Children's Diapers Condition Monitoring in Childcare Centre with Display System

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ABSTRACT

Leaving a babies/children diapers in a wet condition in long times will cause rash/irritation or other skin diseases. Sometimes, in babies/children care centre, the childcare workers cannot changethe diapers often because they will not be noticed that the children diapers already wet. In this paper an online monitoring system for display the condition of the babies/children diapers condition in childcare center is presented. The Wi-Fi module is applied for communication system between the display system and the diaper sensors system. The DHT22 sensor is used for detecting the dampness of the diapers and also for sense the temperature and humidity in and around the diapers, while the sound sensor is used to detect the sound of baby crying. The monitoring system of the device develop able to display more than one diaper condition. The display system used the Blynk application on the user's smart phone. Based on experiments conducted, the system successful to detect more than one diapers and displayed in one application with 85 % accuracy. The application can notify the users when the diapers are wet and or the babies/children are crying with 95 % accuracy.

Keywords: Diaper, Wet, Online monitoring system, Children care centre, Smart phone

1. Introduction

Many parents/husband and wife nowadays are busy working in order to earn more money. Due to the rising cost of living, they have to work hard to make ends meet. At the same time, they need to send their children and babies to the childcare centre. From observation, the number of childcare workers are not proportional to the number of children that they should care [1]. So, it will become risk because the childcare workers do not have a chance to give full attention for each of babies or children and also to change their diapers often enough.

A baby diaper or a nappy is a type of underwear that allows the baby to urinate or defecate without use of a toilet, by absorbing or containing waste products to prevent soiling of outer clothing or external environment [1]. In 2019, the global diaper market which is projected to exceed US$ 51.68 billion according to Laura's report on The Global Baby Diaper Market [2]. It showed that diaper is a product that important and necessary used by the children and babies. The data analysis showed that 50% to 65% of the babies will suffer from diaper rash at some time in their life [3]. That means the baby's skin is inflamed from contact with certain substances. It can be infected by the rash because of the urine and faeces irritate the skin. The diaper rash is a common skin condition among infants which is caused by a mixed of exposure to friction, excess moisture, and increase PH from urine and faeces [4].

In this is presented a device that is able to detect the moisture of the diaper. Taking it even further, the monitoring system developed made easy to monitor about the status of the diaper. Assessing the right time to change the dirty diaper will reduce burden for babies/childcare and reduce the misery of the care receiver too.

2. System Design

The detail requirements of the system develop covers the aspect of the system functions, services and constraints. This is to make sure the system developed will work well. System requirements are described on table 1.

Table 1. System requirements

No.	System Requirements
1	This system allows user to view temperature status based on DHT22 detection.
2	This system allows user to view humidity status based on DHT22 detection.
3	This system allows the user to see LED color change to warn the user about the diaper moisture based on DHT22 detection.
4	This system will send a notification to the user to notify the user when the baby or child is crying based on the detection of the sound sensor.

Figure 1 shows the block diagram of the system developed. The NodeMCU is the microcontroller and used as a brain of this system. Two sensors as input variables are connected to NodeMCU. They are DHT22 sensor and sound sensor. The NodeMCU output will be send to the Blynk application via Wi-Fi for displayed on the smart phone and also will notify the user if the baby's diaper is wet and if baby is crying.

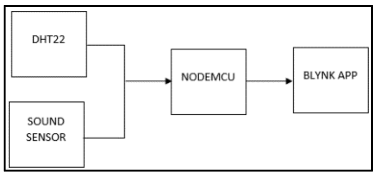


Figure 1. Block diagram of the system

Figure 3.2 illustrates the flowchart how the system work. The system starts the operation by reading the DHT22 sensor value and sound sensor value. The DHT22 sensor is installed at the bottom of device and the sound sensor is installed at the top of the device. The values from each of sensors are sent to Blynk application for monitoring and warning purposes. If DHT22 sensor is active, the Blynk application will display the humidity and temperature status of the diapers. If a LED button in Blynk application in green color meaning the diaper is dry, but if red color it means the diaper is wet. Moreover, the sound sensor function is to detect the sound of baby crying. If baby or child is crying, a notification "Baby crying" will appear on display.

