Decision Making Over Combinatorially-Structured Domains

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GOALS

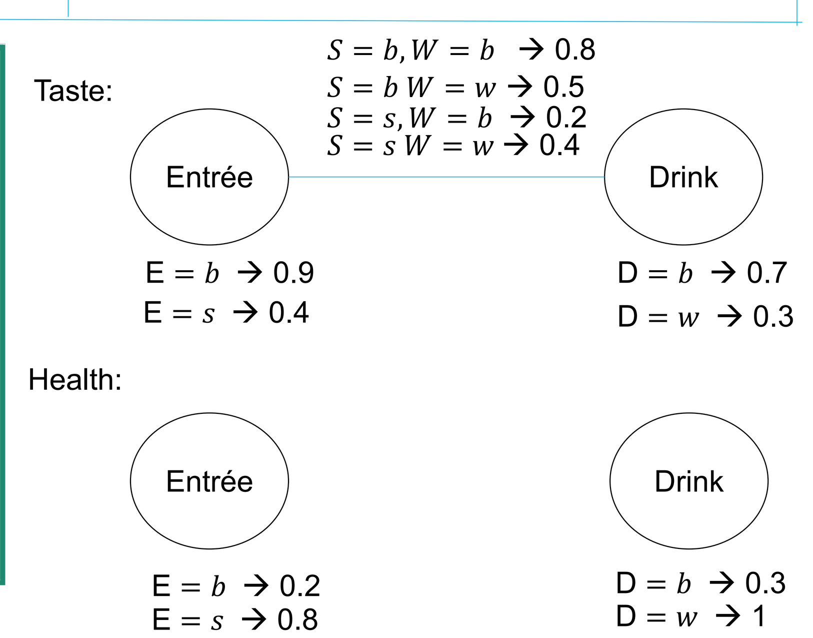
- To build a computational model of how human deliberate when confronted with a sequence decisions.
- To show a way of representing uncertainty in soft constraint problems.

Fuzzy-CSP's

Soft Constraint Problems:
Variables $\{X_1,\ldots,X_n\}=X$
Domains $\{D(X_1),\ldots,D(X_n)\}=D$
C-semiring $\langle A,+,x,\mathbf{0},\mathbf{1}\rangle$

Soft constraint:
c=<f,con> where:
Scope: con=$\{X^c_1,\ldots, X^c_k\}$
Pref Function:
f: $D(X^c_1)x\ldots xD(X^c_k) \to A$

	0.9	0.2
	0.4	0.8
	0.3	1
	0.7	0.3
	0.5	—
	0.8	—
	0.4	—
	0.2	—



Decision Field Theory

- Attributes: Taste and Health
- Eating Options :Burrito, Salad
- Drinking Options: Water, Beer

$$V_1(t) = [v_B(t), v_S(t)]'$$
$$V(t) = CMW(t)$$
$$P(t+1) = SP(t) + V(t+1)$$

C = $\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$ S = $\begin{bmatrix} 0.94 & -0.001 \\ -0.001 & 0.94 \end{bmatrix}$

M = $\begin{array}{cc} T & H \\ \begin{bmatrix} 0.7 & 0.2 \\ 0.4 & 0.8 \end{bmatrix} \end{array} \begin{array}{l} Burrito \\ Salad \end{array}$ $W_1 = [0,1]$ $W_2 = [1,0]$

Sequential Decision Making

FCSP + MDFT → Combinatorial Decision is Made

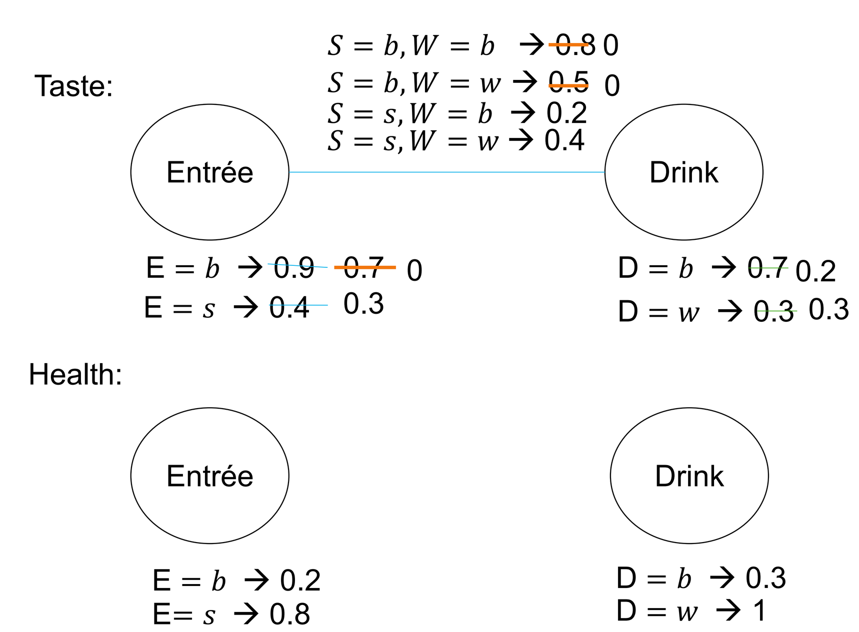
n steps, where at each step i :

