USER

MANUAL

ZATDROID

Satellite Tracking and Augmented Reality App for ANDROID

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3. INTRODUCTION

This document is concerned to explain the features that ZATDROID offers the users, the installation process and a brief description of the main functionalities. The objective of this application is to introduce all the satellites to the users, showing information about any of them; from the orbit parameters up to the characteristics of the satellite.

ZATDROID joins two worlds: space engineering and computer science. From the beginning, this project grew up with the idea of working in the two topics that the author has been studying recently. On the one hand, ZATDROID is an ANDROID App. with the new features applied to devices such as tablets or smartphones. On the other hand, orbital mechanics and the orbit predictions tools and equations are to be included in the project.

There has been a lot of training in the planning because of the new features included in the program with JAVA for ANDROID and also because of the complex calculations involved in the propagations models for orbits predictions. These models are being used at the moment by NASA or satellites companies to performed actual orbits predictions.

ZATDROID takes advantage of GOOGLE MAPS to show real time satellites locations, OPENGL render options, views layers to show Augmented Reality view.

4. WHAT CAN I DO WITH ZATDROID? MAIN FUNCTIONALITIES

Figure 1. Main functionalities.

Once a user has a smartphone or tablet with ANDROID and installed the *apk* file ZATDROID can run.

Basically, with ZATDROID the user:

- Picks a satellite:
  - From a specific type navigating through menus with icons
  - From a search with key words.
- Locates it in GOOGLE MAPS together with its trajectory updated in real time.
- Sees it in the sky through Augmented reality in camera view.

ZATDROID gives the users the opportunity to interact with the satellites from their own devices in short time and simply with some clicks on your device. All those satellites that provide us with such functionalities as phones, TV, GPS are just one click far away from us. Anyone can satisfy curiosity for science and space easily.

In every screen during the search process, here are *BreadCrumbs* that helps the user know the satellite type picked and allows navigating through the type menus and English and Spanish are supported.

5. MINIMUM DEVICE REQUIREMENTS

ZATDROID has been developed and tested with:

- SDK: Eclipse
- Android Version: 2.3
- Device: Smartphone Sony Xperia Neo V (*GPS available, Wifi, 3G*)
- Screen: *480x854 pixels,* 265 *ppi*, 3,7'.
- Processor: Qualcomm 8255 de 1 GHz

Under these conditions, it is tested that every functionality works perfectly. But **compatibility** with other devices and versions needs to be explained:

- ANDROID: versions of Android from 2.3 up to 4.3 have been tested without any problem
- Devices: *LG, Sony, Nexus 4, HTC* seem to work as expected. It is with some *Samsung* devices where a bug has been noticed. In the Augmented Reality View there is a green filter as a layer and sometimes the arrow pointing at the direction of the satellite is not appearing. After some searching to solve it, no solution has been achieved, because the code is running right in every device except for some *Samsung* ones. *Samsung S3Mini* running ANDROID 4.2.1 has not this camera filter bug.
  Tablets with big screens show the windows fitting the size.
- Communications: WIFI or 3G internet connection needed.
- Tablets with no GPS and no phone capability cannot run the application.

6. INSTALLATION INSTRUCTIONS

As ZatDroid is created to run on smartphones or tablets with Android, the first step is getting a device like that with an active connection to the Internet.

There are many ways to get ZATDROID working. Basically, it consists of downloading the *apk* file and installing it in the device.

- By sending it via email, message or in sharing it in the cloud.
- By downloading it from Google Play. It is not at the moment uploaded, but it will be in a few weeks.
- By downloading the *apk* from free repositories like GITHUB, `commonsware.com`. It will be uploaded in some weeks.

Once the user has the *apk* file downloaded into your device, it is as easy as clicking on the installation button and accepting the permissions:

Permissions required when installing the *apk*:

- Internal Storage: To store XML and XSD files for searches
- GPS Location: to allow orbital mechanics
- Network communication: to allow orbital mechanics
- Hardware controls (camera): for the Augmented reality functionality

