IOP Conference Series: Materials Science and Engineering

Movement Parameters for Evaluating the Two-legged Humanoid Robot

Movement Parameters for Evaluating the Two-legged Humanoid Robot

Dirja Nur Ilham[1], Rudi Arif Candra[1], Hardisal[1] Erwinsyah Sipahutar[2] Abdullah Abdullah[3], Suherman Suherman[3] and S Othman[4*]

[1] Politeknik Aceh Selatan, Jl, Merdeka Komplek Reklamasi Pantai, Tapaktuan, Aceh, Indonesia
[2] Politeknik ATI Padang Jl. Bungo Pasang Tabing Padang, Indonesia
[3] Universitas Sumatera Utara, Department of Electrical Engineering 2 Almamater Road, Medan, Indonesia 20155
[4]Faculty of Computing and Multimedia Kolej Universiti Poly-Tech MARA, Kuala Lumpur

*Corresponding e-mail: suherman@usu.ac.id

Abstract. Many robot prototypes have been made and control algorithms have been proposed. The performances are measured through experiments. This paper presents a two-legged robot prototype with and without Kalman filter in processing sensor data and proposes some movement evaluation parameters to measure the robot performances. Experiments show that the evaluated performances are able to differentiate method achievements. Movement parameters: movement angle, distance travelled, and failed frequency have been successfully identified robot performances.

Keywords: humanoid robot, two-legged robot, Kalman filter, movement parameters

1. Introduction

Robot has been used in industrial sector for years. Currently, not only for industrial purposes, robot is also use for service and specialized tasks [1]. Robot development now involves the integration of intelligent system [2] where the mechanical engineering meets information and communication technologies. The first issue initially was about electro-mechanical devices such as motor and its controller. Now it moves to human-like characteristics such as image, language and other learning processes.

Robot is defined as a programmable mechanism in multi axes, moving around its surrounding to perform the intended tasks [3] Robot with intelligence shoul be able to perform environment perception and make decision. Intelligent robot can simulate human behaviors like emotion and thinking. Robot assessment is not only for covering the mechanical function but also how far it follows human commands and finishes the predefined tasks, learns environment and improves behaviors.

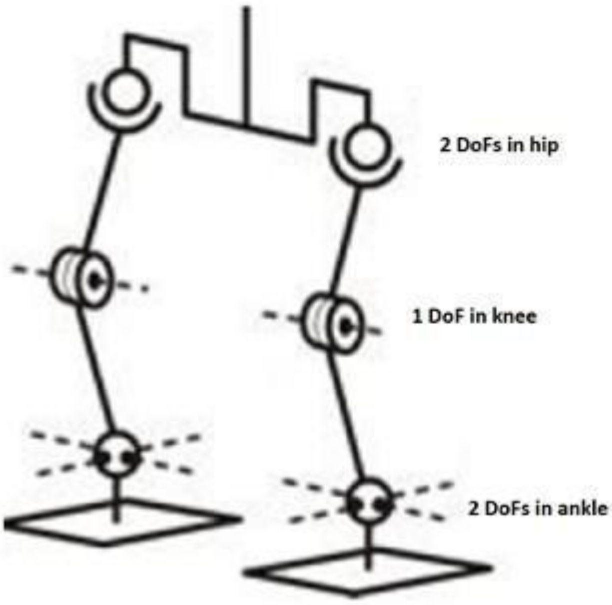
In order to measure robot performances, some measurements were set up. Some researchers used goal accomplishment as the main parameter [4] others use sub task success rates such as task localization, object detection, specific movement, task detachment, cycle time, and failure rates [4] Meanwhile, additional performance parameters for industrial or manipulator robots consider metrics for safety, task quality and task quantity [5].

This paper focuses on performance measurement of the walking performance of humanoid robot. A prototype was developed, three performance parameters were proposed. Since walking robot requires self-balancing, the parameters proposed in this paper include movement angle, travelled distance, and failed frequency. In order to see the effectiveness of the parameter to see performance increment, Kalman filter was inserted to enhance robot performances.

2. Robot Prototype

The humanoid robot prototype that will be evaluated was designed using 5 degree of freedom (DoF) in each leg: 2 DoFs in ankle, 1 DoF in knee and 2 DoFs in hip as shown in Figure 1.

Electrical design includes microcontroller circuit and programming, sensors and drivers, servo control and drivers, and power supplies. Kalman filter is inserted in microcontroller program to evaluate the effectiveness of the proposed measured parameters. Kalman filter is complex mathematical expression but able to improve robot performance [6, 7]. Kalman filter reduces noise generated by sensor circuits when performing maneuver.



(a)

(b)

Figure 1. 5 DoFs prototype.

Robot was controlled by ATmega32 and ATmega8 microcontrollers. ATmega32 processes navigation sensors while ATmega8 controls servo motors. Figure 2 shows the circuit. Two microcontrollers were employed to enhance the processing power. ATmega8 and Atmega32 exchanges information through the parallel data line. Microcontrollers were supplied by 5V power supply while the motors were driven by 12V power supply.

