Introduction

At the end of his 2007 PhD dissertation, Dr. Richard S. Stansbury expressed a need for future work on the research question he addressed: the modeling and evaluation of navigation and 'task' completion as a constraint programming problem. His research addressed only 2D topology, but the results showed strong potential for applications in 3D, too.1 The goal of the research project I formulated in 2016—and have worked on since as the sole Principal Investigator—is to address this open question in the constraint programming field within computer science and computational math.

Methods and Current Work

Constraint Programming Applications in Unmanned Aerial System Flight Pathing

Courtney Thurston, Dr. Richard S. Stansbury
Embry-Riddle Aeronautical University, Daytona Beach

Figure 1 & 2: System and Mission Overview

The constraint satisfaction problem (CSP) is a search-based problem domain from the Artificial Intelligence community where the variables of the problem are assigned values that satisfy the constraints set upon them. Constraint programming techniques are “the legal combinations of values between the variables within the domain that may cause a conflict.”4

Obtaining strong n-consistency is also NP-hard.3 Constraint propagation techniques, like the ones described above, improve arc consistency—necessary to conform to strict regulations, which require strong consistency. The CSP solution can be evaluated according to the following five metrics, and solutions verified with a student’s test:

- CSP solve time / CPU time
- Task execution time
- Resources consumed
- Number of collisions
- Number of failures

traditionally, constraint propagation techniques are performed prior to solving the CSP with backtracking. Forward checking is a technique that can be utilized such that arc consistency is performed during the search. Back-jumping makes the act of backtracking more intelligent within the CSP solver. Rather than backtracking to the previous node when a conflict occurs, the algorithm back-jumps along the search path to the node that conflicts with the current node based on that constraint.4 Conflict-directed back-jumping was proposed for Constraint Satisfaction Problems by Dr. Patrick Prosser in his groundbreaking 1993 paper.5

Figure 5: FAA UAS Aregs

The decision-maker is constructed using many data structures and algorithms in theoretical and applied computer science. The dual-graph technique is used to compare binary and n-dimensional constraints. Constraint propagation methods, like the ones described above, improve arc consistency—necessary to conform to strict regulations, which require strong consistency. The CSP solution can be evaluated according to the following five metrics, and solutions verified with a student’s test:

- CSP solve time / CPU time
- Task execution time
- Resources consumed
- Number of collisions
- Number of failures

Developing a Decision Model

The decision-maker is constructed using many data structures and algorithms in theoretical and applied computer science. The dual-graph technique is used to compare binary and n-dimensional constraints. Constraint propagation methods, like the ones described above, improve arc consistency—necessary to conform to strict regulations, which require strong consistency. The CSP solution can be evaluated according to the following five metrics, and solutions verified with a student’s test:

- CSP solve time / CPU time
- Task execution time
- Resources consumed
- Number of collisions
- Number of failures

References


Acknowledgements and Contact

PI Funded by:

Research Funded by:
Embry-Riddle Aeronautical University, Daytona Beach

PI Funded by: