Resistivity-depth imaging with the airborne transient electromagnetic method based on an artificial neural network

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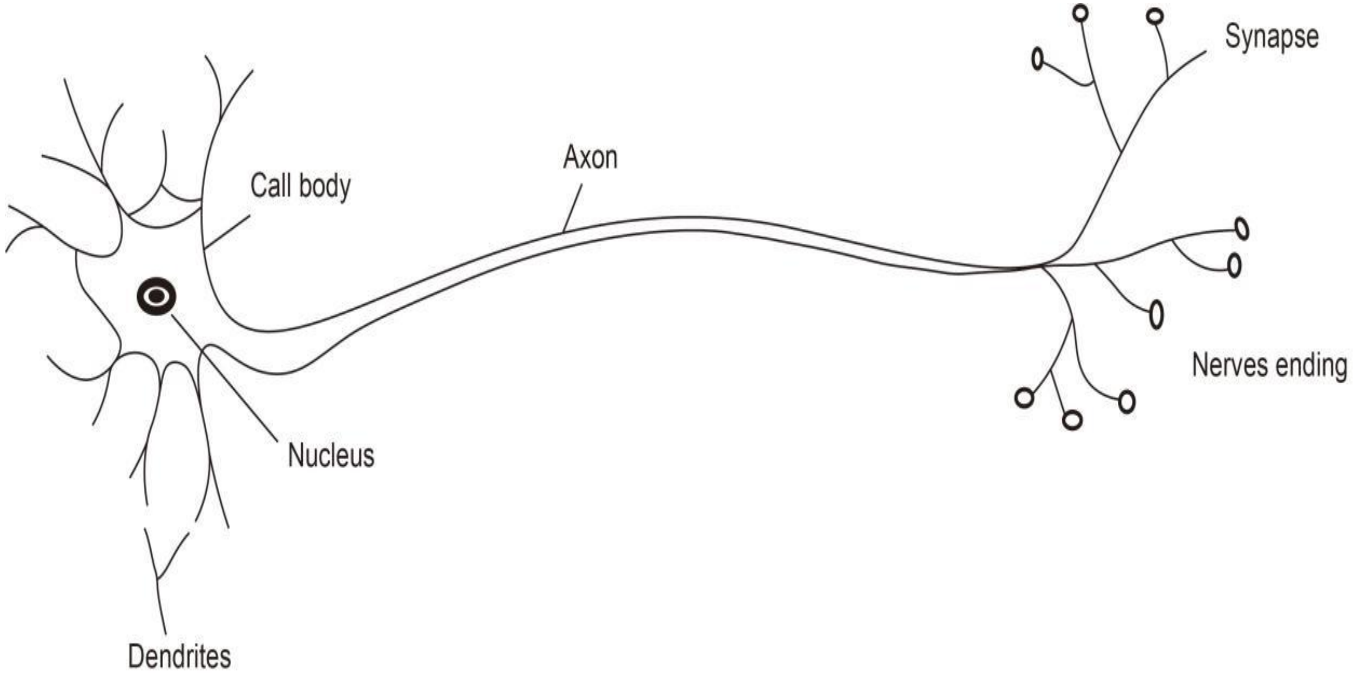
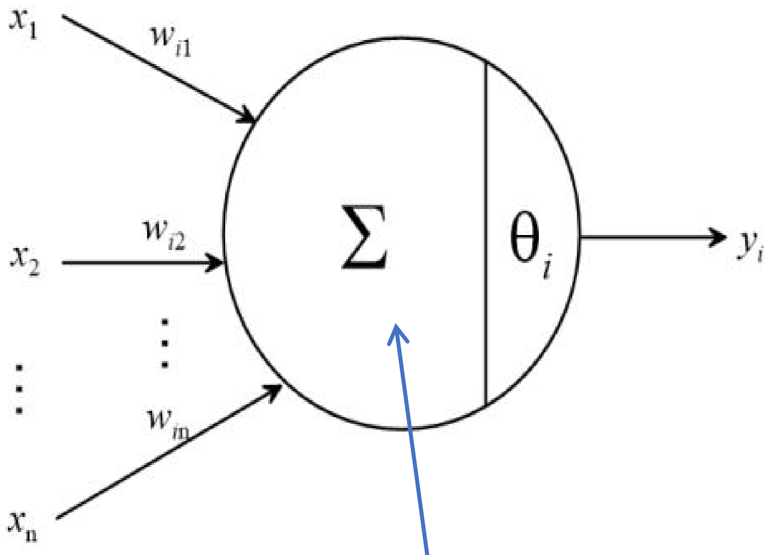
- Theory
- Theoretical model testing
- Field data example
- Conclusion

