ISSN: 2710-0588 DOI: 10.29556/FSE.202109_1(6).0011

Design and Implementation of an Algorithm for Generating Drill Bit Entry Sequence Number

Yujie Cheng[1], Botao Liu[1,*], Lixia He[1], Yifei Li[1], Zhuo Liu[1]

[1]Yangtze University, Jingzhou 434000, China.

*Corresponding Author liubotao920@163.com

Abstract

With the popularity of big data and artificial intelligence and the increase in awareness, it is urgent to put on the agenda how to use big data and artificial intelligence technology to improve the effectiveness of oilfield information construction. Drill bit basic information statistics is the key to drilling statistics, and is an important part of oilfield information construction. In the actual application, the irregularity of the field data source and the imperfect calibration system leads to the missing data of the drill bit entry sequence number, which will affect the subsequent statistical functions of various information of the drill bit. This paper proposes an algorithm for generating drill bit entry sequence number, which can obtain the desired results even with the support of a small amount of data. After analyzing the problem, the solution idea and flowchart are given, and the accuracy of the algorithm is verified with examples. It is proven that the algorithm can calculate the correct drill bit entry sequence number with limited data, which effectively improves the efficiency of the actual basic bit statistics.

Keywords

Informatization Construction; Intelligent Well Field; Single Well Statistics; Oil Drill Bits; Drill Bit Entry Sequence Number.

1. Background and significance

The improvement of national science and technology has had a huge impact on various fields, among which oil extraction work has gradually moved towards information technology and digitalization. The country is using big data technology to minimize the cost of oil extraction. Not only that, the application of big data in the oil industry can also achieve information sharing while ensuring the safety of personnel and data security. The literature [1] has analyzed the benign impact of the application of big data technology on the intelligent oilfield. The information construction of China's oilfields as a whole has made certain achievements, but in terms of details, there is still much to be improved. The standardization and formalization of data in the oilfield is still lacking. A solution for data governance in oil fields is provided in the literature [2] using Datist technology.

The above outlines the development status of the oil industry in a broad sense, but when is comes to the daily work of oil drilling projects, the oil drill bit is an indispensable tool, and the efficiency of the drill bit directly affects the results of drilling, so the daily work of the drill bit is of great concern. Oil drillers keep a basic record of the daily bit work in order to observe the drilling in more detail, include drill bit number, type, size, date of exit and entry, depth of exit and entry, pure drilling time, wear condition, etc. Those are used to calculate the feed of the drill bit per well entry and the average mechanical drilling speed. The drill bit feed, mechanical drilling speed and life time are important indicators to evaluate the performance of a drill bit, and several scholars have taken these indicators as reference for drill bit selection and drill bit analysis. In the literature [3], the ratio method was used to select the type of bit more suitable

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to the formation, aiming to better guide the drilling production. In the literature [4], a certain amount of bit data was collected and base those data using the main component statistical analysis method to make a quantitative judgment on the bit.

To date, there has been little discussion on how to get a defined entry sequence number for the bits used in a well. Thus, when analyzing data, it is not only possible to quickly count the work of one drill bit in a well drilling operation, but also to obtain a clearer picture of the progression sequence between drill bits. The literature [4,5] mentions the problem of incomplete information or obvious errors in the drill bit data provided by oilfield sites, but no detailed explanation is given on how to statistically obtain the ideal data. The drill data management platform proposed in the literature [6] provides information construction for the collected drill data, but the focus of the article is on the implementation of the system functions, and there is a lack of supplementation on the details of the drill statistics. Some of the drilling information requirements indicate that the drill bit entry numbers need to be entered in the order of entry, the different entries of a drill bit also need to be reflected in the entry number. The drill bit entry sequence number is usually in the format of n-m, when n is the nth bit in the current well and m indicates the mth entry of this bit. For example, the first entry serial number of the first bit is 1-1, and the entry serial number of the second entry is 1-2.

