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Rock Cover Electromagnetic Target Search: A Drone Method

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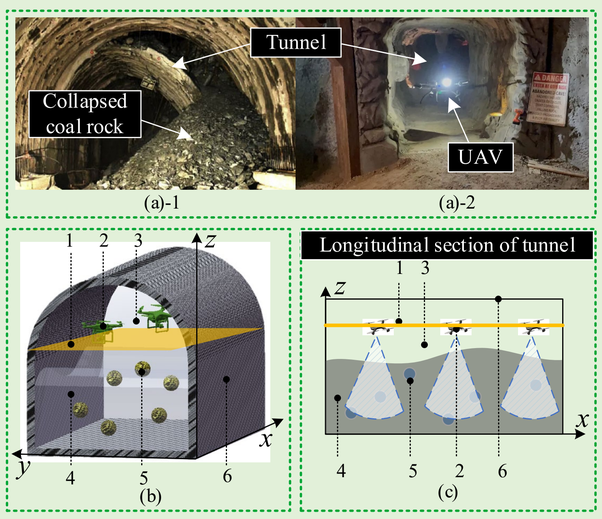
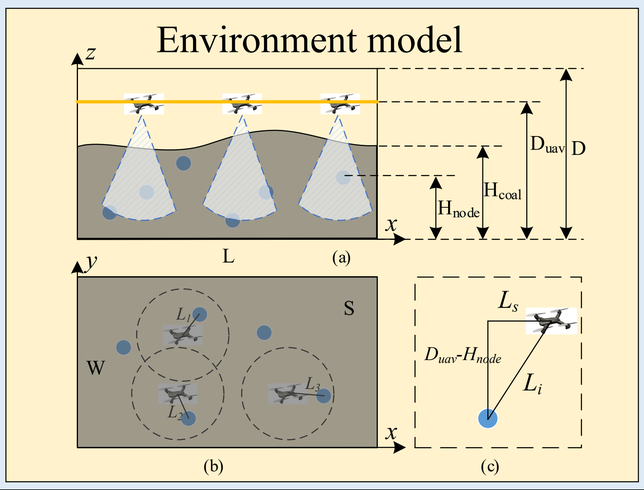
Abstract: The search for electromagnetic targets that residual after a tunnel disaster is crucial for network construction. Therefore, This paper proposes a novel UAV electromagnetic target search method for underground tunnel accident search and rescue scenarios. The RSSI of electromagnetic targets under coal and rock cover is incorporated into the probability update formula to enhance the search process. Furthermore, the proposed search method are compared with greedy search, random search, and parallel search in four different task scenarios.

Problem Description



The electromagnetic target is covered by rock and coal following the tunnel accident in the coal mine, and the UAV searches the accident site for the electromagnetic target. The residual electromagnetic target is located and connected to enable the establishment of an emergency communication network in the accident site.

Modeling



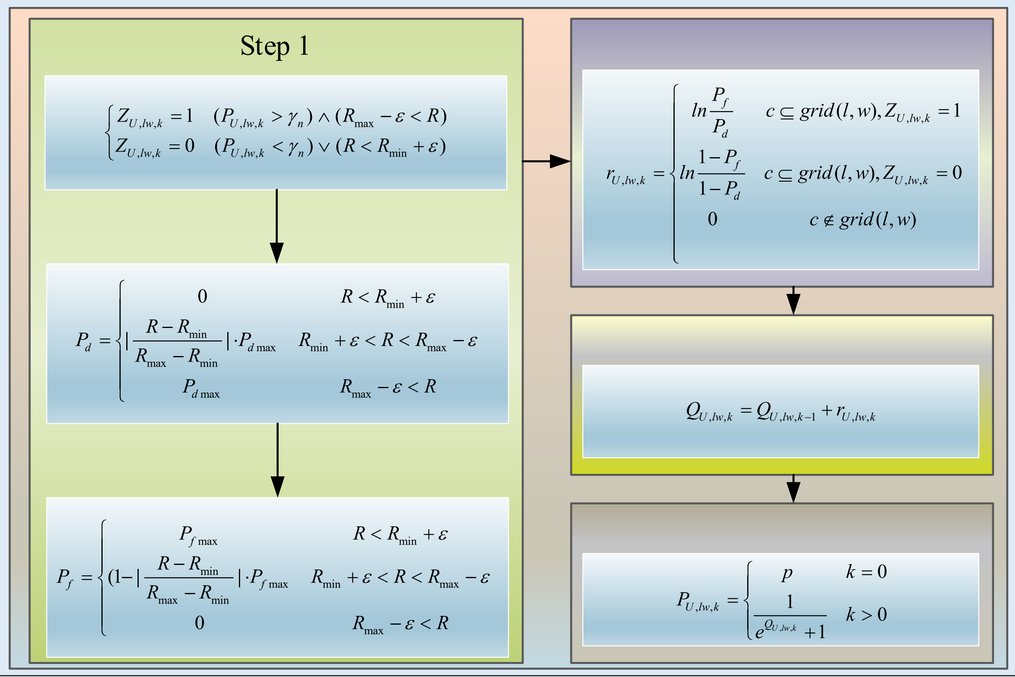
Coal-rock cover model

$$h_{coal}(x)=\frac{1}{\sqrt{2\pi}}e^{-\frac{(x-\frac{\alpha U_{\max}}{2})^2}{2}}$$

