

Smart Beds For Hospitals with Internet of Things Solutions

Moeid M. Elsokah¹, Hend M. Farkash² and Amer R. Zerek³

¹ College of Electronic Technology, Communication Engineering Department
Tripoli, Libya

E-mail moayedmohamedm@gmail.com

² College of Electrical & Electronic Technology
Benghazi Libya

E-mail hend.mf.ceet@ceet.edu.ly

³Zawia University, Faculty of Engineering/ EE Department,
Zawia, – Libya,

E-mail anas_94az@yahoo.co.uk

Abstract - Many industries depend on the technological development of the world. Medical industries need to be more advanced as Internet list things. With the help of Internet tools, doctors can monitor patients remotely and give medicines based on tracked information. This bed not only helps patients but will also help to advance the health system around the world and provide medical and health status studies and ability to perform statistical analysis, data collection and easy handling with the patient. Patients with special needs who need this have depended on their family on a daily basis. Recently, health care facilities have begun to use various specialized sensors in hospitals to improve health outcomes and overall construction efficiency. Provides independence for the patient and does not require the help of others as in the past if there has been a disorder then that makes it impossible to live independently in the home. Technological developments in smart homes and life-saving hospitals allow people to stay indoors in a comfortable, secure and independent way where they want to be. Internet solutions are options that can make living independently possible, easy, fun, less stressful and faster. It provides massage therapy and mobility, takes some heavy duty that nurses usually do, saves lives in the end, and provides greater independence for the elderly and the disabled. Energy used to feed is clean energy using solar energy. A hospital bed is a bed designed specifically for patients in hospitals or other people who need some forms of health care that can be used with voice commands and phone applications. Common features include adjustable height for the entire bed, head and feet, adjustable, adjustable, temperature, pressure, database, voice command and application to run both family using sensors and cameras. This family features are special features for both the ease and comfort of the patient and the comfort of health care workers.

Keywords- sensor, The Internet of Things (IoT), Smart Bed System, Portable system, spherical joint, smart technology, information technology.

I. INTRODUCTION

Today's generation of hospital beds is much more than just a place for patients to rest. It's part of many tools used by hospitals to treat patients, especially hospitals interested in

technological developments. It's part of keeping up with the development and research that brings smart technology to hospital beds to increase patient comfort and reduce the incidence of preventable problems, such as pressure ulcers. It's a system of interconnected computing devices, mechanical and digital machines, objects or people that are equipped with unique identifiers and the ability to transmit data over a high-speed network. Canada's Innovation, Science and Economic Development (ISED) works with Canadians in all areas of the economy and across the country to improve investment conditions, enhance Canada's innovation performance, increase Canada's share of global trade, and build fair, efficient and effective competitive market. We are a federal institution that leads the portfolio of innovation, science and economic development [2]. "It's becoming a golden standard of care," said Dr. Donna Macricci, director of intensive care at the New York General Hospital. The most advanced hospital beds are used in the New York General Hospital intensive care unit, where most patients are treated. Ten of the 24 beds here are "smart beds," with computers that can do everything from patient weight to help prevent pneumonia and bed ulcers. It's estimated that 6.5 percent of Americans have an independent living disability, and 3.6 percent of Americans have self-care disabilities. For those suffering from such disabilities the challenges may range from being unable to dress themselves, to being unable to shop for groceries, running errands, or taking the same doctor. A special concern for older persons can be self-care disabilities with cognitive, mobile, hearing or vision impairments, which require more support for accommodations and devices that enable a person to live a more independent life at home for as long as possible. Objects or things that contain an attachment sensor for data exchange, and with the help of the Internet that is used to communicate for decision-making called "Internet objects". These objects measure and report data. This data can be simple numbers from a static or moving sensor (such as a temperature sensor). The results can also be more complex as devices that measure

