Keeping the Stability of Solutions in Dynamic Fuzzy CSPs

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Introductions

- **Constraint satisfaction problems (CSP)**
  - A constraint is a restriction on a space of possibilities;
    - It is a piece of knowledge that narrows the scope of the space, for formulating regularities that govern our computational, physical, biological problems.
  - Many problems can be naturally modeled as constraint satisfaction problems (CSPs).

Introductions

- Definition of a CSP
  - a finite set of variables $X = \{x_1, \ldots, x_n\}$
  - a set of domains $D = \{D_1, \ldots, D_n\}$
  - a set of constraints $C = \{c_1, \ldots, c_r\}$
- A solution is an assignment of a value to every variable such that all constraints are satisfied.

Introductions

- **Fuzzy CSP is an extended CSP**
  - Traditional CSP is too rigid to formulate real world problems.
  - Fuzzy CSP has **fuzzy constraints**.
  - It admits incomplete solutions for providing useful information for solving real-world problems.

Introductions

- **Dynamic CSP is an extended CSP**
  - It is a framework for modeling the dynamic transform of problems.
  - Dynamic CSP has the following features：
    - To be solved in real time
    - To keep stability of the successive solutions
  - The key to efficiently solving DCSPs is to re-use the resource such adjacent information as much as possible.

Introductions

- **Dynamic Fuzzy CSP**
  - The model combined fuzzy and dynamic CSP was proposed as a sequence of FCSPs in Miguel (2003).
  - The **FLC** algorithm was also proposed.
  - The FLC is a kind of systematic search, so it is impossible to solve large scale problems.

SRS algorithm

- The **spread-repair-shrink (SRS)** algorithm
  - is developed by us,
  - performs an overall local search, and
  - uses systematic search to repair the worst violated constraint intensive and systematic.

SRS algorithm

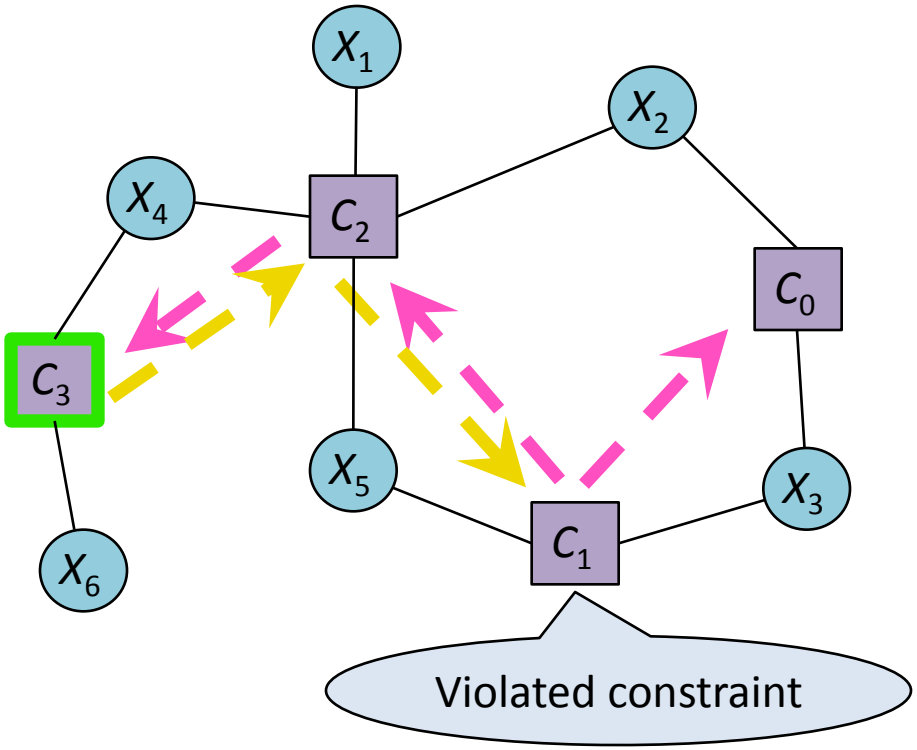
- The concept of the SRS algorithm is repairing violated constraints greedy.

