ICIC Express Letters
Part B: Applications
Volume **12**, Number **4**, April **2021**

ICIC International ©2021 ISSN 2185-2766
pp. **377–382**

IMPLEMENTATION OF WEMOS D1 FOR WI-FI BASED CONTROLLER TANK-BASED MILITARY ROBOT

Widodo Budiharto[1], Vincent Andreas[1], Edy Irwansyah[1]
Jarot Sembodo Suroso[2] and Alexander Agung Santoso Gunawan[3]

[1]School of Computer Science
[2]Information Systems Department
BINUS Graduate Program – Master of Information Systems Program
[3]Mathematics Department, School of Computer Science
Bina Nusantara University
JL. K. H. Syahdan No. 9, Kemanggisan, Palmerah, Jakarta 11480, Indonesia
{ wbudiharto; eirwansyah; jsembodo; aagung }@binus.edu; vincent.andreas89@gmail.com

Received August 2020; accepted November 2020

Abstract. *Wi-Fi technology with long distance capability is an important feature for controlling a military robot. A military robot with video streaming capability is also needed by the military because it can be deployed to the battlefield and the operator able for viewing the condition near the robot. This system is needed to reduce the remaining casualties from the army, and this combat robot system can also be operated at any time with more numbers than regular soldiers and with minimal operator needs. In this paper, we propose a prototype of a military robot with video streaming capability and the ability to shoot an object and control using Wi-Fi. We use a camera that can be controlled using 2 servos. We propose an algorithm for controlling the robot using Wi-Fi and Blynk application and video streaming based on the Web. The methods were explained, and experimental results were presented.*
Keywords: Military robot, Wi-Fi technology, Computer vision, Video streaming

1. **Introduction.** Nowadays, most of the robotic systems in general purpose and military use a camera and sensors for surveillance and obstacle avoidance [1]. The Department of Defense (DoD) of the USA is increasingly interested in Artificial Intelligence (AI). During a recent trip to Amazon, Google, and other Silicon Valley companies, Secretary of Defense James Mattis remarked that AI has "got to be better integrated by the DoD". What do we mean by the term AI? What does "deep learning" mean? What are the advantages, disadvantages, and risks of using AI [2]? This condition is the same as the Indonesian government that wants the implementation of Industry 4.0 and Society 5.0 in the defense sector by developing the military robot.

Robots for military purposes, in general, called an Unmanned Ground Vehicle (UGV) is used to augment the soldier's capability. Many military robots were developed to maintain security and spies in conflict areas or borders based on cameras and firearms and missiles. The study of the military tank robot system has been carried out for example [3,4].

Image segmentation and object detection is an essential task in all applications of computer vision. It addresses the problem of partitioning an image into disjoint regions of interest according to their specific features (gray levels, texture, etc.). The accuracy of image segmentation significantly influences the results of image analysis performed in the following steps [5].

In developing a military robot, to produce autonomous systems, the system must be able to track targets/recognize objects based on computer vision. Robots are also expected to be able to recognize faces/objects that can be enemies to be conquered. Uncertainty is very

DOI: 10.24507/icicelb.12.04.377

common in tracking objects based on vision, so the application of probabilistic robotics in the development of intelligent robots is very important [6]. Robotic systems can take many forms, be stealthy or intentionally noisy, cloak themselves and deceive the enemy physically, electronically, and behaviorally. There are fundamental ethical implications in allowing full autonomy for these robots. Among the questions to be asked are

- Will autonomous robots be able to follow established guidelines of the Laws of War and Rules of Engagement, as specified in the Geneva Conventions?
- Will robots know the difference between military and civilian personnel?
- Will they recognize a wounded soldier and refrain from shooting [7]?

Wi-Fi is a wireless networking technology and stands for "wireless fidelity". Wi-Fi is a high Internet connection and invented by NCR Corporation/AT&T in the Netherlands in 1991. This research is very important to produce models and methods of a military robot that can be controlled remotely. We present an introduction in Part 1, Part 2 as a concept of object detector, the proposed method in Part 3 and experimental results in Part 4 and then conclusion in Part 5. Figure 1 shows a prototype of Wi-Fi-based robot controller for the military as proposed.

FIGURE 1. A prototype of military robot using Wi-Fi technology for controlling the robot. We can control the camera using 2 servos.