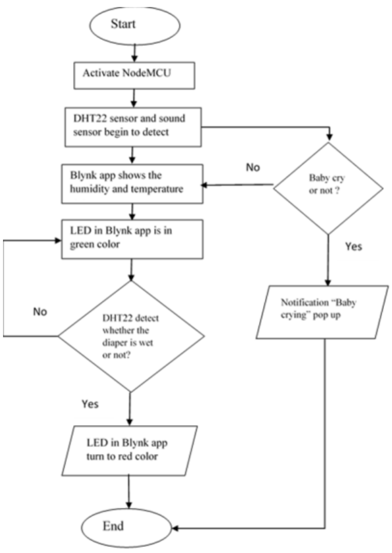


Figure. 2. Flowchart of System

2.1 Diaper Moisture Detection

Figure 3 shows how to determine the temperature and humidity level of the diaper, it depends entirely on the DHT22 reading, if the humidity value is higher than 85% it means the diaper is already wet. Therefore, the LED in the system will change the color from green to red. With this, the user will know that diaper changes need to be implemented immediately in order to prevent babies or children from getting infected.

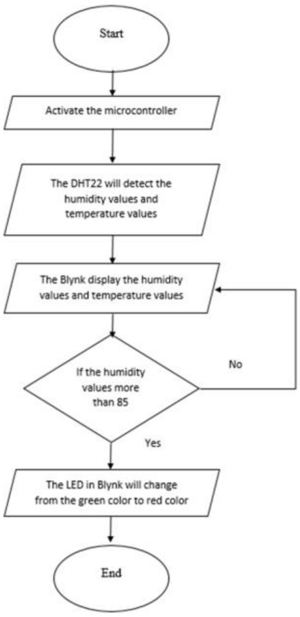


Figure. 3. Flowchart of wet diaper detection system

The diaper moisture, humidity status and temperature status are sensed using DHT22 sensor, how it connected to the NodeMCU is illustrated in Figure 4 below.

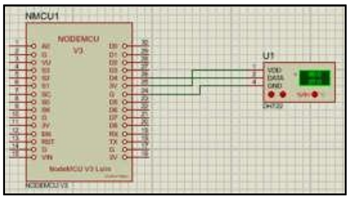
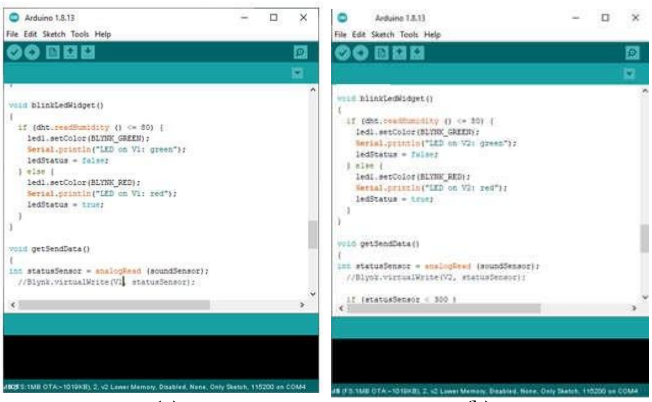


Figure. 4. DHT22 circuit connection

Figure 5 shows the programming to perform a changing of LED in Blynk application. This code is intended for the user notify that if the LED color is turn to red, the diaper is wet, but the LED color still green, it means the diaper is still dry. While figure 6 shows Blynk application configuration for two babies/children. They are Ali and Abu.



(a) (b)

Figure.5. Code for LED on (a) Ali's display, (b) Abu's display

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Figure. 6. Blynk application configuration.

Figure 7 (a) and (b) show the baby Ali's diaper now is in wet condition and the baby Abu's diaper now is in wet condition, respectively.

(a) (b)

Figure.7. LED turn red after (a) detect moisture of Ali's diaper, (b) detect moisture of Abu's diaper.

2.2 Baby/Child Sound Crying Detection

If the babies/children are always leaved crying for a long time period, they will quickly be prone to mental problems and other illnesses if constantly. Therefore, this system also equipped with babies/children sound sensor. Figure 8 shows the flowchart how the system detects a crying baby and give a notification to notify the user that the baby is crying.

