

Auto-generate Landmine Path, Digitize and Visualize the Data for the Sri Lankan Context

DMIM Nadeesha#, RGUI Meththananda, and R Vandebona

Department of Spatial Sciences, Faculty of Built Environment and Spatial Sciences, Southern Campus (KDU), Sooriyawewa, Sri Lanka

<34-sursc-5308@kdu.ac.lk>

Abstract: Landmines could be identified as affordable and effective defensive weapon, but it has many complexities. Human deaths and injuries, agricultural land degradation, destruction to infrastructure, environmental destruction, economic cost for demining humanitarian aid and etc. Those complexities cause due to the unconventional landmine fields which could be find it difficult to demine. To avoid that, landmines had to be laid according to universally accepted methods in a standard pattern. As per the International agreements, Sri Lankan security forces also follow the standards in warfare. But their data recording mechanism is manual and not efficient. The objective of this study is to introduce a new system to record positions of landmine data in digital format. The design of this research was accomplished in three stages, identification of current practice of data recording, develop the computer program to generate locations of landmines and data visualization and analysis using the result of the computer program. Therefore, through reviewing existing mechanism, lapses of existing system could be identified. By developing a computer program we could be able to auto-generate locations of each landmine on a landmine pattern by two initial inputs. Matlab has been used to develop the program which is a very powerful platform. Qgis is a highly demanded spatial data manipulating system, which is utilized in the visualization and analysis of data. The proposed system will be more convenient, efficient, effective, and accurate system that will avoid the malpractices of recording landmines.

Keywords: Landmine, Location, MATLAB, Minefield, QGIS

Introduction

Sri Lanka is one of the most strategically prominent states in the Indian Ocean region. From the past, Sri Lanka has been under many invasions. Sri Lankan Civil War could be taken as the latest example (1983 to 2009).

Sri Lankan security forces used many strategies to face and overcome this civil war. One of that is laying landmines. Sri Lankan Security Forces have not used them as an offensive weapon, but purely as a defensive measure. According to the UN, Sri Lankan Security Forces have laid protective minefields to prevent the terrorists from reoccupying rescued areas. These minefields are laid in keeping with universally accepted standards of laying to a specific pattern, following proper marking and recording procedures (Strategy For Mine Action Sri Lanka, 2006).

According to International Mine Action Standards (IMAS), a landmine is a 'munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or a vehicle'(Zucchetti et al., 2017). Fundamentally, these Landmines can be categorized as Anti-personal landmines (AP) and Anti-tank (AT) landmines which are intended to defeat people and armoured tanks or vehicles respectively.

Since landmines are cheap and effective weapon there are many complexities of landmines. Human deaths and injuries, agricultural land degradation, destruction to infrastructure, environmental destruction, Medical and rehabilitation services exhaustion, economic cost for demining

humanitarian aid, etc. (Strategy For Mine Action Sri Lanka, 2006).

Furthermore, many countries are suffering because of unexploded and unconventional landmines laid in past wars since the World Wars. There are more, approximately 60 countries no longer involved in wars, but suffering due to over 60 million unexploded landmines which cause up to 25000 deaths/injuries per year (Kraenzle, 2000). Also, according to UNICEF there are exploded landmines more than 1 million by damging people since 1975, and are currently thought to be killing nearly 800 people per month around 64 countries. There are estimated 110 million landmines still lodged in the ground. They remain active for many decades since 1975. (The legacy of land-mines, 2020).

That is a considerable fact that effects human life, their activities, and the development of the countries. Many of these cases become complicated because of unconventional data, loss of data, less accurate data as well as failures of proper marking when landmines are being laid. Sri Lanka also faced this case and there were 593 civilian injuries reported due to landmines within four years of time after the war. Those were happened because of landmine fields laid by LTTE which were unconventional. So, it has been taken a long time to clear landmines in Sri Lanka. (Strategy For Mine Action Sri Lanka, 2006).