Spread in local optimal.

Repair the constraint violates.

Shrink to starting point to propagate the effect.

Controlling 3 modes
using open/closed list



This work

- **We use SRS for Dynamic Fuzzy CSP**.
  - The reassignment with SRS is locally limited.

  - Can the "stability" of solutions be maintained?

SRSD method

- The evaluation of (D)FCSP is given from worst violated constraint c*.
- It is possible to boost up the stability by restoring assignments, under the following condition.

$$\mu R(v'[x]) \geqq Cmin(v[x])$$

- We use this method in final cleanup.

```
Procedure SRSD( )
    for each x ∈ X
        if μR(v'[x]) ≧ C_min(v[X])
            v[x] ← v'[x]
            SRSD( )
        End if
End procedure
```

Evaluations

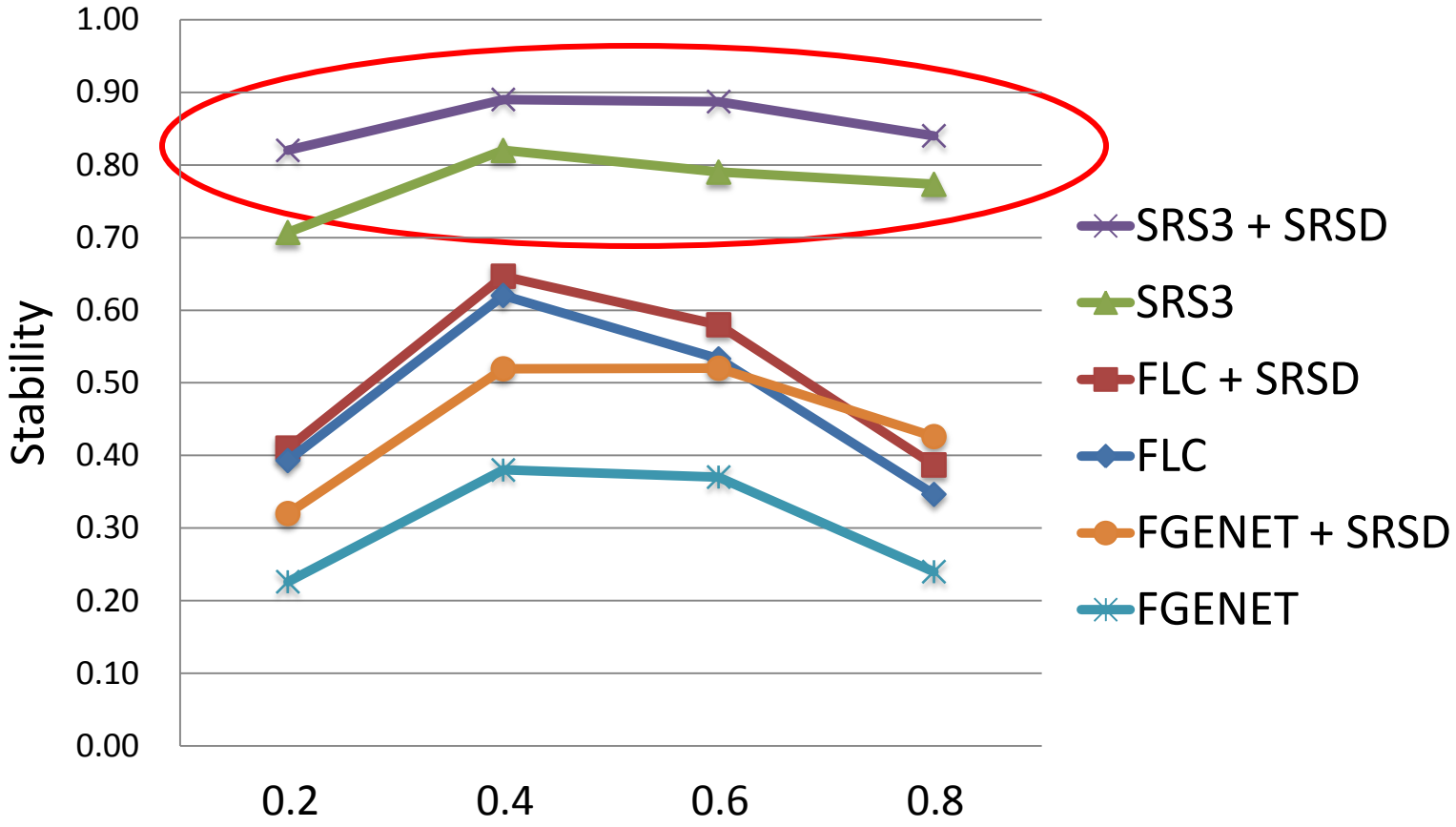
- Get an approximate **solution** of randomly generated FCSPs by using Fuzzy GENET.
- Select a constraint(s), and make a change so that the satisfaction degree falls.
- Apply the FCSP algorithms (FLC, SRS3 and FGENET) again, using the adjacent solution in the way of default assignments.
- Apply the SRSD method → **new solution**.
- Check the stability between **both solutions**.

