DocDispenser: Automated Health Care Unit using NI-MyRIO

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Abstract- The purpose of designing this electronic medical care unit is to provide a solution for the problems faced by the people in the third world countries to get better health incentives and, to improve the equity, efficiency, effectiveness, and responsiveness of health system. My RIO DocDispenser is a form of stand-alone automated health care unit that uses state-of-the-art technology to provide the common man a basic and urgent care services for which doctor need is not essential. Thus, we have confined the basic test facilities into a single unit so that a better, cost effective and more efficient care could be provided to groups of all sizes. The scope of my RIO Doc-Dispenser project is the quick performance of basic incentives, diagnosing diseases with medical devices, improving the chance of recovery by releasing medicines, eliminating travel requirements to urban hospitals and expensive clinics, and cutting the costs of potentially unnecessary visits and mundane medical tasks such as primary level medical inspection. In short, my RIO Doc-Dispenser will become a center for primary health care services.

Index Terms- Healthcare, Assistive Technology, Medical gadgets, Medicine dispenser, NI-MyRIO board.

I. Introduction

The healthcare system in the third world countries is facing critical challenges, which is one of the major causes for those nations that are unable to get basic incentives, be it in urban or rural areas. Not only the patients are burdened, but the doctors are also suffering. We concluded that a cost-effective and time-efficient method need to be introduced in the medical system, and nothing can be best than applying automation. Automation is defined as the use of the information technologies and control systems to reduce the need of human work for services and productions of goods [1].

The time has come to harness the power of automation completely for healthcare [2]. By integrating automation and healthcare, we want to achieve three of the main goals: reduce healthcare costs, improving patient health outcomes and delivering better and more efficient care to groups of all sizes. These goals became our motivation and we have developed a reliable unmanned clinic that will blend into mundane medical procedures by automating primary level medical inspection, diagnosis and dispensing the medicines.

The quick performance of mundane and basic tasks in medical facilities coupled with prompt decision making for improving patient recovery in a durable and compact structure is the notion of my RIO Doc-Dispenser. Thus, this unmanned clinic will improve the equity, efficiency, effectiveness, and responsiveness of health system. For diagnosing a disease, my RIO Doc-Dispenser analyses the real-time data collected from the electronic and medical devices. Moreover, audio, and visual instructions help the patients to use the mentioned gadgets. To improve recovery of the patient, a specially designed automated medicine dispenser releases medicines as soon diagnoses are decided by the state-of-the-art system, so that the patient condition can get stable and can pass a day without seeing a doctor. However, for extreme health conditions, the machine is programmed to immediately instruct the patient to see a doctor immediately. In other words, a common man will no longer have to face basic challenges and problem to get better health incentives at a high price.

II. Related Work

With the recent technological advancements on the internet of things, software, embedded sensors, their communication capabilities, and machine learning, cyber-healthcare has come out as an interesting industry to combat various health problems in developing and developed countries. The Cyber Healthcare Kiosk has been designed that allows monitoring of patient's vital signs, scheduling medical tests, reporting results to a clinician without a traditional office visit and

processing the information by machine learning techniques for recognizing patient condition [5]. A fog computing based cyber-physical health kiosk for patients' condition recognition aims to change the way healthcare is delivered in the rural and low-income areas of the developing world [6]. The SEEK Kiosk is serving as an alternate means for providing care for patients with stable chronic diseases by generating cardiovascular risk according to coronary artery disease risk factors, BP, pulse rate, response to the patient questionnaire and laboratory reports [7]. An autonomous fuzzy-based kiosk infers the health condition of a patient in remote areas using their health records to attain essential health attributes (patient, blood pressure, and pulse rate) for primary diagnosis, the severity of their health and chance of different diseases [8]. MEDICO is a simple medical kiosk designed for rural people that offer various medical services such as measurement of body parameters like height, weight, BMI, blood pressure, and heartbeat, live consultation with specialized doctors through video and voice chats, vending of tablets, notifications of important medical events and so much more [9]. For addressing both internal and external threats to patient data in the multi-user's kiosk, ANOVA proposes a solution by incorporating HIPAA/HITECH standards for privacy and security, and confidentially issue of health records [10].