Sri Lankan Security Forces are laying landmines according to the universally accepted standards. Yet, all the data manipulation and recording of laying landmines are being conducted manually. Thus, the data about laid landmines are recorded in a record sheet (a paper) and a sketch of graphs in papers manually. Also, the practice is to measure the location coordinates of some important points (Starting point, turning points, and end point) of the minefield by using handheld GPS. Those coordinates might not be accurate. This manual procedure

would be lead to unnecessary time consumption, recording less accurate data, and less afford. This recording procedure should be computerized and get use them efficiently by using positioning and mapping techniques in the surveying profession.

By developing a new system it would be able to record data accurately. The system consists of a computer program that could be able to extract the locations (coordinates) of landmines. The computer program has been developed by using 'Matlab' software and the results (coordinates of each landmine of the landmine path) can be store as digital version of documents as 'Ms Excel' sheets which are easier to manage, more efficiently, and more secured. Those coordinates can be used to develop mine maps. It is very efficient and accurate to develop maps by using those coordinates with a geospatial data management platform as Qgis.

Those maps could be very useful within the military operations as well as more efficient when performing the demining process. Also, those maps could be developed as conventional maps that show the areas with landmines by conventional signs, mine danger maps, and any other map according to a relevant operational purpose. Further the damage of each landmine in the minefield can be analyzed and visualized by using the Qgis software framework. Those data also could be visualized and analyzed by the backgrounds of web based maps.

Background Details

In this research, we consider one method which has been universally accepted by the UN. That is the strip method which is one of the most common and accurate universally accepted patterns used by Sri Lankan security forces. In strip method, there are relevant distances to maintain with each landmine and landmines are laying in two parallel lines separated by the baseline. There are four types of strip patterns are existing as Anti-

personal, Anti-tank, fragmentation, and mixed. This system is developed for Anti-personal, Anti-tank, and fragmentation patterns.

In the current process the GPS coordinates of the starting point, ending point and turning points of a mine field is recorded by using the handheld GPS with the other details such as the number of landmines, their type, special landmarks etc. Thus their accuracy is not as efficient as the survey-grade GPS.

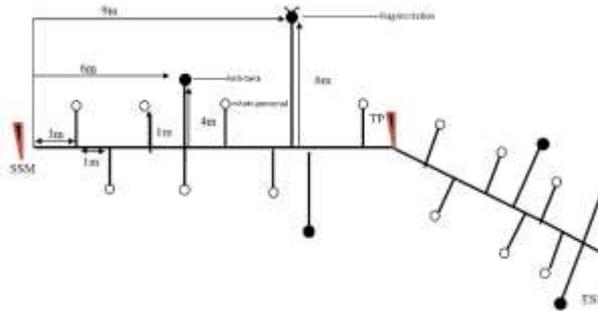


Figure 1. Strip pattern mixed landmine path

Source: Constructed by Researcher (2020)

As per Figure 1, there are standard relevant distances for each type of landmine and relevant gaps. Figure 1 shows the strip method with mixed landmine pattern. When it comes to the individual type of landmine pattern as Anti-personal, Anti-tank, and fragmentation the same distances are being maintained as per Figure 2. Figure 2 shows an example for Anti -personal type in strip pattern.

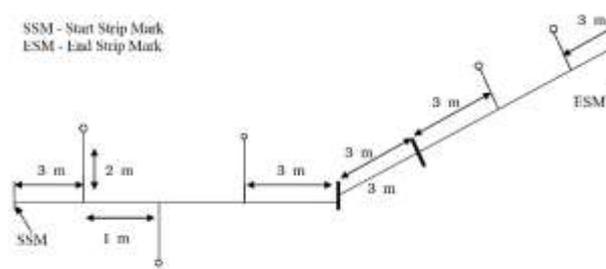


Figure 2. Strip pattern Anti-personal landmine path

Source: Constructed by Researcher (2020)

