Design and Implementation of an Efficient Embedded Temperature Monitoring and Warning System for Medicine Warehouses

by

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LIST OF ABBREVIATIONS

SBC	Single Board Computer
MCU	Micro Control Unit
HDMI	High-Definition Multimedia Interface
USB	Universal Serial Bus
SD	Secure Digital
DSI	Display Serial Interface
RCA	Radio Corporation of America
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
GPIO	General Purpose Input Output
CSI	Camera Serial Interface
Wi-Fi	Wireless Fidelity
WSN	Wireless Sensor Network
SDA	Serial Data
SCL	Serial Clock
LCD	Liquid Crystal Display
LED	Light Emitting Diode
HVAC	Heating Ventilating and Air Conditioning
ROM	Read Only Memory
EEPROM	Electrically Erasable Programmable Read Only Memory
CPP	Capacitor Placement Problem
VDD	Voltage Drain Drain
GSM	Global System for Mobile communications

SMS	Short Message Service
GUI	Graphical User Interface
PCI	Peripheral Component Interconnect
PC	Personal Computer
API	Application Program Interface
DSL	Digital Subscriber Line

ABSTRAK

Cabaran baru-baru ini memberi penekanan kepada melindungi ubat daripada pencemaran dan kerosakan yang disebabkan oleh suhu yang tinggi / rendah di kedai-kedai ubat dan farmasi. Ubat penyimpanan saksi perubahan persekitaran tidak sesuai untuk tempoh yang panjang atau pendek masa hendaklah dilaporkan dan dikenal pasti dengan tepat. Oleh itu, kajian ini bertujuan untuk menyediakan sistem pemantauan suhu cekap ubat dengan kos yang rendah menggunakan Raspberry Pi 2. DS18B20 telah digunakan untuk menyiarkan isyarat profil suhu diterima dan sistem amaran telah dibangunkan untuk memberi amaran kepada pentadbir gudang di Sekiranya terdapat sebarang peningkatan atau penurunan suhu. Hasil bacaan suhu perubatan gudang menunjukkan bacaan yang stabil dan apabila suhu ditukar kepada satu tingkatan kelebihan daripada ambang itulah ditetapkan oleh pengguna sistem akan menghantar mesej waring kepada admin gudang. hasil ini boleh membuka pintu untuk kajian masa depan baru untuk mencuba menggunakan sensor lain untuk tujuan suhu membaca.

DESIGN AND IMPLEMENTATION OF AN EFFICIENT EMBEDDED TEMPERATURE MONITORING AND WARNING SYSTEM FOR MEDICINE WAREHOUSES

ABSTRACT

Recent challenges emphasis on protecting the medicine from contamination and damage caused by high/low temperatures in the medicine stores and pharmacies. Medicines storages that witness of inappropriate environment variation for long or short period of time must be reported and identified precisely. Therefore, this study aimed to provide an efficient temperature monitoring system of medicine with low cost using Raspberry Pi 2. DS18B20 was used in order to posts the profile signal of received temperature and a warning system has been developed to warn the administrator of the warehouse in case of any increase or decrease of the temperature. The reading result of medicine warehouse temperature showed a stable reading and when the temperature is changed to a degree above the threshold that's is set by the user the system sends a waring message to the admin of the warehouse. These result can open the doors for new future studies to try applying other sensors for temperature reading purposes.

CHAPTER 1

INTRODUCTION

This chapter majorly covers the prime idea of this research for monitoring temperature of medicine in warehouse context. It also illustrates the potential of applying warning schemes for the purpose of increasing the compatibility of the current monitoring system. It also elaborates the reasoning of the research conducted and the involvement of the main element in the research. The first phase describes the key aspects related to temperature monitoring along with the motivation that led the researcher in current study to be established. The research objectives and the significance to the context of temperature monitoring are also explained. Nevertheless, the last topic elaborated the way of this research is organized.