Artificial neural network



Abstract



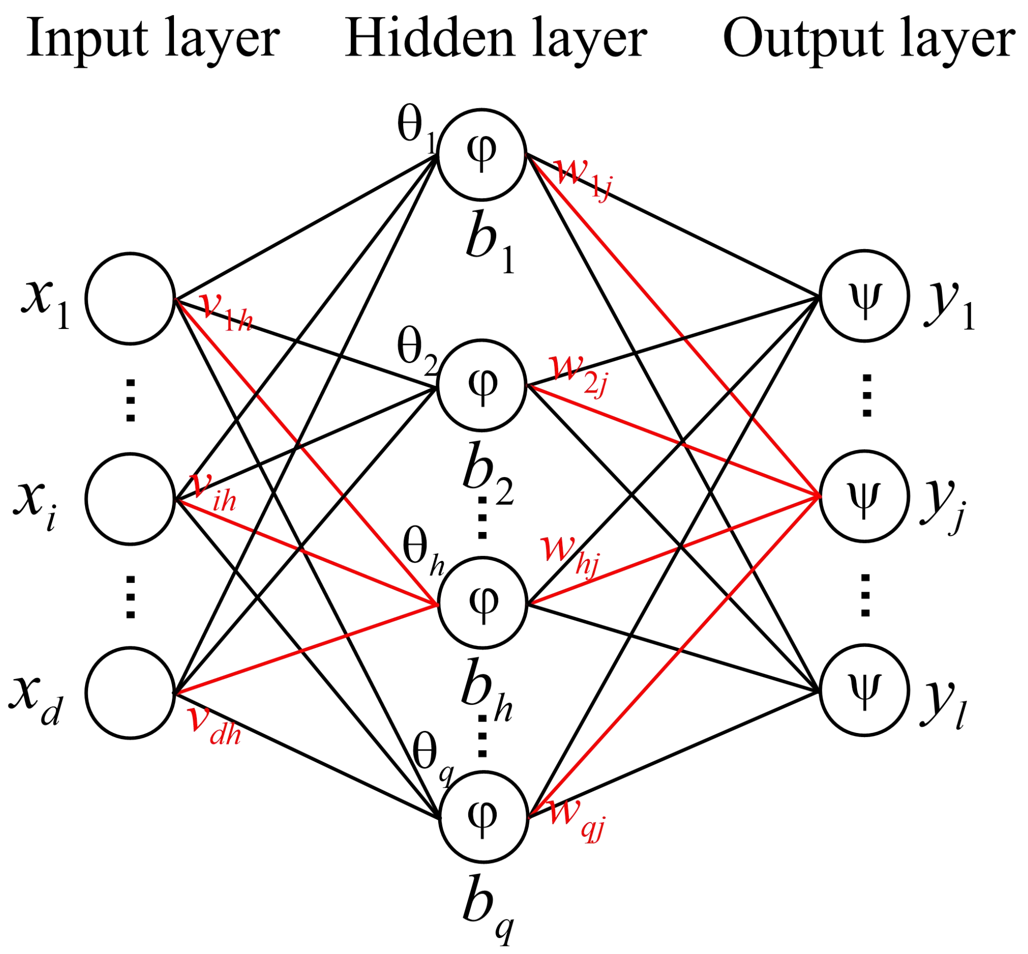
ture

The brain is the concentrated on intelligent development in the biological world, and the biological nervous system is composed of myriad cells and tissues with a high degree of organization .

The basic unit of a biological neural network includes two parts: a cell body and extensions

"Function fitting"

BP neural network structure



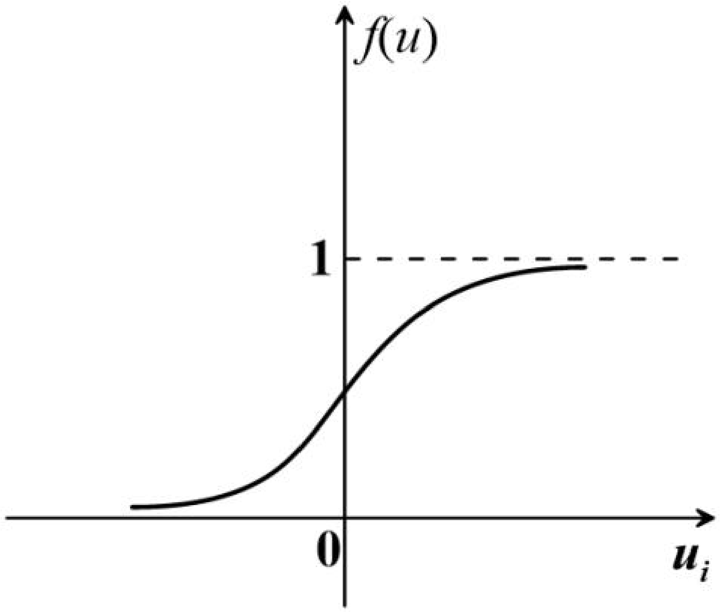
Three-layer BP neural network structure diagram

