Automatic Wi-Fi Monitoring and Flushing System

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Abstract

This paper describes the results of a research project completed in Spring 2008 and shows details of a healthcare system along with future enhancements of the **Automatic Wi-Fi Monitoring and Flushing System (A.Wi.M.F.S).** The purpose of the research was to provide bedridden patients with an automatic collection pan to promote more privacy while eliminating the need for medical personnel to lift patients. In hospitals, the current bedpan [1] is a toileting facility that uses metal or plastic for urinal and fecal discharge. The present system requires an attendant to lift the patient and position the bedpan beneath the bedridden patient to collect excrement. This can cause injuries to the caregivers or the patients [2]. From this emerged the idea of the automatic bedpan which can reduce the risk of injury. The A.Wi.M.F.S has been designed to alleviate the physical strength needed for lifting patients. The Automatic Wi-Fi Monitoring and Flushing System contain a self-cleaning system that can be operated upon user's request. The automatic flushing system can be implemented in already existing patient rooms by tapping into water supply and sewage lines with a built-in waste management system. The main purpose of the system is to provide patients with a system that is easy to use and is comfortable. The A.Wi.M.F.S is currently under review by the office of Intellectual Property Management at the University of Houston for a potential patent.

Introduction

The purpose of A.Wi.M.F.S is to provide patients with an automatic collection bedpan to promote more privacy while eliminating the need for medical personnel to lift the patients. Nurses and other medical personnel may potentially injure themselves having to lift patients. The developed system achieves this objective by providing a fully automatic bedpan. The A.Wi.M.F.S is a monitoring and flushing system that is incorporated into a modified hospital bed. The system is retrofitted into the bed adding unique features and functions. The bedpan is integrated with a MINI-MAX/8051-E microcontroller to control the system that enables the patient to use a bedpan with great ease and least effort. The conceptual model of the A.Wi.M.F.S and its major components are shown in Figure 1.

