Design of an Intelligent Stove Knob Controller using a Mobile Application for Pakistan

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Summary
Kitchen is one of the essential part of day to day human life used for cooking purpose and despite being a simple task has its risks involved especially in South Asian countries like Pakistan. Negligence or lack of attention while cooking leads to disasters such as house fire. Fire detection is an area of interest around the world and kitchen fire is considered a common cause. In this work, a simple design of an intelligent Stove knob controller has been proposed which based on predefined gas threshold values, adjusts the knob of stove preventing hazards with warning buzzer for uncontrolled fire prevention. A mobile application has also been designed to allow controlling the knob remotely. The ultimate aim of the design is to reduce stove hazards caused by stove knobs in context of Pakistan which may result into fire and cause catastrophic damage including loss of human life.

Key words:
Stove knob, kitchen fire, Pakistan, NodeMCU

1. Introduction

Cooking fires are the primary cause of residential fires and fire related injuries [1]. Not only they can cause serious property damage by setting a house on fire, but there is also the scarier risk of causing burn injuries or even death to family members or neighbors. Generally fuel like Liquefied Petroleum Gas (LPG) or Biogas is used in stoves. It is estimated that explosive range of LPG is 1.8-9.5 % volume in air whereas flammable agent of Biogas is methane [2]. An average kitchen is filled with numerous hazards that may go unnoticed until an accident happens. In Pakistan, most of the burn injuries are related with kitchen fire [3]. In a study, it was found that among burn injuries in females, 34% were related to stove incidents [4]. A stove is a necessary household item. It is used on a daily basis, but life can be dangerous if stove is not operated properly. Unattended cooking is a leading cause of fire related accidents taking place in homes around the world. Kitchen fire is an issue not restricted to homes, but hotels also face kitchen fire incidents [5]. To tackle such issues various products are available in the market. [6] . But these wide ranges are not affordable to every common person. In a developing country like Pakistan, there is need to develop automated tools which can be helpful in minimizing stove related injuries and fires, remotely accessible as well as having safety features.

In this work, we have proposed the design of an intelligent stove knob controller which can easily work with the traditional gas stoves with safety features. The focal point of the research is the design of a smart knob which can be attached with a traditional gas stove along with the mobile application through which one can remotely control the knob in case of being far away from the stove. The application allows to monitor the status of the stove and provides alerts accordingly. The controlling mechanism has a gas detecting sensor which detects the gas and turns the burners off to avoid accidental situations like fire.
Rest of this paper is divided in such a way that Section-2 provides literature review. Section-3 describes the design of the proposed stove knob controller. Lastly, Section-4 is the conclusion and Future work.

2. Literature Review

In today's world, detecting fires is an important issue as it causes severe damage and even loss of precious life. Kitchen inside home is considered a place where likelihood of occurrence of fire is high and stove is one of the major equipment available in kitchen. Scientists and researchers are concentrating on development of automated devices, alarms to deal with this problem [7]. According to National Fire Protection Agency (NFPA) USA, kitchen was identified as the most dangerous place in the house. In United States. Statistics showed that cooking equipment was 47% contributor in home structure fires and second most cause of fire deaths [8].
It has been found that South Asian countries have more burn cases than other countries. World Health Organization (WHO) approximation is that more than 90% burns occur in underdeveloped countries. An estimation in line with WHO guidelines is that Pakistan also has the highest number of burn injuries. One of the major causes of burns is flame related burn [9]. In [10], authors performed a study to investigate the causes of burns in the Rawalpindi city of Pakistan. They argued that Pakistan generally has a poor record keeping structure in the area of health management. Results indicated that out of all burn injuries, 40% were women. They investigated that as women are more exposed to appliances at home. Stove burst or gas leakage while

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women were cooking in the kitchen was a significant factor. They concluded that surveillance systems are required to meet the challenge of burn related issues in Pakistan. In [11] , it has been suggested that steps are necessary to avoid burn issues in Pakistan as majority of such cases occur inside home. It has been emphasized that detectors and alarms inside homes are required to be installed and awareness among people to be increased in this regard.

