NONOGRAM TOURNAMENTS IN TAAI 2011

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Two Nonogram tournaments were held in the TAAI computer game tournaments (Lin, Wu, and Yen, 2011), as part of the 2011 conference on Technologies and Applications of Artificial Intelligence (TAAI 2011), held in National Central University, Chungli, Taiwan, from November 12th to 13th, 2011. Table 1 lists the participants and the two final standings.

Game	Rank	Program Name	Author(s)	Affiliation(s)	Score(s)
Nonogram	1	LALAFROGKK	Kan-Yueh Chen, Ching-Hua Kuo, Hao-Hua Kang	National Chiao Tung University (NCTU), Taiwan	4
	2	NAUGHTY	Kuang-che Wu	Google Inc., Taiwan	2
	3	YAYAGRAM	Lun-Pin Yuan, Jian-Han Lee, Yuan-Fu Lou	NCTU, Taiwan	0
Nonogram Solver	1	LALAFROGKK	Kan-Yueh Chen, Ching-Hua Kuo, Hao-Hua Kang	NCTU, Taiwan	1000
	2	YAYAGRAM	Lun-Pin Yuan, Jian-Han Lee, Yuan-Fu Lou	NCTU, Taiwan	766
	3	NAUGHTY	Kuang-che Wu	Google Inc., Taiwan	509

Table 1: The participants and their programs
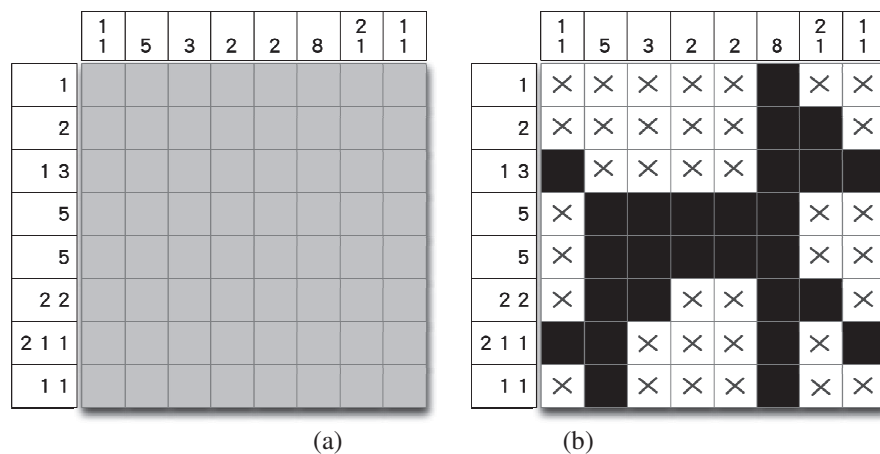

(a) (b)

Figure 1: (a) A Nonogram puzzle designed by Wolter (2012) and (b) its solution.

Nonograms, also known as Hanjie, Paint by Numbers, or Griddlers, are picture logic puzzles on blank grids in which clues are given at the sides of the grid, normally at the left side and upper side, as shown in Figure 1(a). Players are requested to let each cell either be colored or left blank, such that the sizes of segments of consecutive painted cells matches these clues. For example, a row with a clue of "1 3" implies that the row contains two segments with sizes, 1 and 3 respectively, in that order with at least one blank among these segments. The grid in Figure 1(b) is the solution of the puzzle in Figure 1(a).

According to Puzzle Museum (2012), a Japanese graphics editor named Non Ishida invented Nonograms in 1988. In 1990, the UK newspaper *The Sunday Telegraph* started publishing them on weekly basis. Soon, the game was proved to be NP-complete by Ueda and Nagao (1996). The puzzle tournaments had been held by the 15th Computer Olympiad in 2010, TCGA 2011, and TAAI 2011.

In TAAI 2011, two Nonogram tournaments, called "Nonogram" and "Nonogram Solver", were held. The two tournaments were similar to those held by the SAT 2011 Competition (2011) for SAT problems, which are also

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an NP-complete problems. The Nonogram Tournament is similar to the competition catalog *Crafted*, while Nonogram Solver Tournament is similar to *Random*. The detailed rules of both tournaments are described below.

Tournament Rules for Nonogram
The rules of the Nonogram tournament are the same as those played in the Computer Olympiad in 2010 and the TCGA 2011. In the current tournament, the games were played according to a round-robin system in which one program played once against all the other programs. In each game for a pair of programs, one program has to solve 100 25x25 puzzles provided by the opponent within 60 minutes (wall clock time) on a single-core machine. Every program obtains 1 point for every puzzle it solves. In order to ensure that each puzzle has a unique solution, a program loses one point as penalty for each given puzzle if the opponent is able to show multiple solutions for the puzzle. The winner is the program that obtains more points. In the case that both players have an equal number of points, the winner is the program that solves the 100 puzzles in a shorter period of time; otherwise, the result is a tie. For each game, the winner scored 2 and the loser scored nothing. For a draw, both scored 1.