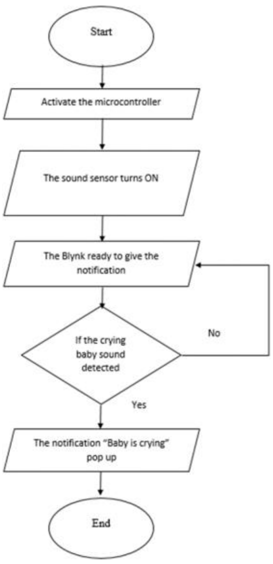
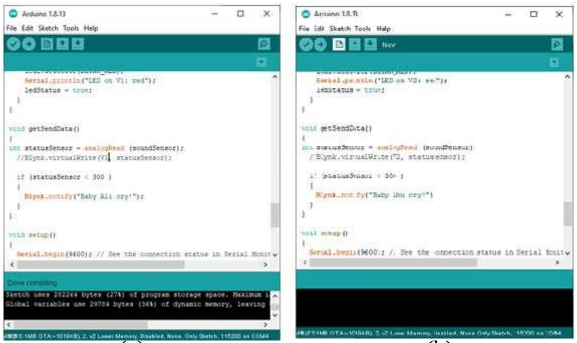


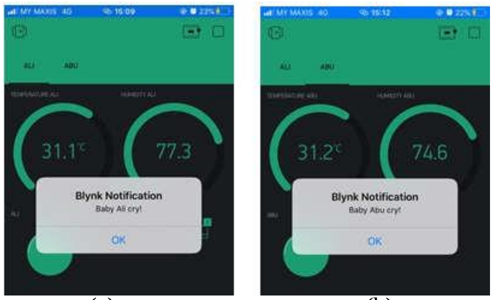
Figure. 8. Flow chart of baby crying detection system

Figure 9 (a) and (b) show the programming code for baby Ali crying notification and (b) baby Abu crying notification respectively. A notification "Baby Ali cry" or "Baby Abu cry" will appear on display. Figure 10 (a) and (b) the notification appears on the display to notify the users that the baby is crying.



(a) (b)

Figure. 9. Code for notification (a) "Baby Ali Crying", (b) "Baby Abu Crying".



(a) (b)

Figure. 10. Notification (a) "Baby Ali crying" pop up, (b) "Baby Abu crying" pop up.

2.3 System Prototype

The prototype of this system is protected by a casing. The casing is made by plastic board. Figure 11(a) shows the top view of the system and figure 11(b) shows how to install the system on the diaper. While figure 11(c) is shown the hand phone as a display.

(a) (b) (c)

Figure. 11. (a) Prototype form, (b) installation on diaper, (c) display

3. Result and Analysis

Several tests have been conducted for analyzing the performance of the system. The first test is to see the effect of urine volume to the response of the system. The second test is to examine the effect of urine temperature on the response of the system. The third test is to examine the effect of the baby's crying volume on the response of the system. While the last test is to examine the effect of the distance between the baby's mouth as a source of crying sound to the response from the system. Each of the tests are elaborated as below.

3.1 Urine Volume Test

This test is aimed to study the effect of urine volume that dropped into the diaper to the system response. The response of system is indicated by changing the LED color from green to red as a notification of the diaper is wet. Table 2 shows the test results.

Table 2. System response to different volume of urine.

No. of Test	Volume of urine (ml)	Value of Humidity (%)	LED Color
1	5	75.2	Green
		74.8	
		75.0	
2	10	77.0	Green
		75.7	
		76.0	
3	15	77.7	Green
		76.9	
		77.2	
4	20	78.8	Green
		79.0	
		79.3	
5	25	80.3	Red
		80.0	
		80.1	
6	30	80.5	Red
		80.4	
		80.5	
7	35	81.4	Red
		81.3	
		81.4	
8	40	81.8	Red
		81.5	
		81.9	
9	45	82.2	Red
		82.5	
		82.7	
10	50	83.3	Red
		83.5	
		84.0	

From above table, it can be seen that the system will respond to a minimum urine volume of 25 ml. Based on [22] example for a baby weighing 10 kg (12 months old [23]) and assuming urination once every 3 hours then the minimum volume of their urination is 10x1.5mlx3 = 45ml, this means the system will work well, because the minimum volume for system working is much lower than the minimum urinary volume of 55.6%.

