, and research suggests that this procedure is more dependable than conventional ones[9]. It has been shown that the Harris corner detector is more accurate at differentiating between edges and corners since it immediately considers the disparity of the corner score with regard to direction instead of requiring shift markings for every 45-degree angle.

1.1.2 SIFT - Scale Invariant Feature Transform, or SIFT, is one of the most important image processing methods that was first introduced in 1999. David Lowe was the one who created it. Using the Euclidean distance, different points are found and matched in the SIFT method. A single image is split up into several feature points using the SIFT approach. To scale and rotation of the image, none of these points change. [8] Additionally, the locations of Key Points are used as Maxima and Minima.

1.1.3 SURF - The SURF algorithm, also known as speeded up robust features, is a computer vision tool with many uses, including feature point extraction, tracking, reconstruction, and identification. It transforms the picture or video capture into coordinates using a pyramid structure approach. [8] In comparison to its competitors, it is quite quick and is recognized for speed.

1.1.4 ORB - Computer vision employs a method for detecting and describing features known as ORB (Oriented FAST and Rotated BRIEF), which is used for tasks such as image stitching and object recognition. The algorithm merges the FAST (Features from Accelerated Segment Test) and BRIEF (Binary Robust Independent Elementary Features) techniques. By locating corners where the intensity of the image changes quickly, the corner detection algorithm FAST locates important areas in an image. With the help of the binary descriptor algorithm BRIEF, each key point is represented by a brief binary code that encapsulates all its distinctive qualities. The ORB algorithm combines these two algorithms by first using FAST to detect key points in an image, then using BRIEF to generate a binary code for each key point based on the intensity values of the pixels around it. The ORB algorithm also includes additional steps to improve the robustness and accuracy of the feature detection and description, such as orientation estimation and scale-invariant feature detection. Overall, the ORB algorithm is a popular and effective algorithm for feature detection and description in computer vision applications, particularly in cases where real-time performance and robustness are important. [8]

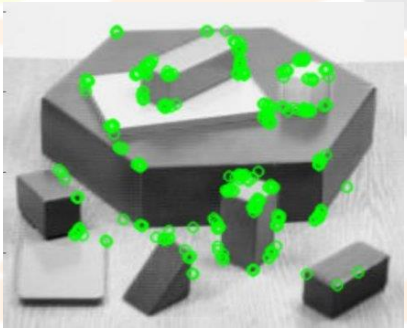

Fig.2 corner detection using orb

1.1.5 FAST - Edward Rosten and Tom Drummond published it in 2006. The Features from Accelerated Segment Test is known as FAST. Faster than most of the alternatives it is compared to, the FAST image processing method stands out for its speed. Accuracy is not present.[8]

1.1.6 BRIEF - This is where BRIEF enters the picture. It gives you a shortcut to quickly locate binary strings without first looking for descriptors. It chooses a collection of nd (x,y) position pairs in a novel manner using a smoothed picture patch (explained in paper). Then, several pixel intensity comparisons are carried out on these location pairings. Let p and q be the initial location pairs in the example. The outcome is 1 if I(p)=I(q), otherwise it is 0. To create and-dimensional bitstring, this is done for each pair of nd locations. BRIEF is an algorithm used as a feature descriptor, it does not offer a way to locate the features, which is a crucial distinction. Therefore, we need to employ any other feature detectors, such as SIFT, SURF, etc.[8]

1.2 DIFFERENT ALGORITHMS FOR FEATURE MATCHING

1.2.1 Brute Force Matcher - The Brute Force Matcher approach compares all features in two images for feature matching, but can be inefficient for large datasets. A ratio test is applied to remove false matches. This technique is useful for small-scale applications, but can be improved with more complex algorithms. [6]

Fig. 3 brute force matcher

1.2.2 FLANN based Matcher - Using an algorithm like SIFT or SURF, the FLANN based matcher algorithm first finds and describes features in two images. These features are represented as high-dimensional vectors, and a search tree is then made by indexing them with the FLANN library. The method looks for each feature vector's closest neighbour in the search tree in order to compare the features between the two images. The match is deemed legitimate if the ratio of these distances is less than a specific value. [6].

