

Development of Walking Gait Cue Stick with Laser and Stability Control for Patients with Traumatic Brain Injury

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ABSTRACT

This project is about the development of a walking gait cue stick for walking gait rehabilitation purposes. In this product development, a mechatronic device with stabiliser is attached to the walking gait cue stick. A line laser marker is accompanied with a stabilizer system to stabilize the projection of the laser. Two parameters that going to be stabilize which are the yaw and roll angle of the laser marking. The result shows good stability control for yaw angle up to 4.4 cm distance variation at the angle of 0 to 90° but relatively low stability control for the roll angle from 0 to 55° with distance variation up to 8.8 cm of the projected line laser mark. This result can further enhance walking gait training using cue stick with the aid of angles stabilising system.

INTRODUCTION

Over the years, the number of stroke patients increased every year and it is estimated in Malaysia alone, around 50,000 new stroke cases arise annually (KOSMO2013). This estimation deemed to be scarier as (Kementerian Kesihatan Malaysia) KKM 2016 Health fact report (2015 data) show a disastrous number related to stroke. About 1 million cases including new and old cases require rehabilitation process especially for the stroke survivors (KKM 2016). This fact is troublesome as stroke is a common non communicable disease nowadays and alarmingly, some patients that been strike by the stroke was as early as teenagers (Platt et. al, 2006). This is due to the bad eating habit, wrong lifestyle, stress from work and no exercise which leads to high cholesterol level and eventually resulting in stroke. This trend is not good as the teenagers is the asset of the country, therefore rehabilitation for stroke survivors is compulsory especially those who bear responsibility as the head of the family or for those who are still young as compared to the elderly.

Rehabilitation is the answer for stroke besides the prevention of stroke. One of the important aspects in rehabilitation is walking gait. Rehabilitation was proven to restore the abilities of a stroke patient as relentless training can build up new nerve system from the muscle to the brain as aspirate by the physiotherapist. The affected side of the patient body is overwhelmed by the non affected side, causing imbalance of the gait especially the walking gait. The disability to properly balance the gait increases the risk of musculoskeletal injury to non-parietic limbs (Van de Port and Ingrid, 2006).

In this study, an attachable mechatronic device for walking gait cue stick is developed. Some researcher did use cue stick for walking gait training (Afzal et. Al, 2016). This device could help the patient to take the next step required as shown on the floor by the laser line marker. This is the novel way on training the walking gait rather than marking the line on the floor using the coloured tape. The patient needs to make sure that their footstep taken is according to the marking on the floor.

MATERIALS AND METHOD

In this study, a laser line projector is attached to a cue stick. The laser projector project a temporary laser marking for the next footstep that needs to be followed by the patient. The line laser is triggered when the cue stick touches the floor and once the patient takes the next step, the cue stick will be lift up and touch the floor again and the process will be continuous.

The main problem with this method is, the temporary laser displayed on the floor is unstable due to shaking of cue stick held by the patient hand. Therefore, a mechatronic stabiliser is developed to stabilise the laser so the laser mark will remain at the same location rather than moving or rotating together with the cue stick. There are two angles that significantly affects the location of the marking which is the yaw and roll as shown in Fig. 1.

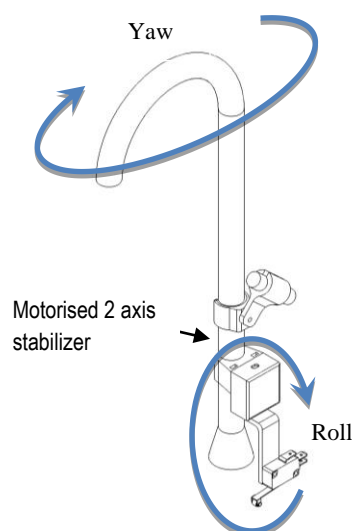


Fig. 1 Standard cue stick attached with laser marker

For the part, the prototype is designed and fabricated with 3D printer. Standard cue stick is used and attached with the device. The device is battery powered and rechargeable using a normal 5 Volt mobile charger. The prototype is developed based on Arduino Uno, Gyro sensor, laser pointer and servomotor for balancing and stability shown on Fig. 2. Two servo is being used to counter the unwanted yaw and pitch angle that measured by the gyro sensor due to unstable cue stick.

