An Intuitive Control API for Catroid

By

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Collaborating with

Catrobat @ MIT Scratch & App Inventor

Institute of Software Technology, TU Graz

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Technology (Honours)

(Information Communication Technology)

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CERTIFICATION OF APPROVAL

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Approved by,

____

(Dr. Mohamed Nordin Bin Zakaria)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

HOO PEI YING

ABSTRACT

In this research, the main objective is to develop an intuitive control API in Catroid to enhance its usability as a graphical programming tool for children and study the human-mobile interaction and experience made possible with this control API. Another objective is to develop this control API in open source development method and benchmark it with the typical software development method.

It would greatly enrich user experience if Catroid can provide support for implementing intuitive control concepts to enhance its usability for children. But currently Catroid do not have control API support to develop intuitive user interaction with the application. In brief, an intuitive control API is missing in Catroid. Without such an API, the potential of Catroid as a programming tool cannot be unleashed.

This research studies the maximization programming power of Catroid and advancement of control API in Catroid into a more intuitive form. This research studies the Open Source Development Model used to develop the control API. The scope of prototype will only covers locating direction, tilting, turning, and shaking motions as the new intuitive control made possible in Catroid

The research methodology is Open Source Development Methodology (OSDM) and the Test-Driven Development Method with Extreme Programming is used for code development. The objective of OSDM is to utilize the online community who is the user and developers of Catroid to review and test source code to improve the software quality.

The intuitive control API where phone sensors are integrated will further improve the user interaction and experience both in using Catroid and its application. The intuitive control API consists of sensor variables and If-Then-Else Command Block. The If-Then-Else Command Block acts as the control and the sensor variables make the control become intuitive. Accelerometer and orientation sensor are implemented in this control API where each of the sensors contributed 3 different

values acted as the sensor variables: X-Sensor Acceleration, Y-Sensor Acceleration, Z-Sensor Acceleration, Azimuth, Pitch, and Roll. These sensor variables can be assigned to or removed from any text field in the Command Blocks using the Formula Editor. The usage of the intuitive control API is simple and straight forward. When a sensor variable is assigned to one of the fields in If-Then-Else Command Blocks, the intuitive control is developed. The Command Blocks in between the If-Statement Command Block and End of If Command Block will be executed whenever the logic condition in the If-Statement is true.

Various intuitive user interactions could be developed depending on the creativity of users. The most popular intuitive user interactions are through locating direction, tilting, turning and shaking motions.

Open Source Development Method allows developers to redefine the user requirements along with the software development which reduce the risk of software failure in the end of development.

ACKNOWLEDGEMENT

I would like to take this opportunity to acknowledge all parties who had contributed to the completion of my final year project. The past one year has indeed been an amazing experience and journey to embark on. I have learnt so many things throughout the completion of my own proposed project.

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I would like to express my utmost and sincere appreciation and gratitude to my collaborator, Catrobat @ MIT Scratch & App Inventor and Professor Wolfgang Slany who gave me the opportunity to contribute to the enhancement of Catroid and provide full technical support and advice to complete my dissertation.

Last but not least, I would like to take this opportunity to thank my family members especially my parents for always being there for me. They have been giving me a great deal of encouragement, advice and support which have led me to the completion of my project. On the other hand, I would also like to thank to my colleagues for the continuous moral and emotional support that they had given me throughout the year.

Thank you.

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CHAPTER 1

INTRODUCTION

1.1 Background

Catroid is a new Lego-style graphical programming system of Catrobat that runs on Android devices which is designed for children and novice programmer to create Android mobile application. Catroid is inspired by MIT Scratch and Google App Inventor. (Catroid, 2011). Similar to other programming language, there are many APIs available to build an application in Catroid. Currently, Catroid lacks a controlling and sensor-detecting APIs like what Scratch has. There are only seven two-dimensional surface gestures or touch screen motions available for the control function in Catroid.

API, Application Programming Interface is a set of routines, protocols, and tools for building software applications. With current APIs in Catroid, children could not do higher-level programming with Catroid. A good API makes it easier to develop a program by providing all the building blocks. The interface of API in Catroid is referred to as *Command Blocks* in the *Block Palette*.

The Catroid's target users are novice programmer and children, thus, the users of the projects created by Catroid are novice programmer and children as well as the normal mobile application users. Due to the popularity of intuitive control in mobile application and the concern that Catroid's projects run on mobile devices, it is especially important to have control function in Catroid's project as intuitive as possible for mobile application users. However, currently Catroid does not have API that could help the Catroid's users to build intuitive control function in their project.

Given the popularity of games and animation, it is desirable to have intuitive user interaction in application created by Catroid but currently no API has support to develop the simple intuitive user experience as the example below in their Catroid's project.

"Imagine you are a 10 year old boy. You have a Sprite, which is an Airplane. If you tilt the phone to the right, you have the plane to fluently move to the right side of the screen. If you tilt it to the left, you have the plane to go to the opposite direction." (Catroid, 2011)

To qualify as a higher-level programming language for children, there is a need to enhance the Control APIs instead of just relying on the seven multi-touch/touch motions. The researches and studies prove that sensors are widely used in most of the mobile applications in Android devices to create the intuitive control in application. Hence, the integration of phone sensors in Control API could help children improve the interactivity of their application created in Catroid.

1.2 Problem Statement

Catroid is a new programming tool for children. However, an intuitive control API is missing in Catroid. Without such an API, the potential of Catroid as a programming tool cannot be unleashed. In fact, it would greatly enrich user experience if Catroid can provide support for implementing intuitive control concepts to enhance its usability for children. But currently Catroid do not have control API support to develop intuitive user interaction in application.

1.3 Objectives

The objectives of this project are as follows:

- To implement an intuitive control API in Catroid.
- To study the user interaction and experience made possible with this control API.
- To develop the software using an open source development model, and to benchmark the methodology with typical software development model.

1.4 Scope of Study

This research studies the maximization programming power of Catroid and advancement of control API in Catroid into a more intuitive form. The intuitive control API is implemented in Catroid as *Command Block* with integration of different phone sensors to help children to program user interaction in Catroid application.

This research studies the Open Source Development Model and adopts it to develop the control API. The development method, tools and license used in Open Source Development Model have to be studied to benchmark its pros and cons with typical software development model in this research project. The specification and definition of open source license have to be clear to developers because Catroid is open source software and different open source libraries used in the software development.

Due to expenses and duration of pilot study within 3 months, the prototype only covers locating direction, tilting, turning, and shaking motions as the new intuitive interaction made possible in Catroid.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section includes research and information that is relevant and necessary to my understanding of the subjects to be discussed in the process of creating the intuitive control API in open source software - Catroid developed using Open Source Development Model to run on Android platform.

2.2 Definition of Intuitive in Control

IUUI research group in Germany defines 'intuitive use' as "*A technical system is intuitively usable if the users' unconscious application of prior knowledge leads to effective interaction"* (Mohs, Hurtienne, Israel, Naumann, Kindsmüller, Meyer & Pohlmeyer, 2006:130).

Two primary input modalities commonly supported by smart phones application are touch screen display and a set of motion sensors. The motion sensors are accelerometers, gyroscopes, orientation sensors (vs. gravity), etc. The two inputs recognized by these devices are different types of gestures. Users can input gestures on the device in two dimensions, using the touch screen of the smart phone as a mobile surface computer. These two-dimensional gestures are *surface gestures*. Users can also input gestures by moving the device, in three dimensions, by translating or rotating the device. These three-dimensional gestures are *motion gestures* (Ruiz, et al., 2011).

The study points out that motion gestures are more intuitive than surface gestures in that the user interacts by using the device itself instead of interacting on the device via a finger or hardware button. To create more intuitive sets of motion gesture sets in a smart phone application, it is important to understand the user's unconscious mental model of how motion gestures are mapped onto the device commands leading to effective interaction (Ruiz, et al., 2011).

2.3 Conceptual Elements of Catroid

According to Daughtry (2008), programming is the new literacy where power will soon belong to those who can master a variety of expressive human-machine interactions. Thus, more programming tools have emerged to educate children nowadays on mastering computer programming skills. Most of these tools run on PC except Catroid. As mentioned in Section 2.1, the aim of this project is to enhance the control API of Catroid.

Catroid is an open source (Perens, 1999) Android software that supports Lego-type graphical programming language designed especially for children. Children interact with software in different ways; they are easily distracted, and they have different motivations as compared to adults. They are likely to 'try out' the software to see what they can do. Thus, Catroid has graphical *Command Block* to represent API in other languages where it eliminates the syntax error and runtime error in programming. In addition, programmers can trial and error in using Catroid by instantly compile and run the project to preview the outcome after modified the *Command Blocks*.

The control API in Catroid only has touch motions *Command Block* shown in Figure 1. The user interactions in application are less intuitive because only surface gestures are implemented in the *Command Block* to control the *Sprites*.

