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DEVELOPMENT OF ANTI-PERSONAL LANDMINES DETECTING AND DE-MINING VEHICLE

Katsuhiko Shimizu, Ken Ichiryu, Hiroshi Katakura
Tokyo University of Technology
Hachiouji City, Tokyo, Japan

ABSTRACT

Although we are in the 21st century, landmines still threat innocent people, regardless age, sex, or race. This project is about building a robot that seeks and destroys anti-personal landmines. The robot is a four-wheel vehicle that uses a metal detector for the detection of landmines, and an impulse gun to remove landmines and destroy them.

1. INTRODUCTION

At present time, there are more that 110 million landmines buried all around the world. Most of these buried landmines are civil war leftovers. Due to these leftovers 26,000 peoples are got maimed or killed each year, 80% of them are civilians. In Cambodia, landmines are buried in villages and agricultural areas, which causes difficulties in their living and economics. These landmine fields obstruct the people from evolution and development.

Specialists, known as de-miners, who detect, dig, and defuse landmines, do the whole process using their bare hands. These de-miners face serious danger that threats their lives. These days, de-mining robots are being developed by Universities and corporations. Those robots could move and detect landmines, landmine removal and defusing action are done by man. This point is a serious issue. So, in this project the purpose is to build a robot that detects, removes and defuses landmines consistently. In this paper, we will explain the principles of the field robot and the de-mining process.

2. THEORY

2.1 Detecting and De-mining Method

According to the environment and the geographical features, anti-personnel landmines are very hard to locate position without using sensors such as metals detectors or Ground Penetration Radar (GPR). As for the de-mining process, these landmines that are covered with soil, that need to be removed carefully. However, the whole landmine removing and defusing process are done by man's hand. That causes a big risk to their lives. Therefore, in this project, metallic detector is used for the landmine detecting, and an impulse gun is used to blow the soil away from above the landmines, and used again to destroy them. With these 6steps, landmine detecting and defusing process are done. It is shown in the following section.

2.2 Detecting-De-mining procedure

1. The robot is sent to the landmine field.
2. The field will be detected by the metallic sensor.
3. If a metallic object is found, the area will be marked with spray or paint.
4. Topsoil around the metallic object will be blown off with the impulse gun.
5. Existence of mines or landmine types shall be confirmed with an installed camera.
6. After it is confirmed that the object is a landmine, the robot aims the impulse gun toward the landmine and defuse it. (Figure 1)

2.3 Topsoil Dispersion

When a water jet hits a solid object on its surface with an almost a right angles, this collision is called IMPINGING JET. There are three regions: FREE JET REGION, IMPINGEMENT REGION, and WALL JET REGION, because of the displacement region from the free jet region to wall jet region, the direction of the flow will suddenly change. Therefore a big pressure slope

occurs along with the jet stream axis and the jet stream. Then the surface of the wall pressure becomes as the maximum stagnation point.

After the detection and paint marking on the target TOPSOIL DISPERSION process will be held. Safe distance is taken in consideration of the safety to avoid explosions. Moreover, by using a convergence nozzle, diffusion of a jet stream is suppressed to the minimum, and the topsoil will be blown away from the landmine.

2.4 Landmine Defusing

If you had a look at landmine structure, you will find that there is a pressure plate, a firing pin and a fuse in the donator, and about 300g of TNT. It explodes when a pressure is added on top of the landmine, as the pressure is added the firing pin is forced into the fuse. By this contact a small sparkle fires the donator, and that helps the TNT to explode. And that leads to a blast and flying fragments that injures and maim people. Blocking the firing pin from the fuse turns a landmine into a harmless case. This process is called DEFUSING. So the principle in this project is to hit the firing point and destroy it, without adding any upper force on the landmine.

3. DETECTING AND DE-MINING VEHICLE

3.1 Vehicle

In our project, detecting and de-mining vehicle, a high performance de-mining robot is in needed. The needed features are as the following:

1. A compact body, which enables it to pass through trees and narrow places.
2. A vehicle that runs in all terrains, all types of geographical features.
3. A strong body that enables it to endure the landmine blasts and fragments.
4. A highly trusted metallic detector.

With these features, De-mining process could be possible. The external appearance of the vehicle is shown in Figure 2.