In the literature, automated devices used to assist in kitchen stove related problems have been reported. In [2], authors have designed an automated gas stove with safety features. It consists of a microcontroller which senses through MQ6 sensor and IR proximity sensor any leakage of LPG. If a leakage is found it is reported to microcontroller. Then a Global System for Mobile Communication (GSM) module activates which turns on the buzzer indicating a warning signal that a malfunctioning has occurred. Also whenever a vessel is placed on the burner, it automatically goes to ON state and when a vessel is removed then it goes to the OFF state. The authors argued that in this way LPG consumption can be reduced. In [12] , the design of a LPG gas stove has been discussed. The system has been designed in such a way the besides sensing a vessel on stove as either ON or OFF state, it also counts the number of vessels on stove by using a pressure counter with a pre-set number. In this work as well, once a leakage is detected by the sensor, it activates the alarm. Another safety feature of the system was that using a GSM technology it can also send a message to a predefined mobile number. The main limitation was the system was use of a power source for working of alarm system and sensors. Authors in [13] have developed an automated gas leakage monitoring system with feedback and feedforward control integrated with Internet of Things (IOT). They used LPG for the design explanation. MQ6 gas sensor was used to sense the level of gas concentration. A relay based switching mechanism with thingspeak cloud was setup if the leakage value crosses 300 PPM. The controller used for the purpose was NODE MCU v 10. It was concluded that this hybrid approach integrating relay switches, embedded system and IOT was able to provide efficient mechanism for stopping the LPG leakage resulting in catastrophic incidents. In [14], a design of smart stove which is a modification of traditional stove has been presented. A timing device has been attached to stove which automatically turns on and turns off stove. A mechanical gear was attached with the stove connected to a stepper motor. Controlling mechanism of smart design also involved Arduino UNO. Authors argued that proposed method was able to save the fuel as well because of time setting and automated control. It was also mentioned the design was economical as well as efficient. Authors in [15] have proposed a design of hazardous gas detection with altering mechanism based on sensors. They analysed that people above the age of 60 have smelling disorders and any find it difficult to smell gas leakage. The proposed system utilized MQ6 sensor and as soon as there is a gas leakage, sensor is invoked and turns off the stove knob automatically and also sends the message to the consumer. Hardware of the design also included ATMEGA which is an AVR architecture. In worst case scenario, power is completely cut off. If the power is cut down before that because of any reason the system can work on batteries as well as on generator or on inverter power supply.

Other than this, in [8] a smart protection device has been proposed which can also be used in kitchen. The device uses a sensor to detect the temperature and OpenMV camera to search for the people around the place. If after a certain amount of time, the result of search is a negative one then an alarm will be activated. It will inform the persons that there is a hazardous situation occurring and to respond to avoid any damage.

The literature review reveals that fire and burn incidents have a strong correlation with kitchen stove around the world including Pakistan. There is need to develop economical safety systems to provide protection from kitchen hazards. In the next section, we describe the methodology used to design the stove knob controller and its management through mobile application.

3. Methodology

As the main design of the system relates with the stove knob, therefore, Fig 1. Shows the structure of stove knob unit whereas Fig.2 shows the block diagram of the proposed design of the stove knob controller. 70 mm Aluminum round shaft is used to construct the knob. Aluminum spherical bars possess lightweight weight and powerful corrosion resistance, whereas being simple to machine and cut. Common applications of metal spherical bar embody supports, trim, shaft, braces, pins, and dowels. It can be seen that knob unit of stove consists of stepper drive, a stepper motor and a NodeMCU. A stepper motor used for design is of 0.5 amp, with 0.8 degrees turn angle and operates on 5 volts. NodeMCU is an open supply IOT platform. It includes code that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware that is predicated on the ESP-12 module. The term "NodeMCU" by default refers to the code instead of the event kits. The code uses the Lua scripting language, and used in design with the Espressif Non-OS SDK for ESP8266. Firebase is connected to knob

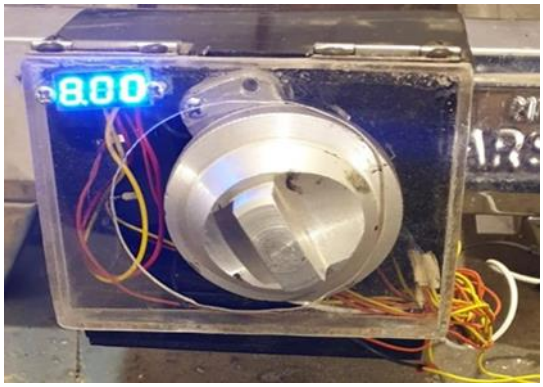

Fig. 1 Stove Knob Unit

unit, sensor unit and also with user by a Mobile application. The Grove - Gas Sensor (MQ5) module has been used for gas sensing as it is beneficial for gas run detection (home and industry). It's appropriate for detection H2, LPG, CH4, CO, Alcohol, Smoke or fuel. The signals are received from the sensor block and then processed. Firebase is used to check the values sent.

