Chapter in Book

Foldable Motorized Walker for Stability and Balancing

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Abstract: *With the population aging in Malaysia, the aged people are increasing gradually. For these aged people, especially those suffering from mobility problem caused by disease, they have more and more difficulties in walking since their physical functions are gradually decreasing. For children and teens who need help walking, walkers designed especially for the needs and bodies of younger users. A walker or walking frame is a tool for disabled people, who need additional support to maintain balance or stability while walking. Whether a child needs short-term assistance after an injury or illness or due to a long-term disability or medical condition, walkers are an excellent solution for safe and comfortable mobility. Older adults are often prescribed walking aids to encourage balance and mobility. Most walkers on the market are only able to be folded only once, causing huge sizes, so these walkers are not convenient for carrying, transportation and storage. The goal of this project is to design a foldable rollator walker into a virtually flat configuration for effective mobility-aid devices. After that, it is used to assess of stability and balancing walking aid users based on the biomechanics principle. Then, to implement the Internet of Things (IoT) through mobile application. This foldable walker is a mobility-aid device that can be folded easily for transportation and reduce the user's physical power when lifting it. With the combination of walker and the motorized system would help the users to walk faster while using a walker. That way, this walker enables users to walk faster with less exhaustion. This walker also can be folded easily and it reduces the physical power when the users lift it. The use of IoT for wireless technology makes it easier for everyone who has a smartphone.*

Keywords: aged people; mobility; balance, stability, biomechanics.

1. INTRODUCTION

At present, with the population aging in Malaysia, the aged people are increasing gradually. For these aged people, especially those suffering from mobility problem caused by disease, they have more and more difficulties in walking since their physical functions are gradually decreasing (Pan, 2017). Aging, injury and disease can lead to users experiencing a loss of stability and being a greater risk for falls. Fall-related injuries contribute to reduced activity, reduced quality of life, depression, social isolation and mortality in vulnerable populations (Rabin & Dong, 2018).

For children and teens who need help walking, walkers designed especially for the needs and bodies of younger users are a powerful boon. The walker is a very popular walking aid. In order to develop a walker, one must understand the basics of walkers. A walker or walking frame is a tool for disabled people, who need additional support to maintain balance or stability while walking, most commonly due to age-related physical restrictions. Basic walkers have a 3-sided frame that surrounds the user. Users lift the frame and place it further in front of them, they then step forward to meet it, before repeating the process. The main purpose of using a walker is to improve the walking performance and minimize the risk of falling.

Whether a child needs short-term assistance after an injury or illness or due to a long-term disability or medical condition, anterior and posterior walkers are an excellent solution for safe and comfortable mobility. Older adults are often prescribed walking aids to encourage balance and mobility. Nevertheless, their use was curiously correlated with increased falls-risk. Most walkers on the market are only able to be folded only once, causing huge sizes, so these walkers are not convenient for carrying, transportation and storage (Pan, 2017). This makes the walker bulky. Such action is very difficult for the users, especially those who have difficulties in walking. In both static and dynamic situations, an individual’s stability is determined by the position and velocity of their center of mass relative to their base of support (BOS). A person’s BOS is their feet (Foley et al., 2010). To develop a walker, we must meet all the criteria for a walker’s stability.The stability of a walker depends on design selection, weight, vertical load strength and stopping the fall of a walker.

As we can see, the majority of people who use walkers are elderly because as a person’s age increases, their muscle mass decreases (Foley et al., 2010). Mostly, people who have problems while walking use a walker as a walking aid. Elderly or disabled patients frequently use walkers comprised of two sided frames with front and back legs, a front brace, and plain or wheeled leg tips. Previous analysis to date has frequently centred on the user’s kinematics and kinetics, presuming that the more the gait pattern resembles that of a healthy subject, the more stable the user is. Indeed, 29–49 percent of older people use walking aids. However, paradoxically, the use of walking aids (versus non-use) has been associated with a 2-fold to 3-fold increase in the risk of falling. Balancing is very important in elderly because it reduces the overall morbidity and mortality and the risk of falling (Thomas et al., 2019). Therefore, balancing has an important role in fall prevention.

The objective of this project is to design a foldable rollator walker into a virtually flat configuration for effective mobility-aid devices. After that, to assess of stability and balancing walking aid users based on the biomechanics principle. Next, to implement the Internet of Things (IoT) through mobile application.