the input signal → $\alpha_h = \sum_{i=1}^{d} v_{ih} x_i$

input signal of theneuron in the output layer → $\beta_j = \sum_{h=1}^{q} w_{hj} b_h$

expected output of the network → $\hat{y}_k = \left(\beta_j - \theta_j\right)$

BP neural network transfer functions

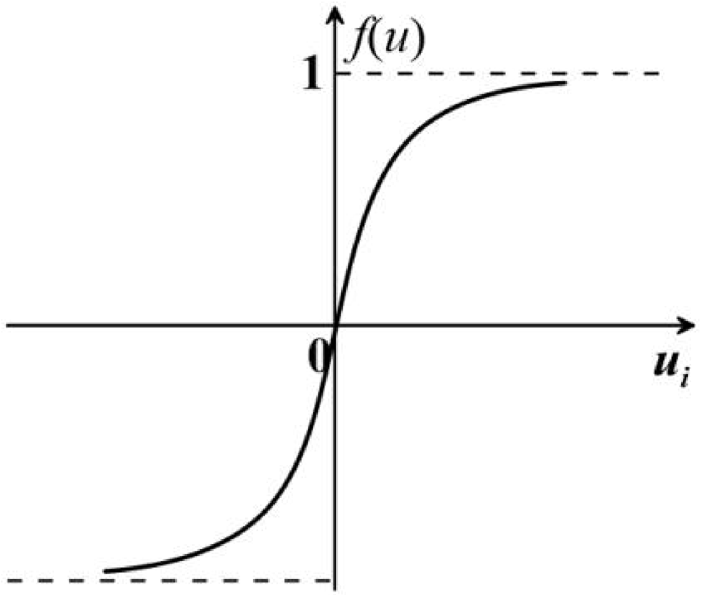


$$f(u_i) = \frac{1}{1+e^{-\alpha u_i}} \qquad \alpha > 0, 0 < f(u_i) < 1$$

Unipolar function S-type

Sigmoid-type fucntion

$$f'(x) = f(x)(1 - f(x))$$

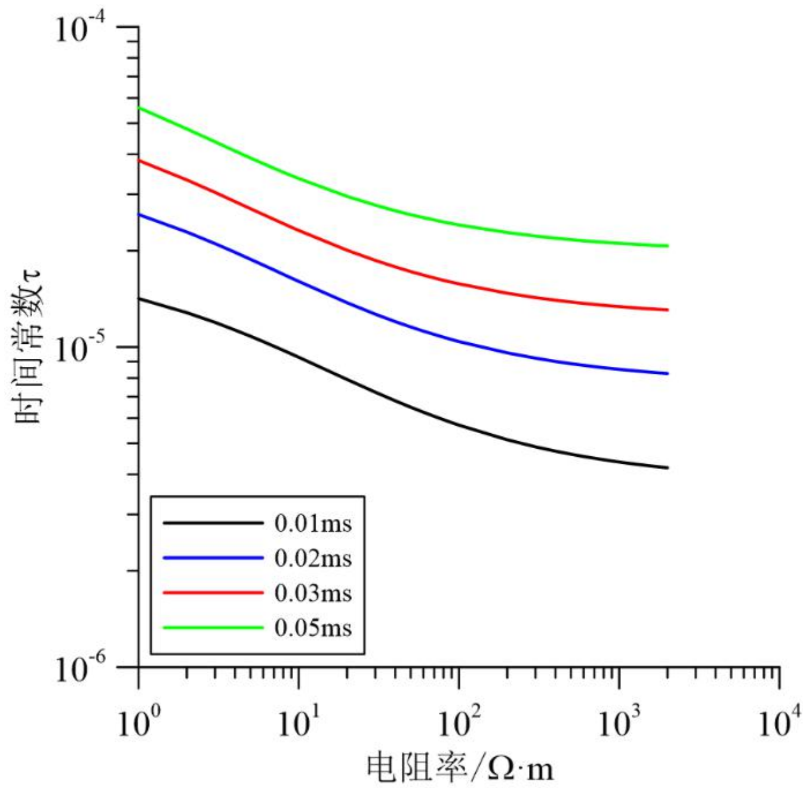


$$f(u_i) = \frac{1-e^{-\alpha u_i}}{1+e^{-\alpha u_i}} \qquad \alpha > 0, -1 < f(u_i) < 1$$

Hyperbolic tangent function S-type

BP neural network parameters

Huang(2008)



