Coupler for a Hybrid Prototype Applied to Civil and Environmental Protection and Further Space Exploration Missions

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Abstract— This paper presents the design and development of a coupler to mount a drone over a rover. The main applications will be civil and environmental protection purposes and further space exploration missions. The coupler device was made using a permanent electromagnet. For the first approach, the rover and drone were previously acquired. An Arduino, motion, distance and infrared sensors were used to control de mechanism. Field tests have sucefully done, the the drone was couplered to the rover until the coupler was activated, after this the rover and the drone continue with their specific task. This is the first stage of a bigger project where is planned to build, from ground zero, the rover and the drone.

Index Terms— Coupler, Civil Protection, Drone, Enviormental Protection, Permanent Electromagnet (PEM), Rover, Space Exploration,

1 Introduction

A drone could bring first aid in case of a disaster by bringing medicines, also by having a better view from the sky it is possible identify in problems (Ollero et al. 2005). Morover, these aircrafts, are jus starting in the space exploration field because they are good opportunities to do mesuarments from different altitudes, to take pictures from a better view and to show that an aircraft can fligh in another planet. A clear example of this is the Mars 2020 mission where it is expetd to have a drone (Figure 1).

Fig 1. Artistic design of helicopter expected to be launched in the Mars 2020 mission. Taken from Volpe (2014).

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Rovers, can have a land view and they can go through places that cannot be reached with conventional tools. For example, some rovers have used to disarm explosives helping to do not put in risk people lives (Figure 2). Additionally, rovers have been used in many space explorations missions and there are new desings constantly that can work in other planets or moons (Wattergreen et al. 2010).

Fig 2. Rover used by the National Guard in United States. Taken from Martinic (2014).

Another application has been using a robotic platform with a drone for a volcanic and industrial surveillance (Longo et al., 2007). They used the terrestrial robotic station to take measurements near a volcanic zone in Sicily. The idea is to use the drone to have a better view from the sky in case of a disaster and use the terrestrial robot to take data that could help the authorities (Figure 3). In this example, we have to say that the drone and

the rover are not joined.

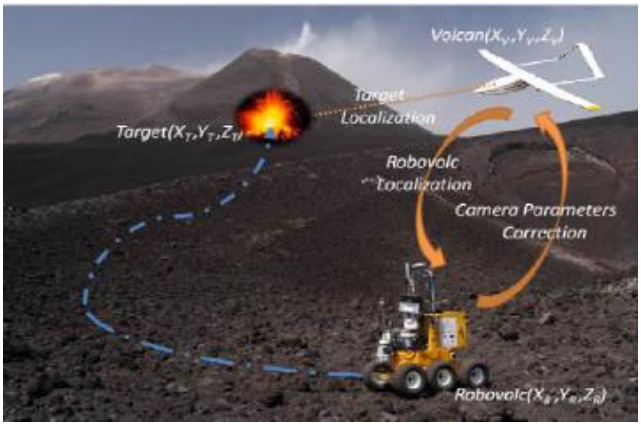

Fig 3 The image shows the terrestrial robot and the drone in an example of a volcanic area. Taken from Longo, Melita, Muscato & Sessa (2007)

The motivation for this work is the fact that our first coupler prototype can be added to a rover and a drone and it will have the ability to help during civil protection activities and ecological disasters. Additionally, it could be used for further space exploration missions as flying a drone on Mars and landing it over the exploration rover. If we can send the rover to a mission and it has a drone over it, we can save the battery of the drone and we can land it in a place we know. Nevertheless, there is not a hybrid prototype between a rover and a drone. Because of this, we are doing the first stage by developing a coupler to join them. The mechanism to join the rover and drone was to use a Permanent Electromagnet (PEM), which has already a magnetic field and once an electric current is activated, it generates a magnetic field of the same intensity but in opposite direction, cancelling the original magnetic field. For the first prototype the rover system was controlled by an Ardunio. There are many rovers that work with a Raspberry Pi and have their own robotic arms (Szabo, 2018), showing that we can control it with this kind of programming board, rovers.

METHODOLOGY

The purpose was to develop a coupler so, the rover and the drone were previously acquired. The rover and drone models are KOOKYE Robot Tank Car and an Aerodrone X6 Quadcopter respectivately.

