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EARTHQUAKE GEOSURVEY, AN APPLICATION FOR REPORTING EARTHQUAKE-INDUCED ENVIRONMENTAL EFFECTS

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Abstract: Earthquake GeoSurvey *is an application that can be used by earth-scientists and engineers during field surveys in order to report the earthquake-induced environmental effects (EEE). The app has been designed based on the EEE form, proposed by the* **INQUA TERPRO Focus Area on Paleoseismology and Active Tectonics**, *for reporting earthquake-induced deformations and processing the collected data at the end of a post-earthquake reconnaissance field survey. As an outcome, the earthquake environmental effects can be documented and the macroseismic intensity will be evaluated based on the Environmental Seismic Intensity-2007 (ESI-07) scale. The post-earthquake report can be exported as kmz file and consequently uploaded to a GIS environment.*

Key words: earthquake, survey, environmental effects, application, android

INTRODUCTION

The basic goal of the project is to develop two applications for tablets and smartphones, using either android system or iOS that will be used by earth-scientists and engineers during field surveys in order to document the earthquake-induced environmental effects.

In order to achieve this, the project was mainly designed based on the Earthquake Environmental Effects form, proposed by the INQUA TERPRO SubCommission Group for reporting earthquake-induced deformations (Michetti et al. (2007), and the recommendations of GEER, Geotechnical Extreme Events Reconnaissance, (GEER, 2011) regarding data processing after a post-earthquake reconnaissance field survey.

In particular, via this application the user is able to document primary and secondary effects, collect GPS waypoints (in decimal degrees using WGS84) and thus, geo-tag the collected photos. The type of effects that can be reported and described in detail are surface faulting, slope failures, liquefaction, tsunami, ground cracks, hydrological anomalies and other effects like trees shaking (Fig. 1). For example, regarding the earthquake-induced liquefaction, the user can select a subtype of liquefaction from a list including the three most characteristic ones (ejection of sandy material, subsidence and lateral spreading), describe in detail the failure within an extra field, report the maximum diameter of sand boils, select either water or sand ejection and finally locate the site by activating the GPS and take a photo of the liquefaction manifestation. In addition, the macroseismic intensity can also be evaluated using the ESI-07 scale and the relevant chart that is provided.

Finally, the data that have been collected during the field survey are saved on the SD card of the smarthphone/tablet as KMZ file and consequently can be used by Google Earth and other GIS application for further processing. The most direct presentation of the collected data can be achieved using Google Earth, where the collected data are plotted with different symbols-icons depending on the type of failure. In this way, the collected information can be separated and maps showing the spatial distribution of one-type or combination of earthquake-induced failures can be developed including geo-tagged photo.
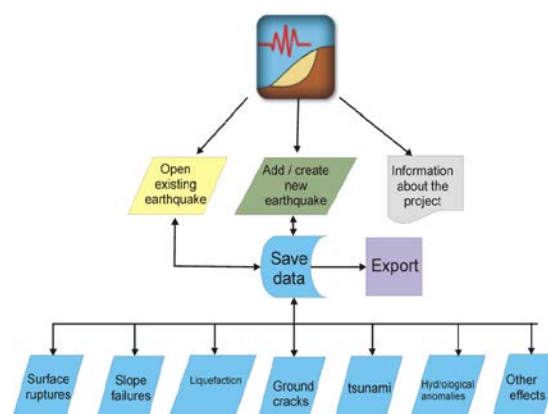

Fig. 1: Flowchart of the Earthquake Geo Survey

DATA MODEL

In this chapter, we describe the data model of the Earthquake GeoSurvey application that was designed to adequately describe earthquakes and environmental

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effects. The main concepts of the Data model are earthquake and ~~effect which~~effect, which are represented in the application according to OOP (object-oriented Programming) principles as classes.

