

# ON POSSIBILITY OF THE EARTHQUAKE'S CENTER ZONE PREDICTION USING SINGLE INFORMATION MODEL OF ELECTROMAGNETIC RADIATION

**Asadov H.H., Mammadov Sh.H.**

Numerous sums of effects of rocks cracking and random character of exposures of seismical activity lead to statistical nature of forerunners of earthquakes. Particularly, as regard anormal electromagnetic irradiation, it is practically not possible to select most informative frequencies, which should be observed. The optimal azimuth angle of receive of such radiation usually also unknown, which creates additional problems for optimal solution of earthquake center prediction problem. Due to above, it can be concluded, that the system destined for gathering and processing of seismological information of electromagnetic radiation type should guarantee receipt and processing maximal amount of such information. This condition leads us to construct the single informational model of electromagnetic radiation before earthquakes, optimization of which makes it possible to predict the center of earthquakes using informational criteria.

First of all, we should stress out, that the intensity of electromagnetic radiation depends on two factors:

1. Distance between the receiver and center zone of earthquake -  $L$ .
2. Frequency of electromagnetic radiation -  $F$ .

Above dependences in both case expressed by fading of intensity of electromagnetic radiation.

Taking into account above, we propose, that each seismosensor can be characterized in the three – sized space as it shown in figure 1, where the point A characterize any single seismosensor, which located at the distance  $L_A$  from center of earthquake, receives electromagnetic radiation of frequency  $F_A$ , and duration of receipt is  $T_A$ .

Taking into account of above, we can find the signal/noise ratio  $\psi$  of the received signal as

$$\psi = (L, F) = \psi_0 + \frac{\partial \psi}{\partial L} \cdot dL + \frac{\partial \psi}{\partial F} \cdot dF, \quad (1)$$

where  $\psi_0 = \psi(L = L_0; F = F_0)$ .

Now considering the whole net of seismosensors consisting of  $n$  ones, and taking into account, that optimal system of processing is designed in such a manner, that it receives signals of duration  $T_i$ ,  $i = \overline{1, n}$ , where value of  $T_i$  increases depending on  $i$ . In this case, the amount of information, which is gathered from all  $n$  sensors can be assessed as follows

$$\Phi = \sum_{i=1}^n \frac{T_i}{\Delta T} \log_2 \left[ \psi_0 + \frac{\partial \psi}{\partial L} dL + \frac{\partial \psi}{\partial F} dF + 1 \right]. \quad (2)$$

Using formula (2) we can solve two type of optimization task, which allow us to form two methods for prediction of earthquakes center using maximal informational criteria.

1. Receive of electromagnetic radiation at the same frequency.
2. Receive of electromagnetic radiation at the same distance used for confirmation of found center of earthquake on first method.

In the first case, the ratio of signal / noise  $\psi$  in the channel of propagation of Low – frequency electromagnetic radiation from the source of these signals as far as receiver in the first approximation can be found as

$$\psi = \psi_0 + \psi' L,$$

where:  $\psi_0 = \psi(L=0)$ ;  $\psi' = \frac{d\psi}{dL}$ .

During the whole period of information retrieval, total amount of gained information can be found as

$$M_0 = \sum_{i=1}^n M_i = \sum_{i=1}^n \frac{T_i}{\Delta t} \log_2 (\psi_0 + \omega' L_i + 1),$$

where  $T_i$  - duration of information retrieval from the sensor numbered as  $i$ .

Next we use a limitation condition, formed as a result of fixed construction of the set of sensors, i.e.

$$\sum_{i=1}^n (\psi_0 + \psi' L_i + 1) = \text{const}.$$

Taking into account above, the functional of effectiveness can be formed as

$$\Phi = \int_0^{T_{max}} \left[ \frac{T}{\Delta t} \log_2 (\psi_0 + \psi' L + 1) + \lambda (\psi_0 + \psi' L + 1) \right] dT,$$

where  $\lambda$  is L'Agrange multiplier.

According to the principle of optimal lowering of dimensionality [2], we should find such type of optimal function  $L = \varphi(T)$  which would lead the functional of effectiveness to its maximal value.

Solution of above maximization task using Euler's formula gives us following type of said function

$$L = \frac{\psi_0 + 1}{|\psi'|} - \frac{T \psi_0}{T_{max} |\psi'|}. \quad (3)$$

As a result, we have possibility to carry out an adaptive control of seismosensors, i.e. all system of gathering and processing of seismic information.