This vehicle has four rubber crawlers that enable it to maintain its stability while at work. At work, front wheel and rear wheel could be steered in same direction and same angle. Therefore, without changing the vehicle’s direction, de-mining process becomes easier, and that leads us to save a lot of time. With a unique steering mechanism (4wheel drive, 4 wheel steer) steering 30 degrees to the left and 90 degree to the right are possible. By steering front wheels and rear wheels the opposite sides, the vehicle can turn in a small circle. And while both, front and rear wheels are steered 90 degrees the vehicle can move side ways, therefore a wide working space is not necessary, and it will save us a lot of time. The steering mechanism is powered by 2 hydraulic cylinders (Figure 3).

According to a closed loop hydraulic circuit, the four crawlers are powered by a pump motor through HST (Hydro-Static Transmission). The vehicle’s specifications are shown in table 1.

3.2 Detecting Mechanism

Metallic detector and Ground Penetration Radar (GPR) are 2 sensing devices that could be installed in vehicle. However, GPR radars are very heavy and highly expensive. During detecting process GRP radar must be close to earth as much as possible, and that is a great risk in case of impact. Metallic detector is easy to manage, and could detect from a distance without getting in contact with the ground.

In this project we are using an Australian metallic detector, F1A4, the best in landmine detecting field. This metal detector is able to detect the small firing pins of the landmines. However, the firing pin is the only metallic thing in an Anti Personal landmine. This metallic detector is installed in an arm robot, with a mechanism that enables it to rotate 180 degree to cover the vehicle's front

3.3 De-mining Mechanism

IFEX (Impulse Fire Extinguishing Technology) Impulse gun is used by fire fighter to put out fires. With a very little amount of water and high air the impulse gun could put out large fires. It is possible to inject 1 liter of water by using 2.5 Mega Pascal of compressed air with a speed of 120 meters per second. Instead of water we could inject sand, mud, and solid objects.

In this project, we examined water for topsoil dispersion experiments, and used sand, plastic, and heavy metallic things in landmine defusing experiments.

4. EXPERIMENT

4.1 Experiment Method

Topsoil dispersion was examined by measuring the impact force of the jet water triggered by the impulse gun. The experiment distance was from 0 meter up to 5 meters. And to blow the topsoil away from the landmine, 100 Newton or less is the best force the landmine could obtain without getting explode. Two nozzles were tried in the experiment, one with a diameter of 20 mm and the other with a diameter of 10 mm.

4.2 Experiment Results

The result of the impact force at intervals from 0.5 meters to 5 meters is shown in Figure 4. With a distance of 1 meter the impact force is about 2000 Newton, but if the distance between the target and the impulse gun gets bigger a phenomenon is occurred, Diffusion Loss Phenomenon.
Impact phenomenon of maximum distance between the gun and the target is shown in Figure 5. The force of the impact gets weaker as the distance gets bigger.

In this experiment, the impulse gun was equipped with a diameter of 20 mm nozzle. The phenomenon occurred is as shown in Figure 6, while shooting at 100 mm diameter steel yellow

can. The water amount was about 1.3 L, and the distance was 3 meters away from the target. The topsoil surrounding the target was washed away and the target appeared.

5. CONCLUSION

As a result, by installing both a metal detector robotic arm and an impulse gun into the vehicle, it will reduce the amount of victims, due to the hand work. Comparing to the hand work, usually it takes about 1 hour to defuse a landmine. The de-mining vehicle is expected to take 10 minutes per mine with a better efficiency.

And the experiment of topsoil dispersion occurred by the impulse gun was a success. And in the future we will build the armour vehicle and equip it with detector and the impulse gun as shown (Figure 7).

6. REFERENCES

This research is partially supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology, Grant-in Aid for Scientific Research, 15510141, 2003-2006.

7. REFERENCES

R.D.Fossey, D.A.Summers etc: Improvements in a multi-use waterjet tool for humanitarian demining, 2003 WJTA Aug.2003 (Houston Texas).

