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Pollution Monitoring Robot Application for Smart Cities

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ABSTRACT: Efficient waste collection is a necessary service in the application of Smart Cities. The use of emerging technology may lead to significant improvement in the waste management process. In this work, we propose an IoT-based architecture that targets two elements. The first is monitoring the waste volume and content in a waste bin, as well as the bin's surroundings. The second entails dynamic scheduling and routing of waste collection vehicles based on the relayed information from the bins. The waste bin design detects any obstacles around the bin and monitors illegal dumping in the vicinity of the bin. The routing protocol provides an optimal solution for waste collection from the filled bins in high density residential areas while minimizing the length of the trip. The combined improvement of these elements will result in increasing the efficiency of waste collection, reducing and carbon footprint.

I. INTRODUCTION

Proper waste management is an integral aspect of city management. Continuous development efforts lead to employing novel technology to reduce operational cost while maintaining consistent levels of service. Current waste collection efforts utilize static route planning with fixed scheduling, which indicates there still exists areas for continued development and improvement in this field.. Such an approach is costly and generates a high-carbon footprint. The slow adoption of recycling in some cities also continues to result in monetary losses. The lack of recycling in Saudi cities, for example, is estimated to result in 40 billion SAR (~\$10.6 billion) per year in losses . Meanwhile, the absence of waste monitoring and limited waste-bin allocation per household may lead the public to overfill their bins or discard waste in non-designated areas. The city may thereby incur additional costs for the added demand for waste removal and management. The latter is most pronounced in areas with strained infrastructure, such as restaurant clusters or narrow pathways between houses. Bursts in waste generation, such as those following national holidays, can also generate a widespread high demand for waste collection.

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sandwiched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed. Polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polarisers are pasted outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction

When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters. The LCD's are lightweight with only a few millimeters thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD's

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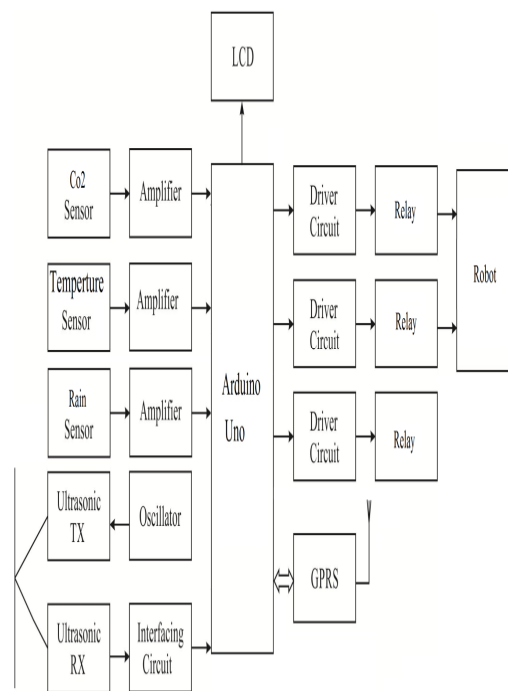
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don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range. Changing the display size or the layout size is relatively simple which makes the LCD's more customer friendly. The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

II. BLOCK DIAGRAM



Background work

This study introduces a rollon-rolloff waste collection vehicle routing problem involving large containers that accumulate huge amounts of garbage at construction sites and shopping districts. In this problem, tractors move one container at a time between customer locations, a depot, disposal facilities, and container storage yards. The complicated constraints discussed in this study arise from having multiple disposal facilities, multiple container storage yards, seven service types of customer demands, different time windows for customer demands and facilities, various types and sizes of containers, and the lunch break of tractor drivers. In addition, real-world issues, such as changing service types, multiple demands at a customer's location, and tractors with different work schedules, are dealt with. This study proposes a large neighborhood search based iterative heuristic approach consisting of several algorithms for the problem. The effectiveness of the proposed methods is demonstrated by computational experiments using benchmark data, some instances of which are derived from real-world problems.

In this paper, an image-based waste collection scheduling involving a node with three waste bins is considered. First, the system locates the three bins and determines the waste level of each bin using four Laws Masks and a set of Support

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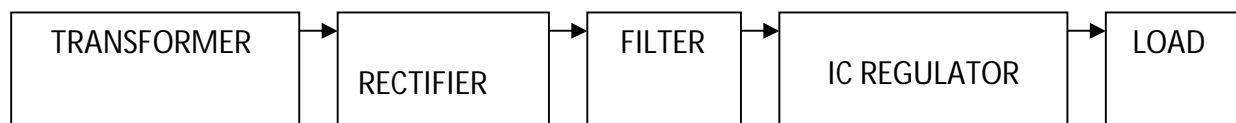
Vector Machine (SVM) classifiers. Next, a Hidden Markov Model (HMM) is used to decide on the number of days remaining before waste is collected from the node. This decision is based on the HMM's previous state and current observations. The HMM waste collection scheduling seeks to maximize the number of days between collection visits while preventing waste contamination due to late collection. The proposed system was trained using 100 training images and then tested on 100 test images. Each test image contains three bins that might be shifted, rotated, occluded or toppled over. The upright bins could be empty, partially full or full of garbage of various shapes and sizes. The method achieves bin detection, waste level classification and collection day scheduling rates of 100%, 99.8% and 100% respectively.