many data flows and reports each time. These advanced devices can operate or affect the data being measured. Your housing needs may change during your retirement period. For example, you may need more help doing work at home or you may need nursing care as you age. The growth of the number of older individuals in Canada is accelerating, with the total number of older individuals expected to reach about 10 million by 2036. Empowering and encouraging older people to share their knowledge, skills and experience with others in society, and to promote social well-being and community vitality for older people are the goals of the New Horizons Program for Older Persons (NHSPs)[3]. There are many types of accommodation options available to you. You can stay in your home and get help at home, or you may live in a retirement home with meals and care provided. The cost of housing depends on the level of service and care you need. For more services and care, it will be more expensive. Find out about the cost of housing for seniors in your county or territory in the Canadian Mortgage and Housing (CMHC) Housing Reports. [4]

II. METHODOLOGY

The objective of this project was to design a smart bed in the hospital that can be relied on by running voice command, application or button so that it can be manufactured locally and developed. With the completion of this project we hope that our bedside design is widely used throughout hospitals in the world. The price of the bed is greatly reduced and allows affordable modern health care for a large part of the patients and the elderly. Once the research is completed successfully, a prototype of our bed is manufactured, and cross-sectional analyses of structural stability and other mechanical properties are performed to ensure the safety of the bed. The final goal of the team will be to design a reliable local hospital bed by completing the following objectives.

1. To analyse all existing bed products and select from the top quality in relation to price.
2. To manufacture a prototype of the bed and develop it.
3. To identify and support the overall quality of the hospital bed.
4. To provide movement by acoustic ultrasound.
5. To provide an application that can be used on the phone to increase the possibility of communication with the patient.

A. Bed frame

The intelligent hospital bed frame is divided into two parts including the upper frame and support lifts. The upper frame of the smart bed consists of three parts of the head, thigh and foot parts. The linear stabilizers are responsible for adjusting the upper frame to different positions such as sitting position, leg height, back height, back and leg height.

B. National Standards

The specific Curatorial Industry Standards recommendations can be seen below in Table 1. The parameters listed below in

Table 1 are the design specifications on which they were worked.

TABLE1: Curatorial Industry Standards of Hospital Beds that have been applied

	Maximum Value	Minimum Value
Bed length	200 cm	190 cm
Bed Width	100 cm	90 cm
Weight Capacity	N/A	230 KG

C. Food and Drug Administration Guidelines

“The American Food and Drug Administration, or FDA, recently released a statement which discusses in extensive detail the many issues involving patient entrapment on Hospital Beds. The FDA performed extensive background research of their own and sought the information of such reputable organizations as the International Organization of Standards, Stryker International, Hill Rom, the American Red Cross and a number of top American hospitals to find out which areas of modern hospital beds are most dangerous for entrapment, ergonomic data, the number of entrapment occurrences over a number of years and the injuries that resulted. The FDA concluded that there were seven zones which were most dangerous and made size recommendations for those zones to reduce the rate of patient entrapment. Combined knowledge of danger zones, as concluded from the hospitals and bedmanufacturers, as well as the ergonomic data, the FDA determined the seven danger zones as can be seen in the following Figure 12: Seven potential entrapment areas in hospital beds determined by the FDA Figure 1.

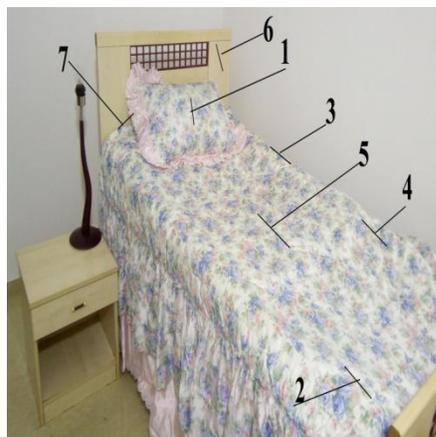


Fig 1: Seven potential entrapment areas in hospital beds determined by the FDA

The seven sections can be defined as follows:

- Section 1 is the area of spacing within the rail
 - Section 2 is representative of the area under the rail, between the rail supports or next to a single rail support
 - Section 3 is the area between the rail and the mattress
 - Section 4 distinguishes the area under the rail, at the ends of the rail
 - Section 5 is defined as the area between split bed rails
 - Section 6 between the end of the rail and the side edge of the head or foot board
 - Section 7 clarifies the area between the head or footboard and the mattress end
- Upon determining the seven zones where entrapment was most likely to occur, the FDA used ergonomic data from the National Centre for Health Statistics to define the spatial limitations for four zones in bed design. Although the FDA recognizes seven potential sections of entrapment, only sections one through four have had dimensional limits recommended because they are the areas where entrapment is most likely to occur. A summary of the limitations imposed upon these zones is described in below Table 2. [5]

TABLE 2: Summary of FDA Hospital Bed Dimensional Limit Recommendations

Zone	Dimensional Limit Recommendation
1 Within the rail	< 120 mm (< 4 3 /4 “)
2 Under the rail, between rail supports or next to a single rail support	< 120 mm (< 4 3 /4 “)
3 Between rail and mattress	< 120 mm (< 4 3 /4 “)
4 Under the rail, at the ends of the rail	< 60 mm (< 2 3 /8 “) AND >60° angle

D. Anthropometric Data

Anthropometric data is a set of measurements to determine the length of the individual appendices based on the height of that person and the calculation of the ratio. This data is determined by conducting many measurements on a random sample of people and averaging the arithmetic mean for them. Anthropometric data is essential to the success of this project to determine the dimensions of the bed and its structural integrity. We need the right distance for the human body to

make this bed reasonably comfortable for the patient. Anthropometric data are available in Figure 2 below. This data is all related to the overall height of the person.

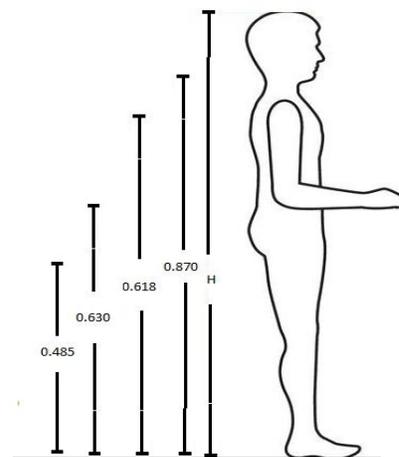


Fig 2: Anthropometric data of a standing person

The second type of anthropometric chart used was someone in the sitting position. Anthropometric data are available in Figure 3 below. In order to determine the lengths characteristic of each part of our hospital bed design, we used the person's data in the sitting position because it is very similar to the location that will be placed on a fully tilted hospital bed.

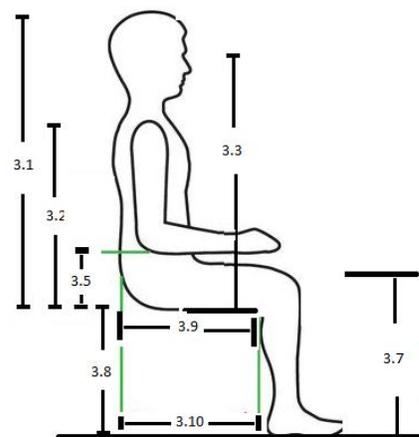


Fig 3: Anthropometric Data showing various human proportions

III. Hardware

Motor, Linear actuator, Coupling, Relay, Spherical joint, Raspberry Pi, Sensors, Jumper cable, Sukam inverter and Battery.

IV. SPEECH RECOGNITION

Google Cloud Speech-to-Text enables developers and innovators to convert audio to text by implementing powerful neural network models in a simple-to-use API where the voice signal is intercepted by the microphone and converted to an analog signal from a digital signal and the API recognizes 120 languages and variants to support your global user base and take advantage of these features by connecting them with Raspberry Pi. It can enable commands and voice control in many applications and can handle real-time or pre-recorded audio and handle these commands using Google's automated learning technology. Figure 4 below shows the Raspberry Pi installation with the bed which receives the voice commands and turns them into signals and then perform the work required.