Evaluations

		t=0.2		t=0.4		t=0.6		t=0.8	
	d	cmin	stb	cmin	stb	cmin	stb	cmin	stb
FLC	d=0.2	1.00	0.39	0.80	0.62	0.59	0.53	0.42	0.35
FLC+SRSD			0.41		0.65		0.58		0.39
SRS3		0.99	0.71	0.78	0.82	0.53	0.79	0.37	0.77
SRS3+SRSD			0.82		0.89		0.89		0.84
FGN		1.00	0.23	0.80	0.38	0.54	0.37	0.37	0.24
FGN+SRSD			0.32		0.52		0.52		0.43
FLC	d=0.4	0.89	0.37	0.63	0.32	0.40	0.31	0.15	0.44
FLC+SRSD			0.43		0.33		0.32		0.47
SRS3		0.84	0.61	0.56	0.55	0.34	0.49	0.09	0.89
SRS3+SRSD			0.72		0.67		0.71		0.93
FGN		0.89	0.32	0.58	0.15	0.34	0.07	0.08	0.22
FGN+SRSD			0.40		0.19		0.19		0.24
FLC	d=0.6	0.79	0.23	0.52	0.20	0.34	0.08	0.00	1.00
FLC+SRSD			0.24		0.24		0.09		1.00
SRS3		0.73	0.71	0.46	0.48	0.25	0.37	0.00	1.00
SRS3+SRSD			0.79		0.61		0.45		1.00
FGN		0.76	0.24	0.46	0.12	0.26	0.19	0.00	1.00
FGN+SRSD			0.25		0.16		0.24		1.00
FLC	d=0.8	0.74	0.23	0.46	0.20	0.26	0.08	0.00	1.00
FLC+SRSD			0.23		0.21		0.08		1.00
SRS3		0.69	0.35	0.42	0.48	0.18	0.40	0.00	1.00
SRS3+SRSD			0.39		0.63		0.52		1.00
FGN		0.68	0.20	0.39	0.08	0.16	0.12	0.00	1.00
FGN+SRSD			0.23		0.16		0.23		1.00