2. Related Works.

2.1. Military robot using wireless technology. Different kinds of robots are specifically employed for doing special tasks in military applications. In military services, there are some areas in which some of the tasks involve greater risk and danger, and therefore, those tasks must be performed without military personnel, solely by the robots. For example, the Guardium is a part of a new category of military robot/UGV. Israel is the first country in the world using these robots to replace soldiers on missions like border patrols. The Guardium is based on a Tomcar dune-buggy-like vehicle and equipped with a range of sensors, cameras and weapons. It can be driven by a soldier sitting in a command center mile away or receive a predesignated route for its patrol, making it completely autonomous [8].

Radio frequency controlled robotic vehicle is designed using a robotic vehicle that is interfaced with radio frequency remote control. RF transmitter is used by a control panel or controlling person and RF receiver is connected to the robotic vehicle that is to be controlled remotely. Radio frequency remote control works over an adequate range (up to 200 meters) by facilitating with a proper antenna with an RF power below 1 Watt.

2.2. Wi-Fi technology for robot. Robot in a military context is a powered machine that (1) senses, (2) thinks (in a deliberative, non-mechanical sense), and (3) acts. There are several possible AI applications for the military robot. Replacing frozen software with systems that do not need to be refreshed periodically creates a broad potential for creating more nimble systems, possibly at lower cost. Again, AI could be used in training systems [2].

Wi-Fi is a wireless networking technology, based on the IEEE 802.11 standards, which is commonly used for local area networking of devices and Internet access. Wi-Fi uses multiple parts of the IEEE 802 protocol family and is designed to seamlessly interwork with its wired sibling Ethernet. Compatible devices can net through a wireless access point to each other as well as to wired devices and the Internet. The different versions of Wi-Fi are specified by various IEEE 802.11 protocol standards, with the different radio technologies determining radio bands, and the maximum ranges, and speeds that may be achieved. Wi-Fi most commonly uses the 2.4 gigahertz (120 mm) UHF and 5 gigahertz (60 mm) SHF ISM radio bands; these bands are subdivided into multiple channels. Channels can be shared between networks but only one transmitter can locally transmit on a channel at any moment in time.

Wi-Fi stations communicate by sending each other data packets: blocks of data individually sent and delivered over radio. As with all radio, this is done by the modulating and demodulation of carrier waves. The Wemos D1 R1 board is an Arduino based controller with an ESP8266 low-cost Wi-Fi chip with full TCP/IP stack and MCU (Micro Controller Unit) capability produced by Shanghai-based Chinese manufacturer, Espressif Systems. Military robot that can be controlled with long distance is very important, and ESP8266 is one of the best choices. The configuration of the board is shown in Figure 2.

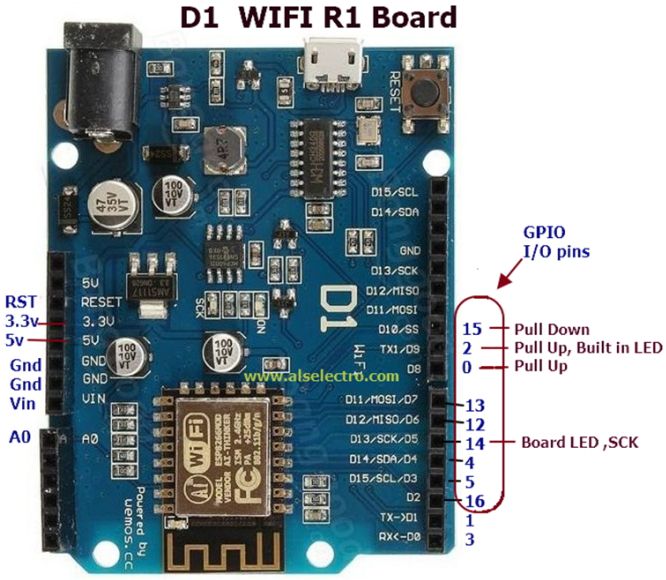

FIGURE 2. Wemos D1 Wi-Fi controller [11]

3. **Proposed Method.** Autonomy in a robot is the capacity to operate in the real-world environment without any form of external control, once the machine is activated and at least in some areas of operation, for extended periods. In this study, we propose a military robot model that wants to be developed as shown in Figure 3, where firearms will be used to be able to shoot targets in long distances. This robot model can also be controlled remotely (teleoperated). Motor drivers and tank wheels and a strong and adequate mechanical model are also needed to be able to move on the battlefield [6]. The previous research has produced a tank robot model but is controlled by an Android Apps and Bluetooth which has certainly lower security than Wi-Fi [9].

