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Design and Development of Real-Time Monitoring & Controlling Infant Incubator with Tilt Stabilizer Using Raspberry Pi Remotely Controlled via PC and Smartphone to Reduce Tilt during Baby Transfer

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Abstract: This research aims to Design and Development of Real-Time Monitoring & Controlling Infant Incubator with Tilt Stabilizer Using Raspberry Pi Remotely Controlled via PC and Smartphone to Reduce Tilt during Baby Transfer. An experimental approach was used, involving data collection, controller determination, hardware design, circuit schematics, software design, and user interface development. Raspberry Pi was selected as the controller due to its sufficient GPIO pins for reading sensors and operating actuators. The tilt stabilizer was created using NEMA 17 stepper motor and a self-designed flexible screw nut to ensure precise tilt adjustment. During testing, the system demonstrated reliable performance, verified through analysis of test data and sensor readings on the HDMI-connected screen, and remote accessibility via PC and smartphone using the internet. The incubator's temperature consistently maintained 37°C using PID control. On an inclined surface of 20°, the tilt stabilizer effectively maintained a stable 10° inclination during baby transfers.

Keyword: Infant incubator, Tilt stabilizer, Raspberry Pi, IoT, Sensors.

INTRODUCTION

An infant incubator (Baby incubator) is a closed place, a place to put the baby in a controlled environment to warm the baby and keep the baby from germs under the observation of a nurse or doctor. (*Permenkes*, 2014). In transferring babies, the aspects that need to be considered are vibration and tilt when being moved (Laurence Blaxter, 2017). The maximum tilt angle is 5° during normal use and 10° during transfer (*Kemenkes RI*, 2014).

The Gyroscope sensor can be used to read the tilt and deep vibration values incubator. A Gyroscope sensor is a sensor that can detect rotational or rotational movements on the three x, y, and z axes. (Wisnu Jatmiko, 2021). A Gyroscope sensor can be applied to Raspberry Pi to give action to reduce tilt and vibration when the baby is moved. Raspberry Pi is a small

mini-computer designed to run a variety of applications and computing projects. (Windu G. Raharjo, 2020), The number of sensors used in a measurement or analysis system can affect the level of precision or accuracy of measurement or analysis results of the intended object (Andika Primary, 2022).

In development, infant incubators can use IoT for access control and monitoring. Internet of Things is a concept where everyday objects or devices are connected and communicate with each other through the Internet network (Nurfajar Muslim, 2017).

Based on the existing problems, development is needed in the infant incubator so that it can reduce the death rate in infants caused by tilt and vibration that occurs during transfer, and can be monitored in real-time by other parameters so that the baby's condition is maintained. (Laurence Blaxter, 2017).

METHODS

This research was conducted to discuss how system control infant incubators equipped with a tilt stabilization system to reduce tilt and vibration when moving the baby as well as other supporting sensors that can be monitored and controlled remotely real-time.

The basic technology of an infant incubator with tilt stabilization to reduce vibration when moving the baby that can be monitored and controlled in real-time this can be realized using Raspberry Pi as a processor that controls input from sensors and output that can be controlled so that it can set the parameters needed so that infant incubator that have been made to work according to requirements. By integrating Raspberry Pi, this system can allow users to monitor and control infant incubators . This provides convenience and security in monitoring the baby's condition and making parameter adjustments as needed on an ongoing basis in real-time. In addition, this system can also provide notifications if changes or emergencies occur, so that medical personnel can immediately deal with them.

A. Planning Hardware

Planning hardware on design and development real-time monitoring and controlling infant incubator with tilt stabilizer to reduce tilt and vibration during baby transfer using Raspberry Pi based on IoT, is to maintain the condition of the slope of the base where the baby is placed on to keep the baby from tilting and vibration caused by moving the baby from one place to another as well monitoring all possible parameters observed and read by sensors that are able to read data on babies who are in the incubator, for more details can be seen in Figure 1.

