Exploring the Use of Fuzzy Constraint Satisfaction Problems to Evaluate the Happiness of Society. Computer Systems Lab, 2009-2010

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Abstract

The goal of this project is to explore the use of and solving of fuzzy constraint satisfaction. In this project, I will apply the prinicpals of fuzzy constraint satisfaction to a randomly generated society with the goal of making the digital populace as happy as possible.
Note: I have images, but am having difficulty getting them into Latex. Just assume you can see the pretty colorful images.

Keywords: fuzzy constraint satisfaction, soft constraint satisfaction.

1 Introduction - Elaboration on the problem statement, purpose, and project scope

1.1 Scope of Study

Fuzzy constraint satisfaction problems are similar to regular constraint satisfaction problems, but are far more useful in the real world. Regular constraint satisfaction problems are useful when all constraints are hard and cannot be violated, however they are only capable of finding a perfect solution. If no solution exists, the algorithm will fail. Fuzzy constraint satisfaction problesn are used instead when the constraints are soft. Instead of demanding a perfect solution, it instead searches for an optimal solution that best satisfies the given constraints.

This is incredibly important in the real world because many real problems do not have simple "perfect" solutions. Instead, it becomes necessary to compromise and come up with the best answer. The work done in this project is a simple demonstration of applying this idea to a easily modeled society.

1.2 Type of research

The ultimate goal of this project is not to make a group of imaginary citizens "happy", but to explore the applications and extensions of fuzzy constraint satisfaction problems. The simulated society is useful in this regards as it posesses sufficient complexity to be nontrivial while being simple enough to easily model.

2 Background and review of current literature and research

To understand soft constraint satisfaction problems, it is essential to understand hard constraint satisfaction problems. The basis of any constraint satisfaction problem, hard of soft, is that there are a number of constraints, formally called tuples, that can be either satisfied or violated.

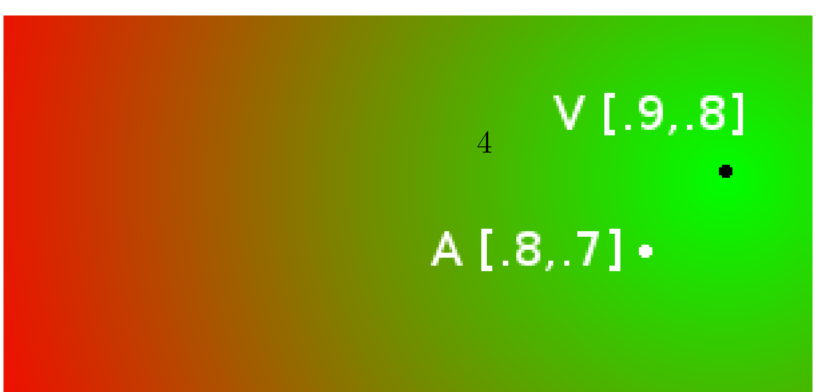
In a hard constraint satisfaction problem, all constraints are considered imperative and inflexible. This means that every tuple can only have two values, satisfied or violated. Furthermore, a solution is valid if and only if it satisfies every tuple. Examples of hard constraint satisfaction problems include Sudoku, the 4-Color Map Problem, and N-Queens. However, as will soon be aparent, this technique is not appropriate for many real world applications. Life often does not give easy answers with perfect solutions.

3 Procedures and Methodology

3.1 Society Model

In order to further explore fuzzy constraint satisfaction, it becomes necessary to create a model of a simplified society. In this society, "Voters" (tuples) are randomly placed on a 1x1 board. A proposal is then placed somewhere on the board. Each Voter's satisfaction is given a value between 0 and 1, determined by a function dependent on the distance between that Voter and the Proposal. Society's satisfaction is calculated as the average satisfaction of each Voter.

For example, imagine for a moment a society with a single Voter, drawn in black at [.9,.8]. The background has been colored to correspond to society's satisfaction, the spots in green represent locations where the most constraints are satisfied and society is happy. By contrast, the spots in red represent locations where the most constraints are violated and society is unahppy. Proposal A [.8,.7] and Proposal B [.3,.4] are both drawn as white dots. Proposal A is closer to Voter V than Prospoal B; as such societies satisfaction is much higher at Point A than Point B.


V [.9,.8]
A [.8,.7]

We now move onto a more complicated example. Image a new society with four Voters, V1, V2, V3, and V4. It is possible to consider multiple scenarios that would make an individual voter happy. For example, Proposal A would make Voter V1 satisfied, but Voters V2, V3, and V4 are much less satisfied. Proposal B would make voters V2 and V3 happy, but Voters V1 and V4 are unsatisfied. Ultimately, the optimal proposal, O, is a locaion in the center of the four dots. The imnportant piece of this model is that the optimal solution can only be obtained when every Voter sacrifices a bit of its personal satisfaction to best satisfy the society as a whole.

3.2 Sympathetic and Antagonistic Constraints

One interesting discussion is the idea of sympathetic and antagonistic constraints. Sympathetic constraints are two constraints located such that increasing the satisfaction of one by necessity increases the satisfaction of the other. Antagonistic constraints are just the opposite, increasing the satisfaction of one decreases the satisfaction of another. In the society model, Voters that are close to one another are sympathetic and Voters that are farther apart are antagonistic.

It is possible to force a society to be sympathetic or antagonistic by controlling the range the Voters are allowed to be placed in. For example, forcing the voters into a .1x.1 square centered at [.5,.5] will create a very sympathetic society, while randomly placing the Voters throughout the board will creatre a very antagonistic society.

As expected, as Society becomes more antagonistic and the Voters become more dispersed, the average satisfaction of society decreases. The very sympathetic society has an average satisfaction of 96 percent. In comparison, the very antagonistic society has an average satisfaction of 57 percent. It is important to note that, even in the incredibly sympathetic society, a perfect solution of 100 Satisfaction cannot be found.

4 Conclusions / Further Research

Next quarter goals include possibly expanding the model, possibly to deal with weighted values or non-constant significance factors. Another goal is coming up with a faster method to find an optimal solution.

References

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