On the basis of above result we can propose a new method of informational forecasting of place of expected earthquakes. We assume that seismosensors are placed on the territory with high seismic risk. In order to forecast the place of earthquake we should designate set of values  $\{L_i\}$ , and set of values  $\{T_i\}$ , where dependance between  $L_i$  and  $T_i$  should be in line with formula (3), which guarantee maximum value of total information gathered from seismosensors. Selected three seismosensors  $S_1, S_2, S_3$  will be commutated during time period  $T_i$  determined by formula (3). Under above conditions computer should detect maximum amount of information, if the point  $A$  is actually the center of expected earthquake. Selected set of sensors should be moved along the territory in order to detect maximum of gathered information. More strictly no sensors, but selector contour of three sensors should be moved over the territory via fixed set of sensors and movement of this

contour should be stopped if maximal amount of information is reached. Then using known set of  $L_i$ , we can find needed placecenter of earthquake.

Receive of electromagnetic radiation at the same distance used for confirmation of found center of the earthquake on first method.

In this case, the ratio signal/noise  $\psi$  in the channel of propagation of low – frequency electromagnetic radiation from the source of these signals as far as receiver in the first approximation can be found as

$$\psi = \psi_0 + \psi'_F \cdot F, \quad (4)$$

where  $\psi'_F = \frac{\partial \psi}{\partial F}$ ;  $F$  - frequency of electromagnetic radiation.

During the whole period of information retrieval total amount of gathered information can be found as

$$M_0 = \sum_{i=1}^n M_i = \sum_{i=1}^n \frac{T_i}{\Delta t} \log_2 (\psi_{01} + \psi'_F \cdot F + 1), \quad (5)$$

where  $T_i$  - duration of information retrieval from the sensor numbered as  $i$ .

Then we use a limitation condition

$$\sum_{i=1}^n (\psi_{01} + \psi'_F \cdot F_i + 1) = \text{const}$$

or

$$\sum_{i=1}^n F_i = \text{const}. \quad (6)$$

A limitation condition (6) means, that band of reasonably received frequencies is limited.

Taking into account of (5) and (6) we can form the functional of effectiveness as follows:

$$\Phi = \int_0^{T_{\max}} \left[ \frac{T}{\Delta T} \log_2 (\psi_{01} + \psi'_F \cdot F + 1) + \lambda (\psi_{01} + \psi'_F \cdot F + 1) \right] dT, \quad (7)$$

where  $T$  - time of information retrieval;  $\lambda$  - multiplier of L'Agrange.

According to the principle of optimal lowering of dimensionality [2], we should find such type of optimal function  $L = \varphi(T)$  which would lead the functional of effectiveness (7) to its maximal value.

Solution of above optimization task using Euler's formula gives us following type of said function

$$F = \varphi(T) = \frac{\psi_0 + 1}{|\psi'_F|} - \frac{T \cdot \psi_0}{T_{\max} |\psi'_F|} \quad (8)$$

As a result we obtain the possibility to carry out an adaptive control of seismosensors, i.e. whole system of gathering and processing of seismic information. This does mean, that sensor with lowest frequency of received signal should be examined during uppermost time period in order to reach maximal efficiency of the system.

On the basis of above result we can propose a new second method for informational forecasting of center of expected earthquakes. We assume that seismosensors are placed on the territory with high seismic risk, forming a rectangular Net (figure 8).

In order to forecast the place of earthquake we should designate a set of values  $\{F_i\}; i = \overline{1, n}$ , and set of values  $\{T_i\}; i = \overline{1, n}$ , where dependence between  $F_i$  and  $T_i$  should be in line with formula (8), which guarantees reaching of maximum value of total information, gathered from seismosensors. Here we should note, that each sensor consists of  $n$  receiver with fixed frequency  $\{F_i\}; i = \overline{1, n}$ .

Hence, each sensor is compound on  $n$  number of receiver and makes it possible to receive in the frequency band  $\{F_1, F_2, \dots, F_n\}$ .

Selected contour of four seismosensors (in figure 3 they are  $S_1, S_2, S_4, S_5$ ) will be moved across the high rise territory – area of placement of sensors, and the movement of the contour should be stopped in the point, where the estimated value of functional of effectiveness reaches a maximal value. Such assessment can be realized using computer, which should also control movement of the contour of sensors.

It should be noted that the above second method is used for confirmation of place of earthquake center, determined by the first method.

On the basis of two above methods we can formulate single general algorithm for prediction of earthquake's center zone (figure 4), which consists of following steps:

1. Using of fixed rectangular net of seismosensors for determination of center zone on first method.
2. Construction of non – rectangular mobile micro – net consisting of three or four sensons located at the same distance from found center zone.
3. Application of the second method.
4. Confirmation, that two results on points 1 and 3 are same.

