Smart Storage Container for Solids

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Abstract: ***In this paper, we introduce a novel smart storage container for tracking the level of solid commodities (dal, rice, sugar, salt,, etc.,) stored to assist in inventory management without human interaction. The intelligent container is an application of Internet of Things (IoT) in kitchen automation. This technology incorporates an ultrasonic sensor that uses pulse echo method to monitor and sense the level of solid commodity kept within storage containers. A microcontroller monitors the level of commodity with the help of sensors and assists in tracking the quantity of commodity. Pulse echo method determines the difference between an empty container and a particular level of completion based on frequency values taken as threshold values. The microcontroller enhanced along with a GSM modem notifies the user or house owner and a request is sent to the store to deliver the commodity on the verge of completion. The smart and intelligent container provides personal assistance in monitoring the usage of day-to-day kitchen commodity.***

Keywords- IoT; ultrasonic sensors; smart intelligent containers; microcontroller; pulse echo method; GSM modem; inventory management.

I. INTRODUCTION

A.Background

The Internet of Things (IOT) is a domain for communication that enables interaction with devices such as monitoring sensors, microcontrollers, transceivers, surveillance cameras, displays, actuators, mobile phones, etc for easy access of multiple devices with suitable protocol stacks. It serves as a paradigm that visualizes the near future, in which objects of everyday life are equipped with recent technological advancement for digital communication that enables to communicate with other devices and with users [1].

It has been applied across different domains in various applications like kitchen automation, security surveillance, healthcare, elderly assistance and energy management. Internet of Things is a world-wide network of uniquely addressable interconnected objects enhanced with a standard communication protocol. It includes a collection of heterogeneous objects in a process. IoT enables low consumption of resources and energy.

The sensor networks play an important role in IoT. They help in monitoring temperature, pressure and movements collected across sensors and serve as a connection between digital and physical world. A smart environment is developed with the help of sensors and actuators. The sensor values obtained are converted into required digital information in a process. Different sensors obtain values based on a specific method i.e. an ultrasonic sensor uses frequency waves, temperature sensor uses thermistors and resistors. An ultrasonic sensor uses pulse echo frequency modulation for obstacle detection [2]. IoT accompanied by wireless technology and Wi-Fi avoids human interaction.

B.Motivation and problem statement

Kitchen automation system utilises a flexible and dynamic technology for operation of various interactive components in the kitchen like interactive cook tops that provides assistance and support to members. A smart and intelligent container is a storage container fitted with ultrasonic sensors that provides personal task assistance in inventory management. Personal Task Assistance (PTA) provides inventory management of kitchen foodstuffs automatically [7]. It helps to monitor the level of solid commodity stored within the containers. Inventory management is a process of automatically updating the completion of a particular commodity to the store for timely delivery.

A smart and an intelligent container is a storage device used in the kitchen to monitor the solid commodity level of component stored. An intimation message is sent to the user and request to the store to deliver the completed component using a GSM modem that deploys wireless network technology. The container is fitted with ultrasonic sensor on the lid that senses the level of commodity using sound waves. Ultrasonic sensors are deployed due to ease of installation and cost effectiveness.

Ultrasonic sensor provides shape recognition of objects with an ultrasonic transmitter, receiver and a recognition unit [7]. Based on the values and positions of sound waves the shape of the object can be determined. It can also determine the shape of transparent objects i.e. a pet bottle. The shape can be determined by ultrasound pressure distribution. Ultrasonic sensor can also determine the volume of a heap and mass of bulk commodity with pulse echo method. The sensor connected to a transducer helps to detect volume of substance [5]. The measurement of flat surface is first considered before calculating the volume of heap of commodity. The mass and volume of irregular heaps of substance placed in partially filled containers or moving conveyor belt is obtained with ultrasonic sensor that utilizes pulse echo method.

C.Principle

The intelligent container employs a wireless sensor network inside a container that utilizes an ultrasonic sensor with frequency sound waves to determine the volume of commodity stored. A supervision unit consisting of microcontroller collects data from sensor and continuously monitors for a particular level of commodity and sets a trigger to send a message using GSM modem to the user and store when it reaches completion.

