KENEN Puzzle
CSP Solver

Report showing analysis and program design

احمد سيد عابد احمد	1700078
احمد عصام الدين احمد الموجى	1300151
اسلام محمد عبد العزيز عبد العال	1700253
أحمد خالد أحمد محمود	1600067

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Repository Link

https://github.com/AhmedEsaam/Kenken-csp-solver

How to run

Run the 'kenken.py' file in the project directory using python:

```
/python kenken.py
```

Introduction

In this report we demonstrate the difference in performance of running three Constraint Satisfaction solving algorithms on the Kenken game with various sizes.

We also provide program design illustration showing the interaction between the modules of the program, and the class diagram.

1. Analysis Results

Glossary

- (BT) : “Backtracking”.
- (FC) : “Forward Checking”
- (AC) : “Arc Consistency”
- (MCV) : “Most Constraining Variable” heuristic.

We ran different variations of algorithms on each board (the 3 techniques (BT, BT with FC, BT with AC), each with and without MCV heuristic)

#	SIZE	TECHNIQUE	ASSIGNMENTS	TIME ELAPSED
1	3	BT	13	0.001002
2	3	BT with MCV	16	0.002996
3	3	FC	8	0.00102
4	3	FC with MCV	9	0.001
5	3	AC	9	0.002977
6	3	AC with MCV	8	0.001
7	3	BT	13	0.001015
8	3	BT with MCV	13	0.002989
9	3	FC	8	0.000994
10	3	FC with MCV	8	0.001001
11	3	AC	8	0.002997
12	3	AC with MCV	8	0.002996
13	3	BT	10	0.001015
14	3	BT with MCV	10	0.001981
15	3	FC	7	0.001016
16	3	FC with MCV	7	0.000985
17	3	AC	7	0.002998
18	3	AC with MCV	7	0.001996
19	4	BT	75	0.01299
20	4	BT with MCV	36	0.003995
21	4	FC	24	0.007996
22	4	FC with MCV	15	0.002999
23	4	AC	27	0.023988
24	4	AC with MCV	14	0.009003
25	4	BT	188	0.032982
26	4	BT with MCV	188	0.030984
27	4	FC	49	0.016989
28	4	FC with MCV	49	0.016994

29	4	AC	16	0.006992
30	4	AC with MCV	16	0.012993
31	4	BT	385	0.065961
32	4	BT with MCV	191	0.03398
33	4	FC	118	0.030984
34	4	FC with MCV	58	0.013993
35	4	AC	35	0.015988
36	4	AC with MCV	15	0.006995
37	5	BT	175	0.042976
38	5	BT with MCV	174	0.034979
39	5	FC	38	0.012995
40	5	FC with MCV	37	0.007993
41	5	AC	23	0.026984
42	5	AC with MCV	22	0.022987
43	5	BT	10066	1.822951
44	5	BT with MCV	4328	0.759564
45	5	FC	597	0.160909
46	5	FC with MCV	707	0.172899
47	5	AC	32	0.050973
48	5	AC with MCV	35	0.046971
49	5	BT	4270	0.969445
50	5	BT with MCV	4139	0.793541
51	5	FC	744	0.154911
52	5	FC with MCV	202	0.054968
53	5	AC	40	0.043977
54	5	AC with MCV	43	0.037976
55	6	BT	74	0.011995
56	6	BT with MCV	64	0.01399
57	6	FC	36	0.010015
58	6	FC with MCV	26	0.004977
59	6	AC	33	0.076956
60	6	AC with MCV	23	0.046973
61	6	BT	1273	0.266847
62	6	BT with MCV	2351	0.487741
63	6	FC	220	0.081935
64	6	FC with MCV	340	0.094943
65	6	AC	39	0.063963
66	6	AC with MCV	44	0.080955
67	6	BT	403	0.094961
68	6	BT with MCV	339	0.086935
69	6	FC	104	0.038978
70	6	FC with MCV	82	0.023987