Initially, ATmega32 microcontroller checks the standing position from sensors to inform ATmega8 how motor should work. If it is accomplished, navigation sensors are read to ensure smooth movement. Output of those sensors are processed by using Kalman filter before adjusting the movement angles as results of ATmega32 and ATmega8 coordination. In order to measure movement angles, trip time, and the failure rates, robot was tested to travel about 50 times.

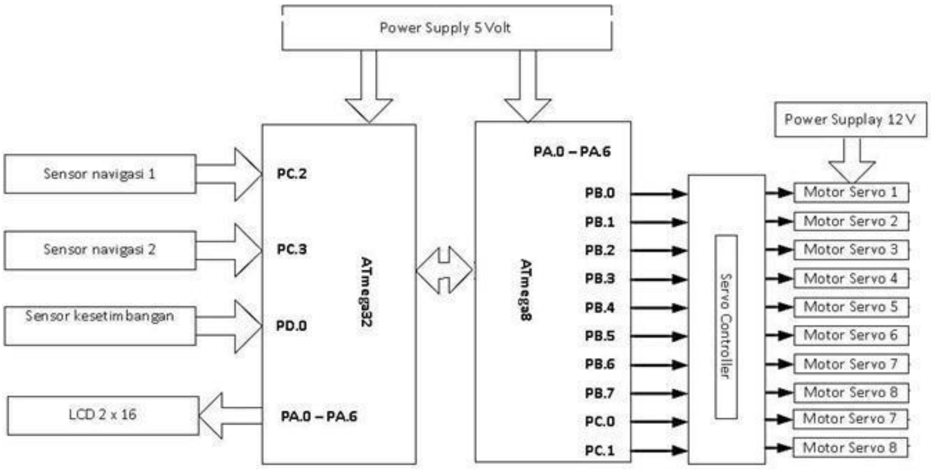
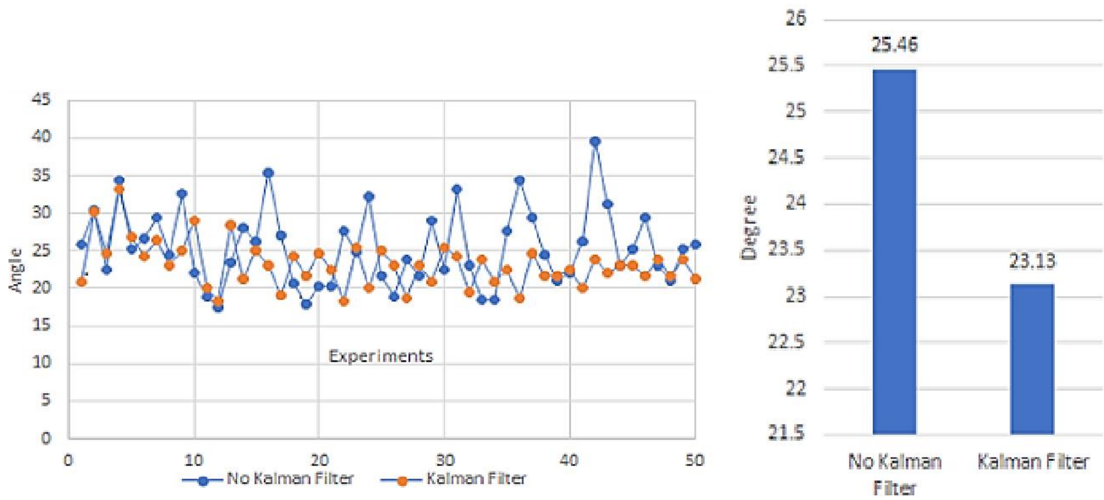


Figure 2. Controller circuit.

3. Evaluation Results

Figure 3 shows the movement angle of robot. The graph shows distinguishable performance parameters where without Kalman filter, robot experiences unstable movement angle that changes very frequently with large amplitude. Kalman filter can make robot hold in its position more steadily. Average angle is 25.46o for robot without Kalman, reduced to average 23.13o with Kalman filter. The performance difference achieves 9.2%. Both experiments and average value are distinguishable, which means this evaluation parameter is working as expected.