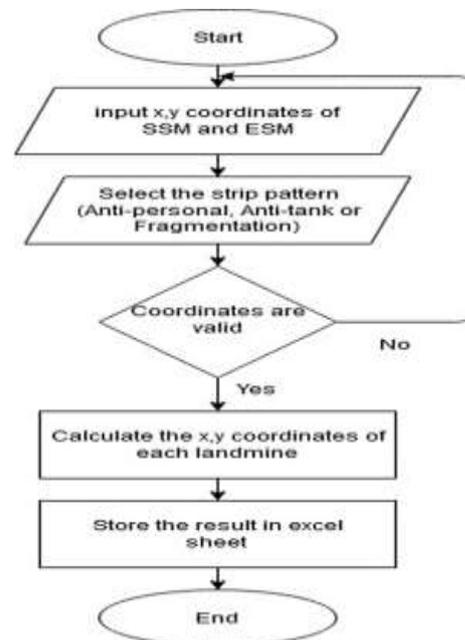
Experimental Design

When designing the research, three stages were identified, the identification of current practice of data recording, develop the computer program to generate locations of landmines, and data visualization and analysis by using the result of the computer program.

Developing of the computer programme

The computer program has been developed by using Matlab software which is flexible for mathematical and logical operations. Matlab is a programming platform that has been designed precisely for engineers and scientists and the most important part of this platform is the MATLAB language, which is a matrix-based language consenting the most natural expression of computational mathematics. (www.dw.com, 2020).

The computer program would return the result, the location (x,y coordinates) of each landmine in the landmine strip according to the initial inputs of the coordinates of the Starting point and the ending point known as 'Start Strip mark' and 'End Strip Mark' of the landmine strip. Those coordinates are being measured also in the manual method by using handheld GPS. Here it is recommended to measure the relevant coordinates by using a



survey-grade GPS which should be in SLD 99 or Kandawala system coordinates.

Figure 3. Flowchart of the program

Source: Constructed by Researcher (2020)

The program has been coded by using mathematical formulas. With the initial inputs, it could be able to calculate the gradient of the landmine strip. Each coordinate of landmines can be calculated by using the gradient and relevant standard distances to landmines in the landmine strip. There could be identified 'Mine raw', a single row of landmines. When there are two parallel mine rows laid simultaneously with the standard distances it is called 'Mine strip'.

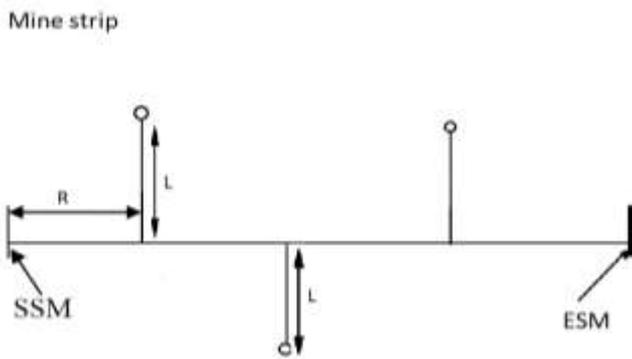


Figure 4. Mine strip

Source: Constructed by Researcher (2020)

Considering the gradient of landmine strip as 'q', and x,y coordinates of starting point and ending point as (xs,ys) and (xe,ye) respectively, the gradient of the baseline is calculated as follows.

$$\tan(q) = (ys - ye)/(xs - xe)$$

A basic mine strip has been shown with Figure 4. 'R' is assumed as the distance to each landmine from the SSM along the baseline of the landmine strip. 'L' is the constant perpendicular distance to any landmine from the baseline of the mine strip. Also, assume

that the x,y coordinates of any landmine included in two mine-rows is (x1,y1) and (x2,y2), then;

$$x1 = xs + R \cdot \cos(q) - L \cdot \sin(q)$$

$$y1 = ys + R \cdot \sin(q) + L \cdot \cos(q)$$

$$x2 = xs + R \cdot \cos(q) + L \cdot \sin(q)$$

$$y2 = ys + R \cdot \sin(q) - L \cdot \cos(q)$$

Those equations have been compound according to the gradient of 'mine strip' to get the result.