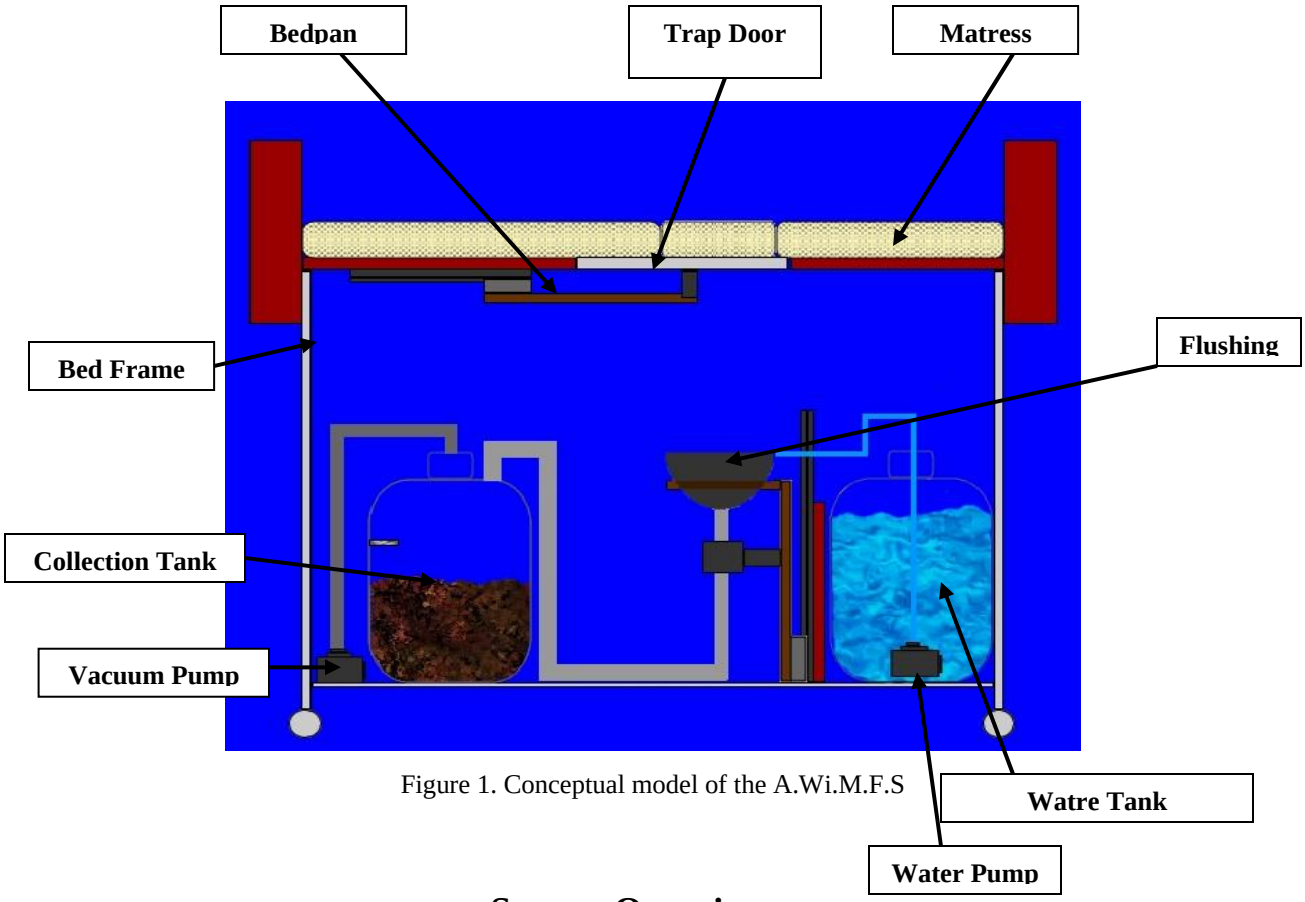

Figure 1. Conceptual model of the A.Wi.M.F.S

System Overview

The system overview is presented here with an insight into the basic building blocks of the system components.

The A.Wi.M.F.S is comprised of the following major components:

- Trap door and bedpan
- Cleansing system
- Flushing system

The trap door and bedpan are each attached to an actuator. The trap door utilizes an actuator to pull the trap door in downward position. The swing of the door reveals an opening in the bed. The actuator is mounted beneath the underside of the bed which allows movement for the trap door. To close the trap door the actuator moves forward which pushes the trap door back into place. The bedpan sits on a wooden platform attached to the actuator by L brackets. The movement of the bedpan is either up or down. Upon opening of the trap door the bedpan moves up into place and upon closing the trap door lowers back down. The cleansing system for rinsing out the bedpan consists of a water reservoir which is a five gallon water bottle that provides the rinsing water. A tube is run from the water reservoir to a water pump through an outlet that is sealed to prevent leakage of water. Another tube is run from the water pump to the bedpan where two outlets were drilled in the bedpan to simulate the rinsing. The flushing system has a vacuum pump [3] attached to a collection tank made from a five gallon beverage cooler.

The original lid of the cooler was replaced with a piece of layered plexiglass. An outlet was drilled through the plexiglass lid and sealed to prevent air leakage.

Design Specifications

The design specifications of the A.Wi.M.F.S are presented here via a hardware block diagram and two software flowcharts. The hardware is comprised of the trap door, bedpan, flushing and cleaning systems and the control box as shown in Figure 2. The trap door reveals an opening in the bed for collection pan, which lifts and lowers within its place. The cleansing system is for rinsing the collection pan. The flushing system is used for emptying of waste into collection tank and a control button for flush operation. The main control is through a box containing the BiPOM MINI-MAX/8051-E microcontroller and relays [4]. The 8051 microcontroller's boot routine has to be completed before the system initialization. The A.Wi.M.F.S operation consists of initialization cycle that allow connection of Wi-Fi capable devices to connect directly to the 8051 microcontroller via wireless connection (wireless router) or physical Ethernet connection. The self-cleaning system is activated upon user's request via an interactive console. The automatic flushing system can be implemented in already existing patient rooms by tapping into water supply lines and sewage lines. A waste system will also be built-in. The system utilizes a vacuum pump, a water pump, and a collection tank for removing waste from the bedpan. A solenoid valve is used to block septic fumes and create vacuum within the collection tank.

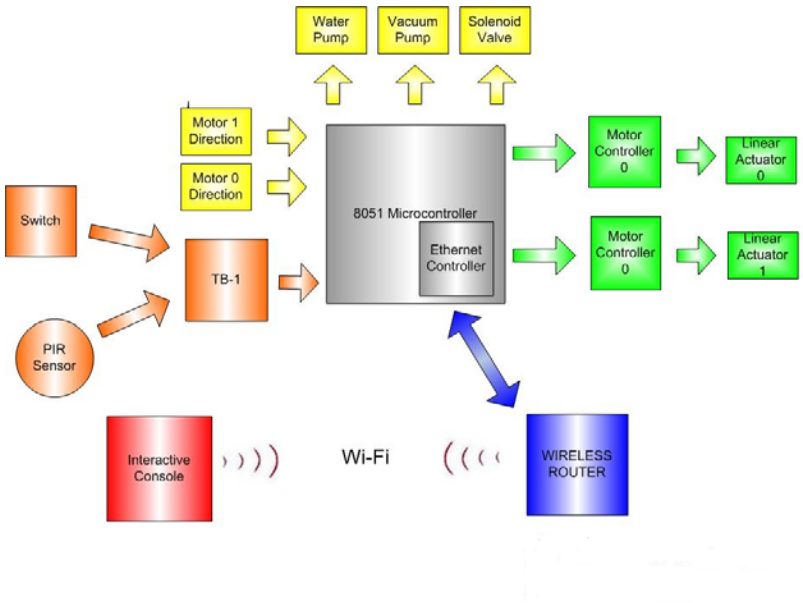

Figure 2. Hardware block diagram of the A.Wi.M.F.S

The A.Wi.M.F.S has two operating modes: manual mode and automatic mode. The software flowcharts for manual and automatic modes are shown in Figure 3 and Figure 4 respectively. Manual mode is operated simply by user's input and is designed for patients

who are responsive to their own needs. In the manual mode, user interaction creates a connection between the collection pan and the mattress. This mode also performs the flushing action of the system.