The *earthquake* class is used for describing the earthquake itself. An earthquake is described by the following attributes: code, date (dd/mm/yy), earthquake magnitude, magnitude type (Mw or Ms), ESI epicentral intensity, epicentral area, country, longitude and latitude (WGS84). The class representation is depicted in Fig. 2.
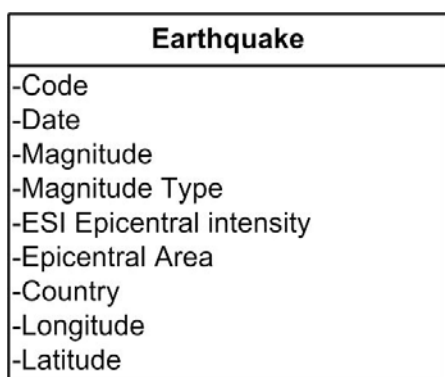
Fig. 2: Earthquake Class

Effect classes describe earthquake-induced environmental effects. Following the recommendations provided by the EEE form (Michetti et al., 2007), the environmental effects have been grouped into 7 types. These types of effects that can be reported and described are: surface faulting, slope failures, liquefaction, tsunami, ground cracks, hydrological anomalies and other effects. Each effect is described by different attributes depending on its effect type. For example, dip information might be meaningful for a surface faulting effect and do not apply for a slope movement effect. However, all effect types share common attributes such as ID and Longitude/Latitude. For that reason our data model was designed according to class inheritance principle. Class inheritance in programming means that a class can inherit behaviour and attributes from other classes, which called base, super or parent classes

In our model, the *Effect* class is used as a parent class and there are seven more child classes that represent each effect type (Fig. 3*)*. The common attributes (which are ID, Subtype, Date, Description, Longitude, Latitude, ESI-07 scale and Photo) are represented by the *Effect* parent class. Each child class hold attributes that are specific to the effect type and also inherits the attributes from its parent class *Effect*. For example, a slope movement effect is represented by the *Slope Movement* class and is described by the attributes ID, Subtype, Date, Description, Longitude, Latitude, ESI-07 Scale, Photo, Blocks Dimension and Total Volume.
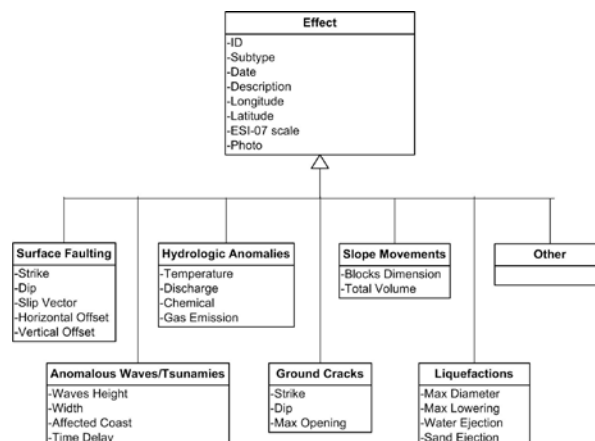
Fig. 3: Effect Class Diagram

KML STRUCTURE

In the Earthquake GeoSurvey application collected data are stored in KML (Keyhole Markup Language) files. KML is an XML notation for expressing geographic annotation and was developed for use with Google Earth, which is a software for viewing of Earth satellite imagery, maps and user defined overlays of geographic information (GEER, 2011). Each KML file holds information about an earthquake, visualization styles and earthquake's environmental effects in XML elements.

At the top of each KML document XML elements *name, Timestamp and Extended Data* holds information about the earthquake itself such as name, date, magnitude etc. (Fig.4).

```
<name>earth-1</name>
<Timestamp><when>24-3-2013</when></Timestamp>
<ExtendedData>
    <Data name="Magnitude"><value>12</value></Data>
    <Data name="MagnitudeType"><value>Mw</value></Data>
    <Data name="Intensity"><value>3</value></Data>
    <Data name="Country"><value>greece</value></Data>
</ExtendedData>
```

Fig. 4: XML elements for describing earthquake

Style XML elements define styles for effect visualization in Google Earth. Each effect, depending on its type, is visualized in Google Earth with its type symbol (icon) and a custom information popup. The Effect icon is similar to the icons proposed by Silva et al. (2008) in order to maintain the consistency between the ESI-07 scale and the application. Therefore, in KML document there are seven *Style* elements, one for each effect type. In these elements, ~~the type~~the type symbol and info popup template are defined (Fig. 5).

