The technology of picking up the first break of surface microseismic based on constraint

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Abstract. In this paper, a constraint based first break acquisition technique for surface monitoring is proposed. This method enables users to automatically pick up the starting point and the ending point of the first arrival position after simply observing the starting point and the ending point of the first arrival position and determining the position. Secondly, because the first break automatic picking method mentioned in this paper will analyze the data characteristics of each channel carefully to find the first break time point in each channel accurately, so that the accuracy of first break picking is significantly improved.

1. Introduction
In the actual production, the seismic data profile generated by the real data is not good, which has a lot of noise; for the impact of noise, the location of the first arrival in the seismic data is not obvious. When the signal-to-noise ratio is set low, the noise error can be easily identified as the microseismic event point by the simple energy superposition location algorithm. In addition, because of the large number of microseismic geophones on the ground, each micro seismic event generally contains dozens or hundreds of time points, the traditional single channel pickup method will consume a lot of manpower. In order to improve the accuracy and efficiency of microseismic event location, we propose a constraint based first break acquisition technique. This method enables users to automatically pick up the starting point and the ending point of the first arrival position after simply observing the starting point and the ending point of the first arrival position and determining the position. Secondly, because the first break automatic picking method mentioned in this paper will analyze the data characteristics of each channel carefully to find the first break time point in each channel accurately, so that the accuracy of first break picking is significantly improved.

2. Data preprocessing
For the two-dimensional microseismic data behind each profile, we can find that there are some characteristics: the data of some channels are very large as a whole: they have a large amplitude average value and a large amplitude variance; and the channel data beside the channel data may have a small amplitude mean value or a large variance, which will give users a poor view when the profile is displayed. In the process of displaying the section map, the amplitude display of each channel data is limited. If the amplitude of the data is too large to exceed the display threshold, it will truncate the excessive amplitude in some places of the channel data in the display area, thus affecting the observation of the user. The biggest effect of observation error is to judge the location of the first arrival. So it is necessary to preprocess the micro seismic data.
2.1 Design scheme
The main work of the normalization of seismic data is as follows: first, traverse each data to find the maximum value in the channel data; then continue to traverse each data in the channel data, and divide the data by the maximum value in the channel data, so that all array amplitude ranges in each data stay in \([-1, +1]\).

The general flow chart of micro seismic data preprocessing is shown in Figure 1.

![Flow chart of micro seismic data preprocessing](image)

Figure 1. Flow chart of micro seismic data preprocessing

3. Constraint based first break picking method
In the traditional manual picking, we need to first observe the position of the first arrival, and then pick it manually. However, there are two disadvantages of manual pickup. The first one is low efficiency. Because for microseismic data, it usually contains hundreds of thousands channels of data, and the first arrival position is generally across hundreds channels of data, so we need to manually pick up hundreds of points, which undoubtedly has a serious impact on production efficiency. Another problem is that there are many noises around each first arrival, resulting in the first arrival position of each data is not obviously, it leads to different people's different cognition of the first arrival position. These problems will lead to the low accuracy of first break picking, so we need to use a constraint based picking method, just need to roughly determine the starting point and the ending point in each first break segment, then we can find the first break point in each data by accurate calculation.

3.1 Method principle
In the traditional manual first break picking, users need to observe each data and then pick up the first break; in the constraint based first break picking method, first observe the profile map to determine the first break position, and then pick up several times on the profile map to determine the start point and the end point of each section of the first break, which will automatically find the first break of the crest / trough / jump point between each two pick-up points, And mark the connection.

The reason why users need to pick up the first break manually many times is because of the data characteristics of the seismic data. In the microseismic data, the approximate shape of the initial section is near straight line or parabola, while the first break of the curve shape will reduce the accuracy of the constraint based first break method. The user manually inserts the first break pick-up to determine the general trend of the pick-up. The first break auto pick-up performs the fine search in this area, so that the position of the first break pick-up can be found relatively accurately only after the general range of the first break pick-up is determined.