Firstly, we tested and learned the mechanism of the rover and then, we made some changes in the structure and software. All the the electronic components were removed from the top to the bottom of the tank chassis. Next, the ultrasonic sensor and the servomotor were mounted on the trunk. These changes were made due to the fact that we installed the coupler on the top chassis. The rover and the sensors were connectd to two batteries model 18650, which give 7.4V in total. The energy was distributed to the sensors thanks to an Arduino board where the programas was previously uploaded.

Secondly, the circuit was created by using PEM with a lengt and an outer diameter of 12mm. According with the fabricant, the PEM has a holding force of 67lbs and it works with 12V, for this reason it has to be used a voltage-voltage converter which allows an increament in the voltage of the system (Figure 4). We designed a PEM container which was installed in the top chasis of the rover (Figure 5).

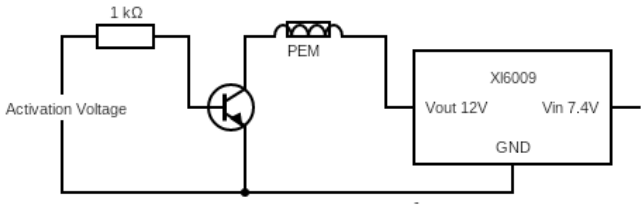

Fig 4. Circuit developed for the PEM

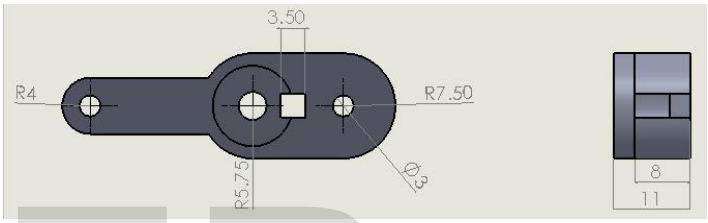

Fig 5. 3D design of the printed PEM base which was printed with a 3D FLsun priter model FLsun T plus. Meassurements in millimeters

For the third point, we added a metal stick in the drone to do the test and join the drone with the magnet.

Finally, the Arduino code used is summarized in the next flowchart (Figure 6). A remote control was used to command the orders to the systems. Number 7 was used to turn on the PEM and number 9 to turn it off. All the others numbers were used to activate the others sensors.

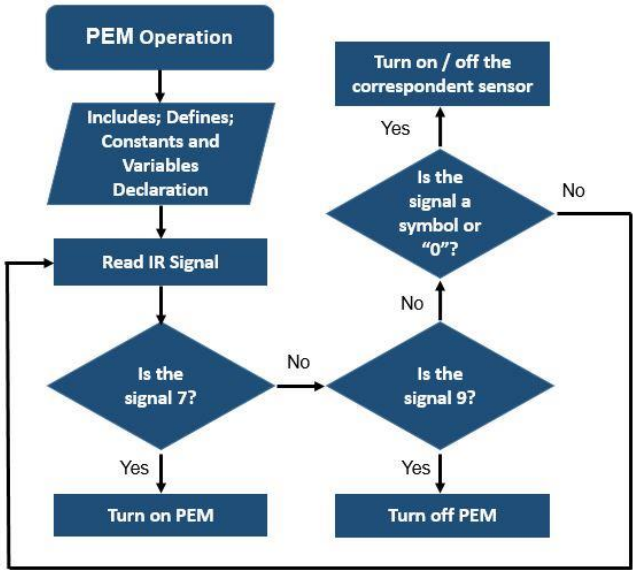

Fig 6. The next flowchart summarizes the code to activate the PEM

3 RESULTS

After the installation of the components test were done successfully. Figure 7 shows the drone and the rover in the campus garden ready for the test. However, due to the fact that the drone is not a professional aircraft, there was not enough control to land it over the rover. As a consequence, we opted to mount the drone over the rover and we tried to flight it, as we expected, it did not fly unitl the PEM was turned on. Figure 8 shows the drone taking off from the rover once the PEM was turned on. The coupler is placed just in the center of the top chasis of the rover.

