Blind Juggler

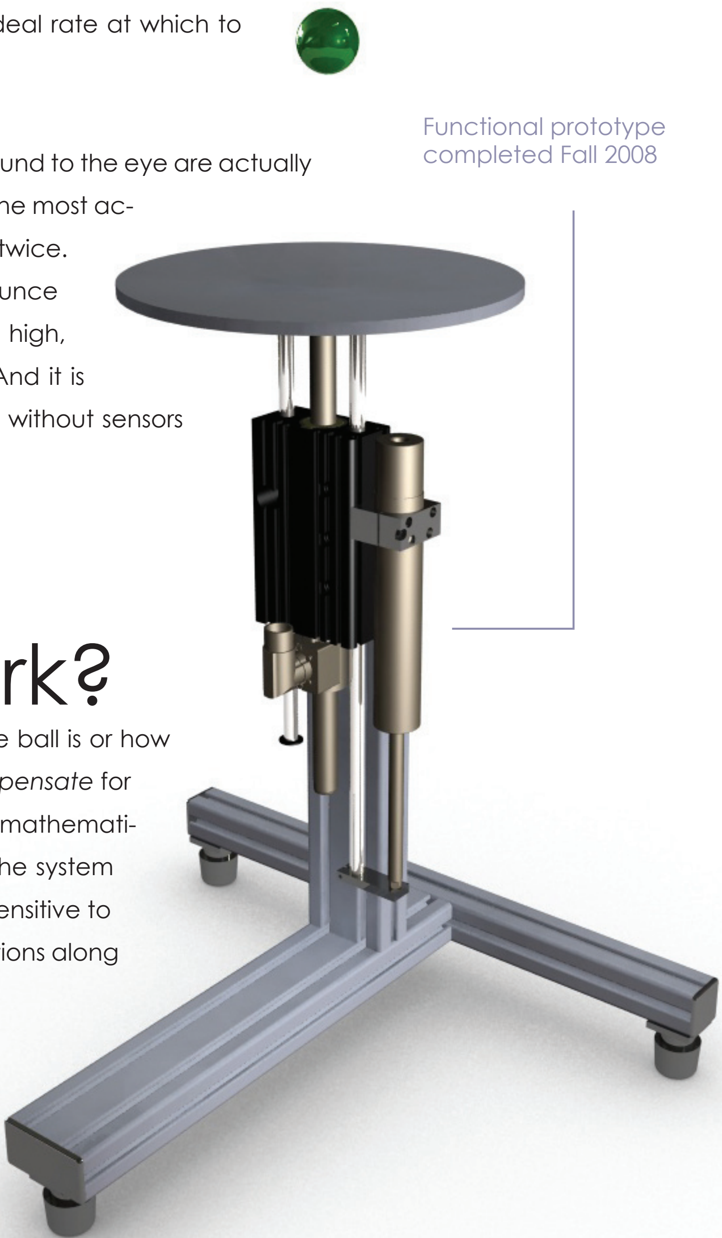
How hard would it be to juggle a ball if you couldn't see it or feel it? Put on a pair of gloves and try it with your eyes closed: it's no easy task!

The Blind Juggler is a robot that can keep a ball bouncing on a paddle without any sensory input. That is, it does not use cameras, microphones, or any other sensors that tell the robot where the ball is.

In a perfect world

it would not be hard to build a robot that could bounce a ball without sensory input: the robot would strike the ball with perfect motion and in perfect time, the ball would be perfectly round, and it would bounce along an identical path to exactly the same height each time. All you would need is a program to tell the robot the ideal rate at which to move the paddle up and down.

The world is not perfect, however. Balls that appear round to the eye are actually covered with tiny manufacturing defects, and even the most accurate mechanisms cannot repeat the same motion twice. The result of this imperfect world is that balls *do not* bounce along a perfect path – they spin, they bounce too high, too low or sideways. In other words, they *deviate*. And it is this deviation that makes the act of bouncing a ball without sensors such a challenge.



Functional prototype completed Fall 2008

How does it work?

The Blind Juggler does not need to 'sense' where the ball is or how fast it's moving because we have designed it to *compensate* for the inevitable deviations of an imperfect world. By mathematically analyzing the imperfections and limitations of the system we were able to optimize the design so that it is not sensitive to deviation. In simple terms, we compensate for deviations along two axes ....

For more information, visit:
www.BlindJuggler.org

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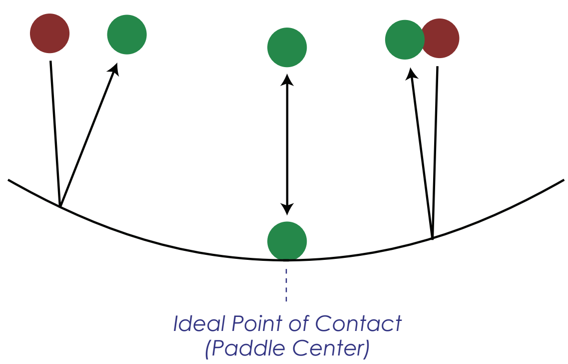
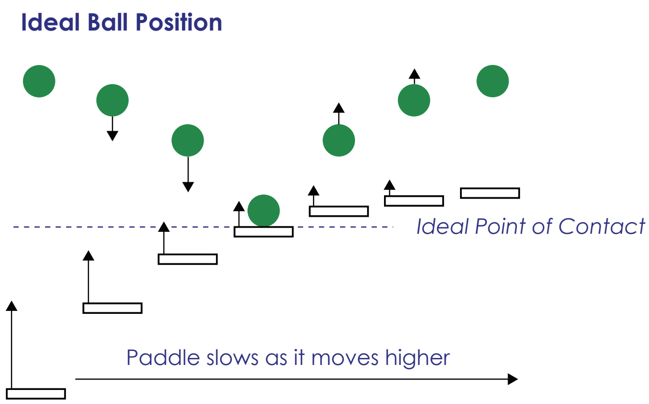
Compensating for Horizontal Deviations

First, we need to keep the ball near the center of the paddle, and we achieve this by using a slightly concave paddle to strike the ball. When the ball strikes the paddle off-center, the curve of the paddle pushes the ball back towards the middle of the paddle. The farther the ball's point of contact from the paddle's center, the greater the 'push' back to center.

The specific curvature of the paddle is critical: too shallow a curve would not provide enough of a 'push' towards the center, while too much of a curve would send the ball past the center and off the other side!

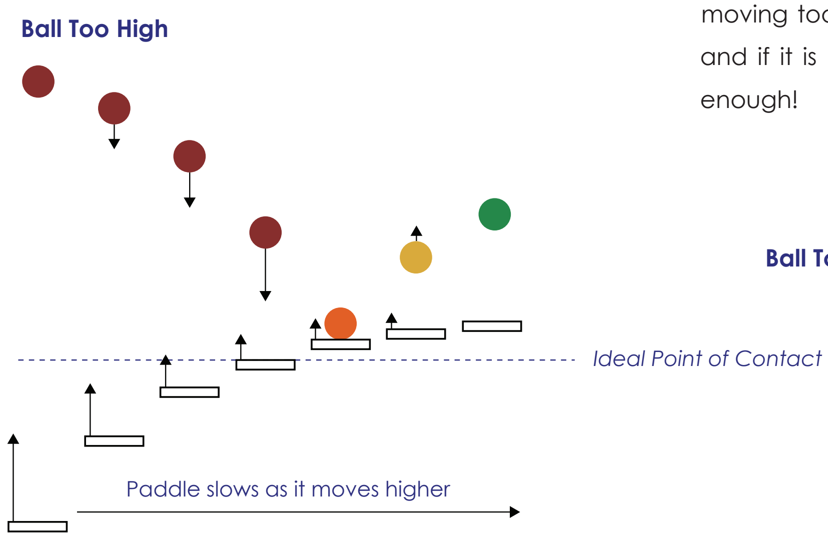


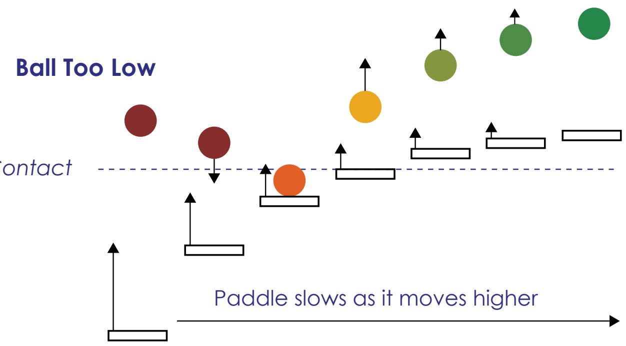
Compensating for Vertical Deviations



Second, we need to keep the ball bouncing at a constant height. We achieve this by slowing down, or decelerating, the paddle at an optimal rate as it strikes the ball. When the ball bounces too high, it takes longer to return to the paddle; the longer it takes to return to the paddle, the slower the paddle is moving when it strikes the ball. The result: the ball is struck with less force and does not bounce as high the next time. The opposite is also true: when the ball bounces too low, it takes less time to return to the paddle, and so is struck with more force and is pushed higher.

The specific rate of deceleration is critical: if the paddle is moving too quickly at impact it will push the ball too high, and if it is moving too slowly, it will not push the ball high enough!





Large Deviation

Ideal Path

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