Formulating Spatial Layout as a Disjunctive Constraint Satisfaction Problem

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Abstract

The spatial layout problem addressed in this thesis is the configuration of rectangular objects in two dimensional space. We formulate spatial layout as a disjunctive constraint satisfaction problem which consists of a set of variables, a set of atomic constraints and a set of disjunctive constraints. The variables are the lines, dimensions and orientations of the objects being configured. Atomic constraints are algebraic equations and inequalities on these variables. Configurations are defined by atomic constraints. A disjunctive constraint is a Boolean combination of atomic constraints. Disjunctive constraints define the space of possible configurations. Disjunctive constraints are derived from problem requirements and specify adjacency, distance, non-overlap and other spatial relations between objects.

The canonical form of a disjunctive constraint is disjunctive normal form, and its top level components are termed its disjuncts. Backtracking search for feasible configurations instantiates a disjunctive constraint by selecting one of its disjuncts. A new state is generated by adding the atomic constraints in the selected disjunct to the constraints defining the current state. Since the compatibility of disjuncts is not explicitly specified, consistency of a configuration is maintained by propagation of the atomic constraints. Forward-checking and singleton-disjunct heuristic are used to increase search efficiency, and at each search state the disjunctive constraint to instantiate is dynamically selected using a function of heuristic measures called textures. Textures are based on topological and other features of constraints and implement fail-first and prune-early strategies.

Adequacy of the disjunctive constraint satisfaction problem formulation is evaluated by solving apartment layout, kitchen layout and bin-packing problems. Textures are evaluated by comparing their performance against fixed and random orderings of the disjunctive constraints. The search architecture is evaluated by comparing it with other systems and by evaluating performance of forward-checking and singleton-disjunct heuristics.