1 Further Results

We list problems that are complete in classes that are likely above PSPACE. For games listed the problem is

given a position in the game, which player wins?

- 1. Chinese Checkers, and other pebble games, were proven EXPTIMEcomplete by Kasai, Adachi, and Iwata [6]. Variants of pebble games were proven EXPTIME-complete by Kolaitis & Panttaja [8].
- 2. Shogi, also known as Japanese Chess, is a 2-player strategy game. It does share some properties of chess, though the games are not that much alike. It was proven EXPTIME-complete by Adachi et al. [1]. The complexity of variants of Shogi was studied by Yato et al. [11].
- 3. Quixo is a complicated variant of tic-tac-toe. It was shown EXPTIMEcomplete by Mishiba and Takenaga [9].
- 4. Cops and Robbers is a game played on a graph where a robber is trying to escape a group of cops trying to encircle them. It was shown EXPTIME-complete by Kinnersley [7].
- 5. The Custodian Capture game is a game where pieces move like rooks and capture by being on either side of a piece. It was shown EXPTIMEcomplete by Ito et al. [4].
- Reachability-Time Games on Timed Automata showed EXPTIMEcomplete by Jurdzínski and Trivedi [5].
- 7. Different versions of Angry Birds were shown NP-hard or PSPACEhard or EXPTIME-hard by Stephenson et al. [10].
- 8. A Graph Request-Response games is a 2-player graph game where the objectives are ANDS of conditions like *if a RED vertex is visited, then later on a BLUE vertex must be visited*. Such games where shown EXPTIME-complete by Chatterjee, et. al [2]. A variant of these called Streett games were shown EXPTIME complete by Fijalkow & Zimmermann [3].

References

- H. Adachi, H. Kamekawa, and S. Iwata. Shogi on n×n board is complete in exponetial time. Transactions IEICE. J70-D, 88-A:1843–1852, 1987.
- [2] Krishnendu Chatterjee, Thomas A. Henzinger, and Florian Horn. The complexity of request-response games. In Adrian-Horia Dediu, Shunsuke Inenaga, and Carlos Martín-Vide, editors, Language and Automata Theory and Applications 5th International Conference, LATA 2011, Tarragona, Spain, May 26-31, 2011. Proceedings, volume 6638 of Lecture Notes in Computer Science, pages 227–237. Springer, 2011. https://doi.org/10.1007/978-3-642-21254-3_17.
- [3] Nathanaël Fijalkow and Martin Zimmermann. Parity and streett games with costs. Log. Methods Comput. Sci., 10(2), 2014. https://doi.org/10.2168/LMCS-10(2:14)2014.
- [4] Fumitaka Ito, Masahiko Naito, Naoyuki Katabami, and Tatsuie Tsukiji. EXPTIME hardness of an n by n custodian capture game. *Algorithms*, 14(3):70, 2021. https://doi.org/10.3390/a14030070.
- [5] Marcin Jurdzinski and Ashutosh Trivedi. Reachability-time games on timed automata, 2009. http://arxiv.org/abs/0907.3414.
- [6] Takumi Kasai, Akeo Adachi, and Shigeki Iwata. Classes of pebble games and complete problems. SIAM J. Comput., 8(4):574–586, 1979. https://doi.org/10.1137/0208046.
- [7] William B. Kinnersley. Cops and robbers is exptime-complete. J. Comb. Theory, Ser. B, 111:201-220, 2015. https://doi.org/10.1016/j.jctb.2014.11.002.
- [8] Phokion G. Kolaitis and Jonathan Panttaja. On the complexity of existential pebble games. In Matthias Baaz and Johann A. Makowsky, editors, Computer Science Logic, 17th International Workshop, CSL 2003, 12th Annual Conference of the EACSL, and 8th Kurt Gödel Colloquium, KGC 2003, Vienna, Austria, August 25-30, 2003, Proceedings, volume 2803 of Lecture Notes in Computer Science, pages 314–329. Springer,

2003. https://doi.org/10.1007/978-3-540-45220-1_26.

- Shohei Mishiba and Yasuhiko Takenaga. QUIXO is exptime-complete. Inf. Process. Lett., 162:105995, 2020. https://doi.org/10.1016/j.ipl.2020.105995.
- [10] Matthew Stephenson, Jochen Renz, and Xiaoyu Ge. The computational complexity of angry birds. Artif. Intell., 280:103232, 2020. https://doi.org/10.1016/j.artint.2019.103232.
- [11] Takayuki Yato, Takahiro Seta, and Tsuyoshi Ito. Finding yozume of generalized tsume-shogi is exptime-complete. *IEICE Trans. Fundam. Electron. Commun. Comput. Sci.*, 88-A(5):1249-1257, 2005. https://doi.org/10.1093/ietfec/e88-a.5.1249.