DESIGN AN AMPHIBIOUS VEHICLE FOR SEARCH AND RESCUE OPERATIONS

ARAMA VE KURTARMA ÇALIŞMALARI İÇİN BİR AMFİBİ ARAÇ TASARIMI

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ÖZET

Küresel ısınma kaynaklı iklim değişikliği tüm dünyada olduğu gibi ülkemizde de artan doğal afetlerin nedenlerinden biridir. Ülkemiz bulunduğu konum itibari ile deprem, çığ ve sel gibi doğal afetlerin meydana geldiği, ayrıca birçok bölgesinde ulaşım açısından güçlüklerin yaşandığı arazilere sahip bir ülkedir. Deprem sonrası oluşan yıkıntıların derinlerinde bulunan afetzedelerin tespitinin yapılmasında büyük zorluklar yaşanmaktadır. Afet bölgesinde ortam dinlemeleri sırasında ortamın gürültülü olmasından dolayı afetzedelerin seslerinin duyulamaması bir diğer problemdir. Çığ ve sel gibi doğal afetlerde afetzedeleri kurtarmak için afet bölgesine giden kurtarma ekiplerinin sahada olması hayati risk teşkil etmekte ve zaman kaybı oluşabilmektedir. Maden ocaklarında meydana gelen göçüklerde mahsur kalan kazazedelerin tespit edilmesi zor olmakta, bunun yanı sıra ortamdaki zararlı gazların tespitinin yapılamaması kurtarma ekiplerinin ve kazazedelerin sağlığı açısından tehdit oluşturmaktadır. Hendek, mağara ve tünellerde saklanan suç örgütleri elemanlarının tespit edilmeye çalışılması sırasında olası tuzakların kolayca fark edilememesi güvenlik ekiplerimiz için hayati tehlike oluşturmaktadır. Bu sebeple doğal afetlerin yanı sıra askeri operasyonlarda da ilgili bölgeler hakkında detaylı bilgiler toplamak, kurtarma ekiplerinin ve arama-kurtarma hayvanlarının giremediği veya girmelerinin riskli olduğu bölgelerde zamanı iyi değerlendirebilmek için uzaktan kontrollü ya da otonom araçların kullanılması daha uygundur.

Bu çalışmada ilgili ortamlara karadan, su yüzeyinden ve havadan ulaşım sağlanıp ortam bilgilerinin elde edilmesi ihtiyacına cevap verecek uzaktan kontrollü bir amfibi araç tasarımı yapılmıştır.

Anahtar Kelimeler: Çok fonksiyonlu amfibi araç, Kablosuz kontrol, Tasarım

ABSTRACT

Climate change caused by global warming is one of the causes of increasing natural disasters in our country as well as all over the world. Due to its location, our country is a country that has lands where natural disasters such as earthquakes, avalanches, and floods occur, and where difficulties are experienced in terms of transportation in many regions. There are great difficulties in identifying the victims of disasters in the depths of the ruins formed after the earthquake. Another problem is that the voices of the victims cannot be heard due to the noisy environment during listening to the environment in the disaster area. In natural disasters such as avalanches and floods, the presence of the rescue teams on the field to save the disaster victims poses a vital risk and a waste of time may occur. It is difficult to identify the victims trapped in the dents in the mines, and besides, the inability to detect the harmful gases in the environment threatens the health of the rescue teams and the victims. It is a life-threatening situation for our security teams that possible traps cannot be easily detected while trying to identify the members of criminal organizations hiding in trenches, caves, and tunnels. For this reason, it is more convenient to use remote controlled or autonomous vehicles to collect

detailed information about the relevant regions in military operations as well as natural disasters, and to make good use of time in areas where rescue teams and search and rescue animals are not able to enter or are at risk of entering.

In this study, a remote-controlled amphibious vehicle was designed to meet the need to obtain environmental information by providing transportation to the related environments by land, water surface and air.