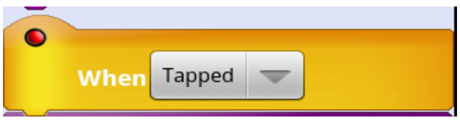

Figure 1: Touch Motions Command Block

Figure 2 is the main menu of the Catroid, when *Current Project is clicked*, *Sprite List* as in Figure 3 appears. After clicking on *Sprite* named "Catroid", Figure 4 which consists of *Scripting Area, Costumes and Sounds* tabs is shown. Programmers can modify the project's code in Scripting Area by dragging and dropping the Command Block. Clicking on the "plus symbol" on top left will show the *Block Palette* shown in Figure 5 while clicking on the "play symbol" will show the *Stage* shown in Figure 7. On block palette, clicking on any category will bring up a list of graphical *Command Blocks* as in Figure 6 where the selected Command Block will add into Scripting Area whenever it is clicked.

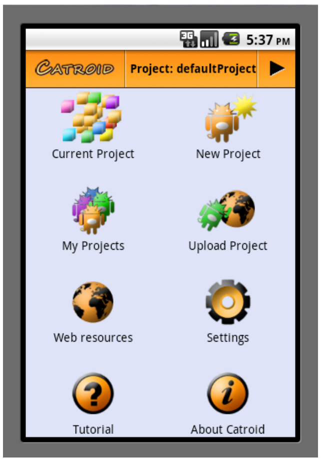

Figure 2: Main Menu

Figure 3: Sprite List

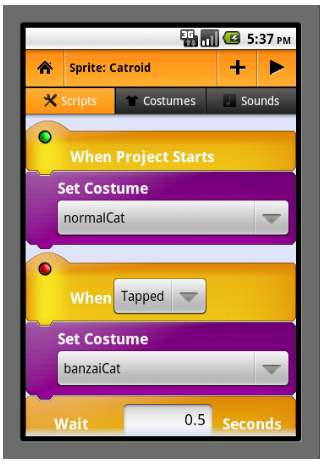

Figure 4:Scripting Area, Costumes, Sounds

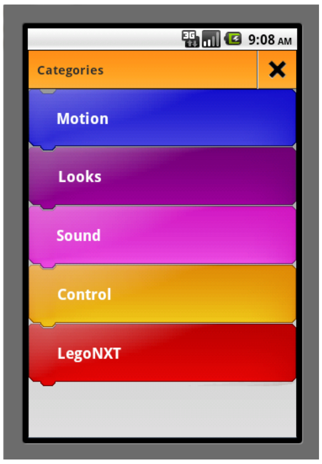

Figure 5: Block Palette

Figure 6: Group of Blocks

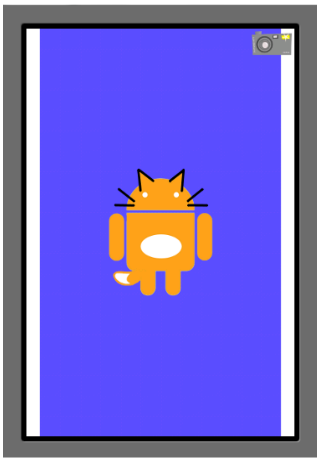

Figure 7: Stage

2.3.1 Children Programming Tools –Control and Concept

According to survey done by Kelleher and Pausch (2005) and Guzdial (2004), Scratch is not the first programming environment and language aimed at novice programmers. Indeed, there is a rich history of different developments for programming tools made for children such as Alice and Greenfoot. Fincher, et al. (2010) and Utting, et al. (2010) have compared Scratch with Alice and Greenfoot and concluded that like Scratch, Alice and Greenfoot are intended to introduce programming to those without prior experience and, as a result, the three systems share many of the same design goals. While all three systems allow media to be imported, Scratch includes tools to draw images and record sounds. According to Maloney, et al. (2010), both Alice and Greenfoot introduce class-based object-oriented programming, and emphasize Java or Java concepts. Greenfoot, since it is Java, also allows students to explore high-performance computation (e.g., complex simulations or cryptography problems) and to extend the system. Alice is the only one of these systems that supports 3-D graphics and it often crashes in middle of programming. Scratch allow the children to create interactive, media-rich projects including animated stories, games, online news shows, book reports, greeting cards, music videos, science projects, tutorials, simulations, and sensor-driven art very easily.

Compared with figures in Section 2.2, Maloney, et al. (2010) claimed that the user interface layout of Scratch (Figure 8) with its prominent command palette and central scripting area, ease children to program. Scratch programming system strives to help users build intuitions about computer programming as they create projects that engage their interests by dragging *Command Blocks* from a palette into the scripting pane and assembling them, like puzzle pieces, to create “stacks” of blocks (Maloney, et al., 2010).

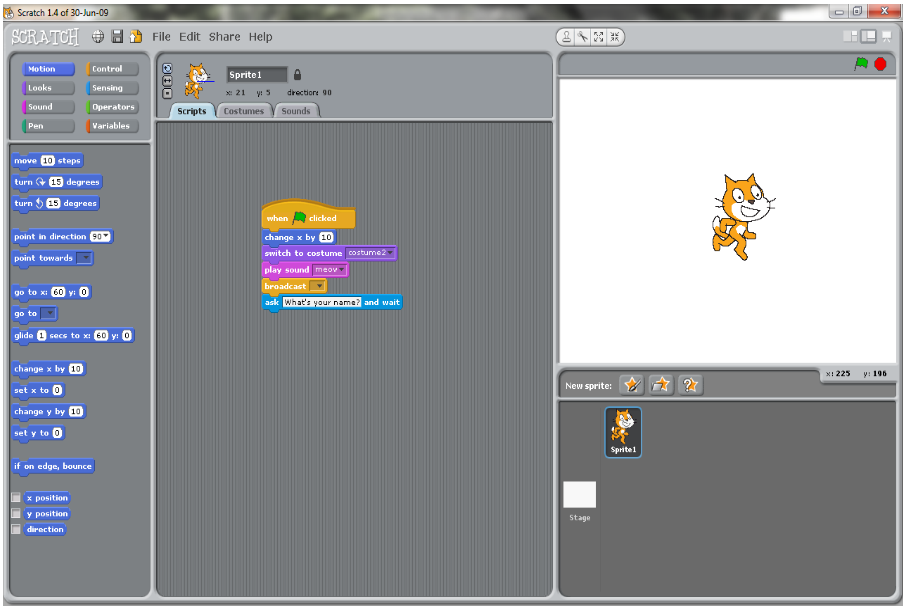

Figure 8: Interface of Scratch

The user interaction for Scratch's application include surface gesture and motion gesture using keyboard, mouse, microphone, game controller and remote sensors. The integration of smart phone sensors in Catroid can reduce short term memory load since some researchers used objects with sensors as an interactive mode to reduce children's cognitive burden to interact with software (Zhou ZY., et al., 2008).

2.4 New Concept of Human-Mobile Interaction

To build the intuitive control API in Catroid, integration of accelerometers with gyros, proximity sensors, or vibratory and shear/torque sensors could greatly enrich the vocabulary motion (Hinckley and Song, 2011). There are several touch+motion techniques that could be implemented on a smart phone which are Tilt-to-zoom, Pivot-to-lock, Hold-and-Shake, Tip-to-select, Soft-vs-Hard-Tap, Swipe-vs-Hard-Drag and Context of touch.

The study shows the users' preference rankings for the techniques in Figure 9. Acording to Hinckley and Song (2011), five of the ten users explicitly mentioned "one-handed" interaction as the best thing about *Tilt-to-zoom*. Users liked how they could combine wrist, finger, and device motion to articulate lightweight interactions with less “friction” in the user interface. Users commented that the techniques were “intuitive and easy to transition to different modes,” “easy and magical,” or that “the icons are alive!”

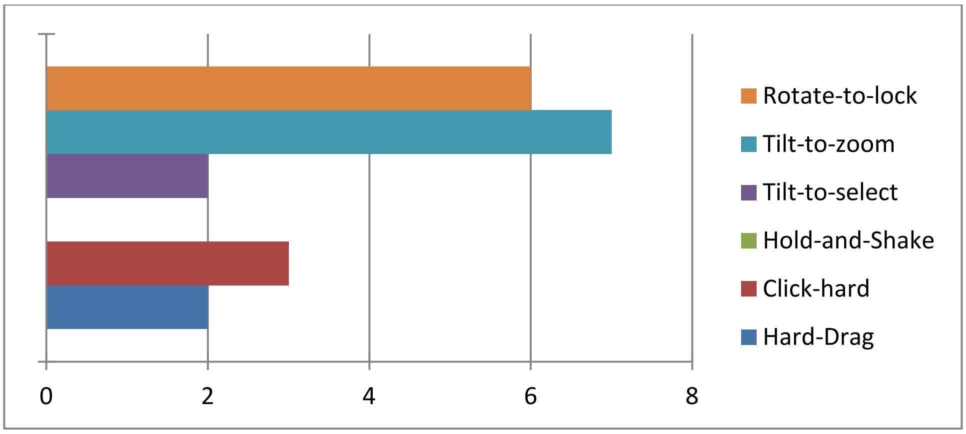

Figure 9: Users' Preference Ranking for the Techniques

Combining motion gestures with touch is a simple idea that has been explored. Hassan (2009)’s “Chucking” technique uses a simultaneous touch+motion gesture to toss a file from a mobile device to a wall display. The user holds a finger on the file’s icon, while indicating where to place the file via a motion gesture. Rahman (2009) also uses touch+motion to measure wrist deflection angles. Motion has also been used as a cue for grip-sensing mobile devices. For example, an accelerometer can trigger implicit grip sensing when a mobile device is held still (Kim, et al., 2006). Graspables use accelerometers to sense the orientation of objects and to trigger grip sensing at the right moment (Taylor, 2009).

