













thin object. Thus, a webcam is attached to the mobile robot so that the current image can be processed by a vision system.

#### ACKNOWLEDGMENT

The authors would like to thank the Office of Research, Innovation, Commercialization and Consultancy (ORICC), Universiti Tun Hussein Onn Malaysia (UTHM) for the funding of this paper publication.

#### REFERENCES

- [1] S. F. R. Alves, H. F. Filho, R. Pegoraro, M. A. C. Caldeira, J. M. Rosário, and W. M. Yonezawa, "Proposal of educational environments with mobile robots," in *2011 IEEE 5th International Conference on Robotics, Automation and Mechatronics (RAM)*, 2011, pp. 264–269.
- [2] M. Beschi, R. Adamini, A. Marini, and A. Visioli, "Using of the Robotic Operating System for PID control education," *IFAC-Pap.*, vol. 48, no. 29, pp. 87–92, Jan. 2015.
- [3] C. Vandeveld, F. Wyffels, M.-C. Ciocci, B. Vanderborght, and J. Saldien, "Design and evaluation of a DIY construction system for educational robot kits," *Int. J. Technol. Des. Educ.*, vol. 26, no. 4, pp. 521–540, Nov. 2016.
- [4] "About ROS." [Online]. Available: <http://www.ros.org/about-ros/>. [Accessed: 26-Mar-2017].
- [5] A. Koubaa, *Robot Operating System (ROS): The Complete Reference*. Springer, 2016.
- [6] Enrique Fernández, L. Sánchez Crespo, A. Mahtani, and A. Martínez, *Learning ROS for Robotics Programming*. Packt Publishing Ltd, 2015.
- [7] L. Garber, "Robot OS: A New Day for Robot Design," *Computer*, vol. 46, no. 12, pp. 16–20, Dec. 2013.
- [8] E. Ruiz, R. Acuña, N. Certad, A. Terrones, and M. E. Cabrera, "Development of a Control Platform for the Mobile Robot Roomba Using ROS and a Kinect Sensor," in *2013 Latin American Robotics Symposium and Competition*, 2013, pp. 55–60.
- [9] E. M. H. Zahugi, A. M. Shabani, and T. V. Prasad, "Libot: Design of a low cost mobile robot for outdoor swarm robotics," in *2012 IEEE International Conference on Cyber Technology in Automation, Control, and Intelligent Systems (CYBER)*, 2012, pp. 342–347.
- [10] V. Bayar, B. Akar, U. Yayan, H. S. Yavuz, and A. Yazici, "Fuzzy logic based design of classical behaviors for mobile robots in ROS middleware," in *2014 IEEE International Symposium on Innovations in Intelligent Systems and Applications (INISTA) Proceedings*, 2014, pp. 162–169.
- [11] A. Araújo, D. Portugal, M. S. Couceiro, and R. P. Rocha, "Integrating Arduino-Based Educational Mobile Robots in ROS," *J. Intell. Robot. Syst.*, pp. 1–18, Feb. 2014.
- [12] G. Fu and X. Zhang, "ROSBOT: A low-cost autonomous social robot," in *2015 IEEE International Conference on Advanced Intelligent Mechatronics (AIM)*, 2015, pp. 1789–1794.
- [13] H. I. M. A. Omara and K. S. M. Sahari, "Indoor mapping using kinect and ROS," in *2015 International Symposium on Agents, Multi-Agent Systems and Robotics (ISAMSR)*, 2015, pp. 110–116.
- [14] M. Quigley, B. Gerkey, and W. D. Smart, *Programming Robots with ROS: A Practical Introduction to the Robot Operating System*. O'Reilly Media, Inc., 2015.