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Hopscotch game to support stimulus in children's gross motor skill using IoT

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Abstract
Every movement that has connection to stability and coordination between each body part were accounted as the gross motor skill system. If gross motor skill development were interrupted especially for 3-5 years old, their activities would be negatively affected. Foot-based games such as jumping and stepping can be used to train a child's motor balance. One example of a famous traditional game is hopscotch. Hopscotch is a game that demand high flexibility of foot movement a coordination skills thus proved scientifically can train children gross motor skill system. Various types of hopscotch games have the potential to improve children's dynamic balance. But in traditional hopscotch games it is difficult to see how the mechanism of improving children's dynamic balance is established. The development of a child's dynamic balance cannot be constantly tracked by teachers or parents. Therefore, we design and create hopscotch with an automated system that can overcome these limitations with digital records, data stored safely, system requirements easily duplicated, and more accurate. In the Hopscotch game, there are features, namely levels 1–3, and memory test, where the memory test serves to train children's memory. The hopscotch game using Footstep based capacitive sensor and LED feedback, the improved gameplay used for training and measuring child's gross motor skill system by their time completion and true/false footstep ratio. As the result the IoT based Hopscotch game with randomized lane are successfully mimic hopscotch gameplay with its added gameplay feature, the player subject performance has increased adaptability performance through each level the capacitive sensor-based footprint system has shown 100% accuracy, the system fully response to the footstep with average 456 milliseconds reading time per step, the system interface can fully control the gameplay level and can show players performance.

1. Introduction

Motor skill development is a child's learning process to skillfully move their limbs [1]. The development of a child's motor skill system is divided into two namely the gross motor skill system and the fine motor skill system. Stimulus or stimulation can help the growth and development by using several gross motor systems, soft motor skill, language, and socialization [2]. Where the gross motor skill system includes body movements that require stability and coordination between limbs, one important ability that is always used in daily activities such as walking or running is balance. using some or all the muscles in the body, which is influenced by age, body weight and physical development of children. The fine motor skill system is an ability related to physical skills that involves small muscles and eye to hand coordination [3].

According to studies, foot-based games such as egrang and *hopscotch* can train children's motor balance, from research showing activation the movement of jumping and stepping supports the child's balance and gross motor skill [4][5]. Research on Hopscotch was conducted by Kati Breitbarth et al, in their research made a hopscotch play game to guess the words or pictures that were provided, so that refugee children could learn German. From this Hopscotch game there are 3 levels which can be used to find out how far the children know German by using this game [5]. Meanwhile, research on the implementation of IoT-based children's games was carried out by Irvan Naufali Rahmanto et al, in their research on Balanced Gross Motor skill in children aged 4-6 years, using the Hopscotch game system that utilizes the Internet of Things (IoT) can support the development of gross motor skill for balance and coordination [6]. Other research conducted by Halim Wajid et al. They conducted research on gross motor systems in children using IoT-based Drop Box games, this study aims to build a device that has been designed and assess the system's ability / performance based on functionality parameters, value accuracy, and reading speed [7]. Research on the effect of kinesthetic play to help motor stimuli was carried out by Haroon Yousuf Mir and Arun K Khosla they conducted research

on games developed for Autism Spectrum Disorder (ASD) children who can develop their skills, both motor skill, sensory and academic, the results obtained from their research are that their sensory skills will improve by using Kinect tool [8].

The dynamic balance of children can potentially be improved in any form of hopscotch game, but in traditional hopscotch games it is difficult to see how the mechanism of improving children's dynamic balance is established [9]. As such made a game of hopscotch using IoT. With iot-based, parents can monitor the process of developing a child's dynamic balance [1] based on data recorded by the system in every game that has been made. This can be shown manually for Hopscotch 's game that the weaknesses from the teacher's point of view are manual evaluation, sensitivity to reading error, tracking all tasks manually, converting grades and reporting to parents takes effort and a long time. The children's progress can not be tracked constantly from the point of view of parents who do not immediately provide a report on the outcomes of children's activities. This is a circumstance with a manual system. While with an automated system all of these limitations can be resolved by digital logging, data securely stored, system requirements easily duplicated, and more accurate [10]. Whereas in this study the Hopscotch game system based on IoT was developed which was not carried out in previous research, the Hopscotch game can be played to train gross motor balance in children, in this game there is a stage which we call the Memory test, where the Memory test serves to train child's memory. All the research mentioned, implements traditional games without integrating with information technology. So that the reading of data, assessment of results, recording data, and accessing data is done manually.

In the field of Education, IoT has an important role to assist organizations in monitoring and controlling Education activities [11]. IoT is defined as the ability of objects to connect and communicate with computers via internet to provide services for humanity [12]. Internet of Things (IoT) in its application can also identify, find, track, monitor objects and trigger related events automatically in real time, also the development and application of computers [13]. The need to records activities fastly, accurately, and can be accessed by parents and teachers in real time and anywhere is a major need. With the availability of IoT technology that can be built on complex architectures, many devices, and which are integrated in the communication system. IoT is a system for increasing the ease of teach and learn [12].