A conventional wireless power transfer (WPT) system uses two coils to transmit power from one point to another. One of these is a transmitter, while the other is a receiver. The transmission range and power transfer efficiency of these systems are two of the most important factors that affect their performance. [9]Three primary techniques, including (i) inductive power transfer (IPT) (ii) conventional capacitive wireless power transfer (CWPT) (iii) magnetic gear wireless power transmission, have been employed as the main methods for developing wireless charging systems for electric vehicles (WCSEV) since the advent of wireless charging. (MGWPT). WPT systems are more effective when the parameters of the transmitter and receiver antennas are optimized. [10][9]These charging points do not get affected due to chemicals, dirt, water, and harsh environment.

1.3 WIRELESS POWER TRANSMISSION TECHNIQUES

1.3.1 Inductive Power Transfer - Inductive Power Transfer (IPT) is a method of wirelessly transmitting electrical power through the use of an electromagnetic field. The setup is composed of a pair of coils, one known as the primary coil that is linked to a power supply, and another called the secondary coil that is affixed to the device undergoing charging. The process of wireless charging using Inductive Power Transfer (IPT) involves the generation of an oscillating magnetic field by the primary coil when an alternating current passes through it. This magnetic field induces an electric current in the secondary coil, resulting in the charging of the device. IPT is widely used for charging electric vehicles and consumer electronics due to its convenience and high efficiency. The transmitting coil used to charge electric vehicles is encased in a charging pad, while the receiving coil is positioned beneath the car. Since there is no need for direct physical contact between the vehicle and the charging infrastructure, IPT charging is seen as a practical and secure substitute for conventional charging techniques. [9]

1.3.2 Capacitive Power Transfer - Capacitive Power Transfer (CPT) is a technology for wireless power transfer that facilitates power transfer between two objects via capacitive coupling, without requiring any direct physical contact between them. It works by creating an electric field between a transmitting plate and a receiving plate, which can be separated by a short distance. The process starts when an AC voltage is applied to the primary plate, which generates an electric field. This field then induces an AC voltage on the secondary plate, which is connected to the load. This AC voltage is then rectified and regulated to provide a DC voltage for the load. The efficiency of CPT is determined by the capacitance between the two plates, the distance between the plates, and the frequency of the AC voltage. Increasing the capacitance and decreasing the distance between the plates can improve the efficiency of the system. However, the distance between the plates cannot be too small as it may lead to arcing and other safety concerns. Overall, Capacitive Power Transfer is a promising technology that has the potential to revolutionize the way we charge our devices and electric vehicles. [9]

1.3.3 Magnetic Wireless Power Transfer - The Magnetic Wireless Power Transfer (MWPT) technique uses magnetic fields to wirelessly send electrical power from a source to a device. A secondary coil and a primary coil of wire are used, and they are spaced close together. The primary coil receives an alternating current, which generates an oscillating magnetic field. The secondary coil experiences an electric current due to this magnetic field, which can be used to power the gadget. MWPT has several advantages over traditional wired power transfer methods. It is more practical because it does not require physical connectors or cables and can be utilized in situations where making physical connections is challenging or impossible. Additionally, because exposed wiring no longer poses the threat of electric shock, MWPT is safer. There are many applications for MWPT, including implantable medical devices and wireless charging for EVs and mobile devices. However, when the distance between the primary and secondary coils increases and there are obstructions in their path, the efficiency of MWPT rapidly declines. Therefore, optimizing the magnetic field frequency and coil design is crucial for MWPT systems to achieve high efficiency. [10][9]

Table 1Comparison between various WPT techniques

Wireless Power Transfer			
	Capacitive	**Inductive**	**Permanent Magnet**
Power Transfer Method	Varying Electric Fields	Varying Magnetic Field	Resonance between circuits
Gap between Coils	< 1mm	> 10 cm	2 m
Gap Power Density	Low	High	High
Medium	Capable of passing through metals	Only through air	Object, materials, body tissues
Power Levels	Low Power Applications	Medium to High Power Applications	High Power Applications
Power Losses	High	High	Low

Thus, the most feasible method would be that of Inductive Coupling.