Although there is a filling requirement for the drill bit into the well serial number, but the actual situation is different from the agreement. There are three main problems resulting from the following:

1) The data on field is often uneven and the awareness of information construction is not strong, the standard format of the drill entry serial number is overlooked when filling in the data upfront because of infrequent bit switching and bit cross-use, filling drill bit entry sequence number in directly in Arabic numerical order will lead to the logical error of the same drill being mistaken for a different drill;

2) The existing records of basic drill bit information are entered manually, and in order to get the drill bit sequence number in standard format, it is necessary to manually project the drill bit sequence number based on the previous data, which is feasible but inefficient and error-prone;

3) Well history data is also important information for oil drilling, and the format of recording well history data may differ from the data format required under the current information technology mindset. When organizing well history data, you will find that many well history files have serious missing data, including a large number of missing drill bit serial numbers.

In summary, it is necessary and meaningful to investigate the algorithm for generating the bit entry sequence number for each well.

2. Analysis of the problem

The basic information of the drill bit contains a lot of information about the drill bit, but not every item provides a direct condition for generating the serial number of the drill bit into the well. Preliminary analysis obtained, the basic information of the drill bit filling date, sequence number, number, starting depth, ending depth, entry time, exit time is conducive to the generation of the drill bit entry sequence number, the author will be from these dimensions to make a specific analysis for those data. The following table simulates the basic drill data obtained by manual filling, which has been sorted from smallest to largest according to the date of filling the basic drill information. Since the accuracy and verifiability of manual filling is poor, the data needs to be cleaned first to screen out dirty data.

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Table 1. Basic data table of drill bit

Date	Sequence number	number	Start Depth	End Depth	Entry time	Exit time
2020-11-30			0	0		
2020-12-01	1	A1	0	50	2020-12-01	
2020-12-02	2	A1	50	-100		2020-12-02
2020-12-02	2	A1	50	100		2020-12-02
2020-12-03	3	A2	100	125	2020-12-03	2020-12-03
2020-12-03			125	180	2020-12-04	
2020-12-04	4	A2	125	180	2020-12-04	2020-12-04
2020-12-05	5	A2	180	240		2020-12-05
2020-12-06	6	A1	240	290	2020-12-05	2020-12-05
2020-12-07	7	A3	352	410		2020-12-07
2020-12-08	8	A2	410	458	2020-12-08	2020-12-08

Cleaning is done in two dimensions respectively:

1) Sequence Number. When the entry number is empty, the algorithm considers this data to be dirty and will screen it out. Because in the preliminary work, drilling has not started, but there will be data of the drill bit, which is part of the worthless data.

2) Starting depth, ending depth. When the starting depth and ending depth are less than 0, the algorithm considers this data as dirty data and will sieve it out. Because the drilling operation uses the ground as the horizontal plane, the positive direction is toward the bottom of the ground, and the negative number indicates that it is above the ground.

In a well, the bit is distinguished by the number of the bit. The algorithm considers the bits with the same bit number to be the same bit, and vice versa for different bits, and for records without the number filled in, they are all considered different bits.

The number entry of the bit is determined by the entry and exit time of the bit, but there are a large number of cases in the actual data where the exit time or entry time is not filled in, and the date of the well cannot be or not as a single factor to confirm the time of the drill bit into the well, but also need to be combined with the number analysis. For these situations, the following analysis is made:

1) Number is empty. The bit is considered to be a new bit and therefore naturally identified as a first entry.

2) The number is not empty, the last record (one row of the table in this article) does not have exit time. In this case, if the number of the last record is empty or the number of this record is not the same as the previous record, it is the case of changing the drill bit into the well. Find the last entry of this bit, add 1 to this. Otherwise, for the first time into the well. If the number of the previous record is not empty and is the same as the number of this record, it is assumed that the previous record has not yet exit the well after the drill bit has been lowered in, this record has the same entry number as the previous record.

3) The number is not empty, and the last record has exit time. It is a case of changing the drill bit, find the last time this drill bit entered the well and add 1 to the number of times it entered the well.

3. Solution of the problem

Based on the above proposed problem and the analysis of the problem, the following flowchart gives the specific flow of the bit entry sequence number generation.