From the rules, the challenge of the Nonogram tournament is not only to design fast solvers, but also to generate difficult puzzles. In order to generate very difficult puzzles, the participants usually need to run the puzzle generators on as many machines as possible in advance. This discourages the new participants. In addition, it is also likely that a program chooses from the 100 puzzles a difficult puzzle to start with and spends a long time in solving it. This also makes the tournament less fair.

Tournament Rules for Nonogram Solver
As mentioned above, the Nonogram tournament may discourage new participants due to extra efforts on Nonogram puzzle generation. In order to let participants focus on solving puzzles, the new tournament, Nonogram Solver, was held in TAAI 2011, where the organizer prepared puzzles for participants. However, it is hard (at least not so straightforward) to prepare puzzles that are not known or guessed by participants and that are sufficiently difficult.

In the Nonogram Solver tournament, the tournament organizer prepared a Nonogram random generator (Wu, 2011), which was announced to all participants before the tournament. The generator produced 1000 25x25 puzzles with a random seed determined by all participants onsite. For example, let the seed be the sum of the numbers given by the participants, who did not know the numbers given by others.

The generator generates a grid by painting cells at random. The densities of black cells in these 1000 puzzles were ranging from 50% to 35% linearly in order. According to Batenburg and Kosters (2009), the most difficult puzzles contain about 20~35% black cells; and the higher density of black cells (more than 35%), the easier the puzzles are. This implies that the generated puzzles (from 50% to 35%) are roughly from easy to hard ones in that order. Then, each program needs to solve these 1000 puzzles in order (without skipping any) on a single-core machine within 120 minutes.

Clearly, it is not ensured that the puzzles generated by the generator have a unique solution. In the case that a puzzle has multiple solutions, programs need to report two solutions. In the case of one solution, programs only need to report one. In fact, producing a second solution is known as *Another Solution Problem* (*ASP*). Ueda and Nagao (1996) proved that ASP of Nonograms is also NP-complete.

The winner is the program that solves the most puzzles. In the case that two (or more) programs solve the same numbers of puzzles, then the winner is the program that solves them in less time; otherwise, the programs tie.

The Tournaments

Ranking	Program	LALAFROGKK'S		NAUGHTY'S		YAYAGRAM'S		Score
		Solved	Time (s)	Solved	Time (s)	Solved	Time (s)	
1	LALAFROGKK	-	-	100	1802	100	1082	4
2	NAUGHTY	5	3600	-	-	60	3600	2
3	YAYAGRAM	2	3600	25	3600	-	-	0

Table 2: The cross table of the Nonogram Tournament.

LALAFROGKK won the gold of Nonogram Tournament of TAAI 2011 by winning all games with solving all 100 puzzles of other opponents. The cross table is listed in Table 2. LALAFROGKK solved all the 100 puzzles of NAUGHTY's within 1802 seconds and all of YAYAGRAM's within 1082 seconds. NAUGHTY solved only 5 puzzles of LALAFROGKK's (within 60 minutes or 3600 seconds), and 60 of YAYAGRAM'S. YAYAGRAM solved only 2 puzzles of LALAFROGKK's and 25 of NAUGHTY's.

Ranking	Program	Solved	Time (s)
1	LALAFROGKK	1000	645
2	YAYAGRAM	766	7200
3	NAUGHTY	509	7200

Table 3: The cross table of the Nonogram Solver Tournament.

LALAFROGKK also won the gold medal of Nonogram Solver Tournament of TAAI 2011 by solving all the 1000 puzzles in 645 seconds. YAYAGRAM won the silver one by solving 766 in 120 minutes (or 7200 seconds), and NAUGHTY won the bronze medal by solving 509. YAYAGRAM was stuck on the 767th puzzle starting from 4989 seconds and NAUGHTY was stuck on the 510th puzzle starting from 2325 seconds.
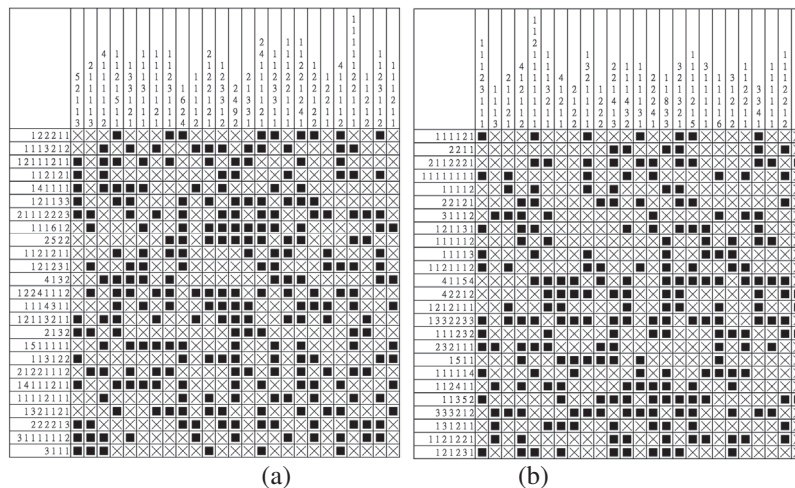

Figure 2: (a) The 510th puzzle, and (b) the 767th puzzle.