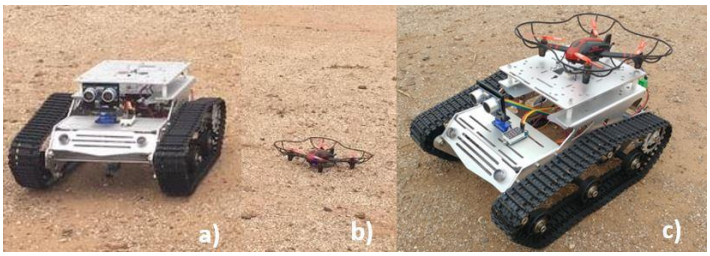

Fig 7. a) Robot Tank Car b) AeroDrone X6 c) Rover and drone coupled and ready for deployment

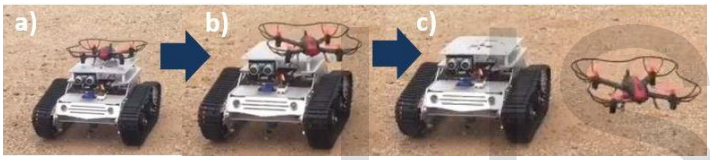

Fig. 8: Coupler test done at the campus garden a) Shows the drone coupled with the rover, here the drone was turned on b) The flight of the drone started once the PEM was turned on c) Shows the drone flying away from the rover

4 DISCUSSION

As it can be seen, the prototype worked satisfactorily. At the beginning of this research we wanted to use a mechanical coupler for our purpose. However, at the end, it was decided to use a PEM to achieve our goal because, the PEM can take in an easier way the drone. If we used a mechanical coupler it could be difficult to land the drone on the rover, specially if the drone has not stability. Using the PEM, we assure the proper land and take off of the drone. The magnetic field pulled the drone base and once it happened, we disconnected the motors of the aircraft (Figure 6). If we wanted to use the drone again, we turned on the magnet just for some seconds.

The problem with the PEM was the battery. To solve this a voltage-voltage convertor was added. From the 7.4V that had our power source, we connected the converter and obtained 12V. We also added a transistor to turn on and turn off the coupler.

The main difficulties during the test were the drone and the rover control. First, the drone used is not a professional aircraft. It means that our drone does not have the stability in air to do our test so, we had a problem piloting the drone. Second, we had one remote control for the drone and another for the rover. This has to be solved so, we will need to configure only a remote control for the whole prototype. For this, we have to add only a channel of communications between the drone and the rover, (Pace, Aloi & Fortino, 2015). Fortunately, our principal goal was not to control the rover and the drone, it was developing the coupler device.

As it was mentioned, this work could be used in civil and enviormental protection where a drone and a rover are required. The work presented by Longo et al. (2007) is a clear example of this. They used a drone to have a better view from the sky and a terrestrial rover to do mesuarments however, if both systems worked together the efficiency could be better, the drone could take off from the rover and save battery. Under other circumstancies, if a helicopter (drone) is sent to Mars an efficiency way to maintain the aircraft on the lander or rover is with a PEM. This could help during meteorologic problems such as sandstorms.

5 CONCLUSION

As we mentioned, there are similar projects, however, there is not only any other hybrid prototype that joins a drone and a rover. Fortunately, we had success in our first goal of joining a drone and a rover by a coupling device. As we mentioned the main problem was the battery, this was solved by adding a voltage-voltage converter.

Another problem was that the drone is not a professional aircraft, for these reasons we did not have to much control over the drone, it was decided to mount the drone over the rover and try to flight it. As the coupler was turned off the drone could not flight, once the magnet was turned on the drone started to fly. This proved that the PEM was enough to maintain the aircraft mounted on the rover. If we want to test a bigger drone, we will need a stronger magnet.

Probably a mechanical coupler can be used to hold the drone over the rover, however we suggest a PEM is a better option. First, it can take the drone in a more comfortable way. Second, it can work with any drone because it is not required to have a specific design of the coupler for each drone. And finally, it only uses energy when the coupler is turned on for a quick moment.

We hope this idea can be used in civil protection activities saving lives by taking the first images in a natural disaster or by taking the first aid kits to people who need it. Also, the idea of the coupler can be used in further space missions that could explore our solar system during the next few years.

6 FUTURE WORK

The work presented is just the first stage of a future project. The next goal is to test some sensors and have a general idea of what kind of limitations we will have. In the future, we want to develop, from ground zero, a rover and a drone that

could be used underwater. The purpose will be the same, civil and environment protection with future space application.

On the other hand, we want to create our hybrid drone it means, that the rover and the drone have to work underwater. There are similar researches with a rover by using a Raspberry Pi that works underwater (Kumar, A. et al. 2018). Also, we need to add only one way of communication for all the devices.

7 ACKNOWLEDGMENTS

We would like to thank all the people involved into the development of this project, particularly to B.E. Alexis Otero for his support to machining the rover chasis, B.E. Carlos Valenzuela for the logistics to obtain the PEM and M.E. César Díaz for let us use his personal 3D printer.

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