A ROBOTIC CANE CONTROL SYSTEM BASED ON IMAGE PROCESSING FOR SUPPORTING THE BLIND PEOPLE

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***Abstract* - This paper proposes an image processing method for determining the navigate lines of blind people by color detection to control the robotic cane for walking assistant. The design of the robotic cane is based on an inverted pendulum model, uses a smart omnidirectional wheel, and is linearized by the Lie algebra method (LAM) combined with a nonlinear disturbance observer to control the robotic cane maintain balancing was proposed by [1]-[3]. In addition, the image processing method to detect the color of the navigation lines is useful to determine the movement of the robotic cane has been proposed. All the results have shown that by using the image processing method when applied to the robotic cane is useful to support the blind people for walking assistance.**

***Index Terms:* robotic cane, inverted pendulum, image processing, assist devices.**

INTRODUCTION

Assist devices for elderly people and disabled person are being studied and developed very well in today's society. Especially, the devices to support blind people to stand and to walk with compact size, convenient is limited. In this paper, the authors present the application of an image processing method applied to the robotic cane to support the blind people maintain balancing while moving to follow the navigate lines of blind people.

The robotic cane included a camera was design as figure 1. The hardware of the robotic cane was developed and test with many good results for support users strong stable when the robotic cane support to stand or walking support in [1] - [3]. Moreover, by using a camera that connects to Raspberry Pi 3 mode B+ can provide a good signal to support the controller calculate and control the motion of the robotic cane to support the blind people to walk follow the navigate lines than traditional sensors as LIDA expensive one and ultrasonic sensors with short detection range, that cannot detect the navigate line for blind people.

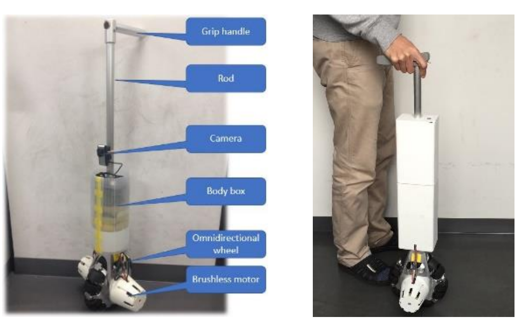

Figure 1: Hardware design of the robotic cane.

As shown in figure 2, we have many types of navigation lines for blind people: straight line, curve line, and zigzag line. However, they are uniform in size and color, so by using an image processing method becomes more efficient and reasonable than other more complex and expensive methods to detect the navigation line to support the blind people to walk.

The image processing method is not a new method for researchers, and they have achieved some best results of colors detection or objects moving detection proposed by [4].

a) straight line *b) curve line* *c) zigzag line*

Figure 2: Navigate lines types for blind people.

To determine the motion of the robotic cane we are using Lagrange equations as follows:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right)-\frac{\partial L}{\partial q}=\tau-d \qquad (1)$$

where L is the Lagrangian, q is the generalized coordinates vector, τ is the output torque on the motor axis, d is the external disturbance torque Ref. [1].

To linearization of the nonlinear system of the robotic cane, we are using LAM [3] with a good result of the stabilization of the system. Also, to estimate the external disturbance torque from the user applied to the robotic cane when support the user maintain balancing the authors used a nonlinear disturbance observer as the authors [3] can be described as below:

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$$\dot{\xi} = -K\xi + K^2 \frac{\partial L}{\partial \dot{q}} + K(\frac{\partial L}{\partial q} + \tau) \qquad (2)$$

$$\hat{d} = \xi - K\frac{\partial L}{\partial \dot{q}} \qquad (3)$$

where $\hat{d}$ is the estimated disturbance, ξ is the observer state variable, and K is the gain of the observer.

RESULTS

Firstly, the robotic cane strong stable by itself without any support from the user by using LAM and the nonlinear disturbance observer as shown in figure 3. With starting point is around *0.01* rad, the robotic cane achieves the equilibrium point with a short time and remaining strong stable with the position as no change in the last period.

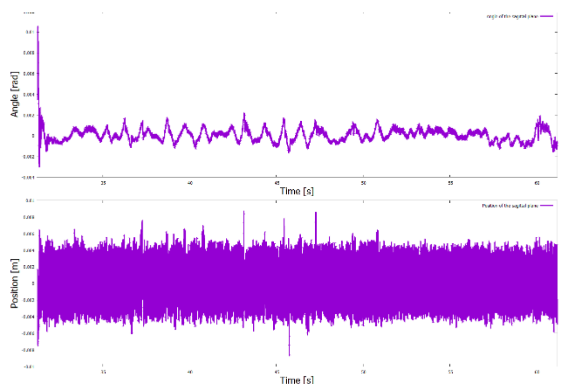
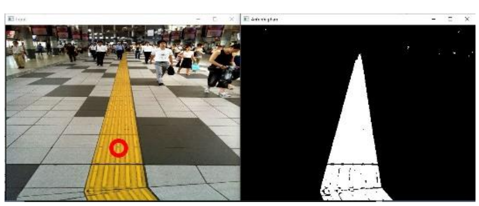
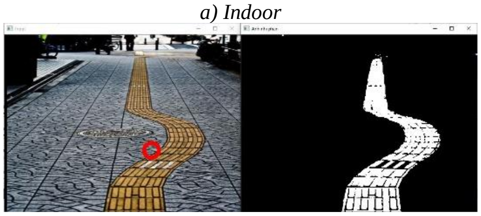


Figure 3: Angle and position of the robotic cane.

Secondly, the results of the image processing method to detect the navigate line by color detection method as shown in figure 4. This figure showed that, when we applied the image processing method to the robotic cane at booth indoor and outdoor environments, the robotic cane can detect clear the navigate lines.



a) Indoor



b) Outdoor

Figure 4. Color detection algorithms results.

The results will provide to the controller to control the motion of the robotic cane to helps the blind people to walk easier than conventional methods.

CONCLUSION

We designed the hardware of the robotic cane based on an omnidirectional wheel included a camera with a high-speed processing controller to detect the navigation lines of the blind people for walking assistance.

The experimental results on the hardware indicate that the robotic cane is effective in helping users maintain their balance and our nonlinear disturbance observer provides a good method to estimate the human force applied to the robotic cane for walking assistance. Moreover, with the good results of the image processing method, we are hoping that when the robotic cane applies this method to detect the navigate line is useful for blind people to walk.

In future work, we have planning to test our image processing proposed method with the hardware of the robotic cane when supporting the user to walk. Also, we intend to reduce the size of the system while increasing the capacity of the battery to increase the running time of the robotic cane without charging and adding more filter for image processing more clearly without being affected by the change of environment.

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