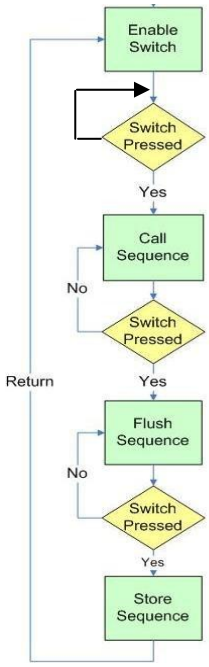

Figure 3. Flowchart for the manual mode

Automatic mode is designed for patients who are unable to respond to their own needs. The system contains one passive infrared sensor which aids in excrement detection. Once excrement passes, the infrared sensor detects the motion. Upon detection, the system notifies the nursing station and awaits proper response from the personnel.

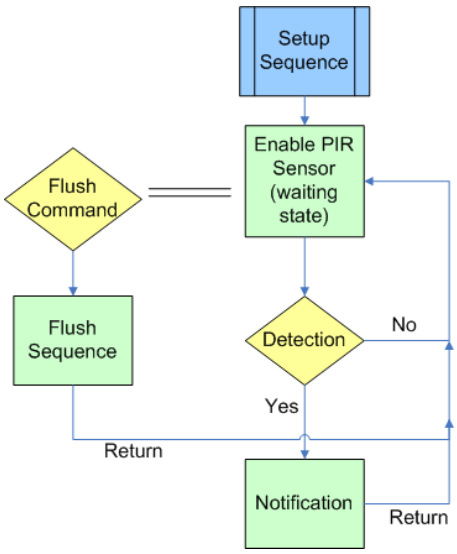

Figure 4. Flowchart for the automatic mode

Design Description

The complete design of the A.Wi.M.F.S consists of four stages (see Figure 5) as shown below.

- Vacuum system
- Assembly of bed
- The control box
- Programming

The vacuum system includes the construction of the collection pan with a draining outlet followed by the construction of a collection tank or the vacuum chamber. The vacuum pump is connected to the collection tank using PVC piping. The vacuum pump is used to create suction within the collection tank. The collection Tank/Vacuum Chamber is used to collect excrement and contain vacuum pressure.