Revised Manuscript Received on February 8, 2020.

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Personal task assistance is provided by a smart and intelligent container in kitchen automation. Inventory management is automated for solid kitchen commodity. Kitchen containers with sensors and microcontroller based network along with GSM modem contributes to the hardware configuration.

An ultrasonic sensor is deployed within the lid of the container due to low cost of installation and maintenance. Pulse echo method is utilized by the sensor where sound waves are transmitted and received within the container. Sensor consists of a high frequency sound wave transmitter and receiver that calculates the distance between the lid and object based on

$$r=c*t$$

Where r is the distance travelled, c is the speed of sound and t is the time interval of transmission.

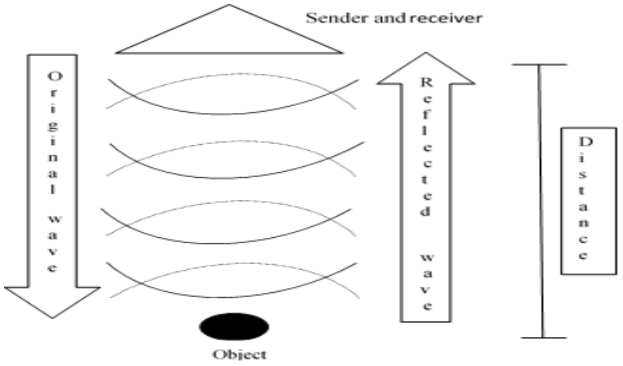

Fig. 1. Pulse Echo method of ultrasonic waves

The hardware components comprises of microcontroller, GSM modem, Ultrasonic sensor, storage container, power supply, LCD, and phone. The storage containers fitted with ultrasonic sensor in the lid transmits frequency sound waves, the waves move through the container and are reflected based on contact with the object inside the container. With the help of time of flight, pressure wave patterns the volume of the material is determined. Initially the value of the empty container and a specific level of completion are obtained.

The microcontroller continuously senses for level of completion of the commodity in the container. The comparison of values is performed in a repetitive manner. As the lid is closed the power supply is turned on and the microcontroller senses the level of commodity based on values obtained from sensor. The commodity in the level of completion within the container triggers the GSM modem to initiate a message transmission to the store and user

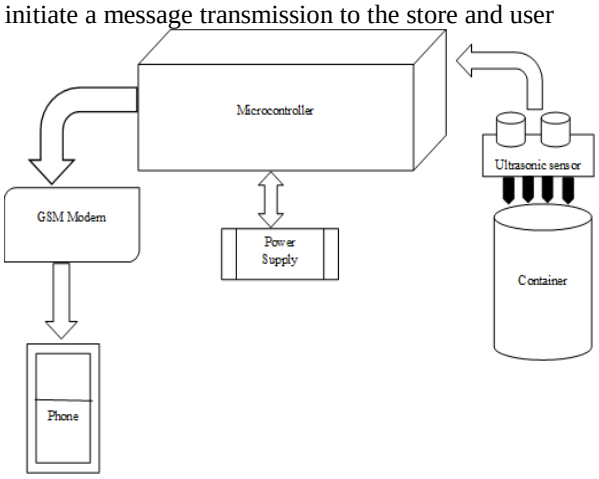

Fig. 2. Architecture of smart and intelligent container

II. LITERATURE SURVEY

A. Measurement of heap of quantity

The mass and volume of materials placed on partially filled container or conveyor belt can be determined using ultrasonic sensor that employs pulse echo method [5]. An inexpensive ultrasonic sensor was used to detect the volume amongst other sensors. The measurement was not limited to only food grains but also minerals and powders. A transducer array was used over the partially filled container or conveyor belt to determine the actual distance D and the commodity distance L_i.