From the background and benefits of previous research, a hopscotch game scheme was proposed to train the children gross motor system using IoT as it base, with hopscotch plots feedback using luminous LEDs for children added with a lane-regulating gameplay feature utilizing applications with attractive displays, traditional hopscotch games can be modernized into Interactive digital games that can match the interests of childrens of this generation who like gadget-based games, the IoT system features will be a regulator and gameplay interface, the system can be opened via WiFi media and the Website application interface. The application of the IoT system can measure the accuracy and speed of a child's footstep as a player, if the integration of the Hopscotch and IoT games applied in the curriculum of the kindergarten and family games, parents and teachers can evaluate and measure the child's gross motor development objectively through the number of footsteps accuracy and time speed that are monitored by the IoT system, so that in the future the parent or teacher can make this game as a reference for the child's gross motor stimulus.

In the introduction section discusses the background of the problem that forms the basis of this research. From the existing problems associated with the studies that have been done before in order to find the weakness that were eventually developed in this research. The Research Method chapter discusses the study of existing literature in order to find advantages and disadvantages. The Result and Discussion chapter discusses the system built and the results of the test and analysis. The Conclusion Chapter discusses the final conclusions obtained from the results of tests that are appropriate for addressing existing problems.

2. Research Method

In the first process this research focuses on the study of literature or research, and refers to previous research, based specifically on the stimulus related to the development of gross motor skill children. After conducting a literature study, hardware and software system design is carried out, software development uses the Arduino platform, then the system is assembled and tested for performance, if the system is deemed appropriate bekerja work then tested, testing using a player sample then measured whether the system can accommodate gamplay and measure the player's gross motor skill skills, in addition a visual observation of the comfort, adaptation and level of understanding of the game from the player.

2.1 Study of Literature

At this time applying IoT in the field of Education will be very important to be used in improving the ability and knowledge of learning. Especially education in children [13]. For learning and education itself will change to the use of technology independently and collaboratively [14]. Technology is very influential for all activities that support learning [15]. In this case, the IoT is a sub-category of internet technology, the benefits of which are very broad because all students can access learning material and information from anywhere and at any time [16]. In other words children's interest in playing, and aims to stimulate children's development by using IoT technology. Therefore, in playing as a

learning media, and development is very necessary for the development of children with a game system that uses IoT to make it easier for parents or teachers to be able to monitor their development.

Ivan Nurdiyan Haris in their research, has found a mechanism so that children can improve their balance of gross motor skill. In their research, applying training on stilts and sodor carts to the balance of the body of students of SDN 1 Subang [4]. The sample consisted of 30 male students divided into two groups, 15 stilts exercises, and 15 Sodor carts. The research instrument was a standing test with the results of calculations and data analysis that the egrag exercise was obtained t count 2.66 and the t table 2.05 at the real level () = 0.05 with dk = 28 then there was a significant effect of playing from the stage. The result of Grobak Sodor analysis obtained the value of T count is 1.71 while the value of t in the table is 2.05 on exact level () = 0.05 with the value of dk = 28, this means that there is no significant effect on Grobak Sodor.

Wiranti Dwiana Asih and Diah Ayu Marwati [17]. Conduct studies related to the effectiveness of crank play in developing gross motor skill skills of early childhood. The research they did by collecting experimental data with one group pretest and posttest. T-test data analysis with t-test technique. The results obtained can prove that most of the children are in the early phase of developing (MB) criteria when doing the pretest and they are in a Very Good Development (BSB) phase after doing the post test.

Kati Breitbarth, et al., conduct studies related to the effectiveness of Exer Learning games - such as HOPSCOTCH, which combines sports, playing games and learning. The research they did by collecting experimental data with refugee children in the acquisition of German. This system is designed for learning German, HOPSCOTCH is carried out in special language classes for young refugees in two schools, and in mixed groups in one kindergarten with a high level of children with immigrant backgrounds [5]. After five months, several positive learning, social, phycological and cognitive effects have been observed. HOPSCOTCH has proven to be a tool that supports learning outcomes and the formation of new social groups consisting of various nationalities and religions.

Irvan Naufali Rahmanto et al., conduct studies related to the Motor System in children aged 4 - 6 years, and most of their activities are the Gross Motor System. By using the Hopscotch game that has been modified using Internet Of Things (IoT) technology, and results in testing the functionality of the system [6]. Halim Wajid et al., conduct studies related to gross motor system in children by using the Drop Box game, which is a game of putting the ball into the hole by moving the game box. And this study aims to build a device that has been designed and assess the system's ability / performance based on the parameters of functionality, value accuracy, and reading speed. The Drop Box game implements the Internet of Things (IoT) to support recording and processing activities of data obtained from children's activities [7].

Haroon Yousuf Mir and Arun K Khosla [8]. Conduct studies related to games developed for Autism Spectrum Disorder (ASD) children who can develop their skills, both motor, sensory and academic skills using Game Kinect assistance. Where the Kinect is played with the help of hand gestures. The method is that autistic children are first taught to count 1 to 10. And they will remember the numbers by sight as well as hearing, after which they proceed to the testing period where they play the game. And they are asked to click a certain number by hand to complete the task. Then the autistic child clicks the number written in the manga as determined by the audio instructions. That way their motor skill will improve. And finally, they have to complete tasks quickly to get more scores at the right time, this way their sensory skills will improve.

M.Randy Wibisono and Yulian Findawati [18]. Conduct studies related to Tuna Grahita is a term used to describe children who experience obstacles in Fine Motor Movement and behavior adjustment. Therefore a Motor Game is made which is expected to be used to train fine motor movements in people with visual impairment, so that it can make it easier to concentrate and move, and can reduce student boredom while learning and students will be more happy to learn and can more easily remember the lessons that have been delivered by the teachers. This Motor Game uses the Research and Development Method. The result was that 25 Tuna Grahita students showed that on average the tutors agreed with the motor game and the students were happier to learn and could reduce student boredom while studying.