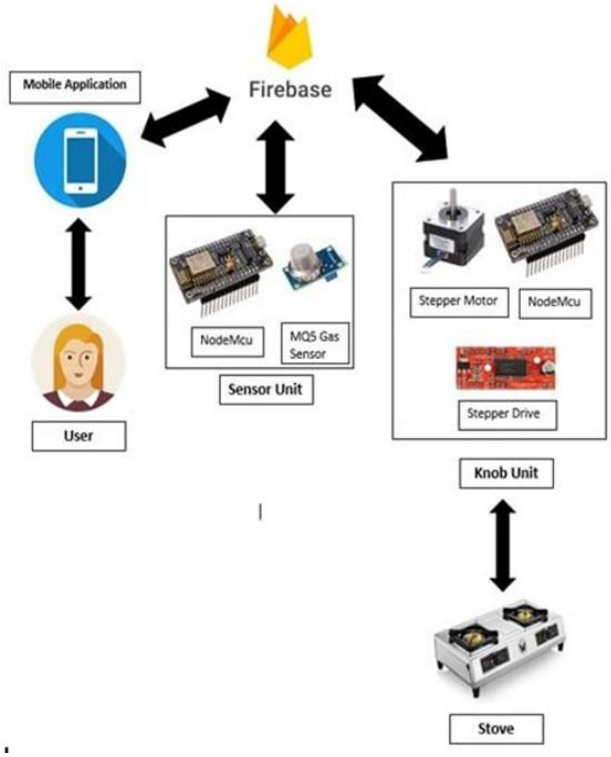

Fig. 2 System Design

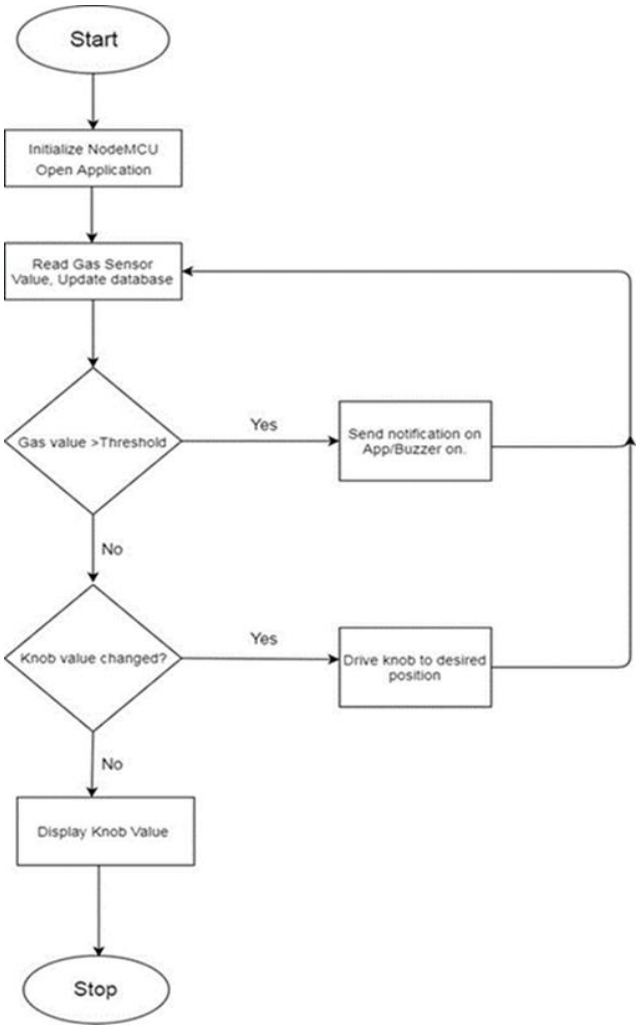

Fig. 3 Flow Chart of Working

For the software development, Java and Android Studio 3.0 have been used. Flowchart of the proposed methodology for the stove knob assistant is shown in Fig 3. It can be seen that initially NodeMCU application is initialized. It is followed by reading the gas sensor value and updating it in the database. The database consists of already defined acceptable gas values. After that gas value is checked. If Gas value is higher than threshold then Buzzer is activated and after that gas value is checked periodically. Activation of buzzer is an indication that gas is higher in the stove which can cause hazard including uncontrolled fire. If gas value is found below threshold then knob value is checked. If it is changed then knob is moved to a desired position and again gas sensor value is read. If knob value is not altered then it is displayed and process ends. To facilitate the process as mentioned in Fig 2, a mobile application has been developed. Use case diagram of developed mobile application has been shown in Fig 4. It can be seen that