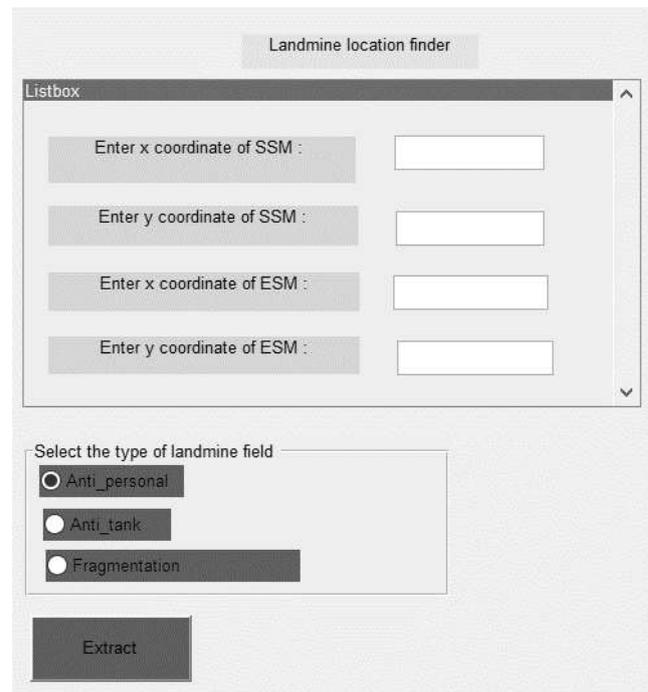


Figure 5. Interface of the computer program

Source: Constructed by Researcher (2020) in Matlab program

The interface of the computer program has been developed to enter x,y coordinates of 'SSM' and 'ESM'. Then to select the type of landmine field and to hit the push button named 'Extract' to get the result as per the Figure 5.

Result data visualization and analysis

The program will return the (x, y) coordinates of each landmine of the landmine strip, which is imported to the Qgis software for visualization. Qgis is free and open-source software that is highly convenient for spatial data manipulation. The result data could be visualized as points in Qgis software and then by using the software it could be able to develop maps, analyze danger buffer zones, open with web-based maps, add conventions, etc.

RESULT



Figure 6. Result visualization with background OSM standard map

Source: Constructed by Researcher (2020) in Qgis



Figure 7. Result visualization with background OSM standard map zoomed

Source: Constructed by Researcher (2020) in Qgis

Since the input coordinates are in SLD 99 coordinates, the result are also in the same. Those coordinates could be able to import to the 'Qgis' software and there can be visualized the landmine locations as a point layer. There

it could be easy to visualize the locations of landmines as well as their places. Also, it could be able to analyze access to the area, the terrain, etc by observing the background map.

By using an "OSM standard" map or else "Google Labels" map to the background with the landmine points layer it could be possible to analyze the place or the relevant area landmines have been included. Also, it could be possible to identify land features near to the landmine field. The roads or paths near to the landmine field and could be analyzed the accesses through the landmine field.

