



On Quantifying the Experience Level of a Cognitive Engine

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Agenda

- Introduction
- Problem formulation
 - Exploration vs Exploitation
 - Some cognitive engine algorithms
- Cognitive engine evaluation
 - The amount of knowledge indicators
- Experimental results
- Applications
- Summary & Conclusions

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Introduction

- Cognitive Radio Engines
- Link Adaptation
- Cognitive engine performance evaluation
- Knowledge indicators

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Problem formulation

- K number of possible communication method
- Eligibility
- Belief states $R_{\kappa}(n)$

$$\pi(n) = [\pi_1(n), \pi_2(n), \dots, \pi_{\kappa}(n)]^T$$

$$(\bar{\mu}_{\kappa}(n), \bar{\sigma}_{\kappa}^2(n), n')$$

Exploration vs. Exploitation

The crucial tradeoff the CE faces at each trial is:

1. "exploitation" of the communication method that has the highest expected payoff
2. "exploration" to get more information about the expected payoffs of the other methods.

Cognitive Engines

- ϵ -greedy
 - The best method is selected with the probability of $1 - \epsilon$
 - And the method is selected at random with probability of ϵ
 - Annealing ϵ -greedy
- Softmax
 - Probability matching strategies
- Gittins-index

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Cognitive engine evaluation

- Different behaviors in different channel conditions
- Various functionalities and expectations
- Distinct levels of situation awareness and cognitive functionalities
- Not depend on objective function and implementation details

Quantifying the amount of knowledge

- Estimating upper and lower bounds by using belief state of each method

$$\bar{\mu}_{\kappa}(n) \pm \left(t \left(\frac{1 - C}{2}, n' - 1 \right) * \frac{\bar{\sigma}}{\sqrt{n'}} \right)$$

- Classify all available methods into eligible and ineligible

$$R_{u\kappa}(n) < \operatorname{argmax}_{j \in [1, K]} \bar{\mu}_j(n)$$

RBI, LBI, and CCI

- Right Brain Index (RBI)

$$I_{RBI}(n) = \frac{N_K - N_E(n)}{N_K - 1}$$

- Left Brain Index (LBI)

$$I_{LBI}(n) = \frac{\operatorname{argmax}_{j \in [1, K]} \bar{\mu}_j(n)}{\operatorname{argmax}_{j \in [1, K]} R_{uj}(n)}$$

RBI, LBI, and CCI

- Corpus Callosum Index (CCI)