Research on Hopscotch was conducted by Kati Breitbarth, Monika Menz, Sarah Grodd, and Lucht Martina [5]. they conducted research related to the effectiveness of Exer Learning games - such as HOPSCOTCH, which combines sports, playing games, and learning. Which aims to memorize German by using the Hopscotch game, then the result is that children can quickly memorize German using the Hopscotch game and no time is generated for the 1 language tested. Meanwhile research on the implementation of IoT-based children's games was carried out by Irvan Naufali Rahmanto et al [6]. they conducted research on Hopscotch based on IoT and aimed to train gross motor balance in children, their play methods developed the traditional crank game is a modern crank game that is modified using IoT. Halim Wajid, Novian Anggis Suwastika, and Rahmat Yasirandi [7]. They conducted research on gross motor systems in children using the Drop Box game. This study aims to build a device that has been designed and assess the system's ability / performance based on parameters of functionality, value accuracy, and reading speed. The Drop Box game implements the Internet of Things (IoT) to support recording and processing activities of data obtained from children's activities. Research on the effect of kinesthetic play to help motor stimuli was carried out by Haroon Yousuf Mir and Arun K Khosla [8]. they conducted a study on games developed for Autism Spectrum Disorder (ASD) children who can

develop their skills, both motor skill, sensory and academic skills. With the help of the Kinect game where the Kinect is played by using the hand. The method is that autistic children are first taught to count 1 to 10. And they will remember the numbers by sight and hearing, after which they continue to choose the level. Then they proceed to the testing period where they play the game. And they are asked to click a certain number by hand to complete the task. Then the autistic child clicks the number written in the manga as determined by the audio instructions. Then the results obtained from their research are that their sensory skills will increase by using the Kinect tool, from this game there is an output including the result of how much time is reached at a certain level and also the score the child has when finished playing.

While in this study the Hopscotch game system based on IoT was developed which was not done in previous research, the Hopscotch game can be played to train gross motor balance in children, in this game there are levels 1 - 3 that children can choose and also they can play a stage which we call the Memory test, where the memory test serves to train children's memory. The results obtained are that children can be monitored for their balance progress through the existing webApp, there are data from levels 1-3 and also true and false, then there is time that the children complete while playing.

2.2 Children's Motor skill System

Development namely the increased ability of the functions of all bodily organs due to increased maturity of bodily organ systems, which are reversible and quantitative which include: the ability of fine and gross motor skill systems, hearing, vision, communication, speech, emotional-social, independence, intelligence, and moral development [19]. Motor skill development is a process of feeling or movement that directly involves the muscles to move and the process of innervation that becomes a person able to move and the process of innervation that makes a person able to move his body. Fine Motor skill System is a movement that only involves certain body parts that are carried out by small muscles. Therefore movements that occur in fine motor skill skills do not require energy, but require careful and meticulous coordination. Rough Motor skill System, which is the ability to move the body that uses large muscles, most or all gross motor skill parts of the body are needed so that children can sit, kick, run, go up and down stairs and adjust the balance of his body [20].

2.3 The Role of IoT in Education

Internet of Things (IoT) allows systems to do work by getting making them communicate together, to give information and coordinate decisions [20]. Internet of Things (IoT) main challenge is connecting between the physical world and the world of information, processing data obtained from electronic equipment through an interface between the user and the equipment [21]. According to (Burange & Misalkar, 2015) Internet of Things (IoT) is a structure in which the system transfers the correct identity and the ability to move data through the network without that don't need connection with human, namely the source to the destination or human-computer interaction [16]. Kevin Ashton 2009 defines that the beginning of IoT is a system that has the ability to change the world because the internet might have done better [22]. Potential applications for IoT are numerous and varied, spreading to almost every area of every individual's daily life, including industry, companies, environment, health and other communities as a whole [23].

To help the knowledge process, this will result in increased access to learning supported by technology, applying Education as an electronic media to the IoT field is the use of this field in the learning process [24]. IoT itself is a development of Information and Communication Technology (ICT) whose aim is to assist the development of Education [25]. The development of information and communication technology continues to develop along with human needs, without exception in the education field. The tendency to use the symbol "e" which is interpreted as electronic, has begun to emerge and is applied in almost all fields [26].

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2.4 Hopscotch

Traditional form of play very simple in the sense that it is not so difficult to find and easy to play because it can be adapted to existing conditions The elements that have a positive effect on the player include agility, speed, agility, honesty, flexibility and cooperation [27]. In turn, spin the spinner. Start by standing up from the Twister Hopscotch path, and then jumping over the hopscotch ring by jumping on each ring with one foot. If there are two or more rings placed side by side, jump with both feet in two separate rings. Avoid jumping in color swirls when you cross the Twister Hopscotch path. In turn, one player turns the spinner. Each player starts by standing from the hopscotch path at both ends, then each player jumps at the same time through the hopscotch path by jumping on each ring with one foot. If there are two or more rings placed side by side, jump with both feet in two separate rings. Each player must avoid jumping in color turns when they cross the Twister Hopscotch track. When the players reach each other halfway, they can adjust Hopscotch Interactions - for example, "high five", "secret hand shake" or "special dance" [28]. The following is an example of the Twister Hopscotch game in Figure 1.