2. METHODOLOGY

There are two parts that involved in this project which is hardware and software. For the hardware, this project uses a motor, walker wheel, and foldable walker. While for the software is used to program the coding to the Arduino and Motor Driver to make the motor and wheel rotate. An Arduino is used as a microcontroller. Motorized system is used to enable the walker moves faster and make the user feel less exhaustion when use a walker. For the aluminium part, aluminium alloy will be used in this project because it is light enough to be picked up and moved easily.

Figure 1 below shows the flowchart of the overall activities in developing the foldable motorized walker. The process consists of three phases that consist hardware and software development.

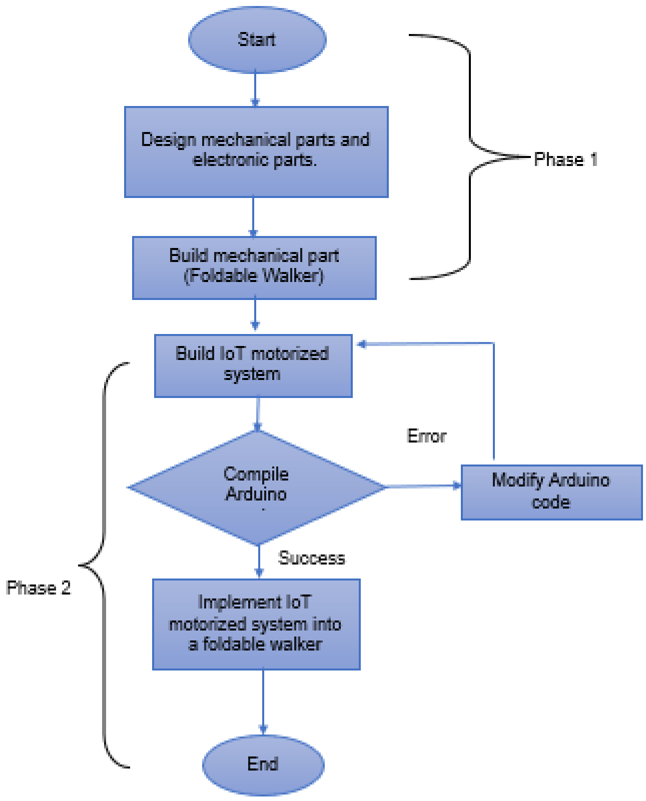

Figure 1. Project flowchart.

Phase 1 of the flowchart shows the process of designing the mechanical and electronics part. After that, the development continued with building the mechanical part which is foldable walker.

For phase 2, the progression carried out on designing IoT motorized system. Since Foldable Motorized Walker uses Internet of Things, smartphone will be used to control the speed of the motorized system. Suitable coding and commands are constructed for this project. In order to ensure the functionality of the program that will be used, the processing of compiling Arduino code of the IoT motorized system is implemented on the device. If we succeed compiling the code, then we move on implementing IoT motorized system into a foldable

Figure 2 below shows a block diagram of the IoT motorized system. It consists of battery, switch button, Arduino, motor driver, Bluetooth module and dc geared motor. When the switch button is ON, the Bluetooth will start blinking and connected to the Blynk. The wheel will rotate as the motor rotates when controlling through smartphone. DC geared motor will be attached to the wheel. Motor driver will control the speed of the DC motor by using slider on Blynk application.

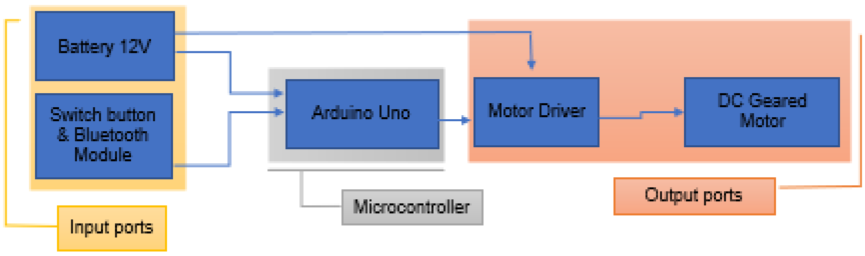

Figure 2. IoT motorized system block diagram.

