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基于压缩感知的随钻测井编码传输方法

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Compressive sensing based coding method for M/LWD transmission

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摘要

随钻测井是一种能在钻头钻进过程中通过安装在钻头附近的传感器实时获取和传输测井数据的技术.实时可靠高效的传输测井数据是随钻测井研究领域的关键问题.目前随钻测井系统普遍使用的测井数据传输方式是钻井液压力脉冲遥测传输.钻井液信道是一种长时延极低速单向无反馈删除信道,因此利用传统的差错控制方法无法在保障测井数据传输实时性的同时纠正信道噪声引起的实时测井数据传输错误.为此本文提出了一种基于压缩感知理论的随钻测井数据信道编码传输方法,该方法具有短码长线性编译码复杂度的优点.地面接收端通过压缩感知重构算法恢复井下测井数据,在保障测井数据传输实时性的同时使得地面施工人员能在随机删除信道条件下正确的获得全部井下实时测井数据.钻井现场真实测井数据编码实验表明,本文所提方法在不影响测井数据传输实时性的前提下大大提高了测井数据的抗信道删除能力,降低了由于信道删除带来的测井数据丢包率,而且允许测井施工人员根据实际钻井液信道状态灵活调整发送码率,以实现不同删除概率信道下的测井数据可靠传输.

关键词 随钻测井, 压缩感知, 测井数据编码

Abstract:

Measurement/Logging While Drilling (M/LWD) is a drilling technique, which incorporates measurement sensors into drill strings, measuring and transmitting logging data in real time with the drilling process. Compared with traditional logging technologies, M/LWD is able to make drilling operations more cost-efficient and available to drill wells in complex geology. The effectiveness and reliability of logging data transmission is one of the biggest technical difficulties and challenges which hinder the development of M/LWD. In the M/LWD system, logging data is transmitted via mud-pulse telemetry from the underground installations to the surface site to help field techniques optimize the drilling process. Because the drilling mud channel is a one-way non-feedback erasure channel with long transmission delay and very low transmission speed, it is hard to correct transmission errors caused by drilling mud channel noise in real time by using traditional erasure correcting code (ECC) and automatic request for repetition (ARQ). In this paper, we present a drilling mud channel coding algorithm based on Compressive Sensing (CS) for reliable real-time logging data transmission in M/LWD systems, which has the advantages of short code length and linear encoding and decoding complexity. By compressive sensing reconstruction algorithms for original logging data recovery at the surface site, field technicians can get all real-time logging data in the random erasure channel conditions. So the proposed Compressive Sensing Channel Coding (CSCC) scheme is tolerant to erasure probability of drilling mud channel and can greatly reduce logging data transmission errors. Numerical experiments performed with a large amount of real field data show that CSCC scheme achieves good erasure decoding performance with good real-time performance and provides precise enough results for drilling field technicians. Furthermore, it also provides a flexible interface for field technicians to adjust an effective coding rate according to various erasure probability of drilling mud channel to meet the

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requirements of transmission accuracy.

Keywords Logging while drilling, Compressive Sensing, Logging data encode

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