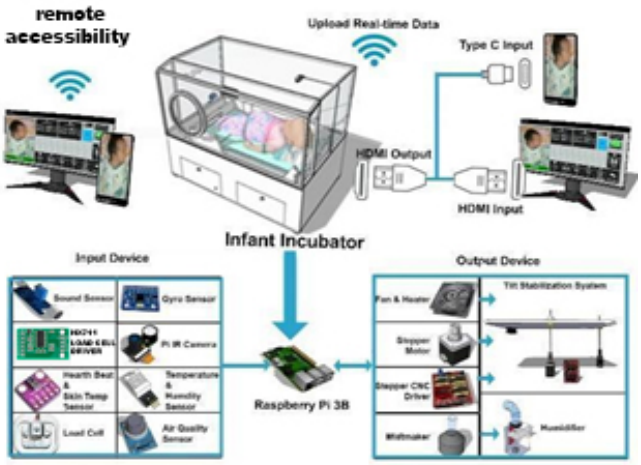

Figure 1. Work Tool Schematic Diagram

From Figure 1. There are eight types of sensor inputs that provide parameter values to Raspberry Pi and also four types of output which are assembled to be tilted stabilizer, fan

heater, and also humidifier. All the input and output devices are processed by Raspberry Pi so that they can work according to the function of the incubator.

Data processed by Raspberry Pi is displayed in accessible HTML form through the browser. For offline use accessed via the HDMI output on Raspberry Pi Displayable Through a monitor with HDMI to HDMI communication cable or mobile phone through HDMI to Type C communication cable.

Some devices have input volts which are different namely 5VDC, 12VDC, and 24VDC while the source voltage used is 12VDC from the battery (battery). For Realize the working scheme of the tool is made of several additional voltage regulator components so that all components needed can work. For conversion voltage from 12VDC to 5VDC the XL4015 voltage step-down module is used with a maximum capacity of 5A, the module is used as input from Raspberry Pi and distributed to other components that require 3.3VDC to 5VDC input through GPIO available from Raspberry Pi, this is shown in Figure 2.

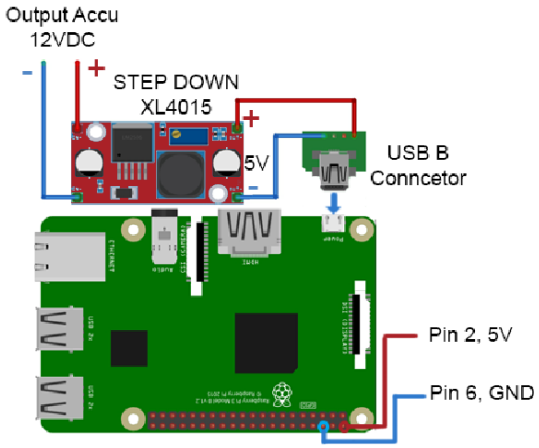

Figure 2. Power Supply for Raspberry Pi 3B

From Figure 2 it is explained that pin 2 and pin 6 function as a source voltage which will be used for components that require a 5VDC supply voltage such as Temperature & Humidity Sensor DHT22, Air Quality Sensor MQ-135, Sound Sensor FC-04, Gyro Sensor MPU6050, Water Sensor, Load Cell Driver HX711, Heart Beat & Oximeter MAX30102 and Relay Modules.

To get a tilt stabilization system uses sensor gyroscope as a tilt sensor from the base where the baby is placed, as well as a stepper motor NEMA 17 as a mover with the aim of adjusting the slope so as not to exceed the regulated limit of 10 °, while the design is so tilt stabilizer can work is shown in Figure 3.

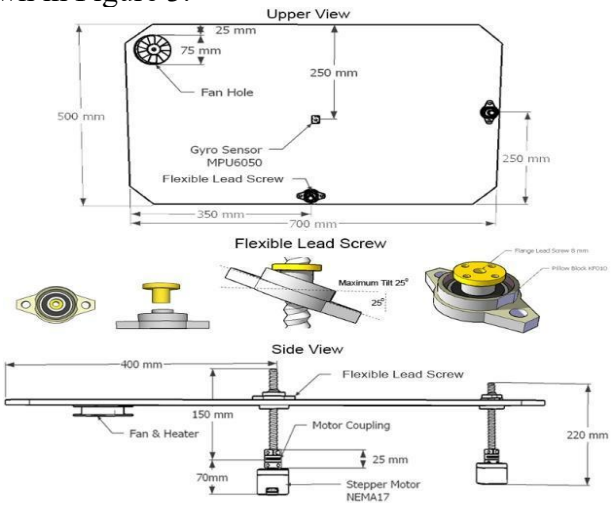

Figure 3. Plan Tilt Stabilization System

Figure 3 Explain planning from a tilt stabilization system where the stepper motor is used as a driver to stabilize the base sustained by a lead screw. The working principle is when the lead screw rotates the base will swing down or up from the screw rotation. To overcome the occurrence of pulling pressure from lead screws use a flexible lead screw nut which has a flexibility tilt up to 25° and can turn to each side. It makes the base perfectly tilt able up to 10° as depicted in figure 4.