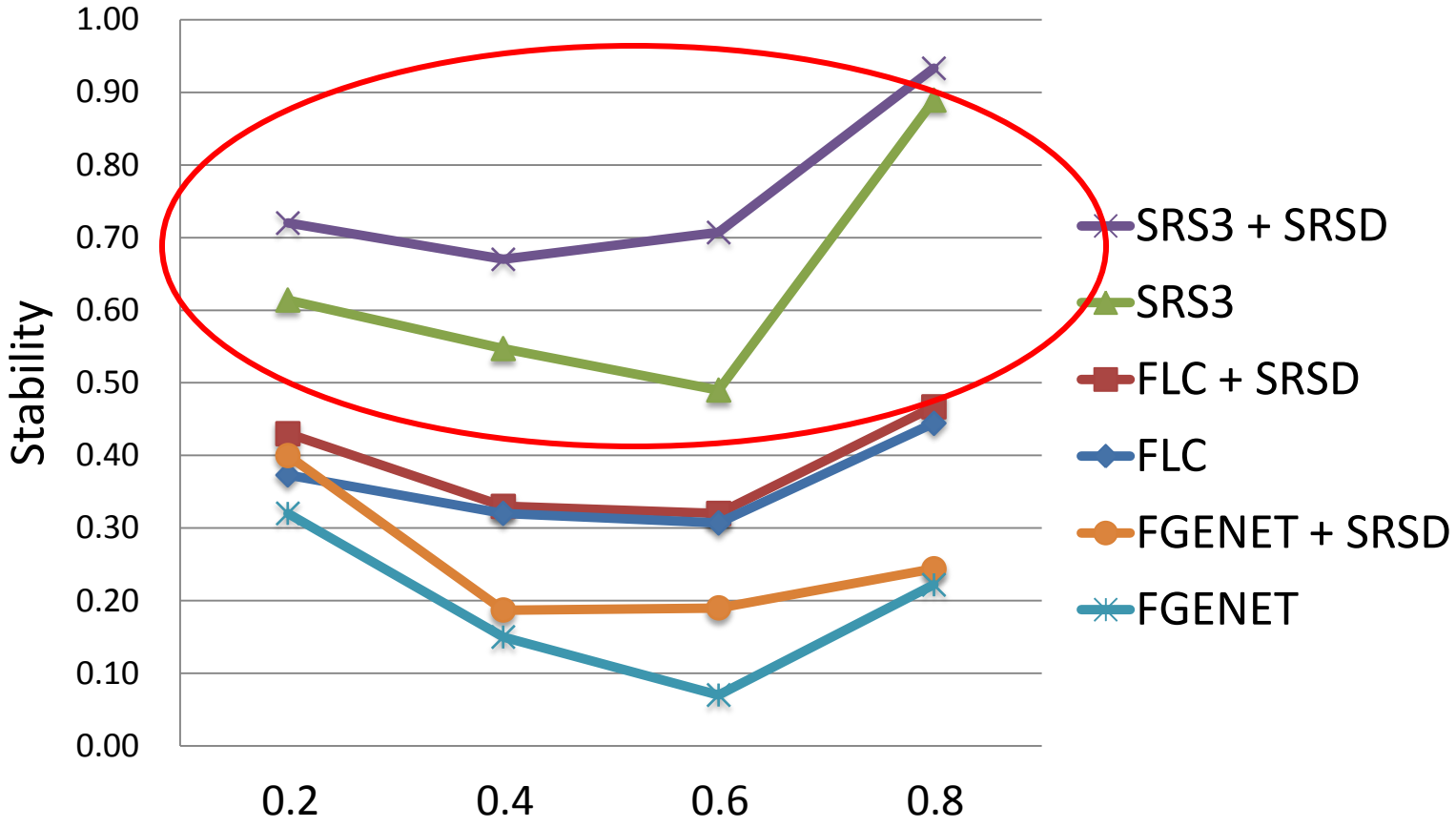
15 variables,
20~160 constraints,
5% transitions

Evaluations



Constraint tightness = 0.2~0.8,
Network density = 0.2

Evaluations



Constraint tightness = 0.2~0.8,
Network density = 0.4

Conclusions

- We have tested the Spread-Repair-Shrink algorithm and SRSD method for obtaining stable approximate solutions to DFCSPs
- The experimental results show that SRS and SRSD is useful under many conditions