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SMART JAR: AI TECHNOLOGY BASED GROCERY SHOPPING

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ABSTRACT

As per the Regional Human Development Report of the United Nations Development Programme (UNDP) on April 26, 2016, India's working population between the ages of 15-64 will rise above 1 billion by 2050. Working in a professionally driven environment is highly cumbersome at times; especially, when the individual is surrounded with the office and household responsibilities. Household responsibilities include various things such as taking care of the grocery stocks, paying various bills on time and other basic daily chores. While fulfilling official duties, it is common for the working individual to be oblivious to his household responsibility. While it is difficult to take care of others' professional work, domestic work can be easily taken care. Through this project, we intend to reduce the significant amount of time devoted by people on replenishing their groceries by providing them with the concept of 'Smart jar'. Apart from refilling the items, through the A.I. model this project not only selects the desired quality, but also a type of delivery based on an individual's buying pattern at the least possible price. This new concept can be a revolutionary as it intends for a paradigm shift in the conventional grocery shopping technique.

Keywords: Piezoelectric, Ultrasonic, Smart Jar, Neural Networks, Training, Epoch, GPRS and Levenberg-Marquardt algorithm.

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1. INTRODUCTION

According to the Time Use Institute, the average shopping trip takes 41 minutes. If you multiply that by the 1.5-trip per week average, that's over 53 hours per year you're spending in the grocery store. Due to the unavoidable rush on weekends, this same time increases by 17%. This spurge on weekends is mostly due to the salaried class spending their valuable

weekend on grocery shopping. This inefficient use of time and forgetting to replenish the groceries marks the first problem. Secondly, to save few bucks or to avail any special discount they wander from store to store just to buy a couple of items. According to the USA Today reports, half of the supermarket shoppers visit three or more stores to purchase bread, milk and household products. This adds to the total time spent, thereby leading to wasting time. This project also takes care of this secondary issue through the use of A.I. model.

The primary issue of forgetting to refill the grocery and spending valuable time in the supermarket is resolved with the help of piezoelectric sensor, ultrasonic sensors and a MCU with GPRS based communication module. Selection of desired quality at the best possible price is taken care through the neural network model which trains itself based on the buying patterns of the individual.

2. OVERVIEW

2.1. Block Diagram

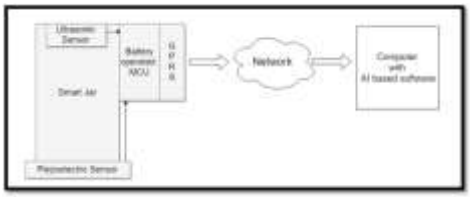

Figure 1 Explaining the Major blocks involved in the Smart Jar

As explained in the above block diagram(Figure 1), the complete system consists of a Piezoelectric sensor, Ultrasonic sensor, battery operated MCU with GPRS interface and a computer at the grocery shop running with a customized AI based software to display the output.

Each Jar will consist of a set of Piezoelectric and Ultrasonic sensors which will be given to the MCU. After receiving the data from Piezoelectric and Ultrasonic sensors; based on a predefined logic MCU will communicate to the GPRS Module via UART and the pertinent data will be sent to the intended PC at the grocery shop. Exclusive software running on the PC will identify the user based on its SIM number and it will generate an output with the help of a pre-trained neural network. Since each customer's buying pattern is unique so as their SIM numbers, consequently, it will be used to uniquely identify them.

2.2. Piezoelectric sensor

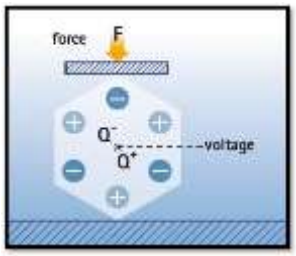

Figure 2 Working principal of piezoelectric effect

The piezoelectric effect can be understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials. The piezoelectric effect is a reversible process in that material exhibiting the direct piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force). When

measuring with piezoelectric sensors (based on piezoelectric effect), there is virtually no displacement, as the quartz already forms the mechatronic component with an electrical output signal as shown in figure 2. The sensitivity of a piezoelectric sensor does not usually depend on its size or on the volume of quartz, but on the material being used and its geometry. A piezoelectric transducer has very high DC output impedance and can be shown as a proportional voltage source and filter network. The voltage at the source is directly proportional to the applied force, pressure, or strain.