Plastic waste is a special category of municipal solid waste. Plastic waste collection is featured with various alternatives of collection methods (curbside/drop-off) and separation methods (source-/post-separation). In the Netherlands, the collection routes of plastic waste are the same as those of other waste, although plastic is different than other waste in terms of volume to weight ratio. This paper aims for redesigning the collection routes and compares the collection options of plastic waste using eco-efficiency as performance indicator. Eco-efficiency concerns the trade-off between environmental impacts, social issues and costs. The collection problem is modeled as a vehicle routing problem. A tabu search heuristic is used to improve the routes. Collection alternatives are compared by a scenario study approach. Real distances between locations are calculated with MapPoint. The scenario study is conducted based on real case data of the Dutch municipality Wageningen. Scenarios are designed according to the collection alternatives with different assumptions in collection method, vehicle type, collection frequency and collection points, etc. Results show that the current collection routes can be improved in terms of eco-efficiency performance by using our method. The source-separation drop-off collection scenario has the best performance for plastic collection assuming householders take the waste to the drop-off points in a sustainable manner. The model also shows to be an efficient decision support tool to investigate the impacts of future changes such as alternative vehicle type and different response rates.

III. METHODS

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.



Block diagram (Power supply)

IV. WORKING PRINCIPLE

Transformer

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op-amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

Bridge rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.

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One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

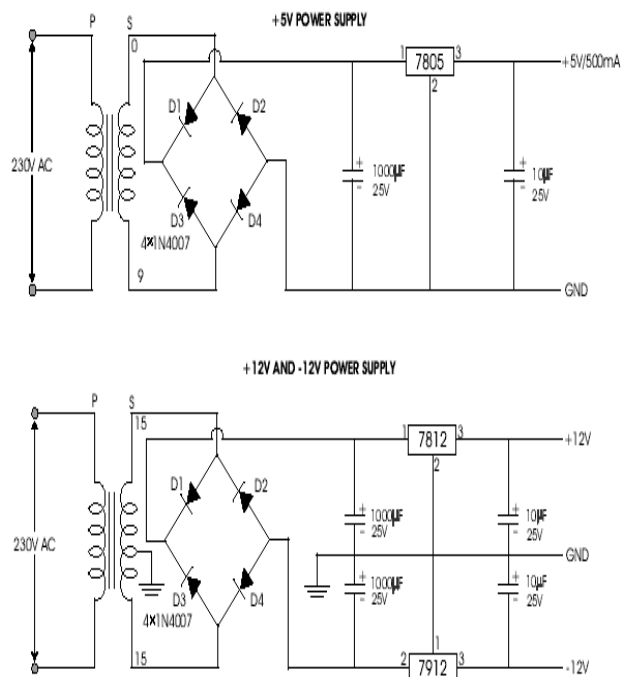
This may be shown by assigning values to some of the components shown in views A and B. assume that the same transformer is used in both circuits. The peak voltage developed between points X and y is 1000 volts in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the center tap to either X or Y is 500 volts. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts.

The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 v0lts, as result of the small voltage drop across the diode. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000 volts. Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

IC voltage regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

Circuit diagram (Power supply)



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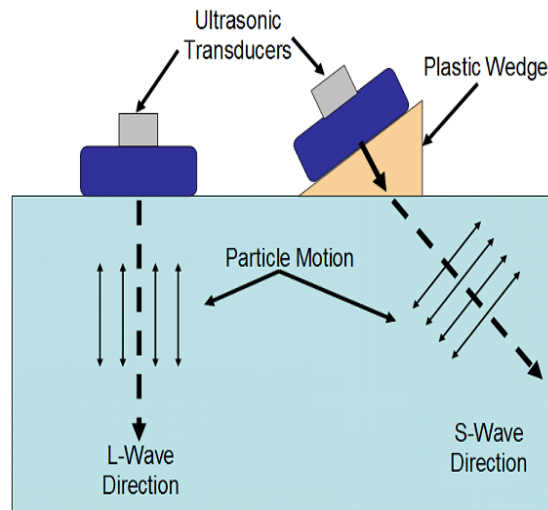
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A fixed three-terminal voltage regulator has an unregulated dc input voltage, V_i , applied to one input terminal, a regulated dc output voltage, V_o , from a second terminal, with the third terminal connected to ground.