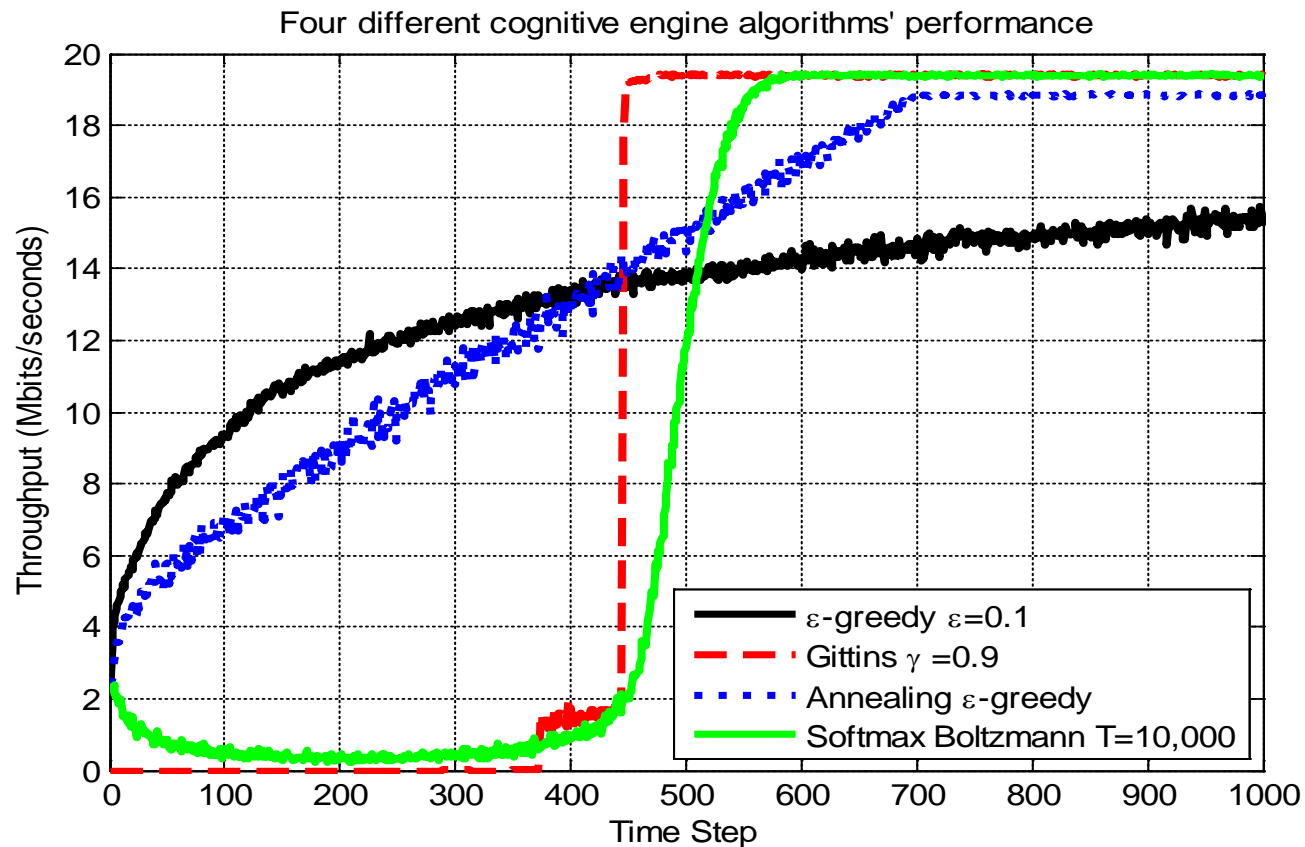
$$I_{CCI}(n) = 1 - \frac{\sum_{i=1}^{N_E} (R_{ui}(n) - \operatorname{argmax}_{j \in [1, K]} \bar{\mu}_j(n))}{\sum_{j=1}^{N_K} (R_{ui}(0) - R_{li}(0))}$$