7. EXECUTING THE APP: SCREEN SEQUENCE DIAGRAM

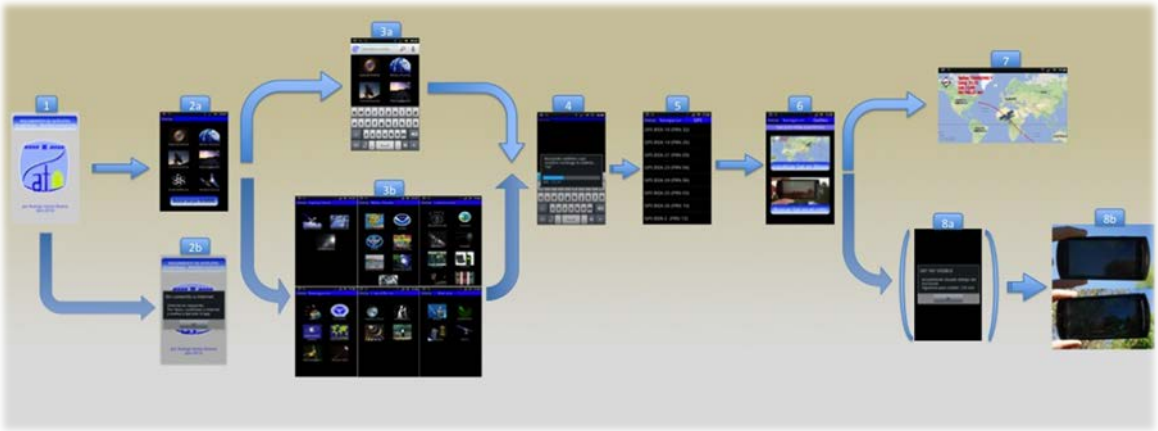

Figure 2. Screen Sequence Diagram

When executing ZATDROID, the users will be prompted several screens through the way. Figure 2 shows the general diagram sequence. This manual explains every screen and the processes followed behind the images.

7.1. INTRO

Figure 3. Screen 1: Intro

The first screen is showing the welcome with a brief description of the functionalities of the App. the logo, the author and the date. The logo includes a satellite at the top, the Android logo at the bottom and a big “Z” in the middle. Along the “Z” it is written the title of the App.

7.2. INITIAL SEARCH MENU

Figure 4. Screen 2a: Initial Search Menu

- This menu shows the two ways to perform a satellite search:
  - Through types pre-defined: there are icons with text, that will lead the user through a way of specific types until reaching finally a satellite.
  - By some key words: it opens a `searchDialog` to perform the search by key words.
- All the icons are adjustable to different screen sizes
- Supports Multilanguage: Spanish and English depending on the default of the device. (as shown in the images)
- *BreadCrumbs* navigation buttons helps the user.

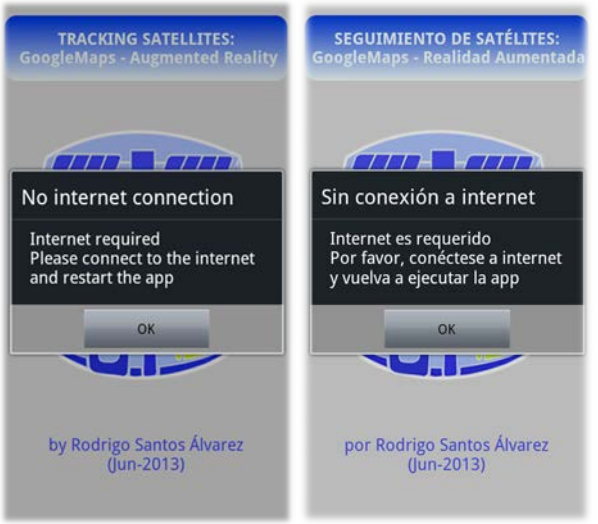

Figure 5: Screen 2b: Internet Connection Checking

Internet connection is needed, so if the device has no active connection, it shows the user a message and stops the application

7.3. SATELLITE SEARCH PROCCESS

Figure 6: Screen 3a: Search by key words

The option to carry out a search typing some key words is performed with the help of the `searchDialog`. Voice typing is allowed.

Figure 7: Screen 3b: Types of satellites

There are 6 screens describing the satellite subtypes. The screen structure is similar to the first screen, with *BredCrumbs* navigating buttons, adjustable icons size, Spanish and English support.

7.4. DOWNLOADING FILES FROM THE INTERNET

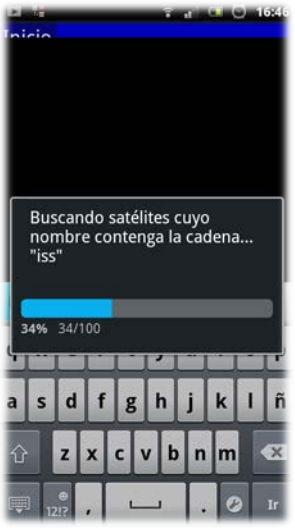

Figure 8: Screen 4: Downloading TLEs Progress Bar

After having picked the final satellite type or having typed the key words, a time-limited screen is shown with a progress bar to let the user know that the program is running. ZATDROID is getting the TLEs (*two line elements sets*) from `celestrak.com` with the information of the satellites in a txt file. Deep inside the code, txt file is transformed into a more easy-managed XML file with its XSD file linked.

The downloading process lasts more that a few seconds sometimes, depending on the internet connection. Actually:

- If the download is launched when a satellite type have been picked, it lasts just 1 or 2 seconds, because the txt file is just from a subtype.
- If the download is launched when a search by key words is performed, all the subtypes are downloaded and merged into one file. Therefore this process lasts more.

It is worth mentioning that the download process is performed using a ASYNTASK method, which allows the program to run in a second thread the download while the progress bar is shown to the user. If an error is found, the program does not stop suddenly. This ANDROID method increases the robustness of the software.

7.5. SATELLITE NAMES LIST

Figure 9: Screen 5: Listing satellite names from XML file

After the downloading process has finished, and then the XML file created from the txt with the satellite information and orbit parameters, only the names of the satellites are shown in a `ListView`. Also the XSD (*XML Scheme Definition*) is created to define the legal building blocks of the XML document.