The relationship of τ and p_s

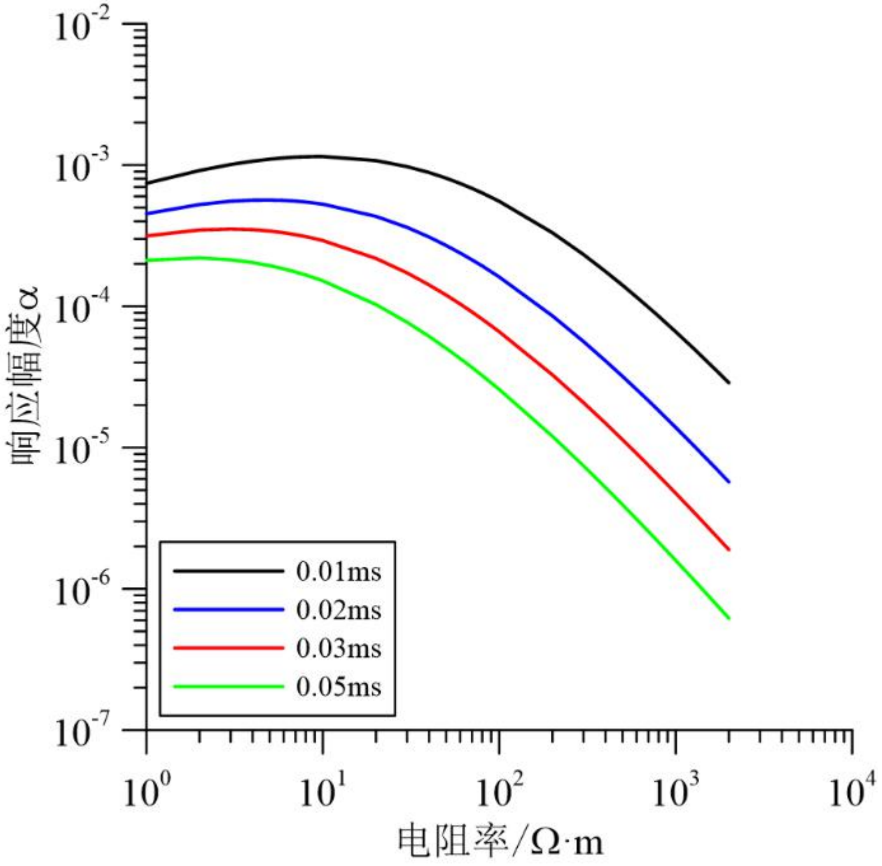
$$\begin{cases} \tau_i = \dfrac{t_{i+k} - t_i}{\ln\left(A_i / A_{i+k}\right)} \\ \alpha_i = \sqrt{A_i^2 + A_{i+k}^2} \end{cases}$$

$$\alpha_i \quad \tau_i \quad h_i$$

the input for the BP neural network

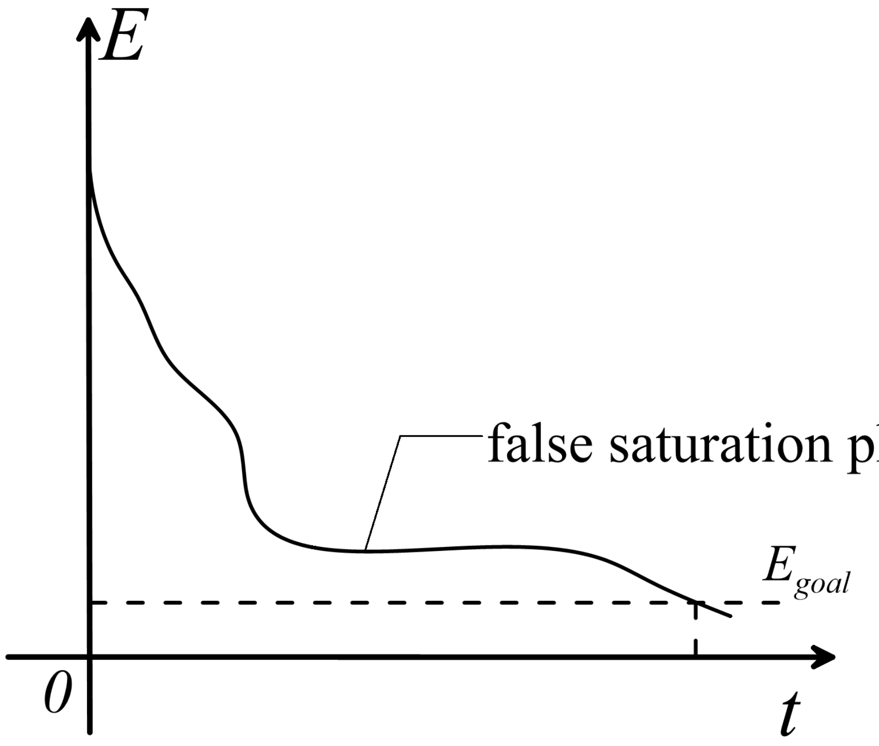
$$\rho_i$$

the output for the BP neural network



The relationship of α and p_s

Error analysis of BP neural network



Error function:

$$E_k = \frac{1}{2}\sum_{j=1}^{l}\left(\hat{y}_j^k - y_j^k\right)^2$$

1) improper initial weighting

2) unreasonable weight correction,

3) poor independence of samples.

