Adaptive Sampling Strategies for Environmental Sensor Networks

Mémoire

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Résumé

Les réseaux de capteurs environnementaux échantillonnent souvent à intervalle fixe, ce qui gaspille de l'énergie lorsque les conditions surveillées changent lentement. Ce mémoire propose une stratégie d'échantillonnage adaptatif qui ajuste la fréquence de mesure selon la variabilité récente du signal, prolongeant la durée de vie de la batterie sans perte notable de fidélité des données.

Abstract

Environmental sensor networks often sample at a fixed interval, which wastes energy when monitored conditions change slowly. This thesis proposes an adaptive sampling strategy that adjusts measurement frequency based on recent signal variability, extending battery life without a noticeable loss of data fidelity. We evaluate the strategy on three deployed sensor networks and show that it reduces energy consumption substantially relative to fixed-interval sampling, at a comparable reconstruction error.

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Avant-propos

This thesis is written in English with the permission of the graduate program, per the program's language policy. All experimental work and analysis presented here are the author's own.

Chapter 1

Introduction

Battery-powered environmental sensor networks are typically deployed for months or years at a time, which makes energy efficiency a first-order design constraint. Fixed-interval sampling is simple to implement but wastes energy whenever the monitored quantity changes slowly relative to the sampling rate (Alippi et al., 2008).

1.1 Motivation

Adaptive sampling schemes adjust the measurement interval based on observed signal behaviour, sampling more frequently when the signal is changing quickly and less frequently when it is stable (Jain et al., 2004). Prior work has largely evaluated such schemes in simulation rather than on real long-term deployments.

1.2 Contributions

This thesis makes the following contributions:

- An adaptive sampling strategy that estimates local signal variability from recent readings and adjusts sampling interval accordingly.
- A field evaluation across three deployed environmental sensor networks with different underlying signal dynamics.
- An analysis of the energy-fidelity trade-off, showing where adaptive sampling offers the largest gains over fixed-interval sampling.

Chapter 2

Related Work

2.1 Fixed and Adaptive Sampling

Classical sampling theory specifies a fixed rate sufficient to reconstruct a signal of known bandwidth, but real environmental signals rarely have a single, known bandwidth throughout a deployment (Jain et al., 2004).

2.2 Energy-Aware Sensing

Energy-aware sensing schemes trade measurement fidelity for battery life, often by adapting either the sampling rate or the transmission rate based on observed conditions (Alippi et al., 2008).

2.3 Gap Addressed by This Thesis

Prior adaptive sampling work has largely been evaluated in simulation. This thesis evaluates an adaptive sampling strategy on real long-term field deployments, where sensor drift and environmental noise are present in ways simulation does not capture.

Chapter 3

Method

This chapter would describe the adaptive sampling algorithm and its deployment across the three field sites (omitted from this starter document).

Chapter 4

Conclusion

This thesis proposed an adaptive sampling strategy for battery-powered environmental sensor networks and evaluated it on real field deployments. Full results are omitted from this starter document.

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