Spherical Robots
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Abstract:

An unevenly balanced sphere will always come to rest in the same position, with the center of gravity at the lowest point. Just as a hamster moves itself around while confined to its ball by shifting the center of gravity (itself) to different points of the sphere, the idea that shifts in the center of gravity in a sphere can cause that sphere to move is the basis for spherical robots. These robots would use weighted actuators to shift the center of gravity inside the otherwise perfectly balanced sphere which allows the robot to move. The robot would control its movement with gyroscopes and accelerometers.

Introduction:

A spherical robot has real-world applications as a learning aid, teaching students of all levels about physics and technology, and has specific design advantages. These include the durability of a spherical design, which leaves no sensitive parts exposed, and the fact that a sphere has no rough edges, no corners, and therefore, less risk of injury. In fact, if the weights are centered, the shell opaque, and the robot turned off, an unknowing person could just confuse it for a strange, somewhat heavy plastic ball. As important as a safe durable design, however, is its use of the concept of center of gravity, as critical to engineering as it is fundamental to physics, as a means of propulsion. From younger students, new to robotics, all the way to high school physics students working to understand balance and how to manipulate the center of gravity, the spherical robot will be a useful, educational tool. In robotics competitions based solely on programming, this robot would be able to safely collide with other, similar robots without causing any damage to them, therefore allowing for competitions based on robot-to-robot interactions. The core could even be fitted with a radio transmitter and receiver through which it could communicate with nearby robots or operators with remote controls. Designing computer software for this robot, students could learn various types of programming, limited only by their imagination, creativity, and skill in manipulating such a seemingly simple design. Even toddlers could be exposed to this robot, perhaps providing entertainment by avoiding them, or playing tag. Combined with the safe design of a sphere and a soft surface on the exterior, this robot might even find success as an educational toy.

Design:

The robot (see Figure 1) would essentially be a core with six weighted, servo linear actuators that are evenly balanced when in the same position. The main controller would be contained inside this core, as well as all the sensors (gyroscopes and accelerometers) needed for the robot. The core might look like a small cube with actuators jutting out of every face. This core would be placed at the center of the sphere, and when actuators moved in and out, the weights on the end would shift the centers of gravity of the core, and hence the sphere. Sensors inside the core would include gyroscopes and accelerometers to allow the robot to understand what position it is tilted in, as well as any unexpected changes in motion, which would signify a collision. This core however, would have to be mounted into the sphere to allow the core to roll with the sphere. This frame would consist of metal beams projecting outward to the sides of the circle. These beams would be connected to the shell in such a way, that with the removal of