Figure 1. Example of a Hopscotch Twister Game

2.5 System Design

2.5.1 System Architecture

The system architecture of the *HOPSCOTCH* game system can be seen in Figure 2, which can represent the architecture of the system being built, by describing how the system works on user involvement, the game being deployed, the device used, and data / information communication from start to finish to data is sent via the internet. Some researches related to uploading sensor data to the internet are modeling LOT parking IoT systems based on Ultrasonic Sensor and Internet of Things [29].

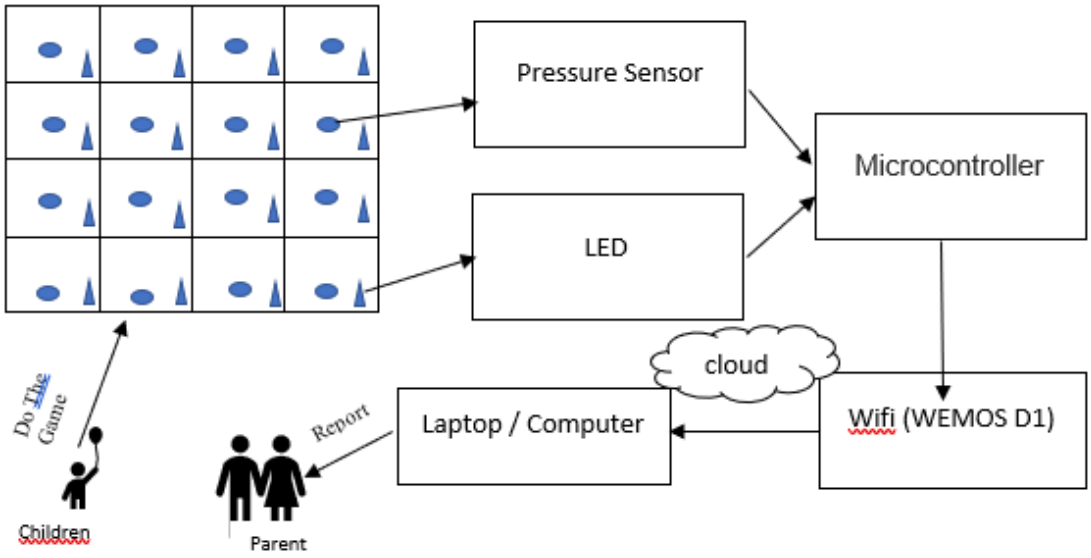

Figure 2. System Architecture

The game system will start when the user starts to step on the hopscotch tool every time the user steps will be recorded as input data that will be stored and processed by the system. Then, when the game ends, the data displayed on the monitor serial will be sent to the IoT platform using the internet as output.

2.5.2 Hardware design

The device representation that is built uses some hardware components by using the device circuitry as shown in Figure 3.

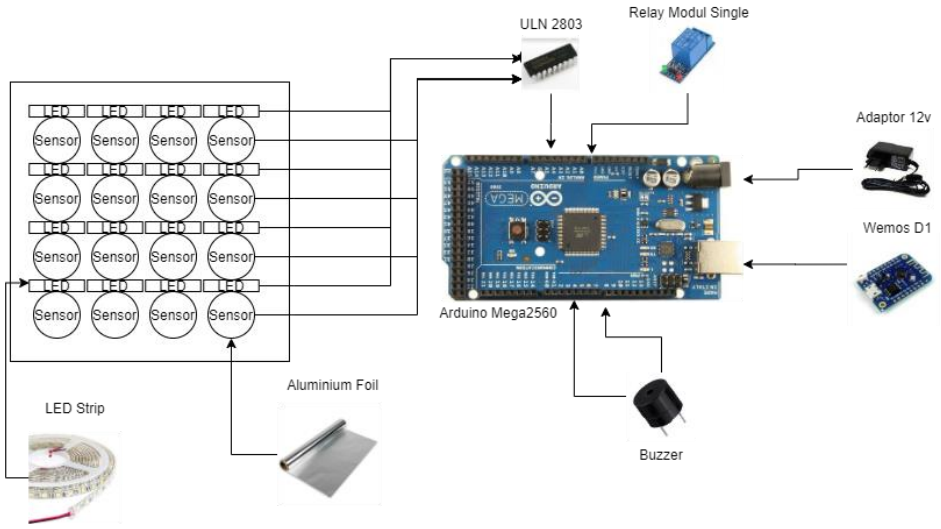

Figure 3. Wiring System

To detect the footing of this system using capacitive sensors, capacitive sensors are electronic sensors that work based on capacity measurements. The concept of capacitors used in capacitive sensors is the process of saving and releasing electrical energy in the form of electrical charges on a capacitor that is affected by surface area, distance and material. Driver electronics that are calibrated to specific output voltage changes are used for the corresponding capacitance changes [30].

The device representation in Figure 3 consists of devices such as a sensor microcontroller, and Wi-Fi module. Its functions will be explained in Table 1.