The authors have conducted prior research for object tracking using a method of color-based object detection and Kalman filters that are adequate for tracking objects. Programming a robot with a good algorithm and supported by artificial intelligence is an important aspect today [10]. The camera system on the robot will be used in this research to obtain the vision of a target. We use high voltage 24 V and current 5 A for the

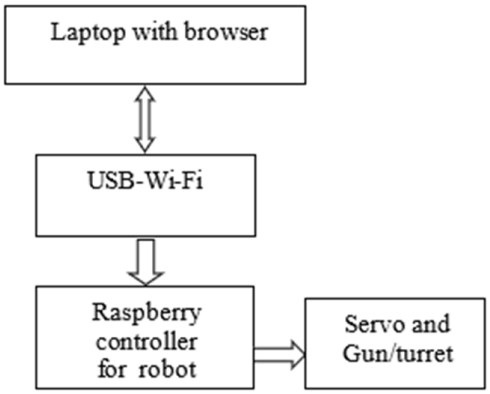

FIGURE 3. The architecture of a military robot with video streaming capability

DC motor and drivers of the tank able to move with enough power [9]. The USB Wi-Fi will be used for accepting commands from laptop under browser application and Raspberry controller as shown in Figure 3. A single-camera was connected to the Raspberry for processing video streaming.

The servo motor is used for controlling camera. We develop a program based on Python, Flask as Web Apps, and OpenCV for controlling the robot and weapon for shooting an enemy. First, the program will make a connection between the controller, server and the robot using Wi-Fi. We find a target using a button in the Web Apps and then if found the robot it will move forward to the target. The algorithm for video streaming and controlling the robot is shown in Algorithm 1.

Algorithm 1. Controlling robot and video streaming using Wi-Fi

```
Declare variables
HOST = " "
PORT = 21567
BUFSIZ = 1024
begin
  data = tcpCliSock.recv(BUFSIZ)
  connect to server
  if server connected, then
        open connection
        //accept control X/Y position of camera
        acceptControllingCamera()
        find a target(controlling manual using Web Apps)
        if not found, then
            move robot forward
        else
            move forward to target
            robot stop and shoot the target
            if the target still found, then
                shoot target again
            end if
            else
                stop shoot
                move backward
            end if
  end if
end
```

The tcpCliSock will send the command to the robot, and then will be processed as a movement or shoot. We can also calibrate the robot movement to make each wheel can move well. GPIO is pinned in the integrated circuit that can be used for Input Output. When we give high voltage (5 V) to GPIO, the servo will move, and if we give low voltage (0 V) the servo will stop.

For capturing and stream the video, we use MJPG Streamer, that can send real-time video camera using Wi-Fi. For using MJPG Streamer [12], we must connect to the same Wi-Fi connection, and must run both software in robot and our gadget. For this research, we use a small camera, that can work with low energy. We can also change the camera to a specialized camera, like an infrared camera or thermal camera, that can easily track enemy.

4. **Experimental Results.** We developed a program for computer vision using a laptop, OpenCV, and Python and Wi-Fi for controlling the robot. We use Flask for developing Web Apps for controlling remotely. The security system of Wi-Fi technology is very good. First, we should connect Apps to the robot and show video streaming. The Web application is built using Flask and Python. The application for controlling using Smartphone and Blynk is shown in Figure 4.

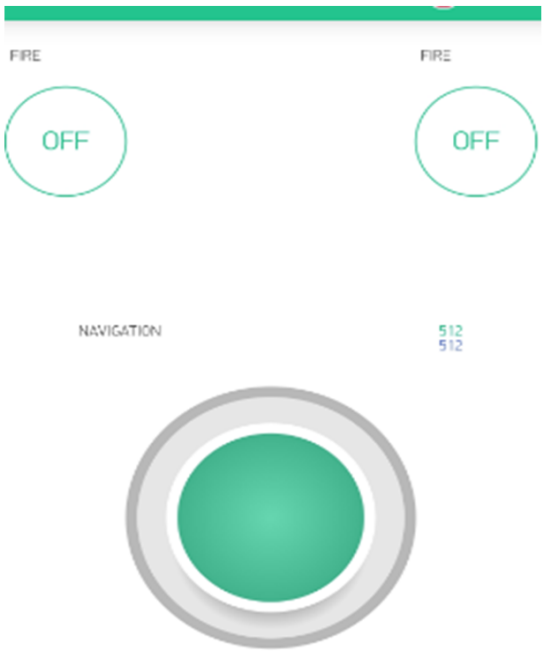

FIGURE 4. Result of the joystick controller using Blynk

Previous research has shown that the behavioral measure of trust in an autonomous vehicle can be measured based on the movements of a driver's body party (e.g., their heads, hands, and feet) as they experience a simulated autonomous system [14]. However, in this study, the trust in the autonomous vehicle was solely determined based on the body movements. Other human factors were not considered [15]. Based on the experiment, the video streaming is very good. This is because of the high-speed connection provided from the server. The camera used is a single camera, but it has a limitation that is only able to measure the maximum distance of obstacle as about 4 meters [13,14]. The ability of ESP8266 as a controller for military robot is very excellent. The weakness of the system is that it cannot track the moving object that moves very fast as shown in Table 1.

