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Virtual Environment and Automated Physical Rolling Maze as Experimental Platform for Deep Reinforcement Learning

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Introduction

We are developing platforms that shall help students to build practical competencies by working on challenging tasks in creative and highly motivating applications. Several of these are systems that autonomously learn to master control tasks. Such systems are typically based on *deep reinforcement learning* (DRL), and related algorithms are frequently demonstrated by agents that learn to play games. This submission reports on first results related to a platform where AI agents learn to manoeuvre balls through virtual and physical hardware mazes while avoiding dropping into holes.

Target platform

The system contains two environments (Fig. 1): a software simulation and a motorized physical maze. The former shall serve to develop and demonstrate DRL agents without hardware and physical time constraints during training. The latter shall demonstrate virtually trained agents on a physical device. From education perspective, it applies fields like deep learning, image processing, computer science, physics, electronics, and mechanics in an interdisciplinary way.

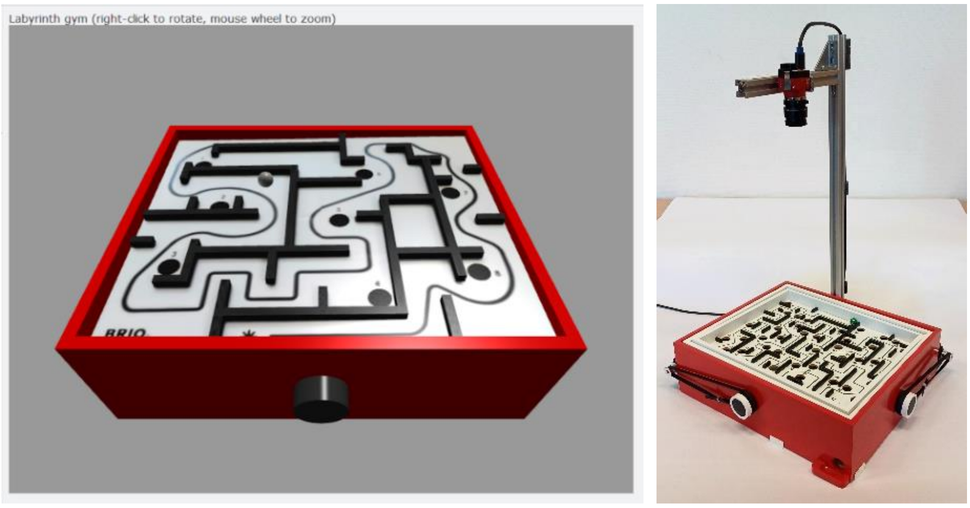

Figure 1: 3D software simulation (left) and automated physical maze (right)

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Reported results

We have developed a fully functional virtual environment, which correctly simulates the related physics and contains six different maze layouts, including all layouts of the game hardware. Noteworthy, we have succeeded to develop Deep Q-Learning (DQN) agents, which are capable to manoeuvre balls from start to finish, for all maze layouts.

Related to the physical demonstrator, we have motorized the game hardware and developed a high-level Python interface to control the game as well as low-level motor control by a connected microcontroller. Moreover, we have integrated an industrial camera required to detect the system's state (e.g., ball location).

Work-in-progress and prospect

At the time of writing, we are developing image processing methods for the physical maze. These shall allow us to address the transfer of virtually trained AI agents to the physical device. Future aspects may include the following:

- Improved image processing to capture the maze layout
- Integration of NVIDIA Jetson boards
- Experiments with different DRL approaches and reward systems
- Fine-tuning of virtually pre-trained agents using the physical device
- General AI agent capable to solve maze layouts which it has not seen before