1. We extract the subjective preference of the user on the values in the domain of X_i. To do this, we will enforce DAC on the FCSP, in reverse order w.r.t. O .
2. DFT is applied to X_i, returning a deliberated assignment for variable X_i.

   DFT(X_i) = i.

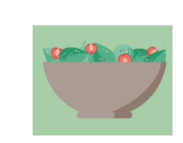
3. Finally, DAC is applied to propagate the effect of the assignment

After n steps have been executed, we obtain a final combinatorial decision.



M = $\begin{array}{cc} T & H \\ \begin{bmatrix} 0.7 & 0.2 \\ 0.4 & 0.8 \end{bmatrix} \end{array} \begin{array}{l} Burrito \\ Salad \end{array}$

Decision 1:



M = $\begin{array}{cc} T & H \\ \begin{bmatrix} 0.2 & 0.3 \\ 0.3 & 1 \end{bmatrix} \end{array} \begin{array}{l} Beer \\ Water \end{array}$

Decision 2:

Non- Sequential Decision Making

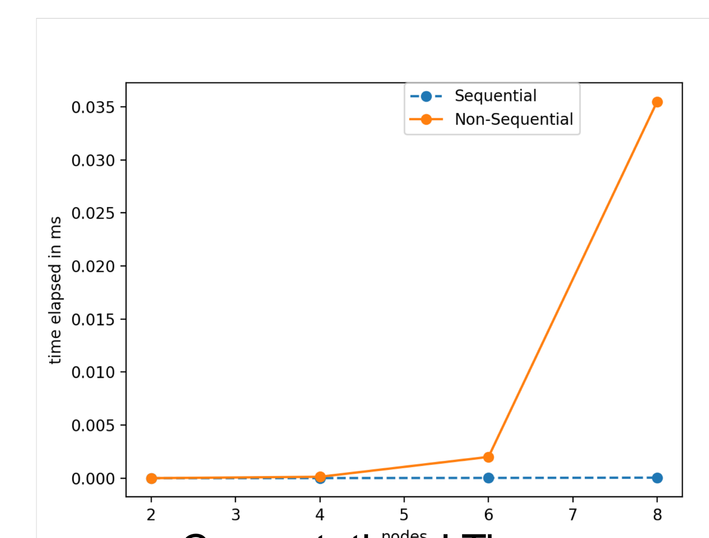
- We run the deliberation process only once over the set of candidate options consisting of all complete assignments.
- We assume a single decision to be made over a combinatorial structure.

$$M_E = \begin{array}{cc} T & H \\ \begin{bmatrix} 0.7 & 0.7 \\ 0.3 & 0.7 \\ 0.7 & 1 \\ 0.4 & 0.8 \end{bmatrix} \end{array} \qquad C = \begin{bmatrix} 1 & -\frac{1}{3} & -\frac{1}{3} & -\frac{1}{3} \\ -1/3 & 1 & -1/3 & -1/3 \\ -1/3 & -1/3 & 1 & -1/3 \\ -1/3 & -1/3 & -1/3 & 1 \end{bmatrix}$$

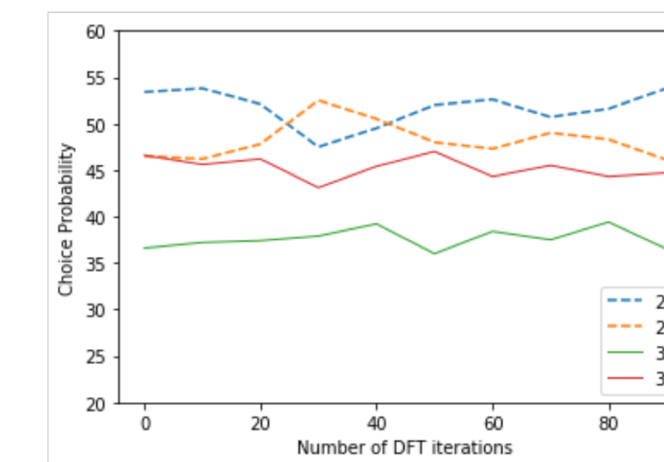
Results

- Implemented both approaches
- Test on randomly generated problems.
- Consider a setting with two attributes and
- We consider a number of variables ranging between 2 and 8 wirh constraint tightness of 20%

