Scientific abstract – Learning and Exploiting Decompositions in Automated Reasoning

We propose an approach for planning and verification through innovative decomposition and compositional analysis techniques. The proposal emphasizes the significance of understanding system structures and patterns for efficient exploration, leveraging these insights to create effective planning and verification methods.

Based on our previous work, we propose two lines of research with the common goal of understanding how automatic and manual decompositions of different types allow efficient analysis: 1) The first line of research delves into the planning domain using decomposition-based search algorithms. We will showcase the limitations of existing methods and present novel approaches to learning and utilizing progress states during the search, effectively decomposing planning tasks into subproblems that improve planning. We will apply advanced tools such as decision trees and description logic to learn descriptive formulas to automate the process. 2) The second line of research focuses on using behavioral programming (BP) for decomposing complex systems. We will use automatic deduction techniques to allow model-checking to analyze components and deduce properties of the composed behavior. We will show that this significantly reduces computational complexity, potentially paving the way for more effective verification methods in various application domains.

Our research plan involves developing compositional analysis techniques, automated decomposition methods, and leveraging mathematical theories to enhance the capabilities of planning, synthesis, and verification algorithms. Our research will pave the way for improved performance and reliability of systems across diverse domains like robotics, autonomous systems, and reactive system development. The proposed road-map for the project is through delineating the investigation into four key work packages:

Work Package 1: Decomposing Reasoning Problems. This segment uses subtask identification to automatically decompose reasoning problems into components that logic formulas can effectively describe. It normalizes the concepts of generalized tasks and subtask systems, paving the way for heuristic search enhancement and automatic decomposition. **Work Package 2: Learning Subtask Systems.** Complementing the first work package, this package delves into learning generalized subtask systems from generated benches. It aims to experimentally validate the scalability and effectiveness of these learned systems across various domains. **Work Package 3: Analyzing Behaviour through Abstraction and Decomposition.** This work package aims to automatically address system complexities by methodically breaking down behaviors into more manageable components. The focus is on abstraction techniques to transform detailed system behaviors into simplified versions for more insightful analysis, using neural networks, evolutionary algorithms, and advanced automata-learning and process mining techniques. **Work Package 4: Inferring Properties of Behavioral Programs from B-threads.** Dedicated to compositional analysis, this work package explores methodologies for inferring system properties by analyzing individual b-threads within reactive systems. It aims to demonstrate the feasibility of automatic verification and property deduction from modules, significantly simplifying the verification and other analysis tasks.

All the work packages revolve around the theme of learning and leveraging decompositions in automated reasoning. Our approach involves having students work on these packages concurrently, fostering collaboration and synergies through a shared seminar. As work packages share common principles across domains, students in one package will benefit from collaborating with those in other packages.