Similarly, to help patients with their medication, a smart medicine dispenser system is designed for different types of medicines that are stored in improved medical boxes, incorporated with an alarm, and calling a caregiver [11]. Another prototype of a smart medication dispenser, a smartphone application, help seniors and elderly patients to take their medicines on time and provides a channel between patient and caregiver and thus, it reduces skipping of medications and over/under dose [12]. A portable smart medicine dispenser is developed which uses an android application to schedules and releases specific dosage of medicines within a specific time and then notifies the caregiver of the activity [13]. A health IOT platform and intelligent medicine box is implemented, which offers connectivity to doctor through an android app, measuring biometric indicators and releasing medicines; it is beneficial for blinds as well [14]. A pill dispenser assists low-income patients and with distractive disorders, such as Dementia by significantly reducing medication adherence that ultimately leads to drops in diseases related medical cost and hospitalization rates [15]. A working model of automated pill reminder is proposed that can alleviate irregularities in taking the prescribed dosage of medicines at the right time rather than depending on a human for supervision.

III. Methodology

The myRIO Doc-Dispenser contains integrated five medical and five electronic gadgets working as an input.

1. Display
2. Speakers
3. Thermometer
4. Pulse oximeter
5. Weight scale
6. Height Scale
7. Glucometer
8. Microphone
9. NI my RIO
10. Bluetooth module

Working one after another, the medical devices collect medical phenomenon as an input that are body temperature, pulse rate, body weight, body height, blood glucose level and a cough sample respectively. Then through Bluetooth communication, the input readings are passed from the display, which has been specifically programmed with audio and visual instructions and to attain medical data, and transmit to the heart of the unit, NI myRIO. NI myRIO is an embedded device that processes the input data for prompt decision making and as a result, the following electronic devices work together to give the output in the form of medicines and print out a prescription.

1. Medicine dispenser
2. Printer

The following block diagram details the implementation method of myRIO Doc-Dispenser.

The most important prominent features of myRIO Doc-Dispenser are NI myRIO, audio and visual instructions, and automated medicine dispenser.

A. NI MYRIO

FIGURE 1. Block diagram of myRIO Doc-Dispenser

The reason for choosing myRIO, a hybrid system by National Instruments, to do engineering for this healthcare system is its programming that is simplified with LabVIEW (Laboratory Virtual Instrument Engineering Workbench) graphical software. Secondly, this technology is used alone for real-time acquiring and processing of the health data from medical and electronic gadgets to make diagnosing decisions using complex algorithms, followed by displaying and

printing of prescription and dispensing appropriate medicines. In other words, it is one device to implement multiple design concepts with one design.

B. AUDIO AND VISUAL INSTRUCTIONS

As myRIO Doc-Dispenser is a mock-up of future automated primary health care unit so, complete usage instructions of this project are provided to make public to become familiar with this project and can easily use myRIO Doc-Dispenser without anyone's help. No matter the user is educated or not, everyone will be able to use myRIO Doc-Dispenser obviously, by only watching and following the audio and visual instructions on the display screen. These instructions run one after another, for five parameters of myRIO Doc-Dispenser and the patient can also reload the instruction to run it again if he/she missed any step.

FIGURE 2. **A clip of audio and visual instructions for temperature**

Furthermore, after decision making, final diagnostic results get publicized on display for patients so, that patients can easily watch his/her resultant diagnostic results before getting the medicament and prescription in hard copy.

FIGURE 3. **Diagnostic report and prescription on display**

C. MEDICINE DISPENSER

The myRIO Doc-Dispenser is not only a healthcare unit but also a drug dispensary, which facilitates every person by providing with respective to their diagnosis results. The dispenser of myRIO Doc-Dispenser will be able to provide several pills at a time, which only depends on the patient's diagnostic reports and several parameters. For diagnosing, the prototype of dispenser contains four tablets and one capsule.

FIGURE 4. **Medicine dispenser of myRIO Doc-Dispenser**

FIGURE 5. **Printout diagnostic report and prescription**

IV. Algorithm

The following algorithm has been taken into consideration for programming NI myRIO using LabVIEW software.