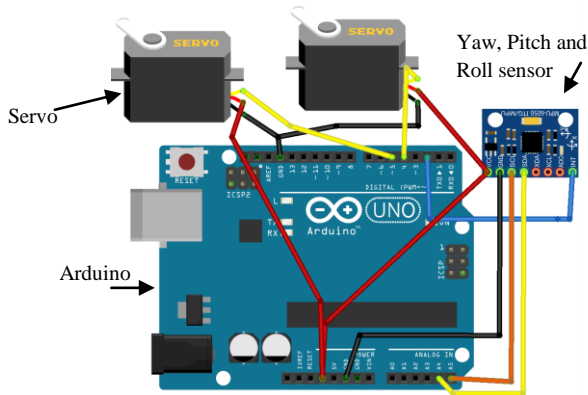
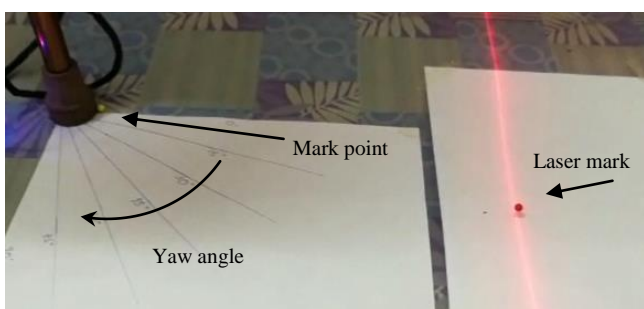


Fig. 2 The electronic part involved for the stabilizer system

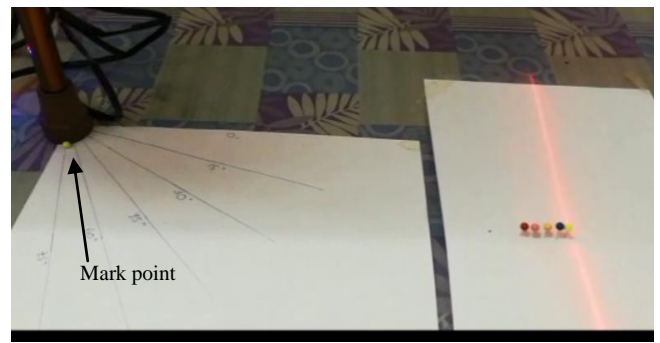
EXPERIMENT SETUP

Yaw test

The experiment setup involves two angle which includes yaw and roll. For each experiment, the value of angle selected is from 0 to 90° and variation of laser marker is measured to determine the effectiveness of the stability control. The setup for yaw in shown in Fig. 3 and roll in Fig. 4. The experiment is set up by using a white paper, one for measuring the yaw angle on the ground and another paper on the ground to measure the distance variation of the temporary laser marking. This experiment is conducted with the aid of servo stabilizer to counter the angle of yaw rotation. Early experiment without the servo stabilizer shows that the line laser also rotates with the cue stick. This is undesired as without the stabilizer, the laser projection marking will be inconsistent and the step laser marker going to be shown on the floor varies greatly and this will not help the walking gait training for the patient. The yaw angle can be measured by using the mark point that attaches to the cue stick. The cue stick then twisted according to the desired yaw angle and the laser projection is marked. Once the experiment is finished, the variation of laser mark distance is measured.



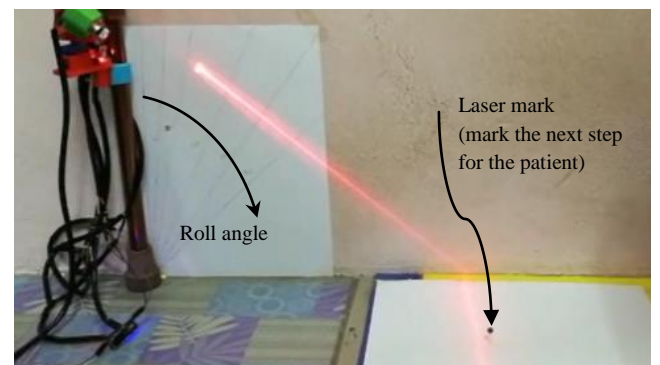
(a)



(b)

Fig. 3 Yaw experiment setup on laser marker distance variation at (a) lower yaw angle and (b) higher yaw angle

For the roll experiment shown in Fig. 4, a paper is attached to the side of the wall to determine the roll angle. The other paper is attached to the ground to measure the distance variation. The cue stick with stabilizer them roll rolled forward according to the desired roll angle in order to obtain the distance variation of laser mark for different roll angle.



(a)



(b)

Fig. 4. Roll experiment setup on laser marker distance variation at (a) lower roll angle and (b) higher roll langle

RESULTS AND DISCUSSION

In the experiment setup, the yaw angle was tested with the maximum rotation angle of 90° and the roll angles are 15°, 30°, 45°, 60°, and 75°. Throughout the experiment, variation distance of laser marker were measured for each individual angle. The result is tabulated in Table 1 and plotted as shown in Fig. 5.

