DTU Electrical Engineering
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Wally, Autonomous Wheeled Racing Robot

Developed as part of 31384 - Modular Robotics, 2012

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Abstract – This robot was built in order to race into an arena against other robots. It uses Braitenberg driving for obstacle avoidance, wall-following behavior and speed/direction optimizations. Experimental result showed the optimizations improved reliability at the cost of slight performance decrease.

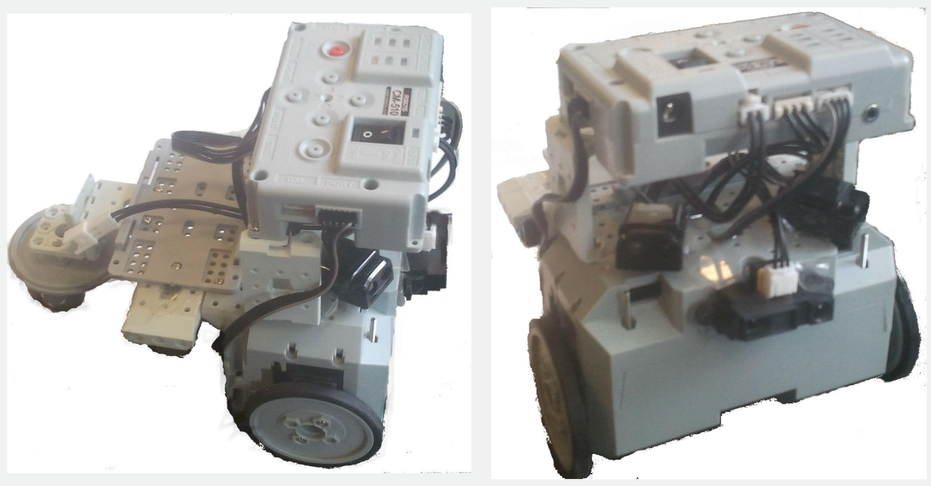

Figure 1. Wally, the autonomous driving wheeled robot developed by the team “Kick-Ass” for project 1 in the 31384- Modular Robotics course, Spring 2012.

Task

The goal of the project is to develop a wheeled robot for speed competitions through the arena in figure 2. Two robots have to race at a time. The robot has to run autonomously and the starting position is unknown.

Figure 1. The racing arena

Figure 3. Dead angles

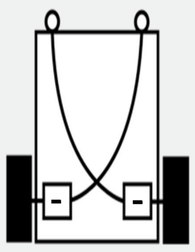

Figure 2. Stucture of a Braitenberg veichle

Development

The first approach has been developing a Braitenberg vehicle as shown in figure 2. The robot mounts two proximity sensors on both front sides. The wheels run at maximum speed and, when something is detected on one side, the speed of the wheel on the opposite side is decreased accordingly. This allows obstacle avoidance. On a second attempt, it turned out that inverting the direction of the wheel on the same side setting the speed proportional to the sensor reading produced smoother and more reliable obstacle avoidance.

However, the problem with this approach is that the direction of the robot becomes unpredictable in presence of dynamic obstacles, as the opponent robot could be, so it may be possible it heads back to the starting position instead of going towards the goal. Moreover, if driving to a dead angle as the one in figure 3, it may get stuck i.e. continuously trying to steer away from both sides.

To overcome these problems a wall-following behavior is introduced: after reaching the front wall it tries to keep it at a constant distance to its left. When the wall is not detected anymore, it returns to the previous behavior until the goal is reached.

To make sure it heads to the right on the first turn, so that it can have the wall to its left, a small speed offset is subtracted from the right wheel. After leaving the wall following behavior this offset is moved to the opposite wheel, so that it will easily head towards the goal.

As a final improvement the maximum speed is adjusted according to the distance detected from a long distance sensor positioned in the front. This allows to safely run at the maximum speed when the path is clear and slowing down as an obstacle approaches. The full logic is shown in figure 3.