However, the touch+motion techniques mentioned above might confuse children as the study of surface gestures for children shows that children tend to make mistakes when doing complex gestures (McKnight and Fitton, 2010). Druin (1999) concludes that children aged 5 –7 want interface interaction that they can easily control but not too simple. The user-defined motion gestures without touch proposed by Riuz, et al. (2011) shown in Figure 10 are more desirable way for children compared to touch+motion techniques.

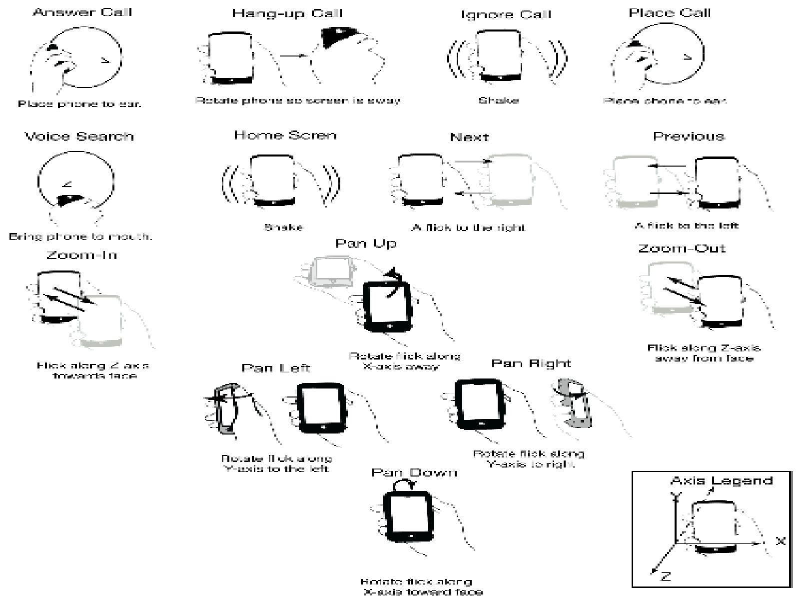

Figure 10: Motion Gestures Sets by Riuz, et al.

Both the studies above concluded that the integration of phone sensors in Catroid could create an intuitive control API for children in a way that reduces children's conscious application of prior knowledge to program an intuitive user interaction.

2.5 Smartphone Operating Systems

Lin and Ye (2009) listed several leading smart phone operating systems in the market which include Apple's iOS, Google's Android, Microsoft's Window Mobile, Nokia's Symbian, RIM's BlackBerry OS and embedded Linux distribution such as MeeGO. Catroid runs on Android operating system. However according to Hall and Anderson (2009), Android is not the only smart phone that has the potential to solve the dissatisfaction that users have with their devices. Hence, Catroid could be possible developed in other smart phone OS as listed above to have intuitive control API.

According to Gartner (2011), by the end of 2011, Android will move to become the most popular operating system worldwide and will build on its strength to account for 49 percent of the smart phone market by 2012 with Apple's iOS remaining as the second biggest platform. Apple's iOS and

Google's Android are the preferred platforms to go to. But Lin and Ye (2009) said the iPhone is a closed smart phone running a closed OS, which means Apple has the full control on its hardware and software. Hence, the open-platform nature in Android is more desirable for Catroid. Android runs on a Linux-based architecture with Java applications running on top of it is illustrated in Figure 11. Android has free Android Software Development Kit provides the tools, APIs libraries, tutorials and demo source codes necessary to develop applications unlike Apple iOS required registration fees to use the development tools and the forum.

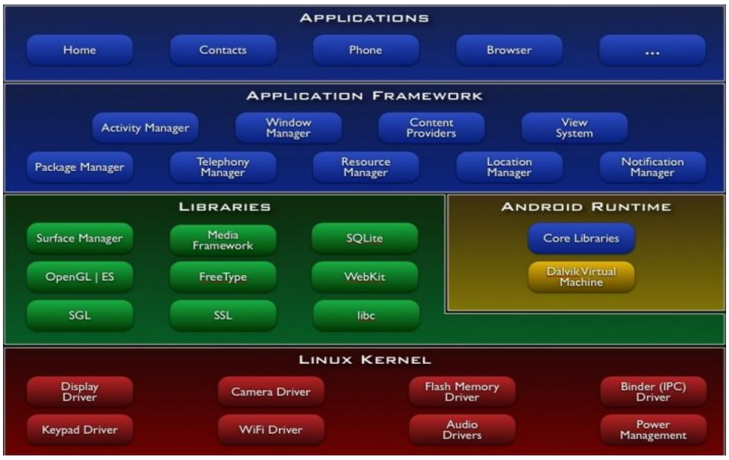

Figure 11: Android Architecture

2.6 Catroid Development Tools & Methods & License

According to writer Martin, et al. (2009), writing clean code is what a developer must do to be called as a professional. To eliminate flawless codes, the whole Catriod development is using 100% test-driven development method where it uses automated tests and Robotium test to reduce resources usage in debugging. For code quality assurance and code refactoring flexibility, writing high quality code is the only documentation for Catroid developers across worldwide, with a bunch of other practises from extreme programming and usability engineering. Catroid team created rules of coding as shown in Appendix 1 based on the book written by Martin, et al. (2009) which results in more efficiency in maintaining the codes without breaking anything.

2.6.1 Development Tools

Catroid is an Android application. Any Java IDE tool can be used to develop open source Android applications. One of the most popular Android application development platforms is Eclipse IDE because it can run on any OS platform and supports many plugins including Android ADT, Open GL ES, Mercurial, Mylyn, Oracle, Apache, UMLet, JSP and etc. Android Development Tools (ADT) can be installed in Eclipse IDE to extends the capabilities of Eclipse to quickly set up new Android projects, create an application UI, debug applications using the Android SDK tools, and even export signed (or unsigned) APKs in order to distribute the application. In general, developing in Eclipse with ADT is a highly recommended approach by Google's Android and is the fastest way to get started with Android.

In Open Source Software development, the participants, who are mostly volunteers, are distributed among different geographic regions. Tools are needed to aid participants to collaborate in the development of source code. In this case, Concurrent Versions System (CVS), Subversion revision control system (SVN) and distributed revision control systems such as Git and Mercurial are useful. These revision control systems help manage the files and codes of a project when several people are working on the project at the same time. This is done by moving the file into the users' directories and then merging the files when users have committed the changes. Revision control systems also enable one to easily retrieve a previous version of a file which is very useful in collaborative programming environment. (Open source software development, 2011). Catroid implemented Mercurial in the beginning then moved to Git recently because Git provides more features and functions such as revert and track of progress in branches.

Most of open source software is stored and made publicly available on code sharing and hosting platforms such as Google Code Hosting, Github.com, Sourceforge.net, Codeplex, and Bitbucker which enable designers and developers to share their code with the web community. The platform also serves as backup for the codes. Github.com is used in this research.

2.6.2 Open Source Development Method

Software or application is developed based on a single or combined software development process model. There are many software process models in software engineering; the most popular models are V model, Prototyping Model, Increments and Iterations Model, and Agile Model (Pfleeger & Atlee, 2010). Open Source Development methodology is not the newest but the most popular method adopted in smart phone application development.

Most of the software developed in Open Source Development Model (OSDM) is open source. Many mobile applications are open source and the mobile application developers prefer to adopt OSDM in their application development. The source code of open source may be freely modified and redistributed without charge or limitations on modifications to encourage collaborative development such as Linux OS, Apache Server and Mozilla Browser. OSDM emphasizes faster development and lower overhead, as well as closer user relationship and exposure to a broader market. In OSDM, when the software is developed under a model of systematic peer-review, it can be incrementally improved and more easily tested, leads to innovation and rapid advancement resulting in a highly reliable product (LONCHAMP) because more people looking at the code will results in more “bugs” found (Raymond, 2001).

Typically, OSDM adopts the Hybrid process models. All of the Agile methods are in essence applicable to OSDM, because of their iterative and incremental character (Open source software development, 2011). Catroid is an open source that adopts OSDM, thus this project will adopts OSDM with extreme programming development methodology.

2.6.3 Open Source License

A license defines the rights and obligations that a licensor grants to a licensee. There are several licenses compatible for open source software such as GNU General Public License, Creative Common Attribution License, GNU

Lesser General Public License and etc. This project adopts GNU AFFERO GENERAL PUBLIC LICENSE as published by the Free Software Foundation, either in version 3 of the license or any later version in future. The complete copy of the original License can be referred to Appendix 3. The benefit of using this license is that it acknowledges the hard work of the contributors while leaving the source free for modification and redistribution.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This project applies Extreme Programming Process Model in Agile Development method and licensed as open source software. The timeline and key milestones for this project are shown in Tracking Gantt Chart in Appendix 2.