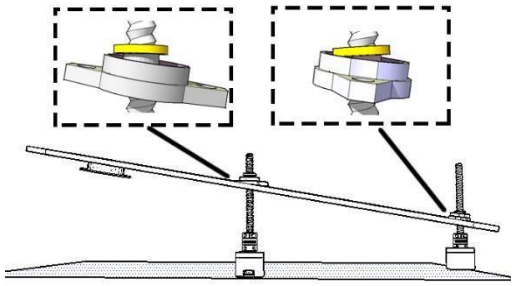

Figure 4. Way of Work Flexible Lead Screw Nut

Figure 4 explains the movement lead screw nut which makes the base tilt able and reduces drag between the screws because of the tilt. Movement of the stepper motor controlled by the connected A4988 stepper motor driver regularly series between Raspberry Pi and Arduino already programmed as a controller stepper motor, so that the stepper can move according to the command from Raspberry Pi.

hardware from tilt stabilization is inserted into the incubator chamber with the shape and size as shown in Figure 5.

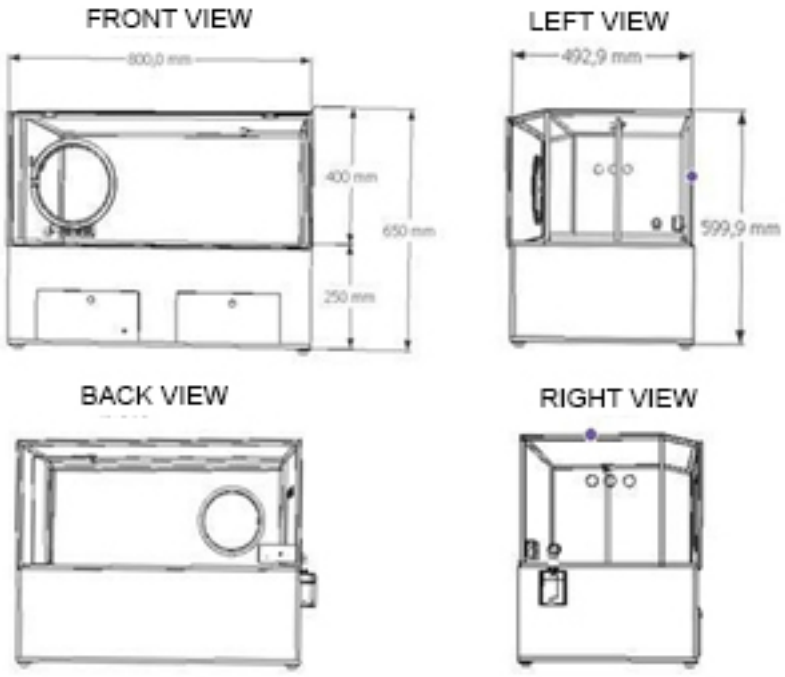

Figure 5. Incubator Room

The entire schematic network for inputs and outputs that have been connected to GPIO on Raspberry Pi can be seen in picture 5.