Taking into consideration of above we conclude, that a proposed new informational method of forecasting of earthquake center zone may increase effectiveness of measures taken for global forecasting of seismic events.

### **References**

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2. Asadov H.H. The Principle of dimensionality lowering for synthesis and optimization of a subclass of measuring systems with fading signals on example of remote sensing systems”. Journal: Devices and Systems. Control, Testing, Diagnostics (Published in Moscow) 2003, No. 8, p, 60 – 67.

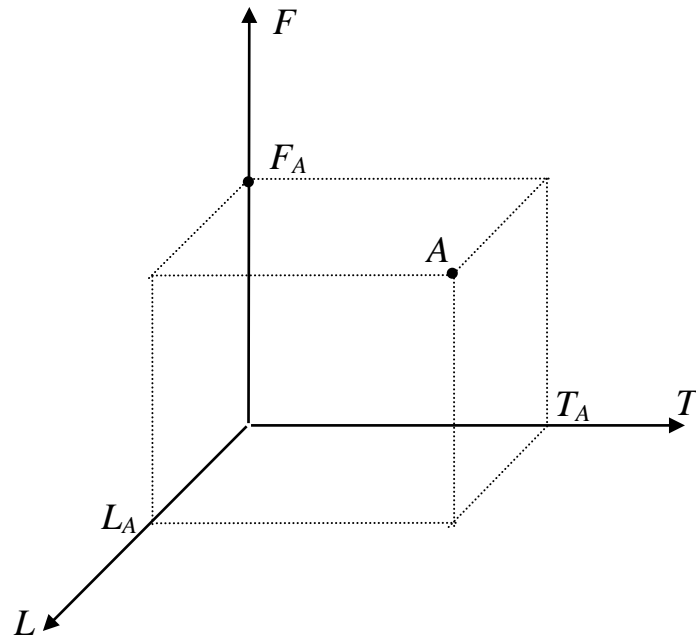


Figure 1: Three – sized interpretation on single seismosensor.

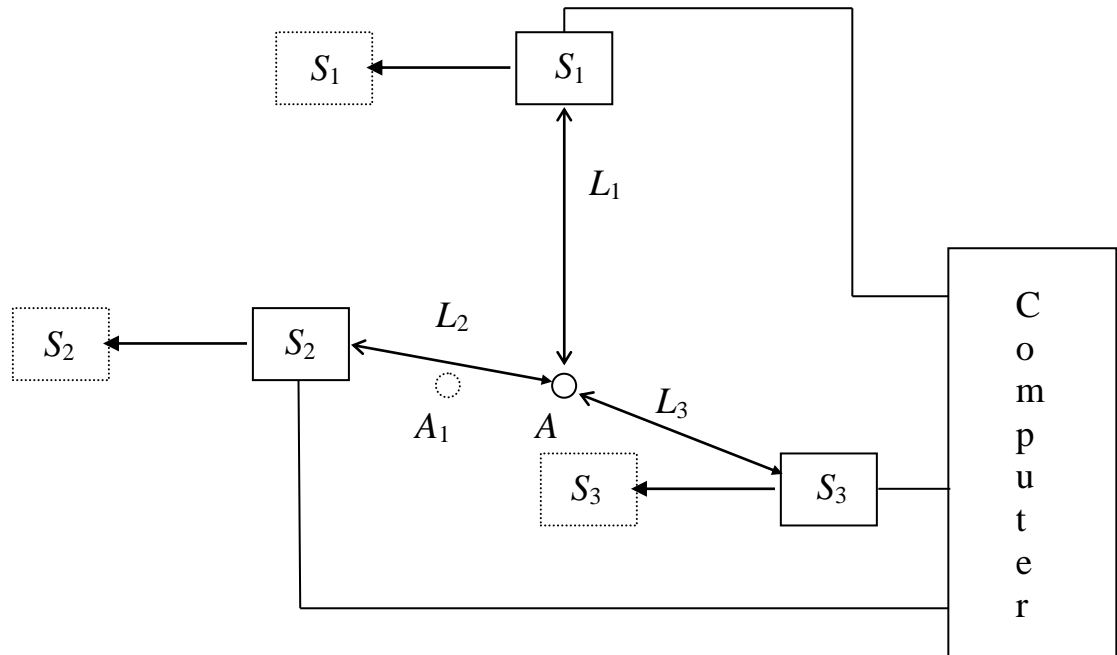


Figure 2: Explanation of method of forecasting.



