EasyChair Preprint

№ 3430

An Analysis on Detecting Underground Objects Using GPR

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May 18, 2020

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Abstract.
Detection of underground water pipes by its dimensions using GPR (Ground Penetrating Radar) device. GPR is used in several applications like ground water, locating buried structures, detection of mines, tunnels, unexploded ordnance, the scope of GPR implementation extends to the buried object description containing object shape recognition, material categorization, size evaluation and deepness observation is one methodological scope. The results can be viewed in GPR as hyperbolic curves to identify the objects in the images. This device gives us highly accurate visual detection to check the accuracy of the proposed methods. These GPR images are processed using feature detection methods which gives the dimensions of the underground objects against the actual GPR images of the pipe.

Keywords: Image Processing, Ground Penetrating Radar, underground pipes.

1. Introduction

Ground Penetrating Radar is a device which is also known as GPR and it is designed to identify and detect the objects under the ground, construction of buildings and bridges, and roads. It provides the high resolution of images which are in the form of 3D images. Nowadays these electromagnetic techniques are used for underground pipes, boreholes and also the roots under the ground. Generally, it is used for investigating environmental, engineering, archeological, and other shallows. GPR contains a transmitter, receiver antenna, a radar control unit and suitable data storage and display. The electrical properties and magnetic properties determine the speed of transmission and frequency of the radar waves. Those waves reflect the different types of objects in different ways. If the energy is more reflected then the image will be brighter on the radar. There are two main primary things to be noted and they are frequency of the wave into the ground and the material type to pass the waves. GPR is good at detecting the metal objects quickly because radar doesn't penetrate metal.

2. Literature Survey

Nowadays people are digging the roads for the purpose of sewerage pipes and water pipes but they are not finishing the work properly and due to that the public is facing many issues regarding that problem, some are taking wrong pipeline connections which are illegal and to avoid those problems there are some papers discussed. S. Delbo, P.Gamba, and D.Roccato [1] have introduced the pattern recognition approach using a fuzzy shell where first they reduced the noise of the image and focused on the shell thickness to get the shape of the object. David Ayala-Cabrera, Manuel Herrera, Idel Montalvo, Rafael Perez Garcia [2] implemented to detect the illegal connections and estimating the lost volume water, evolution pollutant in the particular network. They have taken the raw data and processed two steps and they are matrix visualization process and constructing the classifiers from the raw data, also tested on different types of material like Polyethylene, Poly Vinyl Chloride, Asbesto cement and cast iron and from all these material they proved that Cast Iron and Asbestos cement produce the low noise in the image. Christian Maas, Jorg Schmalzl [3] has come up with pattern recognition by solving through greyscale images and has used the Viola-Jones algorithm for detecting the objects which are taken from OpenCV and also used Adaboost for classification. The advantage they proved is to reduce the time while searching objects in the image as a hyperbola. X. Nunez-Nieto, M. Solla, A. Novo, H. Lorenzo [4] introduced the Finite Difference Time Domain method (commonly known as FDTD) where the frequency is more detected and also improved the standard of the GPR signals and here they have used gprMax software with Matlab for filtering the synthetic data. Ayala-Cabrera D, Herrera M, Izquierdo J & Perez-Garcia R [5] used fieldwork data and synthetic data where they collected in the form of clusters and implemented with Agglomerative Hierarchical clustering technique to reduce the amount of time. M. Grasmueck, A. Novo [7] have detected the linear pipes, small objects and curved roots in the ground by using Rotaru Laser System which projects the 360 degrees horizontally and vertically. Jana Jezova, Laurence Mertens, Sebastien Lambot [8] used classical radar measurements which were compared with application metal shields which act as a perfect electrical conductor but there is a problem during planar metal shields because the reflection will be very less. Franscisco Garcia-Garcia, Ana Valls-Ayuso, Javier Benlloch-Marco, Manuel Valcuende-Paya [9] described the cavity detection in Torrente for sewerage pipes whereby reducing the cost, time and also safety for the people who are living in urban areas by using the odometer to calculate the distance. First, they collected the raw data and removed all the background noise, filtered the bandwidth and applied some simplifications for the 3D visualization surface. F.J.Prego, M.Solla, I.Puente, P.Arias [10] has solved to detect pipes and minimize the pipe leakages in the cities to control the problems by setting different frequency range in the antenna and detected the results and used the MALA proEx system to get the optimal solution for buried pipes. Rajiv, G. Ramesh, B. Basaveswara [11] used a distinctive similarity rendering approach where multiple reflections were avoided due to multiple targets and they analyzed individually and reduced the depth resolution. Namgyu, Sehoon, Yun-Kyu An and Jong-Jae