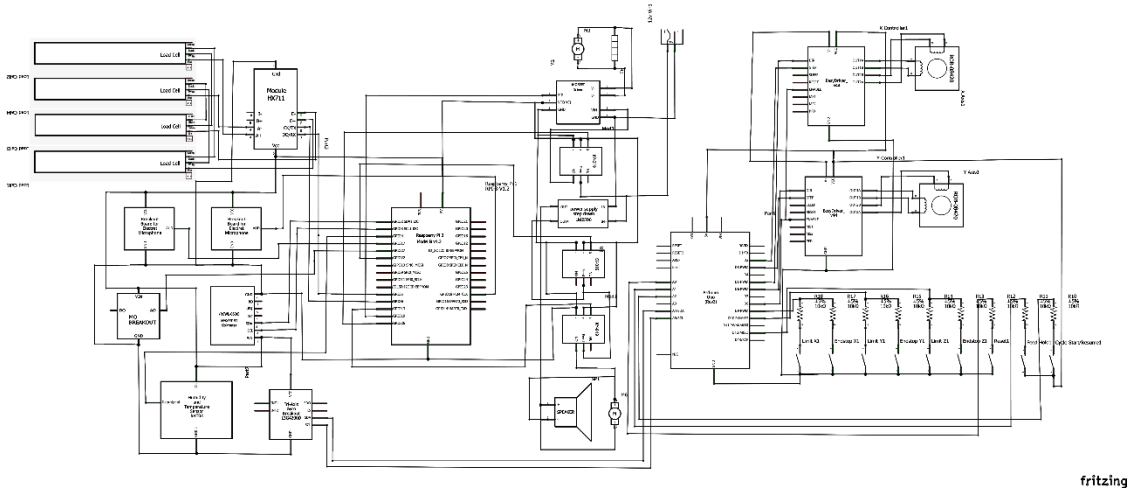

Figure 6. Network Schematic

Figure 5 describes the input and output connections of the components component which is used to GPIO on Raspberry Pi, where the components connected to the GPIO will be processed inside Raspberry Pi corresponding to its GPIO Pin. Suitability between the type of sensor and GPIO is very necessary because the 40 pins of the GPIO have their respective roles.

B. Planning Software

On planning software here consists of a program for the operation of Raspberry Pi as a processor of input and output that is used using the Python program language as the program language default from Raspberry Pi. For planning software other there is a program to operate Arduino as a stepper motor controller that communicates with each other Raspberry Pi serially and displays camera captures, set values, and parameters that can be set on the incubator interface program with Pygame is used for serving as a display function readily available in Python.

RESULT AND DISCUSSION

A. Hardware Result and Discussion

The result of the design and development infant incubator with tilt stabilizer to reduce the tilt when transferring the baby using Raspberry The IoT-based Pi has a complete appearance as shown in Figures 7 and 8 as follows:

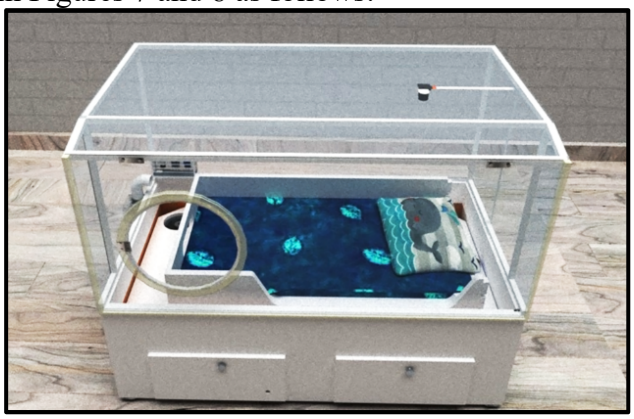

Figure 7. The infant Incubator closed

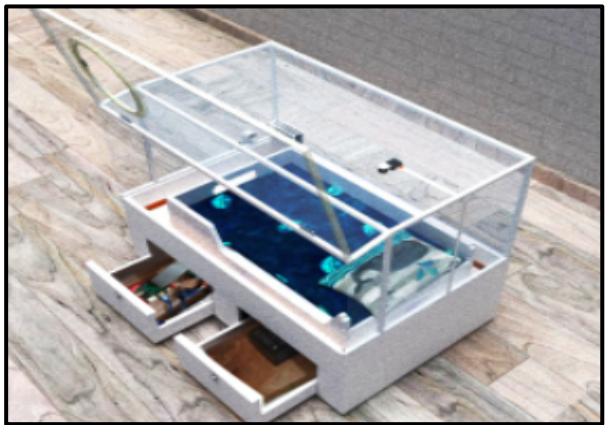

Figure 8. The infant incubator open

Each component used is arranged in accordance with the function and environment required by the component in the incubator put inside the panel, under the pedestal, and on the pedestal. As for what is inside the panel are control components such as Raspberry Pi, Arduino motor stepper driver, voltage increaser, and voltage decreaser, therefore on the panel there are connecting terminals Raspberry Pi to all components, both input and output.

At the bottom of the base supported by a tilt stabilizer of course there is a stepper motor as the driver of the base, at the top of the base there are input sensors that function to get the value of the state inside the incubator and the output is the fan heater, while for humidifier placed outside in order to prevent leakage that can damage other components.

