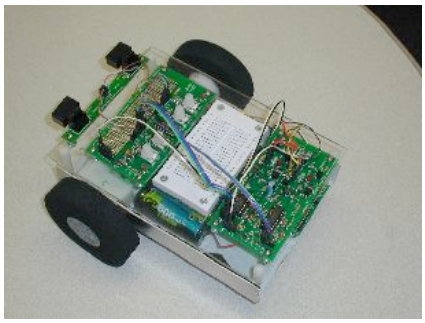

The SPIRIT Project

Educational Robotics

Periodic Sensing (or, Which Way Do the Wheels Turn?)

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Directions: Definition of a Lesson Building Block: This is a "Lesson Building Block" from the SPIRIT educational robotics institute. A 'lesson building block' is in essence an educational activity that might be later turned into a more formal classroom lesson by a creative teacher. The SPIRIT Institute is striving to put a variety of "lesson building blocks" up on the web for the potential use of teachers as they try to prepare more formal educational lessons using the TekBot robotics platform.

I. Concepts: Inquiry, Observation, Perception, Synchronous Sensing

II. Standards: Grade 6 Content Standards: Math 08: Identify, develop, and apply strategies to solve problems using real-life situations. Science 01: Examine problems using scientific inquiry. Research skills.

III. Learning Activity Context: The wheel of a TekBot is modified by attaching a paper disk to the wheel, giving the wheel "spokes." The rotation of the modified wheel of a TekBot will be observed, first in real-time, then using a video camera. The students will find that, when viewing the motion as recorded by a video camera, the wheel of the TekBot appears to turn backwards with respect to the motion of the TekBot. The students can then discuss orally or in writing what the wheel is actually doing and why the wheel does or appears to turn backwards.

IV. Teacher and Student Suggestions/Tips:
This phenomenon also occurs whenever a camera photographs a turning wheel. All that is necessary is that the wheel have some kind of markings on the surface. I first observed this effect watching the stagecoach wheels in the movies about the old west. It is often seen now with the wheel covers of cars in automobile commercials.

V. Teacher Questions :
1. Which way does the wheel turn in real time?
2. If the wheel does not have spokes, which way does it appear to turn as seen by the camera?
3. What effect does adding more "spokes" have on the video's version of the motion?
4. Why does the wheel appear to turn "backwards" relative to the motion of the cart when the camera views the motion?

VI. Assessment Ideas: 1. Evaluate the discussion points brought up by individual students.
2. Evaluate an essay written by the students explaining the phenomenon.
3. An assessment might also be made of the skills of the students as they research the solution to this problem using the internet or other sources.
VII. Other Information: This demonstration/experiment might be started by showing the students a clip from a old "western" which shows the wheels of a stagecoach rotating backwards while the stagecoach is going forward. The students then observe the TekBot in real-time, and explain which way the wheels turn.

One wheel is now modified by attaching a paper circle to the side of the wheel. This paper circle has a black circle on it (slightly smaller than the diameter of the wheel) and one or more diameters have been drawn on the circle. These diameters then serve as "spokes." (See the attached samples of drawn circles shown below in figure 1.)

A television camera is now used to tape the motion of the wheel.

When this tape is played back, the wheel will appear to turn backwards. As circles with more spokes are used, the motion of the wheel will appear to be very erratic. Different numbers of spokes can be drawn easily by hand or by using a computer paint or draw program.

Explanation: The camera is filming at 30 frames/second. In 1/30 of a second, a "spoke" of the wheel doesn't quite rotate enough to appear to have moved forward when the camera takes the next picture. In brief, the sensor (the video camera) and the wheel are out of sync with each other.

In figure 1, the wheel is photographed with the 4 spokes in a horizontal and vertical position. In figure 2, (the next frame) the wheel is photographed with the spokes diagonally. (The spokes do not have enough time to turn ¼ revolution.) In figure 3, the spokes are again horizontal and vertical. The eye does not distinguish between individual spokes of the wheel, but sees all spokes the same. Since the next spoke does not reach the position of the spoke in front of it or a position beyond the position of the spoke before it, it appears to the eye to be rotating backwards. Remember, the eye, unlike the camera, does not take "frames" of what it sees. A repetitive or rotational motion will appear continuous if the projector (television set) shows at a faster rate then 10-12 frames/second.

The eye then sees the wheel going backwards because the eye does not see individual frames but the continuous motion presented on the video.

The TekBot web site (address below) will have a video of a modified TekBot showing the effects of putting "spokes" on the wheel.

http://www.ceen.unomaha.edu/TekBots/2006Workshop/

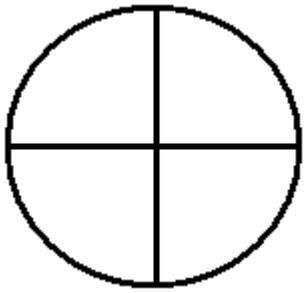

Figure 1

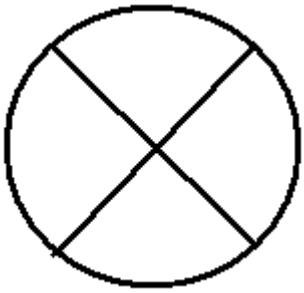

Figure 2

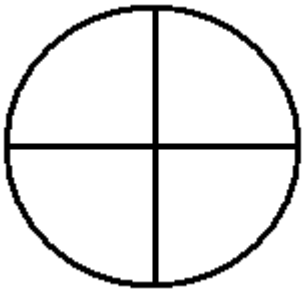

Figure 3

More diameters if desired.

A materials list for my TekBot lesson:

TekBot
Video Camera (low capacity)
VCR
Paper for drawing spokes
Black marker for drawing spokes
Masking tape for attaching spoke paper to wheel