The algorithm is implemented in Java, and the UML diagram of the algorithm design is given below. (shown in figure 2)

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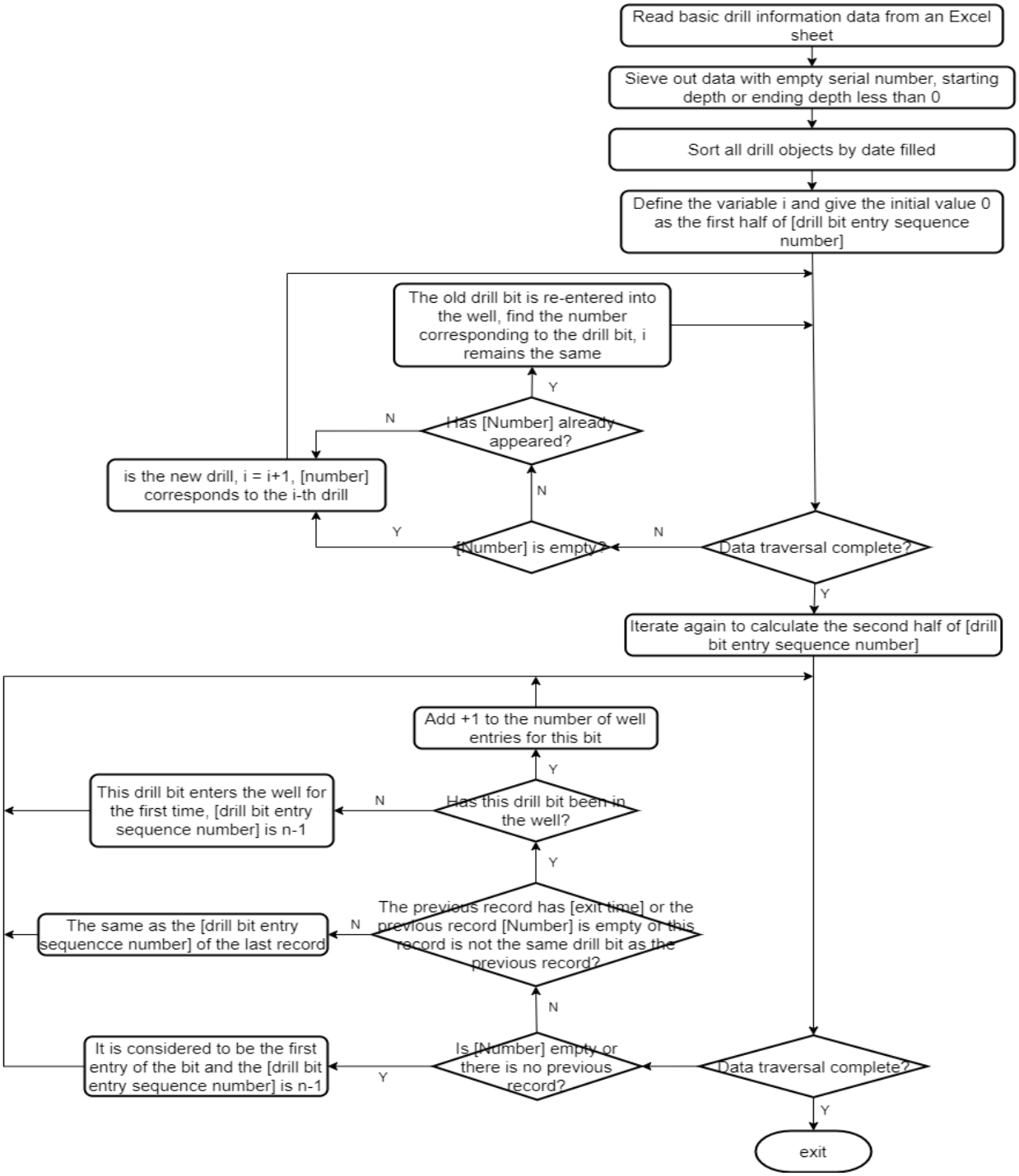

Figure 1. Flowchart for generating the drill bit entry sequence number

The core part of the algorithm is the calculateBitRihSn(List<BitBasoInfo>) method of the BitRihSnUtil class. Since the drill entry sequence number has two parts, the nth drill and the mth entry, these two parts are two separate parts from the idea of computational thinking. To calculate the nth drill bit, think of the drill bit in terms of the whole of all the drill bits. And for the mth entry, it is for a particular drill bit. So the main body of the algorithm consists of two loops, the first loop gives the "n" part of all the drill bits and the second loop calculates the "m" part of the drill. The two parts are spliced together to get the complete bit entry sequence number.