2.1 Hardware Development

This project will undergo the process of design development. The process of designing is one of the crucial parts in developing foldable motorized walker. Hardware that use in this project is divided into 6 types which is DC Geared Motor, Arduino Uno, Rollator Walker, Motor Driver, Bluetooth Module and Rechargeable Li-On Battery. DC Geared Motor is used to rotate the walker wheel. This DC motor will be attached to the walker wheel. Next, Arduino Uno. Arduino Uno allows to construct programs in code segments to perform individual tasks. The code will be programmed in Arduino Uno to give instructions to other hardware to work. Then, the next hardware is Rollator Walker. Rollator Walker that will be used in this project. Rollator is used for a foldable part and it is two smalls wheels at back or one wheel each leg, no need for lifting the whole device. Besides, this walker also uses motor driver. Motor driver is used to regulate the speed of a DC motor. Bluetooth module is used to connect the device to the Blynk application. Rechargeable Li-On Battery is also used as a power source of DC Motor.

Figure 3 shows the circuit diagram of IoT motorized system. We used Fritzing to design the circuit of IoT motorized system.

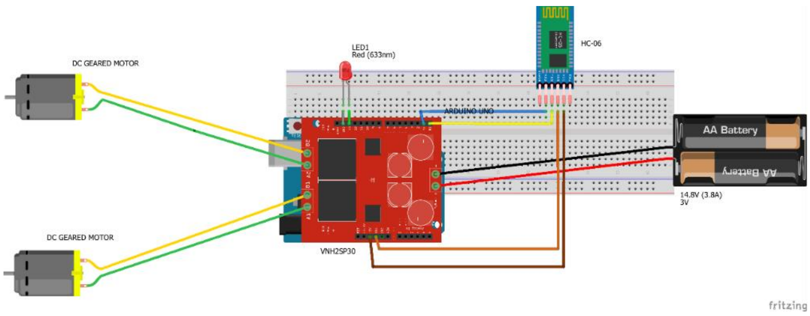

Figure 3. Circuit diagram of IoT motorized system.

2.2 Project Design

Figure 4 shows the 3D design of Foldable Motorized Walker. We used Thinkercad to design the project. Figure 5 shows the prototype of project. The project consists of foldable motorized walker and a smartphone. The smartphone is connected to the project and the device operational is controlled by using Blynk application in smartphone.

Figure 4. Design of project.

Figure 5. Prototype of project.

3. EXPERIMENTAL ON SPATIAL TEMPORAL

There are three parameters that have been measured and analyzed such as velocity, acceleration and force. 3 subjects are tested to analyze the spatial temporal. 3 subjects are selected from different age. Table 1 below shows the demography data of 3 subjects. Subject 1 is children, subject 2 is adult and subject 3 is elderly. The table shows the age and weight of subject.

Table 1. Demography data of 3 subjects.

		
SUBJECT 1 (CHILDREN) AGE : 5 YEARS OLD WEIGHT : 21.9kg	SUBJECT 2 (ADULT) AGE : 22 YEARS OLD WEIGHT : 75kg	SUBJECT 3 (ELDERLY) AGE : 59 YEARS OLD WEIGHT : 60kg

In this experiment, the subject is told to walk for 10m. Then, the time taken of each subject has been recorded. The slider value is set from 30 to 90. The time taken is recorded from slider value 30, 40, 50, 60, 70, 80, and 90. Before using the device, adjust the height of the walker and make sure the height of the handles should be level with your wrists. After that, control the speed of the motor depends on the user suitable speed by using Blynk application. Then, make sure the safety lock is tightened when using the walker.

4. RESULT AND DISCUSSION

4.1 Velocity

Figure 6 below shows the graph of velocity vs time taken for 3 subjects (children, adult, and elderly). In general, it was found that the final velocity is not proportional to the time taken. It means that the higher the time taken, the lower the final veloctiy. The result revealed that the final velocity is ranged between 0.172ms^{-1} and 0.287ms^{-1}. Furthermore, the time taken is ranged between 34.89s and 58.21s. It also can be seen that the adult has the highest final velocity with the value of 0.287ms^{-1} at 34.89s and the children has the lowest final velocity with the value of 0.256ms^{-1} at 39.09s.