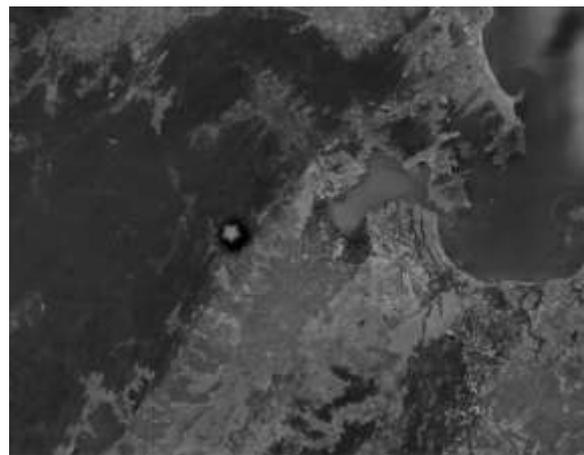


Figure 8. Result visualization with Google satellite map zoomed

Source: Constructed by Researcher (2020) in Qgis

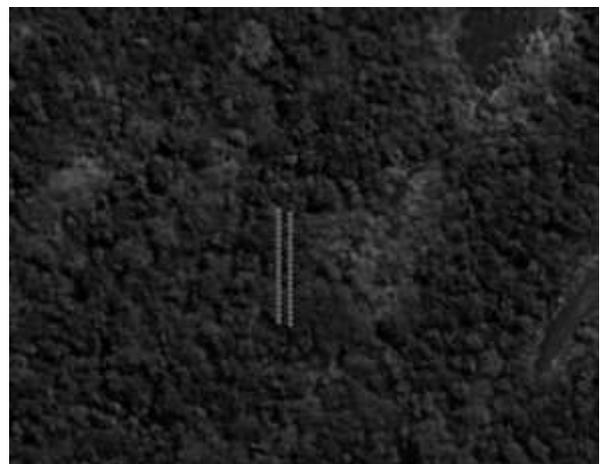


Figure 9. Result visualization with Google satellite map zoomed

Source: Constructed by Researcher (2020) in Qgis

Then by using the satellite based map such as “Google satellite” as background with the landmine points layer there could be able to analyze actual situation of land features near to the landmine field. Also, the terrain as well as the possibility of existing a landmine in a relevant location.

Also, the hazard zone could be able to generate by using the tools in Qgis. The buffer tool has been used there to show a convenient example.

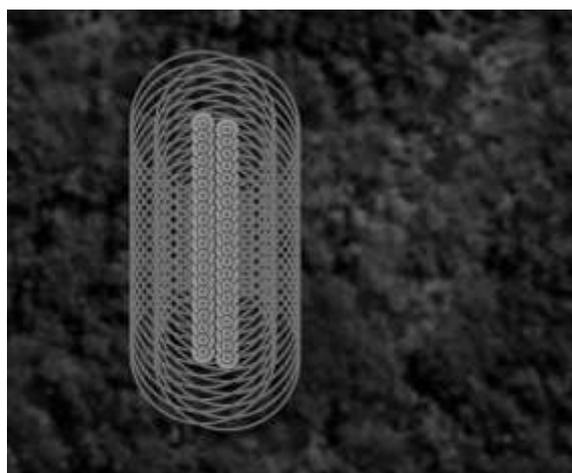


Figure 10. Buffer zones on hazardous areas by landmines

Source: Constructed by Researcher (2020) in Qgis

As per Figure 10, the yellow area having 1 m of radius of a circle could be highly dangerous and can cause deadly injuries or loss of life. A person could be injured, within the area of purple coloured, which is having 1.5 m radius of a circle. Within the blue circles there is possibility to have any damage. The outter side of the blue circle is safe. Likewise, with accurate and precise data, the damage analysis, hazardous area analysis, or accessibility analysis can be done.

Further there could be able to develop conventional or any other maps for the use of military or security purposes. According to the requirements, the details could be used to find safe accessibilities for the demining process, for any military operation, resettlements, etc.



Figure 11. Conventional map on landmines

Source: Constructed by Researcher (2020) in Qgis

By using the result of the computer program it could be very easy, efficient as well as effective to visualize and analyze the landmine fields.

Discussion and Conclusion

Landmines are such an effective defensive weapon but that causes many complexities. There have been introduced standards follow when laying landmines and standard security forces accept those conditions and do accordingly.

Within the Sri Lankan context, the current practice is to record and store the data on laying landmines manually which is not accurate as well as efficient.