Input and output connections on the infant incubator connected to the GPIO pins of Raspberry Pi can be seen in the schematic figure 9.

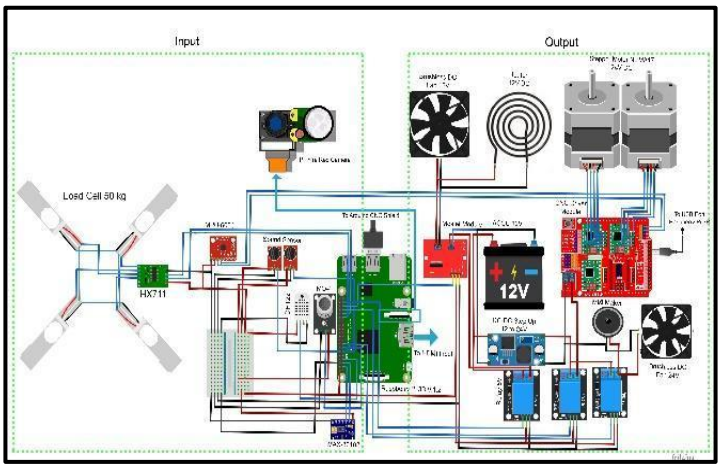

Figure 9. Image Schematic of Infant incubator.

Sensor reading testing is carried out by creating a Python program that is made to read the GPIO pins on the Raspberry Pi, a simple program to receive values received by the sensors used, as well as output testing, namely the heater, humidifier as well as tilt stabilizer. This reading is made with software Thony with Python programming language and is equipped with TKinter shown in Figure 9.

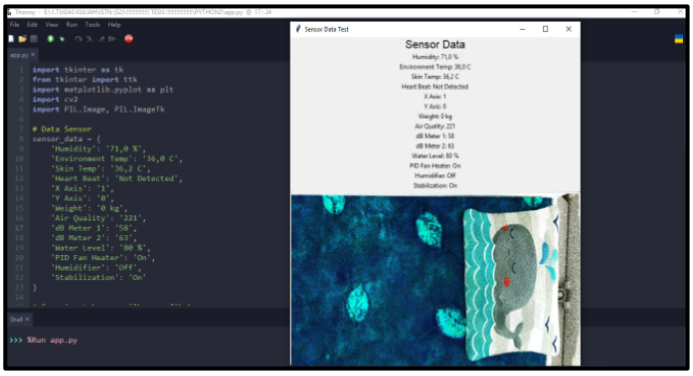

Figure 10. Input Testing

Figure 10 explains that the input values and the camera function are according to the working principle of the sensors used. From those values, a program is made to control output to work according to the required working principles.

For output testing, it is made again by taking one of the required values such as the room temperature value used as input from temperature control, humidity as input from humidity control, and gyro sensor as input from tilt stabilizer.

To get the test value temperature control was carried out for 60 minutes to get the time needed to reach the set value which is set at 37° Celsius, attesting down temperature control can reach a temperature of 37 degrees approximately 19.7 minutes ago it worked in PID at temperatures of 37.2 and 36.8, the test results can be seen from figure graph 11.

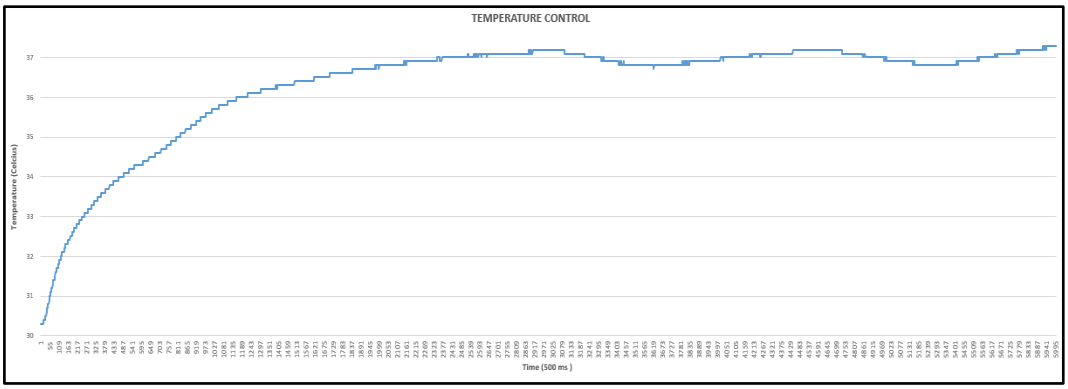

Figure 11. Temperature Control Incubator

For testing, a tilt stabilizer is carried out with an infant incubator as far as 20 meters through flat terrain then descend and return to the starting position by climbing with a slope of 20°. The data being compared is the level of slope that occurs at the time the infant incubator is taken on a trip, by comparing the value of when tilt stabilizer is activated and not activated, here is the comparison chart