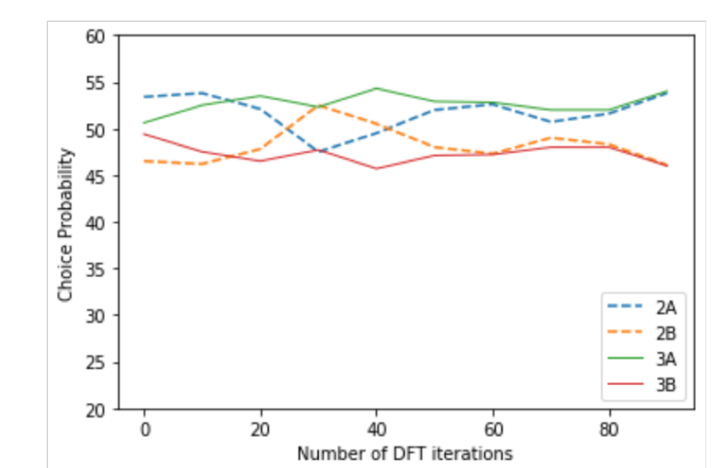
Sequential case: deliberation is stopped after 20 iterations on each variable
Non Sequential case: deliberation is stopped after 20n iterations where n is the number of variables.



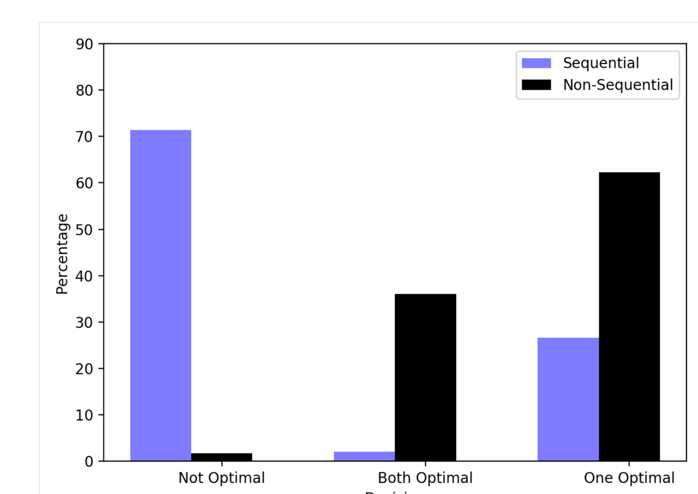
Computational Time: Seq vs non-seq



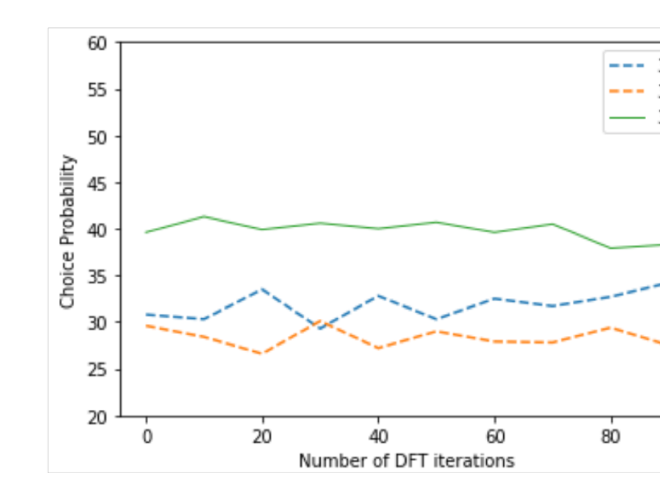
Similarity effect on three variables



Attraction effect on three variables



Percentage of times the decision making procedures return solution that are not optimal/ optimal in one/ both FCSPs.



Conclusions and Future Work

- We have presented an approach for modeling deliberation on combinatorially structured domains.
- We show that decomposing decision making into a sequence of deliberation steps performed with DFT is a feasible approach to tackling this problem.