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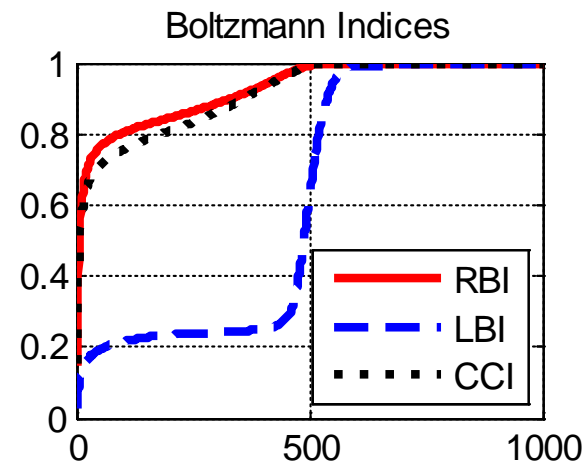
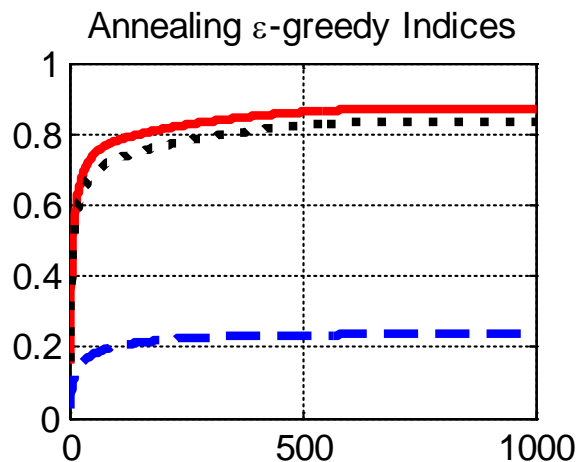
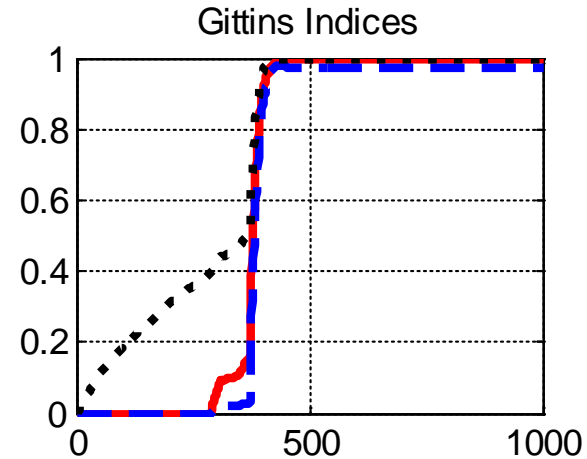
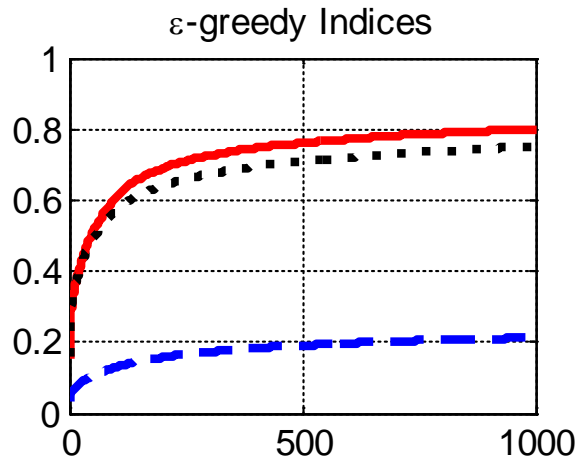
Experimental results

