Research on Inspection Method of Geomembrane Leakage for Automatic Detection Robot

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Abstract

Aiming to the requirement of automatic leakage detection of geomembrane in landfill impervious structure, a quadruped robot inspection method equipped with detection device of electric dipole is proposed. To improve the rapidity and accuracy of automatic detection, the boustrophedon cellular decomposition (BCD) method combined with the improved A* algorithm is used to complete the coverage path planning. According to the inspection data, the potential distribution map is generated to obtain the leakage of geomembrane. The experimental results show that, comparing with the traditional manual detection method, the efficiency and accuracy of detection is much better when the method proposed in this paper is employed.

Introduction

As an important way for solid waste disposal, geomembrane is generally used as impervious structure layer in landfill. Unfortunately, mechanical or artificial nonstandard operation often leads to the breakage, which will cause leakage of landfill leachate and seriously pollute the surrounding soil and groundwater further. At present, domestic and foreign scholars have carried out a lot of research on geomembrane leakage detection[1, 2]. In the practical application scenario, the electric dipole method is generally applicable[3]. However, there are some defects for the traditional manual inspection, some of which is generally inefficient, and working for a long time in a large field people easy fall in fatigue, resulting in wrong or missing detection.

Based on a mobile robot equipped with a detection device of electric dipole, the BCD method combined with an improved A* algorithm is employed to conduct full coverage path planning for geomembrane leakage detection in this paper. According to the data gotten from the inspection, the potential distribution map is generated to obtain the leakage position of geomembrane.

Main Objectives

1. A quadruped robot inspection method equipped with detection device of electric dipole is proposed.
2. The BCD method combined with the improved A* algorithm is used to complete the coverage path planning.

Materials and Methods
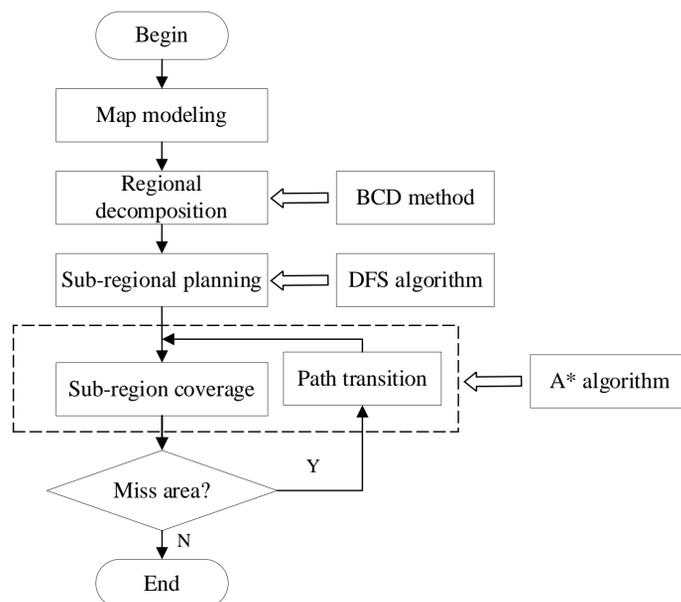
(1) Regional decomposition and sub-regional planning

The BCD method is used to decompose the region and the result is shown as follows.
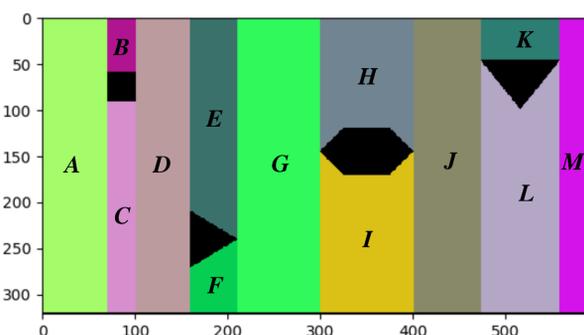
(2) Sub-regional path transition

This paper proposes an improved A* algorithm by referring to the idea in Reference[4].The corresponding cost function can be obtained as follows,
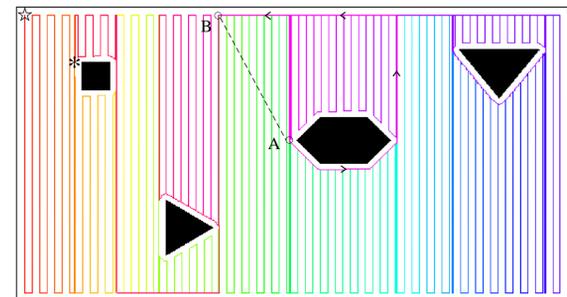
$$g(n) = \sum_{i=1}^{m} p(n)$$

where m represents the number of sections from the starting point to node n. $p(n)$ can be set as linear function $y=ax+b$, considering the terrain fluctuation r, then the estimation function of the improved A* algorithm is as follows,
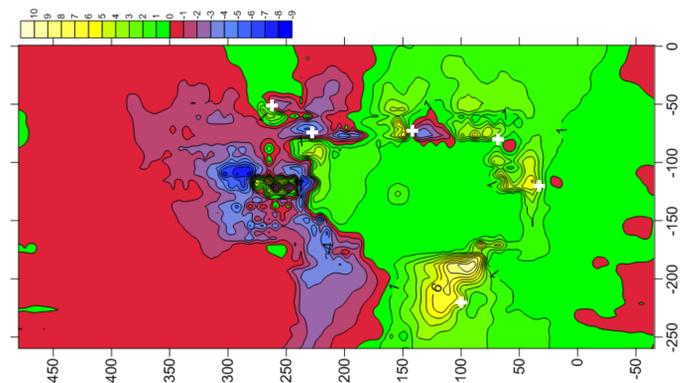
$$f(n) = \sum_{i=1}^{m} (cr+d)x + b + h(n)$$

Results

The simulation result is shown as follows.

According to the collected potential data to generate the potential distribution map shown in Fig. The white mark is the suspected leakage, which is the artificial leakage before the experiment, without missing or wrong leakage.

The comparison of the detection efficiency indexes of the two methods is shown in table.

Type	Net duration /h		Total duration /h		Manpower /p	
	General	Harsh	General	Harsh	General	Harsh
Manual	10	>20	>16	>24	3	>4
Proposed	6	<8	8	<10	1	1

Conclusions

Aiming at the requirement of automatic detection for geomembrane leakage in impervious structure, a quadruped robot inspection method equipped with detection device of electric dipole is proposed. The BCD method combined with the improved A* algorithm is used to complete the coverage path planning of the mobile robot, the simulation results illustrate that through this method the ability of fast passing for the regional boundary is considered fully and the detection requirements for the field with obstacle is satisfied.

References

[1] Lugli, F., Mahler, C.F.: Analytical study of the performance of a geomembrane leak detection system. Waste Management & Research 34(5), 482-486 (2016).

[2] Pandey, L.M.S., Shukla, S.K.: Detection of Leakage of MSW-Landfill Leachates through a Liner Defect: Experimental and Analytical Methods. Journal of Geotechnical and Geoenvironmental Engineering 146(8), 1-11 (2020).

[3] Gilson, A.: Controlling leakage through installed geomembranes using electrical leak location. Geotext Geomembr 47(5), 697-710 (2019).

[4] Wang, X.D., Zhang, H.W., Liu, S., et al.: Path planning of scenic spots based on improved A* algorithm. Sci Rep 12(1), 7 (2022).