Lee [12] generated B-scan images using gprMax which is open source software and these 2d images are trained with CNN for image classification problem. They have used the simulation data for the experiment and collected the data on urban roads for 13kms in Seoul, prepared the data and applied CNN which is Alexnet with max-pooling and fully connected layers. The advantage is reduced false-positive errors and also human errors are reduced. When the samples in the dataset increase then automatically the trained network increases. Jing Zheng, Xingzhi Teng, JieLiu and XuQiao [13] divided into Classification and Regression which is designed separately and one network is to classify the moisture quantitative prediction and other network is for the continuous variable which is water content. They used convolutional layers with max-pooling to extract the features and classification, regression for the output result and here the regression takes less training data and achieved good performance. Mansor Nakhkash and mohammad R. Mahmood-Zadeh [14] used the FDTD model to detect the water leakage in the ground through the antenna signals which are sent using GPR and they identified the soil water mixtures which gets hyperbola, vertical and horizontal detection. C. Windsor, L. Capineri, P. Falorni, S. Matucci and G. Borgioli [15] have used the hough transform method to find the buried pipes with the help of GPR which shows the result as hyperbolic arcs by using the experimental data. They worked with two points and they found the velocity in soil and that velocity value is used for the measurements of the pipe. T Amran, M Ismail, M. Ahmad, M. Amin, M A.Ismail, S.Sani, N. Masenwat and N. Basri [16] used 800MHz antenna by taking the PVC pipe which is of four inches and tested with the help of dry sand for different sizes of pipes. They showed the differences for each size of the pipe before the water leakage, after the water leakage in the form of hyperbolic curves and proved that the water which is having the greatest pressure is shown in one-fourth inch diameter. S.F.Senin, M.S.Jaafar, R.Hamid [17] used the migration analysis technique that finds the dielectric constant with the help of radan software and they used the plastic box which is filled with sand and inserted the pipes which are of different depths by sending the water for at various stages like injecting before, after and during the water. T.Arman, MP.Ismail, Mohamad R Ahmad, MSM.Amin, S. Sani, NA.Masenwat, MA.Ismail, Shu-Hazri Abdul Hamid [18] used 1GHz frequency to detect the leakage in the underground pipes and divided into two parts and they are: one is to detect the pipe and the other is to detect the leakage of the pipes by taking the sample of 512 with the sampling frequency of 11.653GHz and they used the empty steel pipe, plastic pipe along with PVC pipe and proved that steel pipe gets more reflection from the ground compared to PVC pipe. David, Manuel, Joaquin, Silvia, Rafael [19] performed the feature extraction with the preprocessing methods based on statistical and multi systems. They tested by keeping the pipe inside the box with some measurements and covered with a polypropylene plate and filled with dry soil. Next analyzed the location from raw images of the hyperbola and showed the differences between the starting stage and the final stage of the pipe leakage followed by preprocessing the images and developed contour extraction in Matlab. Nurniesya, Amalina Yusup, Zulkarnaini, Mimi Diana [20] detected fluid leakage by retrieving the moisture of soil, soil compaction is performed with maximum dry density by using Reflex 2D software and observed on different types of sand.

Table 1. An overview of Literature

S.no	References	Findings	Conclusion
1	[12]	Used Alexnet with max-pooling and fully connected layers by using simulation data which are collected from urban roads in Seoul.	Reduced false-positive errors and also reduced human errors.
2	[2]	Detect illegal connection, estimate lost volume water.	Collected the data and processed into matrix visualization and construction of classifier from raw data. Proved that Cast Iron and Asbestos produce low noise in the image.
3	[3]	Pattern recognition by solving through greyscale images.	Used Adaboost and OpenCV to reduce the time while searching objects in the image as a hyperbola.
4	[5]	Used fieldwork data and Synthetic data and formed into clusters, implemented hierarchical clustering technique.	By using the Agglomerative clustering method they reduced the amount of time.
5	[7]	Implemented for linear pipes, small objects and curved roots with the rotary system.	Objects are detected which are in the form of curves and also linear objects which project horizontally and vertically.
6	[8]	Used classical radar measurements which were compared with metal shields which act as electrical conductors.	Gaining reflection curves from medium and also internal reflections were observed with some simulations and metal shields where planar reflection will be less.

3. Conclusion

As per the literature, upon rigorous study of various methodologies it is here to conclude that there are many types of approaches to find or detect the underground pipes but the accuracy for each approach will be different. There are certain rules for the pipes which are connected to the households and ductile pipe is used for the water pipes which should be depth of one meter from the road. Till now used methodologies in this paper are Convolutional Neural Network, Fuzzy shell, image processing,

Matlab, Classification and Regression etc. GPR is the best method to identify the dimensions and recognize the shape of the object without digging the ground.

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