The 510th and 767th puzzles are showed in Figure 1(a) and Figure 1(b) respectively. NAUGHTY was stuck on the 510th for at least 4875 seconds, while LALAFROGKK solved this one within 28 seconds and YAYAGRAM solved this one within 107 seconds. YAYAGRAM was stuck on the 767th for at least 2211 seconds, while LALAFROGKK solved this one within 0.374 seconds.

From the above results, LALAFROGKK convincingly outperformed the other two in both tournaments. Although NAUGHTY won the silver and bronze in both tournaments respectively, the program is ranked the fastest for random input set among all the programs (not including LALAFROGKK) collected by Wolter (2012) according to their latest tests.
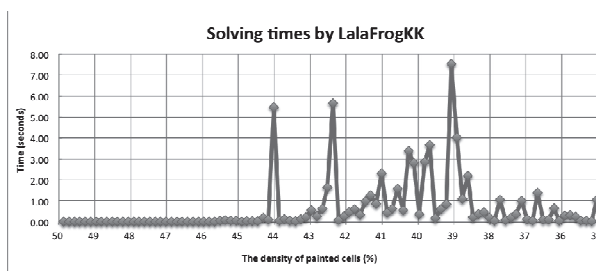

Figure 3: The solving times by LALAFROGKK.

Finally, we want to check the difficulty of the generated 1000 grids by the generator given in the Nonogram random generator (Wu, 2011). The 1000 grids are, in that order, divided into 100 groups, each containing 10 puzzles. Figure 3 shows the averaged times of every 10 grids that LALAFROGKK took to solve these grids. The most difficult grids contain 38%~44.5% black cells. The results are not the same as those in the estimation by Batenburg and Kosters (2009), but include many difficult ones between 38% and 44.5%. They are well suited for tournaments.

F.l.t.r. Kuang-che Wu (Naughty), Yuan-Fu Lou (Yayagram), I-Chen Wu and Kan-Yueh Chen (LalaFrogKK). (Nonogram tournament)

F.l.t.r. Kuang-che Wu (Naughty), Lun-Pin Yuan (Yayagram), Ching-Hua Kuo (LalaFrogKK) and I-Chen Wu. (Nonogram Solver tournament)

References

Batenburg, K. J., and Kosters, W. A. (2009). Solving Nonograms by combining relaxations. *Pattern Recognition*, Vol. 42, No. 8, pp.1672-1683.

Lin, Y.-S., Wu, I.-C., & Yen, S.-J. (2011). TAAI 2011 Computer-Game Tournaments. *ICGA Journal*, Vol. 34, No. 4, pp. 248-250.

Puzzle Museum (2012). *http://puzzlemuseum.com/griddler/gridhist.htm*

SAT 2011 Competition (2011). *http://www.satcompetition.org/2011/*

Ueda, N. and Nagao, T. (1996). NP-completeness results for NONOGRAM via parsimonious reductions. *Technical Report TR96-0008*, Department of Computer Science, Tokyo Institute of Technology.

Wolter, J. (2012). Web Paint-by-Number. *http://webpbn.com.*

Wu, K.-C. (2011). *http://kcwu.csie.org/~kcwu/nonogram/taai11/*

THE 16ᵗʰ COMPUTER OLYMPIAD (PART 2)

Tilburg, the Netherlands
November 19 – November 26, 2011

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Tilburg, The Netherlands

As usual, the Computer Olympiad consisted of many different competitions, each having their own programs and their own rules. Jaap van den Herik served as Tournament Director; Jan Krabbenbos as Assistant Tournament Director for Chess, and I-C. Wu as the Assistant Tournament Director for the Olympiad.

The 16ᵗʰ Computer Olympiad hosted the following eighteen games: Amazons, Backgammon, Chinese Chess, Chinese Dark Chess, Clobber, Connect6, Dots and Boxes, 10×10 Draughts, Ein Stein Würfelt Nicht, Go 9×9, Go 13×13, Go 19×19, Havannah, Hex, NoGo, Phantom Go, Shogi, and Surakarta.

The report on the WCCC 2011 was published in the December 2011 issue. The March 2012 issue contained the WCSC 2011 report and the reports on Backgammon, Chinese Chess, Clobber, and Havannah. This issue contains the reports on: Ein Stein Würfelt Nicht (W. Turner; see pp. 94-101) and Hex (R. Hayward; see pp. 124-127). We aim to publish reports on the other 12 tournaments, viz. Amazons, Chinese Dark Chess, Connect6, Dots and Boxes, Draughts, Go 9x9, Go 13x13, Go 19x19, NoGo, Phantom Go, Shogi, and Surakarta in the September issue of the Journal. Full results and games can be found at http://www.grappa.univ-lille3.fr/icga/ and www.icga.org.

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