Keywords: Multi-functional amphibious vehicle, Wireless control, Design

1. INTRODUCTION

Global warming has been associated with many environmental problems, and over the years, there have been a series of natural disasters that affected millions of people and caused billions of dollars in property damage (Tee, 2013). As in the whole world, the unpredictability of what will happen after natural and unnatural disasters in our country causes more loss of life and property. The main reasons for the increase in the number of people killed in disasters are the inability to perform first aid works on time, delays in responding to the situation, or the inability to determine the status of the disaster victims. For this reason, the chance of survival of the survivors is measured in minutes (Akdemir, 2006). The first 48 hours are vital for reaching the survivors after the disaster (Ozen, 2017). In addition to natural disasters, it is necessary to collect detailed information about the region in military operations and to evaluate the time well in areas where people and animals cannot enter or where it is risky to enter. Modern technologies aim to provide a safer and more comfortable life for people. Studies on this subject are generally on remote controlled or autonomous vehicles (Karatay, 2020 and Jiko et al., 2016). In (Akdemir, 2006), the mechanical design of the mobile robot vehicle was made to be used in search and rescue activities after the earthquake. In (Najeebullah et al., 2018), a long-range quadcopter using a 4G network was designed and controlled. In (Tee et.al, 2010), an autonomous amphibious vehicle is designed for use in support and rescue operations on land and in water. An unmanned amphibious vehicle integrating the features of a multi-rotor UAV and a hovercraft was developed in (Esakki et al., 2018). In another study, an autonomous amphibious vehicle capable of navigating rough terrain and underwater was designed (Boxerbaum et al, 2005).

In this study, a wireless controlled amphibious vehicle (M+RT1) that can move on land, air and water surface is designed. With M+RT1, it will be possible to access the disaster area or scene from land, air or water surface and can be used by search and rescue and security personnel in required environments.

2. RESEARCH AND FINDINGS

2.1. The Design of The Vehicle

The M+RT1 is designed to operate in three different operating modes: land mode, water mode, and air mode. The body has dimensions of approximately 500x600x430 mm (width/length/height) together with the pallets. The design stages of M+RT1 are shown in Figure 1.

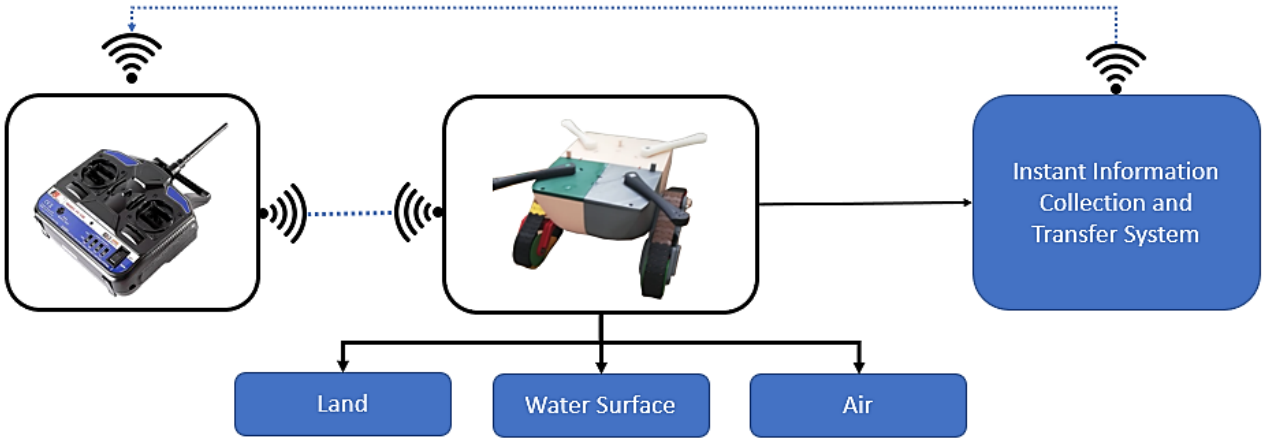

Figure 1. The design stages of the M+RT1.