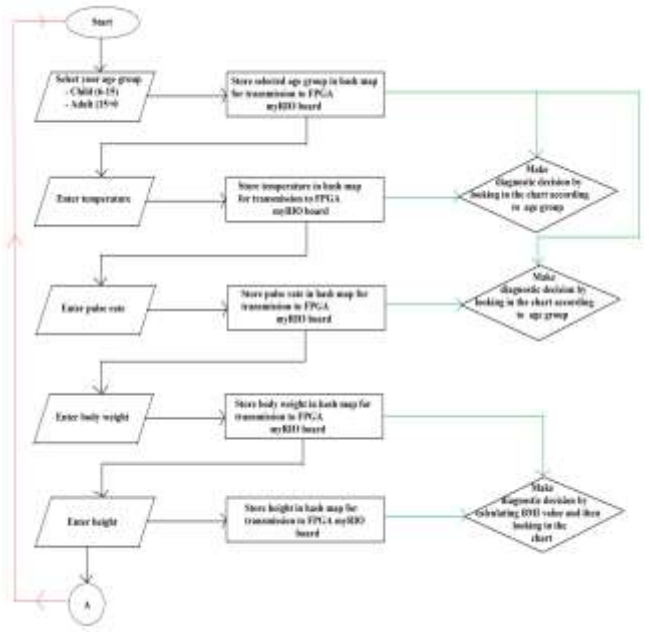

FIGURE 6. **Algorithm for myRIO Doc-Dispenser (a)**

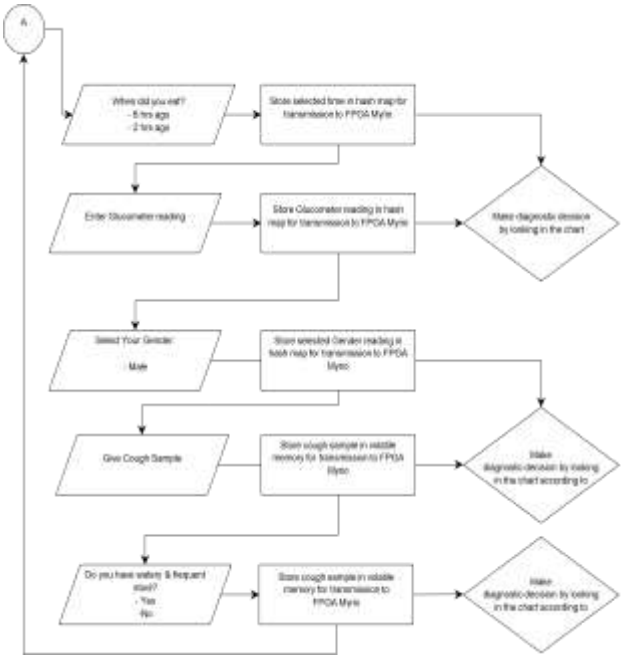

FIGURE 7. **Algorithm for myRIO Doc-Dispenser (b)**

The programming of NI myRIO started with the serial interfacing of HC-05 Bluetooth module and then pairing of FPGA myRIO with display (tablet) to receive medical data, followed by programming algorithm and index for the decision-making using case structures and formula nodes and, transmit of diagnostic report. Furthermore, LabVIEW programming analyses the recorded cough type. Servo motors of medicine dispenser interfaced with NI myRIO are programmed to dispense appropriate medicines. Lastly, display programming ends with the presentation prescription of the diagnostic report and printing.

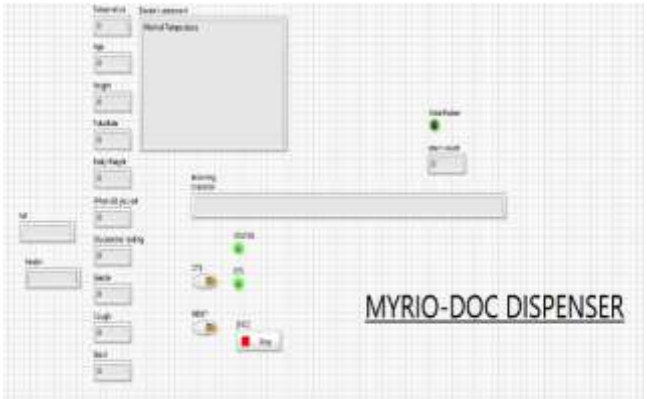

Figure 8. **Front Panel of myRIO Doc-Dispenser**

For the prompt decision making, following indexes were programmed.