Communication model

$$RSSI=RSSI_0-10p\lg\frac{d}{d_0}+q$$

$$p=-0.2871+0.425d-0.0286d^2+5.8354\times10^{-4}d^3$$



$$\begin{cases}Z_{U,lw,k}=1 & (P_{U,lw,k}>\gamma_n)\wedge(R_{\max}-\varepsilon<R)\\ Z_{U,lw,k}=0 & (P_{U,lw,k}<\gamma_n)\vee(R<R_{\min}+\varepsilon)\end{cases}$$

$$P_d=\begin{cases}0 & R<R_{\min}+\varepsilon\\ |\frac{R-R_{\min}}{R_{\max}-R_{\min}}|\cdot P_{d\max} & R_{\min}+\varepsilon<R<R_{\max}-\varepsilon\\ P_{d\max} & R_{\max}-\varepsilon<R\end{cases}$$

$$P_f=\begin{cases}P_{f\max} & R<R_{\min}+\varepsilon\\ (1-|\frac{R-R_{\min}}{R_{\max}-R_{\min}}|)\cdot P_{f\max} & R_{\min}+\varepsilon<R<R_{\max}-\varepsilon\\ 0 & R_{\max}-\varepsilon<R\end{cases}$$

$$r_{U,lw,k}=\begin{cases}ln\frac{P_f}{P_d} & c\subseteq grid(l,w),Z_{U,lw,k}=1\\ ln\frac{1-P_f}{1-P_d} & c\subseteq grid(l,w),Z_{U,lw,k}=0\\ 0 & c\notin grid(l,w)\end{cases}$$

$$Q_{U,lw,k}=Q_{U,lw,k-1}+r_{U,lw,k}$$

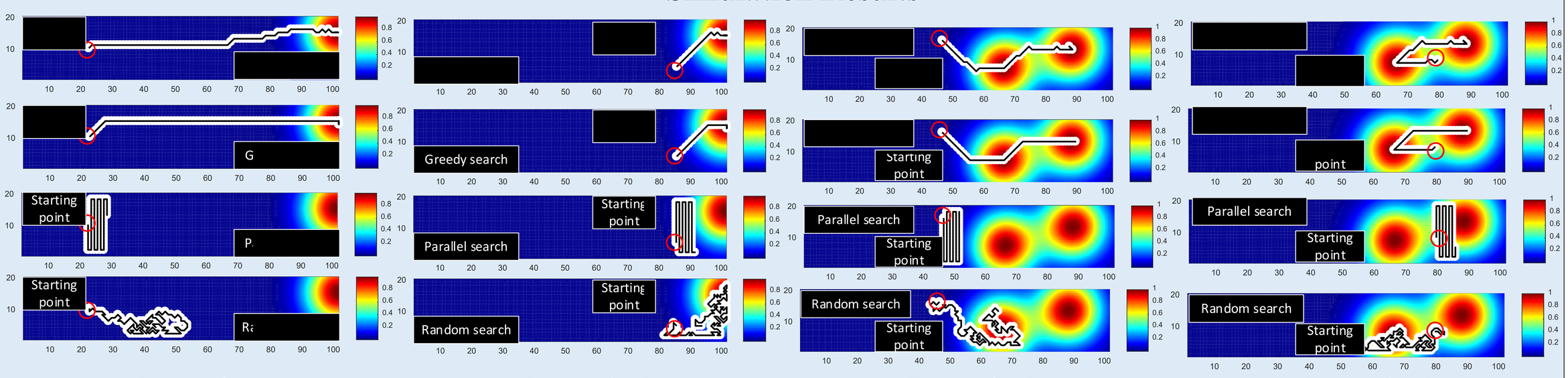
$$P_{U,lw,k}=\begin{cases}p & k=0\\ \frac{1}{e^{Q_{U,lw,k}}+1} & k>0\end{cases}$$

← **Probability update**

Scenario setting

Based on the severity of the accident, determine the number and distribution of residual electromagnetic targets. Combine this with the starting point of the UAV's search to divide into four different scenarios.

Simulation Results



Scenario 1 Scenario 2 Scenario 3 Scenario 4

Conclusion

For emergency rescue search, search efficiency and grid coverage are equally important. Therefore, the search pattern based on signals and probabilities can guide UAV to weigh the influence of probabilities and RSSI when making decisions, thereby exploring more unknown areas.