1.1. Overview

Current studies associated with the development of temperature monitoring systems are mostly emphasis on certain context to which differences environmental conditions may significantly affect the current use of such systems. This led many researcher such as (Jones, Brookes, Whittaker & Lancaster, 2014); Nedrygailov, Hasselbrink, Diesing, Dasari, Hashemian & Karpov, 2012) to conceptualize the temperature measurement and control to be the most common practices for applications of microcontroller-based acquisition systems (Ghoseiri, Zheng, Hing, Safari & Leung, 2015).

Four types of sensors are generally used in order to estimate heat range in commercial and commercial related purposes (Al Ameen, Liu & Kwak, 2012). These

include thermocouples, resistive heat range devices, thermistors and also integrated circuit temperature sensors. Each sensors has unique pluses and minuses and by focusing on how these sensors works, and which signal conditioning are required, it is achievable to produce more accurate and reputable temperature description, monitoring and also control (Webster & Eren, 2014).

Sensors are actually transducers of which detect and measure a new physical amount. A traducer refers to a device of which converts actual quantity in one form completely to another (Al Ameen & Kwak, 2012). The difference between a sensor and a traducer is that actually a sensor works like a traducer but a transducer shows real quantity readings. One other device is a thermocouple that tends to be an inexpensive sensor that is fitted with many temperature variety (Hanson, 2011). Thermocouples develop the principle that after two dissimilar metals tend to be combined, a voltage response along the junction between metals. By means of measuring this kind of voltage, it is possible to get heat range reading. Different combining of metallic create unique thermocouple voltages and there exists many thermocouple readily available for different applications (Brübach, Pflitsch, Dreizler & Atakan,2013).Thermocouple have got non-linear relationship on the measured temperature and since a outcomes of this it will be important either in order to linearize a certain characteristics or to use look-up tables to search for the actual temperature from the predefined measured voltage (Riedinger, Guardia, Curcio, Garcia, Cingolani, Manna & Pellegrino, 2013). To convert analog into digital devices have to be connected to the thermocouples in order to computer-based equipment which are mostly used in warehouses and pharmacies (Villarejo, Zapirain & Zorrilla, 2012). In addition, the change in resistance is quite small and also special circuitry is often needed in order to measure small changes of temperature in certain context.

On the other hand, temperature monitoring and warning system for medicine storage, warehouses and pharmacies using a Raspberry Pi 2 platform is the main focus of the present study. This is because cooling systems for medical field is of great importance due to their usage for storage and transportation stages of medical entities such as medicines and vaccines.

1.2. Research Background

Many previous studies concentrates on supplying adequate track of and caution to temperatures changes in a few environmental conditions(Murugan, Periasamy & Muruganand, 2012;Satyanarayana & Mazaruddin, 2013). Temperature changes has proven to significantly affect medicine quality stored in different placed (Laroussi, 2009; Qiu, Wen, Li & Yang, 2012). Therefore, continues monitoring of temperature change is essential to avoid any chemical damage. As such, designing and fabricating sensors which are either in direct contact with the medicine or indirectly can help keep us alerted to temperature changes.

1.3. Problem Statement

This study is conducted based on the current evidences found in literature on the needs for sufficient and low cost temperature monitoring system of medicine in warehouse context. In addition, recent challenges emphasis on protecting the medicine from contamination and damage caused by high/low temperatures in the medicine stores and pharmacies (Shih, Shen & Otis, 2011; Shahin, 2014). Medicines storages that witness of inappropriate environment variation for long or short period of time must be reported and identified precisely.

Along with this, the researcher's review of the literature led to conclude that there is a need to provide quality temperature monitoring and warning services in wide range areas. Some previous works addressed the challenges for providing embedded temperature monitoring system in term of the coverage range of the sensor nodes which appears to be designed for the area of human body of few meters with small number of nodes utilized to monitor the vital signs of the object (Stankovic, Cao, Doan, Fang, He, Kiran & Wood, 2005).

