

RCK: A Software Toolkit for R-calculus

(Extended Abstract)

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1 Introduction

Scientific theories usually play a fundamental role in guiding practice and predicting events in specific domains. Axioms, principles, or laws in a scientific theory are acquired by induction on the available results of observation and experimentation, and repeatedly confirmed through further observation and experimentation. However, they are to some extent provisional and hypothetical since new findings or empirical facts may contradict with the theory.

If some logical consequence of a theory is inconsistent with experimental results, i.e. the theory is refuted by facts, then the theory should be revised by discarding as few axioms, principles, or laws that contradict the experimental results as possible, to make sure that the remaining is a maximal subset (of the theory) which is consistent with the experimental results. The subset is called a *maximal contraction* of the theory. Afterwards, new axioms, principles, or laws generalized or inspired from the experimental results can be added into the maximal contraction to form a new theory. For example, in the domain of physics, the Galilean transformation is inconsistent with the observation that the velocity of light does not depend on the motion of the body emitting the light, i.e. classical physics meets a refutation by facts. Therefore, the axioms or laws of classical physics should be revised. The special theory of relativity was established accordingly by accepting the result which classical physics (the Galilean transformation) contradicts, deleting the Galilean transformation, generalizing the observed results to obtain that “the velocity of light is a constant” as a new principle, and introducing the Lorentz transformation (to replace the Galilean transformation).

During the process of revising a theory refuted by facts, the acquirement of maximal contractions of the theory is a key procedure. In order to formally deduce all possible maximal contractions, *R-calculus* was proposed [1–3], which is an inference system consisting of four sets of rules (R-axiom, R-rules for logical connective symbols, R-rules for quantifier symbols, and R-cut rule) in first-order language. The reachability, soundness, and completeness of R-calculus have been proved. To some extent, R-calculus may mechanize logical analysis and reasoning which are generally believed to be the insight and logical intuition of scientists in the process of scientific discovery.

Based on the established theories of R-calculus, we implemented a software toolkit, called RCK, to perform R-calculus on computer. The toolkit enable users to obtain and verify maximal contractions of a given theory whenever the theory is refuted by given facts. In what follows, we will briefly introduce the framework of RCK and demonstrate how R-calculus can be applied to scientific discovery.

2 Framework of RCK

RCK contains three main modules: RCsolver, implemented in C++, to compute all maximal contractions of an input theory with respect to refutation by facts; RCprover, implemented in Isabelle, to verify the correctness of the obtained maximal contractions; and a graphic interface for users to control the workflow as presented in Fig. 1.

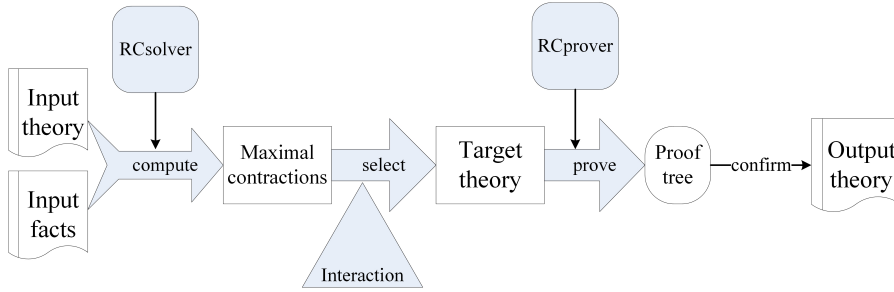


Fig. 1. The Framework of RCK

One can input a theory Γ and a set Δ of facts, where Γ and Δ are formula sets in a first-order language. Then RCsolver will compute a set M of maximal contractions which are the maximal subsets of Γ that are consistent with Δ . Then one may select from M a maximal contraction as a target theory. With RCprover, the correctness of the target theory can be checked automatically or interactively by using R-calculus inference rules without the cut rule [4]. Finally, a theory which is confirmed to be maximally consistent with Δ can be obtained.

3 Concluding Remarks

The development of RCK is ongoing work. Currently, RCsolver is able to compute all maximal contractions of a theory represented in the language of propositional logic. In the next stage, the capability of RCsolver will be enhanced by supporting formula sets in computable fragments of a first-order language as input. Some basic tactics have been implemented for automated proving in RCprover and more tactics will be studied. Moreover, we are constructing a test suite for RCK which includes examples from different domains. Illustrations

will be conducted to show the effectiveness and capability of R-calculus and the usage of R-calculus in practice.

References

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