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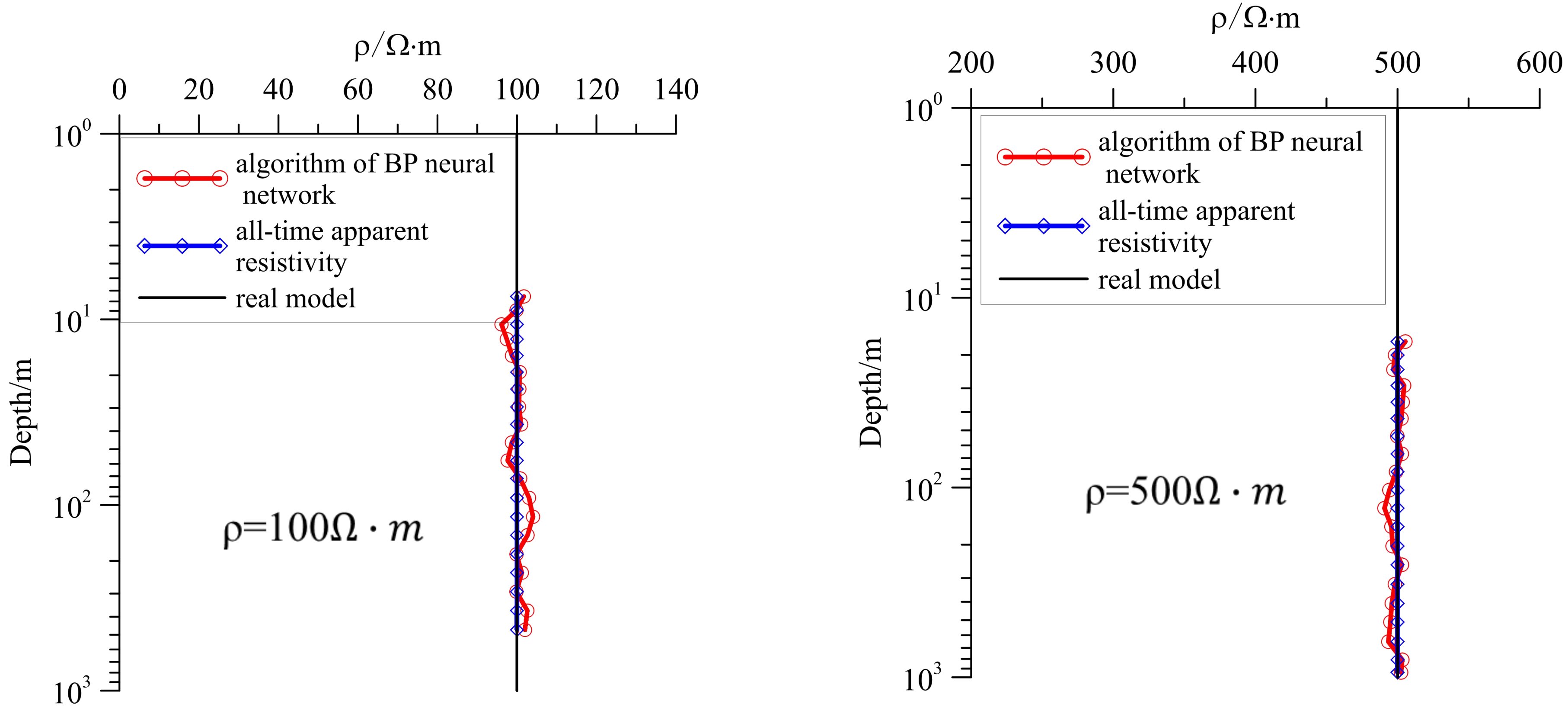
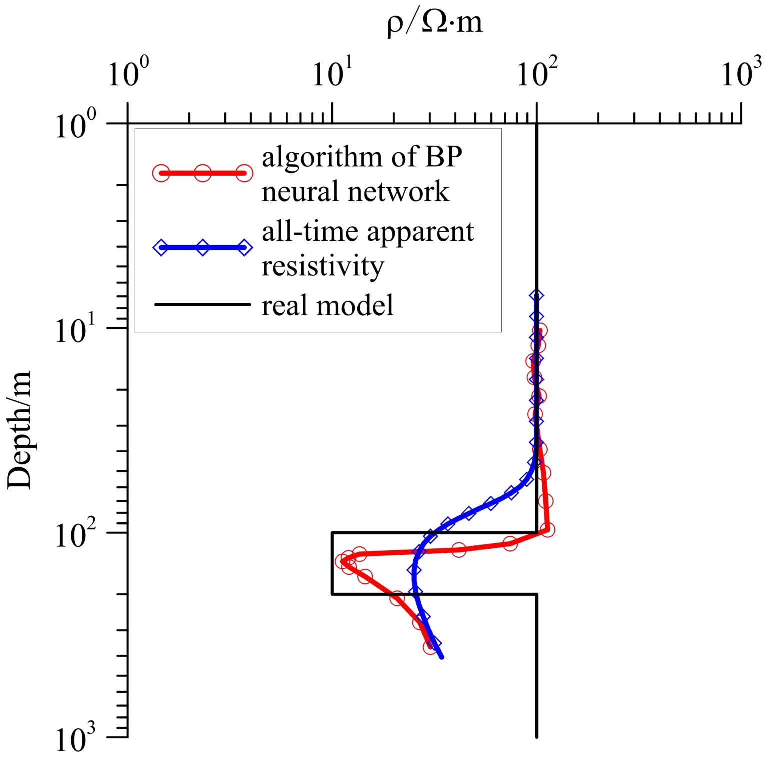
the results in the homogeneous half space

