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Embedded System

Design Of A Portable Mini Pump It Up System Based On Mini Computer For Children's Gross Motor Improvement

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A B S T R A C T

The increasing influence of smartphones on young children has raised concerns about the delayed development of gross motor skills, particularly in early childhood. This issue is significant in Indonesia, which ranks fifth in ASEAN for birth rates, resulting in a large population of children at risk. Excessive smartphone use by children leads to decreased physical activity, potentially causing health problems such as obesity and reduced physical fitness.

The objective of this study is to design and develop a portable system, called the "Mini Pump It Up," based on a mini-computer (Raspberry Pi 5), that encourages children to engage in more physical activities. This device is intended to divert children from excessive smartphone usage, thereby stimulating their gross motor skills development. Additionally, the system is designed to be used anywhere without requiring an external power source.

The research concludes that the system successfully operates in portable mode without the need for a power supply, sustaining functionality for 3 hours, 10 minutes, and 15 seconds. Furthermore, the system effectively captures the interest of children, as evidenced by 84.21% of the 19 children participants choosing to interact with the product instead of engaging with smartphones..

INTRODUCTION

The author discusses the issue of early childhood being influenced by smartphones, which can inhibit motor system development. This is a common issue in Indonesia, where the country ranks 5th in ASEAN with the highest birth rate. Overuse of smartphones can lead to decreased physical activity, potentially causing health issues like obesity and lack of physical fitness. The author suggests addressing this issue to improve children's health.

Indonesia's Central Statistics Agency predicts 33.44% of 0-6 year olds will use cellphones by 2022, while 24.96% can access the internet, with 52.76% using cell phones and 25.5% using the internet [1]. Excessive gadget use can stimulate five senses in children, but excessive use can lead to brain growth issues, obesity, sleep disorders, mental illness, aggression, and addiction [2].

The Interim Population Projections 2020-2023 reveal that Indonesia's child population, aged 0-17 years, constituted 29.15 percent of the total population in 2021, with East Nusa Tenggara Province having the highest percentage [3].

Gadgets play a significant role in children's lives, often given by parents to allow them to play without accompanying them. While children may be happy with these toys, their development is greatly impacted by their constant access to gadgets [4].

Gadgets play a significant role in children's lives, often given by parents to allow them to play without accompanying them. While children may be happy with these toys, their development is greatly impacted by their constant access to gadgets [5].

Based on the previous explanation, the goal to be achieved by the author is to design a tool that is able to keep children away from smartphones so that children move more to stimulate their motor system and the designed tool can be used anywhere, without the need for a power supply.

The product aims to stimulate children's gross motor skills by allowing them to move their limbs more freely and changing their dependence on smartphones. It provides output in the form of sound and images, aiming to improve their ability to move their bodies.

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METHOD

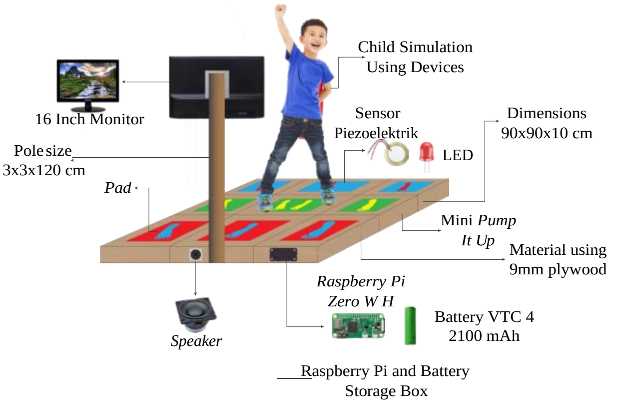
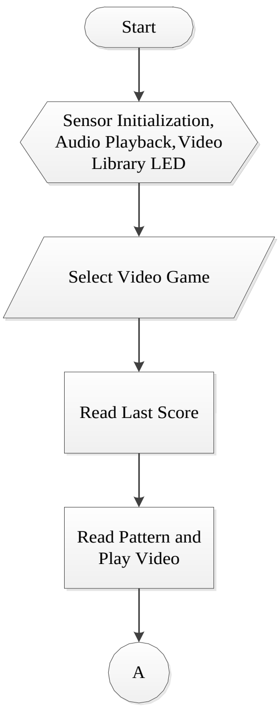


Figure 1. General System Design

The system, designed with 9mm plywood boards for child-resistant durability, measures 90x90x10cm and features a monitor for displaying video instructions. It is built with a stand for easy placement and can withstand pressure.