3.2 Design scheme
The first arrival picking method based on constraint includes manual picking of constraint range and automatic picking of first arrival within the range. The specific design is shown in Figure 2.

(1) pick constraint range manually
After observing the general trend of the first arrival segment, the user determines the position of the constraint points to ensure that the shape of the first arrival segment between the adjacent constraint points is close to a straight line, so as to improve the accuracy of the initial pick-up between the constraint points.

(2) automatically pick up the first arrival within the range
After each constraint point is determined, the initial pick-up method of constraint is calculated accurately according to the range determined by the initial constraint point and the end constraint point, so the first Solstice of each data is determined.

Figure 2. Module function diagram

4. Modular implementation of first break auto pick-up method
For the first arrival segment, a complete first arrival segment is decomposed into several near line first arrival segments after multiple constraint points are determined. For the first arrival segment of straight line fitting, after knowing the straight line fitting slope of each region of the first arrival segment, use the slope to find the starting point of each straight line fitting; for each data, use the characteristics of waveform to find the maximum, minimum and jump points of each data, so as to improve the efficiency of first arrival picking.

4.1 Function overview
The first break auto pick-up technology includes three functions: the first break auto pick-up of wave crest, the first break auto pick-up of wave trough and the first break auto pick-up of jump point.

4.2 Design scheme
The first break auto pick method determines the pick trend and finds the first break time point of each data according to the start point and end point selected by the user in the first break segment. Figure 3 shows the flow of realizing automatic pick-up of first break.
4.3 Examples
Figure 4 and figure 5 show the application effect of the actual data. We can see that for the real data, the first break automatic pick-up algorithm has a good pick-up effect.

![Flow chart of first break auto picking.](image)

Figure 3. Flow chart of first break auto picking.

4.3 Examples
Figure 4 and figure 5 show the application effect of the actual data. We can see that for the real data, the first break automatic pick-up algorithm has a good pick-up effect.

![First break pick-up effect of different signal-to-noise ratio of data.](image)

(a) (b)

Figure 4. First break pick-up effect of different signal-to-noise ratio of data.

![Effect display of three different pick modes.](image)

(a) (b) (c)

Figure 5. Effect display of three different pick modes.
(a) is the pick-up peak, (b) is the pick-up take-off point, (c) is the pick-up trough.

5. Conclusion
It can be seen from the actual data processing that the algorithm can identify the first arrival of the peak, the first arrival of the trough and the first arrival of the jump point of the microseismic data. And for the first arrival position that cannot be accurately identified, it can be handled flexibly to ensure that the first arrival time provided to the subsequent positioning program is true and reliable, so as to improve the accuracy of positioning. At the same time, because of the convenience of the operation of the algorithm, it brings convenience to the first pick-up work and improves the work efficiency.
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References
[1] Huang, W., & Wang, R..2018.Random noise attenuation by planar mathematical morphological filtering.Volume 83.01:11-25
[2] D. E. Diller. System and Method for Narrow Beam Scanning Microseismic Monitoring: U.S. Patent Application 13/696,029[P]. 2012-7-6.
[3] Chen, X., Wang, R., Huang, W., & Jiang, Y..2018.Clustering based stress inversion from focal mechanisms in microseismic monitoring of hydrofracturing.Geophysical Journal International.Volume 215.No.3:1887-1899
[4] S. C. Maxwell, L. Bennett, M. Jones, et al. Anisotropic Velocity Modeling For Microseismic Processing: Part 1-Impact of Velocity Model Uncertainty[C]. 2010 SEG Annual Meeting. Society of Exploration Geophysicists, Denver, 2010,400-457.
[5] D. R. Van, B. Fuller, L. Engelbrecht, et al. Seismic anisotropy in microseismic event location analysis[J]. The Leading Edge, 2011, 30(7): 766-770.