These challenges increase the need of developing embedded technologies for monitoring medicine temperature in large environmental space rather than the available standardized technologies

1.4. Research Objectives

The goal of this study is to develop an efficient temperature monitoring system of medicine in a medicine warehouse :

1. To design and develop a cost effective, open source and efficient temperature monitoring and warning system using Raspberry Pi 2.

2. To maintain the temperature of the medicine warehouse in a range that would keep the medicine in good condition as advised by the health ministry

1.5. Scope and Limitation

The main scope of this study is mostly focuses on providing a less cost and provide continues temperature monitoring status with an open source system. However, this study is limited to the full specification of system development for large storage spaces.

1.6. Research Significance

Temperature changes are typically the main reason to develop an efficient temperature monitoring system. A number of key benefits of such system are summarized as below:

Increase the area size and capital cost savings: An embedded monitoring system utilizes smaller hardware elements to increase its efficiency and affordability.

Energy savings: Temperature monitoring systems permit user to decide whether to sustain or change chiller running time when condensing temperatures improve equipment efficiency.

Extend the capacity of an existing system.

Provide an effective solution for preserving the medicines inside warehouses from damage or contaminated based temperature variation even for short period of time.

Finally, provide fast, cost effective, open source solution, expandable and reliable solution is targeted in this research for the abovementioned problems

1.7. Thesis Outline

A total of five chapters are presented in this thesis:

Chapter 1: The first chapter addressed the introduction and motivation to conduct this study. This chapter explains objectives and scope for conducting this study.

Chapter 2: It explains the literature, previous related work, and more information to understanding the research.

Chapter 3: Discuss the methodology that has been used and hardware and software elements.

Chapter 4: Reports on the temperature monitoring result based on the proposed system design.

Chapter 5: Discusses on conclusion of this research.

1.8. Summary

Based on the area studied, the first chapter provided the insight of the research by describing the motivation factors associated with providing effective and less cost temperature monitoring system. It also explains the objectives of conducting the study, as well as its significances to the real world situation. This research focused on monitoring large space temperature based on the standards of SBC monitoring and alerting system using Raspberry Pi 2. The next chapter deals with the literature review which elaborates on related works that have been established in the same field.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter addresses the literature review of the area of the project studied. Conceptually, it gives an insight or reviews on the previous and existing works that have been conducted on the same area. This chapter is organized into different sections that cover the current trends in temperature monitoring, hardware and software elements used in this study. The chapter also introduces previous efforts for monitoring and controlling temperature remotely.

2.2. Overview

The utilization of technology in existing experiments is often recognized as an ongoing area for exploration. This was due to the fact that different environmental conditions requires certain settings to effectively ensure system efficiently (Dehwah, Taieb, Shamma & Claudel, 2015). With this in mind, the development of any system is aimed at providing low power consumption system.

2.3. Temperature monitoring

The particular temperature monitoring devices here relies on group of nodes where every single node is linked to more than detectors. In addition, temperature monitoring may vary from one sensor to another with regards to its sizes and price tag,

they can offer some different constraints (Davidsson & Boman, 2005; Badia-Melis, Ruiz-Garcia, Garcia-Hierro & Villalba, 2015). It is possible to locate the sub-systems in the sensor node: the computing subsystem, the communication subsystem, the sensing subsystem, along with a power supply subsystem (De Vito, Cocca, Riccio & Tudosa, 2012). Computing subsystem consists of a microprocessor (MCU) which can be used to manage the detectors by many specific verbal exchanges protocols.

Communication subsystem has a short variety radio which can be used to provide the necessary link to the nodes inside sensor communities (Zhao, 2011). Radios frequencies can certainly operate beneath the transmitter, receiver mode (Liu, Chen, Wang & Chen, 2012). The received mode is considered in this study since the main aim is to process the received temperature continually for that sensor to send temperature data, while it should be in be given mode when the sensor detect a possible changes in it (Chen & Wassell, 2012).

