Threaded Paws: A Serious Game for Learning the Pitfalls of Concurrent Programming





Luisa Rojas Garcia • Jeremy S. Bradbury • Michael A. Miljanovic Faculty of Science • University of Ontario Institute of Technology • Oshawa, Ontario, Canada

{luisa.rojasgarcia, jeremy.bradbury, michael.miljanovic}@uoit.ca

1. Motivation

- Developments in multi-core processors continue to increase the need for skilled concurrent programmers.
- The role of concurrency in computing is expected to broaden, not only within industry, but also in the classroom at the undergraduate level.
- Writing concurrent programs remains challenging due to its nondeterministic nature [1].
 - Some of the challenging pitfalls include starvation, deadlocks, and data races.
- Serious games as teaching tools have been shown to motivate and engage learners through a goal-oriented dynamic, while also offering continual and immediate feedback [2].

Research Goal:

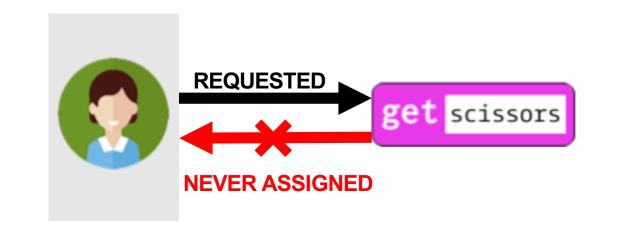
Develop a serious game that allows students to learn how to identify and fix concurrency pitfalls.

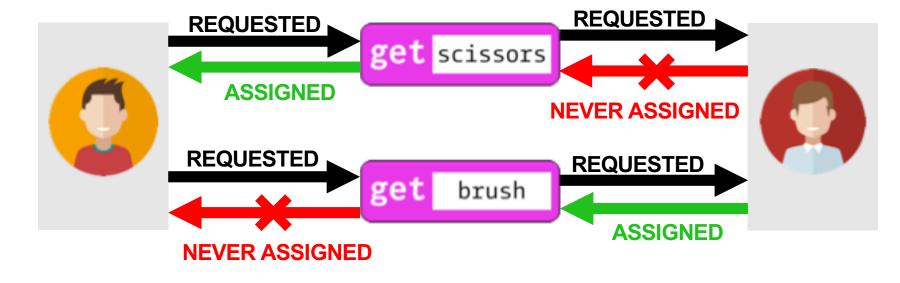
2. Gameplay

- In Threaded Paws [3], the learner assumes the role of manager at a dog grooming salon, where they need to coordinate the workers to attend to all incoming customers before the day ends.
- Within the game, each worker can concurrently perform tasks (e.g. grooming, washing) as well as acquire resources (e.g. brush, shampoo). Pitfalls can occur when the workers don't correctly coordinate.
- The player can initiate a simulation of a complete day at the dog grooming salon in order to check if all tasks have been completed successfully.

3. Level Breakdown

Level	Description
1	Introduces gameplay using a task involving one worker (sequential execution).
2	Introduces the starvation pitfall by providing a two-worker scenario that must be fixed.
3	Introduces the deadlock pitfall by providing a two-worker scenario that must be fixed.





Starvation Deadlock

4. Interface **Action Blocks: Icons:** Remind the **Toolbox Panel: Threads Panel: Simulation Panel:** Using the necessary "Inventory" space that player resources Allows for Area where all resources, they will required for each indicates the workers' tasks to finalized actions will perform the action action, as well as the elements (and be administered be visualized. specified. quantities) available. agenda for the day. and structured. toolbox threads ① 🛢 simulation worker 1 worker 2 a day in the game. The player needs to make sure all checkin x 1 × ∅ actions are executed before the time is get brush \times 1 \times 1 checkin; get scissors \times 1 \times 1 \times 1 \times 1 ret brush \times 1 \times 1 get(brush); get(scissors); ret scissors × 7 checkout x 6 x 5 Waiting for Waiting for scissors... **Play/Stop Button:** nitiates (📂) or terminates () the simulation. Workers: Workers (threads) can be managed Error Bar: Warns the learner of any Get and Return Blocks: Used here. Tabs are provided to switch between them. illegal actions they may attempt. to acquire and return resources.

5. Conclusions and Future Work

- Threaded Paws is a serious game designed to facilitate the learning process with respect to concurrency. Each level aims to assist learners in understanding how to identify and fix a specific concurrency pitfall.
- Does Threaded Paws improve learning? In order to answer this question, we next plan to conduct a user study. It's important to know if there are any significant benefits in using Threaded Paws in comparison to more traditional methods.
- Additional future work includes:
- Design new levels for additional concurrency pitfalls (e.g. data races).
- Add a hint system to provide suggestions and reduce frustration.
- Improve replayability through level data generation.

6. References

- 1] J. Yang, M. Cui, J. Wu, Y. Tang, and G. Hu, "Making parallel programs reliable with stable multithreading," *Communications of the ACM*, vol. 57, no. 3, pp. 58–69, 2014.
- [2] W. S. Yue and W. L. Wan, "The effectiveness of digital game for introductory programming concepts," *Proc. of ICITST 2015*, no. August, pp. 421–425, 2016.
- [3] Threaded Paws. website: http://www.sqrlab.ca/software/threadedpaws/



