LOGIGEAR

LEADING PRACTICE FOR
TESTING MODERN AND COMPLEX

IoT/Robotics: Anki Overdrive

anki™

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EXECUTIVE SUMMARY

Games today must be significantly more complex and innovative from a technological and entertainment perspective to be successful in the hyper-competitive market today. Clearly, these more complex products require a much more sophisticated and smarter testing strategy to support this business need. LogiGear provided product testing services to Anki for its robotic battle-racing game, Anki Overdrive, which included a highly integrated system of robotic cars, mobile controllers and a configurable track. The innovative testing strategy combined many traditional test methods with new smarter testing solutions. This comprehensive plan gave Anki confidence that their product would be market ready and well tested.

ANKI OVERDRIVE - COMPREHENSIVE TESTING

Anki Overview

Named one of the Top 50 Most Innovative Companies by Fast Company, Anki is harnessing robotics and artificial intelligence (AI) to bring to life consumer products with unprecedented level of intellect and interactive capabilities. Founded in 2010 by three Carnegie Mellon Robotics Institute graduates, Anki creates consumer experiences using cutting-edge technology that was once confined to robotics labs and research institutes.

In 2012, Anki hired LogiGear to provide testing services for its innovative use of mobile phones controlling the robot cars developed by the company. LogiGear created a unique testing lab at their company headquarters in Vietnam specifically dedicated for Anki.

Product Overview

• Anki developed a battle-racing game that combines an iOS/Android app with physical robotic cars. Players can battle race against human players or compete with artificially intelligent characters on iOS/Android smart phones and tablets. They can also cross-platform play using both iOS and Android devices.

• The game is played on a modular Anki Overdrive track which can be easily customized by users to create their own racetracks. Anki developed a tracking system that is almost invisible to the human eye. This ink allowed codes to be printed onto the track, allowing the cars to read the code with their infrared cameras and then process it on the mobile device to tell them where they are.

• The cars are controlled by mobile devices using Bluetooth Low Energy. They also communicate with other players through Bluetooth Low Energy (BTLE) or Wi-Fi.

Artificial Intelligence & Robotics

• Each car is a robot. It is equipped with optical sensors, CPU, wireless chips, motors, and AI software, designed to analyze thousands of actions every second. The cars act as characters with individual personality traits and strengths.

• Powered by robotics and AI technology, each car knows where on the track it is positioned, its trajectory, how fast it is going, and where the other cars are on the track. This is possible since each car is equipped with an infrared camera on the bottom which takes 500 pictures of the track every second, relaying the information back to the smartphone or tablet, allowing for stability and more control by the player.

Business Need

Anki Overdrive uses Anki's robotic and AI technology and is a video game programmed for the physical world. The product's artificial intelligence focuses on video game style thinking, personalities and capabilities.

Anki's vision was to test the Anki Overdrive hardware, firmware and mobile device. LogiGear and Anki worked together to develop the testing strategy for both hardware and software aspects of Anki Overdrive.

> "With teamwork, collaboration and the right methods for expanding test coverage of a complex IoT system, such as Anki's Robotic supercars, the success of this test plan and execution gave us confidence that our product was market ready. We are happy that LogiGear is our testing partner on this journey. LogiGear knows what they're doing!"
>
> **-Jane Fraser, Test Director at Anki**

Solution - Testing Anki Drive and Overdrive

Anki Overdrive is a complex system. Each physical car is equipped with optical sensors, wireless chips, motors and artificial intelligence software that analyzes thousands of actions every second. LogiGear chose several testing techniques and strategies to manually test a game driven by AI. The testing solution is complex, combining the interaction of many devices-cars and track, many data feeds, self-thinking devices, the software that runs the product and the smartphone controllers. Reproducing bugs was a major challenge for a constantly changing system, with the added factor that the system is driven by AI. To minimize the impact of this challenge, the test team carried out extensive exploratory testing to thoroughly understand the AI behavior.

Testing Strategy & Techniques

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Combination testing and error guessing

The challenge was to test as many combinations of the game as possible. The combination of 7 tracks, 4 game modes, 600 cars (each with 5-7 functional items) and 20+ commanders created an exhaustive combination. Testing posed serious challenges, given the timeframe. To determine the optimal amount of testing, LogiGear used error guessing, with a focus on high-risk areas. Defect isolation was done as soon as possible using the pairwise testing technique. Just for this test type alone, using a decision table, the LogiGear team played over 500 games with different combinations of inputs just to check the correct implementation of business rules.

Stochastic testing

The target demographic for this product is children under the age of 14.

Besides testing the functionality of the game, the LogiGear team also applied Stochastic testing in order to build scenarios that might have not been defined, scenarios that may not have been the correct game business case, but ones that could be done by a 14 year old.

Usability testing

Because Anki is a forerunner using robots controlled by smart phones, there was no prior end-user feedback to draw from. LogiGear was the first end user to try out the game & provide feedback that was critical to Anki. The team performed Usability testing in every iteration of the project to see how easy the game was to learn and why levels/objectives were difficult to achieve.

Fun-factor testing

Testing a game also involves judging how fun it is for end users. To do this, the LogiGear team used inputs from tester feedback. Besides functionality testing, the team also focused on non-functionality, fun-factor testing. Every team member played the game and shared their thoughts on how interesting it was to play, how difficult it was to win, and overall, how challenging the game was. Anki ultimately used this feedback to enhance gameplay and some features.

Hardware / Software Integration Testing

Manual testing of the robotic cars using Anki's app on iOS and Android smart phones and tablets.