The system uses a piezoelectric sensor to measure pressure applied, which is processed on the Raspberry Pi 5 and outputs sound on the speaker. A monitor displays video instructions to children, guiding them on which sensor to step on. The complete design of the system is illustrated in Figure 1.

This system is able to provide an overview of the improvement of the gross motor system in children by looking at the scores obtained by children when playing. later the system is able to eliminate the habit of children playing smarphone, and start doing physical activity.



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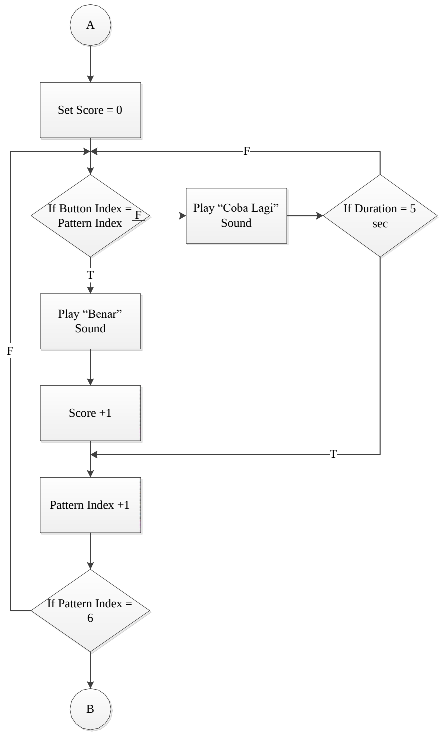

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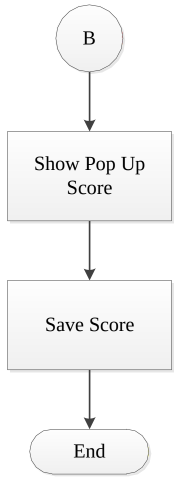

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Figure 2 General System Design Flowchart (a) Initialization Process Flowchart (b) System Work Process Flowchart (c) Score Display and Score Storage Flowchart

The flowchart outlines a system-wide process from initialization to sensor input reading and score display and storage, providing an explanation of the entire process.

The process begins with initializing a Piezoelectric sensor, audio playback, and LED. The video is inputted, and the program calls back the stored score before starting. The system reads the set pattern and plays the selected video. The initial score is set to 0, and the program adjusts the button index with the pattern index. If the button index is the same as the pattern index, the music is played. If not, the music is played again. If the pattern is completed, the program returns to the button index = pattern index. When the pattern reaches maximum, the score is displayed, and the score is saved. The process continues until the pattern is completed.

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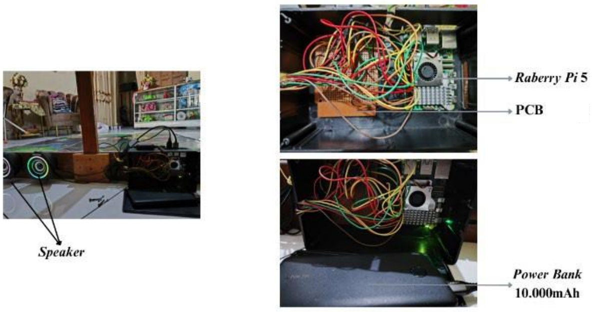
RESULTS AND DISCUSSION

Hardware Implementation

The system was built using several hardware components, including a Raspberry Pi 5, Piezoelectric Sensor, Powerbank, PCB, speaker, and monitor. The complete configuration of the system can be seen in Figure 3



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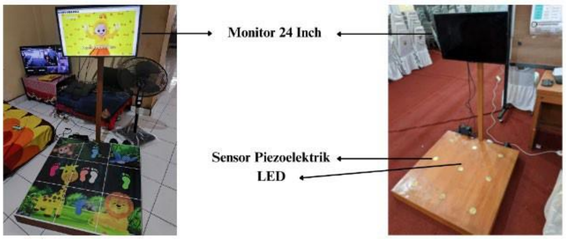

(b)

Figure 3 Hardware Implementation (a) input and output system (b) entire system

The Raspberry Pi is a crucial component for processing data and generating output. It uses a piezoelectric sensor as input and a 10,000 mAh powerbank as a power supply. The Raspberry Pi also uses an LED light and piezoelectric sensors. The speaker serves as an output device for music. The implementation of these devices is illustrated in figure 3 (a).