Table 1. Tool Functionality

Devices	Information
Arduino Mega2560	Function as a *microcontroller.*
Aluminium Foil	Serves to detect footing or footsteps.
Wemos D1	Function as a Wi-Fi module to send data to the internet.
Children Carpet Puzzel	Functioning as a media base for hopscotch games.
Buzzer	Serves as a foothold indicator that has been detected by a piezoelectric ceramic vibrate sensor.
Relay Modul Single	Connect and Disconnect the electric current in a Circuit
Adaptor 12volt	To change AC current into DC current with a certain voltage as needed
ULN 2803	To unite the Sensor and LED to connect to the Arduino Mega2560
LED Strip	To create a playing path at level 1 – 3

2.5.3 Software Design

Mainly software system consist of 2 main module, the microcontroller module which responsible to read and calculate sensor Input from the footstep and the gameplay, and secondly the Wemos D1 mini ESP8266 who role as Web server, webserver has websocket protocol to ensure data flow near-realtime quality to the client, WebServer serve webAPP as main User interface of this whole system.

Footstep detection Algorithm

```
Input: footing, command
Output: Array of Step, True Step count, False step count
Algorithm:
Initialization:
Include Entropy.h
Include CapacitiveSensor.h
Main:
   Input command;
   Case command();
   Generate line random;
   Input footstep
   If step detected:
      If true:
         LED off();
         True Step count++
      Else:
         False step count++
         Buzzer on
 Print array of step, True Step count, False Step count
```

WebAPP server Algorithm

```
Input: array of step, True Step count, False Step count, webpage, css style, css font
Output:WebAPP, WebAPP variable step, WebAPP True/False count
Algorithm:
Initialization:
Include Websocket Server;
Include File System;
Main:

   Input array of step, True Step count, False Step count;
   Pull File;
   Serve WebAPP;
   Open Websocket;
   User Input detected:
      Send Input command data to microcontroller;
```

Footprint pattern at the gameplay created by random number generator function embedded inside main program, although arduino have its own rand() function but it creates same pattern of random number every iteration after resetting the loop, and then this program using Entropy library which creates random number without compromising same pattern and flow of the program, level 1 shows 2 lane with 4 active random footprint, level 2 shows 3 lane with 6 active footprint, and level 3 shows 4 lane with 8 active footprint. Each lane has 2 random number from 4 active footprint that created by this randomization algorithm.

Random activation footprint Algorithm

```
Input: command
Output: First_active_footprint, Second_active_footprint
Algorithm:
Initialization:
Include Entropy.h
Main:
   Input command;
   If command init:
         First_active_footprint=Generate Entropy from(1,4);
         Do:
         Second_active_footprint=Generate Entropy from(1,4);
               while(Second_active_footprint== First_active_footprint):
```

2.5.4 System Testing Scenario

Testing scenarios to be carried out are testing system functionality and system performance contained in the system that is created is the HOPSCOTCH game. The functionality of this system consists of components namely hardware. Hardware components have functions and roles for each test which will be explained in Table 2.

Furthermore, the system performance will use the parameters of rapid reading, using this parameter the device can process When receiving instructions or commands and process them into input how long. Then the accuracy of the assessment parameters, which means the accuracy of the assessment in the game system device can be compared with the value of manual tests.

3. Results and Discussion

In this research, we tested the functionality and performance of the system. In the system functionality, the parts that are tested are Arduino, capacitive sensors, and esp01 Wi-Fi modules. In all three parts, the test is carried out to find out whether each tool is working properly. While the system performance, the test parameters are reading speed and accuracy.

3.1 System functionality test result

Basic functionality requirements for the system are describe at following Table 2.

Table 2. Basic Functionality System Test

No	System Requirement	Testing Scenario	Result
1	Electrical, power supply and feedback system	Assessing the buzzer and led array	Buzzer and Led array can give feedback according to algorithm
2	Footstep based Capacitive Sensor	Test by pressing each 16 sensor and see the serial monitor sensor	Sensor shows different datapoint between pressed and floating condition.
3	communication and system interface	Check input, output, data and communication	Button input, and communication receive input from operator seamlessly

Electrical, power supply and feedback system test were ran at the initial development before the game algorithm and IOT system implementation, and for further system test as shown by following sub section.

3.1.1 Footstep Based Capacitive Sensor Test Result

Testing is done by asking subject to step on each 16 lighted sensor, Then the results of the input from the sensor are sent to Arduino, and Arduino processes the input data from the sensor. an example of a game tool Figure 4. The results of testing the accuracy of reading from 16 sensors are in Figure 5.