TABLE I
TEMPERATURE INDEX & DIAGNOSTIC ACTIONS FOR CHILD (6-15)

Temperature Reading (°F)	Action on Display & Printer	Action for Medicine Dispenser
< 95	very low temperature – see doctor immediately	X
95-99.5	normal temperature	X
99.6-103	fever – take 2 teaspoons of Calpol syrup in every 4 hours	X
>103	very high temperature – see doctor immediately	X

X= no action

TABLE II
TEMPERATURE INDEX & DIAGNOSTIC ACTIONS FOR ADULT (15+)

Temperature Reading (°F)	Action on Display & Printer	Action for Medicine Dispenser
< 95	very low temperature – see doctor immediately	X
95-99.5	normal temperature	X
99.6-103	fever – take 1 tablet of Panadol in every 4-6 hours with water	send PWM to dispense Panadol
>103	very high temperature – see doctor immediately	X

X= no action

TABLE III
PULSE RATE INDEX & DIAGNOSTIC ACTIONS FOR CHILD (6-15)

Pulse Rate (BPM)	Action on Display & Printer	Action for Medicine Dispenser
< 70	low pulse	X
70-120	normal pulse	X
>120	high pulse	X

X= no action

TABLE IV
PULSE RATE INDEX & DIAGNOSTIC ACTIONS FOR ADULTS (15+)

Pulse Rate (BPM)	Action on Display & Printer	Action for Medicine Dispenser
< 70	low pulse	X
70-120	normal pulse	X
>120	high pulse	X

X= no action

TABLE V
BODY MASS INDEX EVALUATION & DIAGNOSTIC ACTIONS

BMI Value	Action on Display & Printer	Action for Medicine Dispenser
< 18.5	underweight	X
18.5-24.9	normal weight	X
25-29.9	overweight	X
>30	obesity	X

X= no action

TABLE VI
GLUCOSE LEVEL INDEX & DIAGNOSTIC ACTIONS FOR MEAL TAKEN 8 HOURS AGO

Glucometer Reading (mg/dl)	Action on Display & Printer	Action for Medicine Dispenser
< 70	low sugar – see a doctor immediately for detailed checkup	X
70-100	no diabetes	X
101-125	early diabetes – take Metformin tablet with meal and exercise regularly	send PWM to dispense Metformin
126-200	high sugar - see a doctor immediately for detailed check-up	X
>200	very high sugar - see a doctor immediately for detailed check-up	X

X= no action

TABLE VII
GLUCOSE LEVEL INDEX & DIAGNOSTIC ACTIONS FOR MEAL TAKEN 2 HOURS AGO

Glucometer Reading (mg/dl)	Action on Display & Printer	Action for Medicine Dispenser
< 70	low sugar – see a doctor immediately for detailed checkup	X
70-140	no diabetes	X
141-200	early diabetes – take Metformin tablet with meal and exercise regularly	send PWM to dispense Metformin
>200	high sugar - see a doctor immediately for detailed check-up	X

X= no action

TABLE VIII
COUGH SAMPLE ANALYSIS FOR MALE & FEMALE

Audio Sample Cough Type	Action on Display & Printer	Action for Medicine Dispenser
wet cough	wet cough – take 2 teaspoons of Prospan syrup every 6 hours along with Vicks tablet	send PWM to dispense Vicks
dry cough	dry cough – take 2 teaspoons of Cerolin syrup in every 6 hours along with 1 Strepsil tablet	send PWM to dispense Strepsil
no match	no dry or wet cough – see a doctor immediately	X

X= no action

TABLE IX
DIARRHOEA INDEX & DIAGNOSTIC ACTIONS

Diarrhoea Detected	Action on Display & Printer	Action for Medicine Dispenser
yes	diarrhea – take 1 tablet of Imodium in a day and sachet of Smecta mixed in a half glass of water	send PWM to release Imodium
no	no diarrhea	X

X= no action

V. Result

Upon reaching to functionality, the most firstly we conducted a hypothesis test to find out the difference between the diagnosis of patients by general physicians and diagnosis by myRIO Doc-Dispenser and which one is more accurate. Furthermore, we wanted to draw a conclusion about the impact of myRIO Doc-Dispenser in general. A total of thirty-two volunteers for diagnosis for myRIO Doc-Dispenser.

Each sample in our data contains temperature measurement by oral (mercury thermometer) and axillary method (armpit), pulse rate calculated manually (for 30 seconds) and using pulse oximeter, body mass index determined by physical appearance and calculated value using weight machine and stature meter, the correct type of diabetes determined from glucometer, determining the cough type, and last but not the least, diarrhea.

General physicians and myRIO Doc-Dispenser diagnosed each sample with either low body temperature (hypothermia), normal body temperature, fever, very high body temperature (hyperthermia), and either diagnose with low, normal, high pulse rate, and either diagnose with low or high blood glucose level, either early or no diabetes, and either diagnose dry, wet, croup or whooping cough, and either with diarrhea. Whereas, due to the absence of medical instruments, the general physicians fail to diagnose patients which myRIO Doc-Dispenser did accordingly to body mass index value that is great importance for a prescription.