II. LITERATURE REVIEW

K Gautam [8] This paper proposes a method for detecting currency using the MATLAB software. This paper employs the Hybrid Algorithm. For feature extraction, the Linear Binary Pattern algorithm is used. For feature matching, the Principal Component Analysis and the Euclidean Algorithm are used.

V S Teja et al. [9] If we use an ultraviolet LED, the watermarks in the note are highlighted. Then, based on the parameters of the currency note's HSV (hue saturation value), determine whether the currency is genuine or counterfeit.

S SVeling et al. [6] capturing notes under UV, regular LED, and multicolor LED illumination. The given note is classified as 100, 500, or 2000 based on the Aspect Ratio. Entropy and Mean values are calculated. A graph is plotted between the real and fake notes at various modes and wavelengths. ROI extraction method is used for feature extraction. Difference in entropy values indicates whether the given note is real or fake.

Jaya Tripathi et al.[10] propose a technique that makes use of four characteristics of paper currency: identification mark, security thread, latent image, and watermark. The coefficient of correlation (r) is used to measure statistical correlation, and its numerical value ranges from +1.0 to -1.0. It tells us about the strength of the relationship.

Kulkarni A [9] discusses SIFT, SURF, and ORB are three of the OpenCV methods for feature identification and description covered by Kulkarni A [9]. Based on how well the algorithms match features, they are ranked in the following order: SIFT<SURF<ORB. The following algorithms are the most effective in terms of picture matching speed: SURF, SIFT, and ORB. The Orb algorithm with the Brute Force matcher turn out to be the most effective for detecting currency in a real-time system.

According to Ebrahim Karami [1] In terms of performance, SIFT is considered the most effective algorithm in many scenarios, while ORB is the quickest. However, in situations where the rotation angle is proportional to 90 degrees, ORB and SURF provide better performance than SIFT. In noisy images, both ORB and SIFT perform comparably well. Additionally, the features detected by ORB are typically concentrated in the center of the image's objects, while SURF, SIFT, and FAST detectors are distributed throughout the image.

Rohit Pokala, Varun Teja [9], present a currency identification system for blind people. Raspberry Pi and PiCamera are used for acquiring images. For feature extraction and matching, OpenCV ORB Oriented FAST and rotated BRIEF) and Brute Force Matcher are utilized.

S R Khutwad et al. [4] The study describes a cutting-edge method for an electric vehicle's wireless charging system that uses an electric vehicle's battery charger to validate the theory that has been created. This paper describes the wireless battery charging system for electric vehicles that has been constructed using the inductive coupling approach.

Naoui Mohamed et al. [7] provides an overview of the various topologies for wireless charging systems that can be used with electric vehicle applications. It presents some data on the application of wireless charging technologies in various industries. Future WPT application concepts are addressed, showing how deploying WPT systems in tandem with renewable energy systems is feasible.

According to P Ram [2] the corner of an image can be identified with the use of a corner detection algorithm. It aids in highlighting each component's corner in a colour image. This increases the effectiveness of detection, and the experimental data demonstrates that this procedure is more trustworthy than conventional ones.

F K Noble [3] et al. This study suggests that the Brute Force (BF) matcher matched the most detected features in an image pair and that the Speeded-Up Robust Features (SURF) detector found the largest number of features in an image.

III. METHODOLOGY

This project can be separated into two sections: wireless power transmission and image processing. We concentrate on the DIP part first. Three LED lights are arranged for Rs 10, Rs 20 and Rs 50respectively. A python code based on ORB and Brute Force Matcher algorithm is then implemented. This program detects the denomination of the currency shown by the user and blinks the respective LED. Optimum lighting conditions must be taken care of while capturing pictures. Three LDR sensors are used to detect which LED is High. The Part 2 circuitry is activated by the microcontroller in accordance with the denomination of the note that was scanned.