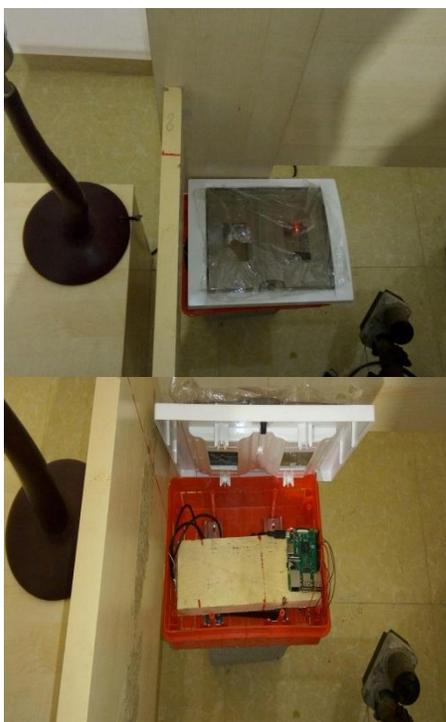


Fig4: Raspberry Pi installation with the bed

V. SHAPING AND ADOPTING TECHNOLOGY

It is time to build the technology nurses want. Nurses do not want to be passive consumers of technology, but they want to be partners in the design and testing of new and innovative applications and devices that are patient friendly and affordable. Nurses have their needs for information systems, technology systems, devices that automate manual functions, speed the delivery of information, and add incremental measures of safety. Nurses unique needs should drive technology development, with better functionality and integration across systems. They want technology solutions that will not only improve delivery of care, but also reduce nursing demand, and reduce the physical burden of work, thus

improving retention. It is important to remember nurses often have information and work process needs different from other healthcare providers, which call for unique solutions. Improved technologies can eliminate waste in nursing workflow resulting from inefficient work patterns, interruptions, inaccessible information, documentation, missing supplies, equipment and medications. Reducing the opportunity for error improves patient safety. Technology driving medication administration systems, improved communications, timely acquisition of equipment and supplies, and fool-proof patient identification are just some applications that improve safety. There is great value in point-of-care devices and systems that accomplish data entry or retrieval and documentation more quickly. Wireless systems that provide rapid efficient communication, free up the nurse to spend more time on patient interaction, as well as higher-level cognitive functions such as planning and analysing care which are needed. The added value and benefits of technology and automation in nursing, enable care to be delivered in a timely, compassionate manner. [6]

VI. IMPACT

Nurses believe it is essential to have smart, portable, point-of-care solutions for capturing and transmitting data, as well as routine communication. They also want technology to reduce demand for nursing time and to facilitate patient life. The study demonstrated the greatest impact of technology is on written communication and data, followed by improvement in safe delivery of care, system integration and oral communications. Technology can also alleviate some employment and workload problems, help track staff, doctors and patients, facilitate the drug cycle, improve the efficiency of the physical environment and facilitate the work flow for the patient. Nurses are not technology averse. They need tools to help prevent errors, reduce them, improve the process and provide information to allow them to practice with confidence and efficiency and get the most accurate results. Technology should be everywhere, helpful and unobtrusive. If appropriately designed. The need to develop technology that will reduce the demand placed on nurses in today's fast-paced and labour-intensive environments.

VII AIR MATTRESS

The hospital bed is equipped with an Alternating Pressure Therapy/Low Air Loss Mattress system developed by Lumex. The mattress system is not only efficient for preventing and treating stages 1 – 4 of pressure ulcers but also convenient for long-term bedridden patients. In order to provide the best therapy and comfort for each type of patient, the hospital bed staff can adjust the pressure and alternating cycle time of the mattress. Providing 6 options of mattress pressure and an optional static mode enables the mattress to meet all the requirements of the patient. Figure 5 presents the air mattress integrated into the bed system.