Yaw test

Table 1 Yaw angle versus distance variaton results

Angle(°)	Distance variation (cm)
15	0.8
30	1.6
45	2.6
60	3.1
75	3.8
90	4.4

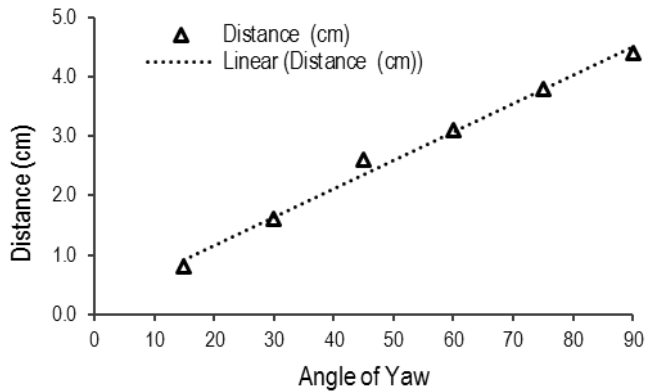


Fig. 5 Yaw angle versus distance variaton of laser mark

According to the graph shown in **Fig. 5**, the first value for distance at 15° is only 0.8 cm. Next, at 30° angle, the distance between angle at 15° only 0.8 cm but for 30° it is 1.6 cm. At 45° the distance is 2.6 cm, an increase of 1 cm. When the angle change from 60°, 75°, and 90° the distance variations are 3.1cm, 3.8cm, 4.4cm. Hence, the maximum distances was 4.4 cm for yaw angle. It can be noted that the distance variation linearly proportional to the yaw angle. However, this is undesired as the ultimate variation that should be achieved is zero. Nevertheless, it is still acceptable as 4.4 cm distance variation is considered small to a naked eye. The yaw angle stabilizer also fullfil the purpose stabilizer as the laser marking remain it straightness as without it, the line laser will be twisted as well.

Roll test

For this part, roll angle testing is conducted to measure the distance variation that influence the effectiveness of attachable cue stick laser marking on the ground with the stabilizer turned on. Five angle were taken but only limited to 35° because during walking gait training, it is unlikely for a patient to roll the cue stick at a very high angle especially when the step need to be taken is small. Considering the practical application, five roll angle were tested which were 5°, 10°, 15°, 25° and 35°. The results of the experiment were shown in **Fig. 5** and **Table 2**.

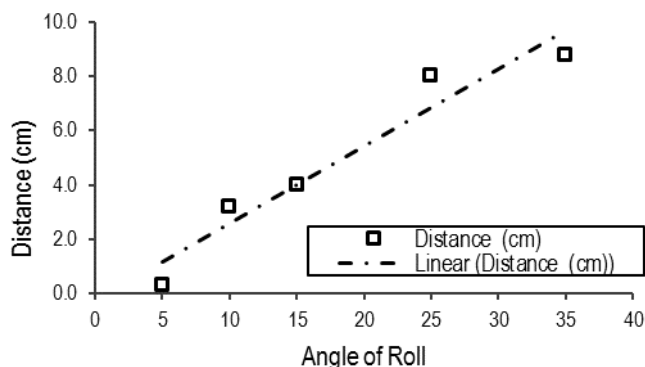


Fig. 5 Roll angle versus distance variation

Table 2 Roll angle versus distance variation results

Angle (°)	Distance variation (cm)
5	0.3
10	3.2
15	4.0
25	8.0
35	8.8

Based on **Table 2**, when the cue stick roll to 5° the distance error shows only a little bit changes which is 0.3cm. Next, at 10° angle roll, the distance error between angles at 5° show large changes which increased by 2.9cm as compared to 0°. At 15°, the distance variation shows 4.0cm length. Then, a further rotation angle of roll of 25° and 35° show obvious distance variation of 8.0cm, and 8.8cm. Again as compared to roll, the distance variation linearly proportional to the angle of roll but this time the variation is higher. This is due to the stabilizer of roll try to maintain the original roll angle of the laser which affecting the laser mark projected farther on the ground. Without the roll angle stabilizer, the laser device would rolled together with the cue stick. As the cue stick roll forward, the laser device roll further as well (without stabilizer) and the laser marking for the next step will become shorter. Furthermore, the roll show more error than the yaw because the angle of the pitch influence the distance reading for roll after a thorough observation from the tables and graphs.

CONCLUSION

The cue stick for walking gait rehabilitation was successfully developed. The yaw angle shows a promising result of stability but for the roll angle, modification of stabilizing angle need to be done as the distance variation is very high especially for low roll angle. The stabilizer fulfills loophole of the walking gait training cue stick by preventing the twisted laser marking and undesired laser projection.

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