Table 1. Vehicle's specifications

Engine	Form	Made by ISM Co.N843L-SH5	
	Engine displacement	1662 cc	
Full length		2680 mm	
Span		1511 mm	
Total height		1800 mm	
Tare		1980 mm	
Tread		1341 mm	
Weight of the body		1000 kg	
weight of rubber crawler (Four)		280 kg	
Vehicle gross weigh		1430 kg	
Maximum steering angle	Of the running	Right direction	30 deg
		Left direction	30 deg
	Of work	Right direction	90 deg
		Left direction	30 deg
Full speed	3.3 km/h		
Gear method	HST(Hydro-Static Transmission)		
Drive method	4WD (Back and forth independence system)		
Steering method	4WS(Personal mechanism by a parallel crank)		
Suspension	None		
Wheel	Rubber crawler		

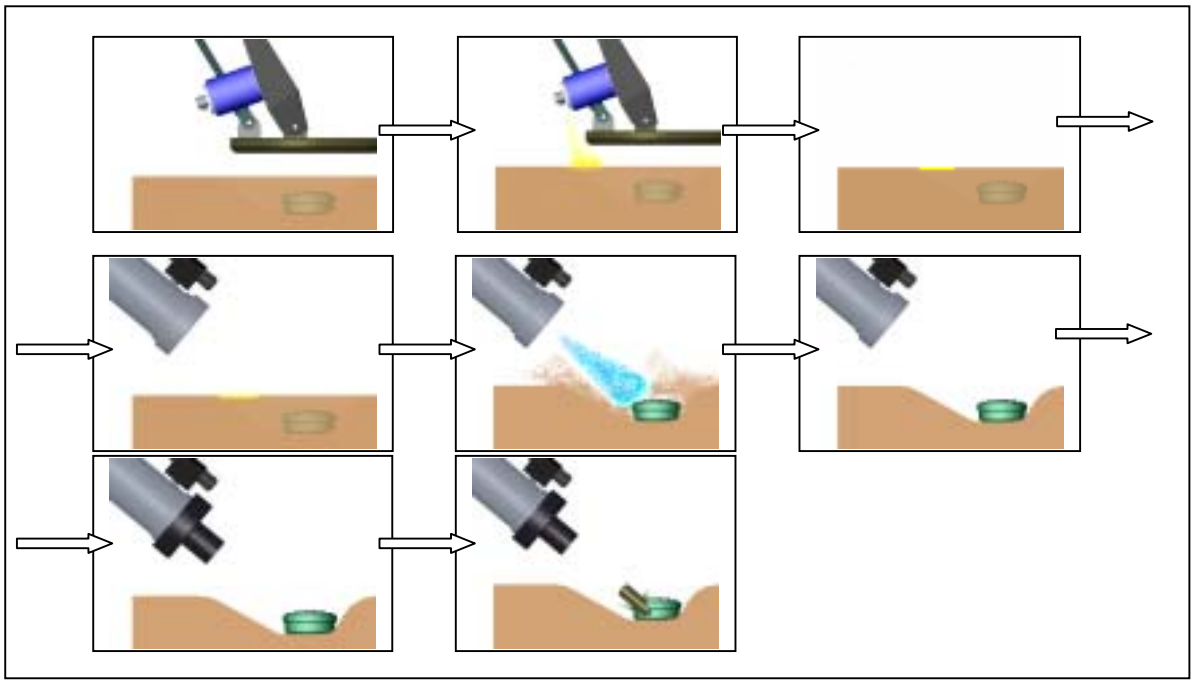

Figure 1. De-mining Process