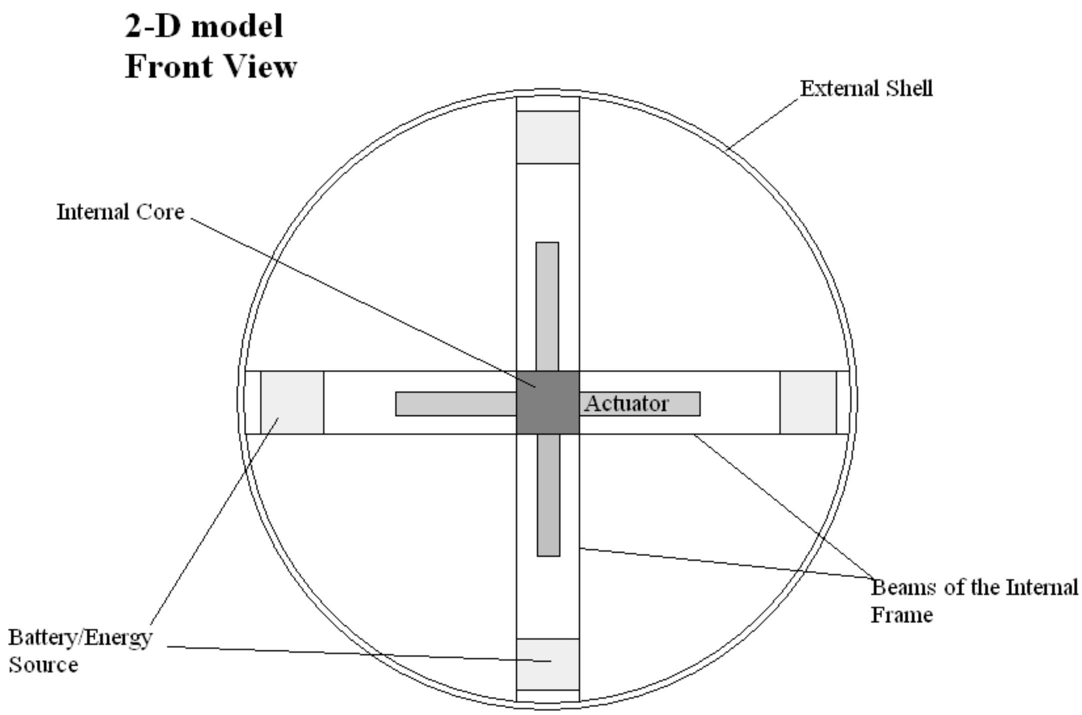

Figure 1

certain screws, the frame and the outer shell could be separated. The actuators would fit between the beams so that the beams don't interfere with the actuators' movement. The actuators would be attached to the outside faces of the core, and would each have uniform weights attached to the ends of each. Each of the actuators would be able to extend and contract to certain positions, thus moving the center of gravity within the sphere. These six actuators will be the driving mechanism of the robot. The frame would be connected to a plastic external shell, which could be given different coverings for different reasons. For example, one may want some soft foam covering when giving the sphere to small children, but maybe a rubber coating with better traction for use on smooth surfaces. The shell could also be made transparent so that students could see how the internals of the robot work. As was mentioned earlier, the frame would be screwed to the outer shell, but the screws would be made to come off, and the shell divided into two halves, with each half threaded to fit the other. Basically, it would be possible to remove the shell entirely from the internal construction. The reason for this is that there could be certain things inside the sphere that need to be accessed by human operators, such as a USB port through which to program the software, and the energy supply for the robot. The power the robot uses would be stored in six batteries, each suspended on its own set of four beams so that it would never move. The robot could be recharged at the core, but the batteries would be spread out around the robot to allow for consistent balance. Figure 1 depicts a basic drawing of what the robot would look like inside. Keep in mind that there are not four but six projecting systems of support beams, actuators, and power supplies. The two that are unseen are on the front and back faces of the core.

Software:

The software in the robot would utilize the information coming from the gyroscopes (inside the core) to measure the robot's tilt in any direction. This information could be used to measure how many rotations have been made, for example, and allow the robot to calculate its travel distance by multiplying the number of rotations times the circumference of the sphere. One basic program of motion would require that the robot first retract all actuators except for one. This one actuator would bring its face of the core down and cause the ball to position and center itself. Next, two opposite actuators perpendicular to the line of the intended motion use the readings from the gyroscope to keep the sphere balanced and from deviating off its intended line of motion. Meanwhile, the bottom actuator, extended the most at that moment, begins to come in, no longer holding the ball in place, while the front-facing actuator extends, causing the sphere to roll forward. Now the previously forward actuator is at the bottom, and the process continues until the ball has traveled the intended distance. One thing about this basic process is that the sphere can change its direction by simply choosing different actuators to balance the sphere while the other four move the ball. The robot could also detect obstacles by taking measurements from the accelerometer (also inside the core) and if there is a sudden, unexpected acceleration or deceleration, the robot knows there is a collision. It could then reverse its motion, and find a different path.

Conclusion:

Whether a student is finishing kindergarten or graduating high school, whether he is new to robotics or an avid competitor in robotics challenges, this spherical robot has plenty to offer. It could even create different types of educational robotics competitions, teaching new concepts of interaction between two or more robots, without the risk of destroying expensive pieces of equipment from minor collisions. Take into account the learning opportunities in programming the robots, as well as the unorthodox design of the drive mechanism, and students will be exposed to new ideas, and perhaps explore more creatively on their own.