There have been introduced a new system to record the data as well as analyze the data on landmines which are being laid according to the universally accepted methods to a standard pattern. A program has been developed which records the coordinates of each and individual landmines and store them in a digitized file. This is very effective, efficient, accurate as well as safe. The program has been developed by using Matlab software which is highly demanded on logical programming operations and very accurate.

Then the location of landmines has been visualized and also have developed some of the analysis applications by using Qgis software an affordable spatial data

manipulation software. With that, there could be able to develop many applications and these results could be able to avoid the complexities of landmine fields. For the military operations, demining processes, go areas and no-go areas analysis and more advantages could be carried out by using this introduced new system.

There in this research, it has been introduced the system only for one standard pattern and that can be able to develop to get used for many standard patterns and that would be applicable to other countries also. Hence, data visualization and analysis can be also further developed by using high-resolution background maps and other spatial tools.

References

AP NEWS. 2020. A Look At Types Of Landmines. [online] Available at: <<https://apnews.com/2f05d1d67a3ffed56cae6f64acb00db5>> [Accessed 2 April 2020].

Behbahani-Nejad, M. and Bagheri, A., 2010. The accuracy and

efficiency of a MATLAB Simulink library for transient flow simulation of gas pipelines and networks. *Journal of Petroleum Science and Engineering*, 70(3-4), pp.256-265.

GICHD (2005) *Mine Action: Lessons and Challenges*, GICHD, Geneva.

Keeley, R., 2003. *Understanding Landmines And Mine Action*. [ebook] Available at: <<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjOwsybyuDpAhU2IEsFHSaaDr4QFjADegQIARAB&url=http%3A%2F%2Fweb.mit.edu%2Fdemining%2Fassignments%2Funderstanding-landmines.pdf&usg=AOvVaw30uhT4H6jWY71qooyOU3Pj>> [Accessed 18 April 2020].

Kraenzle, H. (2000). *GIS and Spatial Databases for Land Mine Mapping*. 10.1007/978-94-011-4357-8_15.

Unicef.org. 2020. *The Legacy Of Land-Mines*. [online] Available at: <<https://www.unicef.org/sowc96/9ldmines.htm>> [Accessed 12 May 2020].

Zucchetti, M. et al. (2017) 'Landmines: Crisis, legacy, international and local action', 2017 1st International Conference on Landmine: Detection, Clearance and

Legislations, LDCL 2017, pp. 22-27. doi: 10.1109/LDCL.2017.7976954.

2006. *STRATEGY FOR MINE ACTION SRI LANKA*. [ebook] Available at: <<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj4p5bq9bDrAhXGcn0KHV0IDDIQFjAAegQIBBAB&url=https%3A%2F%2Fwww.gichd.org%2Ffileadmin%2FGICHD-resources%2Frec-documents%2FNMAS-Sri%2520Lanka-2006.pdf&usg=AOvVaw0a-IXcpmc-po1BqpPW6p->> [Accessed 12 June 2020].

Acknowledgment

Sincere gratitude forward to Mr. CP Ranawaka (HOD) FBESS, the military staff of KDU Southern Campus and all the personals as well as institutions who has given the required data and instructions for the research.

Author Biography/IES



DMIM Nadeesha is a Officer cadet in General Sir John Kotelawala Defence University Southern Campus, following Bsc. (Hons) Surveying Science degree in this university.



RGUI Meththananda is currently a probationary lecturer attached to the department of Spatial Sciences, General Sir John Kotelawala Defence University. She holds a Bachelor of Science degree in the specialization of Mathematics from University of Sri Jayewardenepura and Bachelor of Information Technology from University of Colombo. Her research interests include Computational Mathematics and Mathematical Modelling.



R Vandebona is a probationary lecturer attached to the Department of Spatial Sciences of General Sir John Kotelawala Defence University. He holds a Bachelor of Engineering degree in Surveying and Mapping Engineering from Liaoning Technical University, People's Republic of

China. His research interests include Global Navigation Satellite System, Construction Surveying and Aerial Surveying.