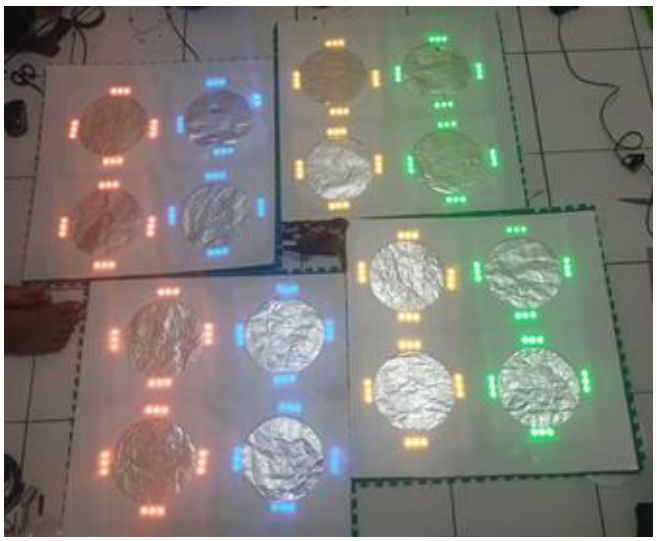

Figure 4. Hopscotch Footstep System

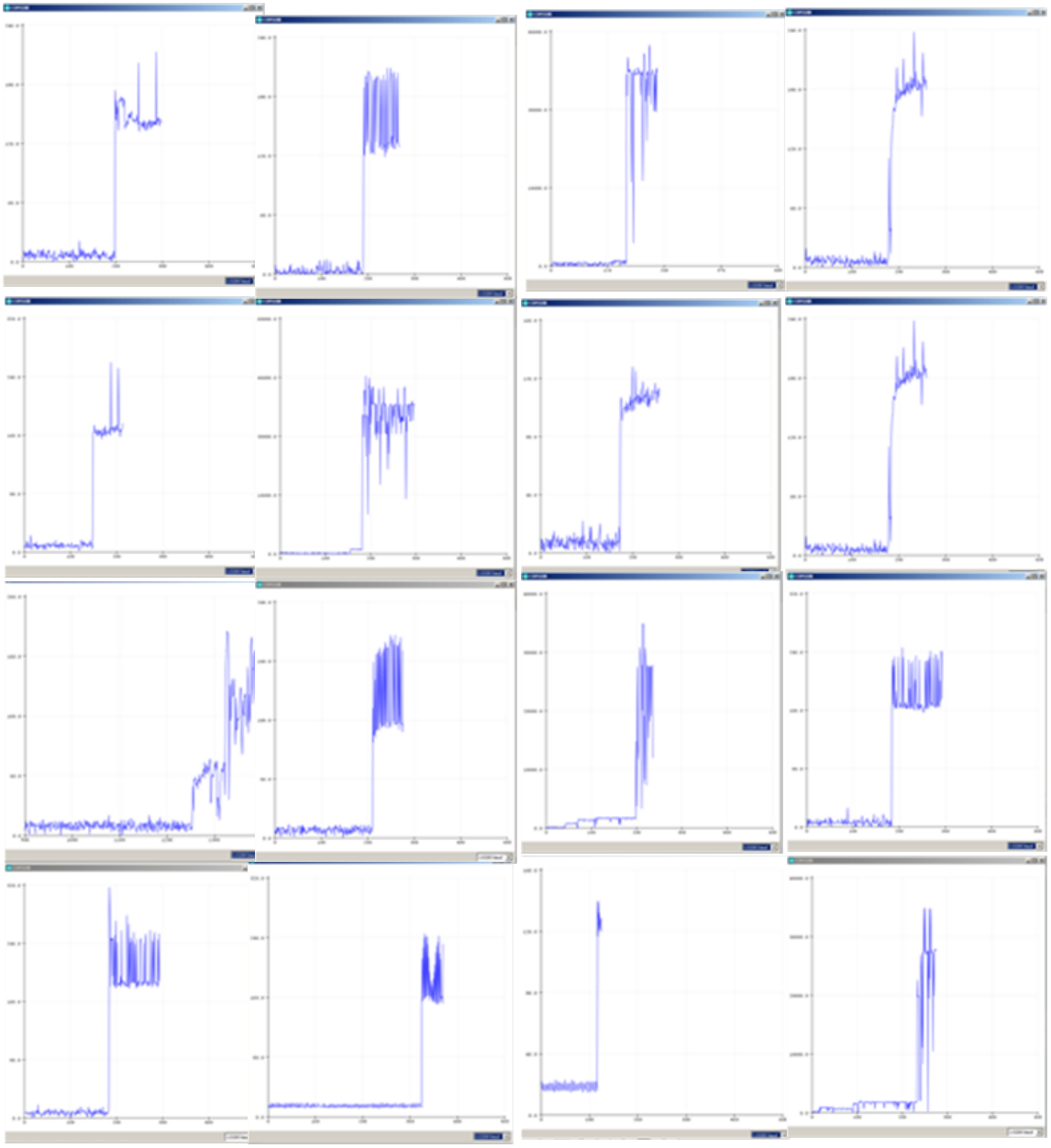

Figure 5. Sensor Performance Data Graph

Table 3. Sensor Reading Speed and Data Threshold Summary

Sensor	No Foot Timestamp	On Foot Timestamp	No Foot Thresold	On Foot Thresold	Delay Avarege
Sensor 1	23:44:15.801	23:44:16.144	12	132	0.343
Sensor 2	23:40:55.692	23:40:56.001	21	133	0.309
Sensor 3	23:50:26.147	23:50:26.661	991	70885	0.514
Sensor 4	23:37:33.585	23:37:33.924	17	119	0.328
Sensor 5	23:46:24.707	23:46:25.035	28	104	0.328
Sensor 6	23:51:50.441	23:51:50.861	237	34025	0.420
Sensor 7	00:01:35.090	00:01:35.418	94	162	0.328
Sensor 8	23:49:33.245	23:49:33.573	28	204	0.328
Sensor 9	23:06:37.068	23:06:37.374	25	188	0.306
Sensor 10	00:02:39.535	00:02:39.862	20	137	0.327
Sensor 11	00:03:42.141	00:03:42.749	159	110293	0.608
Sensor 12	00:04:47.733	00:04:48.061	18	164	0.328

Sensor	No Foot Timestamp	On Foot Timestamp	No Foot Thresold	On Foot Thresold	Delay Avarege
Sensor 13	23:55:08.517	23:55:08.844	14	199	0.327
Sensor 14	23:11:50.121	23:11:50.460	14	143	0.339
Sensor 15	23:57:03.761	23:57:04.229	987	57128	0.538
Sensor 16	22:30:42.338	22:30:43.701	494	28887	1.363
Average					0.456 sec

Each of 16 footstep sensor has 456 milliseconds average to response footstep from subject, short time response means subject can play the hopscotch comfortly without waiting the feedback from the system, every footstep sensor has its own threshold limit when stepped. Capacitive sensor based footprint system has shown 100% accuracy, false reading mitigated by eliminating hardware noise caused by cable and disturbed join, by visual assessment sensor have acceptable delay response. And the results from sensor readings 1 – 16 get less than 1 second, here are the results of the sensor test in Table 3.