With different operating modes, it will be possible to access the disaster area or scene from land, air, or water surface, environmental images can be taken with the cameras on the vehicle, location coordinates can be determined with the GPS module, and toxic and flammable gases that pose danger in the environment can be detected with sensors. In addition, useful products such as medicine and water can be transported to disaster victims and survivors with a load-carrying unit that can be added to it when necessary. Figure 2 shows the environments in which M+RT1 can be used and its general operating principle.

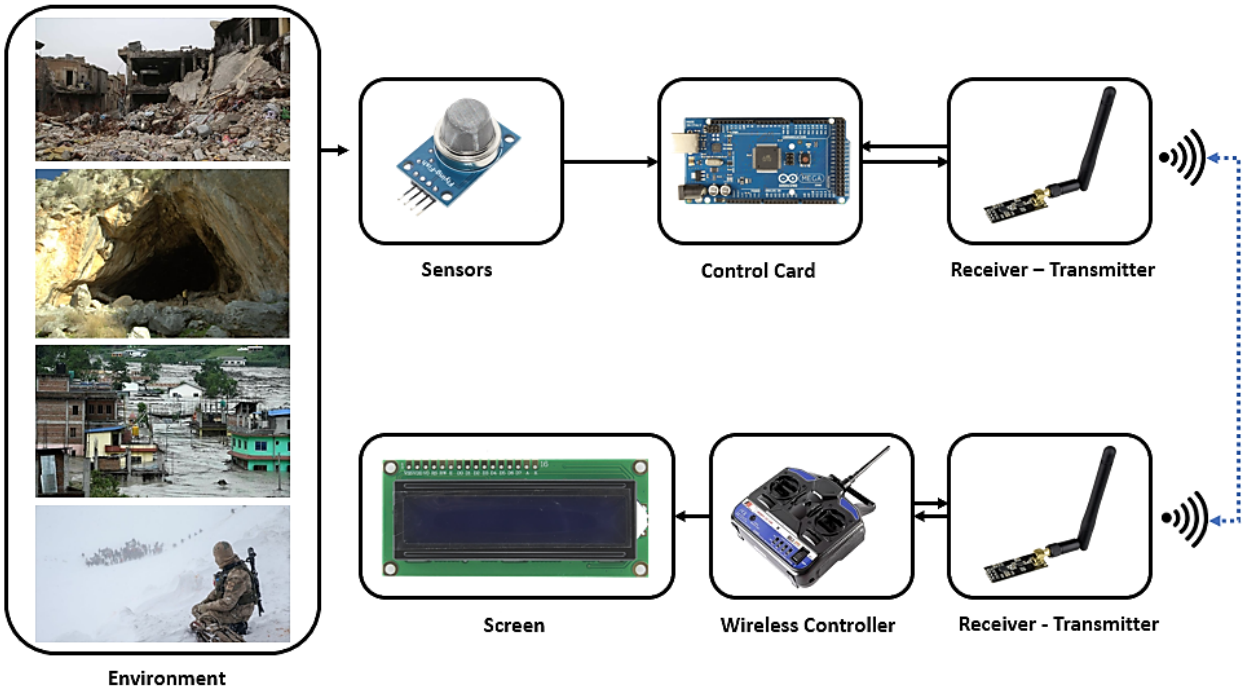

Figure 2. Working environments and working principle of M+RT1.

The operating modes and subunits of M+RT1 are shown in Figure 3.

