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Project 1 - Robot Design

Robot Design – Team 2

Design Overview:

The robot was built with a 4-wheel, 2-tread, tank design. It made use of the two treads provided in the Lego kit and their accompanying tread-wheels. There were two wheels for each tread: front and back. The back wheel of each tread was attached to a drive motor for robot locomotion. The front wheel of each tread was attached to shaft encoders for wheel-speed deduction. Reflectivity sensors were mounted near the front of the robot. The handy board rested centered between the four wheels – held horizontally as viewed from above while the front wheels of the robot are oriented upwards to the viewer. Even though the robot was very top heavy, at least it was well balanced.

Hardware Components:

The basic input/output (sense and act) primitives of the robot consisted of the motors, encoders, and reflectivity sensors:

1. Motors (Act)
   The robot had two motors, each connected to the rear wheels in a 1:1 gear ratio. The 1:1 gear ratio was achieved using the 16 tooth gears. The motors were mounted directly on top of the beam where the wheels were mounted.
2. Encoders (Sense)
   Each front wheel had its own encoder attached to it in a 1:9 gear ratio, so that the encoder shafts would spin 9 times as fast as the wheels. And since each encoder disc has 6 holes, the encoder would read 108 ticks. There were around 2500 ticks for 6 feet. Each encoder disc was attached to its target wheel axis by a large 24-tooth gear on the wheel axle, to a small 8-tooth gear on a middle axle, to another large 24-tooth gear on the middle axle, to a small 8-tooth gear on the encoder disc axle.
3. Reflectivity Sensors (Sense)
   The robot was equipped with two Omron EE-SB5 Reflectivity sensors. These sensors were used to detect the black tape, and to align with the black tape. Since these sensors operate best at about 5 millimeters from the target surface, they were mounted at about 5 millimeters from the floor that the robot is resting on. Our controller program counted the read value from the handy board reflectivity port of greater than or equal to 150/255 as black. The reflectivity sensors were mounted by encasing them inside of legos. A 1x2 lego spacing was left open for the reflectivity sensor to look outside of its encasing. The encasing space was 1x4x2 lego spacings. And the encasing space was covered again with another 1x2 window to accommodate the rest of the sensor and its wires.

Major Design Flaw:

The biggest problem with the robot was that it veered towards the right. The body of the robot was held together very tightly with several beams and pins, which made it especially fortuitous and, ironically, caused the shape of the robot to warp. Not warp speed, but shape warped. The warped shape caused the right wheels to slip more than the left wheels, and this caused the robot to veer to the right. Before we knew that the shape was warped, we spent many hours trying to figure out what was causing it to veer right. Finally, we managed to figure it out and began by first trying to use more pins and beams to hold the body together even more tightly than before. The success of this approach was limited. So, finally we thought of a way to tilt the handy board towards the right of the robot to counteract the slippage of the right wheels. This worked most of the time. But still, the robot consistently slipped towards the right. But as a result of the slippage, we formulated our first axiom for the slipping robot: if the robot does not go straight between any two squares, then it must be going towards the right. We used this fact-of-flaw to program the robot well enough so that it could complete the demonstration.

Design Process:

The robot used in the demonstration was actually the third robot that was built and tested. The first two robots were both front wheel drive, 2-wheeled, caster robots.

1. Robot One: Total Failure

The first robot, as mentioned above, was built with two front drive-wheels, and had three casters on the back. It was designed so that the casters would slide smoothly over the floor, and the robot would be able to make turns around the center of the two drive-wheels. Encoders were attached directly to each drive-wheel axle so that the robot could go straight. Two reflectivity sensors were mounted beneath the drive-wheels to detect the black tape. However, even though encoders were being used to detect the course correction needed, it seemed as though they were not accurate enough. Testing showed that it could not stay on course within 1 foot of the target square at 6 feet away. So, the first robot was destroyed. Actually, it was later found that the failure of the robot to go straight was caused by using 3 casters instead of just one. But this was not found to be the problem until after the construction of the second robot, as described below.

2. Robot Two: Mostly Failure

The second robot was nearly identical to the first robot mentioned above. It used the same two front drive-wheels, and had the same messed up three casters on the back. In short, the second robot was constructed more solidly than the first, and had encoder shafts on it going 9 times the speed of the wheels, rather than the same speed as the wheels. It could be dropped from about 6 feet in the air and its body would remain perfectly intact. Of course, it was never dropped while the handy board was mounted on it. With the three casters on the back, it was still not going in a straight enough line, so all of the three casters except for one were removed. After it was tested with only one single caster, it turned out that the encoders were correcting the course well enough to stay within 1 foot at 6 feet away. This testing was done on both a carpet floor and a linoleum floor. It turned out that the caster being used retarded the motion of the robot. Not only that, but it also caused the wheels to slip, which in turn caused it to go off course. This is because most of the weight of the handy board was resting on the back caster. After testing this robot, it was decided to destroy it and start anew.

3. Robot Three: Kind of Success

The third robot is the same as described at the top of this document, and the one that was used at the demonstration. I would just like to add that it was constructed 30 hours before the demonstration and we had a lot of sleep deprecated fun while debugging it.