Stochastic Coverage in Heterogeneous Sensor Networks


The Coverage Problem in Sensor Networks

One of the primary tasks of sensor networks is to monitor a Field of Interest (FoI). The coverage problem is to quantify how well the FoI is monitored. While several metrics have been proposed for measuring the quality of monitoring, we consider the fraction of the FoI observed by at least \( k \) sensors when \( N \) sensors are deployed to monitor the FoI.

The Coverage Problem under Stochastic Deployment

**Network Model**

- **Field of Interest (FoI) \( A_0 \):** The planar field we want to monitor. \( A_0 \) has area \( F_0 \) and perimeter \( L_0 \) (\( A_0 \) is bounded)
- **Sensor Deployment:** \( N \) sensors deployed according to a distribution \( Y(A_0) \)
- **Sensing Area \( A_i \):** Each sensor has a sensing area \( A_i \) of size \( F_i \) and perimeter \( L_i \). \( A_i \) have any arbitrary shape

**Stochastic Coverage Problem (SCP):** Given a FoI \( A_0 \) sensed by \( N \) sensors deployed in the plane according to \( Y(A_0) \), compute the fraction \( f_r(A_0) \) sensed by at least \( k \) sensors.

**Set Intersection Problem (SIP):** Given a fixed closed set \( S_0 \) and \( N \) sets deployed according to \( Y(S_0) \), compute the fraction of \( S_0 \) where at least \( k \) sets intersect, \( k \leq N \).

**Stochastic Coverage Problem**

- FoI \( A_0 \)
- Sensor deployment \( Y(A_0) \)
- Sensing area \( A_i \)

**Mapping**

**Set Intersection Problem**

- Fixed closed set \( S_0 \)
- Sets deployed according to \( Y(S_0) \)
- Set \( S_i \) with size \( F_i \) and perimeter \( L_i \)

**Fraction of \( A_0 \) \( k \)-covered**

\[
f_r(A_0) = \begin{cases} 
1 & k = 0, \\
1 - \sum_{l=0}^{k-1} \frac{\prod_{j=1}^{N} (2\pi F_{T(j,i,j)}) \prod_{s=1}^{N-l} (2\pi F_0 + L_0 L_{G(i,s)})}{\prod_{r=1}^{N} (2\pi (F_0 + F_r) + L_0 L_r)} & k \geq 1.
\end{cases}
\]

**Selected Publications**

- Loukas Lazos and Radha Poovendran, *Stochastic Coverage in Heterogeneous Sensor Networks*, submitted to Transactions on Sensor Networks (TOSN) (submission date: December 2005)

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