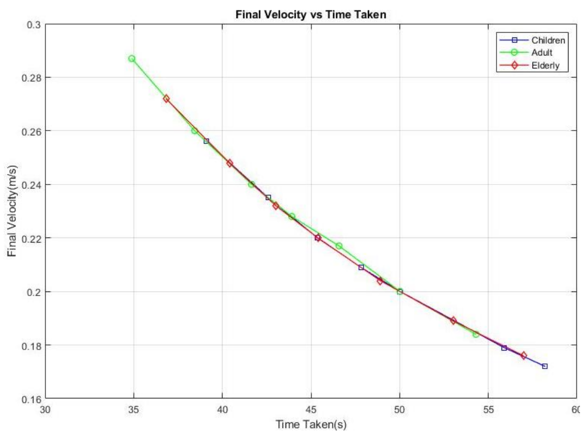

Figure 6. Subjects velocity vs Time graph.

4.2 Acceleration

Figure 7 below shows the graph of acceleration vs time taken for 3 subjects (children, adult, and elderly). In general, it was found that the acceleration is not proportional to the time taken. It means that the higher the time taken, the lower the acceleration. The result revealed that acceleration is ranged between 2.955 x 10^{-3} ms^{-2} and 8.226 x 10^{-3} ms^{-2}. Furthermore, the time taken is ranged between 34.89s and 58.21s. It also can be seen that the adult has the highest acceleration with the value of 8.226 x 10^{-3} ms^{-2} at 34.89s and the children has the lowest acceleration with the value of 6.549 x 10^{-3} ms^{-2} at 39.09s.

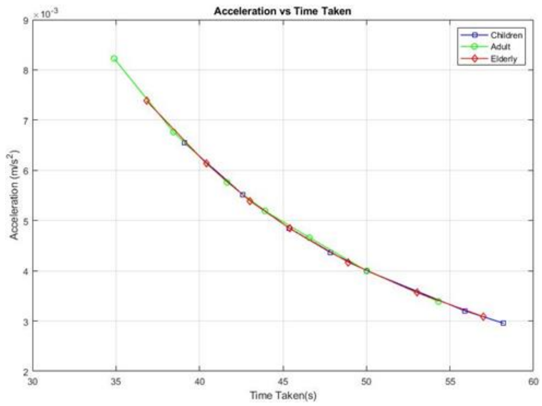

Figure 7. Subjects acceleration vs Time graph.

In summary, it can be said that both final velocity and acceleration has influenced by time taken.

4.3 Force

Figure 8 below shows the graph of acceleration vs force for 3 subjects (children, adult, and elderly). In general, it was found that the acceleration is directly proportional to the force. It means that as the higher the acceleration, the higher the force. The result revealed that the acceleration for Subject 1 is ranged between 2.955 x 10-3 ms-2 and 6.549 x 10-3 ms-2. Then, the time taken is ranged between 39.09s and 58.21s. For Subject 2, the acceleration is ranged between 3.388 x 10-3 ms-2 and 8.226 x 10-3 ms-2. Then, the time taken is ranged between 34.89s and 54.31s. For Subject 3, the acceleration is ranged between 3.089 x 10-3 ms-2 and 7.387 x 10-3 ms-2. Then, the time taken is ranged between 36.82s and 56.98s. It also can be seen that the adult has the highest force with the value of 0.695N at 34.89s and the children has the lowest force with the value of 0.206N at 39.09s.

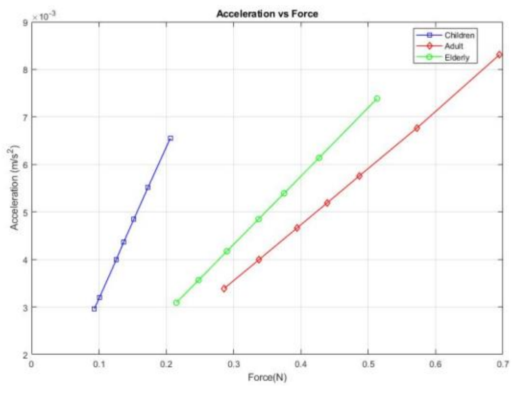

Figure 8. Subjects acceleration vs Force graph.

Table 2. Result for Subject 1.

Slider (control)	Time Taken (s)	Final Velocity (ms^{-1})	Acceleration (ms^{-2})	Force (N)
30	58.21	0.172	2.955×10^{-3}	0.093
40	55.90	0.179	3.202×10^{-3}	0.101
50	50.02	0.2	4×10^{-3}	0.126
60	47.82	0.209	4.371×10^{-3}	0.137
70	45.37	0.22	4.849×10^{-3}	0.152
80	42.59	0.235	5.518×10^{-3}	0.173
90	39.09	0.256	6.549×10^{-3}	0.206

Table 3. Result for Subject 2.