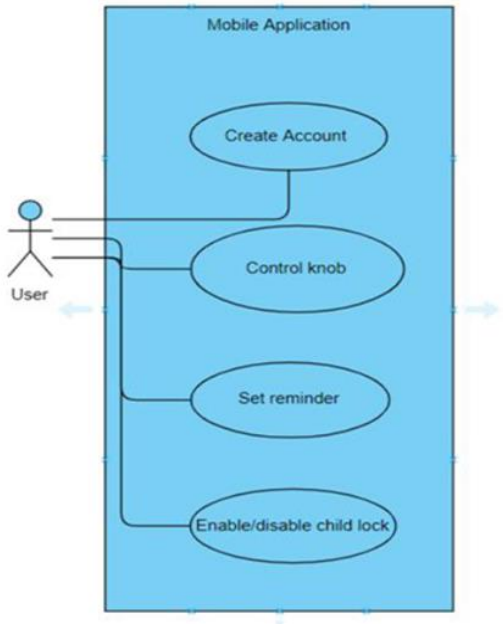

Fig. 4 Use Case Diagram of Mobile Application

once a user has created an account, he/she can use the control mechanism and can also set certain reminders. Similarly there is an option of enabling/disabling Child lock option for safety purpose. Now we discuss the working of the mobile application.

Fig.5 shows the initial screen where user can enter the application by using credential including login and password. Once user enters the mobile application, the home screen is shown in Fig 6. It can be seen that there are five options including two knob controls, gas leakage value, user manual and logout are available. When either Knob 1or Knob 2 are selected. It can be seen that there are five options including two knob controls, gas leakage value, user manual and logout are available. When either Knob 1or Knob 2 are selected, the menu displayed is shown in Fig 7. It can been seen that using options available, reminder can be set, knob movement can be locked using child lock or simply knob movement can be controlled. When the control knob option is selected then screen appeared is shown in Fig 8. It can be seen that it shows the knob current position which can be adjusted as well as gas leakage value. The mobile application has a Child lock feature as well as shown in Fig 9.