3.2 Previous Related Work

Several published works contain different sensor design and framework to develop application or software in different devices. The architectures of their framework were illustrated in diagrams and pictures as a guideline to help the developers smoothly implemented codes and traced back the relationship between the classes and function calls.

In Android Development Reference Library, the APIs that are needed to develop intuitive control API in Catroid are in Package android.hardware.

3.3 Research Methodology

3.3.1 Open Source Development Method

The Figure 12 (M.Abbing, 2006) below shows the development process cycle that this project is going to apply based on Extreme Programming. The existing project that will be further enhanced is Catroid.

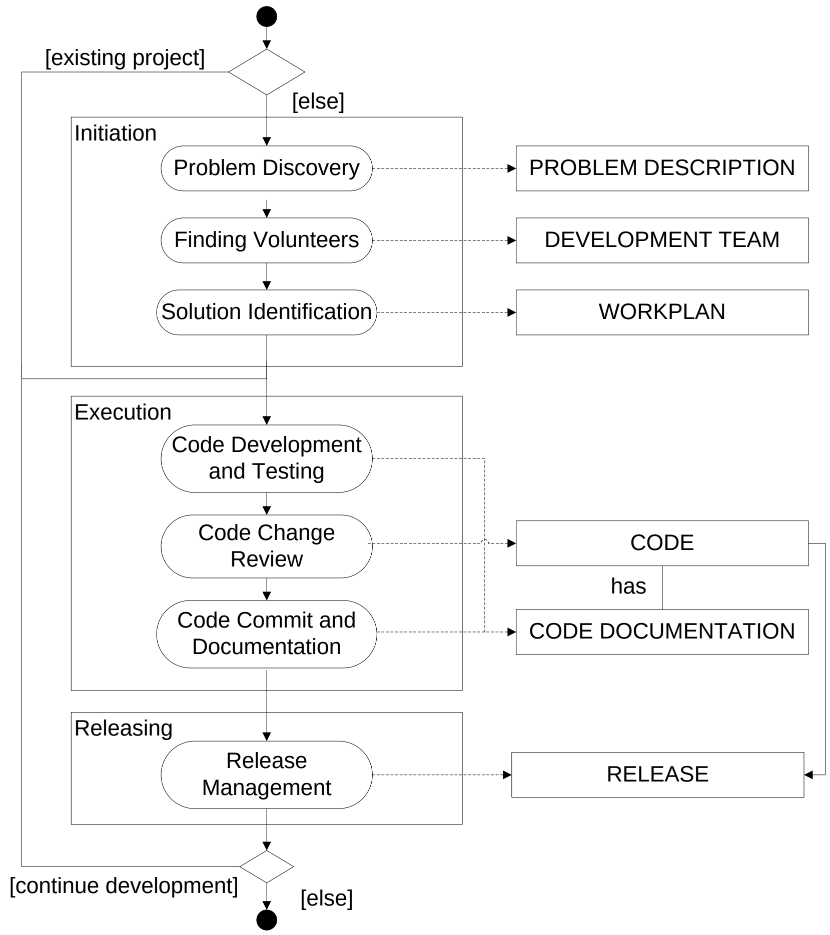

Figure 12: Open Source Development Model

In open source development model, first phase is initiation started by identifying existing projects to be further improved and the problem in existing projects. It is discovered that intuitive control features is missing in Catroid. The identified problems and ideas are being posted online in Google Code Hosting (Appendix 4) and Android community website to find volunteers to form the development team. This project managed to get Software Technology Department in TU Graz, Austria who is the founder of Catroid to support and provide remote assistance. Solution is found after several times of discussion and ideas refining. A work plan which is this proposal is made for outlining the important elements in developing this project.

The next phase is execution which is the development and testing of codes. Any java class that contained core functionality of the project must have its own test class to ensure consistency and continuation of codes. The code is released when it passes the code review phase. This review phase is very important to eliminate flaw in code and for benchmark evaluation. The accepted code is committed and documented properly before deploy to the world.

The last phase is software release. The first software deployment is the first prototype. The first prototype in this project is given to a selected target group to conduct project evaluation and redefine the user requirements. After tested by targeted user, bugs and errors are identified and the project development phase is iterated back to either initiation for planning or execution for coding. Open source software is long term sustainable developing software, there is no end for the development because the software is developed together with the users. Development is stopped only when the software is no longer used by the public.

3.3.2 Test-Driven Development Method

Figure 13 is the flow diagram of Test-Driven Development Method. The Test-Driven Development Method is used in code development phase to ensure that the application is written for testability.

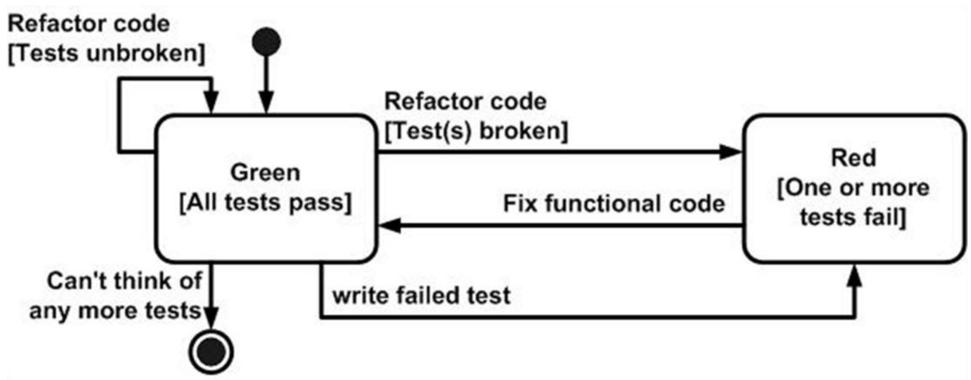

Figure 13: Test-Driven Development Method

Test-Driven Development Method relies on the repetition of a very short development cycle: to add a new functionality, first the developer writes the failing automated test cases which are the Junit Test and Robotium Test that defines a desired improvement or new function, then produces code to pass that test and finally refactors the new code to acceptable standards.

3.4 Technical Specification Design

In the Figure 14 below shown the flow of logics how the control API works. Firstly, block of control API which implements the sensor is added into script and a condition is set. Then the accelerometer and digital value changes when the Android device is tilted or manipulated. Sensor is triggered and immediately the respective script is executed after the condition is checked. The effect and respond are the outputs in the display screen for the view of user. After the sensor event is cleared, it is ready to intercept any input event.

Within the scope, only tilting, turning, shaking motions and locating direction will be designed and implemented with integration of phone sensor in *Command Blocks*. These motions will be feasible to conduct with "one-handed" interaction.

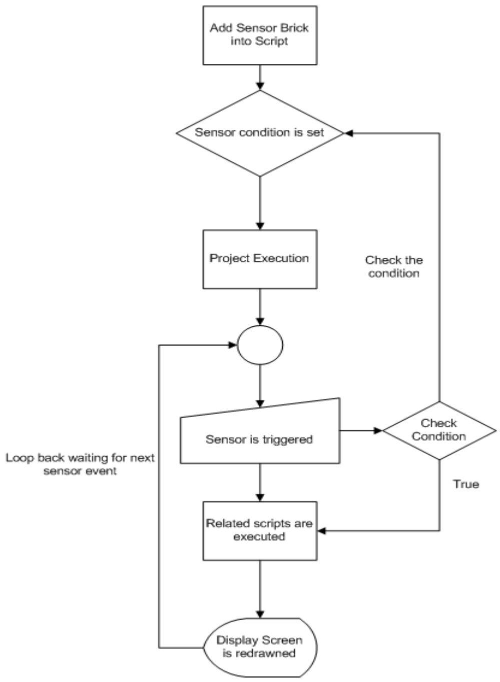

Figure 14: Flow Diagram of Control API Logic

In the designing process of intuitive control API, interface design rules by Schneiderman's Eight Golden Rules can be referred: Strive for consistency, Enable frequent users to use shortcuts, Offer informative feedback, Design dialogues to yield closure, Offer error prevention and simple error handling, Permit easy reversal of actions, Support internal locus of control and Reduce short term memory load. These rules will guide the designers to design the intuitive control API that is consistence, easily understand, no syntax error, easy handling and user-friendly.

3.5 Technology Used

List of technology for this project:

- Android SDK 1.6 r1
- Android Development Tools v9
- Eclipse Helios Sr2
- GitHub.com/ Google Code Project Hosting

Below is the knowledge required for this project:

- Object-Oriented Programming (Java)
- Android Development Framework

The development environment is Eclipse Helios IDE for Java EE developers. Integrating the SDK with Eclipse simply required a download of the Android Development Tools (ADT) Plugin (Android SDK).

