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Noise Influence Analysis in Landmine Discrimination by Curve Characterization Method *

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1. Introduction

Removing landmines is very costly, dangerous and time-consuming, mainly due to high false alarm rate (FAR) which is caused by many other metal fragments (MF), such as exploded landmines and bullets, existing in minefields with landmines [1]. Several demining techniques exist [2] [3] and the semi-autonomous mobile robot Gryphon (Fig.1) was developed to assist these operations. It is equipped with a metal mine detector (MMD) and even though it proved to be better than human operators [4] improvements in FAR are still desired.

In case of Gryphon, a method using Spatially Represented Metal Mine Detector Signal (SRMMDS) is proposed in [5] for depth estimation and results showed to be robust under both laboratory and realistic (testfield data) conditions.

2. Discrimination by SRMMDS

Gryphon scans an area swinging its arm sideways in lines (1,2,...,m) advancing in steps between one line and another. Detected signals are interpolated and displayed to the operator (upper left image in Fig.1), which different colors represent different signal intensities. This signal (V(%)) is a 3D plot which is associated to the spatial position of the manipulator and it changes drastically according to targets physical conditions such as depth, size, material, posture, etc. The proposed discrimination method translates signals to the maximum MMD value to the origin, extracts the main axis (direction of the signal with more peaks and inflections), smooths the signal and simplifies it into mathematical equations (Fig.2), permitting quick comparison to a previous built database, as shows [5] and eq.1. However, databases are built under controlled conditions and in real operations detected signals can contain some noise and discrimination is affected. Noises caused by the MMD oscillation (mechanical vibrations) are be discussed in this paper.

$$Error(\%) = \int abs(f - g)/h * 100 \qquad (1)$$

$$where\ f\ and\ g = polynomials\ to\ be\ compared$$
$$h = max[\textstyle\int abs(f), \int abs(g)]$$

3. Experiments

The discrimination method presented in [5] searches the closest data in the database outputting a target and depth information. 362 data is used, which each one is removed from the database and used as input so that the original data is not in the database during the search. We input some different levels of White Gaussian Noises to simulate mechanical noises, keeping all other conditions unchanged. When inputting this noise (Fig.3), the control parameter is the standard deviation "ST", which higher values represent high errors and ST = 0.01, 0.05 and 0.1 were adopted in this paper.

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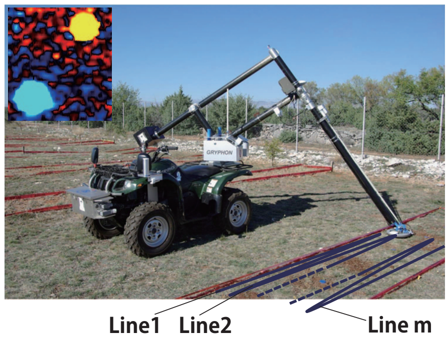

Fig.1 Demining Robot Gryphon

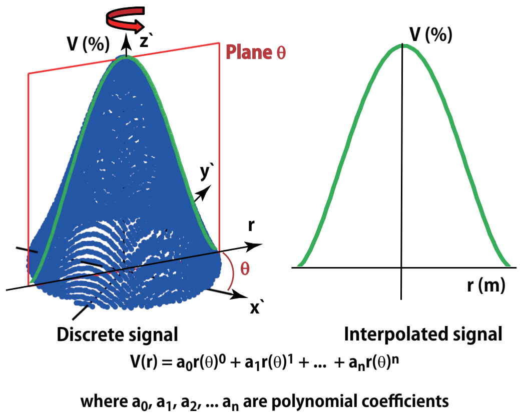

Fig.2 SRMMDS simplified into polynomials

3·1 Depth Estimation Analysis

According to the closest data obtained from database search, we have depth estimation as shown in Table 1. From the results, one can observe that the depth estimation errors tend to increase as the ST values increase. The average depth error for all tested ST values kept small (sufficiently accurate for supporting demining operations), but the maximum error greatly increased (Fig.4). For ST=0.01 and ST=0.05, the maximum error are 84 and 45 mm, respectively. For ST=0.01 it happened for only 1/261 valid data while others kept bellow 45 mm (maximum error with no noise case). For ST=0.05, the maximum error kept similar to no noise case, happening for 3/261 targets, but can be still considered good level for demining operations. For ST=0.1, 8 data has errors higher than 45 mm, with maximum depth error 142 mm, what can be considered high caused by changes in the maximum signal amplitude, main parameter for depth estimation. However, the resulting Error is also high (19.3%) so that adopted safety margins consider the target a potential mine, i.e., there are no risks for the demining operation.