The 24-inch monitor is used to display videos in the form of movements for children to follow. The monitor's wide display maximizes the video display. A piezoelectric sensor is used as an input, providing a foothold on the sensor. LED points to the sensor that needs pressure or step on. The device's implementation is shown in figure 3 (b).

Software Implementation

Rasberry Pi uses Python programming that will process the raspi to be connected to the system. This explanation contains how the system from the hardware works, is integrated and can send data from inputs.

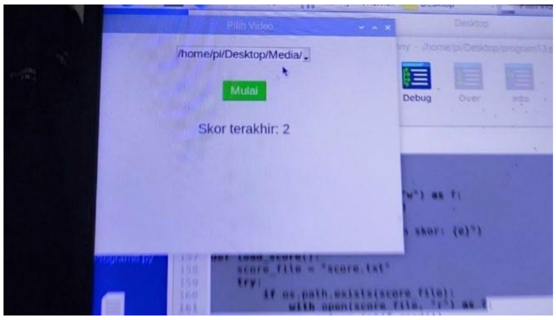

Figure 4 UI Display Before the Game Starts

Figure 4 displays the user interface (UI) when a program is run, featuring a menu to select a video based on the path determined in the previous program. A start button is located under the video menu, allowing the game to begin immediately. The scoreboard below the start button stores the previous game's score.

The GUI display displays the video selection process, as illustrated in Figure 5.

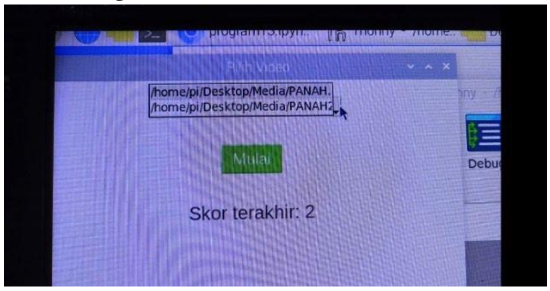

Figure 5 Video Selection Display

Figure 5 displays a GUI display that allows users to select a video to play, with two video options available. The video uses the tkinter library's tk.StringVar(root) module to create string variables that can be bound to widgets in the GUI interface.

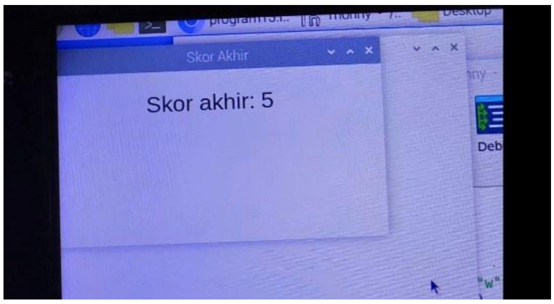

Figure 6 Game Score Display

Figure 6 displays the game's score recording, which is stored in a txt format file using external storage. The program calls the file to display on the system GUI display when the game starts, and automatically saves the score when the game is over.

Figure 7 Display of the played video

Figure 7 displays a video with music, played or run using the OpenCV library. The music is played using the pygame library, which plays wav-format music. The video and music are interconnected.

Sensor Reading Testing

Piezoelectric sensor testing is carried out to get a reading of the pressure on the sensor with a reading of 80% in pressure readings. Piezoelectric sensor testing is needed to get the accuracy of data readings in pressure readings. Useful for providing output to the connected speaker. Testing is done with the system response method obtained from the piezoelectric sensor. Getting pressure readings by experimenting with pressing on the sensor 5 times, testing is carried out on each sensor, then 20 trials will be carried out, aiming to ensure data and get the accuracy of how much the sensor gets the required accuracy. The test results are presented in Table 1.