- Each communication method is defined by a combination of modulation type, coding and antenna techniques:
 - Modulations: QPSK, 8PSK, 16, 32, 64, 128, and 256 QAM
 - Error correction rates: 1 , $7/8$, $3/4$, $2/3$, $1/2$, $1/4$, $1/6$, and $1/8$
 - Antenna techniques: VBLAST, STBC, and MRC
 - We consider an SNR in the range of 0-50 and the log of the Eigen spread in the range of 0-12 by step size of 0.5
 - There are 12 channels available with different SNR and bandwidth (either 1.25 or 2.5 MHZ)

Experimental results



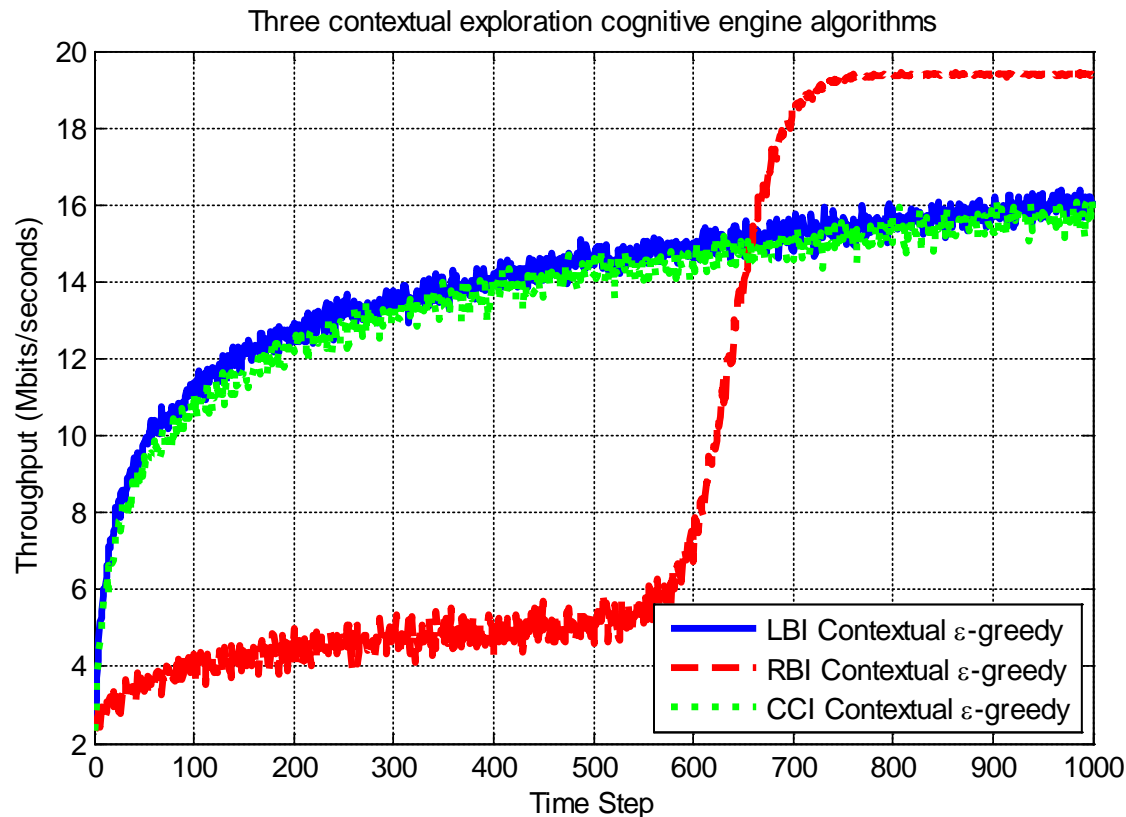
Experimental results



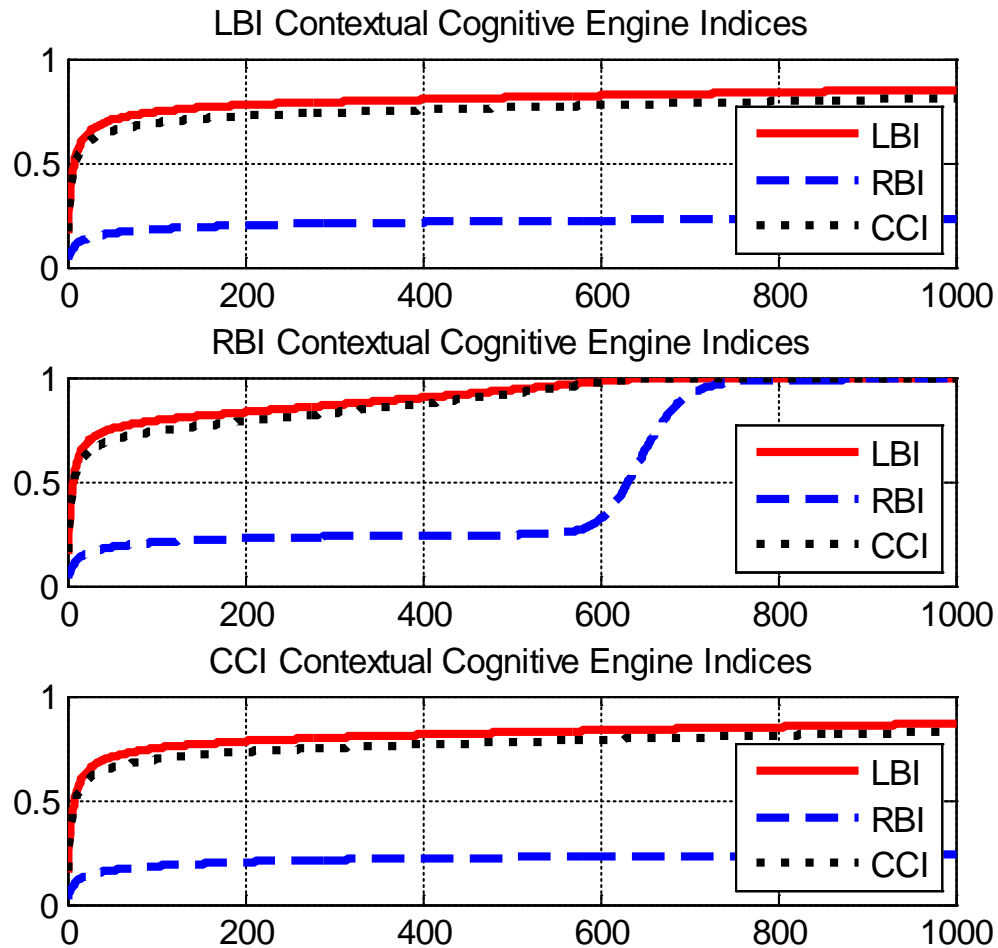
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Applications

- Contextual exploration cognitive engine



Applications



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Conclusions and future works

- Quantifying the knowledge/experience level of a CE is a crucial task
- Standardization
- Metacognitive radio engines

Thank You

Q&A