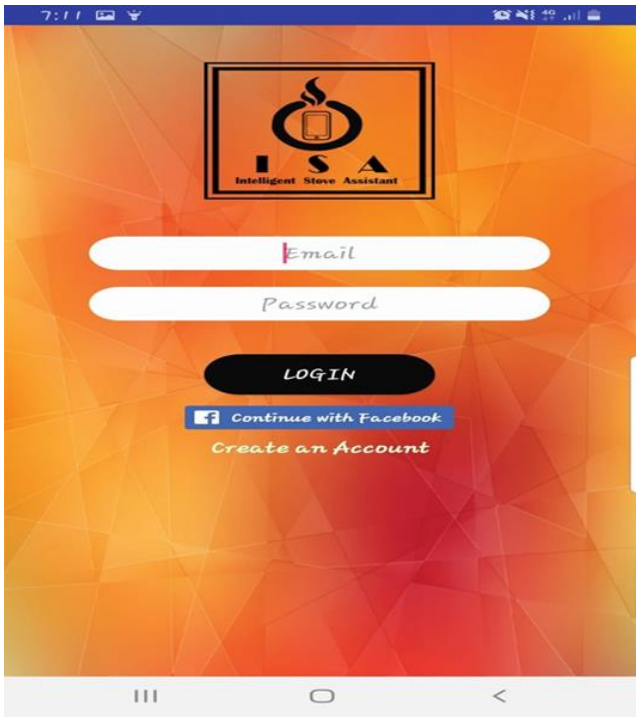

Fig. 5 View of login Screen of Mobile Application

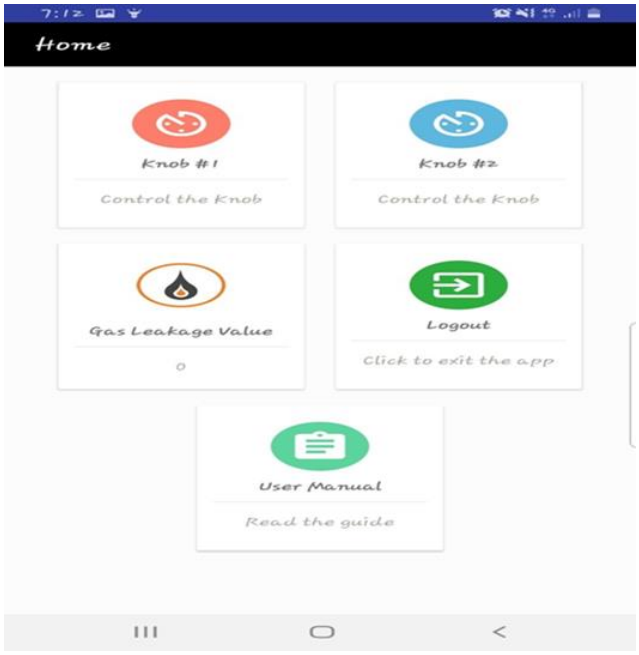

Fig. 6 View of main screen of Mobile Application

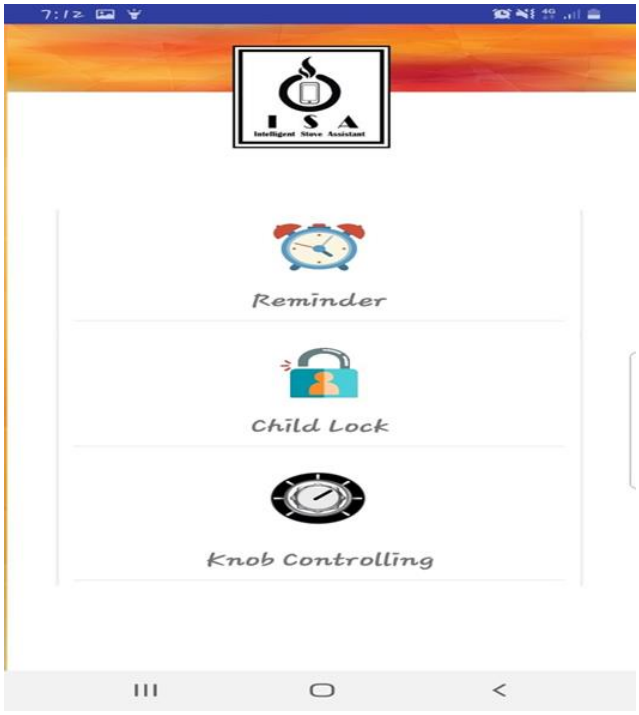

Fig. 7 View of Reminder, child lock and Knob Control

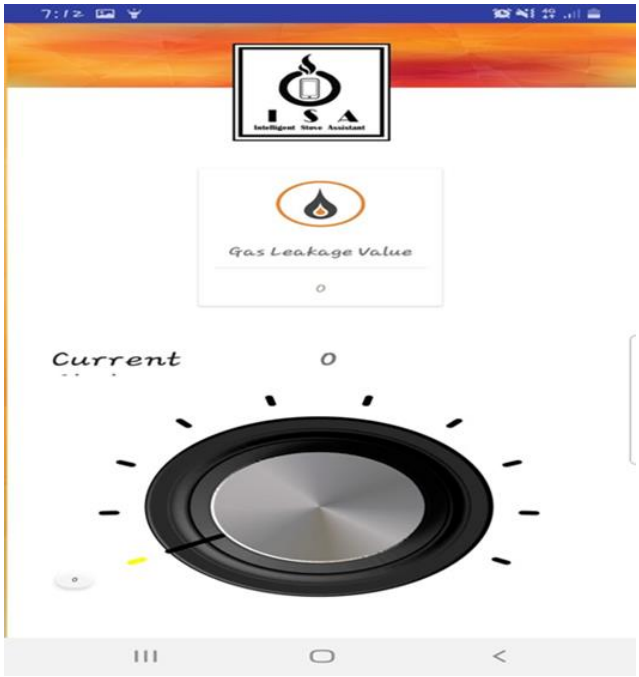

Fig. 8 View of Gas Leakage display on Mobile Application

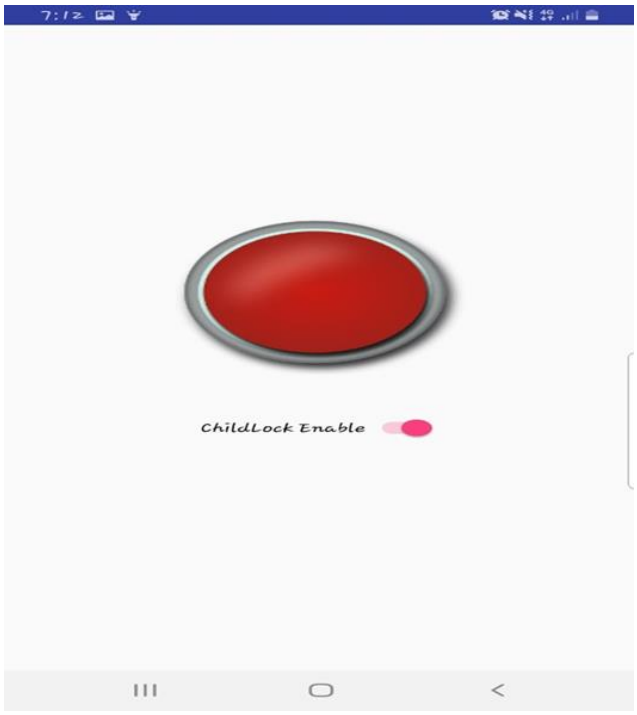

Fig. 9 Child Lock view of Mobile Application

Child lock will be activated by pressing the red button. A reminder option is also available which is shown in Fig 10. By using the option, reminder for the desired knob can be set. User will have to set the time just like alarm clock, it will remind the user after that time by a notification, and an alarm. It will snooze for three times, and if the user does not respond, it will automatically turnoff the stove.

It can be seen that Mobile application can be used to control the stove knobs and also invoke child lock so that added safety features are provided to the user of the system. Gas leakage values can be defined based on the guidelines provided by the government. The complexity of the design is not high so that a better