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Real-time positioning technology in horizontal directional drilling based on magnetic gradient tensor measurement

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Horizontal directional drilling (HDD) technology has been widely used in Civil Engineering. The dynamic position of the drill bit during construction is one of significant facts determining the accuracy of the trajectory of HDD. A new method now has been proposed to detecting the position of drill bit by measuring the magnetic gradient tensor of the ground solenoid magnetic beacon. Compared with traditional HDD positioning technologies, this new model is much easier to apply with lower request for construction sites and higher positioning efficiency. A direct current (DC) solenoid as a magnetic dipole is placed on ground near the drill bit, and related sensors array which contains four Micro-electromechanical Systems (MEMS) tri-axial magnetometers, one MEMS tri-axial accelerometer and one MEMS tri-axial gyroscope is set up for measuring the magnetic gradient tensor of the magnetic dipole. The related HDD positioning model has been established and simulation experiments have been carried out to verify the feasibility and reliability of the proposed method. The experiments show that this method has good positioning accuracy in horizontal and vertical direction, and totally avoid the impact of the environmental magnetic field. It can be found that the posture of the magnetic beacon will impact the remote positioning precision within valid positioning range, and the positioning accuracy is higher with longer baseline for limited space in drilling tools. The results prove that the relative error can be limited in 2% by adjusting position of the magnetic beacon, the layers of the enameled coil, the sensitive of magnetometers and the baseline distance. Conclusion can be made that this new method can be applied in HDD positioning with better effect and wider application range than traditional method.