

Founding Research Article

The General Theory and Applications of a New Expected Volume Confidence Region Complexity (EVCR-COMP) Criterion in High Dimensions

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Abstract Expected Volume Covariance Region Complexity (EVCR-COMP) provides a new information-theoretic framework for statistical model selection by integrating goodness-of-fit, covariance complexity, and the expected volume of confidence regions into a single decision criterion. Unlike traditional information criteria that primarily penalize model dimension, EVCR-COMP quantifies model complexity through the geometry of statistical uncertainty. The resulting methodology balances predictive accuracy, parsimony, numerical stability, and inferential precision within a unified optimization framework. This article presents the general theoretical foundations of EVCR-COMP, establishes its mathematical properties, and discusses its relationships with classical information criteria, including Akaike's Information Criterion, Schwarz's Bayesian Criterion, and Information Complexity (ICOMP). Applications to modern decision analytics, high-dimensional statistics, machine learning, kernel methods, Bayesian inference, and optimization are outlined, illustrating the broad scope of the proposed framework.

Keywords Expected Volume Covariance Region Complexity; Information Complexity; Model Selection; Decision Analytics; Machine Learning; Optimization; Statistical Learning; Information Theory

1 Introduction

Introduce the problem, discuss the importance of statistical model selection in modern decision analytics, summarize the contribution of EVCR-COMP, and outline the remainder of the paper.

2 Background

2.1 Information Criteria

Discuss AIC, SBC/BIC, TIC, and ICOMP.

2.2 Information Complexity

Introduce

$$\text{ICOMP} = -2\ell(\hat{\theta}) + 2C_1(\hat{\Sigma}).$$

3 Methodology

3.1 Model Formulation

Let $\theta \in \Theta$ be the parameter vector.

3.2 Likelihood Function

Present the likelihood.

3.3 Expected Volume of Confidence Regions

Develop the EVCR formulation.

3.4 The EVCR-COMP Criterion

Present

$$\text{EVCR-COMP} = -2\ell + 2C_1 + \log(\text{EVCR}).$$

4 Theoretical Results

Theorem 4.1. State theorem.

Proof. Proof. □

Proposition 4.2. State proposition.

Lemma 4.3. State lemma.

Corollary 4.4. State corollary.

Definition 4.5. State definition.

Remark 4.6. State remark.

5 Algorithms

Algorithm 1 General EVCR-COMP Algorithm

- Require: Data
- 1: Estimate parameters
 - 2: Compute covariance
 - 3: Compute information complexity
 - 4: Compute EVCR
 - 5: Compute EVCR-COMP
 - 6: Select the optimal model

6 Numerical Studies

6.1 Simulation Study

Simulation design.

6.2 Real Data Illustration

Application.

Table 1. Example Table

Model	ICOMP	EVCR-COMP
1	120.34	118.92
2	121.18	119.51

Note. Example table notes.

7 Discussion

Discuss interpretation, practical implications, limitations, and future research.

8 Conclusions

Summarize the principal findings.

Acknowledgments

Optional.

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Conflict of Interest

The author declares no conflict of interest.

Data Availability

State where the data and supporting materials may be obtained.

A Additional Proofs

Appendix.

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19(6), 716-723.

Bozdogan, H. (1990). On the information-based measure of covariance complexity and its application to the evaluation of multivariate linear models. *Communications in Statistics-Theory and Methods*, 19(1), 221-278.