Figure 12 shows the relationship between urine volume and the value of humidity inside the diaper. Based on the test results, the increasing of the urine volume will increase the humidity. It means if the diaper is full or more liquid inside, the Blynk application will alert the user immediately because the diaper is wet. Then, the diaper needs to be changed quickly.

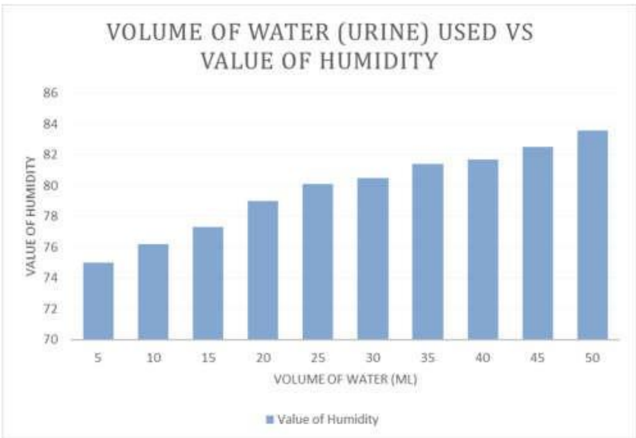


Figure. 12. Volume of urine vs humidity inside diaper.

3.2 Effect Urine Temperature to System Response Test

Table 3 shows the experimental results for urine temperature effect to the speed response of the system. The test is done 10 times, for each test the urine use is taken from a baby who has just urinated. The temperature of the urine is its actual temperature at that time (range between 31^0C – 40^0C [24]). The results also show the change of the speed response of the system is not significant, but the system can response well.

Table 3. Data from effect of urine temperature to system response

No. of Test	Volume of Urine (ml)	Temperature (°C)	Speed Response (second)
1	50	31.8	0.7
2	50	31.8	0.8
3	50	31.9	1.0
4	50	32.0	1.0
5	50	31.7	0.9
6	50	32.2	0.7
7	50	32.1	0.6
8	50	32.2	0.5
9	50	32.1	0.4
10	50	32.3	0.6

3.3 Baby Crying Sound Volume Test

In this test the frequency used as the baby crying frequency is from 336.9 Hz to 502.9 Hz [25] and the lowest test frequency used is 300Hz and increase 10 times by 15Hz. The source of frequency used frequency generator and speaker for generate sound. Based on the results, the system can response well in the baby crying sound frequency.

Table 4. Data collection from different sound volume baby crying.

No. of Test	Sound Volume of Baby Crying (Hz)	Notification appear or not (3 times test)	Time Taken for a Notification pop up (second)
1	300	No	-
		No	-
		No	-
2	315	No	-
		No	-
		No	-
3	330	No	-
		No	-
		No	-
4	345	Yes	10.0
		Yes	11.1
		Yes	10.5
5	360	Yes	9.3
		Yes	8.9
		Yes	8.9
6	375	Yes	6.9
		Yes	7.3
		Yes	6.8
7	390	Yes	6.5
		Yes	6.0
		Yes	5.9
8	405	Yes	4.0
		Yes	4.8
		Yes	4.3
9	420	Yes	3.2
		Yes	3.5
		Yes	2.5
10	435	Yes	2.0
		Yes	1.3
		Yes	1.5

3.4 Distance of Baby Crying Sound Test

Table 5 shows the data based on the results from different distance between the baby crying (sound source) and the system. Based on the table, the sound sensor does not detect sound, if the distance from the sound source to the system more than 35cm. It means this system can be used because of the average distance between baby's mouth and their lower belly less than 35cm.

Table 5. Results of distance of baby crying and sound sensor

No. of Test	Distance Between of Baby Crying and Sound Sensor (cm)	Notification appear
1	50	No
2	45	No
3	40	No
4	35	No
5	30	Yes
6	25	Yes
7	20	Yes
8	15	Yes
9	10	Yes
10	5	Yes

4. Conclusion

Based on the experimental tests performed, the developed system able senses urine existing in baby/child diapers with a minimum volume of 25 ml. It can work well on the temperature range of urine (31^0C – 32^0C) as well as humidity inside diapers, on the frequency range of the sound of the baby crying (336.9 Hz - 502.9 Hz) and also in the maximum distance between the baby's mouth as a sound source with a system mounted on a diaper.

Acknowledgement

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