Table 1. Sensor Reading Test Results

Data Collection	Sensor	Reading Status	Description
1st	Sensor 1	1	Readable
2nd		1	Readable
3rd		0	Unreadable
4th		1	Readable
5th		0	Unreadable
6th	Sensor 2	1	Readable
7th		1	Readable
8th		1	Readable
9th		1	Readable
10th		1	Readable
11th	Sensor 3	1	Readable
12th		1	Readable
13th		1	Readable
14th		1	Readable
15th		1	Readable
16th	Sensor 4	1	Readable
17th		1	Readable
18th		1	Readable
19th		1	Readable
20th		1	Readable
Accuracy		90%	

Table 1 shows that the piezoelectric sensor measures correctly, achieving a 90% reading. However, sensor 1 struggles to read pressure applied multiple times, possibly due to a non-definite pressure size. This issue can be influenced by the application of different pressures. Despite this, the sensor meets the tool's needs by achieving a 90% reading, indicating that it meets the tool's requirements.

Interactive Display Testing

Testing the interactive display itself is done by experimenting with reading the position of the sensor to get a match between the sensor that is pressed with the sensor that is read on the serial monitor system that reads the same. The test is carried out by applying pressure to the sensor for 5 repetitions for each sensor and then looking at the serial monitor reading to find out whether the sensor position reading is correct or not. Before entering the test results, the sensor position and GPIO pins can first be seen in Table 2. The test results are presented in Table 3.

Table 2. Sensor Position and GPIO Pins

Sensors	Sensor Position	GPIO pin
1st Sensor	Top	Pin GPIO 2
2nd Sensor	Left	Pin GPIO 27
3rd Sensor	Right	Pin GPIO 4
4th Sensor	Bottom	Pin GPIO 11

Table 3. Interactive Display Test Results

Data Collection	Sensor	Reading Status	Description
1st	Sensor 1	1	Read on GPIO Pin 2
2nd		1	Read on GPIO Pin 2
3rd		0	Not Read
4th		1	Read on GPIO Pin 2
5th		0	Not Read
6th	Sensor 2	1	Read on GPIO Pin 27
7th		1	Read on GPIO Pin 27
8th		1	Read on GPIO Pin 27
9th		1	Read on GPIO Pin 27
10th		1	Read on GPIO Pin 27
11th	Sensor 3	1	Read on GPIO Pin 4
12th		1	Read on GPIO Pin 4
13th		1	Read on GPIO Pin 4
14th		1	Read on GPIO Pin 4
15th		1	Read on GPIO Pin 4
16th	Sensor 4	1	Read on GPIO Pin 11
17th		1	Read on GPIO Pin 11
18th		1	Read on GPIO Pin 11
19th		1	Read on GPIO Pin 11
20th		1	Read on GPIO Pin 11

In Table 3, it can be seen that the readings on each sensor that is given pressure with the sensor read on the serial monitor are in accordance with the index given to each sensor. Where with the readings on the sensor running as it should, it can support the factor of an interactive display that can provide feedback to children while playing.

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Power Supply Durability Testing

The Powerbank 10,000 mAh battery testing aims to meet the needs of a portable device that can run raspi, speakers, sensors, and LEDs for approximately 3 hours non-stop on one full charge. The testing calculates the time the power supply can last at every multiple of 25% on the power bank, and is conducted when the program is run until the power bank has no more power. The test results are presented in Table 4.

Table 4. Power Supply Durability Test Results

Battery Percentage	Stopwatch Time
100% - 75%	51 minutes 32 seconds
75% - 50%	1 hour 6 minutes 8 seconds
50% - 25%	3 hours 0 minutes 5 seconds
25% - 0%	3 hours 10 minutes 15 seconds

The battery life of portable devices without a monitor, including raspi, sensors, LEDs, and speakers, was tested using a stopwatch. Results showed that the system took 3 hours and 9 minutes to run non-stop, indicating it successfully meets the needs of a system that can run for approximately 3 hours.

