Formal Verification of the Snake Game as a State Machine

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Abstract

The Snake game offers a simple yet non-trivial environment for studying state-based reasoning, safety properties, and termination. In this project, we intend to formalize Snake as a State Machine and verify the correctness of its controller and high-level properties using Stainless, a verification framework for Scala. The set of possible states will have one invalid state and valid states that encode the snake, the walls and the apples on the grid. §1 gives some interesting properties we would like to prove.

As a background reference, we will review the paper [2], which formalizes simple games such as Pac-Man and Chess in ProB.

1 Properties we will verify

We model the snake as `List[(Position, Direction)]` where the list is ordered from the head of the snake to its tail.

- The snake is continuous, that is, the i-th position of the snake is given by the $i+1$-th position plus the $i+1$-th direction for $0 \leqslant i <$ snake length $- 1$
- The snake does not collide with itself or the walls, and remains inside the grid.
- The transition function of the state machine outputs the invalid state from a valid state only if one of the above conditions is not satisfied for the updated state.
- Valid moves are defined according to **Definition 1** in [1].
- Additional safety and liveness properties may be considered as the model evolves.

References

[1] M. {De Biasi} and T. Ophelders. "The complexity of snake". English. In: *Proc. 8th International Conference on Fun with Algorithms (FUN)*. Leibniz International Proceedings in Informatics (LIPIcs). 8th International Conference on Fun with Algorithms (FUN 2016), FUN 2016 ; Conference date: 08-06-2016 Through 10-06-2016. Schloss Dagstuhl - Leibniz-Zentrum für Informatik, June 2016, pp. 1–13. DOI: 10.4230/LIPIcs.FUN.2016.11.

[2] Sebastian Krings and Philipp Körner. "Prototyping Games using Formal Methods". In: *Formal Methods – Fun for Everybody*. Accessed from: https://fmfun.github.io/Papers-2019/Krings-Koerner.pdf. 2019. DOI: 10.1007/978-3-030-71374-4.