

# Sequential Model-Based Diagnosis by Systematic Search (Abstract Reprint)

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## Abstract

Model-based diagnosis aims at identifying the real cause of a system's malfunction based on a formal system model and observations of the system behavior. To discriminate between multiple fault hypotheses (diagnoses), sequential diagnosis approaches iteratively pose queries to an oracle to acquire additional knowledge about the diagnosed system. Depending on the system type, queries can capture, e.g., system tests, probes, measurements, or expert questions.

As the determination of optimal queries is NP-hard, state-of-the-art sequential diagnosis methods rely on a myopic one-step-lookahead analysis which has proven to constitute a particularly favorable trade-off between computational efficiency and diagnostic effectivity. Yet, this solves only a part of the problem, as various sources of complexity, such as the reliance on costly reasoning services and large numbers of or not explicitly given query candidates, remain.

To deal with such issues, existing approaches often make assumptions about the (i) type of diagnosed system, (ii) formalism to describe the system, (iii) inference engine, (iv) type of query to be of interest, (v) query quality criterion to be adopted, or (vi) diagnosis computation algorithm to be employed. Moreover, they (vii) often cannot deal with large or implicit query spaces or with expressive logics, or (viii) require inputs that cannot always be provided.

As a remedy, we propose a novel one-step lookahead query computation technique for sequential diagnosis that overcomes the said issues of existing methods. Our approach (1) is based on a solid theory, (2) involves a systematic search for optimal queries, (3) can operate on implicit and huge query spaces, (4) allows for a two-stage optimization of queries (wrt. their number and cost), (5) is designed to reduce expensive logical inferences to a minimum, and (6) is generally applicable. The latter means that it can deal with any type of diagnosis problem as per Reiter's theory, is applicable with any monotonic knowledge representation language, can interact with a multitude of diagnosis engines and logical reasoners, and allows for a quality optimization

of queries based on any of the common criteria in the literature.

We extensively study the performance of the novel technique using a benchmark of real-world diagnosis problems. Our findings are that our approach enables the computation of optimal queries with hardly any delay, independently of the size and complexity of the considered benchmark problem. Moreover, it proves to be highly scalable, and it outperforms the state-of-the-art method in the domain of our benchmarks by orders of magnitude in terms of computation time while always returning a qualitatively as good or better query.

## References

Rodler, P. 2023. Sequential model-based diagnosis by systematic search. *Artificial Intelligence*, 323: 103988.