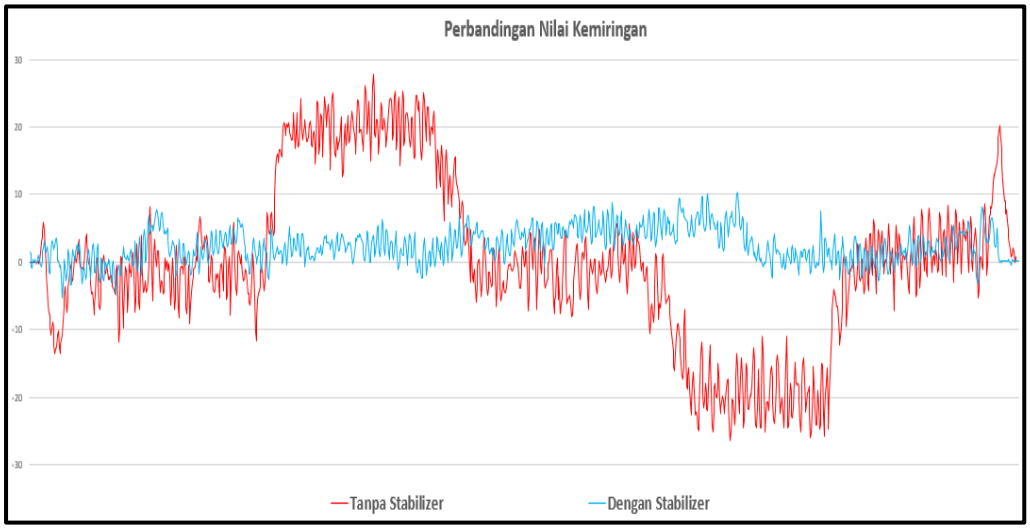

Figure 12. Comparison Between Not Using and Using Tilt stabilizer

In readings every 100ms form and current graph values tilt stabilizer activated is 10.20° this is shown on the blue line, this shows a more gentle change in the slope value compared to not using it tilt stabilizer where the big and significant change in angle when incubator transferred has a maximum value tilt is 27.75°, the value is greater when the incubator is moved without tilt stabilizer compared to the angle of inclination of the terrain due to heat and vibration that occurs when the tool is moved.

Of all the tests carried out, I concluded that the input and output work properly and the data sent can be received properly by Raspberry Pi.

B. Software Results and Discussion

The software used is accessible through browsers like Google Chrome, Mozilla Firefox, Microsoft Edge browser, and others commonly used. The method is designed so that the data displayed can be accessed from anywhere. This aims to facilitate access to the infant incubator in implementing the system IoT (Internet of Things). The following is a flowchart programming an infant incubator that has been made.