We wanted to draw the conclusion that the diagnosis of myRIO Doc-Dispenser is more accurate compared to a general physician. Before deciding the hypothesis test, it is necessary to first calculate the sampled mean.

TABLE X
AVERAGE MEAN & STANDARD DEVIATION OF GENERAL PHYSICIAN'S DIAGNOSIS

	Body Temperature (°F)	Pulse Rate (BPM)	Blood Glucose Level (mg/dl)	Cough	Diarrhoea
Sum	3223	4309	4949	32	32
Total Number (n)	32	32	32	4	2
Sampled mean (μ_0)	100.72	134.66	154.66	8	16
Variance	4.54	591.59	2526.30	34.67	2
Standard Deviation (σ)	2.13	24.32	50.26	5.89	1.41

TABLE XI
AVERAGE MEAN OF MYRIO DOCDISPENSER

	Body Temperature (°F)	Pulse Rate (BPM)	Blood Glucose Level (mg/dl)	Cough	Diarrhoea
Sum	3192.8	4028	4469	21	32
Total Number (n)	32	32	32	4	2
Sampled mean (X)	99.78	125.87	139.66	5.25	16
Variance	5.37	537.40	2545.52	38.25	32
Standard Deviation (σ)	2.32	23.18	50.45	6.18	5.66

To draw a conclusion of the myRIO Doc-Dispenser accuracy, we claim that myRIO Doc-Dispenser diagnosis is more accurate than a general physician. Therefore, the next step would be to prove if the evidence is enough with the confidence level of 95% and level of significance of 0.05 to support the claim and for that a null hypothesis (general physician diagnosis) and alternate hypothesis (myRIO Doc-Dispenser diagnosis) taken into consideration.

Step1: Set up hypothesis and determine level of significance

TABLE XII
NULL HYPOTHESIS (H_0) & ALTERNATE HYPOTHESIS (H_A)

	Body Temperature (°F)	Pulse Rate (BPM)	Blood Glucose Level (mg/dl)	Cough	Diarrhoea
H_o:	μ = 100.72	μ=134.66	μ=154.66	μ=8	μ=16
H_a:	μ <100.72	μ<134.66	μ<154.66	μ<8	μ=16

The statistical data underwent through the most common hypothesis test in healthcare that is left tailed test which is a breakdown of a one-tailed test.

Step 2: Selecting appropriate test statistics

The sample size is large i.e., n≥30 therefore, the appropriate test statistics in (1).

$$z = \frac{X-\mu o}{\sigma/\sqrt{n)}} \quad (1)$$

where X = sampled mean, μo = Population standard deviation, S = Standard deviation, n = sample size.

Step3: Setting up decision rule

For left tailed test, the possible outcome would be to reject Ho if z ≤ -1.645.

Step 4: Compute the test statistics

TABLE XIII
CALCULATION OF Z AND P VALUES ASSOCIATED IN BELL GRAPH FOR ONE (LEFT) TAILED TEST

	Body Temperature (°F)	Pulse Rate (BPM)	Blood Glucose Level (mg/dl)	Cough	Diarrhoea
	0.05	0.05	0.05	0.05	0.05
X	99.775	125.875	139.656	5.25	16
μ_o	100.72	134.66	154.66	8	16
σ	2.132	24.322	50.26	5.89	1.41
n	32	32	32	32	32
z	-2.50	-2.04	-1.69	-2.64	0
P value	0.0061	0.021	0.0455	0.0059	0

The calculation of X values (respective temperature, pulse rate, and blood glucose levels) associated with one-tailed test bell graph for z = 1.645 and z = 0 are determined using the formula of z value mention in (2).

$$z = \frac{X-\mu}{\sigma/\sqrt{n)}} \quad (2)$$

TABLE XIV
X VALUES ASSOCIATED FOR DIAGNOSING HYPOTHERMIA, NORMAL, TEMPERATURE, FEVER, HYPERTHERMIA WITH BODY TEMPERATURE READINGS

z	-1.645	0
μ_o	134.66	134.6563
σ	24.323	24.32258
$\sqrt{n}$	5.6569	5.656854
X (°F)	127.58	134.66