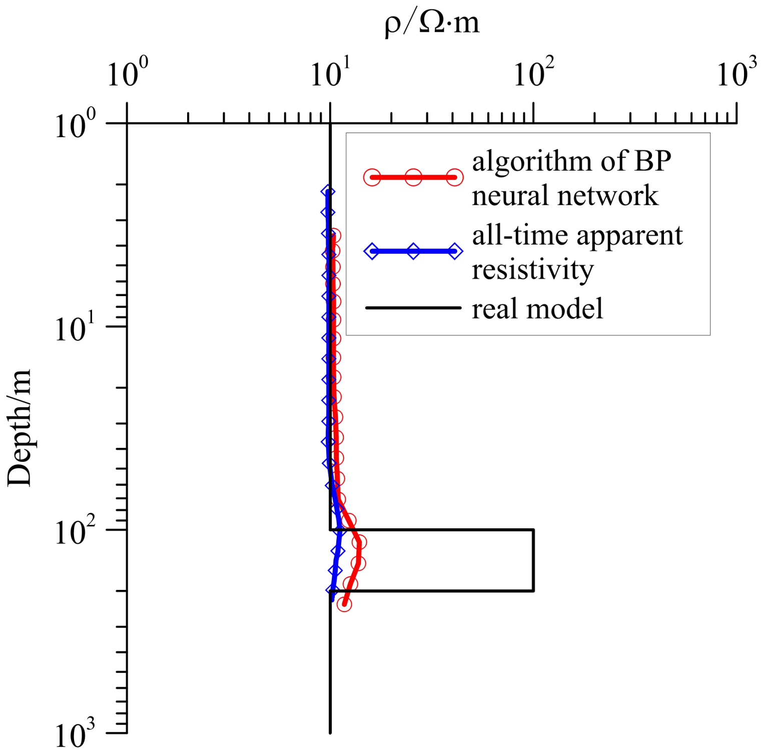


Results of modeling homogeneous half space

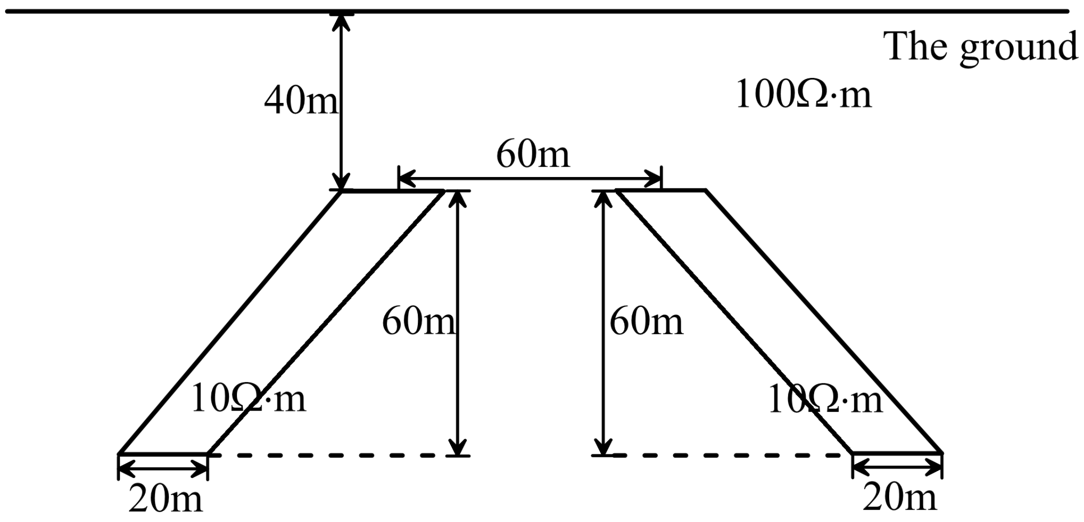
the results in 1D medium

Model	depth (m)	resistivity ($\Omega \cdot m$)	Model	depth (m)	resistivity ($\Omega \cdot m$)
H-type	100	100	K-type	100	10
	100	10		100	100
	INF	100		INF	10