Slider (control)	Time Taken (s)	Final Velocity (ms^{-1})	Acceleration (ms^{-2})	Force (N)
30	54.31	0.184	3.388×10^{-3}	0.286
40	50.02	0.2	3.998×10^{-3}	0.338
50	46.58	0.217	4.659×10^{-3}	0.394
60	43.92	0.228	5.191×10^{-3}	0.439
70	41.65	0.24	5.762×10^{-3}	0.487
80	38.44	0.26	6.764×10^{-3}	0.572
90	34.89	0.287	8.226×10^{-3}	0.695

Table 4. Result for Subject 3.

Slider (control)	Time Taken (s)	Final Velocity (ms^{-1})	Acceleration (ms^{-2})	Force (N)
30	56.98	0.176	3.089×10^{-3}	0.215
40	53.02	0.189	3.565×10^{-3}	0.248
50	48.92	0.204	4.17×10^{-3}	0.29
60	45.39	0.22	4.847×10^{-3}	0.337
70	43.02	0.232	5.393×10^{-3}	0.375
80	40.40	0.248	6.139×10^{-3}	0.427
90	36.82	0.272	7.387×10^{-3}	0.513

Table 2, 3 and 4 above show the result for 3 subjects. The spatial temporal method is successfully achieved in this analysis. The result was obtained using spatial temporal experiment.

5. CONCLUSION

In conclusion, the objective of the project is achieved. The foldable motorized walker has been designed and developed for effective mobility-aid devices. After that, the stability and balancing of the walker has been analyzed through experimental on Spatial Temporal. Lastly, IoT is successfully implemented to the project using Blynk application. At the same time by implementing foldable and motorized system to the walker, it helps the user folded the walker easily and walk faster with less exhaustion when using this walker. This project will assist the aged and disabled people who have problem while walking.

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References

Alves, J., Seabra, E., Caetano, I., & Santos, C. P. (2017). Overview of the ASBGo++ Smart Walker. *ENBENG 2017 - 5th Portuguese Meeting on Bioengineering, Proceedings*, *d*. https://doi.org/10.1109/ENBENG.2017.7889420

Bruijn, S. M., & Van Dieën, J. H. (2018). Control of human gait stability through foot placement. *Journal of the Royal Society Interface*, *15*(143). https://doi.org/10.1098/rsif.2017.0816

Cubo, E., Moore, C. G., Leurgans, S., & Goetz, C. G. (2003). Wheeled and standard walkers in Parkinson's disease patients with gait freezing. *Parkinsonism and Related Disorders*, *10*(1), 9–14. https://doi.org/10.1016/S1353-8020(03)00060-9

Foley, M., Johnson, K., & Mcnally, B. (2010). Improved walker design. *Improved Walker Design*.

Hamacher, D., Liebl, D., Hödl, C., Hesler, V., Kniewasser, C. K., Thönnessen, T., & Zech, A. (2019). Gait stability and its influencing factors in older adults. In *Frontiers in Physiology* (Vol. 10, Issue JAN). https://doi.org/10.3389/fphys.2018.01955

Harip, M. B. . (2021). *Development of Foldable Motorized Walker for Stability and Balancing*. *10*(1), 38–48.

Leonard, J. (2017, July 18). *Mobility aids: Types, benefits, and use*. https://www.medicalnewstoday.com/articles/318463

Osoba, M. Y., Rao, A. K., Agrawal, S. K., & Lalwani, A. K. (2019). *Balance And Gait In The Elderly : A Contemporary Review*. *February*, 143–153. https://doi.org/10.1002/lio2.252

Pan, S. (2017). *Foldable rollator*. *2*.

Rabin, E. & Dong, Z. (2018). *Motorized walker*. *2*(12), 1–4.

Zhang, M., Artan, N. S., Gu, H., Dong, Z., Ganatra, L. B., Shermon, S., & Rabin, E. (2018). Gait study of parkinson's disease subjects using haptic cues with a motorized walker. *Sensors (Switzerland)*, *18*(10), 1–14. https://doi.org/10.3390/s18103549