3.1.2 IOT Based Game Controller

Game controller using WebAPP with dedicated websocket to handle data flow from the microcontroller to the game operator who supervise the game, websocket protocol is used to ensure near-realtime quality to monitor sensor on the field. Game operator can access the game controller by accessing 192.168.4.1 local IP address of Wemos D1 mini ESP8266. The following is an example of the WebAPP display in Figure 6.

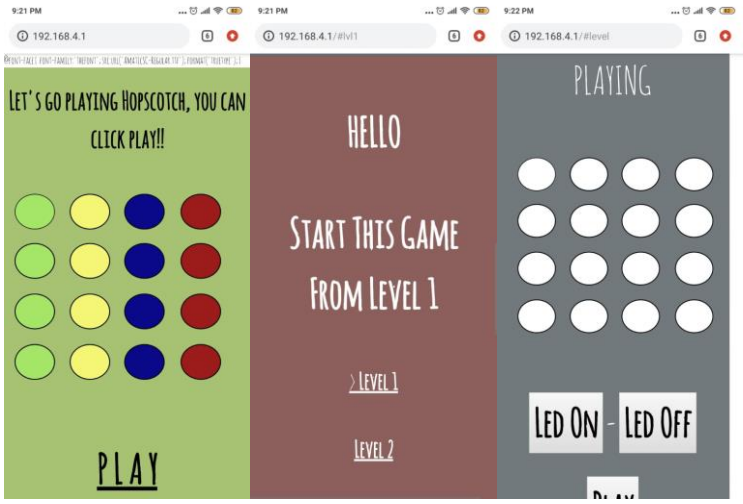

Figure 6. Game User Interface

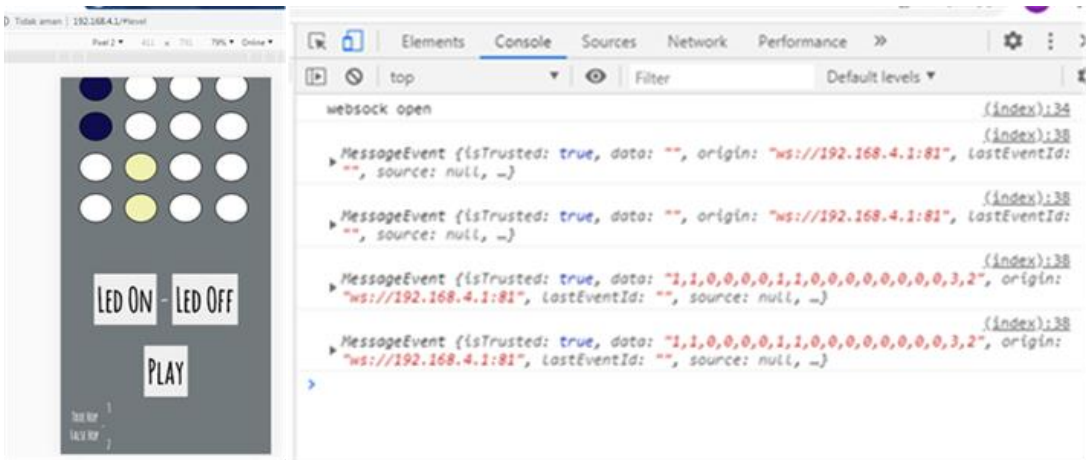

Figure 7. User Interface Dataflow Monitoring

Through browser console dataflow performance of WiFi communication between microcontroller and game operator can be monitored in Figure 7, when operated nearby then webapp shows responsive interface with no visible

communication delay, WebAPP can receive all input from game operator successfully display similar sensor pattern of the game field with true/false footstep data.

3.2 Gameplay Testing

Gameplay testing done by playing each level of the hopscothch game, level 1 will shows 4 active footprint, level 2 will show 6 active footprint, and level 8 will show 8 active foot print, each active footprint generated randomly, as another feature to test coordination between memory and motor skill, LED for active footprint will be turned off by Led OFF button, if player can step on right footstep then the true counter number will be add up, and if the miss-footstep happened then the false counter will be accumulate.