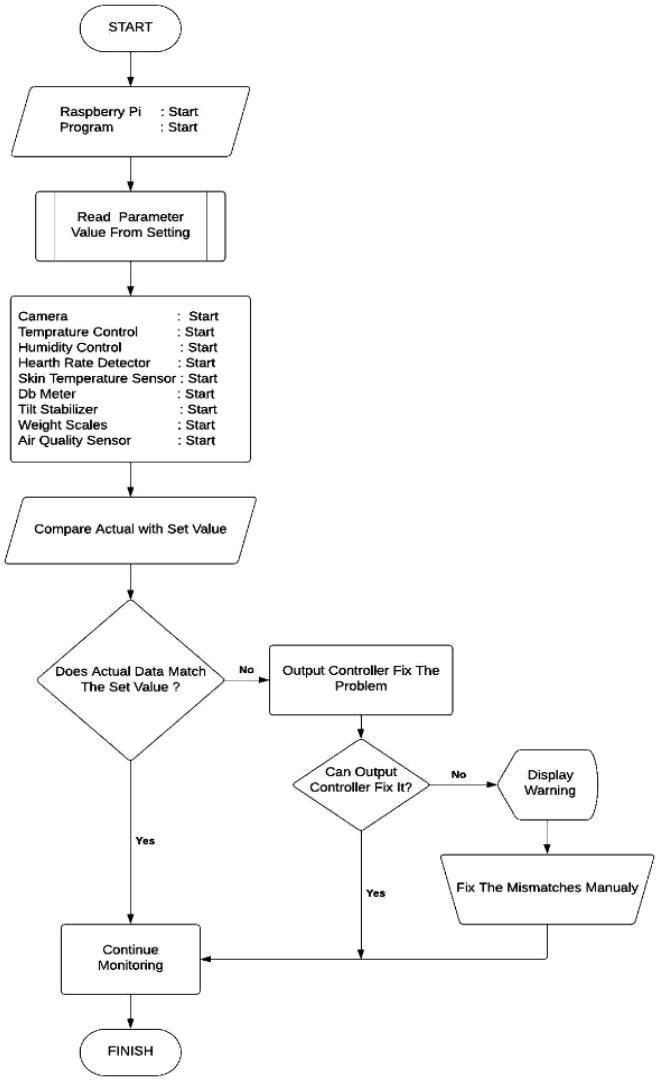

Figure 13. Flowchart Programs Incubator with Python

```
import tkinter as tk
import cv2
from PIL import Image, ImageTk

# Membuat jendela
window = tk.Tk()
window.geometry("1280x720")
window.configure(bg="#444654")

# Membuat frame 1
top_frame = tk.Frame(window, height=90, bg="#202123")
top_frame.pack(fill=tk.X)

# Menambahkan tulisan "Piincubator" di frame dengan font bold
label = tk.Label(top_frame, text="Piincubator", fg="white", bg="#202123", font=("Arial", 20, "bold"))
label.pack(pady=30)

# Membuat frame 2
frame2 = tk.Frame(window, width=432, height=570, bg="#202123")
frame2.place(x=10, y=120)

# Membuat frame 3 (Canvas untuk mengatur latar belakang frame)
frame3_canvas = tk.Canvas(window, width=432, height=576, bg="black")
frame3_canvas.place(x=0, y=100)

# Inisialisasi objek VideoCapture untuk mengakses kamera
```

Figure 14. Program Incubator with Python

In remote access, medical staff are given accounts that allow them to control the entire incubator program, including all programs on the Raspberry Pi. Meanwhile, visitors are granted "view only" access to prevent unintentional changes in settings caused by accessing the incubator without sufficient knowledge or awareness. Therefore, the accounts of medical

staff and visitors are distinguished by different passwords using the features of the Real VNC software. The display of the Raspberry Pi for accessing remote mode using Real VNC Viewer software is shown below.

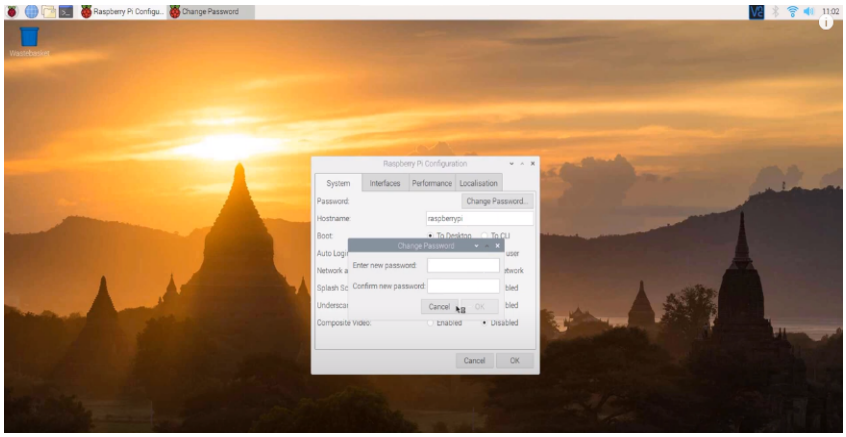

Figure 15. Sign In Acces To Raspberry Pi with Real VNC

In the display, Pygame is used as the display medium, serving as a display function readily available in Python. The display for the incubator is shown in Figure 15.