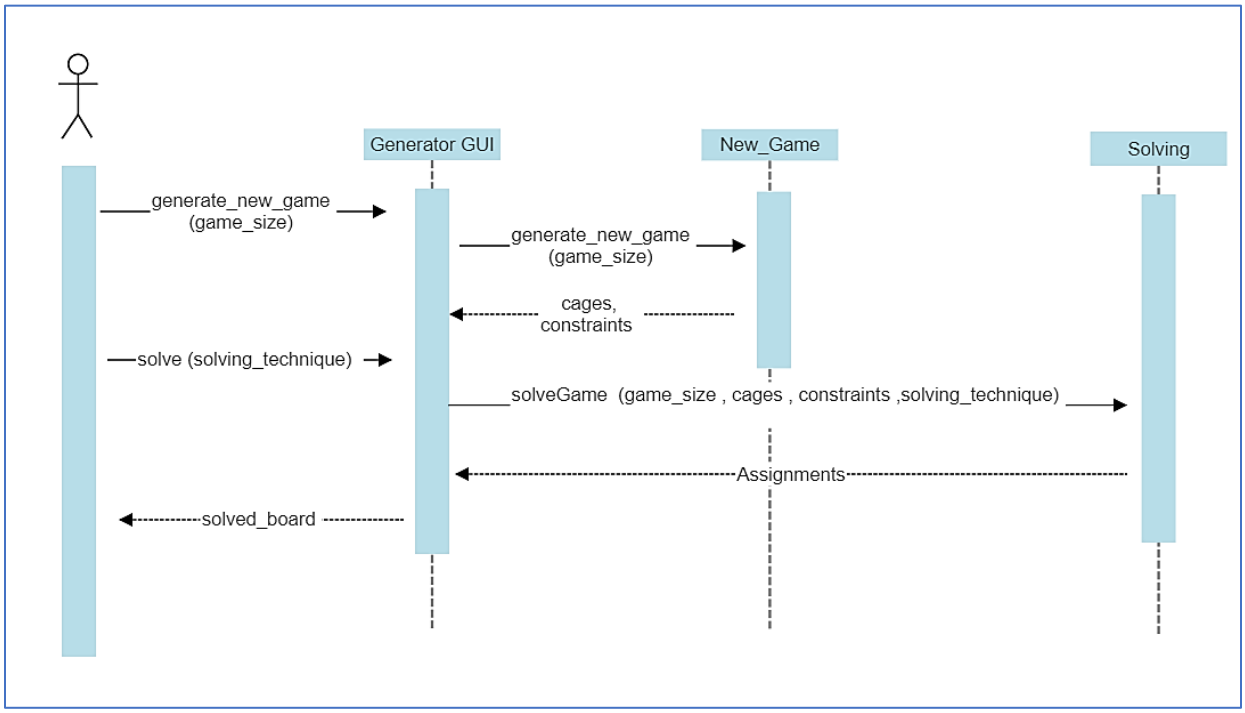
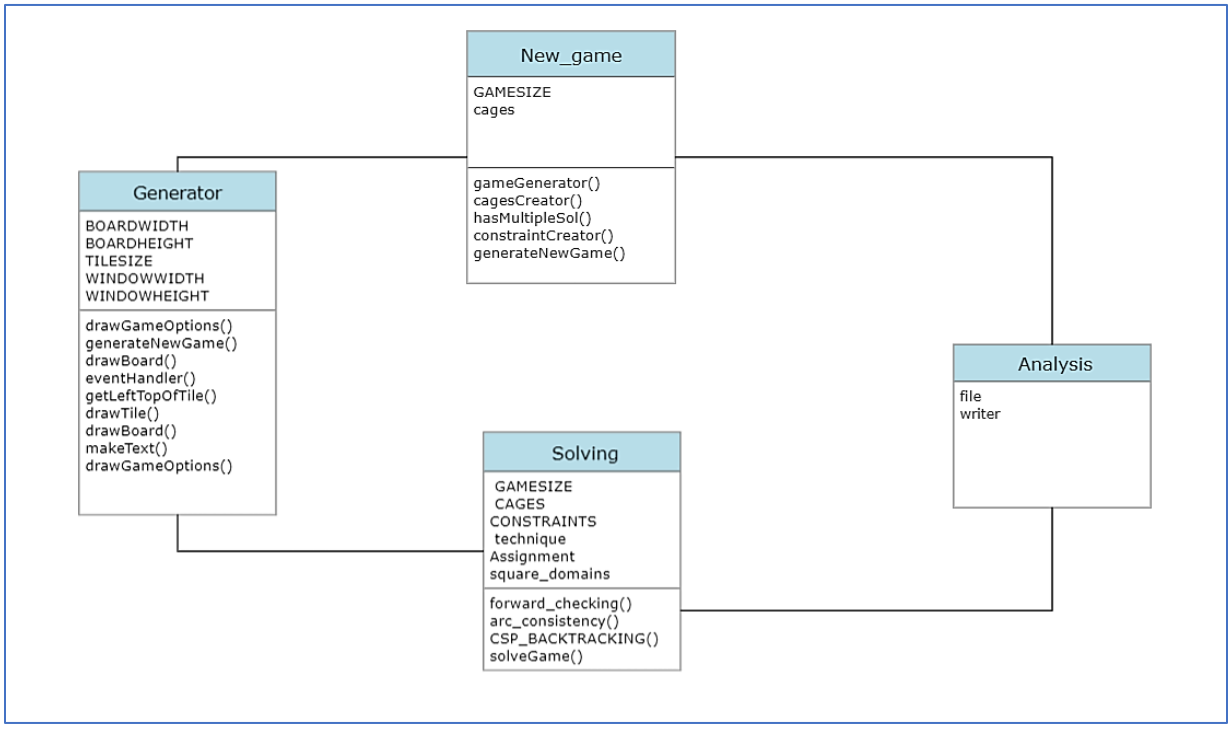
71	6	AC	38	0.074339
72	6	AC with MCV	32	0.053264
73	7	BT	604	0.184895
74	7	BT with MCV	791	0.21689
75	7	FC	149	0.051957
76	7	FC with MCV	147	0.062978
77	7	AC	45	0.140902
78	7	AC with MCV	44	0.119932
79	7	BT	278	0.095943
80	7	BT with MCV	178	0.058966
81	7	FC	57	0.016004
82	7	FC with MCV	50	0.015978
83	7	AC	45	0.181894
84	7	AC with MCV	32	0.118822
85	7	BT	7593	2.24771
86	7	BT with MCV	3604	1.051394
87	7	FC	1350	0.467752
88	7	FC with MCV	1073	0.48612
89	7	AC	46	0.144919
90	7	AC with MCV	41	0.140919
91	8	BT	9306	3.347078
92	8	BT with MCV	5921	2.221559
93	8	FC	299	0.186642
94	8	FC with MCV	666	0.348397
95	8	AC	63	0.346825
96	8	AC with MCV	87	0.432751
97	8	BT	3212	1.049343
98	8	BT with MCV	1779	0.621706
99	8	FC	226	0.100753
100	8	FC with MCV	317	0.154945
101	8	AC	63	0.326183
102	8	AC with MCV	63	0.360795
103	8	BT	1715	0.705614
104	8	BT with MCV	3283	1.223297
105	8	FC	284	0.164885
106	8	FC with MCV	300	0.129411
107	8	AC	65	0.357797
108	8	AC with MCV	50	0.264868
109	9	BT	2741	1.888914
110	9	BT with MCV	11560	5.849909
111	9	FC	391	0.240885
112	9	FC with MCV	1503	1.017395

113	9	AC	85	0.73366
114	9	AC with MCV	127	0.747572
115	9	BT	1571	0.678617
116	9	BT with MCV	11811	4.77325
117	9	FC	291	0.142917
118	9	FC with MCV	2198	1.261276
119	9	AC	76	0.666615
120	9	AC with MCV	63	0.510728
121	9	BT	88396	41.21631
122	9	BT with MCV	99338	48.2323
123	9	FC	8250	4.773257
124	9	FC with MCV	10260	5.436855
125	9	AC	76	0.678096
126	9	AC with MCV	108	0.780575

Comment

- Forward Checking and Arc Consistency proved to be a great improvement over the Backtracking only algorithm.
- (Backtracking with Arc Consistency) had a significant impact on the number of assignments and time taken over the other two algorithms.
- The Most Constraining Variable heuristic had a little impact on the performance of the algorithms, but it worth noting that this highly depends on the cage sizes of the board.

2. Interaction Sequence Diagram



3. Class Diagram