The Android platform is specifically designed for Java as it is available on many different platforms. This project used Object-Oriented Programming style of development for easier code maintenance. Google's Android has provided comprehensive documentation to assist in the development process. To get started, the Android SDK and Eclipse ADT plug-in were required (Android SDK). The Android SDK comes with an emulator that simulates a clean install of an Android device. Multiple screen resolutions are available for testing layouts, as well as an interface to connect actual Android devices. For this project, a real Android device is needed for testing because the emulator does not support sensors. GitHub.com and Google Code Project Hosting are used to store the prototype source code for source code sharing and as a backup.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Deliverable's Interface

The intuitive control API is the combination of sensor variables and If-Then-Else Command Block. The If-Then-Else Command Block acts as the control and the sensor variables make the control become intuitive.

4.1.1 Sensor Variables

Two sensors are being integrated into Catroid: The Accelerometer and The Orientation Sensor. The Accelerometer senses the Android device's accelerometer, which detects measures acceleration in three dimensions. Acceleration is measured in SI units (m/s^2). If the device is at rest lying flat on its back, the Z acceleration will be about 9.8. When it is being lifted, it produces three values:

- **X-Sensor Acceleration**: Positive when the device is tilted to the right (that is, its left side is raised), and negative when the device is tilted to the left (its right size is raised).
- **Y-Sensor Acceleration**: Positive when its bottom is raised and negative when its top is raised.
- **Z-Sensor Acceleration**: Positive when the display is facing up, and negative when the display is facing down.

The orientation sensor determines the phone's spatial orientation. An orientation sensor is a non-visible component that reports the following three values, in degrees assume that the device itself is not moving:

- **Azimuth**: 0 degree when the top of the device is pointing north, 90 degrees when it is pointing east, 180 degrees when it is pointing south, 270 degrees when it is pointing west, etc.
- **Pitch**: 0 degree when the device is level, increasing to 90 degrees as the device is tilted so its top is pointing down, then decreasing to 0 degree as it gets turned over. Similarly, as the device is tilted so its bottom points

down, pitch decreases to −90 degrees, and then increases to 0 degree as it gets turned all the way over.

- **Roll**: 0 degree when the device is level, increasing to 90 degrees as the device is tilted up onto its left side, and decreasing to −90 degrees when the device is tilted up onto its right side.

The values of the two sensors are implemented as the variable/parameter named X-Sensor, Y-Sensor, Z-Sensor, Azimuth, Pitch and Roll These variables can be assigned to or removed from any text field in the Command Blocks using the Formula Editor as in Figure 15. The Formula Editor has the current editing Command Block and an editor textbox on top, 3 buttons at the centre and the keypad at the bottom.

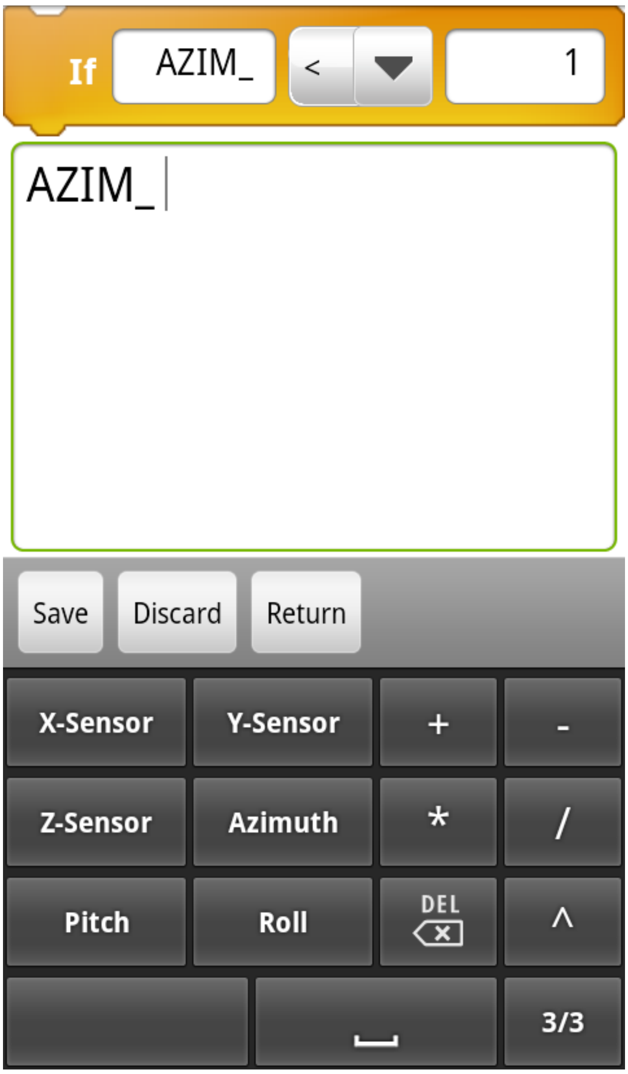

Figure 15: Sensor Variables in Formula Editor

By clicking on the text field of any Command Blocks in Scripting Area, the Formula Editor appears. In the Formula Editor, clicking on one of the 6 sensor variables will append the respective variable identifier in the text field and edit text box. Then, either "Save" button must be clicked to confirm the changes made to the text field or "Discard" button is clicked to discard the changes before clicking on "Return" button. Otherwise, the warning message will be popping out to remind the user as in Figure 16.

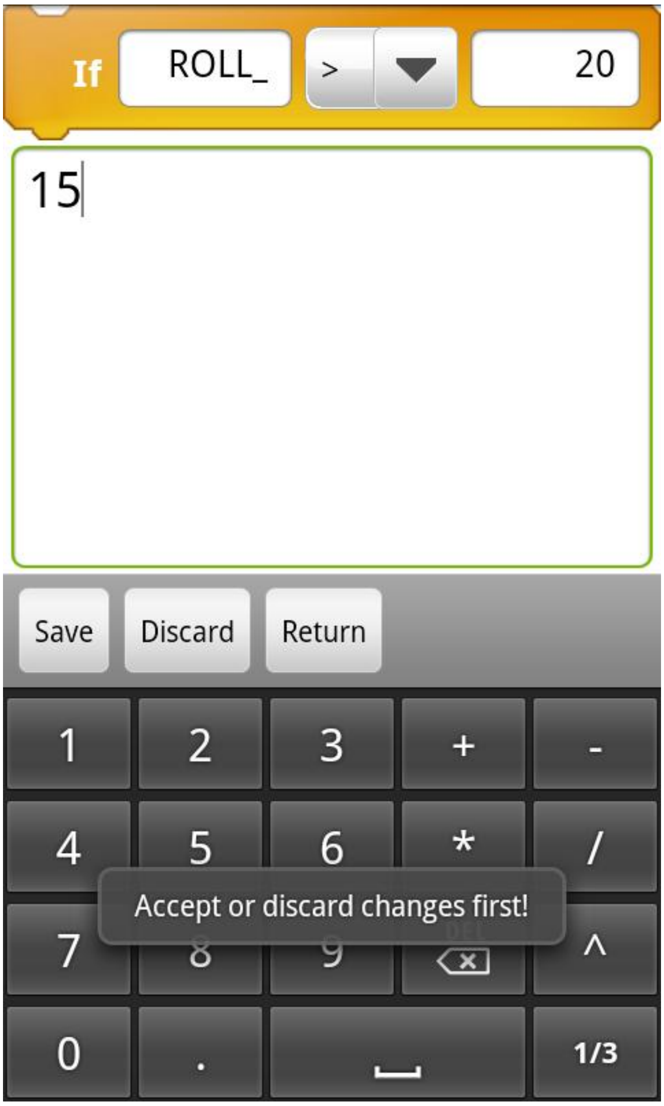

Figure 16: Warning Message to Accept Changes

The layout of Formula Editor and its operation are implemented according to 6 rules in the Schneiderman's Eight Golden Rules: The showing of the Command

Block on top reduces short term memory load and the instant changing of text field value offers informative feedback. The 3 buttons offers error prevention and simple error handling, permits easy reversal of actions and has design dialogues to yield closure. The whole layout design supports internal locus of control of the user.

In addition, the sensor variables can be included in an equation and calculated in the Formula Editor as in Figure 17. Besides mathematic operator, there are also basic mathematic functions to be used in the equation.