Charging is done in the second section. In this part, we use inductive power transmission technique to transfer power wirelessly. Primary coil is present under the charging pad placed on ground whereas the Secondary coil is under the floor of the car. Ground clearance of the car must be such that it does not reduces the magnitude of EMF induced in secondary coil.LDR sensors from Part 1 define the time for which charging is to be performed. 10 seconds for Rs 10 and 15 seconds for Rs 20.

Faraday's Law of Electromagnetic Induction explains how an induced electric current is produced in a conductor due to a changing magnetic field. According to the law, a conductor induces a voltage that compels an electric current to flow as it moves through a magnetic field or when the magnetic field passing through it changes. Few ways to change the magnetic field intensity in a closed loop: (i) by changing the current in the loop (ii) by changing the number of turns in the loop (iii) by changing the area or shape of a coil placed in the magnetic field (iv) by changing the orientation of the loop (v) by using a magnetic core. The basic idea is to keep the flux cutting the secondary coil. Here we use AC power supply. An electrical circuit must convert AC 230V 50Hz to AC 12V, high frequency, and feed this to an air core transformer's primary coil in order to do this. A frequency of 12V is generated by the transformer's secondary coil. In order to run a load, the secondary coil gets power from the primary coil, which also serves as a transmitter.

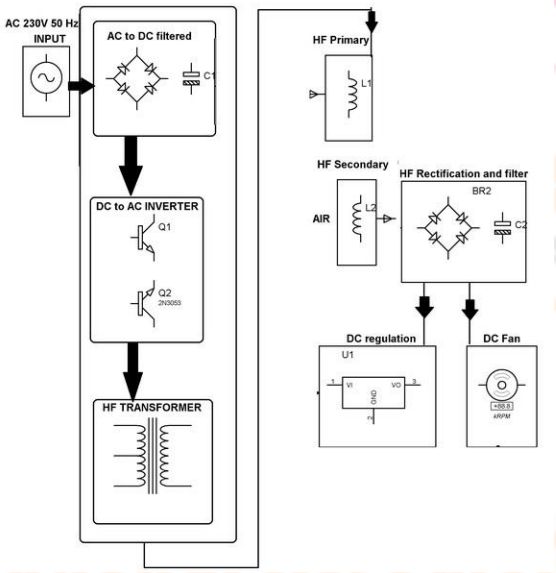

Fig.4 WPT block diagram

IV. CONCLUSION

Electric Vehicles are the Future of Driving. Their operability and accessibility need to be improved to make them more user-friendly. Our project proposes a method to charge them without any hassle at most of the locations in a city. By using digital image processing, we provide a payment gateway for the charging services, that also removes the requirement of any manual assistance. For recharging purposes, the concept of Wireless Power Transmission is considered. In the future this method can be used to build roads with continuous charging pads, so that cars can keep on driving and recharge themselves simultaneously.

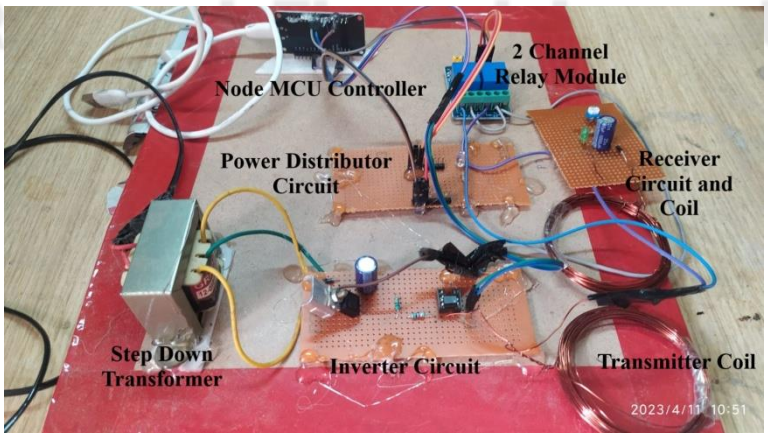

Fig. 5 final project circuitry

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