Figure 2. External figure

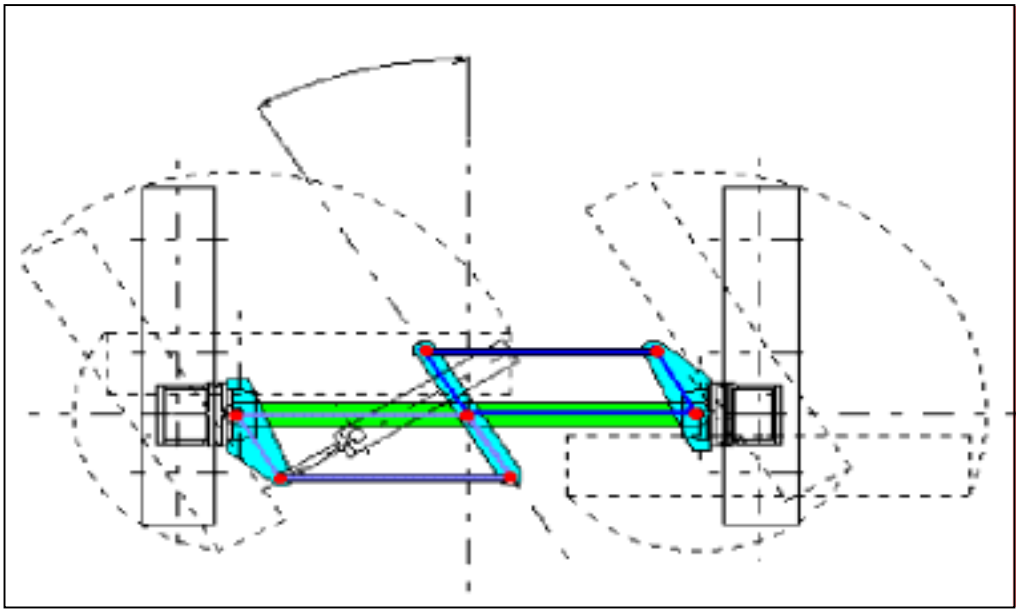

Figure 3. Steering mechanism

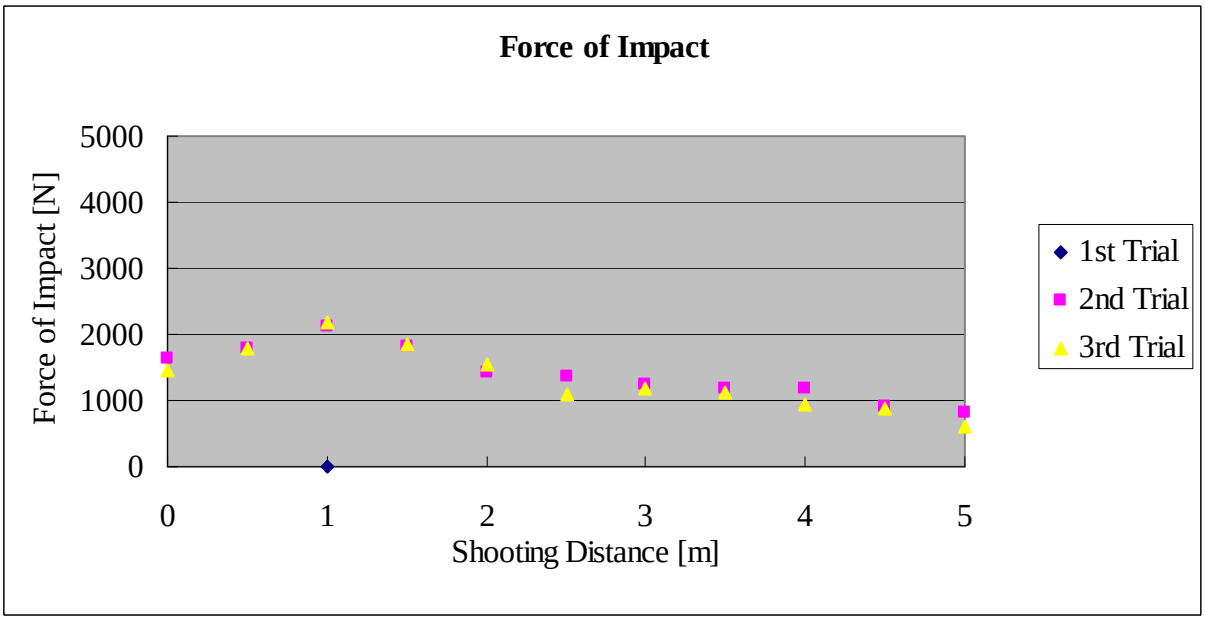

Figure 4. Impact force result graph

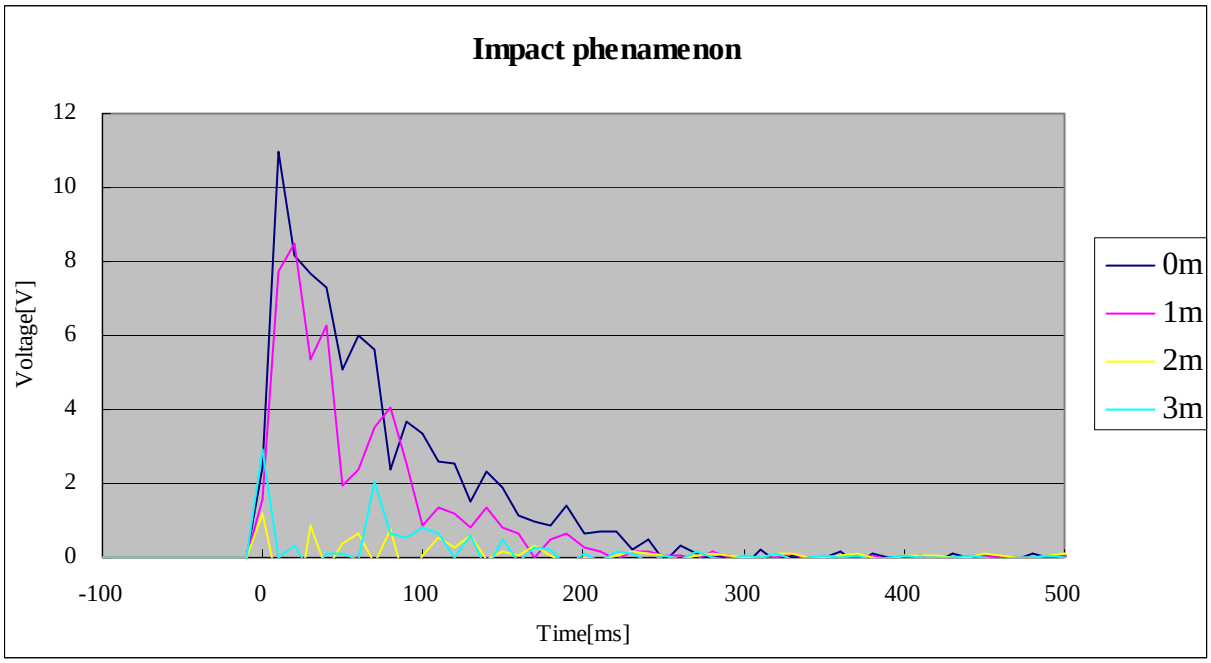

Figure 5. Impulse force wave graph

Figure 6. Topsoil dispersion

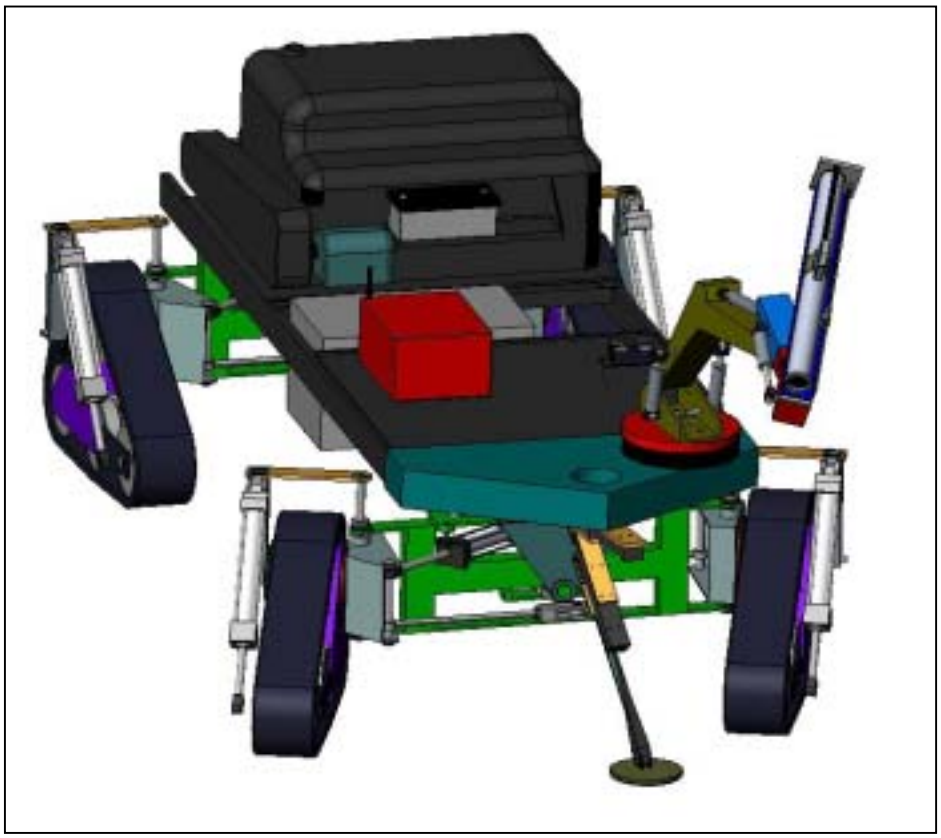

Figure 7. Detecting/De-mining vehicle