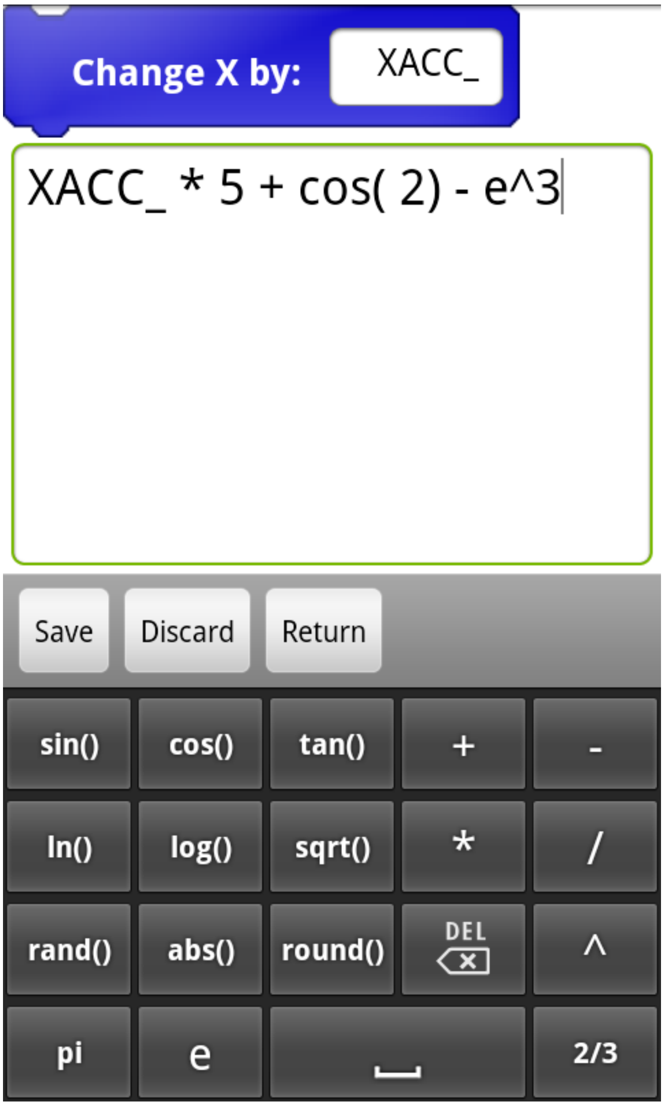

Figure 17: Equation in Formula Editor

4.1.2 If-Then-Else Command Block

The Figure 18 is the interface of the If-Then-Else Command Block to be used together with sensor variables to create intuitive control. The layout of the If-Then-Else Command Block is following the outlook of Control Categories to strive for consistency and it has 2 text fields and a logic operator.

Figure 18: If-Then-Else Command Block

4.2 The Mechanism of Intuitive Control API

The usage of the intuitive control API is simple and straight forward. When a sensor variable is assigned to one of the fields in If-Then-Else Command Blocks, the intuitive control is developed as in Figure 19. The Command Blocks in between the If-Statement Command Block and End of If Command Block will be executed whenever the logic condition in the If-Statement is true.

Figure 19: Intuitive Control API

4.2.1 Sensor Coordination System

In general, the sensor framework uses a standard 3-axis coordinate system to express data values as shown in Figure 20. For most sensors, the coordinate system is defined relative to the device's screen when the device is held in its default orientation. When a device is held in its default orientation, the X axis is horizontal and points to the right, the Y axis is vertical and points up, and the Z axis points toward the outside of the screen face. In this system, coordinates behind the screen have negative Z values.

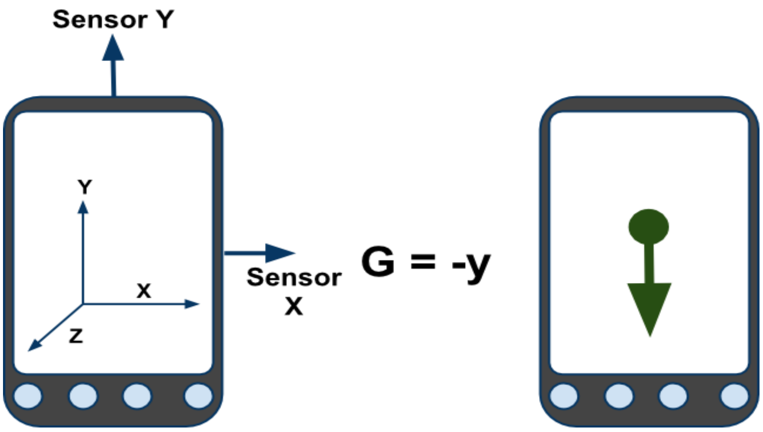

Figure 20: Default Sensor Coordination System

The most important point to understand about this coordinate system is that the axes are not swapped when the device's screen orientation changes—that is, the sensor's coordinate system never changes as the device moves. The Android sensor APIs define the sensor coordinate space to be relative to the top and side of the device — not the short and long sides. When the system reorients the screen in response to holding the phone sideways, the sensor coordinate system no longer lines up with the screen's coordinate system as in Figure 21, unexpected errors are generated in the intuitive control Command Blocks. Originally, X axis refers to Sensor X and Y axis refers to Sensor Y. But, it changes to X axis refers to Sensor Y and Y axis refers to Sensor X after the coordination system reoriented.

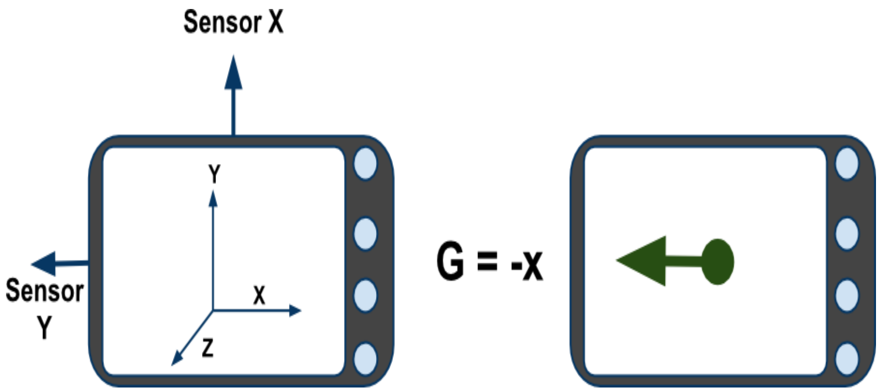

Figure 21: Reoriented Sensor Coordination System

When the sensor variable is used in a Catroid project, the value of Sensor X and Y will be inverted if the orientation of phone changed, thus creating unexpected error. This reduces the usability of the intuitive control Command Blocks and the users will need to take into account this complicated coordination issue whenever they do programming in Catroid. Therefore, the orientation check is implemented to check and swap the reference of the sensors automatically behind the codes to reduce the memory load of users and create usability.

4.3 The Intuitive User Interaction & Experience

The limitation of the current control API in Catroid is eliminated where different phone sensors are integrated to support children to develop new intuitive human-mobile interaction in Catroid. The intuitive control API can program various intuitive user interactions in Catroid depending on the creativity of the programmer. The intuitive user interactions which in common use are shaking, locating direction, titling and turning motion. These four user interactions can be developed according to the script examples below.

The Figure 22 below is the script example to detect shaking motion using X-sensor Acceleration value. The script tells that the particular Sprite will keep rotating anti-clockwise if a user do a shaking motion with the device.

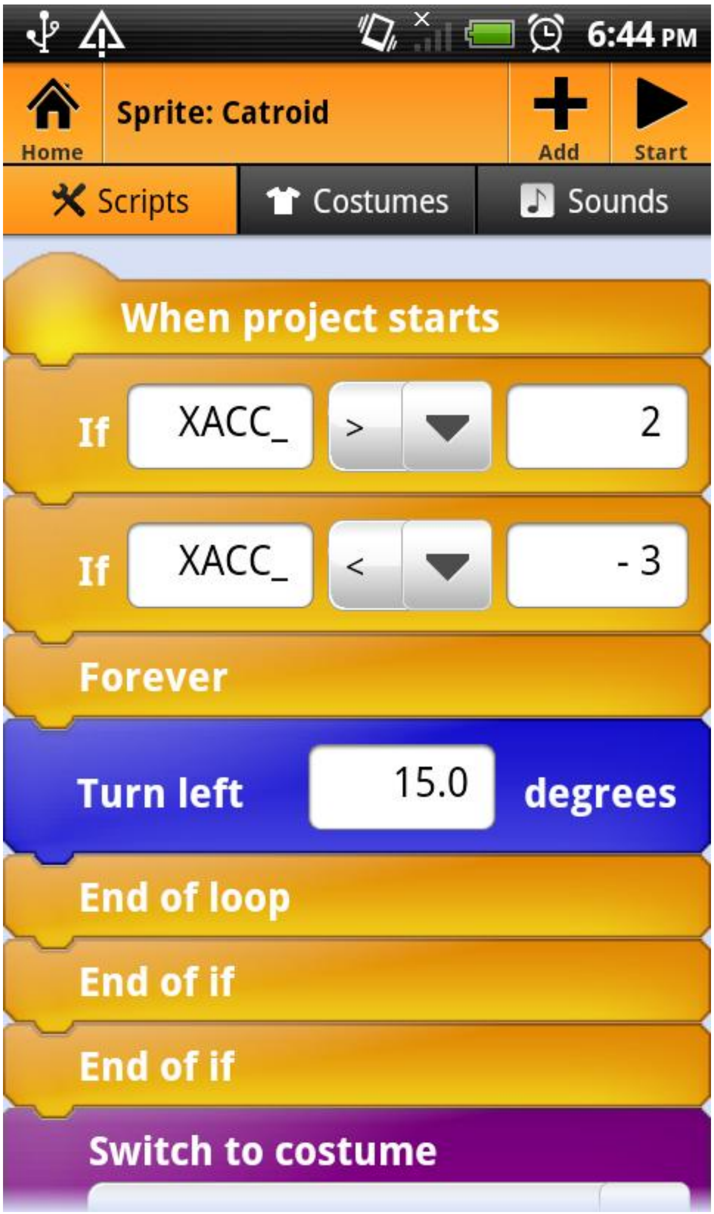

Figure 22: Shaking Motion

The Figure 23 below is the script example to detect direction using Azimuth angle value. The script tells that the particular Sprite will speak out the direction which the top of the device is pointing.