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```
<Style id="Surface Faulting">
    <IconStyle><Icon><href>http://.../rupture.png</href></Icon></IconStyle>
    <BalloonStyle>
        <text><![CDATA[<h1>$[Type]</h1><h2>$[Subtype]</h2><hr/>
                <h3> Description: $[Description]</h3>
                <h3> ESI-07 Scale: $[esi]<h3> Strike  : $[Strike]
                <img src='$[photo]'/>]]>
        </text>
    </BalloonStyle>
</Style>
```

Fig. 5: XML style element

Each effect is described by a *Placemark* XML element. In KML document there are as many *Placemark* XML elements as effects. *Placemark* elements contain sub-elements that fully describe an effect (Fig. 6). In particular, the *Name* sub-element holds ID, the *Style_Url* sub-element associates this effect with a visualization style depending on its type, the *Point* sub-element holds longitude and latitude, the *TimeStamp* sub-element holds effect's reporting date and finally, the *ExtendedData* sub-element contains more sub-elements that hold other information that fully describe the effect such as subtype, description, ESI-07 scale and name of the photograph.

```
<Placemark>
    <name>q1</name>
    <styleUrl>#Surface Faulting</styleUrl>
    <Point><coordinates>26.55899175,39.106032150000004</coordinates></Point>
    <TimeStamp><when>24-3-2013</when></TimeStamp>
    <ExtendedData>
        <Data name="Type"><value>Surface Faulting</value></Data>
        <Data name="Subtype"><value>Oblique</value></Data>
        <Data name="Description"><value></value></Data>
        <Data name="photo"><value>q1.jpg</value></Data>
        <Data name="esi"><value>3</value></Data>
</Placemark>
```

Fig. 6: Placemark XML element

APPLICATION DEVELOPMENT

At present time only the Andorid application has been developed, while the design of the iOS application structure has been already started. Earthquake GeoSurvey application for Android was developed in Eclipse IDE (Integrated Development Environment). Eclipse is anIDE for android application development as it supports the Android Development Tools (ADT) plugin, and integrates the Android SDK (Software Development Kit) which is essential for application developing for Android Devices. The programming language used for the application development is Java.

During development phase application was tested on a HUAWEI U8180 device with the following features: Android 2.2.2 OS, 2.8 in. display, capacitive touch screen, 512MB memory, 3.15 megapixel camera, 4 GB SD card, and GPS. The application runs on devices with Android 2.2 OS version or newer. It requires access to camera and GPS receiver features and permission to write to device's external storage.

Each earthquake is stored in ~~a KMZ file that are~~ a KMZ file that is compressed kml files containing zero or more

supporting files such as images. KMZ files are stored in device SD card under Earthquake GeoSurvey folder. The application makes use of the device GPS receiver in order to capture effect's location (longitude and latitude) in WGS84 coordinate system. Camera enables application users to take pictures for an effect and thus, each photo can be tagged with location.

USE CASE