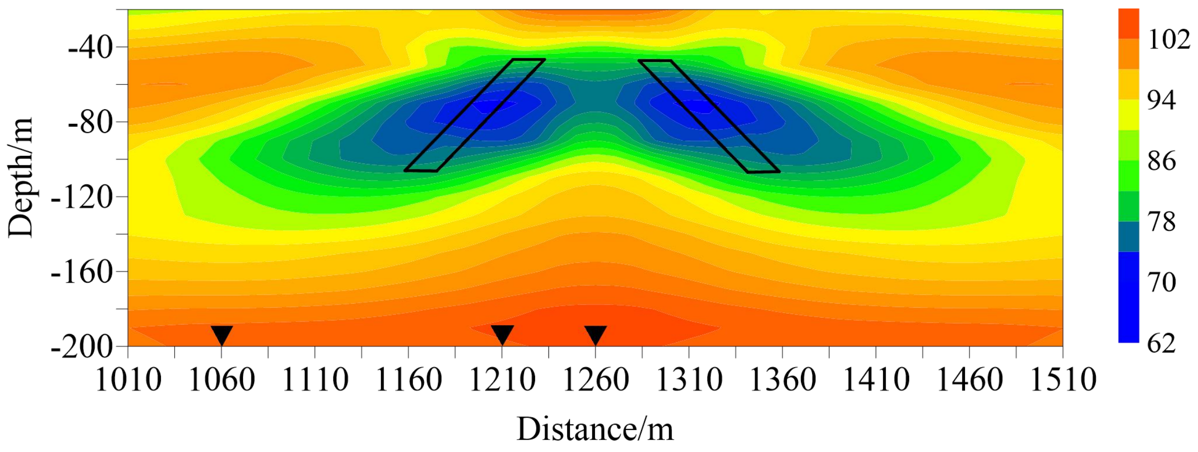




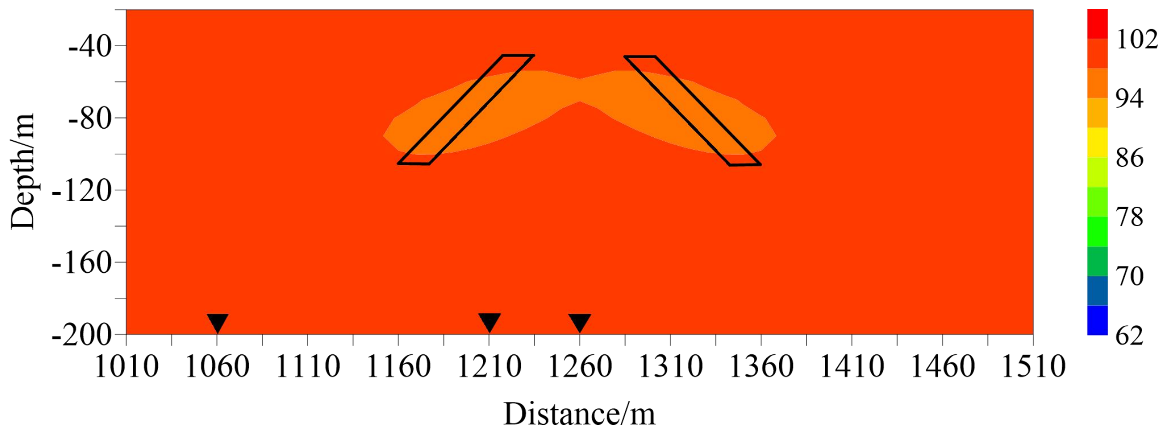
the results in 3D medium



Model Scheme diagram



Quasi-resistivity BP Nuneur network



Full-time apparent resistivity

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Parameters of geoelectrics and flying