The sensors used for monitoring temperature data may be effected by other environmental means in different manner to which it may impose a great effect to interpret efficiently the received temperature data. Therefore, sensing subsystem may consist of quite a few sensors for instance thermal, substance, optical, scientific, and over unity magnetic sensors in order to measure properties in the environment.

The applications of monitoring systems presents the most significant disadvantages of wireless utilization which currently faces a number of challenges associated with slow-moving information exchange and also deficiency of a network

connectivity in order to communicate in order to transfer the captured data into a visual display. To experience proficiency increases within the temperature monitoring context, a few important problems can face current use of USB wireless adapters such as:

1. Appropriate improvement of reading should be considered by making it possible for correct integration of completely new alternatives wireless alternatives.
2. Suitable end user interfaces should be created in order to capture and also admittance information correctly and also well-timed.

Even though many prototypes of temperature monitoring in the indoor activities, they also provide additional endured disadvantages pertaining to program code, integration with present purposes, end user interfaces and also information indication. To allow temperature monitoring flexibility, program code can often be written to accommodate certain data transmitted through certain mediums.

2.4. Issues of temperature monitoring

Any monitoring system has a design and resource constraints due to the limited sizing and charge of sensor node for example limited vitality and short connection range, reduced bandwidth, and limited digesting, which is essential to accurately monitor temperature changes. Recent technology in instant communications and electronics include overcome a lot of the constraints and enabled the particular development of monitoring devices that happen to be low-power, low-cost,

multifunctional, and small size (Nadimi, Jørgensen, Blanes-Vidal & Christensen, 2012). However, three key problems for example energy efficiency, localization, and routing may face network stability to correctly interpret the surrounding temperature. Hence, providing an effective and low cost solution for monitoring temperature changes is essential.

2.5. Hardware

2.5.1 Introduction to Raspberry Pi

Raspberry Pi is an effective element in the size of credit-card that is featured fully on computer which runs the Linux operating system (Figure 2.4). Raspberry Pi consists of all the essential ports for connecting other hardware components. As shown in Figure 2.4, the monitor can be connected to an HDMI output in order to provide an interactive display along with linking a mouse and a keyboard to the USB ports and for the speakers(Aparicio, Fuente, Ranz, Aliques, Izquierdo & Fernández, 2013). It compress of 3.5mm audio jack for warning related purposes where the researcher relays on in this study. In the model B+ there is also an Ethernet socket for the internet connection.