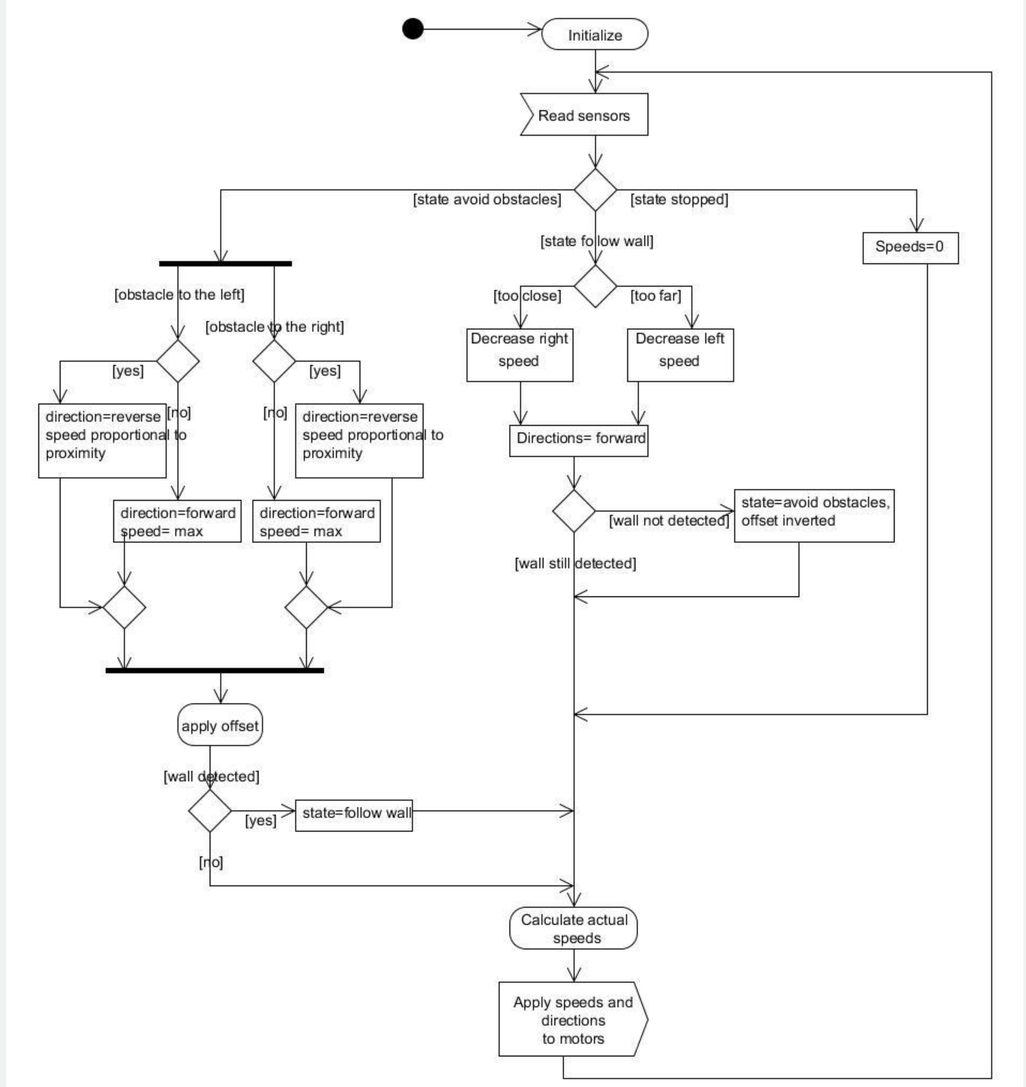

Figure 4. The final optimized robot control logic.

Experiments and results

Experiments have been conducted to compare the pure Braitenberg vehicle with the optimized final version. Time and success rate have been measured as shown in table 1. For each configuration multiple experiments have been run, until 10 successful drive-through have been achieved. All the experimental runs were through the longer path (i.e. started from the left position).

Results show that the pure Braitenberg vehicle is able to reach the goal faster, but with a low success rate. The optimized version, on th other hand, is slower but with a 90% success rate.

CONTROL LOGIC	RESULTS												Success Rate	Average Time	Standard deviation
	Times for successful runs (seconds)										Failures				
	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6	RUN 7	RUN 8	RUN 9	RUN 10	# times stuck in the corner	#times wrong direction			
Pure Braitenberg	8.3	9.1	9.1	9.3	8.8	9.0	10.3	7.8	8.1	8.2	2	5	59 %	8.8	0.73
Braitenberg + Wall-Follow + Speed-Offset	9.6	9.5	10.1	9.6	9.7	10.1	9.3	9.6	9.3	9.4	0	1	90%	9.62	0.29

Table 1. Results of the experiments

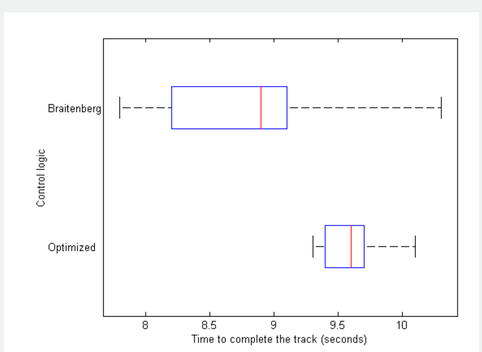

Figure 5. Distribution of the times

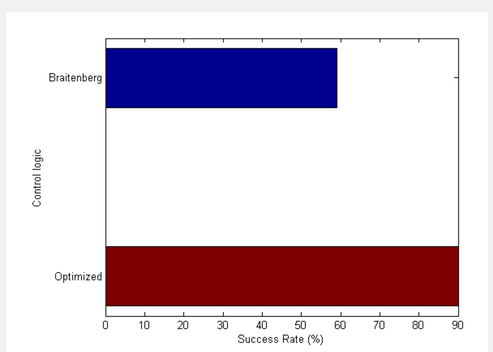

Figure 6. Success rate