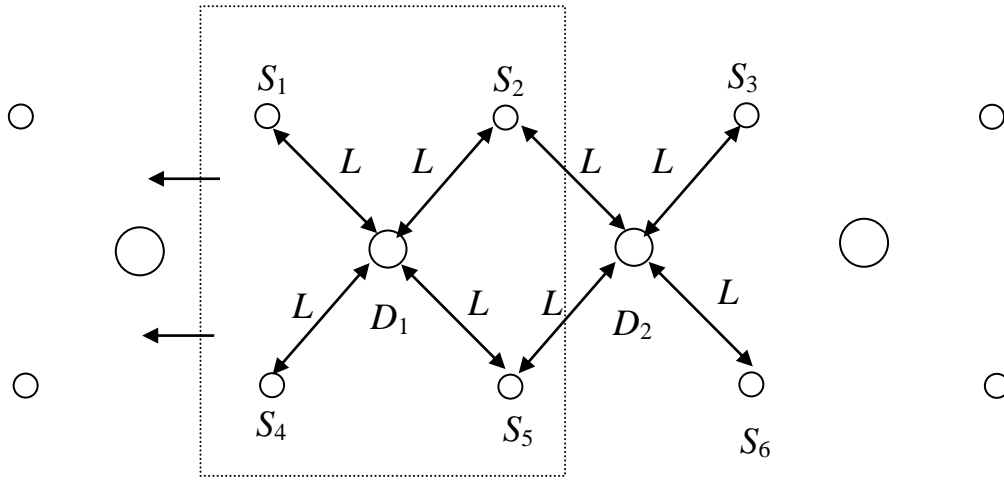


Figure 3: Movement of the contour across the not of sensors.

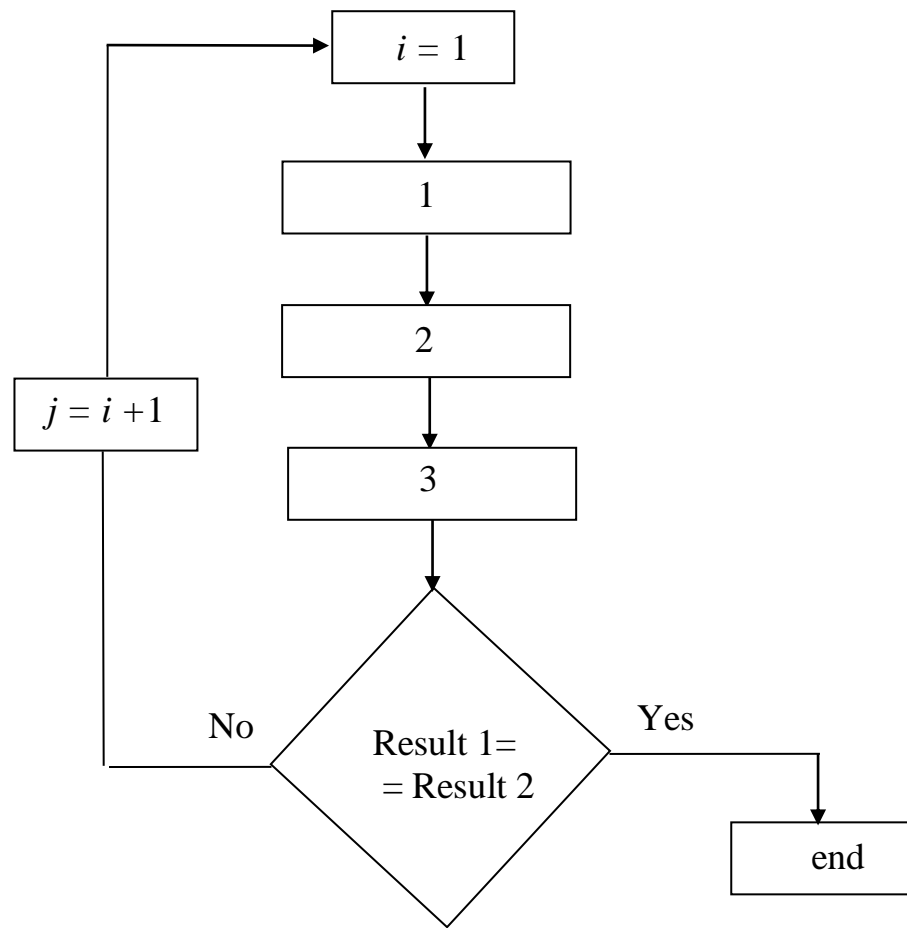


Figure 4. Chart – scheme of algorithm.