Figure 23: Locating Direction

The Figure 24 below is the script example to detect tilting/ turning/ rotating motion using Roll angle value. The script tells that the particular Sprite will move to the left if the right side of the device is raised and vice versa.

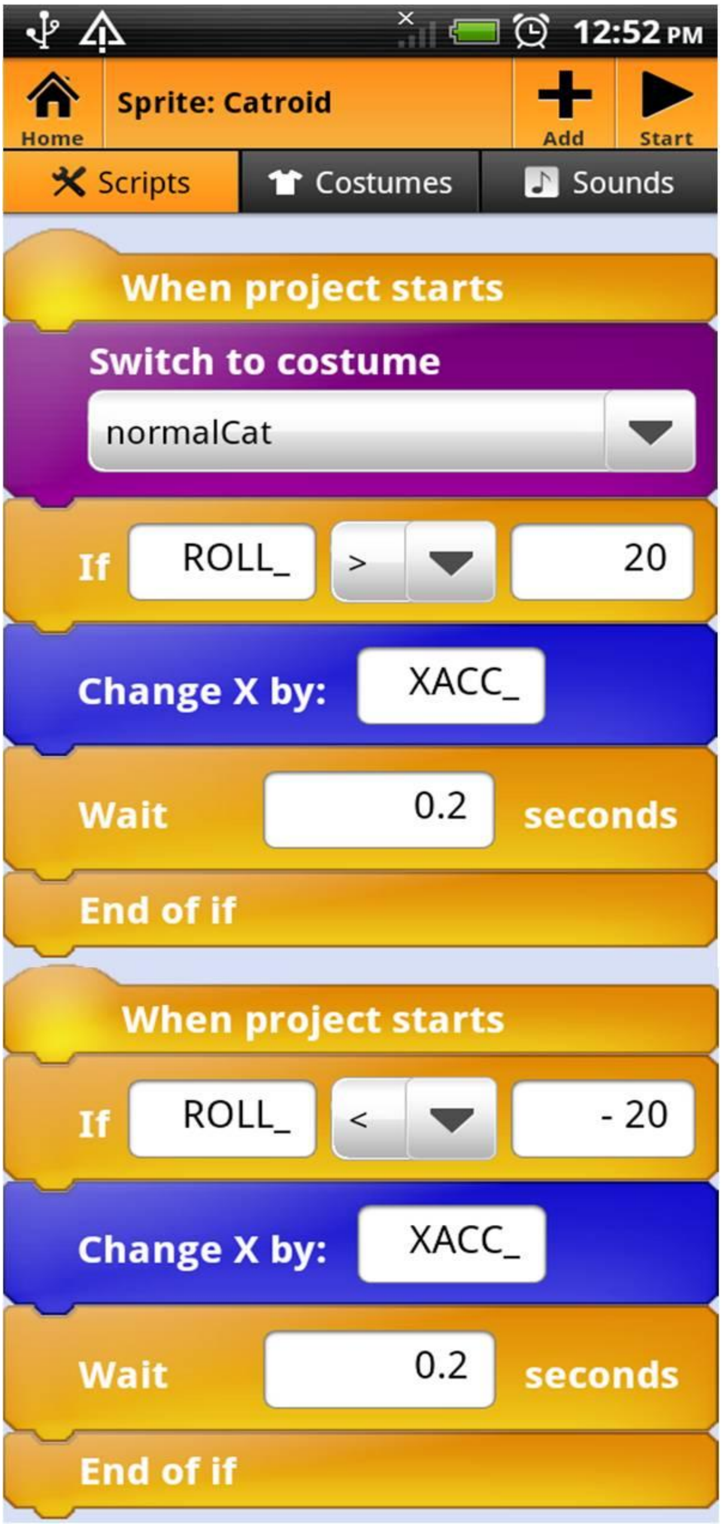

Figure 24: Titling/Turning/Rotating Motion

4.4 Open Source Development Method Benchmarking

The open source development method (OSDM) is different than typical software development method. Its characteristics and good practises can improve code quality, communication, effectiveness, and performance that typical software development method could not achieve.

The OSDM maintains a source code tree that is open and available for all to see and access. This allows full transparency and extensive peer review where all members of the community can comment and offer suggestions and bug fixes. Making the code public without having a fully working version helps the project to redefine user requirements even in the middle of development. Subsequently, the risk of project failure is reduced.

In addition, the OSDM allows this project to make a release available early to be used by the user community and then update the release as the software is modified The "release early release often" practice in OSDM gives a good estimate of the progress and help catch bugs early. It applies small incremental changes in release to make the source code easier to understand and test. Since this project is collaborating with 50 developers, the source code must be easy to understand and test after changes are made.

Usually, the OSDM promotes developers to use open source software and build on top of it to improve efficiency and increases cost savings. The OSDM even foster code reuse practice since it encourages developers to build reusable software components if there is a need to develop from scratch.

The OSDM uses Bottom-up-development approach where project members who done the most work get the most say when it comes to making design and implementation decisions while the typical software development method uses Top-down-development where project management makes the decision and pushes it down to the implements. This approach helps to motivate the developers to contribute more.

The open source development team primarily works together in a decentralized fashion with little hierarchy thus it is essential to have Bug tracking system, Automated test cases, Patch tracking system, and Revision Control System to help monitoring the progress of the team. OSDM welcomes code contributions written by volunteers, however the open source community takes security very seriously and any development or capability that jeopardizes the security of the software is flagged and not included in the software until the security concern is dealt with. In this project, Github is used as the patch tracking system and revision control system. Github is very useful to revert back to the unbroken state and discard all the changes made in the code. This saves time because debugging is time-consuming.

Although there is no formal documentation, the open source community follows a strict coding style to make it easier to understand the code, review it, and revise it quickly. Unclear and messy codes would not be accepted and pushed into the code tree by the community. Furthermore, test projects are created for large open source projects to create test suites and automate testing such as Junit Test and Robotium Test. The strict coding style and test projects can help to enhance the security of the software and ensure the compatibility of the new feature implementation.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Conclusion

This project eliminates the limitation of the current control API in Catroid to become a higher-level programming language for children. Currently, children can only program the user interaction in application with lower-level programming due to the limited functions of the current Catroid control API. With the intuitive control API where phone sensors integrated, children can develop an interactive application easily in Catroid.

The new intuitive control API not only benefits the children as a programmer but also the users who use the application programmed by them. The Catroid has a huge potential to become the next premier graphical programming tool not only for children and novice users of all ages but a new powerful programming tool for academic usage in computer science education.

An intuitive control API consists of sensor variables and If-Then-Else Command Block. The If-Then-Else Command Block acts as the control and the sensor variables make the control become intuitive. The sensor variables are implemented with the integration of Accelerometer and Orientation sensor. The accelerometer has 3 values: X-Sensor Acceleration, Y-Sensor Acceleration and Z-Sensor Acceleration while Orientation sensor has another 3 values: Azimuth, Pitch and Roll. The sensor variables can be assigned to and removed from Command Blocks using the Formula Editor. The intuitive control is created when the sensor variable is assigned to one of the text fields in If-Then-Else Command Blocks. In addition, the value of the sensor variables can be used in equation and calculation.

The interfaces of sensor variables, If-Then-Else Command Block and Formula Editor are designed referring to the interface design rules by Schneiderman’s Eight Golden Rules.

The usage of the intuitive control API is simple and straight forward. When a sensor variable is assigned to one of the fields in If-Then-Else Command Blocks, the intuitive control is developed. The Command Blocks in between the If-Statement Command Block and End of If Command Block will be executed whenever the logic condition in the If-Statement is true. There are various intuitive user interactions in Catroid can be programmed using the intuitive control API depending on the creativity of the programmer. The intuitive user interactions which in common use are shaking, locating direction, titling and turning motion.

This project chose to adopt open source development method to benchmark it with the typical software development method. The open source development method helps to produce higher-quality software with lower cost. Its characteristics and good practises can improve code quality, communication, effectiveness, and performance that typical software development method could not achieve. Besides, the open source development method reduces the risk of the software failed meet the user requirement.

Overall, this project has a significant impact to the programming power of Catroid and its user experience. It makes intuitive user interaction applicable for children to use in their application. This project will bring the programming language for children into the next higher level, subsequently improving usability to novice programmers, both children and adults.

5.2 Recommendation

There are several recommendations that could be considered to make this project better.

The first recommendation is the naming of the sensor variables. The selection of words and language are important for children to understand how the control API works. It will be better if icons or pictures are used to illustrate the functions of control API.