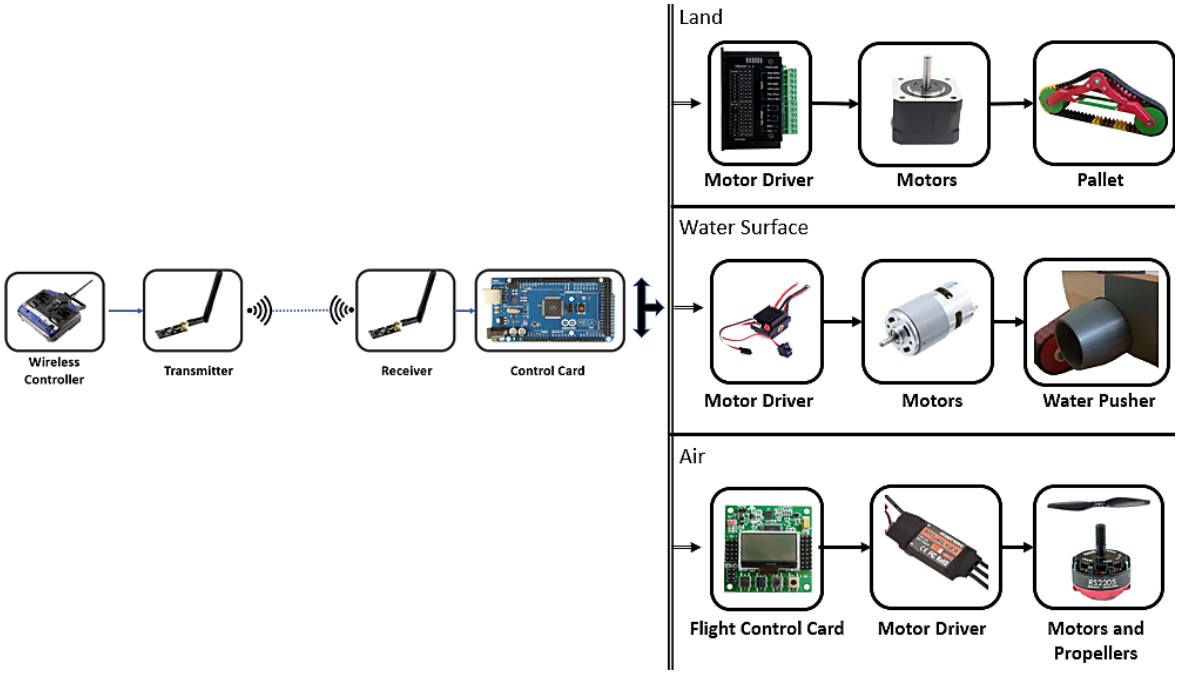

Figure 3. The Operating modes and subunits of M+RT1.

The M+RT1 control system consists of five main parts: land movement system, water surface movement system, air movement system, and instant information collection and transmission system.

2.1.1. Control System

Using the radio frequency (RF) wireless communication method with the control system, it is possible to select one of the vehicle's land, water surface, and air operating modes, to control the movements of the vehicle, to switch between the cameras on the vehicle and to change the viewpoints of the cameras. In addition to these, the location and ambient gas information obtained from the sensors on the vehicle, as well as the images and battery status information obtained from the cameras are sent to the control operator. SolidWorks was used in the mechanical design of the controller and Proteus was used in the electronic circuit design. Commands given by the operator with joystick, buttons, and switches are converted into electrical signals. These signals are processed in the control card and transferred to the vehicle via the Nrfl2401 radio frequency (RF) transmitter module. Figure 4 shows the block diagram of the vehicle's control system, and Figure 5 shows the designed wireless controller.

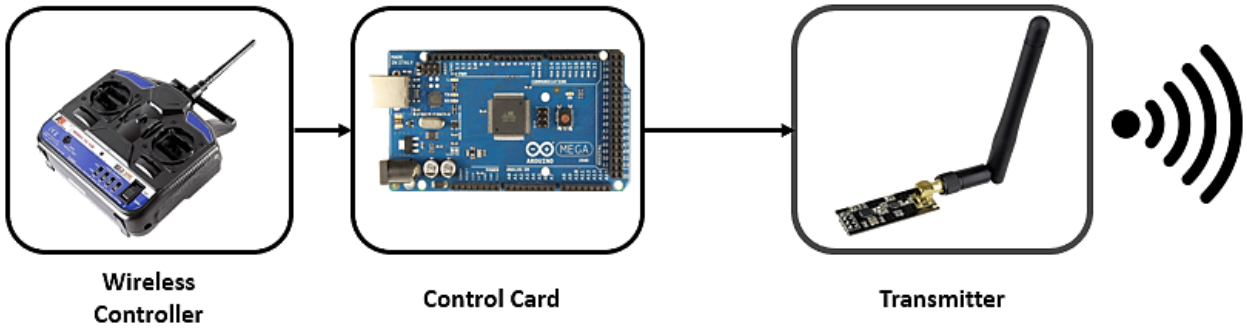

Figure 4. Control System

Figure 5. The designed wireless controller.