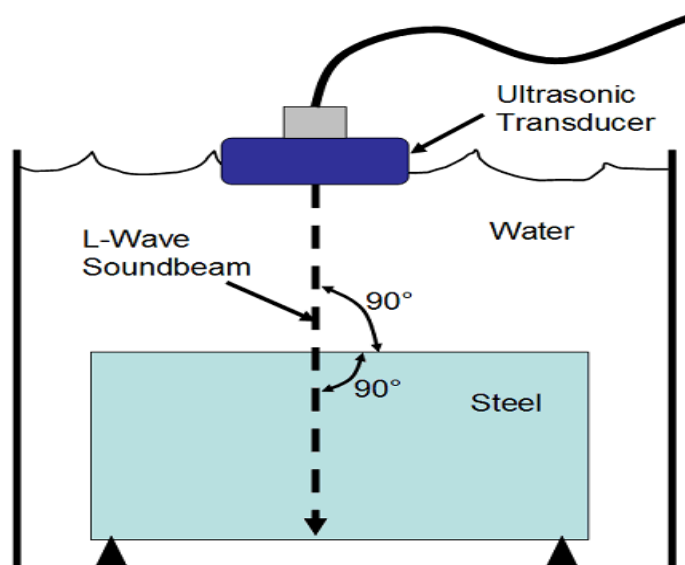
The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

- For ICs, microcontroller, LCD ----- 5 volts

For alarm circuit, op-amp, relay circuits ----- 12 volts



Ultrasonic beam refraction and mode conversion is comparable to light as it passes from one medium to another. Remember how the straw in the glass of water looks broken if observed from the side? The same phenomenon occurs with ultrasonic waves as they are passed into a UUT. The figure below depicts an ultrasonic transducer that transmits an ultrasonic wave through water into a block of steel. Because the direction of the ultrasonic wave is at a 90 degree angle with the surface of the steel block, no refraction occurs and the L-wave is preserved.



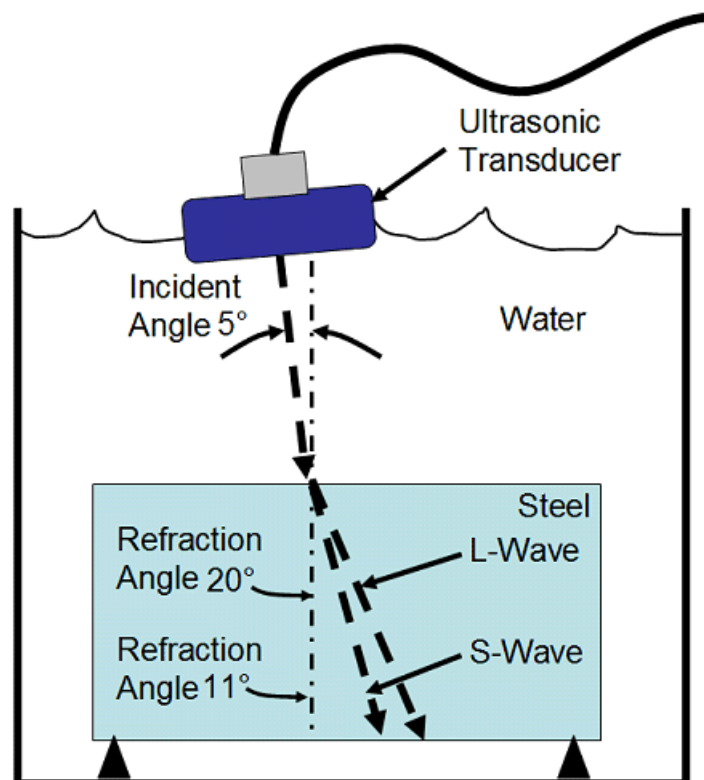
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As the angle of the ultrasonic transducer is altered, refraction and mode conversion occur. In the figure below, the ultrasonic transducer has been rotated 5 degrees. The longitudinal wave from the transducer is converted into two modes, longitudinal and shear, and both wave modes are refracted. Notice that the waves are refracted at different angles. In this example, the L-wave is approximately four times the transducer angle and the S-wave is just over two times the transducer angle. Angles that create two wave modes are not appropriate because they cause the ultrasonic transducer to receive multiple echoes, making it difficult to analyze the data.



Refraction and mode conversion occur because of the change in L-wave velocity as it passes the boundary from one medium to another. The higher the difference in the velocity of sound between two materials, the larger the resulting angle of refraction. L-waves and S-waves have different angles of refraction because they have dissimilar velocities within the same material.

V. CONCLUSION

This paper presents an architecture based on IoT with the objective of improving waste management systems. Our approach is a holistic review of the waste management system, starting from smartening-up the waste-bin to optimize waste collection times and anticipating the nature of collected waste to considerations of the collection vehicles, their route planning and scheduling. The presented architecture depended on a cloud-based implementation for the processing and computation core. The system offers great flexibility in terms of implementation, especially given its complete dependence on off-the-shelf technology. It also allows for varied waste-collection objectives. The architecture is currently undergoing prototyping of its different components, and future work will offer further

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elaboration on their implementation and testing The principle of the development of science is that “nothing is impossible”. So we shall look forward to a bright & sophisticated world.

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