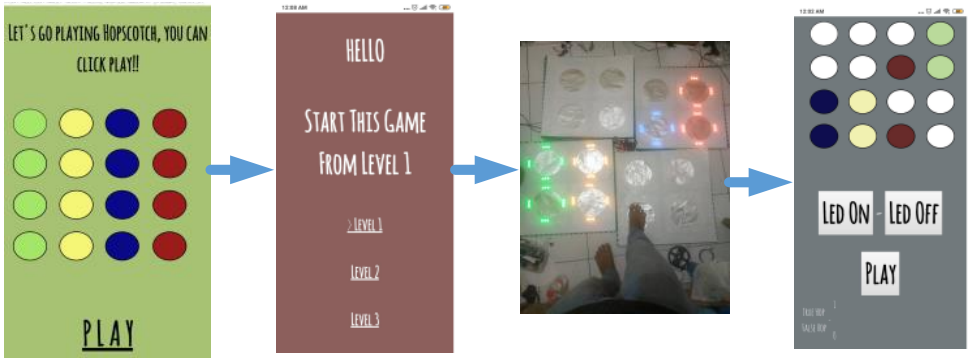

Figure 8. Gameplay Scenario

From the result of the gameplay testing, each player game result will be shown up as assesment for gross motor skill for each player, as the result every player has its own time completion and miss-step, the results can be seen as an example in Figure 8. higher completion average time occured when level 3 played, and miss step often happen when led has been turned off to test their motor skill and memory skill. The following are the results of the experiments of 5 different people in Table 4. Differentiation of time completion for each player seemingly low because every player easily adapt to the gameplay. We can see the average number of times that are resolved when the Led On and Led Off is in Figure 9, and we can see the average number of errors in this game is in Figure 10.

Table 4. Gameplay Test Result

status	trial	level 1	missed	level 2	missed	level 3	missed
led on	1	5.49	0	5.1	0	11.15	0
	2	4.56	0	7.84	0	6.61	0
	3	5.97	0	6.15	0	9.49	0
	4	6.11	0	7.85	0	13.67	3
	5	6.45	2	7.52	0	10.78	0
led off	1	6.2	0	7.61	0	8.21	0
	2	5.87	0	12.72	3	7.24	0
	3	4.24	0	8.72	0	21.04	1
	4	4.99	0	9.82	1	15.86	3
	5	5.1	0	7.88	0	10.4	1

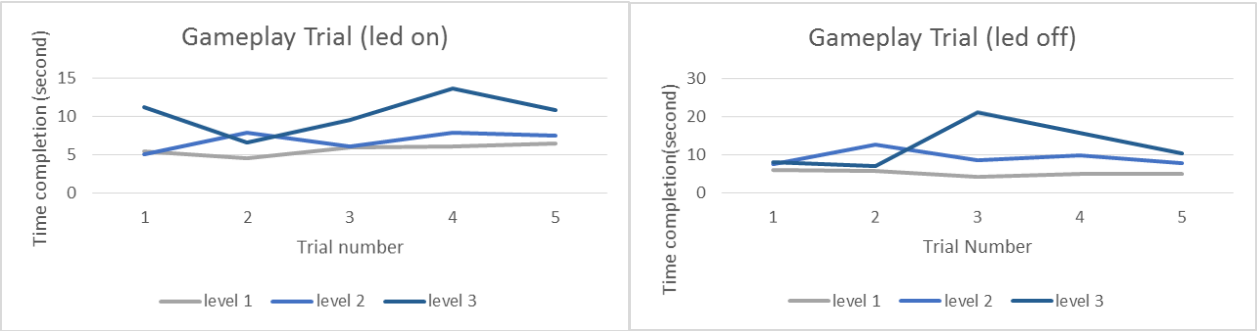

Figure 9. Gameplay Trial Time Completion Graph Performance

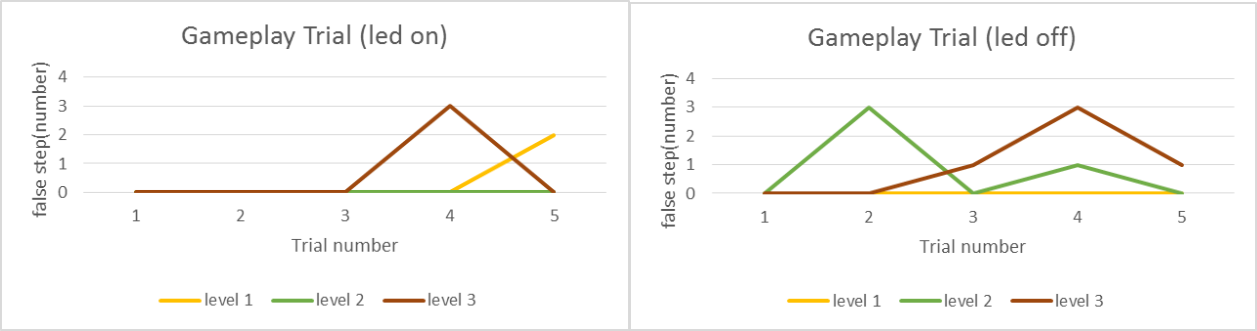

Figure 10. Gameplay Trial player False Step Ratio Graph Performance

4. Conclusion

This proposed system of Hopscotch-IOT with randomize footstep lane performed well to measure gross motor skill performance of subject by measuring time completion, and false and true step ratio, another feature of LED activation that has given shows another motor skill and cognitive coordination test to the player, this digitalized hopscotch can also give another experience and value added to the game. The system can accurately read 100% step of the subject with average 456 milliseconds response so the player can acquired feedback fast from the system. webAPP efectivelly present the field and gameplay. Visually each player shows adaptability of the gameplay for every add up level and unconsciously this condition train their gross motor skill system to.

For futher research the game can developed into real gross motor skill classification machine by analizing game performance by subjects completion time and true/flase step ratio and another medical parameter that might by coherent, and thus give initial assessment not only gross motor skill measurement but also cognitive and memory performance of the player.

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