In this chapter we present the Earthquake Geo Survey application according to the following use case scenario.

Scenario: Creating a new earthquake file and adding an effect

In order to add earthquake effects, first an earthquake file must be created. At the application's home screen (Fig.7), user should click on *New Earthquake* Button. At the new screen, there is an earthquake form that the user should fill with current earthquake-related data (Fig.8). To create the earthquake file the user should click at the *Save* Button at the bottom of the screen. A new KMZ file was created and stored in the SD card of the device. The name of the newly created file is the same with the value that the user entered in the *Code* field.
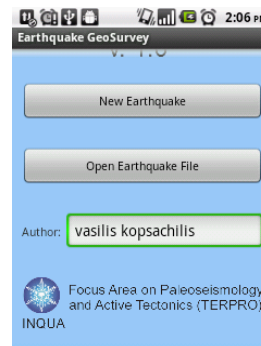
Fig. 7: Home Screen   *Fig. 8: Earthquake Screen*

Now the user can add an effect to current earthquake by clicking on the *Effects* Tab at the top of the screen and then by clicking at *Add New Effect* Button (Fig. 9). We should note that at this time the effect list is still empty for the selected earthquake. At the next screen (Fig. 10) user must select the effect type that he will report. Depending on the user selection the appropriate effect type screen will appear.
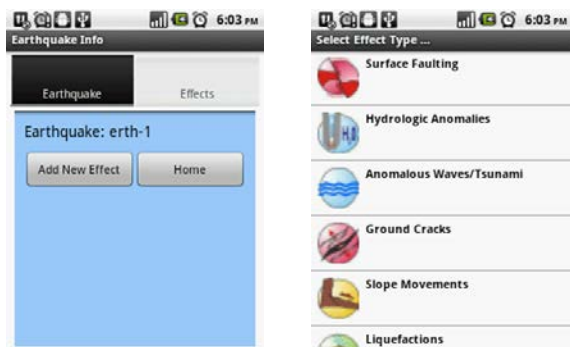
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Fig. 9: Effect List Screen   Fig. 10: Effect Types Screen

Effect Screen (Fig.11) contains a form with fields that the user should fill in order to describe the effect. The effect location can be captured by clicking on the *GPS Off* button. The effect's longitude and latitude will appear on the screen as soon as the user location is detected. User can add a photograph from the effect place by clicking at the *Photo* button. When the user fill the form, can add the effect to the earthquake file by clicking at the *Add Effect* button at the bottom of the screen. He can return to the effect list screen and preview the newly added effect by clicking at the *Effect List* button (Fig. 12).
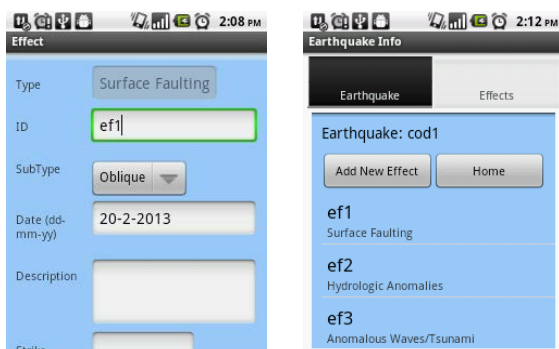

Fig. 11: Effect Screen   Fig. 12: Effect List Screen

Once the earthquake file created, it can be used by Google Earth and other GIS applications. In Google Earth, the collected data are plotted with different symbols depending on the type of failure. Also, when the user clicks on an effect an information popup appears containing information about the effect and a picture (Fig. 13).
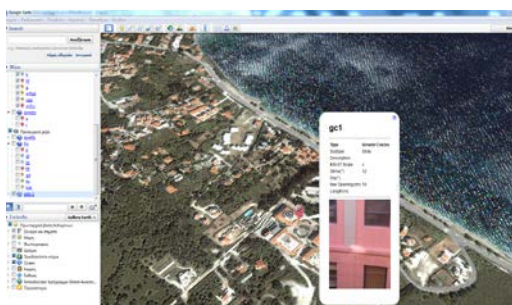

Fig. 13: Google Earth Visualization

DISCUSSION

The development of this application is the first step of the INQUA TERPRO Focus Area on Paleoseismology and Active Tectonics in the new era of online information-exchange. The version presented in this article provides the adequate tools and functions that geologists and engineers are needed on the field for documenting the effects of an earthquake.In addition, new functions are planned to be developed in order to increase the usefulness of the application such as activation of the compass that can be used for reporting surface faulting and the direct linkage to the web site of Earthquake Environemntal Effects for on-line presenation of the collected data.

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