Once the XML is created, a SAX (*simple API for XML*) search is performed to find the satellite names and be able to add them to the `ListView`. In case a search by key words is carried out, the list can be extremely large and also if the "Gestationary" subtype is picked. There are 414 satellites orbiting the Earth in the geostationary belt at this moment.

At the top, *BreadCrumbs* let the user know the satellite type and subtypes picked. The buttons are clickable so that the user can navigate through them.

When the user picks a certain sat name, another SAX search is launched to find the satellite in the XML file and extract all the information and parameters orbit from the file and use them to create a "*sat*" JAVA object with all that information. This "*sat*" object will be fulfilled with other orbit parameters calculated afterwards with orbital mechanics.

7.6. FUNCTIONALITIES MAIN MENU

Figure 10: Screen 6: Functionalities Menu

At the top, *BreadCrumbs* let the user know the satellite type and subtypes picked. The buttons are clickable so that the user can navigate through them. Here the full address is shown and the user can go back to any of the subtypes.

The "sat" Java object is retrieved but no orbital mechanics calculations is developed so far. The menus are composed by an image and a clickable button. The text supports English and Spanish, as usual, and the

- The first icon open the GOOGLE MAPS Activity where the sat will be represented together with its trajectory.
- The second button opens the Augmented Reality Activity, where the user can search the sky to find the satellite with the camera view.

7.7. GOOGLE MAPS FUNCIONALITY

Figure 11: Screen 7: GOOGLE MAPS Funcionality

Over the GOOGLE MAPS View, the satellite icon is positioned, together with its trajectory and the satellite orbit parameters: latitude, longitude and altitude. They are updated instantly, except for the trajectory, that lasts one second, due to the complicated calculations. The trajectory shows the next and past 20 minutes. The complete orbit cannot be drawn due to the big amount of calculations.

If the user ever sees a satellite at high altitudes (30.000 Km) and the trajectory is not drawn, it is not a bug. The satellite follows a geostationary orbit and therefore it is fixed. Actually, it is rotating with the Earth, so for an inhabitant it is always in the same position, same latitude and longitude.

Orbital Mechanics calculations are performed once this screen is shown, following NORAD (*North American Aerospace Defence Command*) SGP4 (*Simplified General Propagation Model Version 4*) / SDP4 (*Simplified General Deep Space Perturbation model version 4*) propagation methodology, according to NASA (*National Aeronautics and Space Administration*) documents.

7.8. AUGMENTED REALITY FUNCTIONALITY

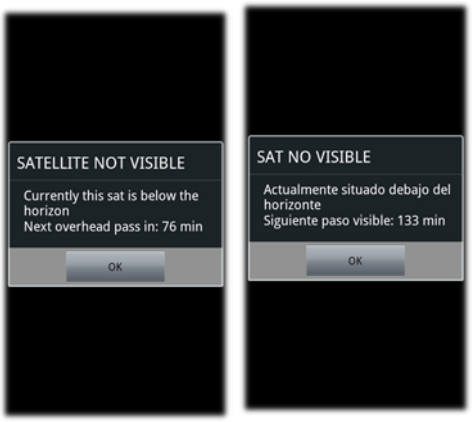

Figure 12: Screen 8a: Visibility Message

Figure 13: Screen 8b: Augmented Reality View

Finally, the last functionality is this Augmented Reality View.

- Orbital Mechanics calculations are developed to get azimuth and elevation of the satellite.
- OpenGL is used to match the camera view azimuth and elevation with the satellite position in the sky.
- Layers over the camera view are to set Text, arrows, central square and satellite icon.
- Georeference is needed to calculate the location of the device, latitude and longitude. GPS or network is used.
- Sensors like accelerometer, gravity and magnetic give the orientation of the camera view device.

If the elevation of the satellite from the device location is below 0 degrees means that the satellite cannot be seen over the horizon. In this case, a message is shown to inform the user and the time lasting until next overhead pass. (*English and Spanish supports, as shown*)

Orbital Mechanics calculations are again performed, following NORAD SGP4 / SDP4 propagation methodology, according to NASA documents.

8. TROUBLESHOOTING

- Some *Samsungs* devices (*Samsung S3, Note*) show a green filter in the Augmented Reality View over the camera view. However, *Samsung S3Mini* runs AR View as expected. Android versions do not influence and other devices have no problems like this. Some research has been done to fix it up, but nothing related have been found so far. The filter allows to see through the camera, so it is not really important.

- GPS or internet or network is a must when running ZATDROID. Tablets without these three features cannot execute the app and an error is shown. Device location (longitude, latitude and altitude) cannot be retrieved.

- Some *Motorola* and *Sony* tablets do not start the app. There is no explanation for this bug so far.

- If the internet connection is not quick enough, the downloads process could last more than 3 seconds as required. Anyway, download files when a search by key words is selected could last more than 3 seconds even with a quick connection.

- In the GOOGLE MAPS View , trajectory is refreshed every second, not instantly. The user notice that trajectory delays when moving or zooming. This is done on purpose, otherwise the big amount of calculations the app hangs.

In case other bugs are detected, please contact with the author. I will be grateful.