understanding of the system can be communicated easily. Integrated with IOT, like other stove controller applications, messages to fire departments, police and other relevant agencies can be integrated in the future.

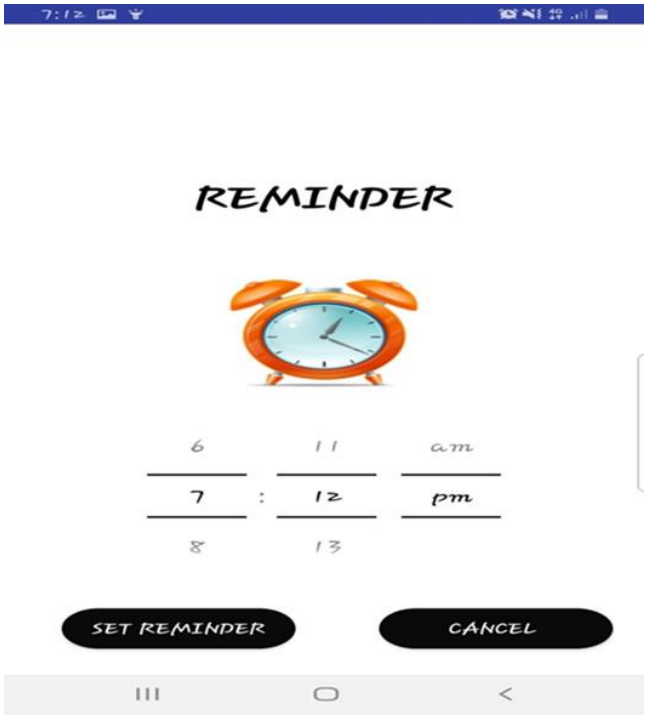

Fig 10: Option to set Reminder on Mobile Application

4. Conclusion and Future Work

Household fire and such type of hazardous situations are increasing day by day at a tremendous rate due to lack of proper attention paid at the kitchen and stove around the world including Pakistan. We have designed a system allowing easy and remote monitoring of the stove knob via a mobile application providing kitchen safety. It has been shown that proposed system provides an easy method for users to control the knobs of stove remotely. The safety feature also allows to provide affective control of children manipulating with the stove knobs as it is a common case in Pakistan. Future enhancements include live streaming of the area of the stove to provide further surveillance and accessibility to the user. We also aim at looking at automated knob control of heaters and geezers and other devices remotely.

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