Abstract:
The main objective of this project is to develop a goal sensor that can accurately determine whether a puck has completely crossed the goal plane. There are several disadvantages to the current system employed by the NHL when determining a goal. In any hockey game, there are two linesmen and one referee, each having the authority to rule whether a goal is scored or not. There are also goal judges positioned 1.2 meters behind the glass directly behind the back of the net, and are usually elevated a few feet from the ice surface level. Additionally, in professional leagues such as the NHL, there is a stationary goal video camera mounted several meters above the net pointing down at the goal area, as well as a puck tracking video camera in the net. Even with all these various vantage points, there are times when whether a goal has been scored or not is not clearly visible by any of these mechanisms. For instance, there are times when a puck is in a goaltenders glove, or underneath a player or goaltender that is partly inside and partly outside the net. There are also occasions where a fast shot hits a bar inside the net and comes out very quickly, appearing to hit either a post or a cross bar, and none of the implemented systems can determine the correct call. These examples, among others, occur frequently, and it is impossible for the current technologies to accurately determine if the puck has crossed the goal plane.

Active vs. Passive Goal Detection Systems:
There are 3 main concerns the goal sensor must satisfy:
- **Hidden Detection**: If the puck is underneath a player or not visible.
- **High Sample Rate**: The sensor must be able to detect a puck moving at upwards of 100 mph.
- **Orientation**: Since the puck is cylindrical, it can rotate and cross the goal line in many different orientations.

Experimental Procedure:
Accelerometers are an active technology that can be used to accurately measure a goal. They can be small, lightweight, and embedded within a puck, and they satisfy the three main issues concerning the goal sensor design. They can be used to find the position of the puck by taking a double integration of the acceleration to get the position. The Pasco Acceleration Sensor PS-2119 was strapped to a skateboard and shot at various distances and speeds, simulating a puck shot along the ice. The skateboard’s wheel alignment prevents sensor rotation, since only one sensor was used. Once at rest, the x and y distances were measured by hand, and compared to the integration from the sensor. 30 total trials were performed and shot at various distances and speeds, simulating a puck moving at upwards of 100 mph.

Results:
The integration from acceleration to position yields an accurate result based on the sensors size. For the puck design, a total of 3 small, sensors would need to be embedded, which would account for the various puck rotations, allowing the puck to be fully dimensioned. Also, since initial conditions are critical when integrating, a sensor system needs to be placed around the puck to effectively triangulate the puck’s signal, showing where it started to calculate its final position.

Conclusion and Recommendations:
- After 30 trials, the average percent error between the measured distance and integration was 3.4% and 13% for the y and x planes respectively. There was little motion in the x-direction, which contributes to the large error.
- More testing with smaller, more accurate accelerometers in the configurations shown and embedding these sensors into a puck to test rotation and triangulation.
- Impact and stress testing with the sensors inside of a puck.
- A cost/benefit analysis to see if the accelerometer system is economically viable.

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