A NOVEL APPROACH FOR REMOTE DIAGNOSIS AND TROUBLESHOOTING FOR LAB INSTRUMENTS

By

Ashraf Nader Mohi Eldeen Rizk

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Biomedical Engineering and Systems

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

Prof. Dr.

Ayman M. Eldeib

Professor Doctor
Systems and Biomedical Engineering
Faculty of Engineering, Cairo University

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Approved by the
Examining Committee

_____
Prof. Dr. Ayman M. Eldeib (Thesis Main Advisor)

_____
Prof. Dr. Ahmad M. Rajab Albialy (Internal Examiner)

_____
Dr. Walid Ibrahim Al-Atabany (External Examiner)
- Associate professor in Biomedical Engineering Dept., Helwan University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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2019

Engineer's Name: Ashraf Nader Mohi Eldeen Rizk
Date of Birth: 17/09/1975
Nationality: Egyptian
E-mail: asnamori@yahoo.com
Phone: 0100 2975 061
Address: 905, 20 St. 5th Neighborhood, 5th District, 6 of October City, P.O.Box 12451, Giza

Registration Date: 01/03/2011
Awarding Date: …./…./2019
Degree: Master of Science
Department: Biomedical Engineering and Systems

Supervisors:

Prof. Dr. Ayman M. Eldeib

Examiners:

Prof. Dr. Ayman M. Eldeib (Thesis main advisor)
Prof. Dr. Ahmad M. Rajab Albialy (Internal examiner)
Dr. Walid Ibrahim Al-Atabany (External examiner)
- Associate professor in Biomedical Engineering Dept., Helwan University

Title of Thesis:

A NOVEL APPROACH FOR REMOTE DIAGNOSIS AND ROUBLESHOOTING FOR LAB INSTRUMENTS

Key Words:
Critical care instruments; direct access remote diagnosis; laboratory equipment; remote diagnosis; troubleshooting

Summary:

The use of remote diagnosis and troubleshooting are widely used nowadays to improve instruments' uptime and minimize workflow interruption. However, such feature is not used in many critical care units or laboratories (labs) either due to limited features offered by manufacturers or high cost of the interface S/W especially in developing countries. The negative impact is more obvious in aged or discontinued machines lacking remote communication ports despite owning an embedded diagnosis or troubleshooting S/W. This research describes a direct access remote diagnosis and troubleshooting for the input and output devices of a critical care/lab instrument using a flat data cable, a 5.5cm x 10cm Arduino Due ready-made board, and a control S/W. The main advantage of this approach is its low cost, compact design and simple implementation besides being convenient and suitable for other instruments possessing in/out devices with the same specifications.

Disclaimer

I hereby declare that this is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Ashraf Nader Mohi Eldeen Rizk Date: 25th of February, 2019

Signature:

Dedication

This thesis is dedicated to my father, mother, beloved wife and daughters, models for intellectual curiosity, diligence, artistry, and compassion in my life.

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Nomenclature

Alphabetically ordered abbreviations:

ASCII	American Standard Code for Information Interchange
BGA	Blood Gas Analyzer
C/D	Control/Data
CASBEC	Center of Advanced Software and Biomedical Engineering Consultations
CCU	Critical Care Unit
Commun.	Communication
DARDT	Direct Access Remote Diagnosis and Troubleshooting
DLL	Dynamic Link Library
DMS	Data Management System
DRA	Direct Remote Access
ECP	Enhanced Capabilities Port
Inst.	Instruments
IP	Internet Protocol
ISE	Ion Selective Electrode
Lab	Laboratory
LAN	Local Area Network
MK	Membrane Keypad
PASA	Purchasing and Supply Agency
pCO_2	Carbon Dioxide Partial Pressure
pO_2	Oxygen Partial Pressure
RL248	Rapidlab® 248 pH/Blood gas analyzer
ROI	Return On Investment
S/W	Software
SPP	Standard Parallel Port
TRA	Traditional Remote Access
VFD	Vacuum Fluorescent Display

Abstract

The use of remote diagnosis and troubleshooting are widely used nowadays to improve instruments' uptime and minimize workflow interruption. However, such feature is not used in many critical care units or labs either due to limited features and accessibility offered by manufacturers or due to high cost for interface software especially in developing countries. The negative impact is more obvious in labs with aged or discontinued instruments lacking remote communication ports despite owning an embedded diagnosis or troubleshooting software. This research describes a direct access remote diagnosis and troubleshooting for the input and output devices of a critical care and laboratory instrument using a custom-made flat data cable, an 8 cm x 10 cm built-in PCB designed for this purpose, a standard parallel cable, and a control software, replaced by the more powerful ready-made Arduino Due board with even a smaller foot print of 5.5 cm x 10 cm and higher processing speed and features. The main advantage of this approach is its low cost, compact design and simple implementation besides being convenient and suitable for other instruments possessing input/output devices with the same specifications. Implementation of the control software and hardware related to accessing the machine's membrane keypad and display using a PC has been successfully accomplished and tested leading to the use of all PC communication capabilities including remote connection and access. By integrating all hardware components, the prototype system was capable of remotely diagnosing and controlling the machine on real-time basis.

Chapter 1 : Introduction

This chapter provides an introduction for the applied principle of remote diagnosis and troubleshooting in industrial and healthcare fields describing its importance, it then addresses the concerned problem handled by this research and the proposed solution. A comparison with other traditionally available solution is presented with emphasis on strength points and merits of the proposed solution over traditional ones.

1.1. Introduction

The principle of remote diagnosis emerges to overcome high cost and difficulty of transportation to far territories, scarcity of service personnel at suppliers, also offering technical support at unreachable regions due to natural disasters, harsh weather conditions or at war time [1, 2].

Telemaintenance is used in the industrial field based on remote supervision and activation of given equipment in an industrial environment [3], benefiting from the technological evolution in the field of electronics and telecommunication. The medical field applies same principle to medical instruments: mainly life supporting categories, and 24hrs running systems. The use of remote diagnosis technique in the medical field greatly resolves problems related to frequent medical staff turnover and shifts, lack of experience and training, and aids in fast intervention without the need to physically access the remote location [3].

Nowadays many critical care and laboratory (lab) equipment manufacturers are offering remote diagnosis services for their products by the aid of built-in communication port(s) i.e. USB, serial (RS232), network, and others that can be connected to a PC. Using a special interface software protocol, the instrument and PC can communicate and interchange data. Remote diagnosis significantly shortens repair time, avoids downtime by taking advantage of predictive methods, and provides general diagnostic assistance [4]. However software packages are not often available or affordable for most instruments especially in developing countries. The situation is more drastic for aged or discontinued but still in service instruments with customers trying to maximize machine features and usage; such condition urges us to find a feasible, low cost, and compact design solution.

1.2. Addressed problem

Although the use of remote diagnosis and troubleshooting are widely used nowadays to improve instruments' uptime and minimize workflow interruption. However, such feature is not used in many Critical Care Units (CCU) or labs; either due to: 1) limited features and access offered by manufacturers of such equipment or because of 2) high cost for interface software packages; especially in developing countries. The negative impact is more obvious in labs with aged or discontinued instruments lacking remote communication ports but having an embedded diagnosis and/or troubleshooting software.