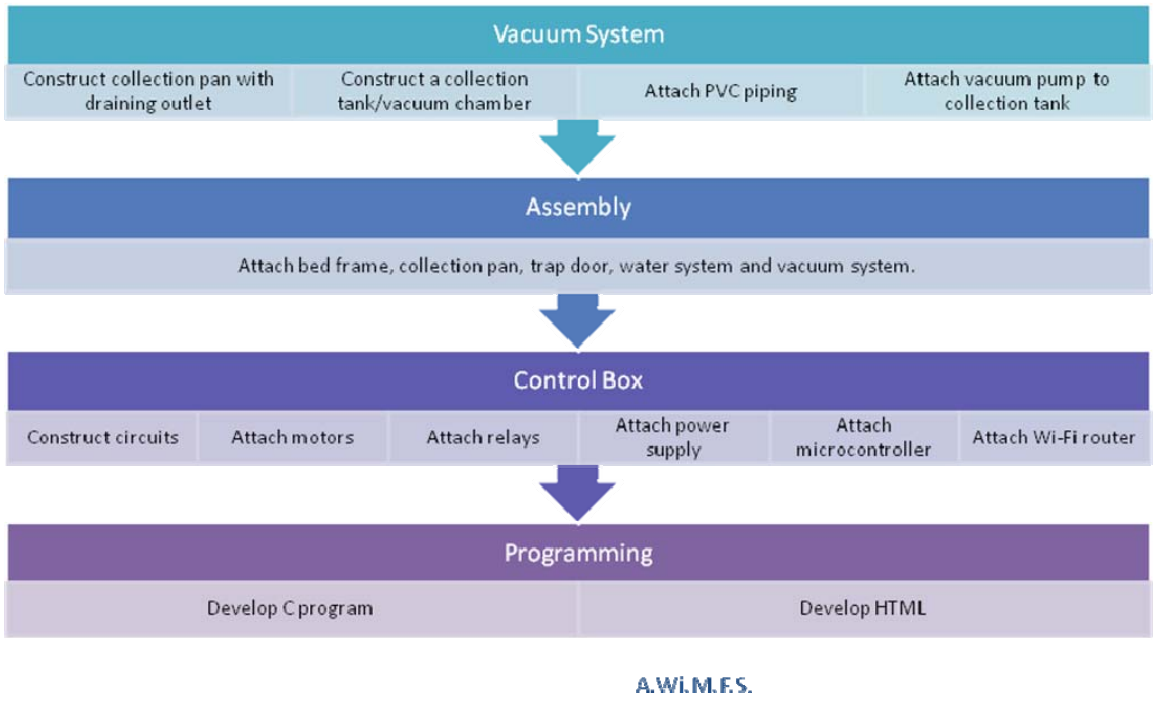

Figure 5. Design description of A.Wi.M.F.S

The assembly of the bed frame comprised of an actual bed frame, collection pan, trap door, water system and vacuum system. The water reservoir is used to store fresh water to be flushed. The control box is comprised of the main electronic components of the system. The linear actuators are used to control the motion of the collection pan and the trap door. The two motors are used to control the linear motion of the actuators. The passive infrared sensor is used to detect presence of excrement. The solenoid valve releases vacuum pressure. The 802.11G router is a connection medium between

interactive console and the 8051 microcontroller. The software for the A.Wi.M.F.S was developed in C and HTML.

Future Enhancement and Conclusion

The primary goal of this research was accomplished by completing the design of a product that is very beneficial for the healthcare industry. The A.Wi.M.F.S is fully functional and incorporates all aspects of the original concept. The system can be redesigned for future upgrades that will add significant advancement. A limit switch can be used to determine the amount of content inside the septic tank [5]. An additional water pump and solenoid valve can be attached to the septic tank drainage valve to drain the contents of the septic tank once a predetermined threshold has been reached. The use of a modern microcontroller will improve the overall system performance capability, and connectivity. Lastly, a pneumatic linear actuator can improve the overall movement of the trap door and the bedpan reducing vibration and mental fatigue.

Acknowledgements

The authors would like to thank Dr. Enrique Barbieri, the ET department chair, Dr. William Fitzgibbon, the College of Technology Dean, Dr. Heidar Malki, College of Technology Associate Dean for Research and Graduate Studies, and Professor Fred Lewallen, the Associate Dean for Academic Affairs for their support in providing the fund for the project and travel to the 2009 ASEE/GSW Conference. In addition, the authors would like to thank Alicia Marcelino of Johnson Supply for the donation of the vacuum pump, and the BiPOM Electronics for their timely response to our software questions.

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Biographies

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Karen Marcelino graduated from the University of Houston in May 2008 with a bachelor’s degree in Computer Engineering Technology from the College of Technology. Karen is currently an Electrical Engineer in the Oil and Gas Industry. She plans to pursue a Master’s in Business Administration. Karen has been a member of Instrumentation, Systems, and Automation Society (ISA) and served as the secretary for the University of Houston Student Chapter since 2007. In the future, Karen hopes to rotate into a project

manager role to see a different aspect of engineering and to develop the different traits associated with being a project manager.

HUNG TRAN
Hung Tran obtained a Bachelor Degree in Computer Engineering Technology in May 2008 at the University of Houston. He has been in the information technology field since 2000 and is looking to enhance his skills by pursuing a Master Degree in Network Communication. Currently, he is working as a Network Administrator at a credit union and is seeking a more challenging position in a corporate environment.

KENNETH JONES
Kenneth Jones obtained a bachelor's degree in Computer Engineering Technology from the University of Houston. Kenneth had been working with electronics for six years and computers for over eight years. He gained most of his electrical/electronic practical experience from working on avionic equipment in the U.S. Army. Currently, Kenneth is an Electrical Engineer for an oil and gas company. He is planning to go back to school for a Master's Degree in Electrical Engineering.

FARROKH ATTARZADEH
Dr. Attarzadeh is an associate professor in the Engineering Technology Department, College of Technology at the University of Houston. He teaches software programming, digital logic, and is in charge of the senior project course in the Computer Engineering Program. He has developed a concept referred to as EMFA (Electromechanical Folk Art) as a vehicle to attract young students to the STEM fields, and is Associated Editor for student papers at ***the Technology Interface*** (http://engr.nmsu.edu/~etti/). He is a member of ASEE and has been with the University of Houston since 1983.

ADITYA GUPTA
Aditya Gupta is currently pursuing his Masters in Electrical Engineering from the Cullen College of Engineering, University of Houston. He plans to graduate in summer 2009.He is interested in Analog Design, VLSI Circuit Design, Layout, Verification and Testing. He is a Teaching Assistant in the Department of Engineering Technology.