5. **Conclusions.** In this paper, we propose a model of a military robot using computer vision that can be controlled remotely using Wi-Fi technology from Web application. The

TABLE 1. Experimental results for controlling a robot for distance 60 meters

No	Results from 10 times simulation		
	Action	***Success***	***Not success***
1	Move forward	9	1
2	Move right and left	8	2
3	Stop	8	2
4	Shoot the target	8	2

ability of video streaming and Wi-Fi technology for robot is very good. A military robot is an important tool for combat. Military robots will rapidly become an inherent part of our fighting forces within the next 10-15 years. Future warfare will involve operators and machines, not soldiers shooting at each other on the battlefield. For future work, we will propose a method for shooting a target with more precision and accuracy and using the real gun.

Acknowledgment. This work is supported by Directorate General of Research and Development Strengthening, Indonesian Ministry of Research, Technology, and Higher Education, as a part of Penelitian Dasar Terapan Unggulan Perguruan Tinggi Research Grant to BINUS University titled "Pemodelan Sistem Kendali Robot Tempur dengan Teknologi Wireless dan Computer Vision" (Basic Applied Research grant to BINUS University with titled "Modeling Control Systems for fighter robot with Wireless Technology and Computer Vision") with Contract No. 225/SP2H/LT/DRPM/2019 and 12/AKM/PNT/2019 and Contract Date: 27 March 2019.

REFERENCES

[1] W. Budiharto, Intelligent surveillance robot with obstacle avoidance capabilities using neural network, *Computational Intelligence and Neuroscience*, 2015.
[2] *AI and Military Robot*, https://www.rand.org/blog/2017/09/artificial-intelligence-and-the-military.html, Accessed on 20 November 2020.
[3] J. H. Lee and W. S. Yoo, Velocity decision for unmanned ground vehicle considering road roughness, *Proc. of KSME 2011 Fall Annual Meeting*, 2011.
[4] W.-S. Yoo, D.-H. Cho, J.-H. Lee and K.-C. Yi, Maneuvering speed of an off-road autonomous vehicle, *Proc. of MOVIC*, 2010.
[5] A. Fabijańska and D. Sankowski, Segmentation methods in the selected industrial computer vision application, *Computer Vision in Robotics and Industrial Applications*, pp.23-48, 2014.
[6] S. Bhat and M. Meenakshi, Vision based robotic system for military applications – Design and real time validation, *2014 the 5th International Conference on Signal and Image Processing (ICSIP)*, pp.20-25, 2014.
[7] P. Lin et al., *Autonomous Military Robotics: Risk, Ethics, and Design*, US Department of Navy, Office of Naval Research, 2008.
[8] *Advanced Military Robot*, https://nypost.com/2017/01/29/why-israel-has-the-mosttechnologically-advanced-military-on-earth/, Accessed on 1 August 2020.
[9] W. Budiharto et al., Android based wireless controller for military robot using Bluetooth technology, *2019 the 2nd World Symposium on Communication Engineering (WSCE)*, Nagoya, Japan, 2019.
[10] A. Billard, S. Calinon, R. Dillmann and S. Schaal, Robot programming by demonstration, in *Handbook of Robotics*, B. Siciliano and O. Khatib (eds.), Secaucus, NJ, USA, Springer, 2008.
[11] *Wemos D1 R1 WiFi Controller*, https://www.instructables.com/id/Arduino-WeMos-D1-WiFi-UNO-ESP-8266-IoT-IDE-Compati/, Accessed on 1 August 2020.
[12] *MJPG Streamer*, https://github.com/jacksonliam/mjpg-streamer, Accessed on 10 September 2020.
[13] W. Budiharto, D. Purwanto and A. Jazidie, A robust obstacle avoidance for service robot using Bayesian approach, *International Journal of Advanced Robotic Systems*, vol.8, no.1, pp.37-44, 2011.
[14] *Information about Blynk*, https://blynk.io/en/getting-started, Accessed on 10 September 2020.
[15] T. Arakawa, Trial verification of human reliance on autonomous vehicles from the viewpoint of human factors, *International Journal of Innovative Computing, Information and Control*, vol.14, no.2, pp.491-501, 2018.