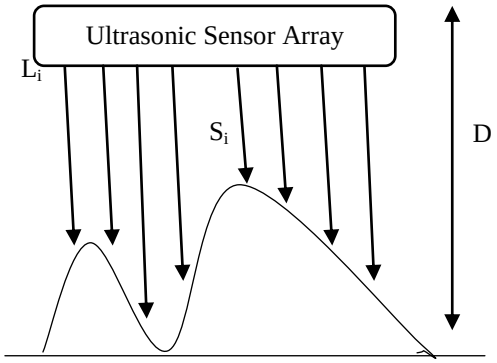

Fig. 3. Measurement of surface

$$S_i = \Delta x \sum_{i=1}^{N} (D\text{-}L_i)$$

The ultrasonic sensor utilizes pulse echo method over the surface of commodity stored in the container. The cross sectional area of the heap of the solid components was denoted by S_i. The sound waves traverse from the sensor array inside the container on contact with the heap of components returns time of flight and cross sectional area of the commodity that helps to determine the volume of heap of solid components stored.

B. Smart wheelchair with ultrasonic sensor

The smart wheelchair was designed using ultrasonic sensor and self-reliance factors for elderly disabled person [2]. The wheelchair could be operated by a joystick and ultrasonic sensor. Based on the self -reliance factor calculation, the controller establishes control over the wheelchair. The ultrasonic sensor employs pulse echo frequency method to determine obstacle in the pathway. It enables the elderly disabled driver to safe and efficiently. The wheelchair utilizes self-reliance factor for safety and assistance. The self-reliance factor for safety was evaluated based on linear velocity and angular velocity of the wheelchair.

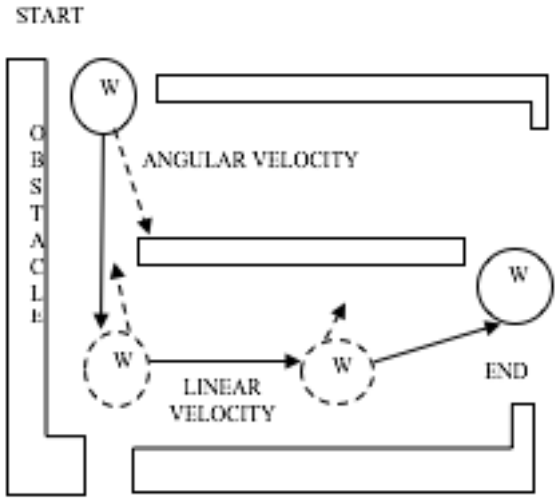

Fig. 4. Sensor based wheelchair

$$E_t = E_{t\text{-}1} + \left(\frac{1}{T_c}\right), \text{ if the driver rested}$$

$$E_t = E_{t\text{-}1} - \left(\frac{1}{T_c}\right), \text{ if the driver tired}$$

The equation represents self-reliance factor for assistance required by the driver where, T_c was the adaptive time taken by the disabled driver. The sensor system maintains the status of the wheelchair. The ultrasonic sensor in the wheelchair detects obstacle based on pulse echo method.

C. Object tracking

In traffic road environments enables tracking of objects using ultrasonic sensor. Ultrasonic sensor employs pulse echo method that uses frequency waves to determinate the distance of the surrounding road object and a temperature sensor along with control unit to specify the texture of the object. Ultrasonic sensors are preferred due to their wide detection angle [3]. Time of Flight (TOF) of the echo waves determine the distance of the road objects. The surrounding objects can be of regular, irregular shapes and different surface of materials. An array of ultrasonic sensors is utilized to collect large amount of data that help in probability distribution of object location. The relative distance of the object from the sensor, shape and material are identified.

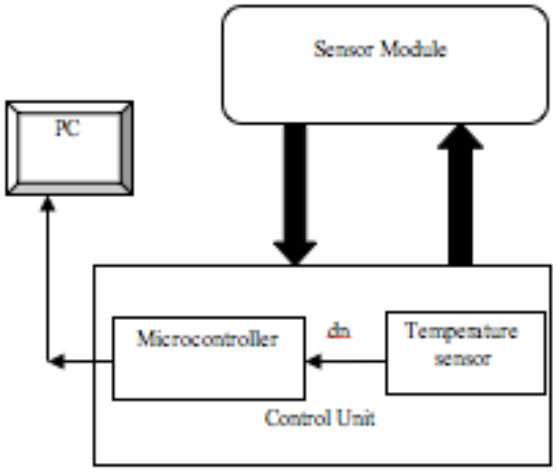

Fig. 5. Tracking Objects experimental setup

The sensor module is made up of an array of ultrasonic sensors, a temperature module that consists of an in built microcontroller and temperature sensors connected to a personal computer to track the surrounding objects on the road.