2.3. Ultrasonic sensor

Ultrasonic level sensors work by the "time of flight" principle. The pulse is transmitted in a cone, usually about 6° at the apex. The pulse impacts the level surface and is reflected back to the sensor, now acting as a receiver, and then to the transmitter for signal processing. Basically, the transmitter divides the time between the pulse and its echo by two, and that is the distance to the surface of the material. The transmitter is designed to listen to the highest amplitude return pulse (the echo) and mask out all the other ultrasonic signals

2.4. MCU and GPRS interface

MCU with at least one UART and two GPIOs should suffice for the application. In order to improve the battery life, one can go for a low power consuming MCUs available in the market. GPRS module provides a wireless communication interface between the consumer and grocery shop for the data communication. TCP/IP protocol can be used over UDP to improve the reliability of the communication.

2.5. System at the Grocery shop

AI-based customized software running on the PC at the grocery shop will process the information and generate the output. The training process of a neural network based on the training data set and a satisfactory Mean square error (MSE) achieved is explained in detail in the AI model section of this paper.

3. FUNCTIONALITY

As seen from fig. 3, in the case of an empty jar, the output of the piezoelectric sensor would represent the weight of the setup alone. While calculating the content of specific item to be stored in the jar, this value has to be taken as reference and hence the output value of piezoelectric (value P0) is scaled to zero in the calibration function. At the same time i.e. when the jar is empty the output of the ultrasonic sensor is recorded (value S0). Ultrasonic sensor value will vary with the level of the content inside the jar whereas piezoelectric sensor value will vary with the weight of the content in the jar. Thus when the controller reads P0 and S0, it can be assured that the smart jar is completely empty.

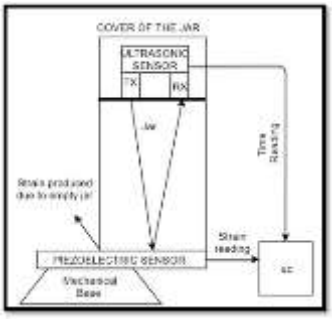

Figure 3 Case when jar is completely empty

For the jar to function as per requirement, it has to be once filled completely with the commodity for which it will be used for. As seen from fig. 4, once the jar is completely filled, the output of Piezoelectric will be P1 (greater than P0) and that of ultrasonic will be S1 (S1 will be zero). Thus when the controller reads P1 and S1 it can be assured that the smart jar is completely filled. The value of P1 would be different for different types of commodities depending upon the density of the commodity. Also, the output of Ultrasonic and Piezoelectric will always be between S1-S0 and P1-P0 respectively.

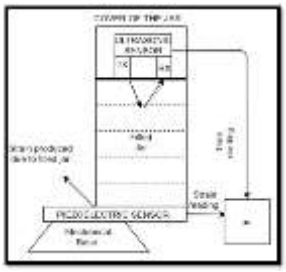

Figure 4 Case when jar is completely filled

3.1. Case 1

If only a Piezoelectric sensor (weight sensor is used), then the reading obtained from the sensor might represent the actual commodity or might represent a false commodity. For example, if somebody places a book on top of an empty jar, it will produce a mechanical force. If the setup is based only on piezoelectric then this false force will be treated as if the commodity is actually present in the jar. Whereas in the same situation when it is coupled with a level sensor, although, the microcontroller will read P1, however, S1 will not be zero (considering filled condition). Thus coupling of a piezoelectric sensor with an ultrasonic sensor is required.

3.2. Case 2

If only Ultrasonic sensor (level sensor is used), then also the reading obtained from the sensor might represent the actual commodity or might represent a false commodity. For example, if somebody fills the jar with any unforeseen commodity other than the intended item (anything like stone) and there's no weight sensor (piezoelectric) then the ultrasonic will sense that something is present and if the decision is made only on this reading then it will be spurious. Whereas in the same situation if piezoelectric is also present, then the reading P2 (reading of piezoelectric when the stone is present) and S2(reading of ultrasonic when the stone is present) will not match the expected reading. Expected reading is found after getting P0, S0, P1 and S1. Thus coupling of an ultrasonic sensor with piezoelectric is required.