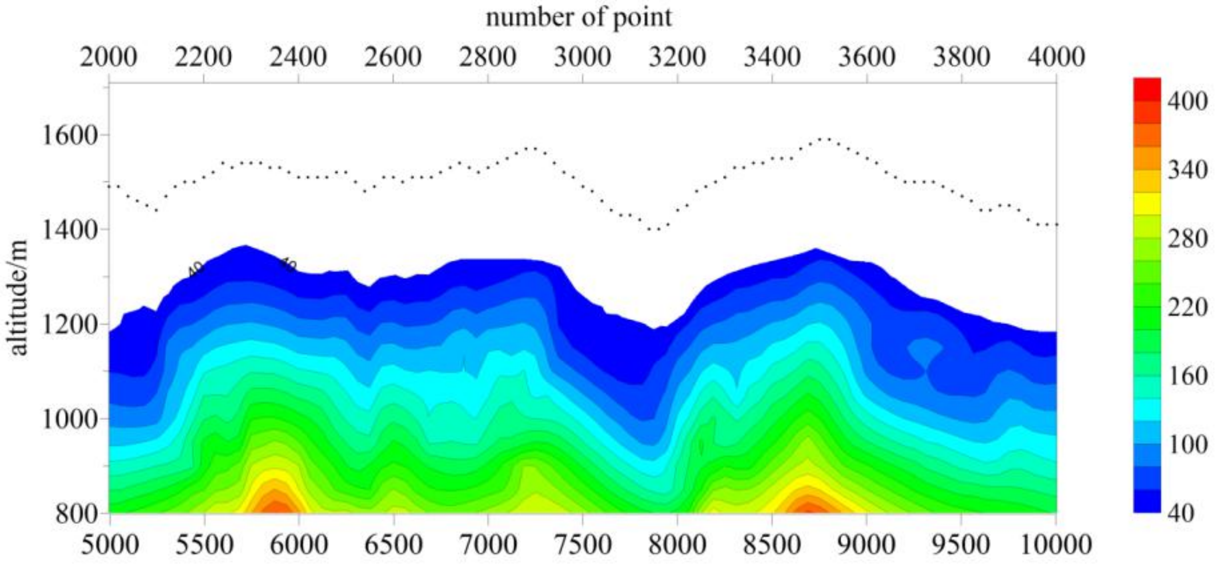
Transmitter parameters		Receiver parameters	
Loop radius	6.25 m	Waveform	Triangular wave
Numbers of turns	5	Flight hight	30~270 m
Current	400.06 A	Sampling time	2.2 ms~4.5 ms

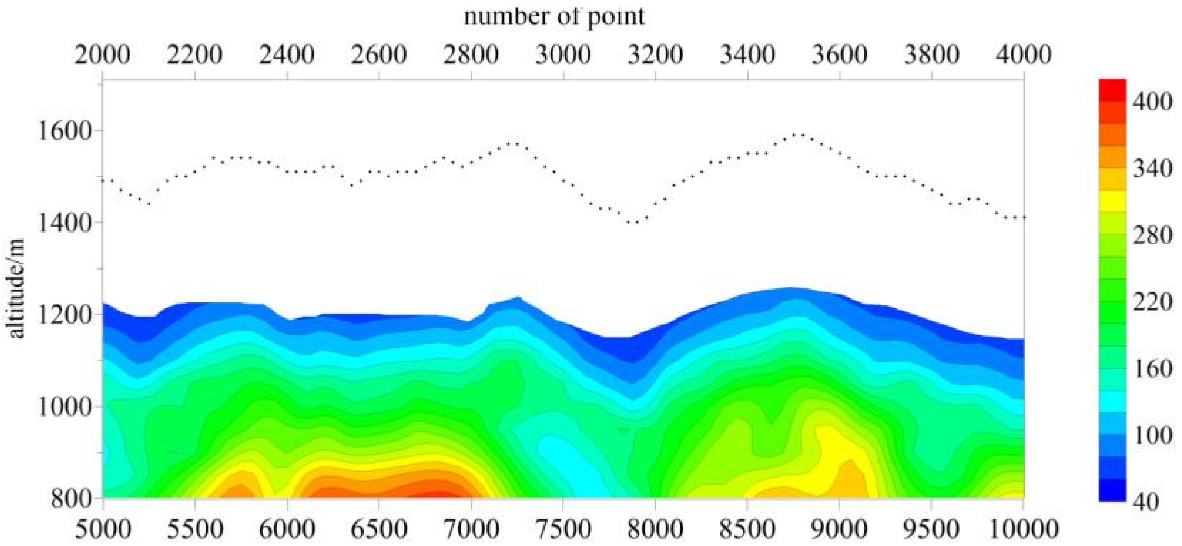
Electrical parameters of rocks and ores in Qinling area

Mineral name	Sample number	Resistivity (Ω•m)	Mineral name	Sample number	Resistivity (Ω•m)
Granite gneiss	30	647.78	Biotite plagio-gneiss	30	540.43
Granite pegmatite	30	259.5	Biotite plagio-gneiss (with Pb ore)	30	335.8
granitic pegmatite vein, long quartz vein	30	177.9	granitic gneiss (with Pb ore)	30	381.2
amphibole plagiogneiss	30	532.51	migmatite	30	3095.7

The results of calculating

Image of all-time apparent resistivity





The quasi-resistivity calculated by BP neural networks slightly larger than the results from the all-time apparent resistivity algorithm, which is consistent with the imaging results of the theoretical model. Similarly, the quasi-resistivity isocline from the BP neural network has several mutation bands, which are also caused by the uniform half-space model of the training sample set.

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1) A BP neural network was combined with airborne TEM; the results show that it was very effective for predicting subsurface geological structures.

2) The imaging results of the theoretical model show that the BP neural network method a better approximates the low-resistivity layer and is closer to the resistivity of the real model.

3) The data from a typical forest-covered area in Qinlin area were processed and interpreted.

4) The applicability and effectiveness of an artificial neural network algorithm in solving airborne TEM problems are verified.

Thank you

for your attention!