D. Object shape recognition

A recognition unit with ultrasonic sensor was used for identification of shape of objects. In addition it determined the shape of transparent objects i.e. a pet bottle. The recognition unit was built using ultrasonic transmitter, receiver and an array of ultrasonic sensors. The sound waves transmitted strike the objects and returned peak values with the help of pressurized sound waves a graph determined the shape of containers. Position of the object along with its shape in obtained. The ultrasonic sensor array consisted of sensors placed within 15mm to attain accuracy [7].

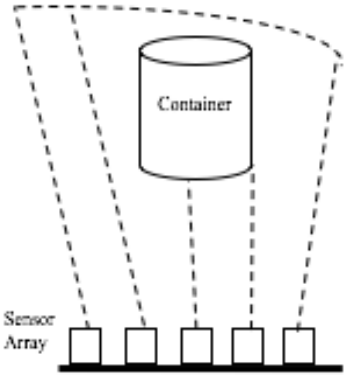

Fig. 6. Shape recognition using ultrasonic sensor

E. Intelligent container

Smart sensors are used inside large storage containers to prevent food loss due to cold chain, change in temperature, moisture content or pressure in large containers with multiple sensors i.e. temperature, pressure sensors help to prevent food loss with continuous monitoring and communication system [4]. Smart containers in kitchen automation employed RFID tags to detect the presence of commodity i.e. meat, pulses, spice, grains. An application was developed to provide personal assistance by constant upgradation of shopping list in the application with constant monitoring in containers using RFID [6].

III. EXPERIMENTAL SETUP

The Experimental setup is as follows: A transparent container filled with rice was used for the process. An Ultrasonic Sensor was placed on lid of the container with ultrasonic transmitter and ultrasonic receiver to sense the level of the commodity that use pulse echo method to detect the level. A Electric button was placed to avoid continuous current flow

Fig. 7. Setup of the smart container

When the lid is closed the button is pressed to initiate the current flow and activate the sensor placed within the container. The Arduino microcontroller reads the value and checks for the threshold value. As The commodity reaches below a certain frequency set as threshold within the Arduino Uno.

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switch is on"5in, 13cm
switch is on"0in, 0cm
switch is on"AT+CMGS="+918754509747"
NEED TO REFILL ITMNO:123 NO 321
 AT+CMGS="+919750216721"
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Fig. 8. Monitoring the levels of Commodity

An indication message has been sent to the departmental store to refill the specific commodity using the GSM Module.

Disadvantages:

Only solid commodities have been used in the process.

Fig. 9. Monitoring the levels of Commodity

In kitchen automation system, Personal Task Assistance (PTA) is provided using IoT, based on the sensor value an intimation message requesting the commodity for home delivery

Table 1 Results of recognition of levels of commodity measured in the smart storage container.

Measure of quantity by the sensor	Indication Message
5 Inches	No message
4 Inches	No message
3 Inches	Message Sent
2 Inches	Message Sent

IV. CONCLUSION

In this paper, the construction of a smart and intelligent storage container for domestic purpose is proposed in kitchen automation for personal assistance in inventory management. The proposed system consists of ultrasonic sensors, kitchen storage containers, battery, microcontroller, and GSM network for communication. It measures the quantity of the components stored within the container on reach of level of completion in the commodity an intimation message is sent to the user/ house owner and a request message to deliver the quantity is sent to the store. The different technologies applied in the proposed system are discussed. The proposed system provides a flexible and a smart way for inventory management.

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AUTHORS PROFILE

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