4. AI MODEL

The A.I. model is a neural network predictor that is trained using the past data of the user. After the model gets trained, it is used to predict the future output using three predictors: Amount of grocery available, quality of goods purchased in the past, present %age of salary spent on buying grocery goods. These predictors act as input to the trained neural network. Before giving the predictors as input, the model is trained using the following past data of the user: Requirement urgency of the user, the price of the product user paid and quality of goods which he ordered.

Qualities of goods are divided into three categories: Premium goods, Average goods, below average goods. Whereas, depending upon the amount of salary spent on groceries, the price of the product is categorized into average price, below average price & irrelevant price.

According to the USA today reports published on August 4, 2017, an average individual spends around 11% of its monthly salary on groceries and dinning. Based on this, individuals spending around 11-24% are termed as average price spenders, while below 11% spenders are termed as below average price spenders. Individuals spending more than 25% of their salary on groceries are classified as premium spenders, for whom price is irrelevant. Average quality and below average quality of goods are available in all the price slots, whereas premium products are available only in the irrelevant price slab. Thus, anyone trying to order a premium product while spending only 11% will be modified to average product.

The combined output of the piezoelectric sensor and Ultra-sonic sensor obtained above will indicate the percentage of grocery present in the jar. Depending upon this reading, the type of delivery is classified as Express delivery, Normal Delivery & No Delivery. If the %age is below 30%, request for express delivery is placed; whereas normal delivery is initiated if the reading is between 30%-50%. If the reading reads above 50%, no delivery is required.

The neural network model shown in fig 4 is neural network fitting model with 10 neurons in the hidden layer along with 3 inputs and 3 outputs. Inputs to the trained model are the predictors mentioned above, while outputs are: Type of delivery, Cost a user might pay, Quality of good the user will purchase.

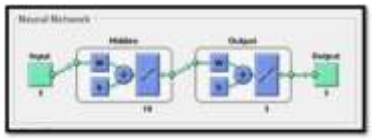

Figure 5 Neural network model

5. RESULTS AND DISCUSSION

The training model used for training the model of fig.5 was Levenberg-Marquardt model and its performance was monitored using the Mean Square Error (MSE). From fig.6 it can be observed that a total of 149 data values of a particular user were divided into training, validation and testing data set in 70-14-14 ratio respectively. After training, the MSE obtained was 0.01, as shown in fig.6. The performance of the model increased as the number of epochs increased while training. The performance graph is shown in fig.7.

Figure 6 Training model

The performance graph depicts the variation of MSE with the number of epochs for each kind of data sets. As observed, while training(Blue line), initially the MSE is quite high, but as it gets trained with different data sets of the user, MSE gets close to 10E-2. A similar pattern is followed by the testing data (red line) and the validation data (green line) as well. The dotted line in fig.7 indicated the best possible MSE in case of available data. Once the model gets trained up to 29 data points, i.e. 29 epochs, the MSE continues to be in a stable state. This indicates that the model is trained and MSE may not increase further thereby predicting accurate results.

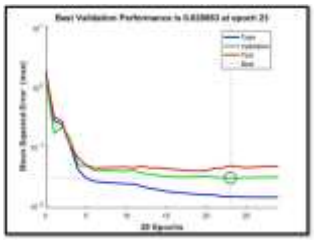

Figure 7 Performance graph of the model

6. CONCLUSION

It is noteworthy that the MSE is settled to an astonishing value in just 29 EPOCHS and a neural network is generating the highly accurate results. The smart jar could be a blessing for both customers and grocery shopkeepers. Customers can save their limited and valuable time for doing something more sophisticated and productive than doing mundane tasks such as grocery shopping. It will be beneficial for the shopkeepers also to plan the material and perform effective capital budgeting. However, As, This concept is at the nascent stage and it can be evolved further in the upcoming time. Multiple jars can be connected to a single MCU and GPRS interface with the help of multiplexer to reduce the cost and complexity. Since the size of the data packet to be transmitted is less, other low power wireless communication technologies such as NB-IOT can be explored. In a nutshell, the idea of a Smart jar can be revolutionary as it intends for a paradigm shift in the conventional grocery shopping.

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