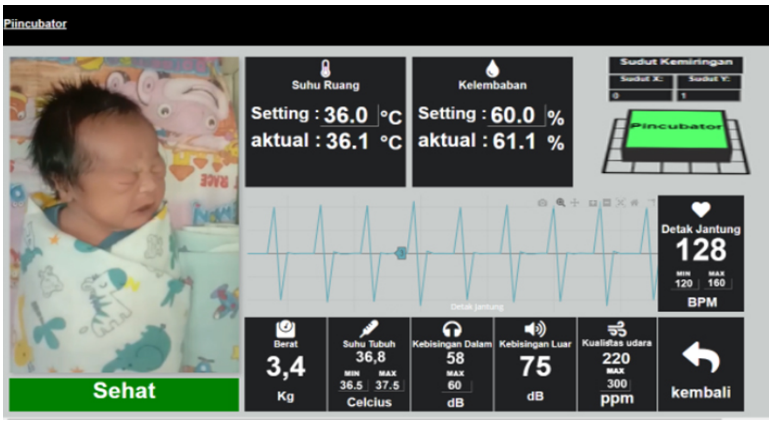

Figure 15. Program Interface for Incubator

When there is a discrepancy between the values set by the medical staff and the values read by the sensors, an alarm will be triggered as a warning for the medical staff to address the issue promptly. The following image shows the display when the alarm is triggered.

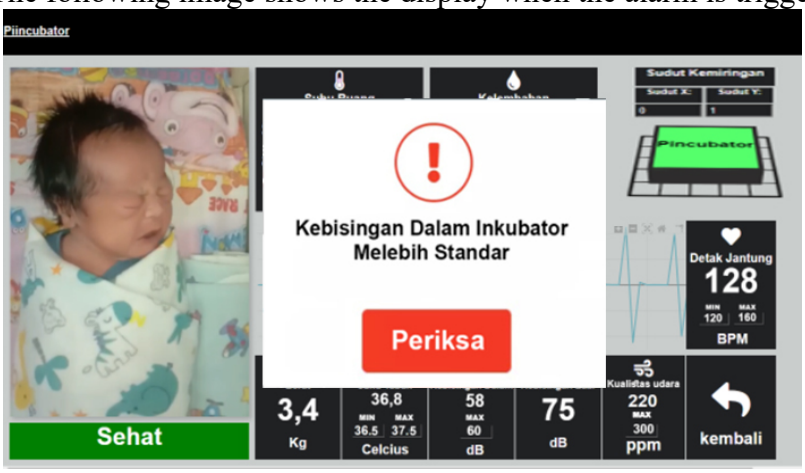

Figure 15. Alarm Triggered

CONCLUSION

From the results of the design of this tool to the findings and discussion, the following conclusions can be drawn:

1. Designed and Development Monitoring & Controlling Infant incubator with Tilt stabilizer to Reduce Tilt When Transferring Baby Using Raspberry IoT based Pi already realized, this is evidenced by looking at the reading data and measurement the sensor values used can be seen on the screen connected via HDMI together with the data display remote accessibility via PC and smartphone using the internet. as well as equipped with an alarm when there is a discrepancy from the value read by the sensor from the parameters that have been set, this aims to provide information to medical personnel so that they can quickly inspect and handle babies.
2. Use of temperature control using the PID method on temperature control tested within 60 minutes at room temperature 30.1° Celsius, the time needed to achieve value set value which is set at 37° Celsius takes 19.7 minutes and then stabilizes at 37.2° Celsius and 36.8° Celsius as the deviation of the upper and lower limits in the application of PID.
3. Usage Tilt stabilizer can reduce the current slope value infant incubator moved because tilt stabilization system can adjust the degree of tilt while moving up to 10°, the evidenced by the results of the incubator transfer test pass terrain with a slope of 20°, when not using tilt stabilizer, slope values tend to be large and change significantly with the maximum reading value the slope is 27.75°, the greater the value when the incubator is moved without tilt stabilizer than the angle of inclination of the field, caused by the pounding and vibration that occurs when the tool is moved, whereas when the tilt stabilizer is activated and moved with the same route and terrain with the previous maximum tilt value decreasing to 10.20°.
4. Remote monitoring and control can be performed using external software such as VNC Viewer and Google Remote Desktop, which offer different access levels. Medical personnel can adjust parameters according to the needs, while other users can use the "view only" mode to prevent unintentional changes in settings caused by visitors accessing the incubator without sufficient knowledge or awareness.

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