• **(Relative) Location Testing:** After reading code from the track using the camera, cars know their location on the track and relay information back to the smartphone or tablet through technology and algorithms. LogiGear checked to make sure that the information relayed back to the smartphone or tablet was accurate and also checked that the app behaved and showed notifications corresponding correctly to the car's position on the track, or car off/on track.

• **Battery Life Test:** LogiGear used the special test mode to check how long the time period was before the car would reach low battery and become unusable. The team recorded the data for each car type and reported to Anki, so that they could adjust as needed and provide guidelines for the user.

• **Camera:** The robotic car uses an infrared camera on the bottom that takes 500 pictures of the track every second. LogiGear used a tool built by Anki to check the quality of the code read from the track, while also providing feedback to improve the quality of track if any areas on the track that car were unreadable.

• **Unavailable/Available car status:** When a car has a low battery, is turned off, or is selected by another player, it has to communicate with the mobile device, and send the information exactly. The app will detect which car is available/unavailable and guide the player to take the correct actions.

• **Ability of app to detect the car type:** Each car has unique identifiers that allow the software to identify what car has which personality and certain characteristics, as well as its own solo abilities. Thus, the displaying information of each car type must be correct in the app after the car communicates with the smartphone. That is why the test team rigorously checked the name, color and default weapons of each car displayed in the app to make sure it was working correctly.

• **Flash type:** Similar to the above section, since each car type has its own unique personality, characteristics and abilities, the team used a specific tool to flash type and change this car type to become another car type and check if the car displays accurately in the app after changing it.

• **Downgrade/Upgrade car's firmware:** The program instructions written for embedded systems are referred to as firmware. Anki used the supported dev. tool to downgrade/upgrade the firmware of the car and tested to see if that car worked with the correct firmware in the app, how the app

handled and detected cars that had out-of-date firmware, and validate upgrade ability.

Mobile device to Car Communication Testing

Each car knows its own location on the track and the location of the other cars on the track based on the infrared downward camera reading from the bottom of each car. After scanning code from the tracks, the car relays the information back to the smartphone or tablet via Bluetooth 4.0. An Important part of the testing was to determine the quality of communication between the car and mobile devices.

• **Responsiveness:** When using mobile devices, players take command of cars in the app by changing speed, changing lanes, turning left, turning right, pausing/resuming or using specific weapons of that car to attack opponents. LogiGear needed to make sure that the responsive ability of the car was implemented immediately after receiving the commands via Bluetooth.

• **Connection distance:** Since Bluetooth 4.0 limits the connection distance, testing was done to ensure that in the specified range, the car could still connect to the app.

• **Interruption cases:** The team used a number of test cases to disconnect communication between the car and app by hitting the Home device button, hitting the Sleep device button and

receiving a phone call/text message. By doing this, the team was able to check the handling abilities of the app and see if the app still kept a connection with the car. For instance, if the car was disconnected by turning off the car or by turning of the Bluetooth of the mobile device, the tests checked the ability to detect the car in the app, given these scenarios.

• Testing was done to ensure that only the host's Anki Overdrive device communicates with the car via Bluetooth. Although other players are able to select cars on their devices, these devices must first send a message (via Wi-Fi) to the host's device to ask the host to communicate with other cars using Bluetooth. Testing was done to ensure turning on/off Bluetooth would not impact communication with cars.

• Since mobile devices communicate with other mobile devices using both Bluetooth and Wi-Fi, LogiGear tested to make sure the game was able to be cross-platform between different iOS and Android devices.

Compatibility testing

The first stage was to test the compatibility of the game on a wide range of devices. Testing was done on both iOS and Android platforms on over 20 different mobile phones and tablets. Different screen sizes /iOS devices like iPhone 4S, 5, 5C, 5S, 6, 6+,iPad mini, IPad, iTouch are used Similarly for android devices like Samsung Galaxy

S4, S5, Note 3, Note 4, Nexus 5, Nexus 6, Nexus 9,etc. Other tablets & devices like Shield, Kurio, Sony Xperia, HTC One, LG G2

Exploratory testing

One of the key features provided by Anki, and the most challenging to test was the AI built into the robot cars. Finding AI bugs and reproducing those bugs was challenging. Since a wide variety of input could impact the robot's reaction, the team had to be creative in finding and reproducing those failures. The team observed the whole context, environment, platform, device, car robot's battery and device's battery, as well as games they played. By using that game experience they gained, the test team was able to narrow "bug zone."

Smoke and Regression Testing: LogiGear developed and optimized the test suite using the following test case design techniques: Equivalence partitioning, boundary value analysis, constraint analysis, state transition and condition combination. Using these test case design techniques, the test team was able to make sure that they covered every requirement, as well as saved time for testers.

In the course of the project, the LogiGear team executed a countless number of games and exposed critical issues in a timely manner, allowing for them to be addressed, fixed and verified.

Summary

Anki approached LogiGear with a complex and multi-faceted product test. In addition to software testing, the project was very heavily hardware dependent for both the user input mobile devices and the software execution (the cars and track). Individual components needed a variety of test types as well as interaction between components, integration testing, whole system tests and compatibility tests. Each phase and type testing needed a specific, well thought through strategy to ensure a superior quality and testing effort. The testing strategy combined traditional methods and new applications of classic ideas and innovative thinking to get a cutting edge robotic game product into the fast-paced consumer product market.

ABOUT LOGIGEAR

LogiGear is a leading provider of software testing services, test automation and application development and maintenance. We help organizations deliver better products while saving time and money. Since 1994, we have completed testing projects with hundreds of companies from early stage start-ups to Fortune 1000s, across a wide range of industries and technologies. To learn more visit *logigear.com*