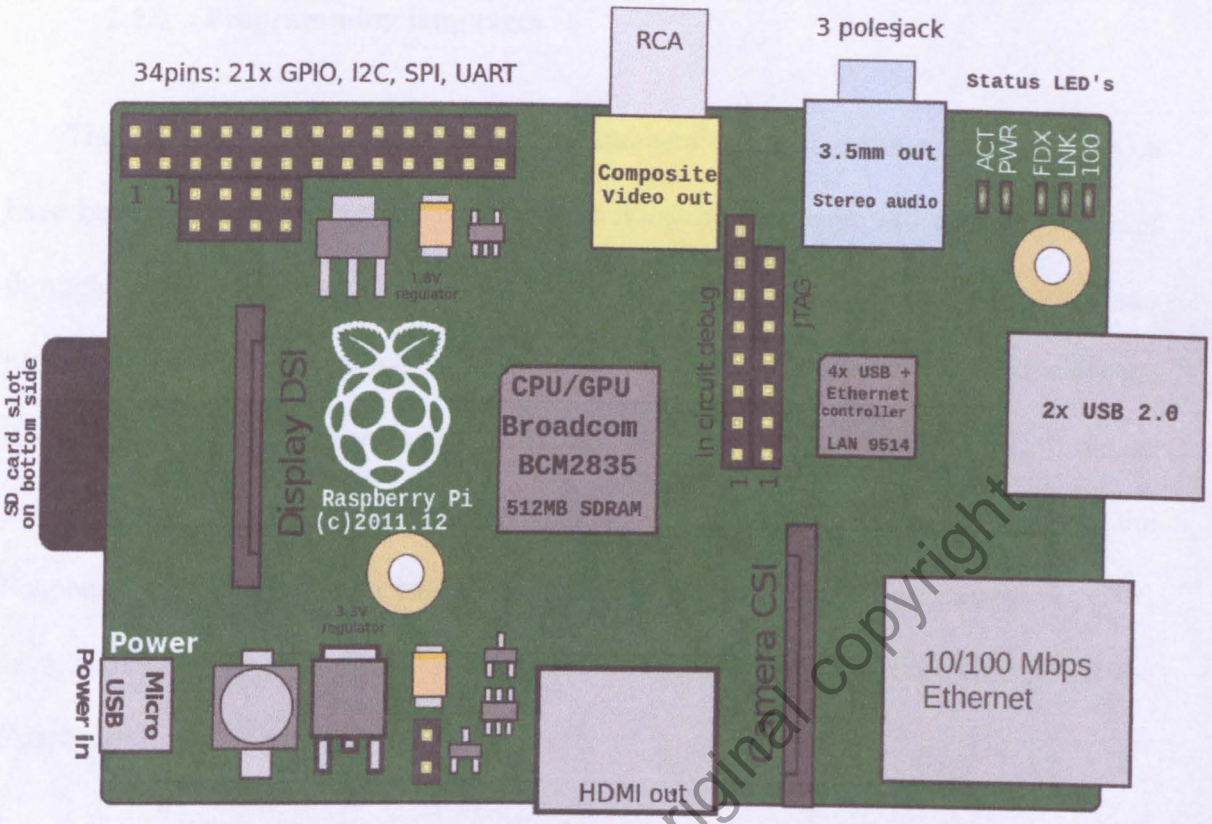

Figure 2.1: Raspberry Pi circuit design

In general, it can be considered as a very little computer which can be used with the same tasks instead of using extra hardware equipment. For example, monitoring and estimating environment conditions throughout a certain settings. Also it's very popular in numerous kind connected with electronic projects especially when using it for learning the encoding. Raspberry Pi is fordable and the prices are starting from 30 USD. With this in mind, the researcher considered its usefulness in conducting this study to which some external computers can be included and purchased separately for extended purposes. As an example, it won't have any form of protective enclosure and the micro-USB power supply is certainly not included sometimes.

2.5.2 Programming languages

The hardware provides a considerable numbers of programming languages which have been adapted for Raspberry Pi. Python selection language will be recommended through the Raspberry Pi foundation specifically the rookies. Basically any programming language which is often compiled for ARMv6 can operated with the Raspberry Pi (Aparicio, Fuente, Ranz, Aliques, Izquierdo & Fernández, 2013). It means that the users usually are not restricted to work with only your Python. Around the Raspberry Pi, it is possible to note preinstalled various languages as an example C, C++, Java, Scratch as well as Ruby. However, in this study the researcher considered the Raspberry Pi with python shell editor.

2.5.3 General Purpose Input Output (GPIO)

Raspberry Pi possesses two rows of pins during one side of the USB ports. These pins are named GPIO connection. The GPIO connection allows attachment of automated hardware towards the Raspberry Pi. It can be a choice option for any USB vent. The pins which might be labeled seeing that GPIO could all be used for basic purpose input/output pins. It means that it is defined to be either a great input as well as a production pin (Aparicio, Fuente, Ranz, Aliques, Izquierdo & Fernández, 2013). The GPIO connection varies small bit in various Raspberry Pi models. In the sooner models B along with the GPIO connector consisted of 26 pins. Furthermore, the model B+ of GPIO includes 40-pin connector the spot that the first 26 pins are identical to in the last versions. Amount 2. 5 exhibit the GPIO connector's pins about the Raspberry Pi model B+ as shown in Figure 2.2.