Most Models are Query Models

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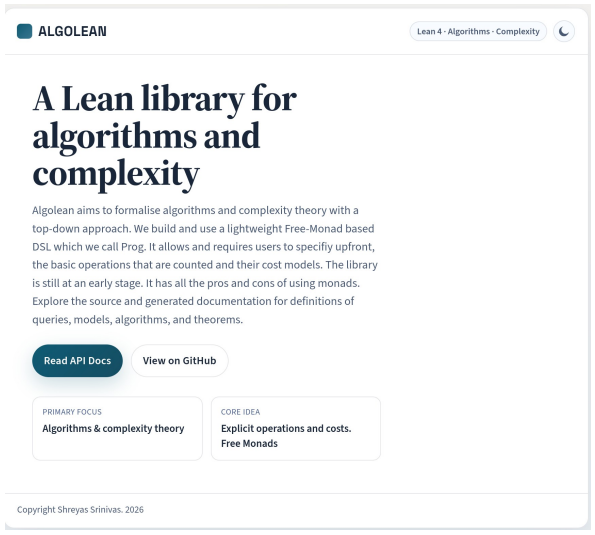

The Challenge: While Lean's mathlib has revolutionized formalized mathematics, a unified library for algorithmic theory remains elusive. A traditional bottom-up approach requires formalizing tedious low-level RAM models and rebuilding decades of theory on top of them.

The Insight: In literature, algorithms are rarely low-level programs; they are compositionally analyzed using existing procedures, data structures, and primitives. More complex primitives are simply expressed in terms of simpler ones.

Our Approach: Building on prior work on free monads & in the spirit of prior work on lightweight formalisation of algorithams, we introduce the query-combinator model, a lightweight Lean framework that treats opaque computational primitives as queries with specific behaviors and costs. Algorithms are built by combining these queries using free monads.

Results: This framework allows complexity bounds to be proved structurally, isolating combinatorial arguments from low-level implementation details. We demonstrate its versatility across sequential algorithms, fair cake cutting (Robertson-Webb), and classical/quantum circuits.

Shreyas Srinivas is a final-year PhD student at the CISPA Helmholtz Center for Information Security, advised by Prof. Christoph Lenzen, currently at Reykjavik University. His work spans distributed clock synchronization, ASIC design for clocking in VLSI systems, and formalization in Lean. He was a maintainer of the Equational Theories Project, and with his co-authors refuted the conjecture that EFX allocations always exist for monotone valuation functions in discrete fair division. His current research focuses on integrating interactive theorem provers into theoretical computer science.

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Lecture Theatre AG66, TIFR, Mumbai
YouTube Live: https://youtu.be/ga5dVa2c8bE