TABLE XV
X VALUES ASSOCIATED FOR DIAGNOSING LOW, NORMAL & HIGH PULSE

z	-1.645	0
μ_o	134.66	134.6563
σ	24.323	24.32258
$\sqrt{n}$	5.6569	5.656854
X (BPM)	127.58	134.66

TABLE XVI
X VALUES ASSOCIATED FOR DIAGNOSING WITH HYPOGLYCAEMIA, EARLY DIABETES, OR HYPERGLYCAEMIA

z	-1.645	0
μ_o	154.66	154.66
σ	50.26	50.26
$\sqrt{n}$	5.66	5.66
X (mg/dl)	140.04	154.66

Using the calculated z values, z score of -1.645 and calculated X values, for normal distribution a one-tailed (left) hypothesis test as bell graphs are depicted as followed:

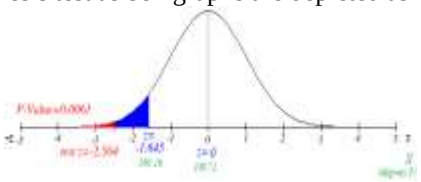

FIGURE 9. Normal distribution for the diagnoses of hypothermia, normal temperature, fever, hyperthermia with body temperature readings

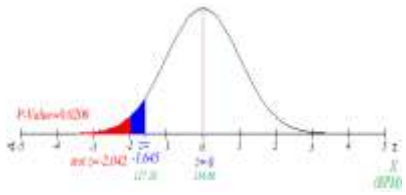

FIGURE 10. Normal distribution for the diagnoses of low, normal and high pulse

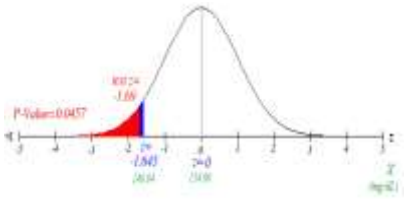

FIGURE 11. Normal distribution of diagnosis of hypoglycemia, early diabetes, or hyperglycemia

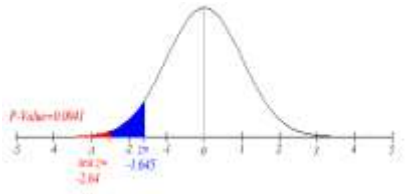

FIGURE 12. Normal distribution of cough diagnosis

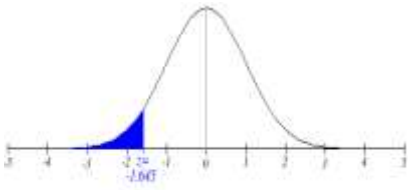

FIGURE 13. **Normal distribution of diarrhea diagnosis**

VI. Discussion

As depicted in mentioned one-tailed test representation of the body temperature, pulse rates, and blood glucose level, the diagnosis of myRIO Doc-Dispenser falls in the rejection region as values of $z \leq -1.645$ therefore, the null hypothesis is not valid. We reject the null hypothesis, Ho, because calculated z values for each medical phenomenon is less than the critical value of -1.64 and hence, have statistically significant evidence at $\alpha = 0.05$. Furthermore, we approximated the p values which is the likelihood of observing the sample data if the null hypothesis is true. Moreover, diagnosis decided with blood glucose level from the given statistically significant evidence is almost similar and very close to each other because the measuring instrument glucometer was used by the physician and myRIO DocDispenser. Furthermore, diagnosis of diarrhoea doesn't fall in the rejection region. Therefore, the null hypothesis fails to reject for diarrhoea diagnosis.

Hence, the alternate hypothesis, the diagnosis of myRIO DocDispenser, can be accepted and the enough evidence is present to support the claim of more accuracy of myRIO DocDispenser compared to a general physician.

VII. Conclusion

The myRIO Doc-Dispenser is the solution to all the basic challenges and problems a common man face to get better healthcare in the third world countries. It is an endeavor revolution in the healthcare industry which will improve efficiency and reduce the operating cost that the medical organizations incurred. The MyRIO Doc-Dispenser will not replace doctor and nurses, instead, it will blend into care delivery processes, therefore; the medical professionals and caregivers staff will then focus on instant caring and further treatment rather than focusing on clinically relevant work. For the people who cannot afford costly medical inspection and basic medical checkup, myRIO-doc-dispenser will be a breath of relief. In this way, a common man will get quality health care services.

FIGURE 14. **MyRIO DocDispenser**

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