Performance analysis of tactical grade inertial systems for MWD process

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Abstract: A complete knowledge of the drill bit direction and orientation during the drilling process is essential to guarantee accurate directional drilling procedure. Presently, three accelerometers and three magnetometers are typically used as a part of the Measurement-While-Drilling MWD equipment. In some cases, the use of magnetometers has deleterious effect on the accuracy of the surveying process. This is due to the magnetic interference of the drill string, downhole ore deposits and other geomagnetic effects. Recently, gyroscopes have been proposed to aid the magnetometers in environments of high magnetic interference. This paper describes the development of a reliable MWD surveying technique utilizing Inertial Navigation Systems (INS) as a replacement of magnetometers. Tactical grade INS consisting of three gyroscopes and three accelerometers to be miniaturized inside the bottom-hole assembly is adopted in this study. The proposed system offers station-based surveying for monitoring of azimuth, inclination and tool face angles. Additionally, it provides continuous surveying by applying Kalman filtering to optimally integrate the sensor measurements and to provide both the drill bit position and orientation in real-time. This study also offers accurate modeling of INS long-term errors in order to achieve the desired accuracy for horizontal drilling applications. Pre-filtering using wavelet multi-resolution analysis is utilized in this study to improve the performance of both gyroscopes and accelerometers. This procedure removes most of the short-term and high frequency errors to separate the motion dynamics from the sources of vibration and shocks experienced downhole. The performance of the proposed system is examined using a special experimental setup that performs rotations similar to that experienced by the drill bit. The results showed that reliable MWD surveying performance can be achieved. The suggested INS-based MWD surveying technique eliminates the costly non-magnetic drill collars for the magnetometers, survey the borehole continuously without interrupting the drilling process and improve the overall accuracy by utilizing real-time digital signal processing techniques.

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