3·2 FAR Analysis

For increasing safety during landmine/MF discrimination, a $dE_{threshold}$ parameter is introduced, which represents the distance between the closest landmine and MF from a target according to eq.1. The variation in FAR according to ST is shown in Fig.5. There is very little increase in FAR according to ST since the search in the database is slightly affected. For ST = 0, there are no False Negatives (FN), but 2 FN happen for ST = 0.05 and 1 for ST = 0.1 when $dE_{threshold} \leq 10\%$. In short, adopting a certain safety margin of $dE_{threshold} \geq 10\%$ is enough for generating no False Negatives.

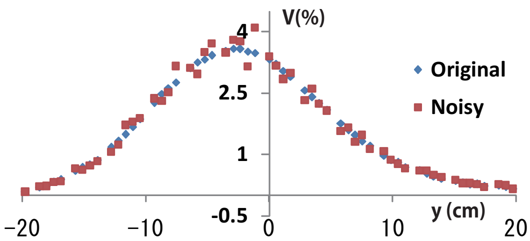

Fig.3 Data with White Gaussian Noise

Table 1 Depth estimation results

	Average Depth Error (mm)	Maximum Depth Error (mm)
No noise	4	45
ST = 0.01	5.1	84
ST = 0.05	5.4	45
ST = 0.1	10.4	142

4. Conclusion and Future Work

This work used White Gaussian Noise for analyzing the influence of random noises in discrimination by SRMMDS. The method is robust for depth estimation for the analyzed standard deviations 0.01 and

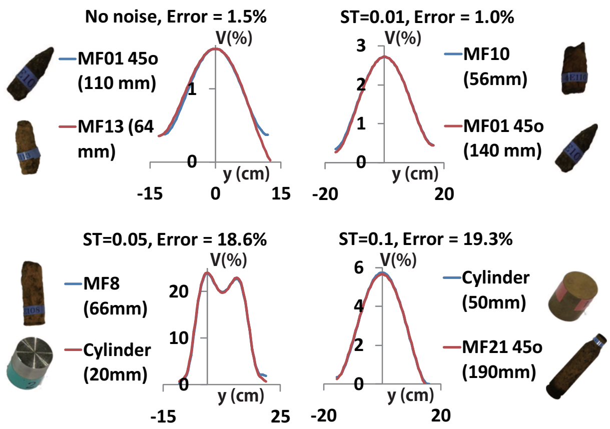

Fig.4 Maximum depth error cases for each target, with depths in parenthesis. Blue lines represent noisy inputs and red ones the closest data in the database.

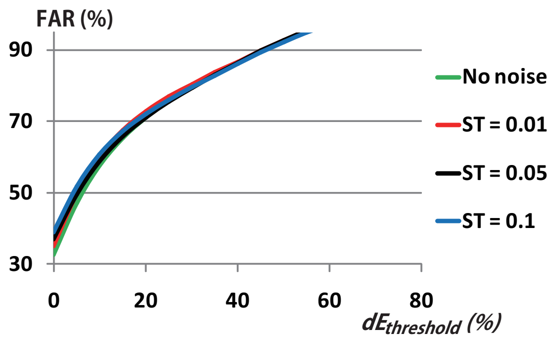

Fig.5 Resulting FAR according to adopted ST levels

0.05, while it presented higher errors for ST = 0.1, but can be compensated by safety margins. FAR increase as ST increases but adopting $dE_{threshold} \geq 10\%$ False Negatives are avoided.

References

[1] Hewish M. and Pengelley R., "Treading a Fine Line: Mine Detection and Clearance," Jane's Int. Defense Review, Vol.30, No.11, pp. 30-47, 1997.

[2] Hayter D. "Training Dogs to Detect Tripwires." Mine Detection Dogs: Training Operations and Odour Detection, June 2003. Geneva International Center for Humanitarian Demining.

[3] Yamanashi Hitachi Construction Machinery. "Contributing to the Mechanization of Demining in Colombia's Mountainous Regions". CSR Report. pp 15-16. 2010.

[4] Pavkovic N., Ishikawa J., Furuta K., Takahashi K., Gaal M., Guelle D., "Test and Evaluation of Japanese GPR-EMI Dual Sensor Systemsat Benkovac Test Site in Croatia", HCR-CTRO TECH GPR 08-001,March, 2008.

[5] Kaneko A. M. and Fukushima E. F. "Humanitarian Demining Robot Gryphon - Mine Detector Scanning Procedure Optimization". JSME Robomec 2013, Tsukuba, Japan.