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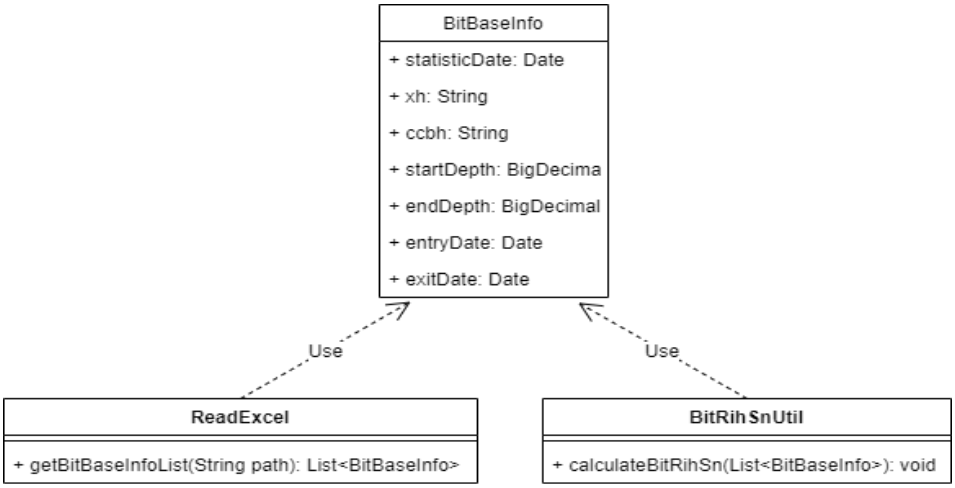

Figure 2. UML diagram for generating the drill bit entry sequence number

4. Instance testing

Take the basic data of a well drill bit in an oil field as an example to check the correctness of the algorithm. The basic drill bit data for the well is shown in Table 2 below.

Table 2. Basic data of original drill bit in an oil field

Date	Sequence number	number	Start Depth	End Depth	Entry time	Exit time
2020-11-17			0	0		
2020-11-18	1		0	51	2020-11-17	
2020-11-19			0	0		
2020-11-20			0	0		
2020-11-21	2	193157	51	175	2020-11-20	
2020-11-22	3	193157	51	461		
2020-11-23	4	193157	51	678	2020-11-20	
2020-11-24	5	193157	51	704		
2020-11-29			0	0		
2020-11-30			0	0		
2020-12-01	6	S15202	704	949	2020-11-30	
2020-12-02	7	S15202	704	1165	2020-11-30	
2020-12-03	8	S15202	704	1323	2020-11-30	
2020-12-04	9	S15202	704	1476	2020-11-30	
2020-12-05	10	S15202	704	1600	2020-11-30	
2020-12-06	11	192708	1600	1696	2020-12-05	
2020-12-07	11	192708	1600	1786	2020-12-05	
2020-12-08	11	192708	1600	1887	2020-12-05	
2020-12-09	12	S15222	1887	1940	2020-12-08	
2020-12-10	13	S15222	1887	2146	2020-12-08	
2020-12-11	13	S15222	1887	2242	2020-12-08	
2020-12-12	13	S15222	1887	2380	2020-12-08	
2020-12-13	13	S15222	1887	2389.3	2020-12-08	
2020-12-14	14	202376	2389.3	2396	2020-12-13	
2020-12-15	15	202376	2389.3	2407.7	2020-12-13	
2020-12-16	16	202376	2407.7	2416	2020-12-15	
2020-12-17	17	202376	2416	2418.46		
2020-12-18	18	202376	2418.46	2435.4	2020-12-16	
2020-12-19	19	202376	2435.4	2442.5	2020-12-18	
2020-12-20	19	202376	2435.4	2453.8	2020-12-18	
2020-12-21	20	S15222	2453.8	2485	2020-12-20	
2020-12-22			0	0		
2020-12-23			0	0		

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The algorithm will sieve out some of the illegitimate data according to the cleaning rules, and then perform the calculation. The final results obtained are shown in the following table.