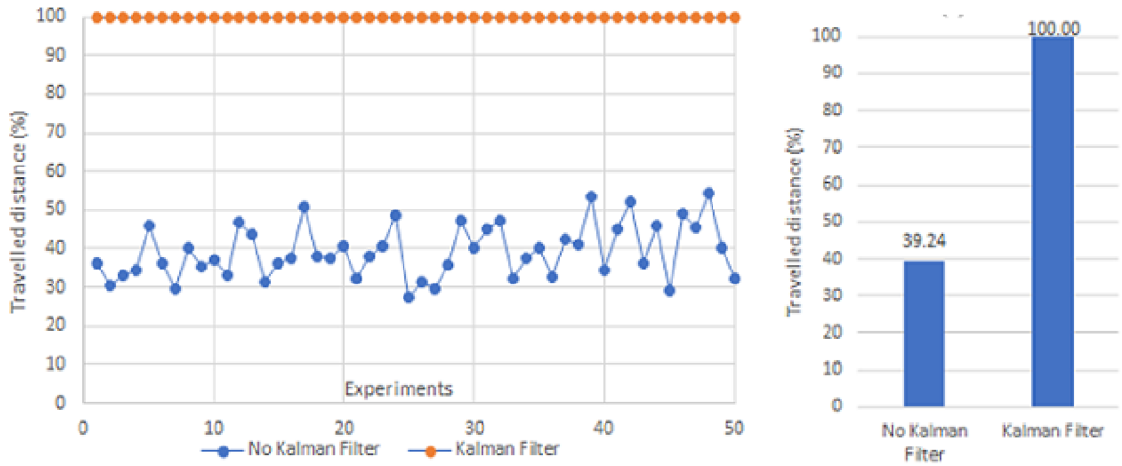
(a) (b)

Figure 3. Movement angle.

Meanwhile, the travelled distance parameter is also able to differentiate robot performance as the robot with Kalman filter experiences zero failure. The plain robot was failed to complete the target which reached only 39.2% of the overall distance (Figure 4). This performance parameter produces in average 60.8% performance achievement differences.

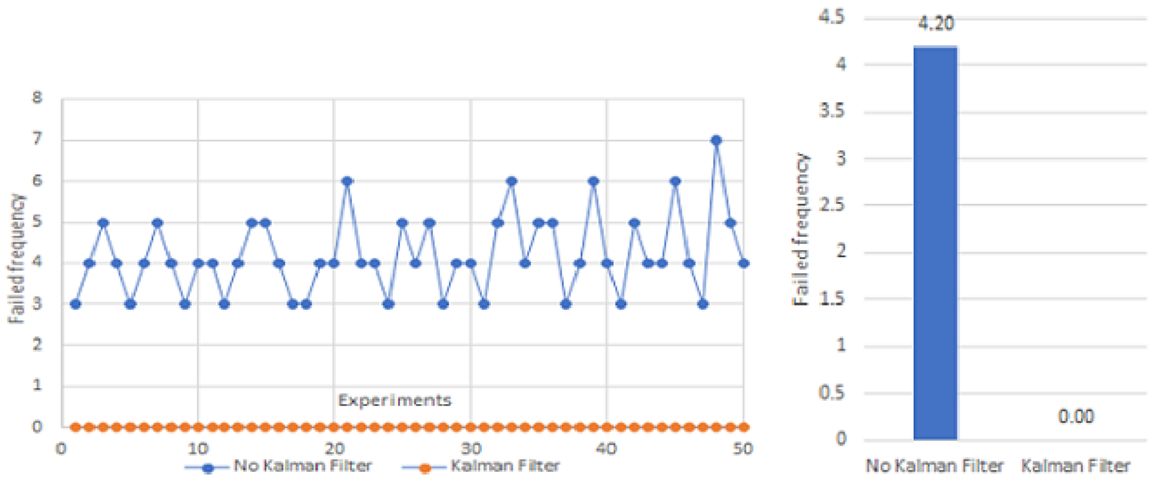
IOP Conf. Series: Materials Science and Engineering 1062 (2021) 012058 doi:10.1088/1757-899X/1062/1/012058

The last parameter is the failed frequency which produced in average 4.2 against 0. This parameter can distinguish the robot performance as can be seen in Figure 5.



(a) (b)

Figure 4. Travelled distance.



(a) (b)

Figure 5. Failed frequency.

4. Conclusions

This paper also proposed three evaluation parameters which are movement angle, travelled distance and failed frequency. The experiment shows that three parameters that can distinguish robot performances. Movement angle distinguished robot performance 9.2%, while travelled distance gives 60.8% differences. Finally, failed frequency produces 4.2 against 0 for system without and with Kalman filter.

References

[1] Berg J, Lottermoser A, Richter C, & Reinhart G 2019 *Procedia CIRP* **79** 614-619

[2] Tian-Miao Wang, Yong Tao, Hui Liu 2018) *International Journal of Automation and Computing* **15**(5) 525-546

[3] International Federation of Robotics. *Industrial Robotics Standardization*. (Online)

[4] Bac CW, Hemming J, Van Tuijl B A J, Barth R, Wais E & van Henten E J 2017 J*ournal of Field Robotics* **34**(6) 1123-1139

[5] Bostelman R, Hong T, & Marvel J 2016 *Journal of Research of the National Institute of Standards and Technology* **121** 342-366

[6] Moore T & Stouch D 2016 *In Intelligent autonomous systems* **13** (335-348 (Springer Cham.)

[7] Congwei Hu, Wu Chen, Yongqi Chen and Dajie Liu 2003 *Journal of Global Positioning Systems* **2**(1)