Augmented Reality Gaming with Sphero

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1. Introduction

Sphero is revolutionizing the augmented reality gaming genre by eliminating the need for a static paper marker and replacing it with a fully motive robot. Robotics unlocks endless possibilities for new gameplay. No longer restricted to playing near a stationary marker or the television screen, the player can run around their entire house using a mobile device as a window into an augmented world. Imagine fighting monsters in your bedroom, saving the princess in the kitchen or even taking the virtual experience outside.

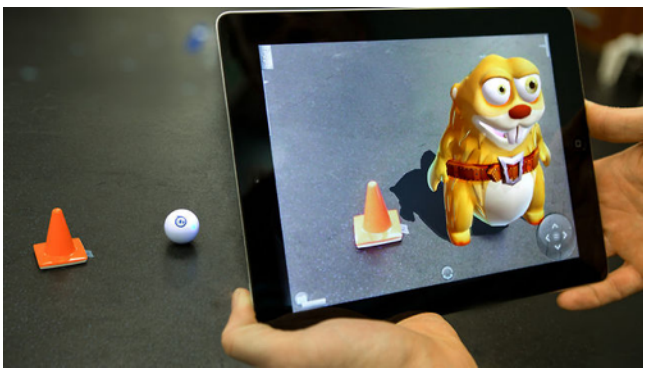

Figure 1. *Sharky the Beaver.*

2. Design

The Sphero Augmented Reality Engine combines techniques from robotics and computer vision to create a robust, stable experience. The system has two central components. The first is an optimized tracking system, which utilizes the back-facing cameras on consumer phones and tablets to identify Sphero's position in the scene and the relationship of the mobile device to it. The second component is a collection of sensor fusion algorithms that generate position estimates from robotic information and integrate those into a final camera pose estimate. Together, these components produce a camera matrix and Sphero position for each frame allowing developers to render arbitrary 3D virtual content at Sphero's location or into the environment at large.

3. Pose Estimation

Sphero's absolute position is approximated robotically by combining IMU and motor output to determine rolling velocity and integrating. The position of the mobile device relative to the robot is determined by the visual tracking system and the mobile device's IMU. We want to combine "absolute" sphero position with relative observed position to produce a camera position. Unfortunately the robot and device (necessarily) operate in their own coordinate systems. Learning the difference between coordinates is treated as a non-linear optimization problem in which the visually observed velocity of Sphero is corollated with its robotically reported velocity.

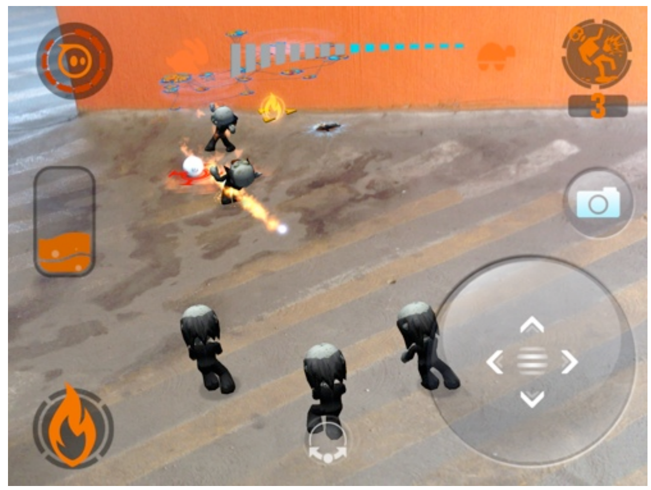

Figure 2. *The Rolling Dead.*

3. Results

Leveraging robotics to estimate the absolute position of a featureless marker allows one to upgrade featureless marker tracking into a full AR engine, which generates camera position estimates. When the marker is not in view it is no longer possible to compute a camera position. However, if the camera is not translated (i.e. it may be rotated in place) the AR experience will continue accurately. In this case it is possible to estimate the location of the marker even though it is entirely occluded.

4. Conclusion

Robotics and visual tracking have a symbiotic relationship. By relying on the strengths of one system when the other fails the hybrid robotics/vision AR platform provides a robust experience. The visual tracking system itself is quite robust because the target object is very simple. But, even if tracking fails for a short period of time (for instance if the marker passes behind a chair), sensors and robotics can be used as a backup to convincingly continue the experience. While many AR experiences break down rapidly in real world use, Sphero AR stands up to the demands of unpracticed users, varying lighting/environmental conditions, and low cost commodity cameras.

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