Table 3. Basic drill bit data after generating the drill bit sequence number in an oil field

Date	Sequence number	number	Start Depth	End Depth	Entry time	Exit time
2020-11-18	1-1		0	51	2020-11-17	
2020-11-21	2-1	193157	51	175	2020-11-20	
2020-11-22	2-1	193157	51	461		
2020-11-23	2-1	193157	51	678	2020-11-20	
2020-11-24	2-1	193157	51	704		
2020-12-01	3-1	S15202	704	949	2020-11-30	
2020-12-02	3-1	S15202	704	1165	2020-11-30	
2020-12-03	3-1	S15202	704	1323	2020-11-30	
2020-12-04	3-1	S15202	704	1476	2020-11-30	
2020-12-05	3-1	S15202	704	1600	2020-11-30	
2020-12-06	4-1	192708	1600	1696	2020-12-05	
2020-12-07	4-1	192708	1600	1786	2020-12-05	
2020-12-08	4-1	192708	1600	1887	2020-12-05	
2020-12-09	5-1	S15222	1887	1940	2020-12-08	
2020-12-10	5-1	S15222	1887	2146	2020-12-08	
2020-12-11	5-1	S15222	1887	2242	2020-12-08	
2020-12-12	5-1	S15222	1887	2380	2020-12-08	
2020-12-13	5-1	S15222	1887	2389.3	2020-12-08	
2020-12-14	6-1	202376	2389.3	2396	2020-12-13	
2020-12-15	6-1	202376	2389.3	2407.7	2020-12-13	
2020-12-16	6-1	202376	2407.7	2416	2020-12-15	
2020-12-17	6-1	202376	2416	2418.46		
2020-12-18	6-1	202376	2418.46	2435.4	2020-12-16	
2020-12-19	6-1	202376	2435.4	2442.5	2020-12-18	
2020-12-20	6-1	202376	2435.4	2453.8	2020-12-18	
2020-12-21	5-2	S15222	2453.8	2485	2020-12-20	

From the above results, it is shown that the computational level of the algorithm with less data information is still considerable. The original basic data of the drill bit in Table 2, the time out of the well are missing, the algorithm still obtained the desired results.

5. Summary and outlook

The algorithm proposed in this paper solves and is not limited to solving the problem of generating the bit entry sequence number with a small amount of data support. The generation of drill bit entry sequence numbers provides greater convenience not only for bit usage statistics, but also for analysis of multiple entries of a bit. The algorithm in this paper is applicable to most current drilling projects for bit usage statistics and is also very useful in combining different drilling files for the same well

This algorithm solves the proposed problem, depending on the individual oil field will have different dimensions to consider, the algorithm can still be optimized to explore. In this algorithm it is considered that the unnumbered record corresponds to the new drill bit. From an optimization point of view, unnumbered records that are adjacent to each other can be inferred from the rest of the fields to be the same drill, For example, the same entry date, the same starting depth. For these records, a similarity value can be set between each other, and the similarity value is calculated by the dimensions covered in this paper but not limited to this paper, and when the similarity value reaches a certain, it will be considered as the same drill

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Acknowledgments

This research is supported by five projects: The demonstration construction projects of "Ideological and Political Course and Ideological and Political Course" in Yangtze University in 2021 (No.41); The project of young people in the Education Hall of Hubei (No.Q20161311); The Yangtze Youth Fund (No.2015cqn53); The Yangtze University Students' Innovation and Entrepreneurship Training Program Project (No. Yz2020157, Yz2020150).

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