The second recommendation is to create a tutorial or video to demonstrate the usage of the intuitive control API. Besides, some sample Catroid projects that contain different intuitive control should be included in Catroid setup.

The third recommendation is to develop more sensor variables such as Light Sensor to detect ambient light, Temperature Sensor to detect surrounding temperature and Pressure Sensor to detect pressure.

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APPENDICES

Appendix 1

Rules of Clean Coding for Code Quality Assurance:

- Refactor & clean up the code for readability and understandable by itself
- Use no abbreviations
- Use as much as possible no comments
- Use good, pertinent names of variables, methods , objects & etc
- The code should be crystal-clear, self-explaining, and we should be annoyingly thorough in making this sure
- Eliminate duplicate code
- Leave no compiler warnings
- Cleanly use known design patterns
- All of above not only for the main code but also for the test code
- Add unit-, regression-, and functional-tests so that the code and functionality is 100% covered.
- Have all the code (include test code) reviewed by independent team members

The Criteria of Open Source Definition (OSI Community, 1998) :

1. Free Redistribution – Copies of the software can be made at no cost.
2. Source Code – The source code must be distributed with the original work, as well as all derived works.
3. Derived Works – Modifications are allowed, however it is not required that the derived work be subject to the same license terms as the original work.
4. Integrity of the Author's Source Code – Modifications to the original work may be restricted only if the distribution of patches is allowed. Derived works may be required to carry a different name or version number from the original software.
5. No Discrimination Against Persons or Groups – Discrimination against any person or groups is not allowed.

6. No Discrimination Against Fields of Endeavour – Restriction preventing use of the software by a certain business or area of research are not allowed.
7. Distribution of License – Any terms should apply automatically without written authorization.
8. License Must Not Be Specific to a Product - Rights attached to a program must not depend on that program being part of a specific software distribution.
9. License Must Not Restrict Other Software - The license must not place restrictions on other software that is distributed along with the licensed software.
10. License Must Be Technology-Neutral – No provision of the license may be predicated on any individual technology or style or interface.

Appendix 2

Gantt chart of Project Tracking

Appendix 3

GNU AFFERO GENERAL PUBLIC LICENSE

Version 3, 19 November 2007

Preamble

The GNU Affero General Public License is a free, copyleft license for software and other kinds of works, specifically designed to ensure cooperation with the community in the case of network server software.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, our General Public Licenses are intended to guarantee your freedom to share and change all versions of a program--to make sure it remains free software for all its users.

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An older license, called the Affero General Public License and published by Affero, was designed to accomplish similar goals. This is a different license, not a version of the Affero GPL, but Affero has released a new version of the Affero GPL which permits relicensing under this license.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS

0. Definitions.

"This License" refers to version 3 of the GNU Affero General Public License.

"Copyright" also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

"The Program" refers to any copyrightable work licensed under this License. Each licensee is addressed as "you". "Licensees" and "recipients" may be individuals or organizations.

To "modify" a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a "modified version" of the earlier work or a work "based on" the earlier work.

A "covered work" means either the unmodified Program or a work based on the Program.

To "propagate" a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

To "convey" a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

An interactive user interface displays "Appropriate Legal Notices" to the extent that it includes a convenient and prominently visible feature that (1) displays an appropriate copyright notice, and (2) tells the user that there is no warranty for the work (except to the extent that warranties are provided), that licensees may convey the work under this License, and how to view a copy of this License. If the interface presents a list of user commands or options, such as a menu, a prominent item in the list meets this criterion.

1. Source Code.

The "source code" for a work means the preferred form of the work for making modifications to it. "Object code" means any non-source form of a work.

A "Standard Interface" means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The "System Libraries" of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A "Major Component", in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The "Corresponding Source" for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work's System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

The Corresponding Source for a work in source code form is that same work.

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You may convey a work based on the Program, or the modifications to produce it from the Program, in the form of source code under the terms of section 4, provided that you also meet all of these conditions:

- a) The work must carry prominent notices stating that you modified it, and giving a relevant date.
- b) The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to "keep intact all notices".
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- d) If the work has interactive user interfaces, each must display Appropriate Legal Notices; however, if the Program has interactive interfaces that do not display Appropriate Legal Notices, your work need not make them do so.

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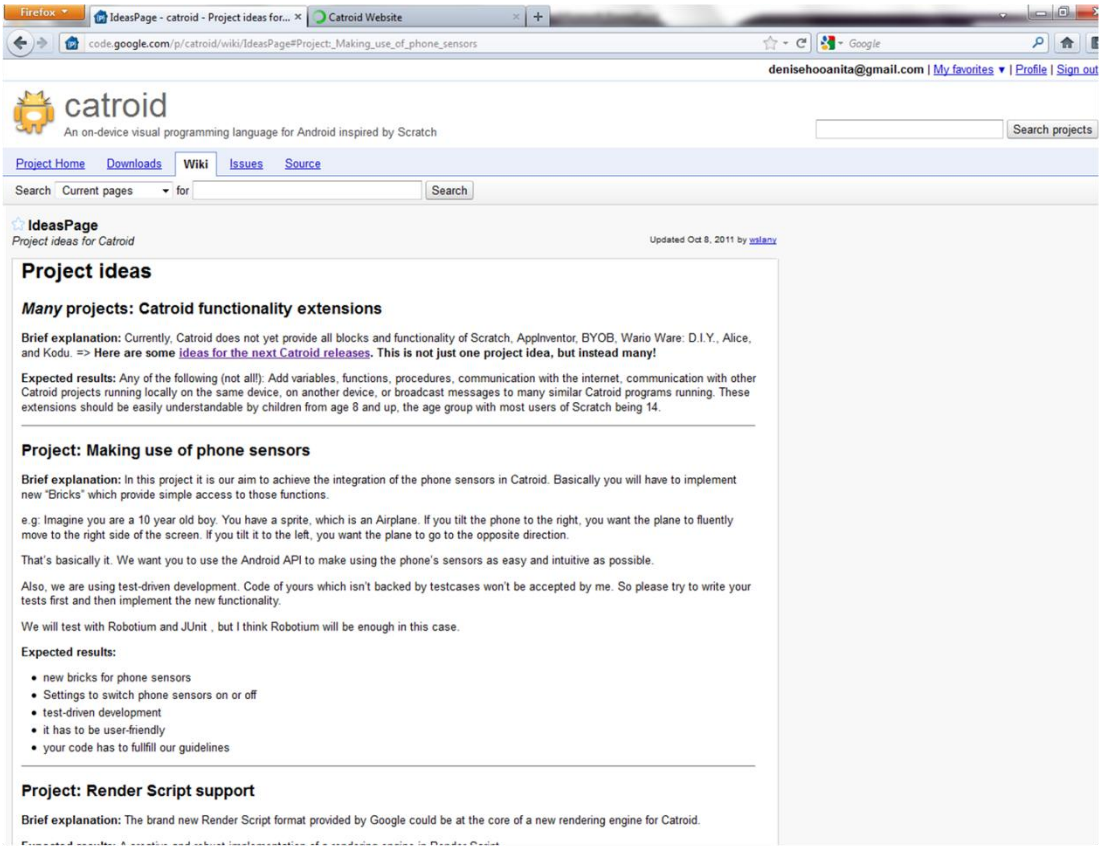
Appendix 4

Wiki Page of Control API for Catroid



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catroid

An on-device visual programming language for Android inspired by Scratch

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IdeasPage

Project ideas for Catroid

Updated Oct 8, 2011 by wslany

Project ideas

Many projects: Catroid functionality extensions

Brief explanation: Currently, Catroid does not yet provide all blocks and functionality of Scratch, AppInventor, BYOB, Wario Ware: D.I.Y., Alice, and Kodu. => **Here are some ideas for the next Catroid releases. This is not just one project idea, but instead many!**

Expected results: Any of the following (not all!): Add variables, functions, procedures, communication with the internet, communication with other Catroid projects running locally on the same device, on another device, or broadcast messages to many similar Catroid programs running. These extensions should be easily understandable by children from age 8 and up, the age group with most users of Scratch being 14.

Project: Making use of phone sensors

Brief explanation: In this project it is our aim to achieve the integration of the phone sensors in Catroid. Basically you will have to implement new "Bricks" which provide simple access to those functions.

e.g: Imagine you are a 10 year old boy. You have a sprite, which is an Airplane. If you tilt the phone to the right, you want the plane to fluently move to the right side of the screen. If you tilt it to the left, you want the plane to go to the opposite direction.

That's basically it. We want you to use the Android API to make using the phone's sensors as easy and intuitive as possible.

Also, we are using test-driven development. Code of yours which isn't backed by testcases won't be accepted by me. So please try to write your tests first and then implement the new functionality.

We will test with Robotium and JUnit , but I think Robotium will be enough in this case.

Expected results:

- new bricks for phone sensors
- Settings to switch phone sensors on or off
- test-driven development
- it has to be user-friendly
- your code has to fullfill our guidelines

Project: Render Script support

Brief explanation: The brand new Render Script format provided by Google could be at the core of a new rendering engine for Catroid.