2.1.2. Land Movement System

A track system has been preferred to easily overcome the obstacles that the vehicle will encounter in the field while ensuring its terrestrial movement. The weight of the vehicle is approximately 8 kg. For vehicle movement, the pallet force must be greater than the friction force created by the weight. To achieve this, two permanent magnet synchronous motors (PMSM) are used. The pallet system works by transferring the commands sent by the Arduino Mega control card to the motors via the electronic speed control circuit. With the rotation of the motors, the track chain is rotated over the helical gears and the vehicle's land movement is provided.

2.1.3. Water Surface Movement System

The commands sent from the controller are processed with the control card, and the propeller is rotated by the direct current (DC) motor that provides the water surface movement. In addition, the movement of the rudder is provided by the DC servo motor, and the vehicle's direction is changed on the water surface.

2.1.4. Air Movement System

The drone system is designed to provide aerial access to environments that cannot be reached by land or water surface. For the vehicle to take off, eight brushless drone motors are placed on the top cover to form an equilateral octagon. The reason why the engines are placed in this way is that the thrust generated by the engines while rotating is evenly distributed around the vehicle. Four motors are positioned to rotate clockwise, and the other four motors are positioned to rotate counterclockwise to reset the torques to be generated by the motors according to their direction of rotation. The motors provide synchronous air movement with the KK2.15 flight control board.

2.1.5. Instant Information Collection and Transfer System

Sensors are used in environments where instant information needs to be collected and transferred. After the location coordinates of the vehicle are detected by the GPS module and the harmful gases in the environment by the gas sensors, they are sent to the control card and then to the operator wirelessly. Images are transferred to the LCD screen on the remote control instantly with two cameras on the vehicle. The cameras in the vehicle have 180-degree rotation angles in the horizontal and vertical planes. With the commands given by the operator, the cameras can be brought to the desired viewing angle. The information gathering and transfer unit of the vehicle is shown in Figure 6.

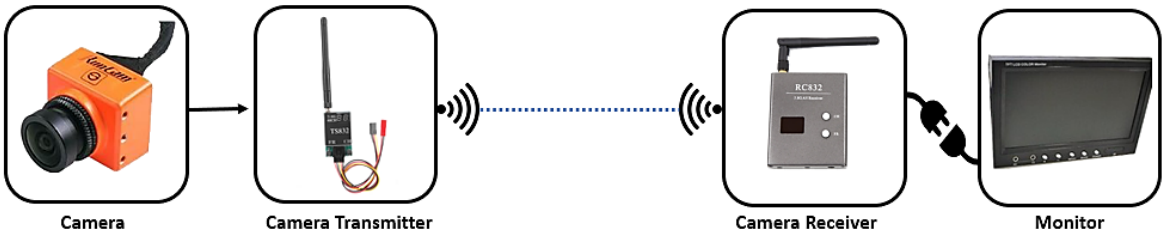

Figure 6. Instant information collection and transfer system.

The designed and manufactured M+RT1 is shown in Figure 7.

Figure 7. The designed and manufactured M+RT1.

3. CONCLUSION

In this study, the design and manufacture of the vehicle named M+RT1, which can move on land, water surface, and in the air, and the remote used to control the vehicle wirelessly were carried out. Hybrid motion combined within a single vehicle has enabled the vehicle to perform complex tasks in a variety of environments. The software of the control unit of the designed vehicle and the design and software of the control system have been prepared uniquely to control the operating modes of the vehicle and to add new features in the R&D process.

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