Fig 5: air mattress integrated into the bed system

It is recommended to use Smart mattresses. The first thing that Smart Ranker does is keep track of your sleep smoothly and record data, eliminating the need to wear a high-heeled bracelet to sleep or sleep with your phone. Smart family collects sleep data without having to do anything. To access the data, you can simply open the application and discover your personal sleep information. By helping you understand your sleep, smart mattresses will guide you to a better sleep and thus improve your health. There is no uniform definition of "smart mattress" but it is used informally to describe a ranking that contains sensors to analyse your sleep patterns, provide information about the quality of your sleep, and in some cases, actively improve your sleep. Smart mattresses in the market do so in a variety of ways. Some of them provide sleep tracking functions to measure sleep duration and sleep cycles by observing your body movement, heart rate and breathing. [7]

VIII COMMUNICATION AND DATABASE

Online database: An online database with statistics and all patient data will be created in real time so that it can be accessed by doctors, health care carriers and close relatives. The screens will be visual and audio screens controlled by the user's privacy level and doctors will have full access to all medical data outputs and sensors. Automatic alerts will be sent via e-mail messages and phone calls.

IX CONCLUSION

This bed not only helps patients but will also help supply a demand all over the world which will help all patients and the elderly. Hospitals and the world continue to focus on technological development to achieve the best results. It is not a new professional or medical intervention in health care. Hospital beds are medically necessary for many situations such as placing the body for example, to relieve pain, avoid respiratory infections, sores and prevent cramps or the need to raise the bed head due to congestive heart failure, suction and chronic lung disease. Hospitals are using a new resource in patient care. The family is designed to move and massage patients and receive voice commands for the user and to adjust different movement situations of the patient which reduces the risk of bed ulcers and lung infections. It takes some of the heavy lifting traditionally done by nurses, ultimately saves lives, and provides greater independence for older people and the disabled. Patients with special needs and need their family on a daily basis. The automatic bed can make life a bit easier for nurses, with 85 percent suffering from back injuries by having to deal with patients. We hope this will help keeping them in a better and healthier shape. One of the most important features of the smart bed is to receive voice commands and is connected to the Internet and this feature to connect to the network provides comfort, help and independence for the patient. Similarly, efficiency of resource utilization, nurses and medical staff with decreased human efforts, lower costs and bring productivity. Also it provides analytics and data collection with best customer experiences and high quality data.

REFERENCES

- [1] techtarget, IoMT " Internet of Medical Things", Available: in <https://internetofthingsagenda.techtarg.com/definition/IoMT-Internet-of-Medical-Things> ,Jul 4 ,2018 7:00 PM
- [2] Public Health Agency of Canada Available:<http://www.phac-aspc.gc.ca> , Jul 13-14 ,2018 2:00 AM.
- [3] Public Health Agency of Canada . Available in https://www.canada.ca/en/employment-social_development/programs/new-horizons-seniors.html , Jul 13-14 ,2018 1:00 PM.
- [4] Public Health Agency of Canada , Housing options for seniors ,Available in <https://www.canada.ca/en/financial-consumer-agency/services/retirement-planning/cost-seniors-housing.html> ,Aug 16,2018 6:00 PM.

[5] U.S. Food and Drug Administration ,Available in :<https://www.fda.gov/ForConsumers/ConsumerUpdates/ucm164366.htm> . Feb 11, 2013 4:00 PM.

[6] Linda Burnes Bolton, Dr PH, RN, FAAN; Carole A. Gassert, PhD, RN, FACMI, FAAN; and Pamela F. Cipriano, PhD, RN, FAAN. “Smart Technology, Enduring Solutions” sep 2008. Available :https://aan.memberclicks.net/assets/docs/fall_jhim.pdf .

[7] H. Nguyen , “Advanced Assistive Control Strategies For Smart Hospital Beds ”, University of Technology Sydney Faculty of Engineering and Information Technology, Sydney, Australia,2016,<https://opus.lib.uts.edu.au/bitstream/10453/90266/2/02whole.pdf>.