Synchronization Testing

Synchronization testing is conducted to ensure system requirements, with a maximum delay of 3 seconds, and to ensure no resolution bugs in the video. The test involves running the system, calculating the time interval between the video and sensor, and recording the time interval using a stopwatch. The expected target delay is 3 seconds. The testing is conducted 10 times per trial. The test results are presented in Table 5.

Table 5. Synchronization Test Results

Trial-	Time Interval	Description
1st trial	2.50 seconds	Video runs smoothly
2nd trial	2.30 seconds	Video runs smoothly
3rd Trial	3.23 seconds	Video runs smoothly
4th Trial	5.13 seconds	Video bug resolution
5th Trial	2.15 seconds	Video runs smoothly
6th Trial	2.45 seconds	Video runs smoothly
7th Trial	6.45 seconds	Video bug resolution
8th Trial	2.28 seconds	Video runs smoothly
9th trial	2.46 seconds	Video runs smoothly
10th trial	2.53 seconds	Video runs smoothly
Average Time	3.14 seconds	

The experimental results show that two times when the system was run 10 times, the video experienced a resolution bug, causing it to display not its actual size. This bug also accelerated the video's duration. The average interval time was 3.14 seconds, which is within the test target of 3 seconds, which is in line with the system's needs. The video's average interval time is 3.14 seconds, which is within the target.

Gross Motor System Testing

The assessment instrument method is used to measure a child's gross motor development. The test is based on the child's score obtained during a game, which is used as a reference for describing their motor improvement. The test is categorized into three categories: mature, in the process of growth, and not yet formed. A score of 6 indicates mature motor development, a score of 3 indicates growth, and a score of 0 indicates not yet formed motor development. The testing was conducted at Melati Ikhlas Kindergarten in Nanggalo, Padang. The results provide insight into the child's motor development. The test results are presented in Table 6.

Table 6. Gross Motor System Test Results

No	Child's Name	M/F	Age/ Year	Score	Category
1	Muhammad Khaeri Putra	M	6	4	The child's gross motor is mature
2	Akhtar Alsheiraz Aghisi	M	6	5	The child's gross motor is mature
3	Rezqi Arkana Ikwan	M	6	5	The child's gross motor is mature
4	Nathania Alysha	F	6	3	child's gross motor in the process of growth
5	Umnasha Azkayra Jaya	F	6	3	child's gross motor in the process of growth
6	Noureen Shanum	F	6	6	The child's gross motor is mature
7	Ahmad Arsya	M	6	5	The child's gross motor is mature
8	Bilal Sidqi Rahagi	M	6	6	The child's gross motor is mature
9	Aira Qaisara	F	6	3	child's gross motor in the process of growth
10	Muhammad Habibie Ansar	M	5	4	The child's gross motor is mature
11	Habib Qayyum	M	5	5	The child's gross motor is mature
12	Aqif Maulana Alwi	M	6	6	The child's gross motor is mature
13	Senandung Kinanti Rukmana	F	5	6	The child's gross motor is mature
14	Vanya Hazirah Agniyah	F	5	6	The child's gross motor is mature
15	Artha Putra Nofyan	M	6	3	child's gross motor in the process of growth
16	Zahra Rahimatullah	F	6	5	The child's gross motor is mature
17	Gibran Alfaro	M	5	4	The child's gross motor is mature
18	Umar Muhammad Syah Teguh	M	5	5	The child's gross motor is mature
19	Yuva Naura	F	7	6	The child's gross motor is mature

The test table reveals that 15 children have mature gross motor systems, while 4 have still developing systems. This indicates that most children at Melati Ikhlas Kindergarten have a mature motor, as indicated by the number of children with mature motor systems.

CONCLUSIONS

1. The system is able to attract children's attention to play the product and leave the habit of playing smartphones. It can be seen in the child's response to the product where children who choose the product are 84.21% of 19 people.

2. The system can stimulate motor improvement by helping to provide an overview of gross motor development in children. Where after testing the child's gross motor system from 19 children, it was found that 15 children already had mature gross motor skills, and 4 children's gross motor systems were still in the process of growth.

3. The system can work in portable mode without requiring a power supply, where the system can last for 3 hours 10 minutes 15 seconds.

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