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Scheduling a Real-Time Railroad System Using Lego MindStorm Hardware

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Extended Abstract

While Computer Science impacts the physical world in significant ways, the most direct fusion between digital and physical occurs when a computing system is embedded into the operations of a physical system. To function properly, such real-time systems must be able to react to environmental stimuli quickly and effectively. A model train was chosen as the platform for the embedded system for its simplicity and additional possible variations such as track turnouts. It was decided not to simulate the system, as one of our goals was to investigate the construction of a sensor system. The goal of the real-time system is to conform the motion of the train to a schedule input by the user. This schedule consists of an input destination and a time allotted for travel. Six sensors are distributed evenly along the rail, tracking the train's position and speed, while the processor works to determine optimum conditions for reaching a scheduled time with maximum possible accuracy and consistency. A robotic rig receives commands from the processor and controls the voltage sent to the rail to adjust the train's speed. High accuracy requires not only a functional decision-making algorithm, but sufficient 'tuning' in the algorithm to compensate for physical constraints inherent in the system. A predictive algorithm was used to control the speed of the train. Before the train begins moving, the system calculates how fast the train should move to keep the schedule. Every time the train passes a new sensor, the remaining distance and time are used to recalculate the new speed.

Two experiments were conducted to test two different track layouts. The first experiment used a simple circular track. The second track was circular in shape, yet had an additional turnout along one end. This added turnout gives the train the option to increase the length of the trip around the track. This layout was considered beneficial, as it was found that traveling at excessively low or high speeds, the train would become difficult to control precisely. The extra distance from the turnout allows the system to dampen high speeds with extra distance, thus leading to more accurate times. After running each experiment through multiple iterations, the overall accuracy of the track layout was determined by comparing the time taken to travel the distance versus the time allotted for travel.

The results of the trials are available. It was found that the average error for the simple track was .21 seconds, while the average error for the complex track was .24 seconds. The range of the recorded errors of the simple track was .472 seconds. The range of the complex track's errors was only .246 seconds. While the addition of the turnout did not significantly affect the accuracy of the train's timing, it did cause more consistent results. We believe the turnout caused this result because it allowed the train to always travel at mild speeds, thus allowing for more precise scheduling. The turnout effected average error to a smaller degree than we anticipated.